REPUBLIC OF KENYA

KENYA NATIONAL BUREAU OF STATISTICS
Keeping you informed

The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

NiPFN
National Information Platform for Food Security and Nutrition
Evidencing Policy Decisions

Special Paper No. 3/2023

Influence of Household Sanitation on Child Stunting in Kenya

Karanja L., Karumba M., Opondo M., Macharia E., Kiriro M., Kipruto S., Musavi E., Ntwiga J., Laibuni N., Kihiu E. and Nyasani B.

Foreign, Commonwealth & Development Office

BILL & MELINDA GATES foundation

Influence of Household Sanitation on Child Stunting in Kenya

By

Karanja L., Karumba M., Opondo M., Macharia E., Kiriro M., Kipruto S., Musavi E., Ntwiga J., Laibuni N., Kihiu E. and Nyasani B.

NIPN Series

Special Paper No. 3

January 2023

Published 2023

Kenya Institute for Public Policy Research and Analysis
Bishops Garden Towers, Bishops Road
PO Box 56445-00200 Nairobi, Kenya
Tel: +254 20 2719933/4; fax: +254 20 2719951
Email: admin@kippra.or.ke
Website: http://www.kippra.org

and

Kenya National Bureau of Statistics
Hospital Road, Real Towers, Upper Hill
PO Box 30266–00100, Nairobi.
Tel: +254-735-004-401, +254-202-911-000, +254-202-911-001
Email: info@knbs.or.ke
Website: http://www.knbs.or.ke

ISBN 978 9914 738 02 5

This study and report was produced by the National Information Platform for Food Security and Nutrition (NIPFN) project team operating under the Kenya National Bureau of Statistics (KNBS) and the Kenya Institute of Public Policy Research and Analysis (KIPPRA). The report was produced with the financial support from the European Union. The views expressed in this report are those of the authors and do not necessarily represent the views of European Union.

Acknowledgements

The Executive Director of the Kenya Institute for Public Policy Research and Analysis (KIPPRA) and the Director General Kenya National Bureau of Statistics (KNBS) wish to acknowledge and appreciate the efforts of the individuals who drafted the report. The report was drafted and compiled by: Dr. Evelyn Kihiu from KIPPRA, Dr Nancy Laibuni from KIPPRA, Allan Gathuru from KNBS, Lucy Maina from UNICEF, Mr. Samuel Kipruto from KNBS, Mary Njeri from State Department for Crops, and Samuel Murage from MoH. Valuable contributions were provided by staff from diverse Ministries in NIPFN's Policy Advisory Committee. KIPPRA, KNBS and NIPFN are indebted to the support, coordination and tireless efforts of NIPFN Project Manager Mr James Gatungu who convened actors from diverse sectors to facilitate the analysis and drafting of this report, as well as Mr Robert Nderitu the Project Director.

Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviations

ATE	Average Treatment Effects
ATET	Average Treatment Effect on Treated
JMP	Joint Monitoring Programmes
OD	Open Defecation
ODF	Open Defecation Free
MTP	Medium-Term Plan
SDG	Sustainable Development Goal
WASH	Water Sanitation and Hygiene

Abstract

Proper sanitation and hygiene and access to safe drinking water can reduce undernutrition and stunting in children by preventing incidences of diarrhoeal and parasitic diseases. However, inadequate sanitation remains a major challenge particularly in low-income countries. Although the proportion of households that practice open defecation in Kenya reduced from 14 per cent in 2009 to 7.4 per cent in 2019 (KNBS Census, 2019), the nutrition situation in Kenya is low. About 1.55 million out of the 5.99 million children under five years are stunted, over 659,000 are underweight, while 239,000 are wasted. Using the 2014 KDHS, the study examined the effect of access to sanitation services on children nutrition outcomes using Average Treatment Effects (ATE) estimates.

The results show that a higher proportion of stunted children are from households with lower levels of sanitation. However, the distribution of stunted children is not linear across the sanitation ladder. About 41.6 per cent were from households with unimproved sanitation; 22.1 per cent from households with limited sanitation; and 20.9 per cent from households practising open defecation. Furthermore, results show that open defection has a high negative impact on child stunting representing 39 per cent probability of stunting. Initiatives that combine sanitation and behaviour change in hand hygiene are likely to improve child linear growth.

Interventions to reduce stunting in Kenya should combine measures to eliminate open defection and graduation from unimproved sanitation facilities given the implications of WASH status on nutrition. Future development strategies will need to include nutrition intentions to accelerate the translation of WASH programmes whose outcomes are not merely measured by coverage and access to facilities but also reduced illness and malnutrition. There is need for a practical approach to reduce stunting through deliberate sanitation interventions. Further, the results imply a need to prioritise elimination of open defection then gradually and linearly improve the conditions of all households' sanitation.

1 Introduction

Proper sanitation and hygiene and access to safe drinking water can reduce undernutrition and stunting in children by preventing incidences of diarrhoeal and parasitic diseases. However, inadequate sanitation has remained a global challenge especially in developing nations. Globally, as of 2017, at least two billion people lacked access to a basic sanitation facility and less than half of the global population (45 per cent) used a managed sanitation service (UNICEF and WHO, 2020). In addition, as of 2020, 2.3 billion people lacked access to basic hand washing facilities (WHO and UNICEF, 2021).

The consequences of poor sanitation translate to the global disease burden and mortality, with an estimated 3.3 per cent global deaths classified as WASH-attributable (WHO, 2019). Prüss-Ustün, et al (2019) estimated that out of the 1.6 million diarrhoeal related deaths in 2016, 60 per cent were WASH-attributable, representing deaths that could have been averted through safe drinking water, improved sanitation services and handwashing with soap. WASH-attributable diarrhoea account for 5.3 per cent of all deaths among children aged five years and below (Prüss-Ustün, et al 2019).

Some studies show that diarrhoea is potentially associated with linear growth in children under the age of five years (Checkley et al, 2003; Checkley et al, 2008; Schlaudecker, et al, 2011). However, Cumming, et al, (2019) concluded three large WASH trials delivered through high compliance and established that access to WASH did not have an effect on linear growth but had mixed effects on diarrhoea. A meta review of demographic health data in Ethiopia indicated a modest link between diarrhoea and linear growth (Girma, et al, 2021). The diversity of findings on the WASH-Nutrition link, as well as the global level attention accorded to WASH investment and commitment to reduction of undernutrition prompted the current study which would further guide programmatic WASH investments.

The implications of inadequate sanitation are not just regarding mortality, ill health, and malnutrition but also economic in nature. A review of 18 African countries estimated that the economic losses as a result of poor WASH are US$ 5.5 billion, which is about one per cent to 2.5 per cent of GDP (Zach, et al, 2017). Further, the cost benefit ratio for investing in improved sanitation demonstrates that every US$1 invested for universal access to sanitation yields US$ 2.9 while every US$1 invested to eradicate open defecation leads to a return of US$ 5.8. This means that sanitation interventions can save lives and money.

The national progress in increasing access to sanitation amenities indicates a positive but gradual decline. According to the Kenya Population and Housing Census (KPHC), 7.4 per cent of households practiced open defecation compared to 20 per cent in 1989, 16 per cent in 1999 and 14 per cent in 2009 (KNBS 2019). Regarding households connected to sewered sanitation, the increase in proportions is slow from seven per cent in 1989, eight per cent in 1999 and 2009 to 9.7 per cent in 2019. Table 1 represents the progress in increasing sewered connection and reducing open defecation, depicting that by 2019 there was an increase in the proportion and actual numbers with access to piped water and sewered sanitation and a decrease in proportion and actual numbers practicing open defecation.

Table 1: National status of water connection and reduction in open defecation

Year	National Population	OD Rates (%) (Households)	OD Numbers	Sewered rates (%) (Households)	Sewered numbers
1989	21,448,636	20%	4,289,727	7.0%	1,501,405
1999	28,686,607	16%	4,589,857	8.0%	2,294,929
2009	38,610,097	14%	5,405,414	8.0%	3,088,808
2019	47,564,296	7.4%	3,519,758	9.7%	4,613,737

Source: KNBS 1989, KNBS 1999, KNBS 2009, KNBS, 2019

However, these national statistics mask significant regional disparities. While the actual population practicing open defecation (OD) is 3,519,758, a review of Kenya's sanitation practices by UNICEF (2020) indicates that 83 per cent of OD practicing households are based in 15 counties whose total population is 10,652,414 (24.3 per cent of the national population). Kenya is one of 26 countries that globally contributes to 90 per cent of open defecation and therefore not on track to meet the goal of eliminating OD by 2030 (UNICEF, 2018). In addition to open defecation, a further 9.4 per cent of Kenya's population use uncovered pit latrines and 0.8 per cent use a bucket latrine representing 4,851,558 people using unimproved sanitation (KNBS, 2019). In total, 8,371,316 people in Kenya practice either open defecation or use unimproved sanitation facilities and thus use a sanitation practice that exposes them and immediate household members and the community to environmental faecal contaminants.

Poor sanitation practices represent both an economic and health risk. At national level, poor sanitation is estimated to cost Ksh27 billion annually, representing approximately 0.9 per cent of the national GDP (Water and Sanitation Programme, 2012). In addition, WASH attributable deaths in Kenya are estimated at 19,500 annually with 17,100 being diarrhoea-related deaths among children under five years (Water and Sanitation Programme, 2012). Impaired linear growth limits future human capital productivity (Kirolos, et al, 2021) and repeated episodes of diarrhoea are associated with impaired linear growth (Checkely et al, 2008), thus investments in WASH need to be approached from a health and human capital perspective. Based on the 2019 census, children aged five years and below in Kenya comprise 12.6 per cent of the national population (KNBS, 2019), and their health and future productivity is therefore a policy concern.

In addition to the challenge of improving access to sanitation, malnutrition in children under the age of five remains a lingering global development agenda. A joint report by UNICEF, WHO and World Bank Group (2021) estimated that 149.2 million children were classified as stunted and another five million were wasted globally in 2020 while approximately 22.1 million children were stunted (32.6 per cent) and 700,000 were wasted (5.2 per cent) in the East African region (UNICEF, WHO and World Bank, 2021).

The nutrition situation in Kenya is similarly not adequate. Based on the 2014 Kenya Demographic and Health survey, 26 per cent of Kenyan children are short-for-age, four per cent thin-for-height and 11 per cent are underweight-for-age (GoK, 2015). This means that out of 5.99 million children under the age of five (KNBS, 2019) approximately over 1.55 million are stunted, over 659,000 are underweight and over 239,000 are wasted. In addition to inhibited linear growth, children under five years are also affected by micronutrient deficiencies with 26.3 per cent of them being anaemic (GoK, 2011), which is approximately 1.43 million children.

Akin to the regional disparities regarding sanitation practices, the nutrition situation in Kenya indicates broad disparities about undernutrition incidence. Seven of 47 counties are classified as having high or very high wasting rates, that is wasting rates exceeding 10 per cent and nine out of 47 counties are classified as having very high stunting rates, that is stunting rates exceeding 30 per cent.

With malnutrition as an underlying factor in 52.5 per cent of deaths among children under five years (Caulfield, et al, 2004), many children in Kenya face the risk of deaths related to undernutrition. In addition to mortality risks, malnutrition poses an economic risk. Kenya lost approximately Ksh373.9 billion in 2014 due to child undernutrition, an equivalent of 6.9 per cent of national GDP (Cost of Hunger Africa, 2019). This indicates a need for heightened efforts for undernutrition prevention to avert preventable deaths and economic losses.

This implies a need to formulate interventions that address the observed deficiency in sanitation in a bid to improve health concerns, avert morbidities and mortalities and potentially prevent undernutrition. Using nationally representative data, the study generated evidence of whether and to what extent access to sanitation using the joint monitoring programme (JMP) sanitation ladder is associated with child stunting. The findings from analysis could inform the implementation of sanitation programmes as a nutrition-sensitive intervention within the country's development plans such as Medium-Term Plan IV (2022/23 – 2027/28) and corresponding county integrated development plans.

The broad objective of the study is to establish the influence of household sanitation on child nutrition outcomes. More specifically the objectives were to compare status of household access to sanitation services with child nutrition outcomes; and determine the effect of household access to sanitation services on child nutrition outcomes.

2 An Overview of Sanitation Policy Evolution in Kenya

This section provides an overview of the policies/programmes, resource allocation and governance that address sanitation access and use in Kenya. It provides a general outline of government investment in terms of policy direction, coordination between the leading government institutions and financial investment.

2.1 Overview of Policy and Programmes in Sanitation

Kenya is one of 26 countries in the world that is responsible for 90 per cent of open defecation (UNICEF, 2017). Achieving the SDG Target 6.2, which calls for the elimination of open defecation by 2030 globally requires a concerted effort. The SDG WASH goal six calls for access to safe and sustainable WASH for everyone by 2030. In this regard, Kenya has put in place several sanitation-related policies, legislations, development plans and strategies, as outlined in Figure 1 and discussed below.

Sanitation Legislation

The Constitution of Kenya 2010 assures every Kenyan of a right to the highest reasonable standards of sanitation. This is further protected under Cap 242 and Cap 254 that spells out rules for protection of food hygiene. The country has enacted various laws that have direct or indirect influence on how this right to reasonable sanitation is achieved. These include Public Health Act Cap 242; 2012 County Governments Act; 2012 Environmental Management and Co-ordination Act and the 2016 Water Act. Further to this, at national level, the Vision 2030 and the various Medium Term Development Plans spell out prioritised government interventions and flagship plans for the achievement of the constitutional aspirations with regards to sanitation.

Sanitation Policies and Development Plans

At the national level, responsibilities for sanitation are divided between the Ministry of Health and the Ministry of Water, Sanitation and Irrigation and both ministries have sanitation-related policies. The proposed National Sanitation Management Policy[1] (NSMP) provides an inclusive sanitation management framework to address the identified policy gaps and challenges as well as the country's national, regional and international sanitation commitments. The NSMP encompasses both non-sewered and sewered sanitation systems and associated services across the sanitation service chain from containment, conveyance, treatment to safe disposal or end use. Other supportive policies to the issue of sanitation include: Kenya Environmental Sanitation and Hygiene Policy 2016–2030, Kenya Health Policy 2014–2030, Sessional Paper No.1 of 1999 on National Policy on Water Resources Management and Development, The

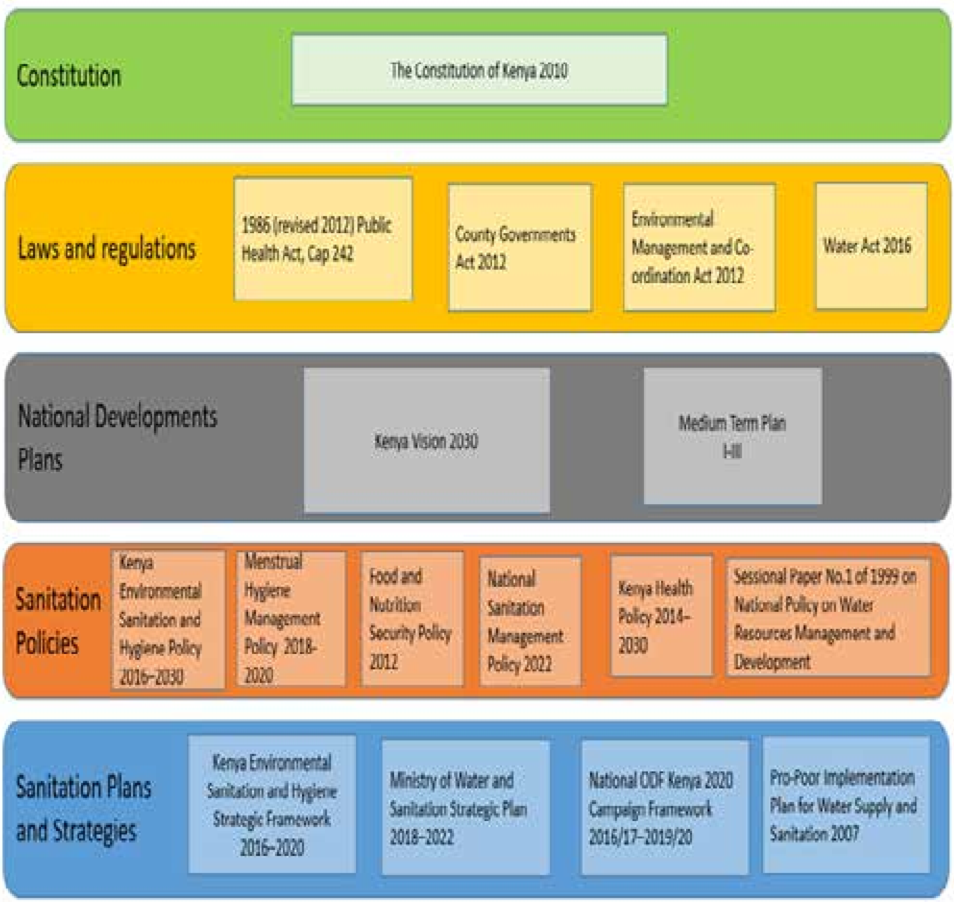
1 The Ministry of Water, Sanitation and Irrigation is developing the National Sanitation Management Policy (NSMP) as a framework to universal access to equitable and safely managed sanitation.

Kenya Food and Nutrition Security Policy 2012 and Kenya Menstrual Hygiene Management Policy (2019-2030).

Sanitation Strategies

There are various plans and strategies to implement the existing sanitation-related policies. These including Kenya Environmental Sanitation and Hygiene Strategic Framework 2016–2020; Ministry of Water, Sanitation and Irrigation Strategic Plan 2018–2022; National ODF Kenya 2020 Campaign Framework 2016/17–2019/20 and Pro-Poor Implementation Plan for Water Supply and Sanitation 2007. The 2008 Guidelines on Drinking Water Quality and Effluent Monitoring is important as it gives regulations on how to ensure there is quality drinking water as well as outlining how monitoring of the same will be done.

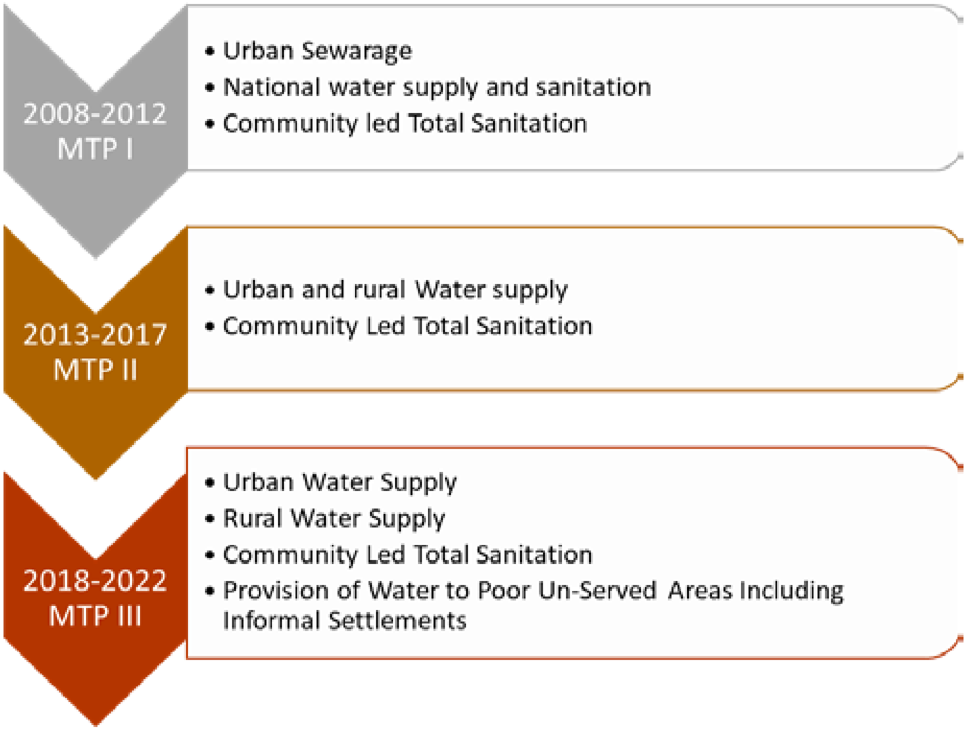
Figure 1: Summary of the legal, policy and planning frameworks used to support sanitation agenda in Kenya



2.2 Evolution of Sanitation Programmes Evolved Over Time

Over the three different medium-term plans, the country has progressively increased programs targeted at ensuring the citizenry can access reasonable sanitation. The diagram below shows the programs that have been the focus of the two sectors responsible for sanitation. The Ministry of Health's focus is mainly to ensure the country is progressively and steadily moving towards achieving elimination of open defecation while the Ministry of Water, Sanitation and Irrigation has progressively aimed at ensuring access to safely managed sanitation services as well as access to clean and safe water.

Figure 2: Summary of the programmes implemented in sanitation over time



The Urban Water Supply programme has focused on increasing water supply and sanitation in major urban areas over a five-year period starting 2018. During the review period, some projects were completed while others were at different levels of implementation: Gatundu Water and Sanitation Project (80 per cent), Limuru Water and Sanitation (77 per cent), Kikuyu Water Supply and Sanitation (75 per cent), Kiambu and Ruaka Water Supply and Sanitation (66 per cdent), Mandera Water and Sewerage project (75%), Marsabit Water and Sewerage (76.7%).

The Rural Water Supply programme which aimed to achieve universal access to safe water in rural areas, during the period under review, saw completion of Chwele Water and Sanitation, Masalani Water and Sanitation Project, Wote Water Supply and Sanitation Project, and Chwele Water and Sanitation. Other Projects which are still at different levels of implementation include Malava Water and Sanitation Project (20%).

The programme on Provision of Water to Poor Un-Served Areas Including Informal Settlements targeted to implement rural and urban water and sanitation projects in low income areas including a social/flat rate water tariff, saw 75 sanitation projects implemented in urban areas benefiting an additional 436,720 people with sanitation services, while in rural areas, 133 sanitation projects benefited 69,773 with sanitation services.

The National Open Defecation Free (ODF) Kenya 2020 campaign and by extension the Community Led Total Sanitation (CLTS) program under the Ministry of Health is cognisant of the devolved system of governance that embraces the transformative process aimed at overall societal change with respect to sanitation, whilst underscoring engagement of decision makers at national and county levels. The ODF protocol and guidelines have since been developed and seek to promote coherence, leverage synergies between different stakeholders, assure quality and adherence to agreed-upon standards in relation to verification and certification processes.

Service levels for sanitation as defined in the Rural Sanitation Protocol are: clean safely managed, basic, limited, unimproved and open defecation and are also referred to the five grades of the sanitation protocol. The protocol focuses on: ending OD and promoting transition to higher sanitation service levels. It also advocates for behaviour change using the Community-led Total Sanitation (CLTS) approach in addition to promoting hand hygiene behaviour change and sanitation marketing. Other areas of focus in the protocol include: promotion of non-sewered services, enhancing local ownership and bottom-up planning. Underpinning the rural sanitation protocol is the intention for long-lasting sanitation and hygiene improvements through leadership and buy-in of all stakeholders at national and subnational levels and advocacy for government funding in sanitation and hand hygiene initiatives and lastly inclusion.

In summary, sanitation-related interventions are designed with a dual intention of increased infra-structure development and positive behaviour change that creates demand for sanitation facilities. While the Ministry of Water and Irrigation in Kenya is tasked with providing infrastructure, it works closely with the Ministry of Health to ensure uptake and demand for safely managed facilities through behaviour change.

2.3 Budget Overview

Table 2 below summarises government investment in the area of sanitation under the different programs during the three planning periods MTP I, II and III. The analysis shows that over time the government has progressively been increasing its investment in the sanitation result area. The indicative budget for sanitation in MTP I was Ksh16.2 billion and this increased to Ksh350.4 billion in MTP III.

Table 2: Key sanitation programmes Under MTP 1, 2 and 3

Programmes	Objectives	Expected Output/ Outcomes	Implementing Agency	Time Frame	Source of Funds	Indicative Budget (in Ksh million)
Urban Sewerage	To construct and expand urban sewerage	Improved sanitation and hygiene; Reduce environmental pollution	Ministry of Water and Sanitation, Water Services Boards, Water Resources Management Authority, Ministry of Public Health and Sanitation	2008-2012	Gok	16,200

Urban and Rural Water Supply Sub Programmes	To expand and upgrade water supply and sewerage systems	Strengthened increase in access to safe water.	Ministry of Water, Environment and Natural Resources, Water Services Board, National Water and Conservation Pipeline Cooperation, Council of Governors.	2013-2017	GoK, DPs	280,007
Urban Water Supply	To increase access to safely managed water and sanitation supply in urban areas	Access to safely managed water and sanitation supply in urban areas increased	Ministry of Water and Sanitation, Water Services Institutions	2018-2022	GoK, DPS	330,000
Rural Water Supply	To increase access to safely managed water and sanitation supply	Large rural water and sanitation schemes rehabilitated and expanded	Ministry of Water and Sanitation, Water Services Institutions	2018-2022	GoK	20,474.40

Source: Authors' Compilation

2.4 Governance in WASH

In addition to policies, programmes and resources, addressing sanitation also calls for coordination between several actors. The Ministry of Health through the WASH Division, Department of Public Health has continuously sensitised, created awareness, capacity-built officers and spearheaded the development of coordination mechanisms for sanitation. The Ministry coordinates and implements WASH activities through the Environmental Health and Sanitation inter-agency coordinating committee (EHS – ICC), which is the National Sanitation and hygiene advisory body in the country. Members of the EHS – ICC are drawn from MOH, Ministry of Water and Sanitation (dealing with Sewerage), Ministry of Education, Council of Governors, UNICEF, WHO, World Bank, INGOs dealing with WASH and Local NGOs.

To accelerate WASH service delivery, the sector works through seven thematic technical working groups, including: 1) Sanitation promotion, focusing more on rural sanitation, 2) Hygiene Promotion including Menstrual Hygiene Management, 3) Urban sanitation – focusing on informal settlements (slums), where there is no sewage connection, 4) Household water treatment and safe storage (HWTS), where there is no piped treated water, 5) WASH in Schools (WiNS), 6) Policy, advocacy and research and 7) Health care waste management.

The involvement of the Division of Nutrition within the stated technical working groups needs to be better stipulated and strengthened. The policies stated above do not indicate clear links between nutrition and WASH. Future policies and strategies need to include nutrition intentions to accelerate the translation of WASH programmes whose outcomes are not merely measured by coverage and access to facilities but also reduced illness and malnutrition. The evidence generated in this write-up is aimed at influencing the design of WASH programmes that include nutrition improvement as a potential benefit to improved sanitation.

3 Literature Review

3.1 Sanitation Definition and the Sanitation Ladder

The Kenya Environmental Sanitation and Hygiene Policy (MoH 2016 – 2030) page xiv defines sanitation as:

> “the hygienic means of preventing human contact from the hazards of waste to promote health and environmental integrity. It is generally used to refer to the provision of facilities and services for the safe disposal of human and faeces and urine.”

The WHO sanitation definition is: “a group of methods to collect human excreta and urine as well as community waste waters in a hygienic way, where human and community health is not altered” (Huuhtanen and Laukkanen, 2006). In this write-up, sanitation refers to interventions that increase uptake and use of facilities of human waste disposal (Danguor, et al, 2013). In Kenya, sanitation is approached using the UNICEF/WHO Joint Monitoring Programme (JMP) sanitation ladder which classifies sanitation infrastructure and practices in five levels. Open defecation is the lowest level and includes disposal of human faeces in the environment; unimproved sanitation includes disposal of faeces in a container such as buckets or in an uncovered pit latrine; limited sanitation refers to use of improved facilities that are shared with other households; basic sanitation refers to use of improved facilities that are not shared with other households and lastly, safely managed sanitation refers to use of improved facilities that are not shared with other households and further, excreta is safely managed, transported and treated. The analysis section of this review is approached using this ladder.

Table 3: JMP sanitation ladder

SERVICE LEVEL	DEFINITION
Safely managed	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated off-site.
Basic	Use of improved facilities that are not shared with other households.
Limited	Use of improved facilities that are shared with other households.
Unimproved	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines.
Open defecation	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or with solid waste.
Note: Improved facilities include flush/pour to piped sewer systems, septic tanks or pit latrines, ventilated improved pit latrines, composting toilets or pit latrines with slabs.	

Source: UNICEF and WHO (2020)

3.2 Sanitation – Nutrition Pathways

Poor sanitation leads to malnutrition by enabling the intake of faecal matter leading to one or more of three WASH-related infections: (i) diarrhoea, (ii) intestinal worms and (iii) environmental enteric dysfunction which in turn limit the body's ability to absorb nutrients optimally (Black, et al, 2013, Dodos, et al, 2017). The effect of diarrhoea on stunting has been evidenced through studies such as Checkley, et al, (2008) which used a pooled longitudinal meta-analysis and established that five cumulative episodes of diarrhoea by 24 months of age increases the odds of child stunting by 1.13 per cent, and further, that five or more episodes of diarrhoea explain up to 25 per cent of childhood stunting for children aged 24 months.

Incidence of intestinal worms has similarly been linked to stunting. or instance, in a cross-sectional clinical study in Rwanda, worm infestation more than doubled the odds of stunting for children in both rural and urban areas (Heimera, et al, 2015). Environmental enteric dysfunction (EED) is a leakiness or permeability of the intestines leading to nutrition malabsorption. In cases where this condition is prolonged there was increased likelihood of sub-optimal growth resulting in childhood stunting (Owino, et al, 2016). This arises as a result of ingesting faecal matter due to exposure to an unsanitary environment, poor hygiene practices and consuming unsafe drinking water (Chase, et al, 2019).

3.3 Evidence on the Effect of Sanitation on Nutrition

The effect of sanitation on health and nutrition outcomes has been the subject of study in several countries whose results provide inconsistent findings. A review of the relationship between WASH and child stunting for seven East Africa countries applied adjusted regression models to determine the influence of sanitation based on the ladder on child length-for-age (Rakotomanana, et al, 2020). After adjusting for maternal, child and household characteristics , the findings revealed that for four of seven countries, improvement in the sanitation facilities based on the sanitation ladder translated to an increase in linear height-for-age z scores (Rakotomanana, et al, 2020). Similarly, an analysis of association between WASH and nutrition in Ethiopia indicated a positive influence of sanitation on child growth. Following a four-year intervention, an end line cross-sectional matched control evaluation that included 1,007 households in two districts established that child mean height-for-age z scores improved with each increasing sanitation level based on the ladder within the comparison group (Head, et al, 2019). In this evaluation, infrastructure improvement based on the sanitation level translated to improved child growth.

Improvement in sanitation infrastructure does not consistently translate to improved health and nutrition outcomes. In Tanzania, a Randomised Control Trial (RCT) to study the isolated and combined effects of sanitation and handwashing, resulted in increased construction and use of improved latrines.

However, the interventions failed to register improved health outcomes with regard to diarrhoea incidence and height-for-age scores for children in intervention group compared to the control group. The authors postulated the reason for this as failure to attain the critical mass required to meaningfully affect faecal-oral transmission pathways that result in substantial health outcomes (Briceno, et al, 2017). These findings are in tandem with another RCT in India that increased household latrine coverage from nine to 60 per cent over a period of about 19 months without resulting in significant difference in diarrhoea incidence, worm infestation, weight-for-age and height-for-age scores (Clasen, et al, 2014). This was attributed to inconsistent use of latrines in the intervention groups as well as lingering exposure to faecal pathogens at community level from the population that hadn't adopted latrine use (Clasen, et al, 2014).

This means that sanitation initiatives should not merely seek to increase infrastructure coverage, but further, should aim at influencing their consistent uptake and use by a critical mass of its population. For instance, in Mali, an RCT intervention aimed at eradicating open defecation applied CLTS and attained a 97 per cent open defecation free status within the intervention group (Pickering et al, 2015). In this study, children within the intervention group were found to be taller and less likely to be stunted compared to the control group. Latrine ownership also increased significantly from 33 to 65 per cent, but remained lower than the ODF rate. In the case of Mali, improved child growth was more likely associated with sanitation practices than infrastructure.

A study in India went further to demonstrate the influence of population density when considering sanitation practices. A quasi-experiment study in Maharashtra, indicated a height increase of 1.3 cm within children aged below five in sanitation intervention group compared to non-intervention (Hammer and Spears, 2013). Within this study, the coverage of latrines and sanitation were modest and their effect on child height was attributed to low density population within the villages, such that a modest improvement in sanitation was likely to reduce faecal-oral pathogen transmission. This means a consideration of sanitation programmes need consider not just infrastructure, but also behaviour change to enable the consistent adoption.

3.4 Evidence on the Effect of Water and Hand Hygiene on Nutrition

Other WASH interventions that are complementary to sanitation and have bearing on child linear growth and health are access to water and hand hygiene. Hand hygiene, specifically, handwashing with soap is considered a barrier for faecal-oral transmission (Freeman et al, 2014). A systematic review of 43 studies from 19 countries on the effect of both handwashing and broader hygiene on diarrhoea found a 40 per cent reduced risk for diarrhoea based on hand washing with soap (Freeman, et al, 2014). Of importance to note is that the review by Freeman (2014) alluded to handwashing after visiting the toilet, implying combined sanitation and handwashing practices. Similarly, a review of demographic health survey in Ethiopia applied a multivariable regression model to establish that sanitation combined with handwashing reduced the chances of stunting by 29 per cent (Bekele, 2020).

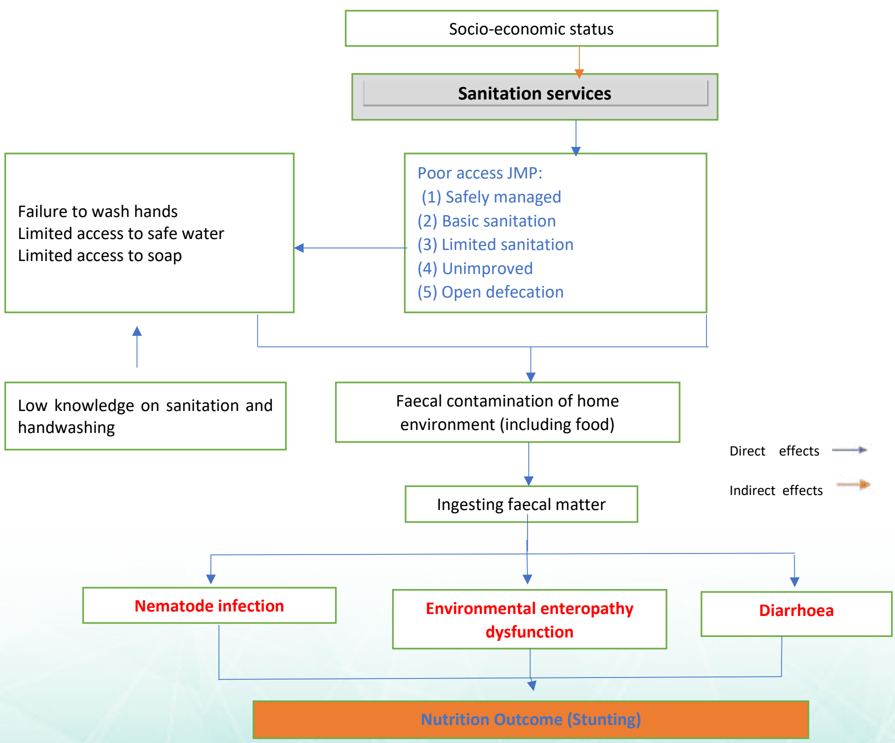
An underpinning requirement for handwashing is the availability of water. Access to water implies not just quantity but also water quality that is free from disease-causing pathogens. A cross-sectional study in Tanzania found that children under five years who consumed water from unprotected sources were 1.22 AOR times more likely to be stunted than children who consumed water from protected sources (Chirande, et al, 2015). The possible impact of water on nutrition does not merely apply to drinking water but also the quality of water used for domestic purposes. Mshida, et al, (2018) cross sectional survey in Tanzania applied multivariate regression and identified that children in homes that used surface water for domestic purposes had 13 times higher chances (AOR) of being stunted than children in homes using piped water. The study attributed this outcome to pathogen contamination of surface water (Mshida, et al 2018). Overall, investments to improve sanitation are likely to improve child linear growth especially if combined with hand hygiene and safe water to inhibit oral transmission of faecal pathogens.

4 Methodology

4.1 Conceptual Framework

Figure 3 represents Sanitation-to-Nutrition conceptual framework that will guide interpretation of findings in Chapter 5. The analysis will consider the effect of sanitation adoption based on the sanitation ladder on child nutrition outcomes (stunting). Socio-economic status is postulated to affect the type of sanitation services a household can access. This then influences which of the five sanitation ladders the household adopts. Poor access to sanitation coupled with low knowledge on sanitation and hygiene is linked to poor hand hygiene practices, leading to faecal contamination of the home environment as well as food. Finally, ingesting faecal matter is likely to cause one of three infections (diarrhoea, environmental enteropathy and nematode infection) leading to stunting.

Figure 3: The sanitation-to-nutrition analytical framework



Source: Borrowed from Action Contre la Faim (2017) and adapted by authors

4.2 Sample Design

This study uses data from the 2014 KDHS survey by the Kenya National Bureau of Statistics. The sample for the 2014 KDHS was drawn from a master sampling frame – the Fifth National Sample Survey and Evaluation Programme (NASSEP V). The 2014 KDHS was designed to produce representative estimates for most survey indicators at the national level, as well as for urban and rural areas separately, at the regional (former provincial) level, and for selected indicators at the county level. The sample includes 40,300 households from 1,612 clusters spread across the country, with 995 clusters in rural areas and 617 clusters in urban areas. Samples were selected independently in each sampling stratum using a two-stage sample design. The 1,612 clusters were chosen with equal probability from the NASSEP V frame in the first stage. The households from the listing operations served as the sampling frame for the second stage of selection, in which 25 households from each cluster were chosen.

The data had WASH-related as well as nutrition indicators making it the only fit nationally representative data for purposes of the current study. To address the objectives of this study, socio-economic, anthropometric and demographic variables pertaining to lack of proper sanitation and poor hygiene behaviours that lead to stunting in children under the age of five were extracted. Among the variables of interest were residence, household size, mothers' age, parents' educational attainment, wealth quintiles, sex of child, child age in months, child anthropometric data, sanitation facility, presence of detergent and water at homestead, and number of critical times members wash their hands with soap. The relevant data were extracted using an inclusion criteria of children aged 59 months and below who had anthropometric data. This resulted in a dataset of 18,600 children from 13,453 households across 1,593 clusters from the 2014 KDHS.

The first stage of data analysis included generating descriptive statistics (means, frequencies) of the adopted household WASH amenities (household sanitation, access to drinking water and hygiene practices) based on rural-urban divide. It also included a means and comparison of child stunting based on adopted household WASH amenities.

4.3 Model Specification

This study adopts the theory of impact evaluation to understand the impact that adoption of WASH amenities has on child nutrition outcomes. There were ongoing WASH interventions by both State and non-State actors spread across different parts of the country as illustrated in introductory part of this study. There were also other related interventions to improve child nutrition outcomes. The interest of this study was to isolate the contributory effect of WASH amenities on child stunting as an outcome. The outcome was observed because of several interventions and the interest of the study is on one specific intervention: in this case a given WASH amenity (in the JMP sanitation ladder) where we observe in the data that some children live in households that have adopted some class of WASH amenity while others have not.

The difference (treatment effects) in the nutrition outcomes when a child is and is not living in a household with a given WASH amenity defined as:

y_{i1}-y_{i0} where:

y_{i0} is the nutrition outcome observed when the child is living in a household without a given WASH amenity (not treated or t_i=0 and y_{i1} is the nutrition outcome observed when a child is living in a household that has not adopted a given WASH amenity (treated or t_i=1). Based on Khandker, Koolwal and Samad (2010) and Lin (2012) impact evaluation is essentially a problem of missing data. This is because we cannot observe both nutrition outcomes y_{i0} and

y_{i1} on the same child (or have t_i=1 and t_1=0 on the same individual). The child as observed in the dataset is in one state (t_i=1) or the other (t_1=0), implying that individual-level treatment effects cannot be computed.

To compute the effect (the difference), the task then becomes reconstructing outcomes that have not been observed or counterfactual observation units in a novel way (Lin, 2012). Two main aggregate estimates have been proposed in literature: the average treatment effect (ATE) and the average treatment effect on the treated (ATET).

$$ATE=E(y_i|t_i=0,1)-E(y_{i0}\,|t_i=1;0) \text{ and } ATET=E(y_i 1 t_i=1)-E(y_{i0}\,|t_i=1)$$

ATE is the average difference in nutrition outcome that would be observed if every child currently living in a household with a given WASH facility or without the given WASH facility was placed in a household that has the specific WASH facility compared to if none of either child lived in a household with the specific WASH facility.

ATET on the other hand is the average difference in nutrition outcome that would be observed if all the children living a household that has a specific WASH facility were placed in households that have that WASH facility compared to if none of either child lived in a household with the specific WASH facility.

There are several approaches that can be used to estimate both ATT and ATE, the most ideal of which is the randomised controlled experiment whose design ensures that ATT=ATE. However, since we are using observational data in a non-experimental setting, allocation of children across households with different WASH facilities across the JMP sanitation ladder was not randomised. This meant that stunting and sanitation did not always have to be mutually exclusive. The study applied matching techniques to construct counterfactual and regression adjustment to estimate the ATT following the procedure in Li (2012).

To estimate the propensity scores the following co-variates were used to condition a logistic treatment model with four JMP sanitation categories: open defecation; Jmp_unimproved; Jmp_ limited and Jmp_basic combined with jmp safely managed. Due to data limitations, analysis through treatment effects was explored for sanitation only and was not applied for hygiene or access to drinking water. The inverse probability weights calculated from the propensity scores were calculated for purposes of adjusting each treated and untreated child following Li (2012).

The weights were then used in adjusting the logistic regression models for each of the outcome (stunted or not stunted; that was constructed from the anthropometric scores in the data). The other covariates included in the outcome model are: child age in months, child sex, place of residence, number of household members, mother's current age, mother's educational attainment, and wealth index. The third and final step was to compute the means of the treatment-specific potential outcomes and a contrast of the same that gives the estimate of the ATT.

5 Results and Discussion

5.1 Descriptive Statistics

Table 4 provides a description of sanitation, handwashing, and drinking water amenities by place of residence for households in the survey that had children under the age of five years.

Table 4: Sanitation, handwashing and drinking water amenities by residence

Characteristics	Urban	Rural	Total
SANITATION			
Proportions of JMP[2] sanitation			
JMP safely managed	16.1%	0.5%	5.8%
JMP Basic	11.3%	17.0%	15.1%
JMP Limited	48.0%	13.3%	25.2%
JMP Unimproved	22.5%	46.2%	38.1%
JMP Open Defecation	2.1%	23.0%	15.8%
HAND WASHING AMMENITIES			
Proportions of place where household members wash their hands by residence			
Observed	39.0%	22.6%	28.2%
Not observed (not in dwelling)	28.9%	39.6%	35.9%
Not observed (no permission to see)	1.3%	1.4%	1.4%
Not observed (other reason)	30.8%	36.4%	34.5%
Where handwashing stations were observed:			
Proportions of soap and water by residence	59.0%	34.1%	46.0%
Proportions of water and cleansing agent (ash, mud, sand) only by residence	0%	0%	0%
Proportions of water only by residence	22.8%	21.7%	22.2%

2 SANITATION: SAFELY MANAGED: Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or removed and treated offsite; BASIC: Use of improved facilities which are not shared with other households; LIMITED: Use of improved facilities shared between two or more households; UNIMPROVED: Use of pit latrines without a slab or platform, hanging latrines or bucket latrines; OPEN DEFECATION: Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches and other open spaces or with solid waste https://washdata.org/monitoring/sanitation

Characteristics	Urban	Rural	Total
Proportions of soap only, soap and another cleansing agent by residence	2.8%	3.3%	3.0%
Proportions of cleansing agent (ash, mud, sand) other than soap only by residence	0.0%	0.0%	0.0%
Proportions of no water, no soap, no other cleansing agent by residence	15.3%	40.7%	28.6%
DRINKING WATER			
Proportions of JMP[3] drinking water safely managed by residence	urban	rural	Total
jmp_water safely managed	42.4%	9.7%	20.9%
jmp_water_basic	32.6%	26.9%	28.8%
jmp_water_limited	11.2%	17.7%	15.5%
jmp_water_unimproved	7.1%	16.6%	13.4%
jmp_water_surface	4.7%	27.8%	19.9%
Nutrition status of children under five years of age by residence			
Stunted	19.7%	29.3%	26.0%
Overweight	5.6%	3.6%	4.3%
Wasted	3.5%	4.5%	4.2%
Diarrhoea proportion by residence			
Diarrhoea	15.3%	16.1%	15.8%

The data reveals a sharp rural versus urban distinction in the types of sanitation facilities adopted at household level. In urban households, the order of sanitation facilities in terms of proportion adopted from highest to lowest is: JMP limited, followed by JMP unimproved, JMP safely managed, JMP basic and finally open defecation. For rural areas, the highest proportion is JMP unimproved, followed by open defecation, JMP basic, JMP limited and finally, JMP safely managed which comprises less than one per cent of the sampled population. Specifically, about 69.2 per cent of rural households use either open defecation or JMP unimproved sanitation facilities, representing a significant population that uses a faeces-exposing sanitation facility. Upon combining both rural and urban, JMP unimproved is the most common sanitation amenity, constituting 38.1 per cent of households where children under five years are based.

Regarding handwashing amenities, only 28.2 per cent of households had a handwashing station observed in dwellings with children aged five and below. Handwashing amenities similarly indicated notable disparities between rural and urban based households, with 39.0 per cent of urban households having a handwashing station observed compared to 22.6 per cent of rural households. Of the households with a handwashing station observed, 46.0 per cent had soap and water, once again with a rural-urban disparity of 59.0 per cent of urban

3 DRINKING WATER: SAFELY MANAGED: Drinking water from an improved water source that is accessible on premises, available when needed and free from faecal and priority chemical contamination; BASIC: Drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip including queuing; LIMITED: Drinking water from an improved source for which collection time exceeds 30 minutes for a roundtrip including queuing; UNIMPROVED: Drinking water from an unprotected dug well or unprotected spring; SURFACE WATER: Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal. https://washdata.org/monitoring/drinking-water

households, and 34.1 per cent of rural households. Likewise, 28.6 per cent of the households with a handwashing station observed had no water, no soap and no other cleansing agent with a rural-urban divide of 15.3 per cent of urban homes and 40.7 per cent of rural homes.

Finally, regarding drinking water, the highest proportion of the children (28.8 per cent) were based in households that had access to basic drinking water. The trend of rural-urban disparity lingers with regard to access to drinking water, with the highest proportion of households (42.4 per cent) in urban areas accessing drinking water from a safely managed water source, whereas, the highest proportion of rural households (27.8 per cent) access drinking water from the surface, i.e. drinking water directly from a river, pond or dam. This means that in urban areas, the highest proportion of household's access drinking water from a source that is highest in the JMP drinking water ladder, while in rural areas the highest proportion of households access their water from a source that is lowest in the JMP drinking water ladder.

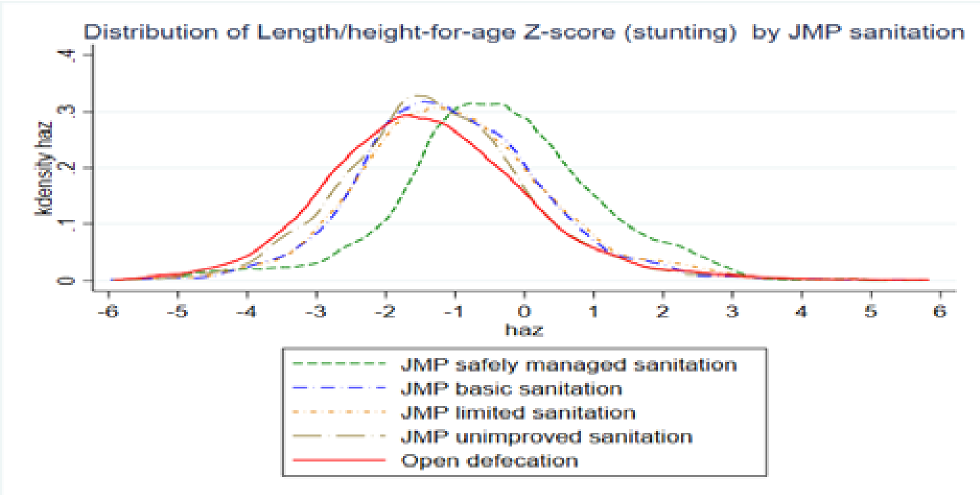
Regarding nutrition status by anthropometry, we notice the national stunting average of 26 per cent differs sharply between rural and urban areas at 19.7 per cent stunting for children in urban areas and 29.3 per cent stunting for children in rural areas. Other malnutrition indices have slight rural urban disparity but not as sharp as the stunting disparity. Similarly, the disparity in the proportion of children that reported to have had diarrhoea in the two weeks before the survey was not very distinct between children in rural areas (16.1 per cent) compared to urban areas (15.3 per cent).

In summary, the descriptive results indicate a distinct rural-urban divide with regard to sanitation and hygiene practices. Within rural areas, open defecation was the second highest sanitation practice (23.0 per cent followed by JMP unimproved (46.2 per cent) which jointly comprise 69.2 per cent. This is compounded by low hygiene practices, with merely 22.6 per cent of the rural households having a visible handwashing station, and of these, 40.7 per cent had no water, soap or other cleansing agent. This means a significant proportion of households in rural areas are potentially exposed to faecal pathogens. Child stunting prevalence similarly display a rural-urban divide pattern (29.3 per cent in rural and 19.7 per cent in urban). This implies that with regard to sanitation, hygiene and child stunting, rural areas of Kenya are distinctively disadvantaged compared to urban areas. The next stage of analysis sought to assess the outcome of child stunting based on a household's mode of sanitation.

5.2 Comparison of Household Access to Sanitation Services and Child Nutrition Outcomes

The analysis applied kernel density curves to assess the distribution of stunted children based on the JMP sanitation ladder. The graph suggests that the distribution of child stunting differs based on the mode of sanitation a household adopts. The curve with children in households that practice open defecation leans towards the left with its peak clustering at -2 SD while the curve with children in households that practice safely managed sanitation leans towards the right with its peak clustering between -1 and 0. This implies that a larger proportion of children in households with safely managed sanitation have height for age z scores that are closer to standard, while a larger proportion of children in OD households have height for age z-scores that are lower than standard.

Figure 4: Distribution of Child Stunting Based on Sanitation Ladder



The analysis went further to distribute the proportion of stunted children based on the JMP sanitation ladder of the households they reside in and the results are displayed in Table 5 below.

Table 5: Distribution of Child Stunting Based on JMP Sanitation Ladder

Proportion of Stunting Based on	**Not Stunted**	**Stunted**	**T**	**P Value**
SANITATION				
Proportion of stunting based on JMP sanitation ladder				
JMP safely managed sanitation	7.0%	2.3%	6.07	0.00***
JMP basic sanitation	15.7%	13.2%	3.12	0.00***
JMP limited sanitation	26.3%	22.0%	3.50	0.00***
JMP unimproved sanitation	36.8%	41.6%	-3.77	0.00***
JMP open defecation	14.1%	20.9%	-7.39	0.00***
COMBINED WATER SANITATION AND HYGIENE				
Improved[4] not shared sanitation + improved water sources	17.3%	9.4%	8.07	0.00***
Improved not shared sanitation + soap and water observed	20.5%	11.2%	3.68	0.00***
Improved not shared sanitation + handwashing at 5 critical times	0.4%	0.1%	2.84	0.00***

4 Improved not shared sanitation includes JMP safely managed sanitation and JMP basic sanitation.

Proportion of Stunting Based on	Not Stunted	Stunted	T	P Value
Improved not shared sanitation + improved water sources + soap and water observe	17.9%	8.5%	3.88	0.00***
Improved not shared sanitation + improved water sources+ handwashing at 5 critical	0.4%	0.1%	3.57	0.00***

Results indicate that the proportion of stunted children is lowest in the highest two levels of the sanitation ladder at 2.3 per cent for children in households with JMP safely managed and 13.2 per cent for those in JMP basic. It is possible that this is attributed to the number of children per household since households with better socio-economic status, including sanitation facilities, tend to have fewer children.

The highest proportion of stunted children are based in households with JMP unimproved sanitation facilities (41.6 per cent), followed by those in households with limited sanitation (22.0 per cent) and finally those in OD practicing homes (20.9 per cent). This means the proportion of stunted children does not linearly mirror the JMP sanitation ladder. However, despite a lower proportion of stunted children in OD households compared to limited and unimproved sanitation, it is important to consider the possible externality of OD to non-OD practicing households in terms of environmental influence. OD increases the potential of non-OD households being exposed to disease causing pathogens, which could then lead to inhibited linear child growth with this probability being heightened in densely populated localities (Brown, et al, 2015; Mara, 2017).

A study in India sought to assess the impact of village-level sanitation coverage on child diarrhoea and concluded that there was no improvement in terms of diarrhoea reduction until a 30 per cent sanitation coverage was attained, and further, 75 per cent coverage was required to achieve at least 50 per cent diarrhoea reduction (Andres, 2014). This implies that there is need to consider the potential negative externalities of OD to households that have adopted limited, unimproved or even higher sanitation models.

The analysis went further to explore the impact of combined water, sanitation and hygiene. Findings imply that when households with the highest two levels of sanitation include improved access to safe water and/or improved hygiene the result is a lower proportion of stunting in children and higher proportions of children that are not stunted. This is in tandem with findings from the Ethiopia Demographic and Health Survey (EDHS) 2016 which indicated 33 per cent reduced chances of child stunting in households that adopted a combination of improved drinking water, improved sanitation and hand hygiene practice (Bekele, et al, 2020). Similarly, a meta-analysis that reviewed 10 studies to assess the impact of combined WASH interventions on height-for age z scores of over 16,000 children under five years of age concluded that combined WASH increased the pooled mean height-for-age z-scores compared to the children that received a single intervention (Gizaw and Worku, 2019). Findings from this stage of analysis imply that the form of sanitation a household adopts is likely to be protective of or causative to child stunting and that adoption of combined WASH is likely to translate to reduced proportions of child stunting.

The next stage of analysis explores average treatment effect of household sanitation facility class (based on the ladder) on child stunting (nutrition outcome). Household sanitation is explored as the treatment, while child age in months, sex, place of residence, number of household members, mothers current age, mother's educational attainment, and wealth index are controlled to condition treatment (belonging to a given category of sanitation facilities). Other WASH variables, i.e. access to drinking water and hygiene infrastructure and practices were not explored at the next stage of analysis due to data limitations. The results of this model are available in Table 8 of Annex 2. Further, the results of the weighted logistic regression (outcome) model are also available in Table 9 of Annex 2.

5.3 Effect of Household Access to Sanitation Services on Child Nutrition Outcomes

The third and final step involved estimation of the average treatment – specific (across the JMP sanitation classifications) effects. Table 6 indicates the potential outcome means (probability of a child being stunted) based on the mode of household sanitation adopted, having controlled for the confounders previously stated.

Table 6: Potential outcomes means based on sanitation ladder levels

	b	se	z	p-value	ll	ul
Open defecation	0.392	0.018	21.627	0.000	0.356	0.428
JMP Unimproved	0.274	0.008	32.660	0.000	0.257	0.290
JMP Limited	0.267	0.011	24.930	0.000	0.246	0.288
JMP Basic, JMP Safely managed	0.247	0.011	23.171	0.000	0.227	0.268

From Table 6 above, results suggest that a child living in a household that uses basic or safely managed sanitation facility has the lowest probability of being stunted. This finding is similar to those of a study in Pakistan that applied regression analysis to assess child stunting based on the household sanitation ladder and determined that children in households adopting the highest two levels of the sanitation ladder had the lowest odds of stunting (Khan, et al, 2021).

Further, the probability of a child being stunted is highest (at 39.2 per cent) if the child lives in a household that uses open defecation as sanitation facility while children in households using unimproved (27.4 per cent) or limited (26.7 per cent) sanitation facility have almost equal odds of being stunted. From this analysis, having a better sanitation facility is associated with reduced probability of child stunting in a linear manner as one moves higher up the sanitation ladder from OD, JMP unimproved, JMP limited, to JMP basic and JMP safely managed.

This suggests that OD, despite having lower proportions of stunted children at the means and comparison stage of analysis, is the sanitation practice with the highest potentially negative effect on child stunting. Further estimation procedure sought to compare the effect on the potential outcome (stunting), from improving the sanitation facility up the ladder, with the aim of estimating the likely stunting reduction to be achieved.

Table 7: Effect of improving sanitation facilities on stunting outcome

		b	se	Z	pvalue	ll	ul
ATE	Jmp_unimproved vs open defecation	-0.118	0.020	-5.890	0.000	-0.158	-0.079
ATE	Jmp_limited vs open defecation	-0.125	0.021	-5.929	0.000	-0.167	-0.084
ATE	Jmp_basic, jmp_safely managed vs open defecation	-0.145	0.021	-6.838	0.000	-0.186	-0.103
POmean	open defecation	0.392	0.018	21.627	0.000	0.356	0.428

Table 7 presents the average treatment effects. The average probability of a child being stunted in a household using open defecation facility reduces by 11.8 per cent (from the potential outcome mean of 39 per cent), if the household changes the toilet facility to unimproved facility. The probability reduces significantly by even higher points with adoption of limited sanitation facility and basic/safely managed facility (by 12.5 per cent and 14.5 per cent, respectively). The magnitude of reduction in the probability of stunting follows the gradual improvement in the sanitation facility up the ladder.

The results of the study imply that improvement of sanitation facilities may positively affect stunting (nutrition outcome) placing the results in a literature that finds contradictory results. For instance, a review of seven East Africa countries indicated that child linear growth improved with every increased in the sanitation ladder for four countries, but in three countries, the child height-for-age scores in households with unimproved sanitation was negative compared to those in OD households after adjusting for maternal, child and household characteristics[5] (Rakotomanana, et al, 2020).

Similarly, in Ethiopia, a WASH-Nutrition intervention sought to assess impact of WASH on nutrition outcomes following a four-year intervention. The evaluation compared height-for-age z-scores for children in intervention and non-intervention villages. The results indicated child linear growth increased linearly with every increase of the sanitation ladder in non-intervention villages, while child height in OD practicing households was higher than in unimproved practicing households for the WASH-Nutrition intervention group (Head, et al, 2019). Likewise, in Pakistan, despite the odds of stunting being lowest in households adopting higher sanitation models, children in homes with pit latrines had the highest probability for child stunting, even in comparison with OD practicing households in spite of pit latrine being the third rung in the sanitation ladder (Khan, et al, 2021). This was attributed to the pit latrines being of poor quality and therefore heightening exposure to faecal contamination at household level.

In conclusion, the results from the analysis suggest the need for a practical approach to stunting reduction through deliberate sanitation interventions. Further, the results imply a need to prioritise OD elimination then gradually and linearly improve the household sanitation conditions. The study finding needs to be approached through awareness of other studies which suggest that sanitation interventions should not merely seek to move up the ladder linearly, but rather, trigger communities to adopt high quality sanitation infrastructure.

5 Models were adjusted for: child sex, age, and breastfeeding status, for maternal highest level of education, age, and height, and for household wealth index and area of residence

6 Conclusion and Recommendations

6.1 Conclusion

The overall objective of the study was to establish the influence of household sanitation on child nutrition outcomes. Using nationally representative data, the analysis compared child nutrition outcomes based on household access to sanitation services which was classified using the JMP sanitation ladder. Thereafter, the analysis applied Average Treatment Effects (ATE) to determine the influence of household access to sanitation services on child nutrition outcomes.

Results suggest that a higher proportion of stunted children are in households adopting lower level of sanitation with safely managed households comprising 2.3 per cent of stunted children followed by basic sanitation households (13.2 per cent). However, the distribution of stunted children is not entirely linear across the ladder with the largest proportion being based in households with unimproved sanitation (41.6 per cent), and the second largest is limited sanitation (22.1 per cent) and finally children in households practicing OD 20.9 per cent. A combination of the two highest proportions of stunted children stratified by the sanitation ladder indicates 63.7 per cent reside in household using limited or unimproved sanitation. Improving sanitation facilities in households with limited and unimproved sanitation is therefore likely to have an impact in terms of total number of stunted children.

At comparison level, the study further assessed the proportions of stunted versus not stunted children when sanitation is combined with improved water sources and/or improved hand hygiene facilities with combined WASH resulting in higher proportions of children that are not stunted compared to stunted. This suggests combined WASH to be protective of child linear growth. Sanitation initiatives that promote both infrastructure uptake and behaviour change are likely to improve child linear growth especially if combined with hand hygiene and safe water to inhibit oral transmission of faecal pathogens.

Although the results from means and comparison indicate the greatest proportion of stunted children are domiciled in households with unimproved sanitation followed by basic facilities, after applying treatment effects, open defecation has the highest negative impact on child stunting presenting a 39.2 per cent probability of being stunted. Furthermore, graduating a child from OD households to unimproved sanitation, would reduce their chance of being stunted by 11.8 per cent. The analysis also reveals that the chances of a child being stunted as a result of adopted sanitation reduces with every increase in the sanitation ladder in a linear manner. The probability of child stunting reduces from 39.2 per cent for OD households to 27.4 per cent in unimproved, 26.7 per cent in limited and is lowest at 24.7 per cent in households with basic or safely managed sanitation. This suggests that the approach of improving nutrition through sanitation should follow the philosophy of sanitation ladder with heavier infrastructure investment (in terms of toilet facilities, water and hygiene) being directed to households currently using open defecation.

However, based on the significant proportion of stunted children residing in homes with limited and unimproved facilities, and cognisant of other studies that indicate higher negative effect of mid-level sanitation facilities on child stunting compared to OD households, it is likely that stronger protection on child linear growth in Kenya would be realised by adoption of the highest two sanitation models. This involves efforts to improve sanitation facilities with the aim of impacting on child stunting in Kenya would need to consider both OD elimination and graduation from unimproved sanitation facilities simultaneously.

6.2 Recommendations

(i) Policies to reduce child stunting in Kenya could combine measures to eliminate open defecation and graduation from unimproved sanitation facilities.

(ii) The involvement of the Division of Nutrition within the stated technical working groups needs to be better stipulated and strengthened while ensuring strong link between nutrition and WASH.

(iii) Future policies and strategies need to include nutrition intentions to accelerate the translation of WASH programmes whose outcomes are not merely measured by coverage and access to facilities but also reduced illness and malnutrition. The evidence generated in this write up is aimed at influencing the design of WASH programmes that include nutrition improvement as a potential benefit to improved sanitation.

(iv) There is need for a practical approach to reduce stunting through deliberate sanitation interventions. Further, the results imply a need to prioritise OD elimination then gradually and linearly improve the conditions of household sanitation.

References

Action Contre La Faim (2017), WASH nutrition: A practical guidebook on increasing nutritional impact through integration of WASH and nutrition programmes for practitioners in humanitarian and development contexts.

Andres, L.A., Briceño, B., Chase, C. and Echenique, J.A. (2014), Sanitation and externalities evidence from early childhood health in rural India. The World Bank South Asia Region Sustainable Development Unit and Sustainable Development Network. Water and Sanitation Program Policy Research Working Paper 6737.

Bekele T, Rahman B, Rawstorne P. (2020), "The effect of access to water, sanitation and handwashing facilities on child growth indicators: Evidence from the Ethiopia Demographic and Health Survey 2016". PLoS One, Vol. 15, Issue 9: 1-21.

Black Robert E., Bhutta Zulfiqar A., Das Jai K., Rizvi Arjumand, Gaffey Michelle F., Walker Neff, Horton Susan, Webb Patrick, Lartey Anna (2013), Evidence-based interventions for improvement of maternal and child nutrition: What can be done and at what cost?

Briceño B., Coville A., Gertler P., Martinez S. (2017), "Are there synergies from combining hygiene and sanitation promotion campaigns: Evidence from a large-scale cluster-randomized trial in rural Tanzania". PLoS One, Vol. 12, Issue 11: 1-19.

Brown J, Cumming O. and Bartram J., et al. (2015), "A controlled, before-and-after trial of an urban sanitation intervention to reduce enteric infections in children: Research protocol for the Maputo Sanitation (MapSan) study, Mozambique". BMJ Open, Vol. 5: 1-11.

Bowen Anna, M.D., Agboatwalla Mubina, MBBS; Luby Stephen, M.D.; Tobery Timothy; Ayers Tracy, MS and Hoekstra, R. M. (2012), "Association between intensive handwashing promotion and child development in Karachi, Pakistan: A cluster randomized controlled trial". Archives of Pediatrics and Adolescent Medicine, Vol. 166, Issue 11: 1037-1044.

Caulfield, L. and Black, R.E. (2004), Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles.

Chase, Claire, Aroha Bahuguna, Yue Chen, Sabrina Haque, and Mik Schulte (2019), Water and nutrition: A framework for action. World Bank, Washington, DC.

Checkley, W.; Epstein, L. D., Gilman, R. H., Cabrera, L. and Black, R. E. (2003), "Effects of acute diarrhea on linear growth in Peruvian children". American Journal of Epidemiology, Vol. 157, No. 2: 166-175.

Checkley, W., Buckley, G., Gilman, R. H., Assis, A.M., Guerrant, R. L., Morris, S., Mølbak Ka°re, V. P., Lanata, C.F. and Black, R. E. (2008), "Multi-country analysis of the effects of diarrhoea on childhood stunting". International Journal of Epidemiology, Vol. 37: 816-830.

Chirande L., Charwe D., Mbwana H., Victor R., Kimboka S., Issaka A., Ibrahim B., Surinder K., Dibley M. J. and Agho Kingsley E. (2015), "Determinants of stunting and severe stunting among under-fives in Tanzania: Evidence from the 2010 cross-sectional household survey". BMC Pediatrics, Vol. 15, Issue 165: 1-13.

Clasen T, Boisson S, Routray P, Torondel B, Bell M, Cumming O, Ensink J, Freeman M, Jenkins M, Odagiri M, Ray v, S, A, Suar M, and Schmidt W.P. (2014), "Effectiveness of a rural sanitation programme on diarrhoea, soil-transmitted helminth infection, and child malnutrition in Odisha, India: A cluster-randomised trial". Lancet Glob Health, Vol. 2: 645-653.

Cost of Hunger Africa (2019), Social and economic effects of child undernutrition. Kenya Country Report

Cumming, O., Arnold, B.F., Ban, R., Clasen, T., Mills, J.E., Freeman, M.C., Gordon, B., Guiteras, R., Howard, G., Hunter, P.R., Johnston, R.B., Pickering, A.J., Prendergast, A.J., Prüss-Ustün, A., Rosenboom, J.W., Spears, D., Sundberg, S., Wolf, J., Null, C., Luby, S.P., Humphrey, J.H. and Colford J.M. Jr. (2019), "The implications of three major new trials for the effect of water, sanitation and hygiene on childhood diarrhea and stunting: a consensus statement". BMC Medicine, Vol. 17, No. 173: 1-9.

Dangour, A. D., Watson, L., Cumming, O., Boisson, S., Che, Y., Velleman, Y., Cavill, S., Allen, E., and Uauy, R. (2013), "Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children". Cochrane Database of Systematic Reviews, Issue 8: 1-78.

Dodos J, Blanche M, Jean L, Altmann M, Aït-Aïssa M. (2017), "Relationship between water, sanitation, hygiene, and nutrition: What do Link NCA nutrition causal analyses say?" Waterlines, Vol. 36 Issues No. 4: 285-303.

Fenn B., Bulti A.T, Nduna T., Duffield A. and Watson F. (2011), "An evaluation of an operations research project to reduce childhood stunting in a food-insecure area in Ethiopia". Public Health Nutrition, Vol. 15, Issue 9: 174-1754.

Freeman M.C., Stocks M.E., Cumming O., Jeandron A., Higgins J.T., Wolf J., Pruss-Ustun A., Bonjour S., Hunter P. R., Fewtrell L. and Curtis V. (2014), "Hygiene and health: systematic review of handwashing practices worldwide and update of health effects". Tropical Medicine and International Health, Vol. 19, No. 8: 906-916.

Girma, M., Hussein, A., Norris, T., Genye, T., Tessema, M., Bossuyt, A., Hadis, M., Cornelia van Zyl, Goyol, K., Samuel, A., (2021), "Progress in water, sanitation and hygiene (WASH) coverage and potential contribution to the decline in diarrhea and stunting in Ethiopia. Maternal and Child Nutrition. 10.1111/mcn.13280. pp 1–13.

Gizaw, Z. and Worku A. (2019), "Effects of single and combined water, sanitation and hygiene (WASH) interventions on nutritional status of children: A systematic review and meta-analysis". Italian Journal of Pediatrics, Vol. 45, Issue 77: 2 -14.

Government of Kenya (2011), Kenya National Micronutrient Survey.

Government of Kenya (2015), Kenya Demographic and Health Survey 2014.

Hammer, J. and Spears, D. (2013). Village sanitation and children's human capital - Evidence from a randomized experiment by the Maharashtra Government. Policy Research Working Paper 6580. The World Bank Sustainable Development Network Water and Sanitation Programme.

Huuhtanen, S. and Laukkanen, A. (2006), A guide to sanitation and hygiene for those working in developing countries. Available at https://www.ircwash.org/sites/default/files/Huuhtanen-2006-Guide.pdf.

Head, J.R., Pachón, H., Tadesse,W., Tesfamariam, M and Freeman, M.C. (2019), "Integration of water, sanitation, hygiene and nutrition programming is associated with lower prevalence of child stunting and fever in Oromia, Ethiopia". Africa Journal of Food, Agriculture, Nutrition and Development, Vol. 19, Issue 4: 14971-14993.

Heimera Jakob, Staudachera Olga, Steinera Florian, Kayongab Yvette, Havugimanac Jean Marie, Musemakweric Andre, Harmsa Gundel, Gahutuc Jean-Bosco, Mockenhaupta

Frank P., (2015), “Age-dependent decline and association with stunting of Giardia Duodenalis infection among schoolchildren in rural Huye district, Rwanda”. Acta Tropica, Vol. 145: 17–22.

Kenya National Bureau of Statistics (1989), Kenya Population and Housing Census.

Kenya National Bureau of Statistics (1999), Kenya Population and Housing Census.

Kenya National Bureau of Statistics (2009), Kenya Population and Housing Census.

Kenya National Bureau of Statistics (2019), Kenya Population and Housing Census.

Khan A.Y, Fatima K., Ali M. (2021), “Sanitation ladder and undernutrition among under-five children in Pakistan”. Environmental Science Pollution Resistance International. August 28(29): 38749-38763. doi: 10.1007/s11356-021-13492-7. Epub 2021 Mar 19. PMID: 33740192.

Kirolos A, Goyheneix M, Kalmus Eliasz M, et al (2022), “Neurodevelopmental, cognitive, behavioural and mental health impairments following childhood malnutrition: A systematic review”. Biological Medical Journal Global Health, Vol. 7: 1-14.

Mara, D. (2017), “Elimination of open defecation and its adverse health effects: A moral imperative for governments and development professionals”. Journal of Water, Sanitation and Hygiene for Development, Vol. 7, Issue 1: 1-12.

Ministry of Health, Kenya Environmental Sanitation and Hygiene Policy 2016-2030.

Mshida, H.M., Kassim, N., Mpolya, E., Kimanya, M. (2018), “Water, sanitation, and hygiene practices associated with nutritional status of under-five children in semi-pastoral communities Tanzania”. American Journal of Tropical Medicine and Hygiene, Vol. 98, Issue 5: 1242–1249.

Owino V, Ahmed T, Freemark M, et al. (2016), “Environmental enteric dysfunction and growth failure/stunting in global child health”. Pediatrics, Vol. 138, Issue 6: 1-10.

Rakotomanana, H., Komakech, J.J., Walters, C.N. and Stoecker, B.J. (2020), “The WHO and UNICEF Joint Monitoring Programme (JMP) Indicators for Water Supply, Sanitation and Hygiene and Their Association with Linear Growth in Children 6 to 23 Months in East Africa”. International Journal of Environmental Research and Public Health, Vol. 17, Issue 6262: 1-14.

Saxton Jennifer, Rath Shibanand, Nair Nirmala, Gope Rajkumar, Mahapatra Rajendra, Tripathy Prasanta and Prost (2016), “Handwashing, sanitation and family planning practices are the strongest underlying determinants of child stunting in rural indigenous communities of Jharkhand and Odisha, Eastern India: A cross-sectional study”. Maternal and Child Nutrition, Vol. 12: 869-884.

Schlaudecker, E. P.; Steinhoff, M. C. and Moore, S. R. (2011), “Interactions of diarrhea, pneumonia, and malnutrition in childhood: Recent evidence from developing countries”. Current Opinion in Infectious Diseases, Vol. 24; Issue 5: 496-502.

Pickering A.J., Djebbari H., Lopez C., Coulibaly M., Alzua M.L. (2015), Lancet Global Health, Vol. 3: 701-711.

Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, M. C., Gordo, B., Hunter, P.R., Medlicott, K., and Johnston, R., (2019), “Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low and middle-income countries”. International Journal of Hygiene and Environmental Health, Vol. 222: 765 -777.

United Nations Children's Fund - UNICEF and the World Health Organization - WHO (2020), State of the world's sanitation: An urgent call to transform sanitation for better health, environments, economies and societies.

United Nations Children's Fund, World Health Organization, International Bank for Reconstruction and Development/World Bank (2021), Levels and trends in child malnutrition: Key findings of the 2021 edition of the joint child malnutrition estimates.

UNICEF (2020), Desk review: Kenya CLTS Protocol.

UNICEF (2018), UNICEF's game plan to end open defecation.

Water and Sanitation Programme (2012), Kenya economic impacts of poor sanitation in Africa study.

World Health Organization - WHO (2019), Water, sanitation, hygiene and health: A primer for health professionals.

World Health Organization and the United Nations Children's Fund (2021), Progress on household drinking water, sanitation and hygiene 2000-2020: Five years into the SDGs.

Yantio, D.Y. (2015), Impact of water supply and sanitation on diarrhoea prevalence among children under the age of five: evidence from Cameroon, 3ie Grantee Final Report. New Delhi: International Initiative for Impact Evaluation (3ie).

Zach, W., Ian, R., Tomas, L. and Peter, B. (2017), Value for money in the water, sanitation and hygiene sector. Collaborative Africa Budget Reform Initiative (CABRI) Policy Dialogue - Keynote Paper: Key policy challenges and opportunities for improving service delivery in water, sanitation and hygiene (WASH) in Africa.

Annex

Table 1: Undernutrition Classification by Sanitation Classification in 47 Counties

	Households	Main Sewer (%)	Population density persons per sq km	Open/ Bush (%)	OD Classification	Stunting (%)	Stunting Category	Wasting (%)	Wasting Category
TURKANA	62,627	0.4	14	68.1	High	23.9	high	22.9	very high
SAMBURU	63,951	0.4	15	65.6	High	30.1	very high	13.6	High
TANA RIVER	66,984	0.8	8	48.6	High	28.1	high	5.1	medium
MARSABIT	76,689	0.1	6	47.4	High	26.5	high	16.3	very high
WAJIR	126,878	1.7	14	43.6	High	26.4	high	14.2	High
WEST POKOT	115,761	0.2	68	42.7	High	45.9	very high	14.3	High
MANDERA	123,954	1.2	33	39.4	High	36.1	very high	14.8	High
GARISSA	138,940	5.2	19	36.2	High	15.6	medium	11.4	High
KWALE	172,802	0.9	105	31.7	High	29.7	high	4.4	Low
BARINGO	141,877	0.3	61	30.8	High	29.5	high	6.9	medium
ISIOLO	53,217	4	11	30.6	High	19.1	medium	9.1	medium
NAROK	238,115	0.5	65	28.2	High	32.9	very high	2.4	very low
LAMU	34,231	2.1	23	17.9	High	29.2	high	4.2	low
KILIFI	297,990	2.4	116	17	High	39.1	very high	4.1	low
KAJIADO	313,218	2.8	51	13.6	High	18.2	medium	3	low
HOMA BAY	260,290	1.1	359	10.2	Moderate	18.7	medium	2.3	very low
LAIKIPIA	145,776	8.9	55	9.4	Moderate	26.9	high	4.4	low

	Households	Main Sewer (%)	Population density persons per sq km	Open/ Bush (%)	OD Classification	Stunting (%)	Stunting Category	Wasting (%)	Wasting Category
MIGORI	238,133	0.5	427	9.4	Moderate	26.4	high	4	low
KITUI	261,814	0.5	37	9.2	Moderate	45.8	very high	3.4	low
ELGEYO/MARAKWET	99,119	0.3	150	6.8	Moderate	29.9	high	4.3	low
SIAYA	249,341	0.3	393	6	Moderate	24.7	high	0.2	very low
KISUMU	296,846	4.8	554	3.6	Moderate	18	medium	0.8	very low
BUSIA	197,944	0.6	526	2.5	Moderate	22	high	2.2	very low
TAITA/TAVETA	94,468	1.1	20	2.4	Moderate	23.8	high	7.2	medium
NANDI	199,040	0.4	311	1.5	Moderate	29.9	high	3.9	low
KERICHO	205,932	1.7	370	1.5	Moderate	28.7	high	5.6	medium
MERU	423,931	0.7	220	1.4	Moderate	25.2	high	2.9	low
TRANS NZOIA	222,989	1.7	397	1.4	Moderate	29.2	high	3.9	low
BUNGOMA	357,714	1	552	1.4	Moderate	24.4	high	1.8	very low
MAKUENI	243,979	0.4	121	1.2	Moderate	25.1	high	2.1	very low
THARAKA-NITHI	109,450	0.6	153	1.1	Moderate	32.9	very high	3.3	low
KAKAMEGA	432,284	0.8	619	1.1	Moderate	28.4	high	1.8	very low
BOMET	187,230	0.3	349	1	Low	35.5	very high	1.8	very low
NYAMIRA	150,499	0.3	675	1	Low	25.5	high	4.1	low
MOMBASA	376,295	16.6	5,495	0.9	Low	21.1	high	4.1	low
MACHAKOS	399,523	5.7	236	0.9	Low	26.5	high	6.5	medium
KISII	307,254	1.9	957	0.9	Low	25.5	high	1.7	very low
NAKURU	598,237	7.7	288	0.8	Low	27.6	high	4.5	low

	Households	Main Sewer (%)	Population density persons per sq km	Open/ Bush (%)	OD Classification	Stunting (%)	Stunting Category	Wasting (%)	Wasting Category
EMBU	182,427	2.2	216	0.7	Low	26.8	high	3	low
VIHIGA	143,288	0.3	1,047	0.6	Low	23.5	high	2.6	low
UASIN GISHU	301,110	9.6	342	0.5	Low	31.2	very high	3	low
NYANDARUA	178,224	0.3	194	0.2	Low	29.4	high	2	very low
KIRINYAGA	203,576	0.7	413	0.2	Low	17.2	medium	3.9	low
MURANG'A	317,496	2.3	419	0.2	Low	19.3	medium	1.4	very low
NYERI	244,564	6.7	228	0.1	Low	15.1	medium	2.4	very low
KIAMBU	792,333	9.1	952	0.1	Low	15.7	medium	2.3	very low
NAIROBI CITY	1,494,676	54.3	6,247	0.1	Low	17.2	medium	2.5	low

source: Authors' compilation based on UNICEF 2020 and KNBS 2019)

Annex 2:

Table 2: The estimated Average Treatment Effects using the IPWRA estimator with four levels of sanitation

	b	se	z	pvalue	ll	ul
Potential Outcome Means (POMs)						
Open defecation	0.392	0.018	21.627	0.000	0.356	0.428
JMP unimproved	0.274	0.008	32.660	0.000	0.257	0.290
JMP limited	0.267	0.011	24.930	0.000	0.246	0.288
JMP basic, JMP safely managed	0.247	0.011	23.171	0.000	0.227	0.268
RA coefficients for the untreated (open defecation)						
place of residence						
urban	0					
rural	0.578	0.620	0.932	0.351	-0.638	1.793
Number of household members	0.029	0.047	0.606	0.544	-0.064	0.121
Mother’s current age	-0.008	0.019	-0.413	0.680	-0.046	0.030
Child’s age in months	0.008	0.005	1.611	0.107	-0.002	0.017
Mother’s educational attainment						
no education	0					
incomplete primary	0.349	0.135	2.591	0.010	0.085	0.613
complete primary	-0.074	0.228	-0.326	0.744	-0.522	0.373
incomplete secondary	-0.989	0.424	-2.332	0.020	-1.820	-0.158
complete secondary	1.133	0.864	1.312	0.189	-0.559	2.826
higher	-5.258	1.225	-4.291	0.000	-7.659	-2.856
wealth index						
poorest	0					
poorer	-0.229	0.165	-1.384	0.166	-0.552	0.095
middle	-0.644	0.354	-1.817	0.069	-1.338	0.050
richer	-1.914	1.099	-1.741	0.082	-4.068	0.241
richest	16.148	1.188	13.589	0.000	13.819	18.477
sex of child						
male	0					
female	-0.695	0.186	-3.740	0.000	-1.059	-0.331
constant	-1.118	0.753	-1.484	0.138	-2.595	0.358
RA coefficients for the treated group (JMP unimproved)						
place of residence						
urban	0					

	b	se	z	pvalue	ll	ul
rural	-0.078	0.103	-0.753	0.452	-0.280	0.125
Number of household members	-0.005	0.017	-0.306	0.759	-0.038	0.027
Mother's current age	-0.004	0.007	-0.617	0.537	-0.017	0.009
Child's age in months	0.009	0.002	3.822	0.000	0.004	0.014
Mother's educational attainment						
no education	0					
incomplete primary	0.011	0.146	0.073	0.942	-0.275	0.297
complete primary	-0.210	0.154	-1.361	0.173	-0.512	0.092
incomplete secondary	-0.232	0.187	-1.236	0.216	-0.599	0.136
complete secondary	-0.391	0.218	-1.796	0.072	-0.818	0.036
higher	-0.237	0.310	-0.763	0.445	-0.844	0.371
wealth index						
poorest	0					
poorer	-0.311	0.090	-3.435	0.001	-0.488	-0.133
middle	-0.516	0.101	-5.093	0.000	-0.714	-0.317
richer	-0.589	0.135	-4.382	0.000	-0.853	-0.326
richest	-1.219	0.239	-5.106	0.000	-1.687	-0.751
sex of child						
male	0					
female	-0.577	0.088	-6.597	0.000	-0.749	-0.406
constant	-0.185	0.264	-0.699	0.485	-0.702	0.333
RA coefficients for the treated group (JMP limited)						
place of residence						
urban	0					
rural	0.048	0.146	0.333	0.739	-0.237	0.334
Number of household members	0.034	0.035	0.975	0.330	-0.034	0.102
Mother's current age	-0.019	0.011	-1.703	0.089	-0.042	0.003
Child's age in months	0.008	0.003	2.248	0.025	0.001	0.014
Mother's educational attainment						
no education	0					
incomplete primary	0.160	0.215	0.744	0.457	-0.261	0.581
complete primary	-0.075	0.260	-0.287	0.774	-0.584	0.434
incomplete secondary	-0.077	0.265	-0.289	0.772	-0.596	0.443
complete secondary	-0.237	0.272	-0.871	0.384	-0.771	0.297
higher	-0.747	0.364	-2.054	0.040	-1.461	-0.034
wealth index						

	b	se	z	pvalue	ll	ul
poorest	0					
poorer	-0.064	0.189	-0.339	0.734	-0.435	0.307
middle	-0.080	0.207	-0.386	0.699	-0.486	0.326
richer	-0.423	0.243	-1.738	0.082	-0.900	0.054
richest	-0.651	0.272	-2.391	0.017	-1.185	-0.117
sex of child						
male	0					
female	-0.156	0.125	-1.244	0.213	-0.401	0.089
constant	-0.587	0.414	-1.418	0.156	-1.398	0.224
RA coefficients for the treated group (JMP basic, JMP safely managed)						
place of residence						
urban	0					
rural	0.124	0.152	0.816	0.414	-0.174	0.423
Number of household members	0.022	0.025	0.870	0.384	-0.028	0.072
Mother’s current age	-0.017	0.010	-1.712	0.087	-0.037	0.002
Child’s age in months	0.010	0.004	2.839	0.005	0.003	0.017
Mother’s educational attainment						
no education	0					
incomplete primary	0.062	0.241	0.259	0.796	-0.410	0.535
complete primary	-0.027	0.247	-0.111	0.912	-0.512	0.457
incomplete secondary	-0.249	0.284	-0.879	0.379	-0.805	0.306
complete secondary	-0.294	0.287	-1.023	0.306	-0.857	0.269
higher	-0.330	0.308	-1.072	0.284	-0.933	0.273
wealth index						
poorest	0					
poorer	-0.448	0.180	-2.492	0.013	-0.800	-0.096
middle	-0.745	0.188	-3.958	0.000	-1.114	-0.376
richer	-0.915	0.197	-4.635	0.000	-1.301	-0.528
richest	-1.348	0.262	-5.134	0.000	-1.862	-0.833
sex of child						
male	0					
female	-0.599	0.123	-4.854	0.000	-0.841	-0.357
constant	-0.218	0.442	-0.494	0.621	-1.084	0.647
coefficients for the logit treatment model (JMP unimproved)						
place of residence						
urban	0					

	b	se	z	pvalue	ll	ul
rural	-0.838	0.105	-8.021	0.000	-1.043	-0.634
Number of household members	-0.008	0.014	-0.536	0.592	-0.035	0.020
Mother's current age	0.023	0.005	4.579	0.000	0.013	0.033
Child's age in month	0.002	0.002	1.266	0.206	-0.001	0.006
Mother's educational attainment						
no education	0					
incomplete primary	1.525	0.085	18.018	0.000	1.359	1.691
complete primary	1.764	0.102	17.350	0.000	1.565	1.963
incomplete secondary	1.992	0.156	12.766	0.000	1.686	2.297
complete secondary	2.190	0.231	9.483	0.000	1.737	2.643
higher	2.307	0.733	3.148	0.002	0.871	3.743
wealth index						
poorest	0					
poorer	2.270	0.085	26.577	0.000	2.103	2.437
middle	3.446	0.149	23.099	0.000	3.154	3.739
richer	5.072	0.473	10.731	0.000	4.145	5.998
richest	5.357	0.999	5.364	0.000	3.400	7.315
sex of child						
male	0					
female	-0.140	0.065	-2.159	0.031	-0.267	-0.013
number of critical times members wash hands with soap						
No wash	0.000					
One time	-0.248	0.099	-2.500	0.012	-0.443	-0.054
Twice	0.392	0.096	4.082	0.000	0.204	0.580
Thrice	0.238	0.181	1.312	0.190	-0.118	0.594
Four times	0.673	0.403	1.671	0.095	-0.116	1.462
Five times	1.785	0.478	3.732	0.000	0.848	2.723
constant	-1.735	0.196	-8.844	0.000	-2.120	-1.351
coefficients for the logit treatment model (JMP limited)						
place of residence						
urban	0					
rural	-2.042	0.106	-19.316	0.000	-2.249	-1.835
Number of household members	-0.153	0.020	-7.759	0.000	-0.191	-0.114
Mother's current age	0.009	0.006	1.462	0.144	-0.003	0.021
Child's age in months	0.002	0.002	1.031	0.302	-0.002	0.007
Mother's educational attainment						

	b	se	z	pvalue	ll	ul
no education	0					
incomplete primary	0.603	0.107	5.615	0.000	0.392	0.813
complete primary	0.922	0.122	7.541	0.000	0.683	1.162
incomplete secondary	1.124	0.175	6.435	0.000	0.781	1.466
complete secondary	1.325	0.241	5.488	0.000	0.852	1.798
higher	1.278	0.739	1.730	0.084	-0.170	2.726
wealth index						
poorest	0					
poorer	1.938	0.110	17.670	0.000	1.723	2.153
middle	3.487	0.164	21.314	0.000	3.166	3.808
richer	6.037	0.476	12.675	0.000	5.104	6.971
richest	6.942	0.996	6.972	0.000	4.991	8.894
sex of child						
male	0					
female	-0.117	0.076	-1.540	0.124	-0.265	0.032
Number of critical times members wash hands with soap						
No wash	0					
One time	0.100	0.116	0.856	0.392	-0.128	0.327
Twice	0.207	0.111	1.868	0.062	-0.010	0.425
Thrice	0.068	0.194	0.349	0.727	-0.312	0.448
Four times	0.696	0.424	1.641	0.101	-0.135	1.528
Five times	1.330	0.501	2.654	0.008	0.348	2.312
constant	0.156	0.213	0.734	0.463	-0.261	0.574
coefficients for the logit treatment model (JMP basic, JMP safely managed)						
place of residence						
urban	0					
rural	-0.910	0.118	-7.688	0.000	-1.142	-0.678
Number of household members	0.113	0.016	7.125	0.000	0.082	0.145
Mother’s current age	0.033	0.006	5.543	0.000	0.021	0.044
Child’s age in month	0.006	0.002	2.539	0.011	0.001	0.010
Mother’s educational attainment						
no education	0					
incomplete primary	0.762	0.109	7.018	0.000	0.549	0.975
complete primary	1.163	0.124	9.352	0.000	0.919	1.407
incomplete secondary	1.537	0.178	8.632	0.000	1.188	1.886
complete secondary	1.898	0.240	7.894	0.000	1.427	2.369

	b	se	z	pvalue	ll	ul
higher	2.901	0.732	3.963	0.000	1.466	4.335
wealth index						
poorest	0					
poorer	2.254	0.111	20.327	0.000	2.037	2.471
middle	3.790	0.165	22.998	0.000	3.467	4.113
richer	6.126	0.477	12.838	0.000	5.191	7.061
richest	7.785	1.001	7.780	0.000	5.824	9.746
sex of child						
male	0					
female	-0.167	0.075	-2.221	0.026	-0.315	-0.020
Number of critical times members wash hands with soap						
No wash	0					
One time	-0.026	0.119	-0.217	0.828	-0.259	0.207
Twice	0.291	0.110	2.641	0.008	0.075	0.506
Thrice	0.077	0.196	0.396	0.692	-0.306	0.461
Four times	0.806	0.422	1.912	0.056	-0.020	1.633
Five times	1.049	0.502	2.089	0.037	0.065	2.033
constant	-3.663	0.237	-15.431	0.000	-4.129	-3.198

ISBN: 978 9914 738 02 5