THE IMPACT OF WATER AND SANITATION ON DIARRHOEAL DISEASE BURDEN AND OVER-CONSUMPTION OF ANTIBIOTICS

PRESENTED TO THE REVIEW ON ANTIMICROBIAL RESISTANCE

Pablo Araya, Julia Hug, Genevieve Joy, Felicia Oschmann, Susana Rubinstein

Master of Public Administration
London School of Economics and Political Science

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THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Review on Antimicrobial Resistance

Tackling drug-resistant infections globally

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ABBREVIATIONS AND ACRONYMS

AMR	Antimicrobial resistance
AMRHAI	Antimicrobial Resistance and Healthcare Associated Infections
CDDEP	Center for Disease Dynamics, Economics & Policy
CEBDS	Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável (The Brazilian Business Council for Sustainable Development)
CLTS	Community-led total sanitation
CBA	Cost-benefit analysis
CDC	Centers for Disease Control and Prevention
CEA	Cost-effectiveness analysis
CI	Confidence interval
DALY	Disability-adjusted life year
DHS	Demographic and Health Surveys Program
ECDC	European Centre for Disease Prevention and Control
FSM	Faecal sludge management
GDP	Gross domestic product
GWA	Gender and water alliance
HI	High income countries
IGBE	Instituto Brasileiro de Geografia e Estatística (Brazilian Institute for Geography and Statistics)
IMF	International Monetary Fund
IO	International organisation
IRC	International Rescue Committee
JMP	Joint Monitoring Programme for Water Supply and Sanitation
LAC	Latin America and the Caribbean
LMIC	Low- and middle-income countries
M&O	Maintenance and operations

MDG	Millennium Development Goal
NGO	Non-governmental organisation
NEEDS	National economic empowerment and development strategy
NGP	Nirmal Gram Puraskar
OECD	Organization for Economic Cooperation and Development
OHCHR	Office of the United Nations High Commissioner for Human Rights
ORS	Oral rehydration salts
PAF	Population attributable factor
Plansab	Plano Nacional de Saneamento Básico (National Sanitation Plan)
PPP	Purchasing power parity
R&D	Research and development
RCT	Randomised control trial
RR	Relative risk reduction
SDG	Sustainable Development Goals
SNIS	Sistema Nacional de Informações Sobre Saneamento (National Sanitation Information System)
SUS	Sistema Único de Saúde (Unified Health System)
TSSM	Total Sanitation and Sanitation Marketing Programme
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
WSP	Water and Sanitation Program
WASH	Water, sanitation and hygiene

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EXECUTIVE SUMMARY

Infectious disease control through improved water, sanitation and hygiene (WASH) infrastructure needs to be placed at the centre of the antimicrobial resistance (AMR) agenda. The spread of infectious diseases caused by inadequate WASH standards is a major driver of antibiotic demand in developing countries. Growing usage of antibiotics together with persistent infectious disease levels have led to a dangerous cycle in which reliance on antimicrobials increases while the efficacy of drugs diminishes. This report combines recent findings on the costs of reaching the Sustainable Development Goals (SDGs) for water and sanitation with an analysis on the potential reduction in the related disease burden to assess how antibiotic consumption may fall by improving WASH. The focus countries of this report are Brazil, India, Indonesia and Nigeria – all large countries with big populations that have access to antimicrobials and scope for improvements in WASH.

Improving WASH infrastructure is feasible, nevertheless 2.4 billion people around the world do not have access to adequate sanitation and 1 billion individuals still practise open defecation. The most marginalised population groups have seen the least progress and continue to endure the greatest burden in terms of child deaths and diseases associated with inadequate WASH. This report shows that the cost of achieving the SDGs for drinking water, sanitation and hygiene by 2030 are reasonable, ranging from just 0.3 percent of GDP per year in Brazil to 2.1 percent of GDP per year in Nigeria. However, this is not where the story ends: current spending on WASH is far below the necessary level in most developing countries and the success of all interventions is strongly dependent on institutional factors such as political will, cultural and behavioural contexts, and numerous demographic issues.

WASH interventions are highly effective in reducing the infectious disease burden. Currently, inadequate access to water and sanitation causes more than half of diarrhoeal disease, a largely preventable illness that still kills 2,500 children a day. Through the use of a burden of disease model, this report shows that access to safe water and sanitation could reduce the diarrhoeal disease burden by as much as 47-50 percent and 69-72 percent, respectively. The results highlight that up to 17 million deaths could be prevented through improving water and sanitation in the four countries of concern. Reducing the diarrhoeal burden also strongly benefits the most vulnerable, including children under five and low-income households.

The majority of diarrhoeal cases in developing countries are mistreated with antibiotics, indicating that a decrease of the disease burden could lead to a reduction of antibiotic consumption. The rising levels of resistance among diarrhoeal pathogens are a strong indicator of substantial use and misuse. While 70 to 80 percent of diarrhoea is caused by viral pathogens, the WHO estimates that around 40 percent of cases are treated with antibiotics; and some local studies reviewed in this report indicate treatment in over 80 percent of cases. By 2030, a reduction of the diarrhoeal disease burden through improved WASH infrastructure would result in large decreases in the number of diarrhoeal cases treated with antibiotics, ranging from 5 million in Brazil to up to 590 million in India for sanitation. Overall, WASH infrastructure can motivate a 47-72 percent decrease of diarrhoeal cases treated with antibiotics in 2030 depending on the type of intervention and its effectiveness. The strong link between increased consumption and resistance indicates that this will directly mitigate the accelerating spread of AMR.

While these gains are already substantial, the reduction of antibiotic consumption through a decrease in the WASH-related diarrhoeal disease burden could be accelerated by complementary interventions. Rotavirus vaccinations, regulation of over-the-counter access to antibiotics and community-tailored interventions have all already shown promising results in developing countries.

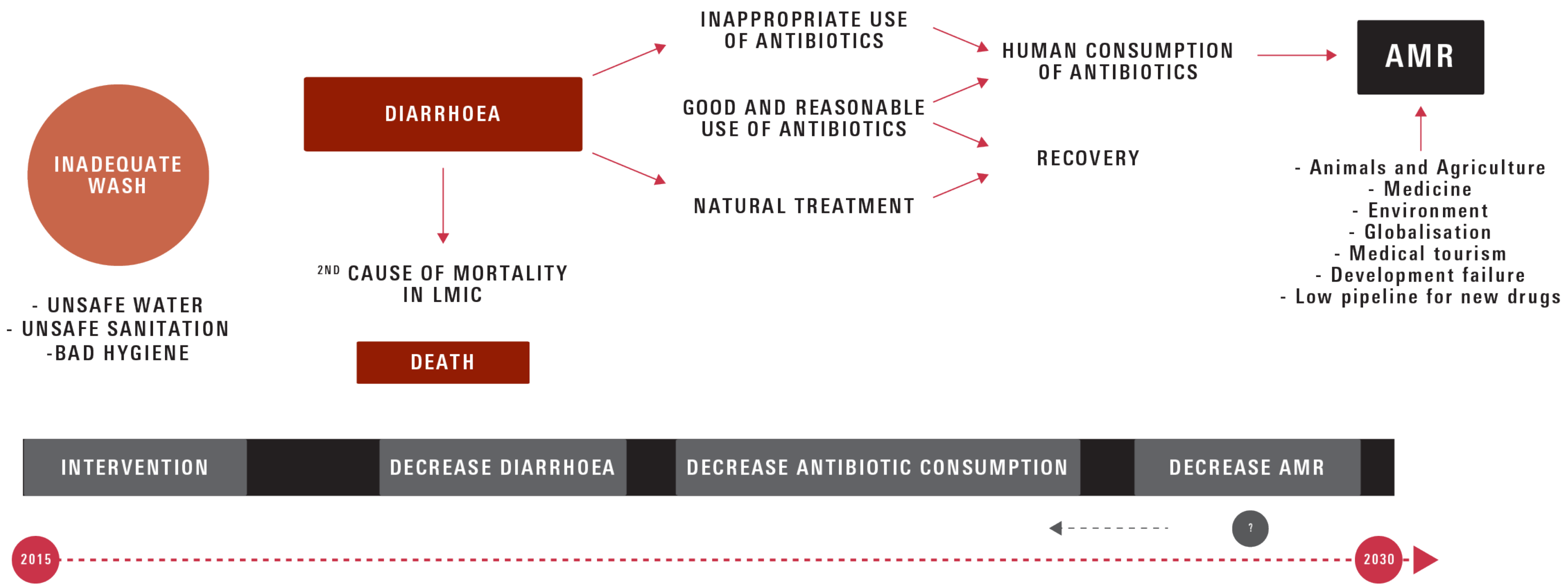


Figure 1.1: Project overview

1. INTRODUCTION

Antibiotics have accelerated the reduction of infectious disease, saving the lives of millions in the developed and developing world. In recent decades, remarkable progress has been made in improving access to drugs, especially for the poorest parts of the world's population. At the same time, increased access to and availability of antibiotics has turned them into a substitute for proper infection control interventions in many low- and middle-income countries (LMICs).

While antibiotics are often cheap, readily available, and sometimes reimbursed by governments, infection control interventions are considered unaffordable and too complex to implement. This has led to a dangerous cycle in which on one hand, infection rates and reliance on antibiotic treatments are rising, while on the other hand, the effectiveness of drugs is decreasing due to increasing rates of antimicrobial resistance (AMR). Infection control mechanisms, particularly through water and sanitation interventions, can slow this dangerous development.

1.1. Objectives

This report's main objective is to define how safely-managed sanitation and water infrastructure might reduce infection rates as a strategy to mitigate AMR in LMICs. Specifically, this report will address three main questions by focusing on how better access to water, sanitation and hygiene (WASH) services would reduce diarrhoeal disease in Brazil, India, Indonesia and Nigeria:

• What are the costs of providing universal, safe access to water and sanitation for the countries?
• How much would access to WASH reduce diarrhoeal diseases in these countries?
• How would the reduction of diarrhoeal disease likely impact the overuse of antibiotics?

Ultimately, this report seeks to communicate how these changes in infrastructure, access and disease might reduce AMR.

1.2. Scope and approach

The scope of this report has been narrowed in terms of country and disease focus. Rather than discuss LMICs in broad terms, it draws on the cases of Brazil, India, Indonesia and Nigeria to make proposed interventions more concrete. These four nations share common characteristics: large populations with growing middle classes, notable problems with sanitation, and increased antibiotic consumption in recent years. Despite rapid spurts in development, infectious disease levels still remain a concern across the four countries. By analysing them, we hope to create a framework that can be used in further research to assess the link between inadequate WASH and antibiotic consumption in other LMICs. Understanding the impact of improved WASH infrastructure for these four can provide useful information about costs across different continents and country sizes with varying baseline levels of access.

Safely-managed water and sanitation infrastructure is a feasible improvement that is already on the policy agenda for most developing countries. Diarrhoea, and malnutrition resulting from it, constitutes more than half of the global disease burden related to WASH (Prüss-Üstün, 2008), causing 1.5 million deaths annually (CDC, 2012). Since the broader objective of this report is to identify how reductions in disease due to better WASH infrastructure might lead to lower antibiotic use and ultimately AMR, the disease scope of this report was limited to diarrhoea, as it is the most significant illness stemming from poor WASH. A further motivation to look at diarrhoea stemmed from the fact that misuse and overuse of antibiotics to treat diarrhoea is large and widespread (Van Boeckel et al., 2014). Although 70 to 80 percent of diarrhoeal cases are viral and only bacterial diarrhoea should be treated with antibiotics (Cheng, McDonald and Thielman, 2005), an estimated 40 percent of children under five who suffer from diarrhoea receive antibiotics (WHO, 2011).

Figure 1.1 provides an overview of the project and maps out how infection control through WASH interventions can contribute to the mitigation (if not reduction) of AMR in both the developing and developed world. In simple terms, inadequate WASH in LMICs is responsible 58 percent of the diarrhoeal burden (Prüss-Üstün et al., 2014). People use antibiotics to treat diarrhoea and most of it is misuse or overuse. This contributes to the overall AMR problem along with other factors such as animal antibiotic use and hospital acquired infections. This report therefore argues that by improving water and sanitation infrastructure, LMICs can contribute to the fight against AMR through the reduction of the disease burden. It also attempts to quantify those gains on a localised scale.

1.3. Structure and methodology

Studies have looked at the costs of implementing better WASH infrastructure (Hutton and Haller, 2004; Hutton et al., 2007; Hutton, 2012; Hutton and Varughese, 2016); while others have linked such interventions to the reduction of WASH-borne diseases (Esrey, 1991; Curtis et al., 2000; Von der Hoek et al., 2001; Curtis, 2003; Fewtrell et al., 2005; Prüss-Üstün et al., 2008; Cairncross and Curtis, 2010; Clasen and Schmidt, 2014; Wolf et al., 2014). We aim to combine the most rigourous and recent of these methods.

The report is separated in three sections, each drawing on a different qualitative or quantitative methodology that will be described within the sections. In Section III, we use existing data aggregated by the World Bank's Water and Sanitation Program (WSP) (Hutton and Varughese, 2016) to determine the costs of water and sanitation infrastructure from different baselines of coverage by country between 2015 and 2030. In Section IV, we develop a disease burden model to estimate the impact of water, sanitation and mixed interventions on diarrhoeal disease. The intervention risk reductions were drawn from Wolf et al. (2014), although we discuss these within the context of more in-depth research by country. We then draw on the cost data from Section III and the disease reductions in Section IV to determine the cost per person of averting diarrhoea from WASH that would otherwise have resulted in either sickness or death as well as the cost per DALY averted as a result of a sanitation intervention.

For Section V, we reviewed the literature to understand current global usage of antibiotics in our four countries, with a specific emphasis on antibiotics for diarrhoea. Using the findings, we calculated estimates of the reduction of antibiotic use associated with the reduction in diarrhoea found in Section IV.

2. BACKGROUND

2.1. Antimicrobial resistance

The discovery of antibiotics and the subsequent development of antimicrobial drugs is considered to be one of the greatest medical advancements of modern times. Antibiotics have limited the spread of infectious diseases and facilitated the execution of complex medical procedures. While the dependence of modern society on antibiotics has increased, their efficacy is slowly diminishing due to the naturally occurring process of AMR. AMR is the resistance that microorganisms develop to an antimicrobial drug that was originally effective for treatment of infections caused by those microbes (WHO, 2015). Through natural mutation, resistant microorganisms (including bacteria, fungi, viruses and parasites) survive attacks by antimicrobial drugs, including antibiotics, antifungals, antivirals, and antimalarials (Figure 2.1). While resistance has been present for decades (Figure 2.2), the increasing use and availability of antimicrobial drugs, which has not been accompanied by a growing pipeline of new drugs, has accelerated the appearance of resistant strains (Littmann, Buyx and Cars, 2015).

AMR was a named a key "global health threat" of our times at the 2015 meeting of the G7 health ministers. The growing healthcare costs and increased mortality caused by AMR have potentially catastrophic consequences for both developing and developed nations. Conservative estimates attribute 700,000 annual deaths worldwide to AMR, 50,000 of which are in the United States and Europe (AMR Review, 2014). By 2050, it is estimated that AMR will take an additional 10 million lives, a figure which surpasses current annual cancer-related deaths (AMR Review, 2014). The OECD estimates that US$2.9 trillion of gross domestic product (GDP) could be lost across OECD countries due to AMR by 2050 (OECD, 2015). AMR treatment already costs an additional US$10-40,000 per patient and an extra US$23 billion for healthcare systems in Europe and North America (OECD, 2015). While less data is available on resistance levels in developing countries, LMICs are susceptible to AMR due to high infection rates combined with unregulated access to antibiotics, resulting in heightened levels of misuse (Laxminarayan and Heymann, 2012).

An essential global strategy for mitigating the acceleration of AMR is reducing demand for antibiotics by curtailing the spread of infectious diseases. As inadequate WASH levels in developing countries contribute massively to the spread of infectious pathogens, improving access to water, sanitation and hygiene (WASH) practises can contribute to slowing the spread of AMR and maintaining the effectiveness of antibiotics.

Figure 2.1: How AMR breeds

1. Bacteria cells in a human body, some are drug resistant

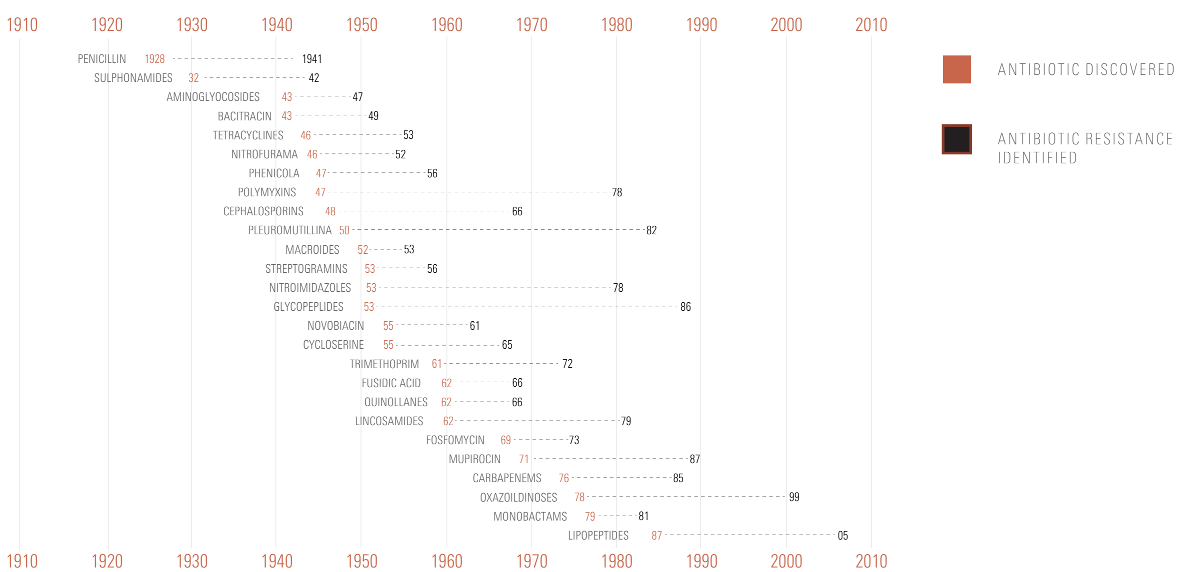
2. Antibiotics taken to treat an illness kill bacteria, but resistant strains remain

3. The antibiotic resistant bacteria then multiplies

4. Resistance spreads

SOURCE: SHUTE, 2014.

Figure 2.2: A history of AMR

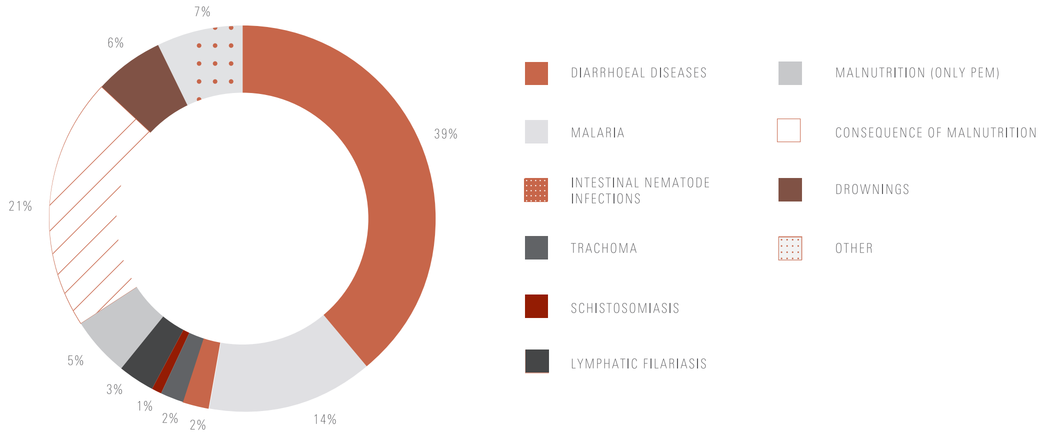


SOURCE: SHUTE, 2014.

2.2. WASH: burden and definitions

Continuous access to clean water and sanitation reduces the risk of infectious disease including diarrhoea, trachoma, malaria and schistosomiasis. At least 9 percent of the global disease burden could be alleviated by improvements to drinking water, sanitation, hygiene and water resource management (Prüss-Üstün et al., 2008). Diarrhoea from inadequate WASH is responsible for approximately 842,000 deaths per year in LMICs, and accounts for more than half of the total WASH disease burden when malnutrition from diarrhoea is included (Figure 2.3) (Prüss-Üstün et al., 2014). It is clear that diarrhoea is a significant contributor to the WASH disease burden, and the reverse is also true: poor WASH accounts for 58 percent of diarrhoeal disease, a large-scale and preventable killer, particularly of children under five (Prüss-Üstün et al., 2014).

Figure 2.3: Diseases contributing to the WASH disease burden



SOURCE: PRÜSS-ÜSTÜN ET AL., 2008.

The paramount importance of raising WASH standards and access is reflected in Target 6 of the recently-defined Sustainable Development Goals (SDGs) adopted for 2015-2030, which seeks to ensure availability and sustainable management of water and sanitation for all, and to end open defecation by 2025 (Figure 2.4).

The SDGs are the successors to the Millennium Development Goals (MDGs), which ended in 2015. Target 7C of the MDGs sought to halve the proportion of people without sustainable access to safe drinking water and sanitation; globally, the target for water was met, yet this was not the case for sanitation.

Figure 2.4: Sustainable Development Goals (SDGs) related to water and sanitation, 2015- 2030

6.1 BY 2030, ACHIEVE UNIVERSAL AND EQUITABLE ACCESS TO SAFE AND AFFORDABLE DRINKING WATER FOR ALL.

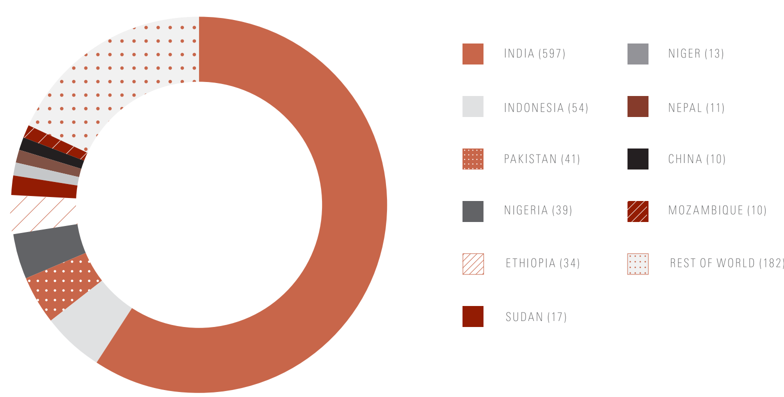
6.2 BY 2030, ACHIEVE ACCESS TO ADEQUATE AND EQUITABLE SANITATION AND HYGIENE FOR ALL AND END OPEN DEFECATION, PAYING SPECIAL ATTENTION TO THE NEEDS OF WOMEN AND GIRLS AND THOSE IN VULNERABLE SITUATIONS.

SOURCE: UNITED NATIONS SUSTAINABLE DEVELOPMENT, 2016.

Open defecation is a perfect example of why it is important for both the household and community level to have access to adequate WASH and follow safe hygiene practises. If the whole community does not participate, sickness can still spread to those with good infrastructure and habits.

Alarmingly, about 82 percent of the approximately 1 billion people practising open defecation live in just countries – including India, Indonesia and Nigeria – and all of them are LMICs (Deen, 2014) (Figure 2.5).

Figure 2.5: Number of people practising open defecation (millions), 2014



SOURCE: JMP, 2014.

3. THE COSTS OF PROVIDING SAFE ACCESS TO WATER AND SANITATION

KEY FINDINGS

- Data on cost, infrastructure coverage and usage by country is limited
- Annual costs per country will be between 0.3 and 2.1 percent of GDP
- There are large discrepancies in costs between rural and urban areas
- Achieving safe, universal WASH will require more than financial capacity

POLICY IMPLICATIONS

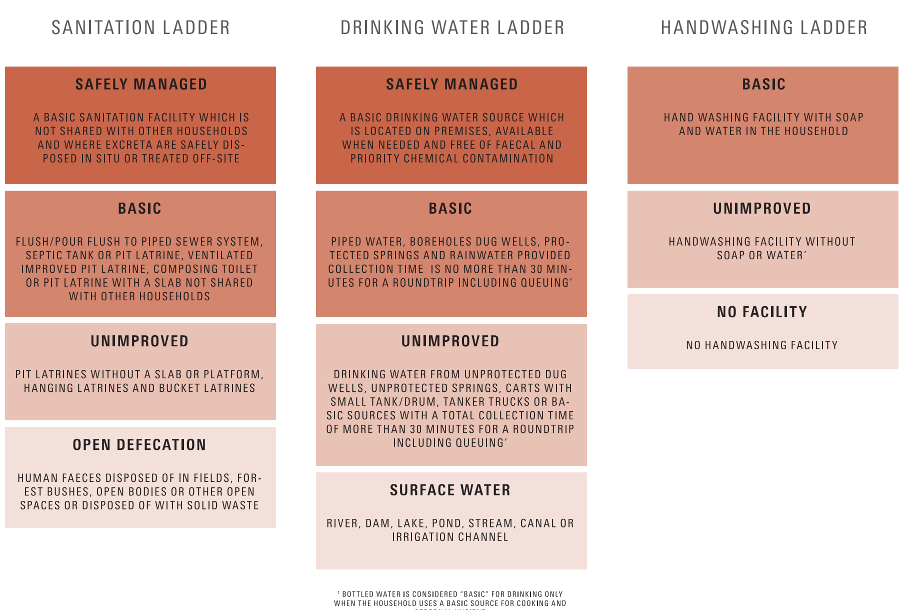
- International emphasis should be placed on improving the quality and consistency of data collection at country level
- Priorities need to be realigned to ensure the necessary funds are going towards WASH infrastructure
- Interventions should be tailored to each community as much as possible to ensure maximum uptake

This section estimates the cost of achieving the SDG targets for WASH in Brazil, India, Indonesia and Nigeria. After defining the different categories of WASH infrastructure and establishing current coverage levels, it compiles the costs of reaching universal safe water and sanitation using data from the World Bank (Hutton and Varughese, 2016). In addition, this section highlights key local factors that may promote or mitigate the effectiveness of achieving the SDGs.

DEFINITIONS

The MDGs and SDGs have created categories of WASH standards. Unfortunately, these classifications have developed over time and the terms are not consistent or self-explanatory, so "ladders" have evolved that clarify the current terms and their order of sophistication (Figure 3.1). "Safely managed" sanitation and water are the 2030 target for the SDGs, requiring household-level, continuous, clean access. The lowest rungs of the ladder in each category are counted under "unimproved", but they are essentially zero access. The SDGs measure handwashing through infrastructure as seen below; but in general, hygiene refers to the practise of washing hands with soap, which may depend on access or on cultural habits.

Figure 3.1: Definition ladders for sanitation, drinking water and handwashing



SOURCE: WHO/UNICEF JOINT MONITORING PROGRAMME FOR WATER SUPPLY AND SANITATION.

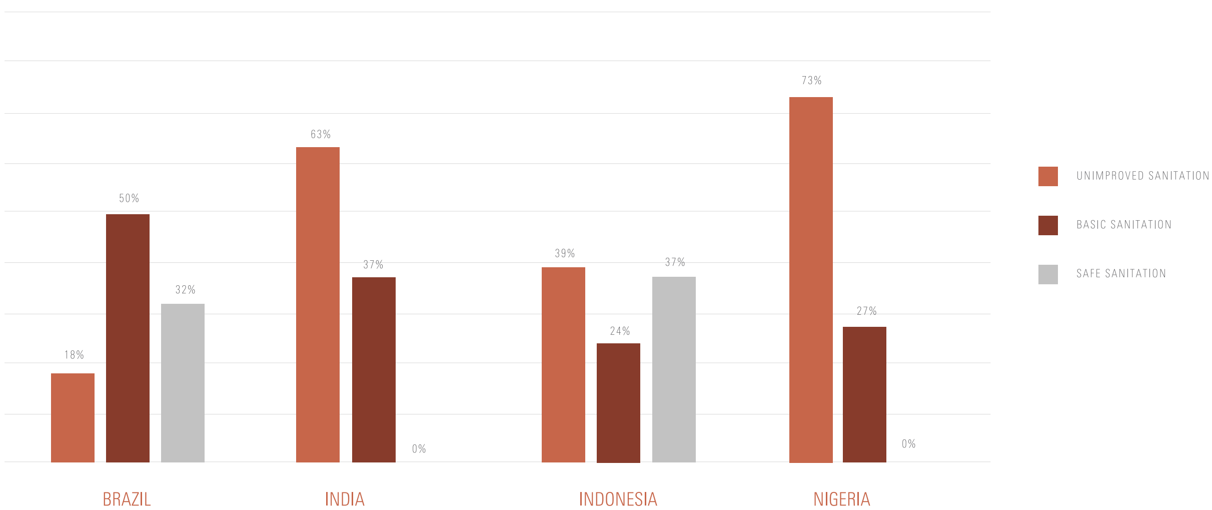
COVERAGE

At the end of the MDGs, the United Nations (UN) reported that the global target of halving the population without improved access had been met for drinking water but not for sanitation. Although 2.1 billion people had gained access to improved sanitation in 2015, 2.4 billion still use unimproved sanitation facilities, including 1 billion practising open defecation (UN, 2016). Moreover, the most marginalised people have seen the least progress and continue to endure the greatest burden in terms of child deaths and diseases associated with inadequate WASH.

Although universal basic coverage would be a notable achievement in many countries, the importance of adequate WASH and the aims of the new SDGs have made it clear that universal safe coverage is the aim.

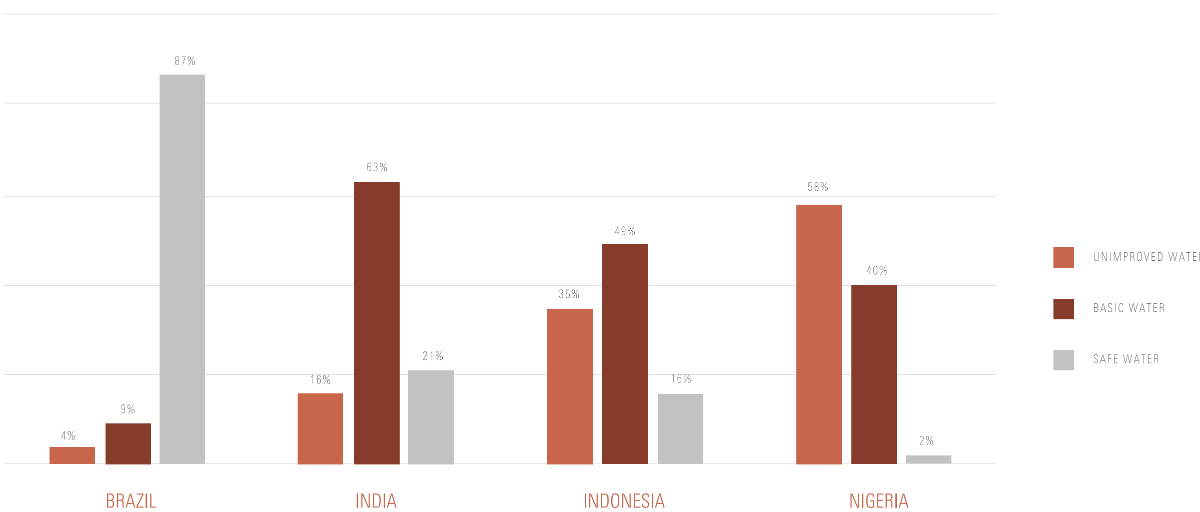
Based on Hutton and Varughese (2016) and our own analysis, Brazil and Indonesia are the only countries with any safe access to sanitation. In the case of Brazil, some households are connected to sewerage, with waste either collected and treated off-site or treated at the household level. In Indonesia, there is little connection to sewerage but 40 percent of households have safe faecal sludge management (FSM).

Figure 3.2: Baseline access to sanitation, 2015



SOURCE: HUTTON AND VARUGHESE, 2016.

Figure 3.3: Baseline access to water, 2015



SOURCE: HUTTON AND VARUGHESE, 2016.

3.1. Cost estimates of WASH interventions

Global WASH costs have been consistently revised upwards since 2004. Hutton and Varughese (2016) have the latest update of global and country-level WASH cost estimates and therefore serve as the data source for this report's estimates. Their costs are also higher than previous estimates, in part because of the use of more comprehensive definitions. While older reports look at the transition of people from unimproved to improved standards because they were linked to the MDGs, their report draws on the updated SDG definitions (Figure 2.4). Measures of handwashing infrastructure access can also be found in the 2016 report, which did not exist in earlier versions.

In addition, the difference is partly explained by the inclusion of maintenance and operation (M&O) costs that give a better approximation of overall WASH costs. Improved information and the inclusion of more countries have also changed the estimates.

The Hutton and Varughese (2016) report is therefore the most up-to-date and detailed assessment of the baseline water and sanitation status in our four countries of interest with the most comprehensive estimate of costs to reach different coverage levels of interest to governments and donors by 2030.

METHODOLOGY OF DATA SOURCE

The Hutton and Varughese (2016) study looked at 140 countries, covering approximately 84 percent of the world population. The analysis established baseline coverage to WASH infrastructure in rural and urban regions by income quintile. It then separated out the costs required to achieve universal coverage for safe WASH at "basic" and "safe" levels by 2030, although this report only looks at the path to safe.

Their costs were calculated by establishing the full dollar amount to reach universal, safe WASH coverage between 2015 and 2030, taking into account population estimates due to growth and rural-urban migration, and dividing the final numbers into 15 equal parts to establish an annual rate. Finally, not all households and communities will achieve the "safe" standard of access immediately, so half are assumed to do so while the other half is assumed to first attain the next standard of coverage before reaching the top level (Hutton and Varughese, 2016).[1]

Country-level data was obtained where possible to determine the costs, which is essential to have a realistic picture of the situation. However, in many cases data had to be extrapolated from nearby countries. While normal, this practice limits the confidence we can have around the country-level findings, especially in cases where 0 percent of the data came from country sources. The amount of country versus extrapolated data for our four countries of interest can be seen in Table 3.1.

Table 3.1: Percentage of country sources for WSP estimates

COUNTRY	BASIC WATER	SAFELY MANAGED WATER	BASIC SANITATION	SAFELY MANAGED SANITATION	BASIC HYGIENE
Brazil	0%	100%	25%	50%	0%
India	50%	100%	100%	75%	0%
Indonesia	75%	100%	100%	75%	100%
Nigeria	50%	100%	25%	0%	50%

SOURCE: HUTTON AND VARUGHESE, 2016.

[1] *For more information on the data, assumptions, levels of uncertainty, service indicators and data sources, see Hutton and Varughese (2016).*

3.2. WASH overview and costs by country

The costs of achieving safe, universal WASH, including O&M, range from 0.3 percent of GDP per year in Brazil to 2.1 percent in Nigeria (Table 3.2).

Table 3.2: Annual costs of universal, safe access to WASH by 2030

COUNTRY	COST (PPP thousands)	COST (an annual % of GDP)
Brazil	151,233,865	0.3%
India	1,214,637,384	1.2%
Indonesia	192,968,954	0.5%
Nigeria	318,124,045	2.1%

SOURCE: HUTTON AND VARUGHESE, 2016.

Poor water and sanitation are estimated to cost developing countries 1.5 percent of GDP per year (Hutton, 2012), so the numbers in Table 3.2 may seem reasonable for such an important goal.

However, it is not a straightforward one to achieve. In 2014, Nigeria spent 0.005 percent of its GDP (US$26 million) on WASH, making it the ninth highest spender in the world, and second in terms of non-emergency spending (UNICEF Annual Results Report, 2013; The World Bank, 2016). This is down from 2013, when it spent US$36.6 million, or 0.007 percent of GDP, which put it in second place for sectoral spending. In comparison, Brazil spent 1.2 percent of GDP on water and sanitation in 2012 (TrackFin Initiative, 2015) while the Indian government spent 0.2 percent (GLAAS, 2012). This latter figure may have increased since the start of Prime Minister Modi's Swachh Bharat Initiative in 2012 (see Annex 5), but exact figures could not be obtained.

In comparison, in 2013 Nigeria spent 3.9 percent of GDP on health[2], Brazil spent 9.7 percent, India spent 4 percent, and Indonesia 3.1 percent (The World Bank, 2016). If the WASH debate is framed as a health issue – and in some countries, a crisis – then perhaps governments and households will prioritise it.

The numbers in Table 3.2 are not without precedent. In 2008, more than 30 African governments signed the Thekwini Declaration in South Africa, which committed to spending 0.5 percent of GDP on sanitation alone as part of an effort to achieve the MDGs by 2015. In 2012, however, half of the signatories stated that they were not on track with the spending or with the MDG target (GLAAS, 2012)

[2] This indicator includes public and private preventive and curative health services, family planning, nutrition, and emergency aid, but does not include water and sanitation (The World Bank, 2016).

3.3. Achieving WASH: mitigating and promoting factors beyond costs

In addition to the challenges associated with costs, there are promoting and mitigating factors that can hasten or slow countries' achievement of adequate WASH levels. Ten categories were identified following country-level research, and while the four countries studied share some commonalities, the underlying causes behind why WASH interventions might succeed or fail are highly context-dependent.

A central factor for the success of a WASH intervention is political will (Awuah and Ryan, 2009). Understanding the political pressures that shape views and debates is essential to foreseeing the results of an intervention. In India, for example, WASH investments are closely linked to political initiatives. In Maharashtra, a successful sanitation intervention was attributed to a long history of social movements led by local leaders supporting the liberation of oppressed castes (WSP, 2011a). The support of national and local political leaders behind sanitation investment indicates that the issue has garnered a consensus across parties, stimulated in part by an understanding of the growing political importance of sanitation investment among rural voters (WSP, 2011a). For more information on WASH-related political initiatives in India and their associated costs, see Annex 5.

Financial commitment mirrors political will. As was seen in the case of Nigeria, 0.005 percent of GDP is considered a substantial sum of money for WASH infrastructure. In Brazil, "there is a hierarchy of investments where industry goes first, then what is left over goes to urban projects, first in areas of high income, then finally with the poor always being the last to receive government investment" (Hosek, 2013). Indeed, research suggests that governments' limited sanitation expenditures are determined mainly by political rather than technical or economic constraints in the context of competing demands for resources (World Bank, 2006; Satterthwaite and McGranahan, 2006). However, recent approval of Brazil's National Sanitation Plan ("Plansab") is a big step forward, showing a vision for the next 20 years.

Beyond the above, the legal and regulatory framework and the enforcement of policies can create problems for a number of reasons: the spectrum ranges from weak political ability to enforce legislative initiatives to deficient capacity of service providers. Control mechanisms to guarantee accountability are critical. One participatory mechanism in place is the Program on Growth Acceleration in Brazil, which has however witnessed many irregularities when it comes to implementation.

According to Transparency International's Global Corruption Report 2008, corruption drains project funds by 10 to 40 percent. In Nigeria for example, the water sector suffers from corrupt practises among government officials paying contractors handling various water projects across the country. According to the Executive Director of the Rural Water and Sanitation Initiative, "contracts were given on the basis of political affiliation or as compensation to individuals" (Hassan, 2012). The sector has one of the highest records of abandoned water developments and incongruous quotes (Hassan, 2012).

Moreover, the weak enforcement of regulation and the occurrence of corruption in the sector can partly be attributed to the lack of incentives and motivation. In fact, financing is sometimes allotted to local governments in the hope that decentralisation will disincentivise corruption by being more inclusive (GWA, 2006; Swedish Water House, 2006). On the other hand, absence of technical capacity at the local government level and lack or inconsistency of financial transfers from central to local could also affect the sustainability of community-level interventions.

Lack of clearly-defined institutional arrangements has been a major barrier to the effective implementation of WASH programmes, mainly because of the absence of proper organisational structures for administration and coordination. Even where there are well-established organisations, poor management and low or no coordination can stall success. In Brazil, each level of government can handle legislation on natural resource management, making the implementation of national water policy complex. For this reason, the Agência Nacional de Águas (National Water Agency) was created with the objective of managing and coordinating roles. This multi-level governance comes with coordination challenges across levels of government, however; in fact, water resource management plans have been deemed weak by some because of opaque priorities and poor implementation (Brazil Policy Brief: Improving Water Resources Governance, 2015).

The cultural context is a significant determinant of willingness-to-pay and use of services, hence it is important to understand what values shape demand for WASH and uptake once they are installed. India is probably the best example, where meeting basic sanitation standards requires not only building toilets but changing habits too. In fact, the availability of sanitation facilities does not necessarily translate into effective use: although billions of dollars have been spent constructing toilets, many people today still show a preference for defecating in the open, even if they have latrines at home (The Economist, 2014).

Religion also plays a role. In India, 67 percent of Hindu households practise open defecation as compared to 42 percent of Muslim households (The Economist, 2014). Although Indian Muslims are typically poorer than Hindus, there is a mortality gap between children, with 1.7 out of 100 more Muslims surviving to age five than Hindus (The Economist, 2014). This correlation of mortality with religion may reflect the practice of "wudu", or ablutions, before prayer in Islam, but the preference of open defecation in particular is clearly linked to culture, habit and perception. Large-scale behavioural interventions on a community-level will be required to make a fundamental shift in mind-set.

On another note, demographics play a role in the effectiveness of WASH infrastructure and access. Population growth, urban and rural coverage disparities and income all affect the impact that improved WASH access can have on health. In the four countries, a growing middle class and increasing urbanisation are driving changes that will both help and hurt WASH coverage. For example, in Nigeria, population growth has exceeded infrastructure growth, de facto decreasing the level of coverage (Awuah and Ryan, 2009) despite relatively high investment in WASH as compared to other countries.

Similarly, rapid urban population growth and the development of informal settlements has pushed over one billion people into slums (WaterAid, 2008). Brazil has witnessed a massive population influx into its major cities in the 1990s and 2000s. Consequently, in 2013, 85 percent of Brazil's population was urban (World Bank, 2016). Nevertheless, although urbanisation has aggravated a public health crisis, it has also served as a promoting factor: Brazil's federal government stimulated the adoption of the condominial system, which counts on community participation and inexpensive technology available to state and local governments (Leal, 2013).

In terms of the environment, seasonality and disasters affect not only the infrastructure and capacity of existing water systems, but public health as well. During floods or tidal surges, like the monsoon season in India, natural sources of fresh water are contaminated or destroyed, causing great damage and losses. However, during droughts inadequate water supply can also be a problem. WASH needs are fundamental after emergencies and natural disasters (CDC, 2016) yet it is difficult to build and sustain resilient infrastructure in environmentally tenuous situations.

DISCUSSION

As targets have evolved from the MDGs to the SDGs, there has been a renewed focus on establishing baseline levels of WASH access, costs of infrastructure and maintenance, and the status of existing interventions. By looking at the literature, we have found large differences between costs, changes over time as calculations have been updated, and inadequate country-level data. Even regional numbers are often extrapolated from small and localised studies. As a result, it is important for countries and the international community to commit to improving the quality and consistency of data. Aggregations of country-level baselines and costs through such comprehensive studies as Hutton and Varughese (2016) would greatly benefit from this, as would the many reports that cite them. Based on the literature, we have found that annual costs per country per year are reasonable, especially when considered within the context of other public spending like health. The SDGs should increase the pressure on governments to shift priorities and ensure that the necessary funds are going toward WASH infrastructure. If individual governments show a strong commitment and an integrated approach to WASH, private citizens and foreign donors may be more likely to contribute to the costs, reducing the burden on the government.

We have also seen that the baseline levels of coverage and the costs required to reach safe, universal WASH are quite different across countries, between rural and urban areas, and between regions. Interventions must be tailored to communities by encouraging community participation for maximum uptake of services. It is only with behavioural change and community support that sustainable change will occur.

The costs calculated in this section estimate the total dollar amount for countries to achieve the SDGs by 2030. In order to understand how effective these interventions are, it is essential to know how much they reduce infectious disease. In the next section, the report looks at how WASH interventions will impact the diarrhoeal burden in terms of death and illness averted.

4. ACCESS TO SAFE WASH INFRASTRUCTURE HAS THE POTENTIAL TO HIGHLY REDUCE DIARRHOEAL DISEASE IN THESE COUNTRIES

KEY FINDINGS

- Inadequate access to water and sanitation drives more than half of the diarrhoeal disease burden
- Diarrhoea disproportionately affects the most vulnerable populations including children under five and low-income households
- Access to safe water could reduce the diarrhoeal disease burden up to between 48 and 51 percent
- Access to safe sanitation could reduce the diarrhoeal disease burden up to between 69 and 71 percent
- Causal data on the risk reduction from the various interventions is difficult to find at the regional and country level
- Sanitation interventions are more cost-effective than water interventions
- Costs per person are fairly reasonable given the returns

POLICY IMPLICATIONS

- Safe WASH is a way for countries to reduce the diarrhoeal disease burden, associated pernicious health effects such as malnutrition and secondary impacts such as impaired cognitive development
- WASH interventions are a direct way to impact the lives of the most vulnerable and need to be considered as a priority on the health agenda in LMICs
- The results of the "bang for the buck" analysis cannot be taken at face value: policy makers will need to interpret them in light of costs, country and region-level coverage of infrastructure, and specific demographic factors that might affect the results of the intervention

The disease burden from poor WASH is preventable but causes an unacceptably high loss of human life and capital in LMICs. Diarrhoeal illness is the most severe consequence of insufficient water and sanitation standards in developing countries (Prüss-Üstün et al., 2008). As a result, measuring the impact of safe, universal WASH on the diarrhoeal disease burden will provide perspective to the important health effects that this infrastructure change can have.

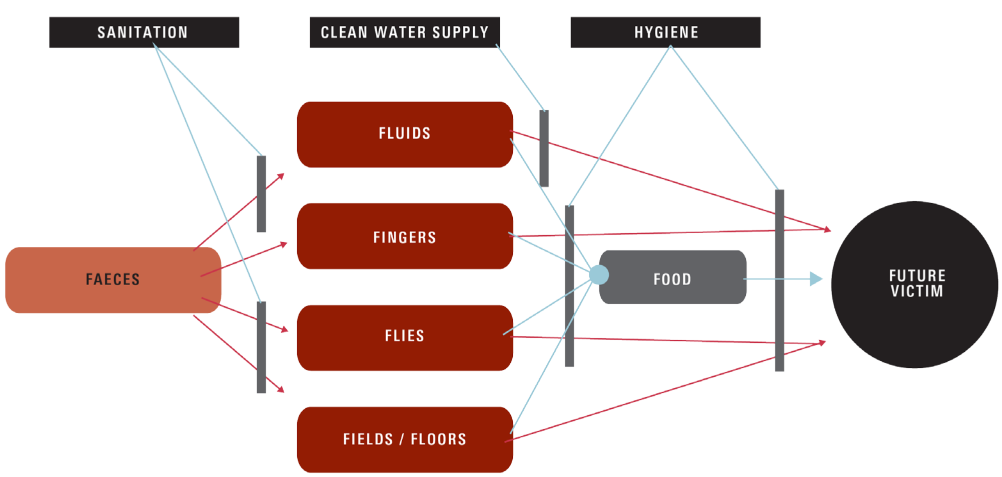
Drawing on the most comprehensive research to date, this section develops a disease burden model to measure the potential reduction in diarrhoeal disease as a result of different WASH interventions. These measurements are analysed within a country-level context and used to explore the most cost-effective interventions.

4.1. The link between diarrhoea and WASH

While the number of diarrhoeal deaths has dropped significantly in the last decades, the illness remains the second leading driver of child mortality, killing 760,000 children under the age of five per year (WHO, 2016). The actual death toll may be higher since diarrhoea often results in malnutrition, leading to death or other long-lasting consequences including physical stunting and inhibited cognitive growth for children (WHO, 2016).

Exposure to unsafe WASH levels is responsible for most diarrhoea cases in the developing world. While a downward estimate from the WHO's 2000 estimate of 88 percent, WHO's 2014 estimates that 48 percent of the global diarrhoeal burden is attributable

Figure 4.1: F-Diagram: routes of faecal disease transmission and protective barriers



to unsafe WASH. This stems from the fact that most diarrhoeal infections are transmitted through the consumption of food or water contaminated with faecal matter (Figure 4.1). Water and sanitation therefore constitute important barriers to infection; but secondary barriers in the form of good hygiene practises are also needed to prevent further contamination. This means that WASH interventions are indispensable to the prevention of diarrhoeal disease, which is a particularly notable problem in the four countries of concern. It is the third or fourth leading killer in India (IHME, 2006), Indonesia (UNICEF, 2012) and Nigeria (WHO, 2014) and is still a dominant public health threat in Brazil. The prevalence can be traced to low levels of WASH and high open defecation levels.

Despite rapid spurs in development, Brazil still ranks remarkably low when it comes to access to toilets as well as hygiene: approximately 7 million Brazilians still practise open defecation on a daily basis (OHCHR, 2013). Poor sanitation has been named as one reason that life expectancy in Brazil (73.3 years) lies below the Latin American average (74.4 years) (CEBDS, 2014). India, Indonesia and Nigeria are all among the top ten countries that practise open defecation, with India in first place, Indonesia in second, and Nigeria in fifth. Half of the Indian population practises open defecation, which is more than double the cumulative number in the next 18 countries (WHO, 2012).

4.2. Data

This report reviewed the literature on the quantitative impact of WASH interventions, both separate and combined. Due to the wide range of quality and intervention type, a specific emphasis was placed on systematic reviews and meta-analyses. In the end, the most comprehensive were Wolf et al. (2014), Clasen and Schmidt (2014), Cairncross and Curtis (2010), Fewtrell et al. (2005) and Esrey (1991). Wolf et al. (2014) represent the most recent and comprehensive of the literature, so this section uses the risk reduction (RR) estimates from that paper.

While it is widely accepted that safer WASH infrastructure is effective at reducing the outbreak and spread of diarrhoea, to date only a few studies rigorously evaluate and/or compare the effect of particular interventions (Clasen and Schmidt, 2014). Additionally, while individual WASH interventions mostly have a positive impact, it is unclear whether single programmes or multidimensional interventions are more effective at reducing the burden of diarrhoea (Briscoe, 1984; Fewtrell et al., 2005; Clasen and Schmidt, 2014; Wolf et al., 2014).

There is overall substantial variability in methodological quality of studies (as explained in Fewtrell et al., 2005; Cairncross et al., 2010; Clasen and Schmidt, 2014) as well as heterogeneity in estimates. This makes it difficult to compare and reach conclusions on the effectiveness of WASH interventions. In particular, studies differ in choice of baseline (see Wolf et al., 2014); often suffer from the lack of appropriate counterfactual and blind testing of subjects (see Fewtrell et al., 2005; Clasen and Schmidt, 2014, Wolf et al., 2014); do not have a random sample or do not justify their sampling (see Clasen and Schmidt, 2014); and/or use different measures (odd ratios, RR, number of episodes, etc.). Most studies look at the health effect of these interventions on children as they are the most vulnerable group, but this limits the generalisation of results. Particularly relevant to our context, there are few experimental evaluations of water and sanitation interventions in Brazil, Nigeria and Indonesia. Most studies in Brazil take place either in urban or peri-urban settings (Lima, 2000; Castro, 2003; Melo et al., 2008) and date back to the 1980s. Many studies analyse the impact of WASH in India, but there is substantial variation in the type of intervention studied, the methodology used, and the region considered – although there is disproportionate representation of rural areas.

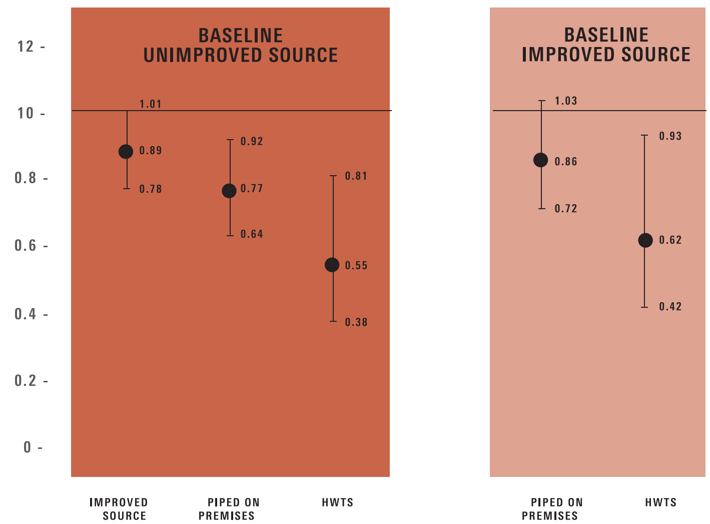
METHODOLOGY OF DATA SOURCE

Wolf et al. (2014) estimate the impact of WASH interventions on mortality and morbidity from diarrhoeal diseases. They employ a two-step approach: first, a systematic review of existing studies; and second, for water and sanitation interventions, they perform statistical random effects meta-analyses to evaluate the effect of improvements in drinking water and sanitation on diarrhoeal morbidity. They also estimate the impact of different intervention types, baseline water and sanitation conditions and additional study characteristics. The results provide relative RRs per intervention from specific baselines.

REDUCTION RATES

Water. The greatest benefits from water interventions come from transitioning from an unimproved baseline to safe, with an RR of 45 percent (Figure 4.2). Moving from an improved baseline to a safe baseline reduces the risk of diarrhoea by 38 percent.

Figure 4.2: Relative RR for diarrhoeal disease from water interventions

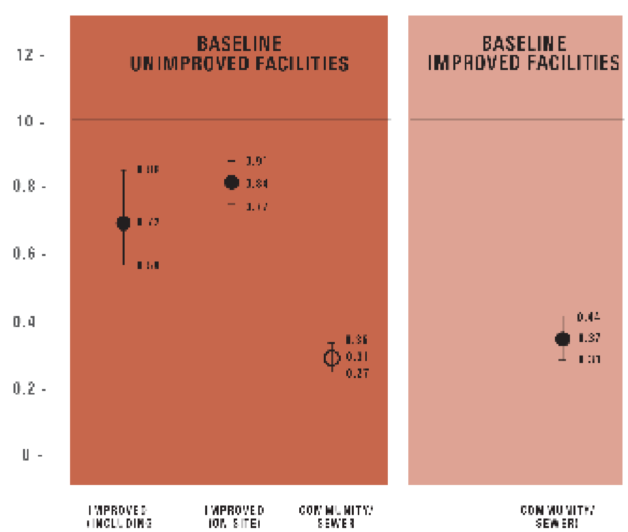


Note: HWTS - Only filtration with safe storage is considered in the model as an example of water efficiently treated and safely stored in the household. Transitions to systematically managed water supply are based on limited evidence and should be considered preliminary.

SOURCE: WHO, 2015.

Sanitation. Sanitation interventions reduce diarrhoeal risk by 28 percent when sewage is included, and only 16 percent otherwise (Figure 4.3). The results are quite encouraging, with 63 and 69 percent reductions from unimproved and improved baselines to safe.

Figure 4.3: Relative RR for diarrhoeal disease from sanitation interventions



SOURCE: WHO, 2015.

Mixed interventions. Wolf et al. (2014) estimate the effect of additional WASH interventions to be 12 percent on top of the original reduction. This means that, given a sanitation intervention, a water intervention will only improve the RR by 12 percent since there is likely overlap of benefits between the two interventions: exposure to pathogens from WASH are not independent from each other so the overall impact of mixed interventions cannot be the sum of the three interventions. It is impossible to differentiate between the two impacts, but it is likely that 12 percent is a lower bound.

4.3. Disease burden probability model

THE MODEL

To calculate the burden of diarrhoeal disease, we developed a disease burden model with two time periods to reach safe WASH by 2030. In the model, an intervention scenario is compared to a "do-nothing" scenario where everything is being held constant between the two scenarios except for the intervention. As observed in the review of existing evidence, the length of an intervention usually ranges from just a few weeks to two years. Therefore, we set our effect period to five years to allow for the full impact to take place, assuming that the entire average reduction in the relative risk of unsafe water or unsafe sanitation applies to the whole population of interest. The model plays out as follows:

Period 1 (T_1) - Everyone in the population receives a water or sanitation intervention over five years.

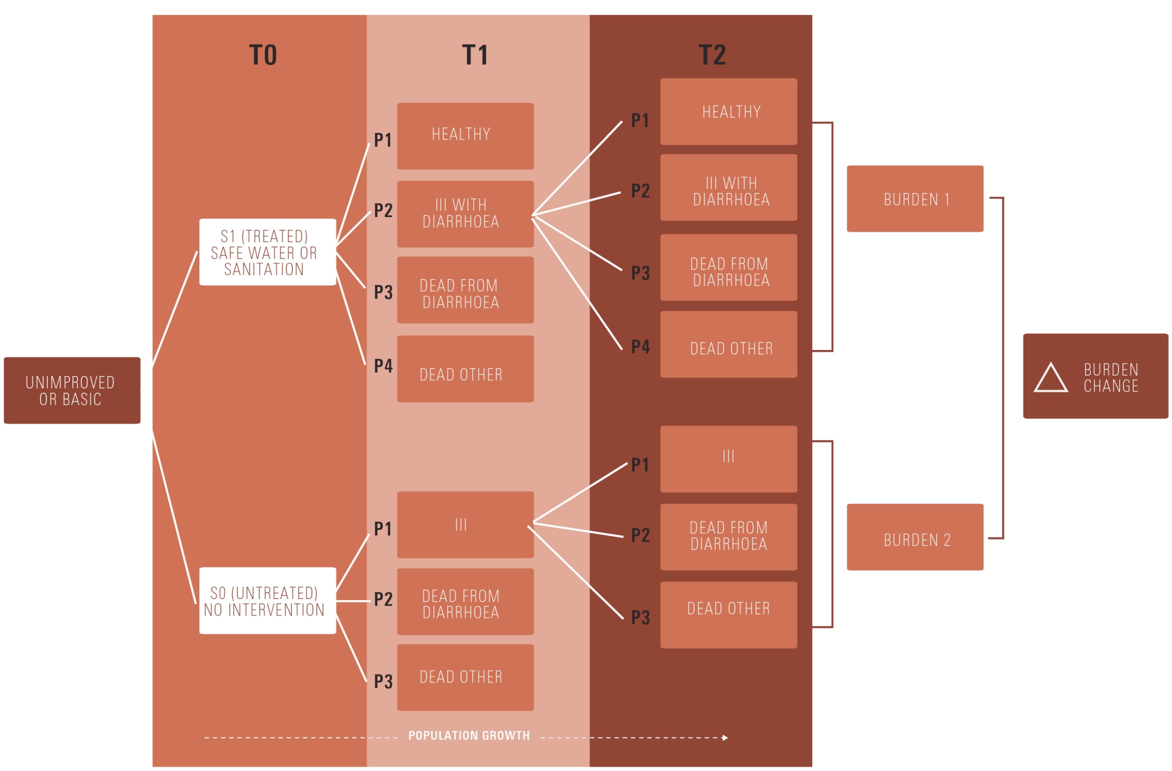
Period 2 (T_2) - Everyone receives the complementary mixed interventions over 10 years to reach safe water, sanitation and hygiene.

States. Across 15 years, the population can move along four states: ill from diarrhoea, healthy from diarrhoea, dead from diarrhoea and dead for other reasons. We assume that everyone exposed to unsafe water or sanitation has diarrhoea in $T_{0,}$ which means that everyone shares the average number of annual cases for someone in their age group. In the four countries, this is estimated to be below one for adults, while it may be up to more than four for children under five in Brazil and Nigeria (Fischer Walker and Black, 2005; Lamberti et al., 2010). This may mean that the current model provides an upper bound estimate of the gains to be made from WASH interventions. However, this is a useful tool for policymakers to understand the magnitude of the issue at stake. In addition, we assume that there is no regression to diarrhoea once individuals are healthy, although we do apply the standard mortality rate to them. Similarly, the death states are absolute. The only state that evolves across time periods is the ill from diarrhoea group, which can enter the same range of states in T_2 as in T_1.

Baselines. For each intervention, the starting point is the number of people that have access to either 1) unimproved or 2) basic infrastructure in each country of interest. Although each baseline is modelled to receive safe infrastructure by 2030, they are modelled separately because the RR is different for each.

Annex 2A explains the parameters chosen to model the probabilities, the values of the parameters and baselines values. The effect of each intervention (relative RR) is not country specific due to lack of good quality data. Figure 4.4 is a stylised summary of the model.

Figure 4.4: Burden of disease probability model for the effect of WASH interventions until 2030



Sensitivity analysis. In line with new WHO guidelines (2013 p.5), we do not use weighting and time discounting for the interventions, as the same weight should be allocated to lives today and tomorrow. We also perform two types of sensitivity analysis. First we use the lower and upper bound estimates of the RRs to give a range of estimates of the gains in diarrhoeal burden in all four countries. We find that the results are overall consistent. Second, we include a natural recovery rate from diarrhoea of 10 percent. As expected, this reduces the gains in diarrhoeal burden by nearly 10 percent. This shows that the tool can be easily adapted to the needs of policy-makers. Results can be found in Annex 2B.

4.4. Results

Sanitation infrastructure has the highest impact on reducing the diarrhoeal burden in the four countries. This is driven by the fact that 1) the coverage for sanitation in all four countries is lower than for water and 2) the reduction in relative risk from safe sanitation is higher than for safe water. Results are displayed in Tables 4.1 and 4.2. Overall, there is a reduction of the diarrhoeal burden between 47 and 50 percent for water interventions and between 69 and 72 percent for sanitation interventions.

The percent reduction range from S_0 to S_1 in a given intervention is small across countries because the same global estimates of the RR are used. As mentioned above, the country-level differences in the model are expressed through the baseline populations, crude birth and death rates and death from diarrhoea rates.

Table 4.1: Gains in diarrhoeal burden from water intervention

Water				
	Diarrhoeal deaths averted	Diarrhoeal illness averted	Total burden saved	Percentage change S0 to S1
Brazil	11,002	14,432,717	14,443,719	48%
India	6,371,666	576,839,692	583,211,357	47%
Indonesia	626,721	125,959,388	126,586,109	48%
Nigeria	4,055,706	132,948,408	137,004,114	51%

Table 4.2: Gains in diarrhoeal burden from sanitation intervention

Sanitation				
	Diarrhoeal deaths averted	Diarrhoeal deaths averted	Total burden saved	Percentage change from S0 to S1
Brazil	75,501	109,790,917	109,866,419	69%
India	10,866,260	1,108,386,371	1,119,252,631	71%
Indonesia	869,602	139,262,601	140,132,203	71%
Nigeria	5,359,712	197,838,540	203,198,252	71%

DISCUSSION OF RESULTS

The model assumes that the RR for each intervention category will be the same for all countries, which is an oversimplification. For example, a water intervention that moves a share of a population from an unimproved baseline to a basic state is assumed to reduce diarrhoea by the same amount whether people are in India or Nigeria. This underplays the differences between countries such as the disease environment, existing policies, or behavioural factors that might promote or mitigate interventions. Since the RRs are global numbers, the direction and size of the inevitable bias will depend on the comparability of baselines as well as these other factors. In addition, the RR might be different across age groups. As children are the most vulnerable to diarrhoeal disease, it is likely that the effect of an intervention on children will be higher than on adults. Assuming a left-skewed distribution of the diarrhoeal burden per age where children have a higher relative RR, these results underestimate the effect of WASH interventions.

In order to understand the applicability of the Wolf et al. (2014) numbers to the four countries in question, we conducted a literature review on the different types of interventions. The review was specific to each country and included proxy countries in the case of insufficient availability of studies. Reviewed literature is listed in Annex 2C. This research adds on to the qualitative analysis in Section III, and reveals that there are many factors influencing whether water and sanitation infrastructure can yield the expected result. These include hygienic storage, continuous access, shared versus household access, and behavioural influence.

For example, in India, Jalan and Ravallion (2003) looked at the impact of piped water on child health and found that it varied based on the income of the family and education of females in the household. They concluded that children in households with piped water would have had a 21 percent higher diarrhoeal prevalence without it. However, having a woman in the household with an education higher than primary school increases the benefits of piped water in the lowest quintiles. Alternatively, a study by Ercumen et al. (2015) compared the impact of intermittent versus continuous piped water supply in an urban area in India. They found a 37 percent reduced prevalence ratio of bloody diarrhoea in low-income households with continuous supply as compared to those with intermittent access.

Behavioural response is also essential for evaluating potential for risk reductions. In Indonesia, an evaluation of the Total Sanitation and Sanitation Marketing Project (TSSM) found that an increase in people building their own toilets reduced the prevalence of diarrhoea by 30 percent, although it is not possible to isolate the effect of the sanitation alone because of the behavioural nature of the program (WSP, 2015). Impacts on diarrhoea may be a mixed effect of sanitation and hygiene. On the other hand, Clasen et al. (2014) measured the effectiveness of latrine promotion and construction on diarrhoea and other illnesses. The intervention increased coverage from 9 percent to 63 percent in the control villages, yet they only found a prevalence ratio of 0.97, meaning that children under age five in the treatment group reported diarrhoea less often than in the control group. This low change suggests that uptake and behaviour are essential aspects in infrastructure interventions.

Finally, there are a few additional factors of uncertainty that need to be highlighted in order to put results into perspective. First, the review of studies has shown that effects of WASH interventions are rapid, ranging from a few weeks to one or two years. However, few studies looked at the long-term effects on diarrhoeal disease. Looking at a 15 year timeframe, uncertainty about potential spill-overs over time arise. Our model applies the RR associated with a particular intervention once in the first five years followed by the RR associated with mixed interventions once in the next 10 years. It is unclear whether the RR should apply throughout the five years (and similarly the 10 years) but at a gradually declining rate, since it is reasonable to believe that the marginal gains from an intervention decline over time. Alternatively, the full reduction might apply in the first year with a lower residual reduction in the following years. While it is impossible to make a reasonable guess of what those probabilities would look like over time with the current state of empirical evidence, it seems safe to assume that our current estimate is an underestimation of the effect over time.

Lastly, most of the studies analysed for this exercise do not look at national level interventions but often at smaller-scale interventions: for example, in Nigeria studies range from 100 subjects to 7,000. This analysis assumes that the effect can be scaled up to the national level: that is, that a 45 percent reduction in diarrhoeal disease risk due to a safe water intervention in a population of 500 will translate into a 45 percent reduction at the national level. This is likely to be an underestimation of the results, as it seems reasonable to assume that the spillover effects of WASH interventions are quite large.

This report has drawn out costs and disease reduction related to WASH infrastructure in Sections III and IV. In order to better understand where maximum impact is achieved, a "biggest bang for your buck" analysis highlights the relative cost per life saved from death or diarrhoea, which can be useful for policymakers.

4.5. "Bang for your buck" analysis

The relative "bang for your buck" can be determined by dividing the total cost by the number of lives saved. Using results from Section III and Section IV, we use the two measures to establish the impact of an intervention per dollar spent. The results show that across all four countries, sanitation interventions have higher returns in terms of lives saved from death and illness per dollar spent than water interventions. The cost-effectiveness of interventions in Indonesia is on average the same while in Brazil, water interventions are 7.6 percent less cost-effective than sanitation. Interestingly, Nigeria and Brazil are the two countries where the cost-effectiveness is the lowest. Table 4.3 summarises these results. The rural/urban analysis shows that on average, interventions in rural areas are more cost-effective than in urban areas. In particular, the dollar spent per life saved in water interventions in urban areas is particularly low. As highlighted by Hutton and Varughese (2016), costs of service provision in cities are higher than in rural towns, contributing 70 percent of the total capital expenditure requirements.

In addition, we used the WHO's DALY worksheet to calculate the DALYs that would be averted as a result of the sanitation intervention, which has the biggest impact. We used the lives saved from death and illness in our burden of disease model, illness duration from Lamberti, Fischer Walker and Black (2012) and the disability weight for moderate diarrhoea from Salomon et al. (2015). Drawing on costs from Section III, we then calculated a cost per DALY averted, which may be more useful to policymakers.

Table 4.3: "Biggest bang for the buck" analysis per person per year to reach safe WASH by 2030

	Total			
	Water		Sanitation	
	Total cost per person per year (PPP)	Ranking	Total cost per person per year (PPP)	Ranking
Brazil	$698.04	4	$237.05	4
India	$138.84	2	$72.34	1
Indonesia	$101.64	1	$91.81	2
Nigeria	$154.81	3	$104.37	3

Table 4.4: "Biggest bang for the buck" analysis per person per year to reach safe WASH by 2030 in rural areas

	Rural			
	Water		**Sanitation**	
	Total cost per person per year (PPP)	Ranking	Total cost per person per year (PPP)	Ranking
Brazil	$143.26	4	$63.40	3
India	$108.07	3	$64.02	4
Indonesia	$54.72	1	$52.13	1
Nigeria	$91.83	2	$62.87	2

Table 4.5: "Biggest bang for the buck" analysis per person per year to reach safe WASH by 2030 in urban areas

	Urban			
	Water		**Sanitation**	
	Total cost per person per year (PPP)	Ranking	Total cost per person per year (PPP)	Ranking
Brazil	$1,176.51	4	$96.29	2
India	$240.81	3	$89.72	1
Indonesia	$153.51	1	$131.12	3
Nigeria	$225.70	2	$149.59	4

Table 4.6: CEA using cost per DALY averted to reach safe WASH by 2030

Sanitation		
	Total cost per DALY averted	Ranking
Brazil	$4,357.93	4
India	$186.31	2
Indonesia	$333.23	3
Nigeria	$83.43	1

4.6. Analysis

To understand the results, four main elements deserve attention: 1) capital costs within a particular country; 2) the current extent of coverage of water and sanitation infrastructure and death from diarrhoea rates; 3) the breakdown between basic and unimproved baselines of access; and 4) the urban/rural divide.

Capital costs, including material and labour, determine how expensive a particular intervention is in each country. It is dependent on the level of economic development and the strength of the investment environment. For example, capital and labour costs per intervention are much higher in Brazil than in the other countries (Hutton and Varughese, 2016). As highlighted in Section III, pre-existing socio-economic, institutional and cultural factors contribute to a higher cost per person in Nigeria as compared to the other countries. Yet this is reflected in a lower dollar spent per life saved than Brazil because the caseload is also quite high.

Second, current coverage of infrastructure and diarrhoeal burden are important considerations when comparing cost-effectiveness both across interventions and countries. In Brazil, the coverage for safe sanitation is already at 90 percent and the rate of death from diarrhoea is also the lowest among all four countries. Therefore, as the costs of interventions are relatively higher in Brazil, there are decreasing marginal returns to water interventions in particular since the marginal cost of reaching those last 10 percent is very high. This is reflected in the cost analysis results above. In comparison, 0 percent of Nigeria's population has access to safe WASH infrastructure and the rate of death from diarrhoea is the highest of all four countries. Therefore, there are important increasing marginal returns from WASH interventions: reaching those very few people with safe interventions is relatively cheap. Interestingly, Indonesia shows similar cost-effectiveness ratios for sanitation and water supply interventions. Water supply coverage is slightly better than sanitation (49 vs. 24 percent basic coverage [Hutton and Varughese, 2016]), but neither has high safely managed levels. This means that the number of lives saved from death or sickness in Indonesia is relatively close across the two intervention types.

Third, the breakdown between unimproved and basic infrastructure is also important to understand the relative cost-effectiveness of interventions. While most of the population in Nigeria has access to unimproved infrastructure (73 percent for sanitation and 58 percent for water), most of the population in Brazil has access to basic infrastructure. Going from an unimproved baseline, for example an unprotected tank, to safe infrastructure, for example sewage, is much more expensive than going from a basic baseline to safe infrastructure.

This above breakdown needs also to be analysed in terms of the rural/urban divide. In all countries but India, the urban population is either as high or higher than the rural population, reaching up to 85 percent in Brazil. While people are more concentrated, the geography and structure of cities in many developing countries make interventions in urban areas more expensive than in rural areas. Brazil's favelas, with their irregular layout and spontaneous construction, make the expansion of WASH networks into densely populated areas challenging. Not only is there not much space left for the construction of water, sanitation or treatment facilities given high population density, but because slums lack land tenure, providing water and sanitation services through investments in large infrastructure is extremely difficult (Corcoran et al., 2010). This situation is comparable in large urban centres in Nigeria and Indonesia. However, while the urban centres probably experience similar challenges in India, more than 60 percent of the population still lives in rural areas among which 80 percent with unimproved access, providing a strong case for prioritising rural interventions there (World Bank, 2016). Interestingly, in comparison to the other countries, the gap in effectiveness of sanitation in urban and rural areas is the lowest in India, which means that the share of the costs in rural/urban areas are proportional to the benefits and the size of the population.

Finally, Nigeria and Indonesia are currently experiencing the highest urban population growth out of the four countries of interest, with 4.5 percent and 2.7 percent a year in 2014, respectively (World Development Indicators, 2016). Rapid urban growth and increasing rural-urban migration add further pressure to the capacity of most cities in those countries to provide adequate services and are likely to push the estimates up in the next few years.

4.7. Discussion and policy implications

Infectious diseases are a preventable burden in developing countries, draining human capital and exacerbating AMR. WASH infrastructure is a straightforward and efficient way for governments to reduce the burden of one important infectious disease: between 48 and 72 percent of the diarrhoeal burden could be avoided in 2030 with the implementation of a strong and comprehensive water and/or sanitation programmes in LMICs at reasonable costs per person. As mentioned, sanitation interventions give more bang for your buck than water interventions, although it should also be noted that water deaths are a higher proportion of the overall diarrhoeal death toll than sanitation deaths. Poor water supply is associated with 502,000 deaths per year, while sanitation is estimated to cause 280,000 per year (WHO, 2014). This highlights the importance of taking the local context into account when selecting and designing interventions: sanitation infrastructure may be more appealing financially across the board, but if a country or region's main problem is inadequate water supply, this may be the priority – regardless of cost.

WASH interventions are effective at saving lives and preventing illness and, more than an infrastructure investment, they need to be considered as a priority on the health agenda in LMICs. They are a direct way to impact the lives of the most vulnerable. The biggest bang for your buck results should be interpreted in light of four factors: 1) financial expenditure, 2) current coverage of infrastructure; 3) the breakdown of the population that has access to unimproved and improved infrastructure; and 4) the urban/rural divide and how costs and burden affect those populations differentially. In addition, the rate of urbanisation, cultural factors, and peoples' willingness-to-pay should also be taken into account when choosing which intervention to prioritise.

5. REDUCTION OF DIARRHOEAL DISEASE CAN HAVE A LARGE IMPACT ON THE OVERUSE OF ANTIBIOTICS

KEY FINDINGS

- While only around 15 percent of diarrhoeal cases are caused by bacterial pathogens, the percentage treated with antibiotics is much higher
- Around 40 percent of cases of diarrhoea are treated with antibiotics and local studies report treatment rates in over 80 percent of cases
- By 2030, a reduction of the diarrhoeal disease burden through improved WASH infrastructure and access could result in large decreases in the number of diarrhoeal cases treated with antibiotics, ranging from 5 million in Brazil to up to 590 million in India for sanitation
- WASH infrastructure can motivate a 48-51 percent decrease for water and 69-71 percent decrease for sanitation in diarrhoeal cases treated with antibiotics in 2030

POLICY IMPLICATIONS

- Infection control through WASH interventions can cause large potential reductions in the misuse or overuse of antibiotics for diarrhoea
- In the short- and medium-run, WASH interventions will need to be complemented by secondary preventive measures such as the promotion of exclusive breastfeeding and rotavirus vaccinations
- Improvements in the surveillance of AMR in developing countries will lead to further insights into the link between overconsumption and resistance

5.1. Diarrhoea, antibiotics and AMR: the missing link

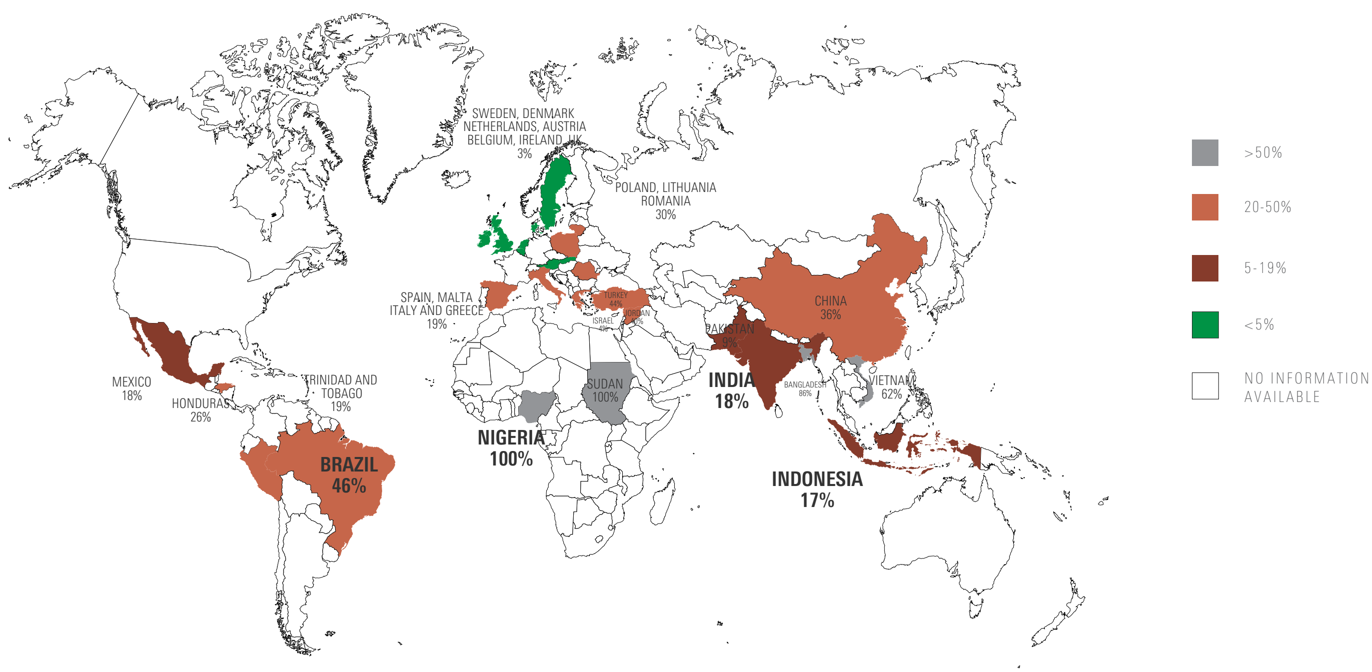
Decades of use and misuse of antimicrobials at the community and hospital level have contributed to the rapid development of drug-resistant strains of disease-causing pathogens. The emergence of AMR is caused by a natural biological process of selection, accelerated by the use of antibiotics (Van Boeckel et al., 2014). While the nature and quantification of the effect of antibiotic consumption on resistance remains difficult to establish, data from several studies have indicated a strong correlation between increased usage and resistance levels (Vernet et al., 2014).

In particular, high levels of non-prescription use of antimicrobials, indicating serious misuse, have contributed to this phenomenon (Figure 5.1). Additionally, countries with the highest per capita antibiotic consumption consistently face the highest resistance rates (Cižman, 2003). In the past two decades, the spread of AMR has accelerated in several of the world's developing countries, including Brazil, India, Indonesia and Nigeria (Stelling et al., 2005; Laxminarayan and Heymann, 2012).

In the fight against overconsumption of antibiotics, infection control plays an essential role. In its 2014 "State of the World's Antibiotics" report, the Center for Disease Dynamics, Economics & Policy (CDDEP, 2015) named the reduction of "the need for antibiotics through improved water, sanitation, and immunization" as the first of its six strategies to slow resistance and maintain the effectiveness of current antimicrobial drugs. So far, the AMR debate has been heavily dominated by the "empty pipeline" argument as well as the overuse of antimicrobials in agriculture (see AMR Review, 2014). However, the large and rapid growth of antibiotic usage in LMICs in recent decades is forcing policymakers to take a closer look at the forces driving increased demand for drugs. Poor WASH standards are one of the main causes of the high level of infectious diseases in developing nations (Prüss-Üstün et al., 2008). This report has shown that universal WASH access can be achieved by spending less than 2.1 percent of GDP annually in some LMICs. The resulting reduction of the diarrhoeal disease burden of 48 to 72 percent can be expected to significantly reduce the demand for antibiotics.

Section V reviews current evidence on the misuse of antibiotics to fight diarrhoeal disease in order to assess the magnitude of the issue. Using results from Section IV on the changes in the diarrhoeal burden, it also quantifies the reduction in antibiotic consumption that could be achieved through the implementation of well-targeted WASH interventions.

Figure 5.1: Percentage of children born in the at least 3 years preceding the survey with diarrhoea



SOURCE: MORGAN ET AL., 2011.

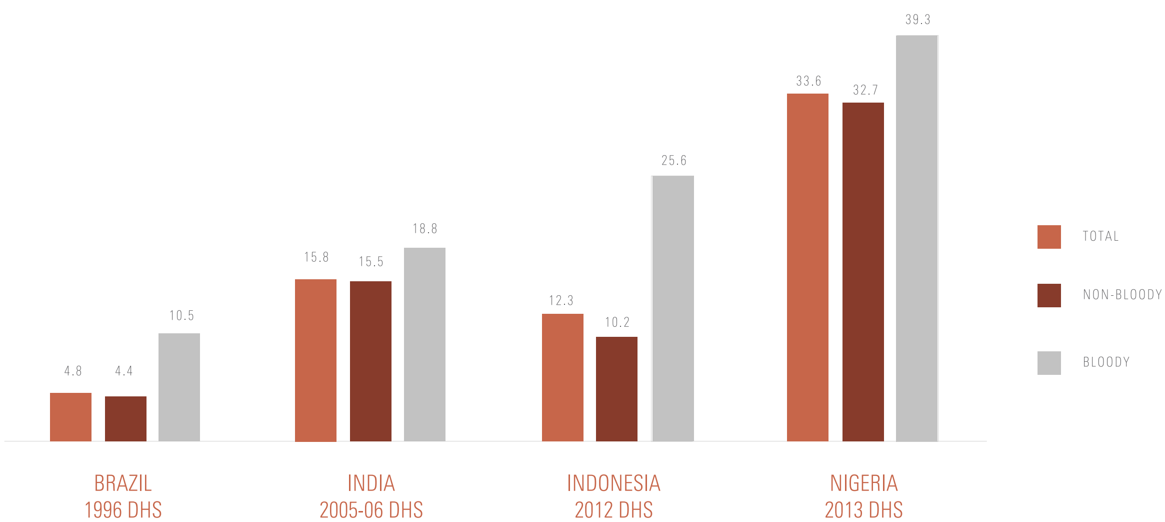
5.2. Antibiotic usage for diarrhoea

Antimicrobial drugs are only effective for the treatment of bacterial diarrhoea, such as Shigella dysentery, amoebiasis and giardiasis, which together account for only 15 percent of all global diarrhoeal episodes (Muhuri, Anker & Bryce, 1996a; 1996b). Even in bacterial cases, antibiotic treatment is mostly unnecessary due to the self-regulating nature of the disease. Despite this widespread knowledge, antibiotics continue to be used as the first-line treatment for diarrhoea in developing nations (Van Boeckel et al., 2014). While viral pathogens, more specifically rotavirus, are responsible for the majority of cases of diarrhoea in children, the WHO estimates that 40 percent of children under the age of five who suffer from diarrhoea receive antibiotic treatment (WHO, 2011). With rising levels of antibiotic resistance among bacterial-causing diarrhoea, such as fluoroquinolone, typhoidal Salmonella and Shigella, the misuse of antibiotics for the treatment of diarrhoea is becoming a pressing global concern (Vernet et al.,2014). There is at the core a severe lack of surveillance on the type and appropriateness of care sought for the treatment of infectious diseases in developing countries (Knobler, 2003a; Knobler, 2003b). In order to gain a more nuanced understanding of the volume of antibiotics used for the treatment of diarrhoea in the countries of interest, and the potential reduction of usage from a reduction in the disease burden, this report consulted 1) the Demographic and Health Survey (DHS) Program's health surveys and 2) recent cross-sectional surveys conducted at the local level. These numbers were then compared to 3) the WHO's estimate of 40 percent of diarrhoeal cases being treated with antibiotics.

DHS RESULTS

The DHS Program publishes statistics on levels and trends in care-seeking for childhood illness in both public and private settings. Surveys were conducted in several rounds between 1990 and 2014, with sample sizes ranging between 5,000 and 30,000 households in 60 countries. The survey includes statistics on the percentage of children up to five years old who experienced diarrhoea in the two weeks preceding the survey and received antibiotics. Findings are divided between bloody diarrhoea episodes (some of which require antibiotic treatments) and non-bloody diarrhoea (most of which do not). Figure 4.2 shows average usage rates of antibiotics for the treatment of diarrhoea across all countries included in the survey.

Figure 5.2: Percentage of children born in the at least 3 years preceding the survey with diarrhoea who received antibiotics



SOURCE: DHS, 1996-2013

Global findings of the DHS show that on average, 23 percent of children with symptoms of diarrhoea were treated with antibiotics. Antibiotic treatment for children with diarrhoea under the age of five occurs in more than one-third of children in 17 countries. Table 5.1 displays the results of the survey for the Brazil, India, Indonesia and Nigeria.

The DHS data confirms large discrepancies between the countries of focus: treatment ranges from 4 percent in Brazil to 34 percent in Nigeria. There is no large discrepancy between the treatment of bloody and non-bloody diarrhoea (non-bacterial origin), indicating a higher rate of misuse for non-bacterial diarrhoea.

Table 5.1: Percentage of children up to age three suffering from diarrhoea who received antibiotics (DHS)

Country	Survey	Age between 0-3	
		Non-bloody	Bloody
Brazil	1996 DHS	4	11
India	2005-06 DHS	16	19
India	1992-93 DHS	31	38
Indonesia	2012 DHS	10	26
Nigeria	2013 DHS	33	39
Nigeria	2008 DHS	33	35
Nigeria	1990 DHS	11	17

LIMITATIONS OF DHS SURVEY

While the DHS survey is the most comprehensive one on the subject of treatment courses for diarrhoea, there are several limitations. An important issue is the reliance on the reporting of caregivers. Such sources of information are often subject to recall bias, reporting bias, and misclassification due to the absence of clinical diagnosis (Winter et al., 2015). Especially in multiple-children households, caretakers potentially face a difficult task in remembering treatment courses for diarrhoeal episodes. Another major shortcoming of the survey is its focus on children. While diarrhoea largely affects young children, other segments of the population are also susceptible to infection and consumption of antibiotics. Finally, contrasting with the DHS, other studies have only observed limited improvements in diarrhoea case management over time (Boschi-Pinto, Bahl, and Martines 2009; Geldsetzer et al., 2014).

REVIEW OF LOCAL STUDIES

In order to gain a better understanding of the local scenarios and national discrepancies in the countries of interest, small- and medium-scale cross-sectional studies of antibiotic usage for the treatment of diarrhoea were also reviewed. A search of the terms "diarrhoea", "treatment", "antimicrobials", "misuse" for the countries of concern on PubMed and Google Scholar resulted in seven relevant studies for India, three studies for Indonesia and Nigeria, and one for Brazil. Table 5.2 shows an overview of the results for the percentage of diarrhoeal cases treated with antibiotics. Most studies were conducted at the community level since this is where 80 to 90 percent of antibiotics usage occurs in developing countries (Kotwani & Holloway, 2011).

Table 5.2: Results of local studies

Author	Year	Country	Level	% treated with antibiotics
Diwan et al.	2015	India	Community	40%
Ahmed et al.	2009	India	Community	77%
Kumar et al.	2008	India	Community & hospital	82%
Kotwani et al.	2012a; 2012b	India	Community	43% (public) 69% (private)
Rogawski et al.	2015	India	Community	29%
Pathak, D.	2011	India	Community & hospital	71%
Alvarez-Uria et al.	2014	India	Hospital	52%
Zwisler et al.	2013	India	Community	59%
Santoso, B.	1996	Indonesia	Community	70%
Munaf, S.	2005	Indonesia	Community	79%
Ekwochi et al.	2013; 2013a; 2013b; 2013c	Nigeria	Community	47%
Ogunrinde, O.	2012	Nigeria	Community	36%
Okoro & Okoro-Jones	1995a; 1995b	Nigeria	Community	40%
Schorling et al.	1991	Brazil	Community	19%

Reported usage of antibiotics varies greatly between studies as well as within countries, however they are consistently higher than estimates reported in the DHS (Table 5.2). Antibiotic treatment is found to be the highest in India (40-84 percent), followed by Indonesia (70-79 percent), Nigeria (36-47 percent) and Brazil (19 percent).

Several factors can explain the variation that exists between the DHS survey and the studies. One of the main differences is that most of the other studies surveyed larger age cohorts experiencing diarrhoea. For example, Okoro and Okoro-Jones's (1995) study on the home management of diarrhoea in Nigeria shows that self-medication and misuse of antibiotics is higher among adults than children.

In addition, the studies focus on prescriptions of antibiotic drugs from medical facilities, pharmacies and over-the-counter drug vendors rather than relying on the judgment and recall of patients or caretakers. Such studies therefore give more reliable information by compiling actual prescription patterns (Diwan et al., 2015; Kumar et al., 2008; Pathak, 2011; Santoso, 1996). Recall and misclassification bias are also potentially minimised in studies that survey patients' exit interviews from public and private medical facilities (Kotwani et al., 2011; Munaf, 2005). An additional potential benefit of consulting prescriptions or patient records is the insight on the link between providers and choice of treatments.

Finally, higher observed rates of antibiotic prescription in the reviewed studies can also be explained by the longer observation periods. Ahmed et al. (2009) highlight that since seasonality is decisive for diarrhoeal disease incidence, house-to-house surveys were conducted to determine the prevalence in all four seasons. Similarly, Alvarez-Uria et al. (2014) collected information from hospital databases throughout the full year to avoid seasonal variation while Rogawski's (2015) study followed children from birth to three years of age in India to find longer-term effects of antibiotic consumption. The study also showed that children who were treated with antibiotics for diarrhoea early in life experienced subsequent diarrhoea sooner than children who were not treated with antibiotics. Such factors cannot be reflected in a survey that is conducted twice every decade. Comparative results between DHS, the literature and the global WHO figures are summarised in Table 5.3.

Table 5.3: Range to estimate the cases of diarrhoea treated with antibiotics

Country	Lower bound (DHS)	Upper bound (literature)	WHO
Brazil	7%	19%	40%
India	17%	84%	40%
Indonesia	18%	79%	40%
Nigeria	34%	47%	40%

5.3. Diarrhoea and antibiotics: quantifying the relationship

METHODOLOGY

Infection control through WASH infrastructure can have a significant impact on the consumption of antibiotics. Drawing on the model and disease burden numbers from Section IV, the subsequent fall in antibiotic use can be measured.

First, the number of people affected by diarrhoea in 2015 and in 2030 based on the Section IV numbers in the do-nothing and two intervention scenarios are converted into number of episodes of diarrhoea per year. The average number of episodes per person per year used is extracted from two systematic reviews: one by Lamberti, Black and Fischer-Walker (2010) for children, and the other by Fischer Walker and Black (2005) for adults. Second, the percentage of diarrhoea episodes treated with antibiotics in each country as outlined above is applied to the change in diarrhoeal burden to find the total number of episodes of diarrhoea treated by antibiotics in 2015 and in the do-nothing and intervention scenarios in 2030.

Table 5.4: Average episodes per person per year by age group

	Average episodes adult	Average episodes children
Brazil	0.57	4.58
India	0.39	2.85
Indonesia	0.39	2.54
Nigeria	0.42	4.55
Source	Fischer Walker and Black (2005)	Lamberti et al.(2010)

Tables 5.5 to 5.7 show the estimate ranges of cases of diarrhoea treated with antibiotics in 2015 and 2030, divided between water and sanitation interventions. We then use these results to estimate how much antibiotic use could be reduced through WASH interventions.

Table 5.5a.: Cases treated with antibiotics in 2015 for water

Country	Lower bound (DHS)	Upper bound (Literature)	WHO estimates
Brazil	1,116,935	4,421,200	9,307,790
India	107,918,993	539,594,963	256,949,982
Indonesia	15,654,253	100,543,576	50,908,140
Nigeria	26,920,936	94,706,886	80,601,605

Table 5.5b.: Cases treated with antibiotics in 2015 for sanitation

Country	Lower bound (DHS)	Upper bound (Literature)	WHO estimates
Brazil	5,842,428	23,126,278	48,686,901
India	136,606,320	683,031,599	325,253,142
Indonesia	11,740,690	75,407,682	38,181,105
Nigeria	27,470,343	96,639,680	82,246,536

Table 5.6: Estimated cases treated with antibiotics in 2030 in the do-nothing scenario

		Lower bound (DHS)	Upper bound (Literature)	WHO estimates
Water	Brazil	1,279,756	5,065,700	10,664,632
	India	131,349,581	656,747,903	312,737,097
	Indonesia	19,052,991	122,372,867	61,960,945
	Nigeria	40,550,899	142,656,605	121,409,876
Sanitation	Brazil	6,694,107	26,497,508	55,784,228
	India	166,265,292	831,326,460	395,869,743
	Indonesia	14,289,743	91,779,650	46,470,709
	Nigeria	41,378,468	145,567,964	123,887,629

Table 5.7: Estimated cases treated with antibiotics in 2030 in the intervention scenarios

		Lower bound (DHS)	Upper bound (Literature)	WHO estimates
Water	Brazil	670,873.78	2655542	5590615
	India	69901845	349509224	166432964
	Indonesia	9873099	63412589	32107640
	Nigeria	20650731	72648529	61828535
Sanitation	Brazil	2,061,872	8,161,578	17,182,269
	India	48,120,050	240,600,252	114,571,549
	Indonesia	4,126,919	26,506,230	13,420,876
	Nigeria	11,602,025	40,815,506	34,736,601

S1 vs. S0. Table 5.8 shows the reduction in antibiotic consumption in 2030 from a do-nothing scenario to an intervention scenario – and there are substantial gains to be made. In order to avoid double-counting, we refer to the sanitation intervention scenario, which represents an upper bound for our estimates. In particular, we find that in 2030, the reduction in antibiotic consumption from a do-nothing scenario to an intervention scenario ranges from 600,000 in Brazil to 590 million in India. In addition, there will be an average decrease of diarrhoeal cases treated with antibiotics of 47-50 percent for water and 69-72 percent for sanitation from a do-nothing scenario to a do-something scenario in 2030.

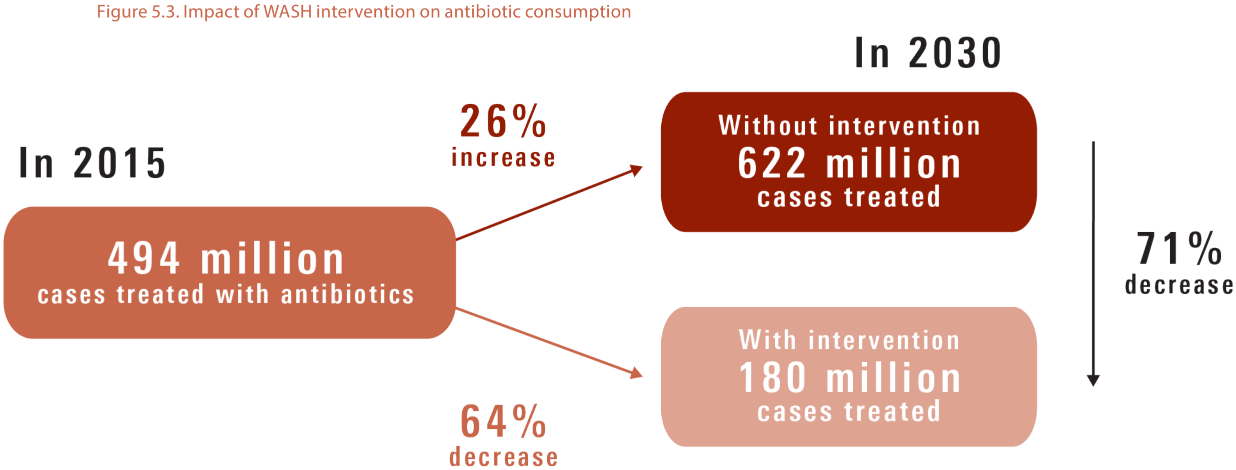
As the country with the largest population and the highest upper bound value for the percentage treated with antibiotics (84 percent), India subsequently faces the highest number of cases of diarrhoea treated with antibiotics in 2015. Finally, the lowest estimate comes from the DHS survey in Brazil conducted in 1986, which due to its age and the fact that it is the lowest of the estimates, can be considered an underestimate of the consumption of antibiotics.

Table 5.8. Reduction in antibiotic consumption in 2030 from a do-nothing to an intervention scenario

Country	Water (thousands)	Sanitation (thousands)
Brazil	600 to 5,000	5,000 to 39,000
India	61,000 to 400,000	118,000 to 590,000
Indonesia	9,000 to 59,000	10,000 to 65,000
Nigeria	20,000 to 70,000	30,000 to 105,000

2015 vs. 2030. We also compare the current levels of antibiotic consumption to the amount predicted by our model in 2030 to understand potential growth trends. Using the WHO range of 40 percent of cases treated, using the two period sanitation intervention as our model, we find that on average more than 494 million cases of diarrhoea were treated with antibiotics in 2015 in the four countries. If WASH is not improved, the model predicts that the number of antibiotics consumed will increase to approximately 622 million cases treated. This is a 26 percent increase in the consumption of antibiotics in 2030 as compared to 2015. On the other hand, with the implementation of a well-targeted WASH intervention, the consumption of antibiotics in 2030 will be 64 percent lower than in 2015. Figure 5.3 summarises the gains in antibiotic consumption from a well-targeted sanitation intervention, if 40 percent of cases of diarrhoea are treated with antibiotics in 2015 and 2030.

Figure 5.3. Impact of WASH intervention on antibiotic consumption



LIMITATIONS

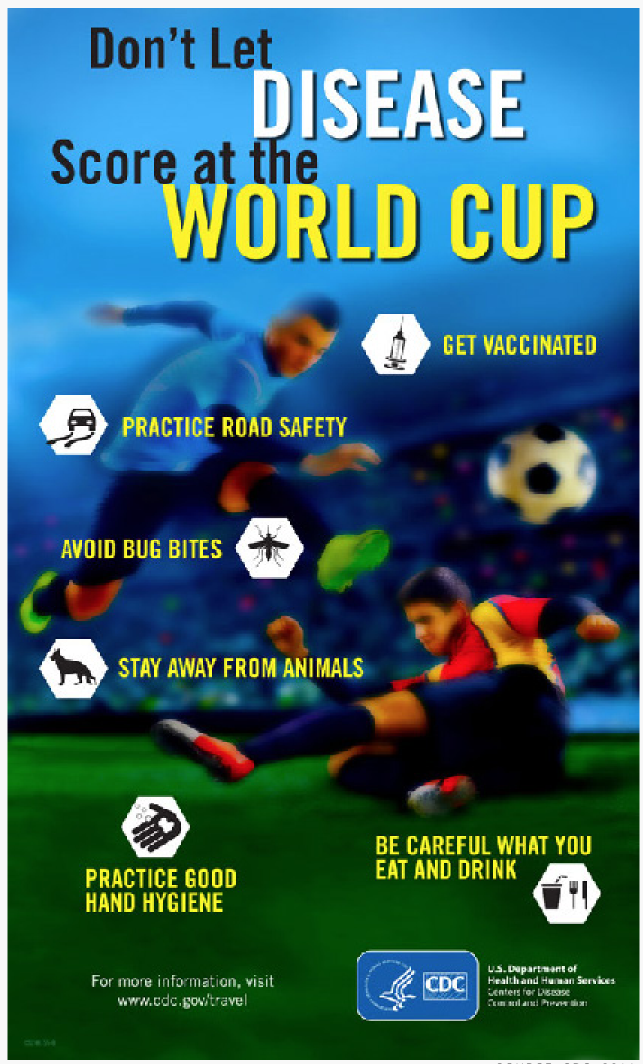
Apart from the limitations regarding the estimated cases of diarrhoea (discussed in Section IV), these results face further constraints. As discussed, the lower-bound DHS figures suffer from potential recall, misclassification and misreporting bias. The studies included in the report also need to be treated with caution. Apart from often-restricted sample size, most of the studies are conducted at the local level, making it difficult to extrapolate on the larger national scale. Any attempt to extrapolate antibiotic consumption figures will need to consider local socio-economic factors and adjust consumption estimates accordingly. For example, Kumar et al.'s (2008) study has shown that rates of antibiotic prescription varied significantly in urban and rural settings as well as between government and private treatment settings. Factors such as education of caretakers (Béria et al., 1998; Ogunrinde, 2012), proximity to the next private or public medical facility or pharmacy (Zwisler, 2013) and the influence of the informal health-sector (Pathak, 2011) play decisive roles in the rate of antibiotic treatment. The above studies and the DHS can only be regarded as snapshots into the community-level consumption of antibiotic drugs for the treatment of diarrhoea. Until the roll-out of large-scale surveillance efforts examining antibiotic consumption in developing countries, such figures will remain uncertain.

Box 5.1: Brazil and the case of the 2014 FIFA World Cup

International travel will be an increasing factor of risk and resistance spread in the coming years (Woodford, 2016). This potential is epitomised by mass gatherings such as the World Cup. These events bring together individuals from around the world who can transmit diseases and resistance before returning to their home countries, precipitating the spread of certain pathogens (Abubakar et al., 2012). Host countries are in a particularly difficult situation given that they are the ones who have to mitigate and deal with the consequences of the introduction of communicable diseases, entry of susceptible individuals, overcrowding, outbreaks of endemic or imported infectious diseases, etc. (Kaiser and Coulombier et al., 2012). For example, Brazil has successfully eliminated measles and rubella, which are still pervasive in other countries and thus could be brought back by tourism (ECDC, 2014).

For this reason, the European Centre for Disease Prevention and Control (ECDC) conducted a risk assessment to identify which infectious diseases were the major risks to Europeans visiting Brazil during the World Cup as well as the public health implications after the travelers' return. The report recognised that EU citizens visiting the mass gathering were more at risk of gastro-intestinal illness and vector-borne infections. Consequently, hygienic measures to reduce risk were high priorities. Furthermore, Barreto et al. (2007) found that in the last 20 years in Brazil, the cause of diarrhoeal diseases in the general population shifted from bacterial infections through faecal-oral transmission to viral infections through person-to-person transmission.

Indeed, because of the concentration of people from different countries and regions of the world, the ECDC was concerned about the spread of resistant infections from Brazil as a result of the 2014 World Cup (ECDC,2014). As similar sporting events, tourism, and globalisation continue, this will be a growing threat to the spread of AMR.



SOURCE: CDC, 2014.

DISCUSSION

This report focuses on the reduction of antibiotic consumption through large-scale preventive interventions to reduce diarrhoea incidence in LMICs. It has shown that a significant part of diarrhoeal cases are mistreated with antibiotics and that improvement in water and sanitation levels could significantly reduce the demand for the drugs simply by lowering the disease burden. However, the eradication of diseases is always a long-term effort that demands an integrated approach with complementary interventions in the short- and medium-run. Many aspects should therefore be considered by policymakers alongside WASH infrastructure. Policy and regulation will need to complement any infection control efforts to control the rising demand for antibiotics. In an unregulated environment without proper antibiotic stewardship, demand for treatment will persist due to different demand and supply side factors. In countries such as India, doctors receive commissions from drug sellers in exchange for directing patients to pharmacies (Laxminarayan and Heymann, 2012). Competition from unofficial and over-the-counter providers of antibiotics also increases competitive pressure on doctors to prescribe antibiotics (Laxminarayan et al., 2013). Unregulated (mostly over-the-counter as well as black market) availability of antibiotics further exacerbates this problem. Regulation will need to be supported by government-led educational campaigns, informing both the supply- and demand-side about the dangers of antibiotic misuse.

In the short-term, as infection rates remain high, demand for diarrhoeal drugs needs to be diverted towards more effective alternative treatments. As it is difficult to restrict access to drugs to ill patients from both an ethical and political standpoint, policymakers should encourage the use of low-cost remedies such as oral rehydration salts (ORS) and zinc[5], which are the most effective treatments of diarrhoea. Gill et al. (2013) identify strong barriers in LMICs that prevent the use of ORS and zinc treatment, including incentives for medical staff to recommend antibiotics over zinc or ORS for the treatment of diarrhoea; incomplete supply chain mechanisms; lack of government policies or incentives to stimulate private sector investment in supply chain management systems; and low demand from patients (Gill et al., 2013). Diversion to other treatments, without directly restricting access, has the potential to accelerate the reduction of antibiotic consumption in developing countries.

Rotavirus is responsible for a majority of diarrhoeal deaths and infections across all developing countries (Jiang et al., 2010). Most of these cases are entirely preventable thanks to the introduction of rotavirus vaccinations. Increased availability and utilisation of such vaccinations will rapidly decrease diarrhoeal cases and are therefore an essential complementary preventive intervention.

The utilisation of community-based health workers has proven to be incredibly effective in reducing antibiotic demand and improving the uptake of more effective treatments and vaccinations (Bhutta et al., 2013; Geldsetzer et. al., 2014). Despite community case management now being central to UNICEF and WHO strategies, the level of community health workers is still alarmingly low in many countries (Herbert et al., 2012). Governments' efforts to integrate and expand the presence of community health workers can directly aid the reduction of antibiotic consumption for infectious diseases.

The speed and volume of today's intercontinental travel and trade forms new opportunities for antimicrobial-resistant pathogens to spread internationally (AMR Review, 2014). AMR affects developing economies proportionally more than developed ones (WHO, 2014), but resistance is a global threat in today's world. For example, studies conducted in several European countries, as well in New Zealand, Canada and Australia, show that international travellers who visited India have a higher risk of carrying antimicrobial-resistant Enterobacteriaceae than people without a recent history of overseas travel (van der Bij and Pitout, 2012). Recent increases in medical tourism, which in 2015 amounted to 3.2 million visitors in India alone (The Economic Times, 2014), are of special concern, as an estimated 50 percent of bacterial infections acquired in Indian hospitals are resistant to commonly used antibiotics (Shah, 2012).

The problem of AMR spread can be exacerbated by the varying levels of AMR surveillance in developed and developing countries. The lack of surveillance networks, laboratory capacity, and appropriate diagnostics in developing countries mean that the extent of AMR in the developing world is often underestimated (Vernet et al., 2014). However, studies have shown that the mapping of AMR is achievable even in under-resourced countries (Solomon and Ijaz, 2015). Recent advancements in the use of cheaper and more effective molecular tools for the diagnosis of infections and resistances have shown promising results (Woodford, 2005). Advocacy tools for improvements in AMR surveillance in developing countries will be essential for the successful roll-out and maintenance of initiatives. In 2012, the WHO's South-East Region member states agreed on recommendations for preventing and containing AMR, which included increased surveillance capacities (Vernet et al., 2014). Similar unified regional efforts need to be expanded into other regions in order to address such a pressing international concern.

[5] The WHO and UNICEF recommend the provision of low-osmolarity ORS with zinc supplementation, as the first-line treatment for diarrhoea in children under age 5 (WHO and UNICEF, 2004).

6. FINAL THOUGHTS & RECOMMENDATIONS

Statistics on costs, disease burden and antibiotics use can provide a general understanding of the scope of the problem. Yet our research has highlighted the importance of good data and monitoring, complementary and community-level interventions, and other factors that will be essential to reducing infectious disease, antibiotics use and AMR. The main points and our recommendations are discussed in this section.

DATA

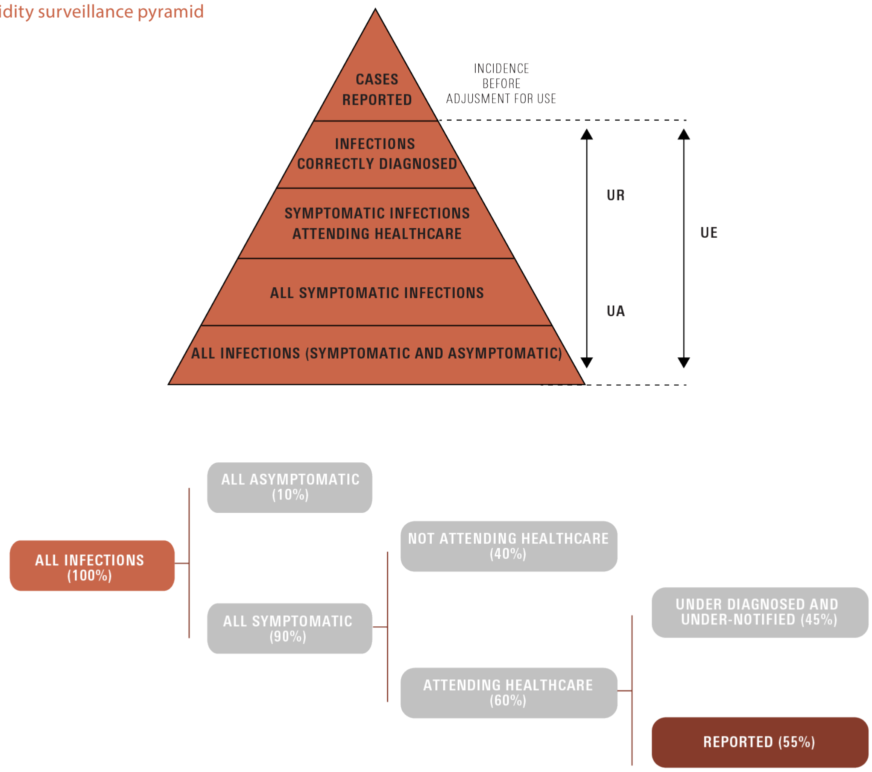
One of the key findings of the literature reviews on costs, WASH access, diarrhoeal disease burden, and antibiotics is that rigorous data collection and intervention evaluation are limited. Even the most widely-used and accepted numbers are subject to numerous assumptions and extrapolation. In order to meet the SDGs, it is essential for countries and researchers to begin monitoring the baseline levels of access to WASH services, reporting on interventions, and collecting data in consistent ways. The UN could form a task force under the SDGs to create country-customised frameworks for interventions that fit within the broader goals and allow for international monitoring and evaluation. Until the data becomes more detailed and consistent, it is impossible to assess the exact status of WASH access and the precise impact of an intervention.

SURVEILLANCE

Under-estimation (Figure 6.1) is a pernicious problem for measuring all infectious disease burdens. It has however been shown that illness is disproportionately underestimated when it affects low-income population distributions, or when the illness is self-limiting, difficult or expensive to test for or under-ascertained (i.e. occurs in individuals that do not seek healthcare) (Gibbons et al., 2014). The surveillance of diarrhoeal disease in developing countries largely focuses on patients visiting healthcare facilities, despite the acknowledged fact that care-seeking rates are low for diarrhoea (Nelson and Williams, 2007). This problem is aggravated by the overt focus on passive surveillance, such as routine reports by healthcare workers for health officials. Passive surveillance mechanisms have been shown to result in high levels of bias, delay and under-reporting (Nelson and Williams, 2007). Gibbons et al. (2014), estimate that only 55 percent of all infections are reported in developing countries (Figure 6.1).

More primary research on diarrhoea incidence in developing countries, including household visits and surveys, is necessary to adjust current estimates for the true burden of diarrhoea (Kosek, Bern and Guerrant, 2016a, 2016b). The potential reduction

Figure 6.1: Morbidity surveillance pyramid



SOURCE: GIBBONS ET AL. 2014

of mortality and morbidity rates due to diarrhoea may therefore be significantly higher than the conservative estimates of this report.

Improved surveillance, in combination with the use of simple, standardised guidelines for the identification and treatment of diarrhoea in the community and health facilities, is indispensable for understanding the magnitude of the illness. Persistent neglect of clinical and epidemiological research in the field of diarrhoea has left some uncertainty about the character and magnitude of the illness (GAPPD, 2013). Inadequate testing mechanisms for multi-pathogen infections, as well as reluctance of health workers to test patients with diarrhoeal infections, augment this problem.

While WASH intervention strategies have the potential to reduce the spread of a wide range of diarrhoeal pathogens and do not necessarily require knowledge of diarrhoea aetiology, other complementary interventions such as rotavirus vaccines would benefit greatly from a more comprehensive understanding of the overall burden of pathogen-specific diarrhoeal disease (Lanata et al., 2013).

COST OF INFRASTRUCTURE

Achieving safe and universal access to WASH services is not financially prohibitive for countries. Ranging from 0.03 to 2.1 percent of GDP per year in our four countries of interest, this is an amount that is less than other comparable spending priorities like health and education. In general, investments in water supply and sanitation do not come from health sector funds and are not compared with other health interventions when investment decisions are made, even though health benefits do arise from water supply improvements. By reframing WASH infrastructure as a health policy issue, countries may be willing to change the allocation of funding to this sector. In addition, if citizens are convinced of the importance of WASH infrastructure and are certain that paying for services will ensure their continuity and safety, there may be a higher contribution of private willingness-to-pay, which will reduce the burden on the state.

An important contribution of Hutton and Varughese (2016) to the larger WASH infrastructure cost literature is the inclusion of maintenance and operations costs over time (refer to Annex 4). True life-cycle costs of the infrastructure need to be paired with government commitment to revisiting communities and ensuring that the hardware has not broken down, as has often been observed in India. The commitment to change needs to extend beyond the optics of the initial intervention.

SOCIO-ECONOMIC AND GENDER FACTORS

Studies analysing the effectiveness of interventions continually highlight the importance of income. In some cases, the impact of improved infrastructure passes over low-income households (Kumar and Vollmer, 2012) while in others, the effect passed over high-income households (Jalan and Ravallion, 2003). Different forces are at work behind these divergent findings: in lower-income houses, poor access to WASH infrastructure is likely accompanied by lower quality water storage, lower levels of waste treatment, etc. so an intervention on its own may be insufficient to improve health. On the other hand, an intervention that targets this type of household may not significantly improve the health of higher-income households because they already meet some of the standards. This need to be taken into consideration when planning an intervention as household-level changes will only be effective if they are reflected in the whole community, since infectious disease is by nature not isolated.

In a low-income setting, the education of the mother or oldest woman in the household has been found to have an impact on the benefits of WASH infrastructure (Jalan and Ravallion, 2003). In another study, treatment effects bypassed girls from all income levels but not boys (Kumar and Vollmer, 2012). Finally, in southeast Asia, diarrhoea disproportionately affects women as compared to men at all age groups (WHO, 2011). Policymakers should consider the importance of empowering and educating women in order to reduce their undue burden and improve the overall effects of interventions at the household and community level.

NEED FOR COMPLEMENTARY INTERVENTIONS

A majority of diarrhoeal infections in developing countries can be tackled by improving the state of WASH. However, this is not where the story ends: due to the variety of pathogens and transmission pathways that can cause diarrhoeal infections, a multi-faceted approach is therefore needed. The recent 2013 "The Integrated Global Action Plan for Pneumonia and Diarrhoea" (WHO) recommends the improvement of WASH alongside the promotion of exclusive breastfeeding for infants and the use of vaccines against rotavirus as key interventions to reduce the diarrhoeal disease burden. Furthermore, beyond prevention, effective treatment courses such as ORS and the use of zinc supplements with ORS will continue to be crucial for reducing the mortality rates, especially for children under the age of five.

EFFECT ON OTHER DISEASE BURDENS

While the disease focus of this report lies in the reduction of diarrhoeal illness, the benefits of WASH interventions on the spread of other diseases should also be considered by policymakers. Improvements of WASH standards in developing countries have been shown to reduce the disease burden of neglected tropical diseases such as schistosomiasis and lymphatic filariasis (Strunz et al., 2014), as well as vector-borne diseases such as malaria (Emerson et al., 2000). Prüss-Üstün et al. (2014) estimate that in 2004, approximately 881,000 non-diarrhoeal deaths were attributable to WASH. While diarrhoea constitutes the largest disease burden of inadequate WASH, the health benefits will reach far beyond it.

ACCESS TO DRUGS

Effective treatments and preventive interventions such as the ones just mentioned can divert the rising demand away from antibiotics. Regulating direct access to antibiotics can be difficult from both a practical and ethical standpoint. On one hand, some severe cases of diarrhoea require the use of antibiotics, and restricting access could therefore be perceived as denying individuals life-saving treatments. On the other hand, tighter regulation could increase informal market demand for antibiotics, which would increase inappropriate antibiotic use without the guidance of doctors, as well as increase the circulation of counterfeit drugs.

BEHAVIOUR

All in all, the success of all WASH interventions depends on how successfully people adopt the infrastructure and associated practises. While the calculation of costs and risk ratios may improve over time, it is important to place the individuals affected by such interventions at the centre of the debate. Policymakers, non-governmental organisations and community groups need to educate people about the dangers of inadequate hygiene and sanitation and the misuse of antibiotics in order to change behaviour. Long-term change of embedded behavioural patterns such as open defecation will have to be supported by long-term political commitment and financial support at the top level and by the know-how and commitment of local officials and community leaders, who can tailor interventions by community-specific targeting.

Beyond the aforementioned, there are other opportunities: improvements in surveillance and rigorous evaluations will provide strong evidence for the effectiveness of WASH interventions, which could attract more financing and political attention. Also, while it may take time, behaviour can be changed. The recently-published SDGs have created a positive momentum which governments can now use to implement changes.

7. CONCLUSION

This report has estimated the costs of improving WASH infrastructure to reduce infection rates so as to mitigate the development of AMR in Brazil, India, Indonesia and Nigeria. While WASH infrastructure costs have gone up continuously because of improved estimates and the incorporation of more factors, the annual spending required per country is not prohibitive, especially given the benefits. This report has underlined how WASH interventions can be cheap yet effective. By spending up to 2.1 percent of GDP, citizens of Brazil, India, Indonesia and Nigeria could have access to safe, universal WASH.

By looking at countries instead of regions, the analysis was able to identify the importance of context-dependent promoting and mitigating factors to enable successful WASH interventions. Interventions will need to be developed on a localised level to maximise impact, and scaling up may be difficult and require innovative solutions.

We are optimistic that this report will be a starting point for establishing and advocating the important link between WASH and AMR. The scope should be extended to other countries or to LMIC regions in order to understand the scale of WASH interventions. In addition, the impact on other diseases would be an interesting factor to consider in order to have a full picture of WASH's effect on the total disease burden.

While WASH interventions demand commitments on the local and national scale, the threat of AMR moves beyond any geographical considerations. Rising resistance levels can only be addressed through deepened cooperation both between and within developing and developed nations. As the recent Ebola and Zika virus outbreaks have shown, health threats will increasingly demand global response mechanisms. The far-reaching character of AMR should therefore not only be considered as threat but also as an opportunity for the world to move towards a more unified global health agenda.

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ANNEX 1. TERMS OF REFERENCE (ToRs)

Client: Review on Antimicrobial Resistance (Wellcome Trust)

Capstone Project – London School of Economics and Political Science

Supervisors: Professor Patrick Dunleavy and Brett Meyer

Undertaking an economic analysis to estimate the costs of improving sanitation practices to reduce infection rates and antibiotic usage as a strategy to mitigate AMR development in Brazil, India, Indonesia and Nigeria.

Project background:

Antimicrobial resistance (AMR) is the phenomenon whereby microbes develop resistance, or the ability to be less affected by the drugs that are commonly used to treat them. AMR is a naturally occurring process in nature, but poses a significant threat to health due to the increased usage of antibiotics and the emergence of highly resistant strains of microorganisms such as Methicillin Resistant Staphylococcus aureus (MRSA), Vancomycin resistant Enterococcocci (VRE) among others. Antibiotics essentially put a selection pressure on populations of microbes, allowing those with favourable mutations, i.e. the ones that are already resistant to particular drugs to proliferate. This leads to antibiotics becoming less effective over time, and in extreme cases, could lead to them becoming completely useless.

Antimicrobial resistance is a growing health concern with drug resistance infections already responsible for more than half a million deaths across the world each year. This number is set to rise, if resistance is not controlled, killing as many as 10 million extra people by 2050, which could cost the world $100 trillion in lost output between now and 2050.

Organisational Background:

The Review on Antimicrobial Resistance is an independent UK government funded review which was set up to produce analysis of the global problems concerning AMR and to propose concrete international solutions to these. (See https://www.gov.uk/government/news/prime-minister-warns-of-global-threat-ofantibiotic-resistance). It is led by the economist Jim O'Neill, the former Chairman of Goldman Sachs Asset Management, and now a peer and a minister in the UK government. The Review was set up in July 2014 by PM David Cameron to investigate ways to increase the numbers of antibiotics being researched and created. It will also analyse other ways to reduce the worrying rise in resistance to antibiotics and other antimicrobials, which could lead to large-scale health problems and risks in the near future, unless recent trends can be reversed or ameliorated. The review is funded by the Wellcome Trust and the UK Department of Health. Internationally the review has already had considerable salience and resonance, and there are close links with WHO and many countries in the G20, particularly the USA and China and other bodies seeking to provide economic and policy solutions to this health problem. So far the Review has come out with three papers. The first paper (December 2014) dealt with the economic costs of not tackling AMR and suggested that drug resistant infections could lead to 10 million deaths a year and cost up to US$ 100 trillion by 2050. Initial recommendations to address the international AMR research funding landscape were the subject of the following second paper (February 2015). The third paper released in May 2015 sets out proposals to reinvigorate the drug discovery and the antibiotic pipeline.

Last year's capstone project undertaken with the Wellcome Trust addressed an issue slightly tangential to the main line of the Review's third report, looking at International Coordination Against AMR: A Sustainable Future for Antibiotic Development. Copies of the review are available from the MPA office or Professor Dunleavy, and each team member will receive a PDF

2015-16 Capstone Project Objectives:

This year's project aims at estimating the costs of improving sanitation practices to reduce infection rates so as to mitigate the development of AMR in the four key countries – Brazil, India, Indonesia and Nigeria – each large countries. This topic is important to understand the costs other than those directly related to healthcare that can slow down progress in reducing antimicrobial resistance rates in low and middle income settings.

AMR is primarily thought to arise and spread through hospitals and healthcare networks and the role of water, sanitation and hygiene (WASH) is largely being overlooked in current literature and policy. The idea behind this year's project is that if infection rates are brought under control through improved WASH in society, then the need for antibiotics and the subsequent potential for increased antimicrobial resistance will be constrained or limited. The role of WASH in reducing infection rates for diseases common to low and middle-income countries is well documented and we would like this to be extended to AMR.

Research Question:

The capstone team will explore the costs of improving sanitation practices such as improved access to toilets and increased hand washing in reducing the diarrhoeal disease burden, which is not always bacterial but is often treated with antibiotics. The team will create a cost-effectiveness analysis of bringing better water and sanitation standards to the four countries, particularly in relation to antimicrobial resistance. With respect to sanitation practices, the ideal situation would be if the team could focus on both infrastructure costs (such as improving the sewage system, building toilets) as well as on inculcating behavioural changes in the public (like increased hand-washing, using toilets etc.).
However, our primary interest lies in the infrastructure costs.

Key activities to answer the question:

The team will have to:

A. Refine and limit the research question based on available information. A literature review will be important in understanding the methodology to estimating these costs in other low-income settings.

B. Scope the project for four key countries (Brazil, Indonesia, India and Nigeria) based on the availability of relevant information and relevance in terms of regional and economic characteristics as well as known antibiotic consumption.

C. Collate together the Information available in public domain sources and present it systematically and in synoptic form

D. Survey the available data on costs of water and sanitation infrastructure.

E. Develop and undertake their own qualitative and quantitative analyses of issues identified in the review

F. Develop and write a full report to the Review team on the potential for improved water and sanitation infrastructures to reduce the current levels of over- use of antibiotics in combating easily preventable diarrhoeal diseases. The report should begin to be part-written as soon as feasible in the Capstone process and emerging results must be discussed with the AMR Review liaison team in a very interactive process.

A final presentation should be presented to the AMR Review team in late February 2016 and a final report for the Trust and LSE examiners by the end of the first week in March 2016.

As last year, all the main contacts for this project at the Review team are alumni from LSE's MPA programme. Hala Audi is the Head of the Review Team; she completed the MPA in 2008 and has worked in the UK Treasury ever since (from where she is seconded for the Review's duration). Anthony McDonnell is the lead research economist with the Review : he graduated from the MPA in 2014. Lastly, Anjana Seshadri completed the MPA in July 2015, was a member of last year's Wellcome Capstone team, and is now a policy advisor and researcher with the Review.

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The first Capstone meeting with the client will take place at 11.30 am on Monday 12 October, 2015 at the Wellcome Trust HQ building, Gibbs Building, 215 Euston Road, London NW1 2BE.

ANNEX 2. METHODOLOGY

The methodology of the report varies by section. Section III does a cost analysis based on the most recent and thorough literature on the topic, as identified through an overview of the related literature. The costs are determined by extrapolating baseline levels of unimproved, basic and safe access from Hutton and Varughese (2016), then using the full costs of safe, universal access for each infrastructure type, including maintenance and operations costs. These are then communicated through a total number and an annual percentage of GDP by country.

Section IV uses a model created by the authors to measure the reduction of the diarrhoeal disease burden as a result of different interventions. The risk reductions associated with the infrastructure interventions are informed by Wolf et al. (2014) as explained in the report. The parameters used are also described within the text and in Annex 2A. The costs from Section III and the disease reduction from Section IV are then used to run a "bang for your buck" analysis to determine the cost of saving one life from death or illness.

Section V uses a linear model to measure the reduction in antibiotics that would occur based on the reduced diarrhoeal disease burden found in Section IV.

As part of this research, numerous semi-structured interviews were conducted with experts. These provided a deeper understanding than would be obtained from purely quantitative methods and gave us insights from different areas of expertise. We met with the following experts:

Dr. Val Curtis, Director of the Environmental Health Group, and Katie Greenland, Research Fellow, both from the London School of Hygiene and Tropical Medicine (LHSTM). They offered background insights and papers on hygiene and WASH and helped scope our project.

Dr. Sandy Cairncross, Professor of Environmental Health at LSHTM. He is a leading researcher on environmental interventions for disease control and he has also been involved in WASH interventions, procedures, and their rollouts.

Dr. Guy Hutton, Development Economist and Lead Economist of the World Bank's Water and Sanitation Program. He provided us with our main data source on the costs of meeting the SDGs for WASH.

Eduardo Pisani, Director-General and Nina Grundmann, Associate Manager of Global Health Policy, at the International Federation of Pharmaceutical Manufacturers and Associations (IFPMA).

Professor Neil Woodford, the Head of Public Health England's national research lab and a scientific advisor of the AMR Review.

Dr. Mike Sharland, consultant in paediatric infectious disease at St George's University Hospitals NHS Foundation Trust. He advised us on antimicrobial prescriptions and resistance.

Dr. Jeroen Luyten, Fellow in Health Economics and Health Policy at LSE, Dr. Huseyin Naci, Assistant Professor of Health Policy at LSE and especially Estela Barbosa, LSE Fellow, all advised us on our model.

ANNEX 2A. PARAMETERS OF THE BURDEN OF DISEASE MODEL

PARAMETERS OF THE BURDEN OF DISEASE MODEL

CRUDE DEATH RATE. The crude death rate of each country was used, minus the death from diarrhoea rate to avoid double counting deaths. This implies that the mortality rate goes down slightly as the death from diarrhoea rate goes down due to an intervention.

DEATH FROM DIARRHOEA RATE. Country-level data on death from diarrhoea is available for children under five (GHO Diarrhoeal diseases, 2016) and regional data for LMICs is available for age groups above five (GHO Projection of number of deaths, 2016). These were used to determine death from diarrhoea rates per country, weighted by age.

CRUDE BIRTH RATE. Since population growth accounts for both births and deaths, this would also double count deaths so we use the crude natural birth rate instead. Crude birth rate minus crude death rate is the natural rate of increase and corresponds to the population growth without migration. The parameters are shown in Table A.2A.1

DISCOUNTING. In line with new WHO guidelines (2013b p.5), we do not use weighting and time discounting for the interventions, as the same weight should be allocated to lives today and tomorrow. Table A.2A.3 highlights the parameters chosen to model the probabilities. Values of the parameters and baselines are as indicated in Table A.2A.2. The effect of each intervention (relative RR) is not country specific due to lack of good quality data.

Table A.2A.1. Population growth parameters

Variables	Brazil	India	Indonesia	Nigeria
Population size	203,657,000	1,282,390,000	255,709,000	183,523,000
Crude death rate (without diarrhoea)	.0000519	.0007634	.0004865	.0022664
Death from diarrhoea rate	0.00003	0.00059	0.00012	0.00067
Crude natural birth rate	1.015	1.02	1.02	1.04

Table A.2A.2 Baselines per country (number of people)

	Sanitation		Water	
	Unimproved	Basic	Unimproved	Basic
Brazil	36,658,260	101,828,500	8,146,280	18,329,130
India	807,905,700	474,484,300	205,182,400	807,905,700
Indonesia	99,726,510	61,370,160	89,498,150	125,297,410
Nigeria	133,971,790	49,551,210	106,443,340	73,409,200

SENSITIVITY ANALYSIS. We performed a sensitivity analysis using the lower and upper bound estimates of the RRs to give a range of estimates of the gains in diarrhoeal burden in all four countries. This is discussed further in Annex 2B.

Table A.2A.3 Parameters for burden of disease model

T1	Probability	Measure	Source
P_1	Probability of dying from other causes than diarrhoea	Crude death rate	World Bank (2013)
P_2	Probability of dying from diarrhoea conditional on being exposed to a water or sanitation intervention	Death from diarrhoea rate	WHO (2014)
P_3	Probability of remaining ill	1- (P1+P2+P4)	
P_4	Probability of becoming free from diarrhoea from being exposed to a water or sanitation intervention	1- RR from water or sanitation intervention	Wolf et al. (2014)
T2	**Probability**	**Measure**	**Source**
P_1	Probability of dying from other causes than diarrhoea	Crude death rate	World Bank (2013)
P_2	Probability of dying from diarrhoea conditional on being exposed to a water or sanitation intervention and a mixed intervention	Death from diarrhoea rate in 2013	WHO (2014)
P_3	Probability of remaining ill	1- (P1+P2+P4)	
P_4	Probability of becoming free from diarrhoea conditional of being exposed to a mixed WASH intervention	1- RR from water or sanitation intervention	Wolf et al. (2014)

ANNEX 2B. SENSITIVITY ANALYSIS

EFFECTIVENESS RATIOS (US $ 2015) LOWER BOUND

TOTAL COST/(N° LIVES SAVED + LIVES AVERTED)

Water	
	Effectiveness Ratios
Brazil	5,951
India	454
Indonesia	450
Nigeria	986

Sanitation	
	Effectiveness Ratios
Brazil	990
India	305
Indonesia	516
Nigeria	836

AVG. ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)

Water	
	Effectiveness Ratios
Brazil	396.72
India	30.30
Indonesia	30.03
Nigeria	65.73

Sanitation	
	Effectiveness Ratios
Brazil	66.03
India	20.36
Indonesia	34.42
Nigeria	55.71

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED) — URBAN

Water	
	Effectiveness Ratios
Brazil	667.54
India	53.07
Indonesia	45.93
Nigeria	95.95

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED) — URBAN

Sanitation	
	Effectiveness Ratios
Brazil	69.13
India	25.08
Indonesia	48.95
Nigeria	79.75

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED) — RURAL

Water	
	Effectiveness Ratios
Brazil	81.58
India	23.51
Indonesia	15.98
Nigeria	38.95

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED) — RURAL

Sanitation	
	Effectiveness Ratios
Brazil	46.28
India	18.07
Indonesia	19.63
Nigeria	33.60

EFFECTIVENESS RATIOS (US $ 2015) UPPER BOUND

TOTAL COST/(N° LIVES SAVED + LIVES AVERTED)

Water (15 years)	
	Effectiveness Ratios
Brazil	17,819.65
India	1,421.40
Indonesia	1,288.74
Nigeria	2,637.60

Sanitation (15 years)	
	Effectiveness Ratios
Brazil	1,155.30
India	348.31
Indonesia	589.08
Nigeria	947.37

AVERAGE ANNUAL COST/ (N° LIVES SAVED + LIVES AVERTED)

Water	
	Effectiveness Ratios
Brazil	1,187.98
India	95.28
Indonesia	85.92
Nigeria	175.84

Sanitation	
	Effectiveness Ratios
Brazil	77.02
India	23.22
Indonesia	39.27
Nigeria	63.16

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	URBAN

Water	
	Effectiveness Ratios
Brazil	2,018.43
India	157.37
Indonesia	122.70
Nigeria	255.05

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	URBAN

Sanitation	
	Effectiveness Ratios
Brazil	81.04
India	29.02
Indonesia	56.37
Nigeria	90.65

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	RURAL

Water	
	Effectiveness Ratios
Brazil	241.58
India	75.30
Indonesia	48.80
Nigeria	104.80

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	RURAL

Sanitation	
	Effectiveness Ratios
Brazil	52.31
India	20.47
Indonesia	22.19
Nigeria	38.00

EFFECTIVENESS RATIOS (US $ 2015) 10% RECOVERY RATE

TOTAL COST/(N° LIVES SAVED + LIVES AVERTED)	
Water (15 years)	
	Effectiveness Ratios
Brazil	13,468.03
India	1,046.10
Indonesia	1,002.01
Nigeria	2,132.83

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	
Water	
	Effectiveness Ratios
Brazil	897.87
India	69.74
Indonesia	66.80
Nigeria	142.19

Sanitation (15 years)	
	Effectiveness Ratios
Brazil	1,463.90
India	441.99
Indonesia	747.62
Nigeria	1,201.95

Sanitation	
	Effectiveness Ratios
Brazil	97.59
India	29.47
Indonesia	49.84
Nigeria	80.13

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	URBAN
Water	
	Effectiveness Ratios
Brazil	1,516.24
India	119.57
Indonesia	99.47
Nigeria	207.03

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	URBAN
Sanitation	
	Effectiveness Ratios
Brazil	102.64
India	36.78
Indonesia	71.48
Nigeria	114.98

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	RURAL
Water	
	Effectiveness Ratios
Brazil	183.87
India	54.48
Indonesia	36.44
Nigeria	84.45

AVERAGE ANNUAL COST/(N° LIVES SAVED + LIVES AVERTED)	RURAL
Sanitation	
	Effectiveness Ratios
Brazil	66.47
India	25.99
Indonesia	28.19
Nigeria	48.22

ANNEX 2C. REFERENCE OF LITERATURE ON EFFECT OF WASH INTERVENTIONS

Country	Category	Author (Year)	Year	Urban/Rural
Brazil	Sanitation Intervention	Gross et al.	1989	Urban
Brazil	Water Intervention	Gross et al.	1989	Urban
Brazil	Water Intervention	Kirchhoff et al.	1985	Rural
Brazil	Sanitation	Melo et al.	2008	Urban Slum
India	Hygiene	Ahmed et al.	1993	Rural
India	Hygiene	Alam et al.	1989	Rural
India	Hygiene	Aziz et al.	1990	Rural
India	Hygiene	Bateman et al.	1995	Rural
India	Hygiene	Biran et al.	2009	Rural
India	Hygiene	Fan, V.Y. and Mahal, A.	2011	Rural
India	Hygiene	Luby et al.	2007	Rural
India	Hygiene	Luby et al.	2004	Urban
India	Hygiene	Luby et al.	2004	Urban
India	Hygiene	Luby et al.	2010	Urban
India	Sanitation	Anand et al.	1994	Rural
India	Sanitation	Clasen et al.	2014	Rural
India	Sanitation	Fan, V.Y. and Mahal, A.	2011	Rural
India	Sanitation	Kumar and Vollmer	2012	Rural
India	Water	Clasen et al.	2008	Semi-urban
India	Water	Jalan and Ravallion	2003	Rural
India	Water	Jensen et al.	2004	Rural
India	Water	Freeman and Clasen	2011	
India	Water	Ercumen et al.	2015	Urban
India	Water	Fan, V.Y. and Mahal, A.	2011	Rural
India	Water and hygiene	Luby et al.	2006	Urban
India	Water and sanitation	Aziz et al.	1990	Rural
India	Water and sanitation	Begum, Ahmed and Sen	2013	
India	Water and sanitation	Bose, R.	2009	Mixed
India	Water and sanitation	Gouda et al.	2015	Mixed
India	Water and sanitation	Khanna	2008	Rural
India	Water, sanitation and hygiene	Hoque et al.	1996	Rural
India	Water, sanitation and hygiene	Huda et al.	2011	Rural

ANNEX 3. BACKGROUND ON FOUR COUNTRIES

BRAZIL

Brazil is the largest country in South America and the world's seventh biggest economy (IMF, 2015). With a population of 200.4 million, the country's GDP is estimated at US$2.246 trillion (WB, 2016). Despite being in the upper layer of medium development countries, Brazil has high levels of social inequality (Castro & Heller, 2012): the Gini index was 52.9 in 2013 according to WB estimates.

The country has taken positive steps towards the MDGs. Among the achievements (Table A.3.1), the JMP shows an increase in access to water piped on premises, an increase in access to improved sanitation, a functioning national system to finance water and sanitation infrastructure; a high level of cost recovery compared to most other developing countries, as well as a number of notable technical and financial innovations such as condominial sewerage and an output-based subsidy for treated wastewater.

Nonetheless, the 4.1 percent yearly sanitation expansion rate decreased in the 2010s – in the previous decade it was 4.6 percent – placing Brazil even further from the already far goal established by the national government to offer universal access to these services by 2030 (CEBDS, 2014).

Among the challenges that Brazil faces are the high number of poor Brazilians living in urban slums or squatter settlements (favelas). According to the 2010 IGBE census, about 6 percent of Brazil's population lives in these shanty-towns: that is around 11.25 million people across the country, and could be even more. Challenges are also present in rural areas without access to piped water or sanitation, water scarcity in the Northeast, water pollution, especially in the Southeast, and the low share of collected wastewater that is being treated. According to data from the 2011 National System of Sanitation Indexes (SNIS), about 36 million Brazilians do not have access to treated water and only 48.1 percent of the population has access to sewage collection. Also less than 40 percent of the sewage collected is treated.

Furthermore, the country has extreme climate conditions, uneven distribution of surface water availability, and heterogeneity in the pattern of demographic occupation – often aggravated by socio-economic, political and cultural constraints, which configure systemic conditions that frame and even shape policies and actions in the water supply and sanitation sector (Heller, 2008).

Additionally, long-standing tensions between the federal, state and municipal governments about their respective roles in the sector complicate improvements.

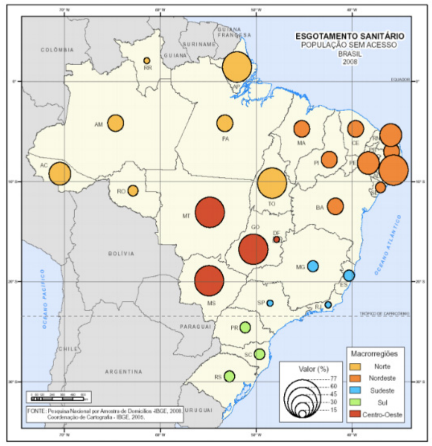
Table A.3.1. Status of sanitation and water MDGs in Brazil

FACILITY	1990	2000	2010	2015
Improved water source, urban (% of urban population with access)	95.9	97.6	99.3	100
Improved water source (% of population with access	88.5	93.5	96.9	98.1
Improved sanitation facilities, urban (% of urban population with access)	79.1	82.8	86.5	88
Improved water source, rural (% of rural population with access)	67.7	75.7	83.8	87
Improved sanitation facilities (% of population with access)	66.6	74.7	80.5	82.8
Improved sanitation facilities, rural (% of population with access)	31	39.6	48.1	51.5

SOURCE: WORLD BANK INDICATORS, 2015.

The sanitation deficit in Brazil is particularly serious in the North (see Map A.3.1), where less than 10 percent of the population, or 14 million people, have sewage collection. Belém and Ananindeua in Pará essentially don't treat their sewage at all (Heller, 2008).

Map A.3.1. Sanitation coverage in Brazil



SOURCE: PLANSAB, 2013.

INDIA

India has a population of over 1.2 billion and is the world's fourth largest economy. Since the country's independence from Great Britain, there have been significant improvements in health indicators – life expectancy has doubled to 66 years of age – yet maternal and child mortality rates remain quite high and variable across states (World Bank, 2016). Health expenditure per capita in PPP is approximately $215, or 4 percent of GDP, yet the number of under-five deaths is an unacceptably high 53 percent (World Bank, 2016), One hundred children die per day due to diarrhoea. (WaterAid, 2008).

Notable steps were made toward achieving the MDGs but the country fell short in sanitation (Table A.3.2). Statistics continue to be sobering: 800 million Indians do not treat their water at all, 770 million do not have access to safe drinking water near their houses, 800,000 remove human faeces manually from the latrines, and 73 million working days are lost annually due to waterborne disease (WaterAid, 2008). India is last in the world in diarrhoea rankings despite billions of dollars that have been spent constructing toilets. From 2007-2012, there was an investment of over US$22 billion in water supply and sanitation in the country, of which the private sector contributed just 0.4 percent (Hall and Lobina, 2012). Yet inadequate sanitation and water still cost India an estimated US$53.8 billion, which was equivalent to 6.4 percent of GDP in 2006 (WSP et al., 2011).

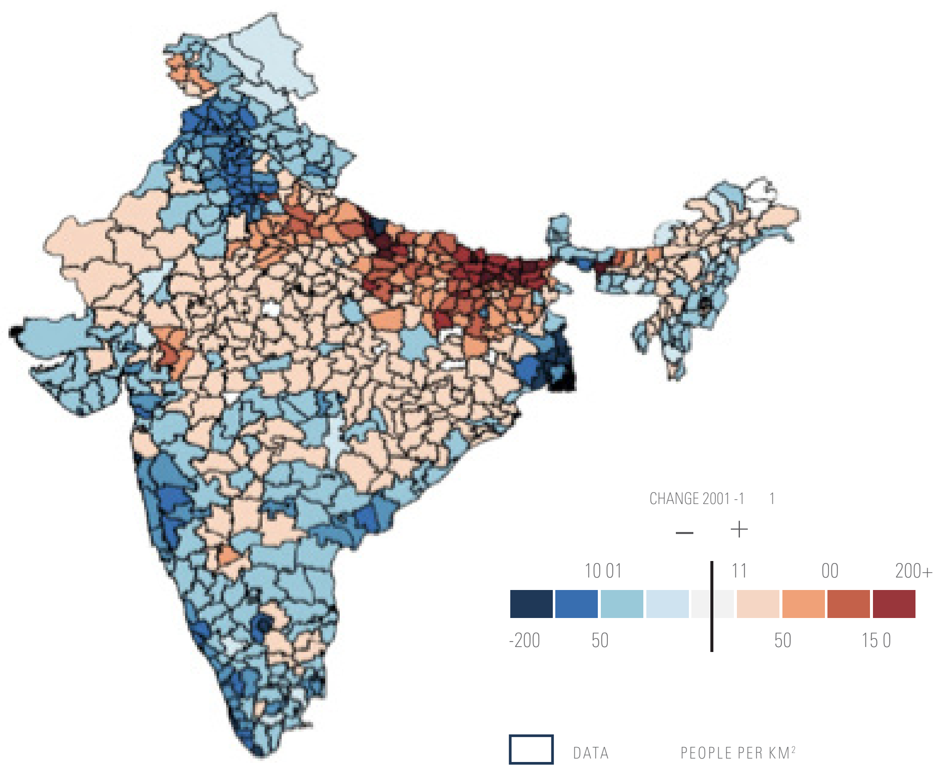
Table A.3.2. Status of sanitation and water MDGs in India

FACILITY	1990	2000	2010	2015
Improved water source, urban (% of urban population with access)	88.9	92.3	95.7	97.1
Improved water source (% of population with access)	70.5	80.6	90.3	94.1
Improved water source, rural (% of rural population with access)	64.2	76.1	87.9	92.6
Improved sanitation facilities, urban (% of urban population with access)	49.3	54.5	60.3	62.6
Improved sanitation facilities (% of population with access)	16.8	25.6	35.5	39.6
Improved sanitation facilities, rural (% of rural population with access)	5.6	14.5	24.5	28.5

SOURCE: WORLD BANK INDICATORS, 2015.

The widespread practice of open defecation (Map A.3.2.) is a scourge on the country that is linked to access to sanitation infrastructure and, perhaps more importantly, long-standing habit. Of the 1 billion people worldwide who do not have toilets, India accounts for 600 million of them (UNICEF, 2013). Since the start of the MDGs, India has reduced open defecation by 31 percentage points but mostly in the richest quintiles of the population: the poorest have seen little improvement (UNICEF, 2013; WHO, 2013a).

Map. A.3.2. Trends in open defecation in India, 2001-2011



SOURCE: THE ECONOMIST, 2014.

While inequities in access due to income quintile and geography are notable, and variations across state borders are stark, India has taken national steps toward improvement. Since 1980, India has had a series of initiatives to increase sanitation coverage, particularly in rural areas.

The most successful of these has been the Total Sanitation Campaign (TSC), which started in 1999 and has seen coverage rise from 18 percent to over 65 percent on average – although some states still have coverage below 30 percent. From 2005 onwards, the Nirmal Gram Puraskar (NGP) was added as a fiscal incentive that rewards communities that achieve full coverage. Between 1998 and 2007, the Indian government allocated approximately US$1 billion to the TSC and NGP campaign (WSP et al., 2011a). A second notable initiative is the Swacch Bharat Bhiyan, launched by President Narendra Modi in October 2014, which has the lofty goal of making the country open defecation-free by 2019.

INDONESIA

Indonesia is the largest archipelago in the world with an area of almost 2 million km^2. It is the fourth most populous country in the world with 254.5 million inhabitants. Although Indonesia is the largest economy in Southeast Asia with an estimated GDP of US$888.5 billion, it is a low middle income country with a GDP per capita of US$3,630 (World Bank, 2016).

Over the last 20 years, Indonesia has made enormous efforts to improve its social indicators. While it has made headway against poverty, inequality has been going up: the poverty rate is 11.3 percent and its Gini inequality index is 0.38. Over the same period, there has been an increasing trend in life expectancy from 63 in 1990 to 71 years in 2013. In addition, the under-5 child mortality rate (per 1,000 live births) decreased from 84 in 1990 to 27 in 2014. The maternal mortality ratio also shows improvements over time, reaching an estimated level of 126 deaths per 100,000 live births in 2014. Interestingly, health expenditure has remained around 3 percent – US$293 per capita – during the last years, showing no significant increase from the late 1990s (UNICEF, 2012).

Indonesia has made moderate improvements in sanitation and water supply interventions. According to UNICEF (2012), 100 million people still do not have access to improved sanitation (40 percent) and around 33 million do not have access to adequate water supply. In rural areas, only 47 percent of the population has access to improved sanitation; thus there are still 62 million people that do not have adequate sanitation facilities. This gap between urban and rural is relevant from a policy perspective because of the process of migration: in 1990 only 30 percent of the population lived in urban areas compared to 53 percent in 2015.

Table A.3.3. Status of sanitation and water MDGs in Indonesia

FACILITY	1990	2000	2010	2015
Improved water source, urban (% of urban population with access)	89.4	91.3	93.2	94.2
Improved water source (% of population with access)	69.5	77.9	84.5	87.4
Improved water source, rural (% of rural population with access)	60.7	68.2	75.7	79.5
Improved sanitation facilities, urban (% of urban population with access)	61.1	65.8	70.4	72.3
Improved sanitation facilities (% of population with access)	35.2	47.1	57	60.8
Improved sanitation facilities, rural (% of rural population with access)	23.7	33.6	43.5	47.5

SOURCE: WORLD BANK INDICATORS, 2015.

From a market perspective, the most relevant constraint is the lack of demand for WASH services. This has been a historical problem associated with low willingness-to-pay for sanitation services given that people expect the public sector to provide these services for free (McCawley, 2015). However, Cameron's evaluation (2013) of the Total Sanitation and Sanitation Marketing Programme (TSSM) shows that by improving information on benefits of WASH interventions, the household expenditure on sanitation increases significantly (an increase of 31 percent, or 3.3 percentage points, in toilet construction).

NIGERIA

Nigeria is the most populous country in Africa with approximately 177.5 million inhabitants with an average population growth of 2.7 percent a year. Population growth has been accompanied by large urban expansion and slum formation. The country's GDP is estimated at US$568.5 billion and the current GDP per capita is evaluated at US$3,203.3 (World Bank, 2016). In 2009, the World Bank estimated that 46 percent of the population lived on less than US$2 a day. Life expectancy in Nigeria remains lower than the average for Sub-Saharan Africa at around 54 years old as compared to a regional average of 57. It is also much lower than the average life expectancy for lower middle-income countries, which is currently at 67. The health situation in Nigeria remains worrying. The mortality rate for under-five children is estimated at 112.5/1,000. The total health expenditure per capita was US$207 in 2013, accounting for about 3.7 percent of GDP according to the WHO.

While coverage of improved water infrastructures has increased, Nigeria is one of the few countries in the world where coverage of improved sanitation infrastructures has decreased. The discrepancy between urban and rural areas as well as between North and South remains very stark. In fact, Nigeria has been both reducing coverage and increasing urban/rural inequality in access to sanitation infrastructures (JMP WHO/UNICEF, 2014). In 2015, only 29 percent of the population have access to improved facilities as compared to 38 percent in 1990. In addition, 24 percent use shared facilities and 25 percent still defecate in the open. Those rates are the same as in 1990. The rest use other forms of unimproved sanitation. This means that, although some infrastructures might have been built, population growth has been greater than infrastructure growth, de facto decreasing the level of coverage. The picture is particularly worrying when differentiating the analysis between the urban and rural areas.

Table A.3.4. Status of sanitation and water MDGs in Nigeria

FACILITY	1990	200 0	201 0	2015
Improved water source, urban (% of urban population with access)	76.4	78.2	79.9	80.8
Improved water source (% of population with access)	39.9	51.8	63.4	68.5
Improved water source, rural (% of rural population with access)	24.6	37.7	50.7	57.3
Improved sanitation facilities, urban (% of urban population with access)	37.7	35.8	33.8	32.8
Improved sanitation facilities (% of population with access)	38.1	34	30.5	29
Improved sanitation facilities, rural (% of rural population with access)	38.2	33.1	28	25.4

SOURCE: WORLD BANK INDICATORS, 2015.

Drinking water coverage has on the other hand made better progress in coverage. Sixty-eight percent of the population has some form of improved water source in 2015 as compared to 28 percent in 1990. However, the proportion of households with piped water systems has decreased from 12 percent in 1990 to 2 percent in 2015. The divide between urban and rural areas is once again quite stark.

While 78 percent or urban dwellers have access to some form of improved water source, only 56 percent have access to one in rural areas. Moreover, a large share of the Nigerian population still lives with inadequate hygiene conditions. In 2014, only 19 percent of the population has a handwashing facility at home with soap and water in urban areas while only 8 percent have one in rural areas (JMP WHO/UNICEF, 2014). Table A.3.4 summarises the improvements in water and sanitation infrastructure coverage since 1990.

Akpabio (2012) synthesises the most important policies that have shaped the water and sanitation situation in Nigeria in the last 50 years. In 2007, and to replace the National Economic Empowerment and Development Strategy (NEEDS), the government implemented the National Development Plan (vision 2020) with a provision of ensuring targeted water and sanitation subsidies for the poor.

Most approaches in implementing sanitation and hygiene programmes such as subsidy-based promotional slabs, sanitation centre's operations, hand-washing campaigns, among others, have yielded little results in enhancing the national sanitation coverage. The shortcomings of these approaches led to the adoption of approaches such as Community Led Total Sanitation (CLTS) and WASH in schools in 2008 to scale up access to improved sanitation and hygiene in the country. The government approved Strategy for Scaling up Sanitation and Hygiene to meet the MDGs in Nigeria (2007). The scaling up of CLTS in most states effectively commenced in 2008 coinciding with the International Year of Sanitation.

ANNEX 4. OVERVIEW OF THE COST LITERATURE

Despite the political and economic importance of obtaining accurate cost estimates of WASH interventions, there is limited systematic data available at the regional and country levels (DFID UK, 2013). This is due to a lack of studies and the variability of costs in different settings. The first Global Water Supply and Sanitation Report (2000) provided minimum average benchmarks for sanitation and water supply: US$60 per capita for the construction of basic sanitation facilities and US$40 for water supply improvements in developing countries (Cairncross & Valdamanis, 2006). This study has been the basis for other analyses of the benefits and effectiveness of WASH interventions through two main methods: cost-benefit analysis (CBA) (Hutton & Haller 2004; Hutton et al. 2007; Hutton 2012; Hutton 2015) and CEA (Haller et al. 2007). These studies provide the best estimates of WASH intervention costs since they have the most comprehensive coverage from a global and regional level. Moreover, these studies are associated with the work of international organisations such as the WHO and the World Bank's WSP. A summary of the main studies, systematic reviews and their findings can be found in Table A.4.1.

Table A.4.1. Evolution of global cost estimates, 2000-2016

Authors	YEAR	Global Estimate (Universal Access to sanitation and water supply – MDG / universal access)	Key features
JMP Report	2000	US$60 per capita for construction cost for basic sanitation facilities and US$40 for water supply improvements in developing countries (averages)	The study provides estimates about investment cost in 3 major regions (Africa, LAC and Asia/Oceania).
Hutton, G. and Haller, L .	2004	Annual intervention cost of US $ (2004) 18 billion per year from 2005 to 2015.	First WHO study on global cost and benefits of WASH (after 2000).
Hutton, G. and Bartram, J.	2007	Anual intervention cost US $ (2000) of 22 billion per year from 2000 to 2015.	Less than 100 countries.
Hutton, G. (WHO)	2012	Annual cost inverventions cost US$ (2010) of 32 billion per year from 2010-2015.	Information about 136 countries
IRC Programme	2012	Minimum benchmark for WS&S in developing countries (in US$ (2011) per person: -Water Supply: 20-152 (capital cost) + 3 – 15 (recurrent costs). -Sanitation: 92-358 (capital cost); + 3.5 – 11.5 (recurrent costs).	Based on the WASH Project, a five years work in India (Andhra Pradesh), Ghana, Burkina Faso and Mozambique.
Hutton, G. (WSP)	2016	Annual intervention costs US$ (2014) of 58 billion per year; from 2015 to 2030.	Information about 140 countries, includes CB ratios by income quintiles and open defecation cost.

SOURCE: AUTHORS' COMPILATION.

WASH studies have mainly focused on water-borne diseases like diarrhoea, thus health losses and gains are associated with these diseases. Other water-related vector diseases such as malaria are not considered within these studies. WASH costs are estimated using an incremental cost analysis. The logic behind this method is to calculate the costs of providing or widening access to adequate water supply and sanitation given the current baseline scenario. Until 2012, WASH costs were sorted in two categories: investment costs and recurrent costs. Investment costs include planning and supervision, hardware, construction and alteration. Recurrent costs refer to maintenance of hardware and replacement of parts (Hutton and Haller, 2004). Given the difficulties of obtaining data on recurrent costs, World Bank studies before 2015 assumed that they represented 10 percent of capital costs. However, Hutton and Varughese (2016) included maintenance costs separately following the approach in Fonseca et al. (2010), for which maintenance costs are assumed to be 30 percent of the total capital cost every five years due to hardware maintenance. In addition, 10 percent of the capital cost is added for software and implementation of behavioural programmes.

The challenges of analysing WASH intervention costs are clear. Collecting information is critical, as cost analyses of WASH are data hungry. Usually, studies do not provide details about how cost estimates are constructed and where information comes from. In addition, WASH costs vary hugely in different settings (countries, rural areas, etc.), thus they are not immediately comparable, which may be lead policymakers to draw incorrect conclusions.

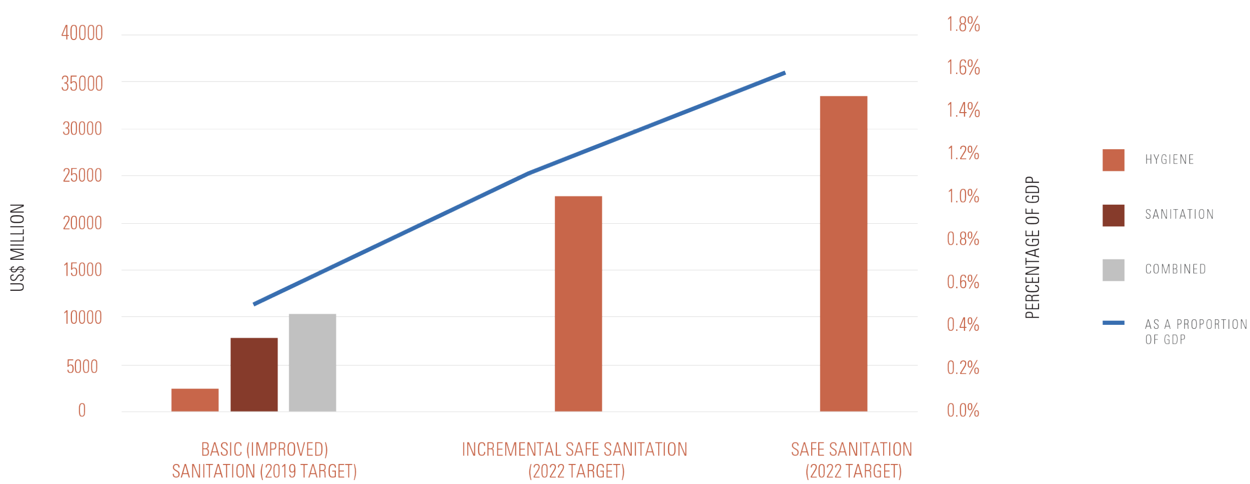
ANNEX 5. COST OF INDIA'S NATIONAL SANITATION GOALS

While the SDGs have a goal of universal access to safe sanitation by 2030, India's own ambitious goals have an earlier timeline. Prime Minister Narendra Modi overhauled the existing sanitation and water improvement initiatives when he was elected in 2014, replacing them with the Swachh Bharat Abhiyan (SBA), or "Clean India Initiative". The most notable of the SBA's aims is to eradicate open defecation by 2019, which is laudable considering the extent of the practice: half of the country's sizeable population defecates outside. Prime Minister Modi has brought this issue to the forefront by committing to construct 120 million toilets, enlisting celebrities from sports, film and television to support the initiative, helping raise national support (Sharma, 2013). The programme was projected to cost 1.96 lakh crore, or US$29 billion (Sharma, 2013).

In the first year, a reported 9.5 million toilets were constructed – surpassing the goal of 6 million by nearly 60 percent – although this achievement has not been met with sufficient behavioural change to have the expected impact (The Huffington Post, 2015). A national survey found that under 50 percent of toilets were being used in rural or urban areas (Sharma, 2013).

In addition to the 2019 target, the Department of Drinking Water and Sanitation developed a Rural Sanitation and Hygiene Strategy for 2012-2022 that set a goal of full sanitation coverage of all gram Panchayats, or villages. The success of these programs will require a combination of government subsidies, political will, and behavioural change.

Figure A.5.1. Estimated costs for India's goals



Note: The basic (improved) 2019 target indicates the costs of achieving the goal of eradicating open defecation.

SOURCE: WORLD BANK, 2016.

Table A.5.1. Evolution of India's sanitation initiatives

Initiative name	Years	Description	Main goals
Central Rural Sanitation Programme (CRSP)	1986-1999	First national programme on rural sanitation.	• Construction of household toilets through hardware subsidies.
Total Sanitation Campaign (TSC)	1999-2012	Restructured CSRP. Focus turned toward "demand driven, community-led approach to total sanitation". In 2003, a grant scheme called Nirmal Gram Puraskar (NGP) was created to reward communities for reaching total sanitation including eradicating open defecation. Considered a failure.	• Eradicate open defecation by 2017 • Encourage toilet construction through financial assistance and incentives
Nirmal Bharat Abhiyan (NBA)	2012-2014	New campaign replacing TSC.	• Sanitation coverage of all gram Panchayats by 2022
Swachh Bharat Abhiyan (SBA, or Clean India Mission)	2014-?	Relaunch of NBA by Prime Minister Narendra Modi.	• 10 million household toilets • 500,000 community and public toilets • Scientific solid waste management in 4,041 cities and towns

Note: Crore = 10,000,000; Lakh = 100,000.

SOURCE: WATER AND SANITATION PROGRAM, 2010.

ANNEX 6. MAIN COUNTRY STATISTICS

MAIN COUNTRY STATISTIC	Brazil	India	Indonesia	Nigeria
GENERAL				
	14%	67%	46%	52%
Population	203,657,000	1,282,390,000	255,709,000	183,523,000
% Urban population	86%	33%	54%	48%
% Rural population	14%	67%	46%	52%
GDP 2015 (US $ thousands)	2,357,133,710	2,067,844,594	970,626,363	579,412,561
GDP per capita 2015 US $	11,574	1,612	3,796	3,157
WATER AND SANITATION COVERAGE				
% unimproved sanitation	18%	63%	39%	73%
% basic sanitation	50%	37%	24%	27%
% unimproved water	4%	16%	35%	58%
% basic water	9%	63%	49%	40%
% unimproved sanitation URBAN	11%	13%	15%	33%
% basic sanitation URBAN	48%	20%	17%	15%
% unimproved sanitation RURAL	7%	50%	24%	40%
% basic sanitation RURAL	2%	17%	6%	13%
% unimproved water URBAN	2%	5%	23%	29%
% basic water URBAN	5%	12%	16%	18%
% unimproved water RURAL	2%	10%	12%	30%
% basic water RURAL	4%	51%	33%	22%
WATER COST				
Total Cost WASH (in thousands - 15 years)	116,430,098	362,012,537	76,628,622	179,318,162
% URBAN	90%	40%	72%	69%
% RURAL	10%	60%	28%	31%