

Relationship between water, sanitation, hygiene, and nutrition: what do Link NCA nutrition causal analyses say?

JOVANA DODOS, BLANCHE MATTERN,
JEAN LAPEGUE, MATHIAS ALTMANN,
and MYRIAM AIT AISSA

Defined by UNICEF as ‘the outcome of insufficient food intake and repeated infectious diseases’, undernutrition is one of the world’s most serious problems, with long-lasting harmful impacts on health and devastating consequences for social and economic development. The three main underlying causes of undernutrition, namely unsuitable or insufficient food intake, poor care practices, and infectious diseases, are directly or indirectly related to inadequate access to water, sanitation facilities, and hygiene practices (WASH). There is a growing base of evidence showing the links between poor WASH conditions, especially exposure to poor sanitation, and stunting (low height for age ratio). However, the effects of WASH interventions on wasting (low weight for height ratio) and the impact of environmental enteric dysfunction (chronic infection of small intestine caused by extended exposure to faecal pathogens) on undernutrition should be explored further. Action Against Hunger (Action Contre la Faim) promotes a participatory nutrition causal analysis, the Link NCA methodology, which is used to analyse complex, dynamic, locally specific causes of undernutrition. This article aims to assess the main findings from 12 most recent Link NCA studies, conducted from the beginning of 2014 until the end of 2016. Results show that inadequate WASH conditions are often identified as major contributors to undernutrition in the study areas. The article also provides lessons learned and a set of practical recommendations for better alignment and integration of WASH and nutrition interventions.

Keywords: water, sanitation, hygiene, nutrition, health

IN 2015, AN ESTIMATED 156 MILLION children under five were stunted (low height for age ratio) and 50 million were wasted (low weight for height ratio), most of them living in South-east Asia and sub-Saharan Africa (UNICEF/WHO/World Bank Group, 2015). So far, global efforts to fight undernutrition have achieved some success.

Jovana Dodos (jovana.dodos@gmail.com), MPH, is a public health consultant; Blanche Mattern (bmatter@actioncontrelafaim.org) is a Link NCA technical expert; Dr Jean Lapègue (jlapegue@actioncontrelafaim.org) is a senior WASH advisor; Mathias Altmann (maltmann@actioncontrelafaim.org) is an operational research advisor; Myriam Ait Aissa (maitaissa@actioncontrelafaim.org) is a research and analyses coordinator, all at Action Contre la Faim, France.

© Practical Action Publishing, 2017, www.practicalactionpublishing.org
<http://dx.doi.org/10.3362/1756-3488.17-00005>, ISSN: 0262-8104 (print) 1756-3488 (online)

The prevalence of stunted children has fallen from 36.9 per cent in 1990 to 23.8 per cent in 2015 (IFPRI, 2016). However, global wasting prevalence among children under five has remained stable and billions of people still suffer from vitamin and mineral deficiencies. Despite the substantial headway that has been made, undernutrition remains the largest underlying factor for disease in children under five, accounting for 3.1 million child deaths annually (Black et al., 2013).

At the most immediate level, undernutrition is the outcome of inadequate dietary intake and repeated infectious diseases (Blössner and de Onis, 2005). The underlying determinants include food insecurity, inappropriate care practices, poor access to health care, and an unhealthy environment, including inadequate access to water, sanitation, and hygiene (UNICEF, 1990).

Figure 1 illustrates multiple pathways, both direct and indirect, through which faecal bacteria come into contact with humans and demonstrates the dependence of nutritional status on the WASH environment. Poor WASH conditions facilitate ingestion of faecal pathogens, which leads to diarrhoea, intestinal worms, and environmental enteric dysfunction, a 'chronic infection of the small intestine caused by extended exposure to fecal pathogens' (Humphrey, 2009). This directly relates to the body's ability to resist and respond to sickness by affecting the absorption of nutrients and decreasing the body's immunity (Rodríguez et al., 2011). Other water and sanitation-related illnesses (e.g. malaria, dengue, leishmaniasis, trypanosomiasis, yellow fever), together with chronic poisoning due to poor chemical quality of water, also contribute to the deterioration of nutritional status (Action Contre la Faim, 2011, 2014a).

Indirect links between WASH and nutrition refer primarily to a broader socio-economic environment such as access and affordability of water, sanitation, and hygiene services, distance from the household to a water point, education, and poverty. Time wasted on water collection translates into decreased productivity, lower school attendance, and less time for caring for children and the household (Cairncross et al., 2013). Inadequate access to water and sanitation impacts the educational success of school-age children, resulting in reduced opportunity to work, perpetuated poverty, and undermined household food security – the underlying causes of maternal and child undernutrition (Action Contre la Faim, 2011, 2014b).

Numerous publications and studies have reported that improvements in drinking water, sanitation facilities, and hygiene practices have positive effects on disease reduction (Curtis and Cairncross, 2003; Luby et al., 2005; Wolf et al., 2014). When carried out effectively and at scale, WASH interventions have the potential to bring significant health and non-health benefits (Brown et al., 2011; Fewtrell et al., 2005; Strunz et al., 2014; WHO, 2016).

Through decreasing the pathogen load in the environment and overcoming the causes of infectious diseases such as diarrhoea, intestinal worms, and environmental enteric dysfunction, WASH interventions lead to improvements in nutritional status (Dangour et al., 2013; Prüss-Ustun et al., 2008). A growing base of evidence indicates that WASH interventions can positively impact stunting incidence rates, with the greatest effect on children under the age of 2 years (Dangour et al., 2013). For example, it was found that Peruvian children at 2 years old with the worst conditions for water source, water storage, and sanitation were 1 cm shorter than children with

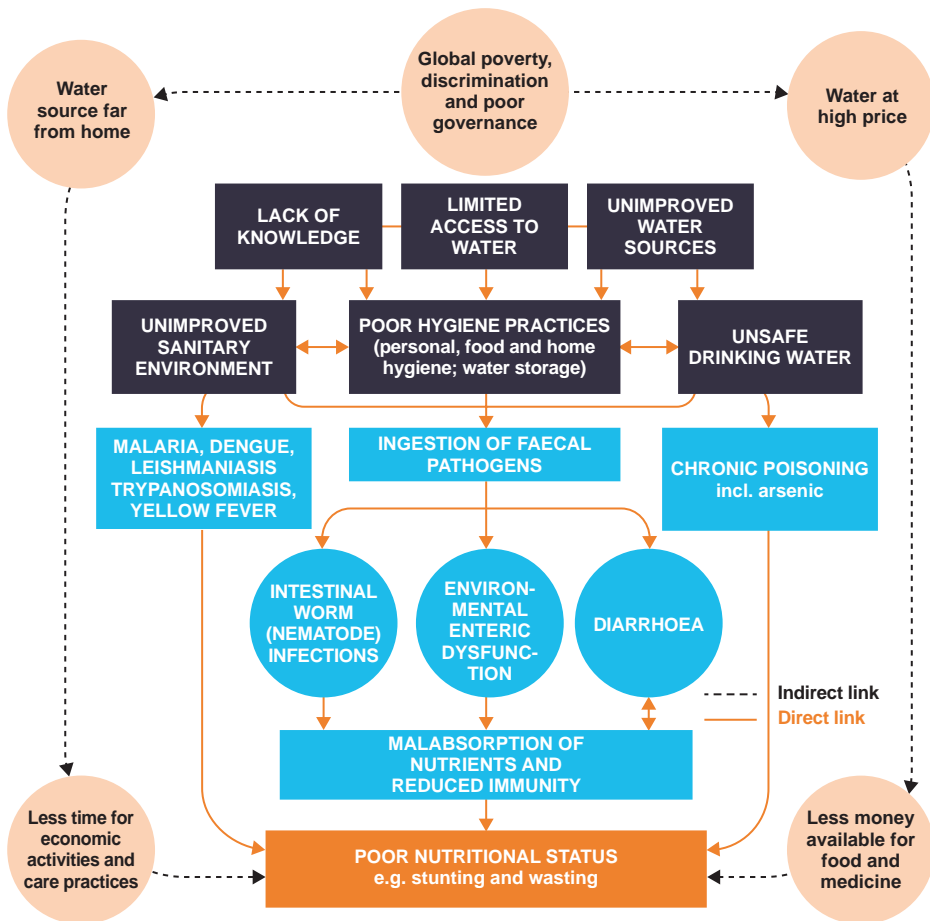


Figure 1 Relationship between poor WASH environment and poor nutritional status
 Source: Dangour et al. (2013), adapted by Dr J. Lapègue, Action Contre la Faim (2014c)

the best conditions (Checkley et al., 2004). Analysis of cross-sectional data from 65 countries reports that open defecation explains 54 per cent of international variation in children’s height. The link is even stronger when population density is high (Spears, 2013). This suggests that India’s widespread open defecation and high population density might place children at increased risk of stunting and may help explain the ‘Asian enigma’: despite the increase in economic growth, children in Asia are shorter on average than those in Africa, who are poorer (Spears, 2013).

While the evidence regarding the consequences of poor WASH conditions (principally exposure to poor sanitation) on stunting is growing, the effects of WASH interventions on wasting are still to be explored. It should be noted, however, that wasting and stunting share mainly common direct and underlying risk factors and follow similar causal pathways (WHO, 2014b). This indicates that WASH interventions may also play a role in reducing wasting. More data is needed to demonstrate

how and in which ways specific WASH mechanisms affect nutrition outcomes and determine which implementation modalities are most likely to lead to strong and sustained impact on nutritional status.

The Link NCA methodology

In order to strengthen the analytical foundation on which its programmes are built, Action Against Hunger (Action Contre la Faim) invested in the development of a structured method for conducting a nutrition causal analysis (NCA), which it has called the 'Link NCA' (www.linknca.org). This is a method for analysing the multiple causes and mechanisms leading to undernutrition as a starting point for improving the relevance and effectiveness of multisectoral (WASH, health, food security, mental health, and care practices) nutrition security programming in a given context. Since the causes of undernutrition often differ from one location to another (Action Contre la Faim, 2015), the purpose of this method is to go beyond generic interventions by identifying context-specific determinants of nutritional status in order to propose adequate and sustainable solutions.

The draft protocol for the method was designed by a small group of researchers and technical experts. Action Against Hunger then formed a multidisciplinary scientific committee to provide feedback on the draft protocol. The protocol was then field-tested within Action Against Hunger's operational settings in Zimbabwe and Bangladesh, where it was assessed for its ability to yield plausible results, using accepted scientific research methods, while also being operationally feasible and relevant for Action Against Hunger's programming decisions. Based on the results of these initial field tests, the method was overhauled, reviewed again by the scientific committee, and field-tested in Burkina Faso. After the field test in Burkina Faso produced results in line with the method's objectives and criteria, guidelines for conducting a Link NCA were designed and published in late 2014.

The Link NCA employs a mixed-methods approach, combining both qualitative and quantitative research methods, and draws conclusions from a synthesis of results. The Link NCA relies on quantitative surveys to assess undernutrition status and the prevalence of known risk factors, including WASH-related ones. Qualitative methods are incorporated throughout the protocol to address questions regarding how and why undernutrition occurs, as well as to consider the interactions between causes, common feedback loops, and the evolution of the causes through time, seasons, and following shocks. The information generated from multiple data sources is triangulated and reviewed through a participatory process to generate consensus on undernutrition causality and better inform programmes (Action Contre la Faim, 2017).

Figure 2 provides an overview of the Link NCA process, from the initial preparatory phase and point at which Link NCA study is considered to the point at which results are used to guide nutrition security interventions and/or to advocate for changes in policies affecting the condition of undernutrition.

In the preparatory phase, technical experts from the organization that is planning to conduct the Link NCA study meet to discuss the relevance and feasibility of this type of study in a given context. If there is sufficient justification and a decision to conduct the

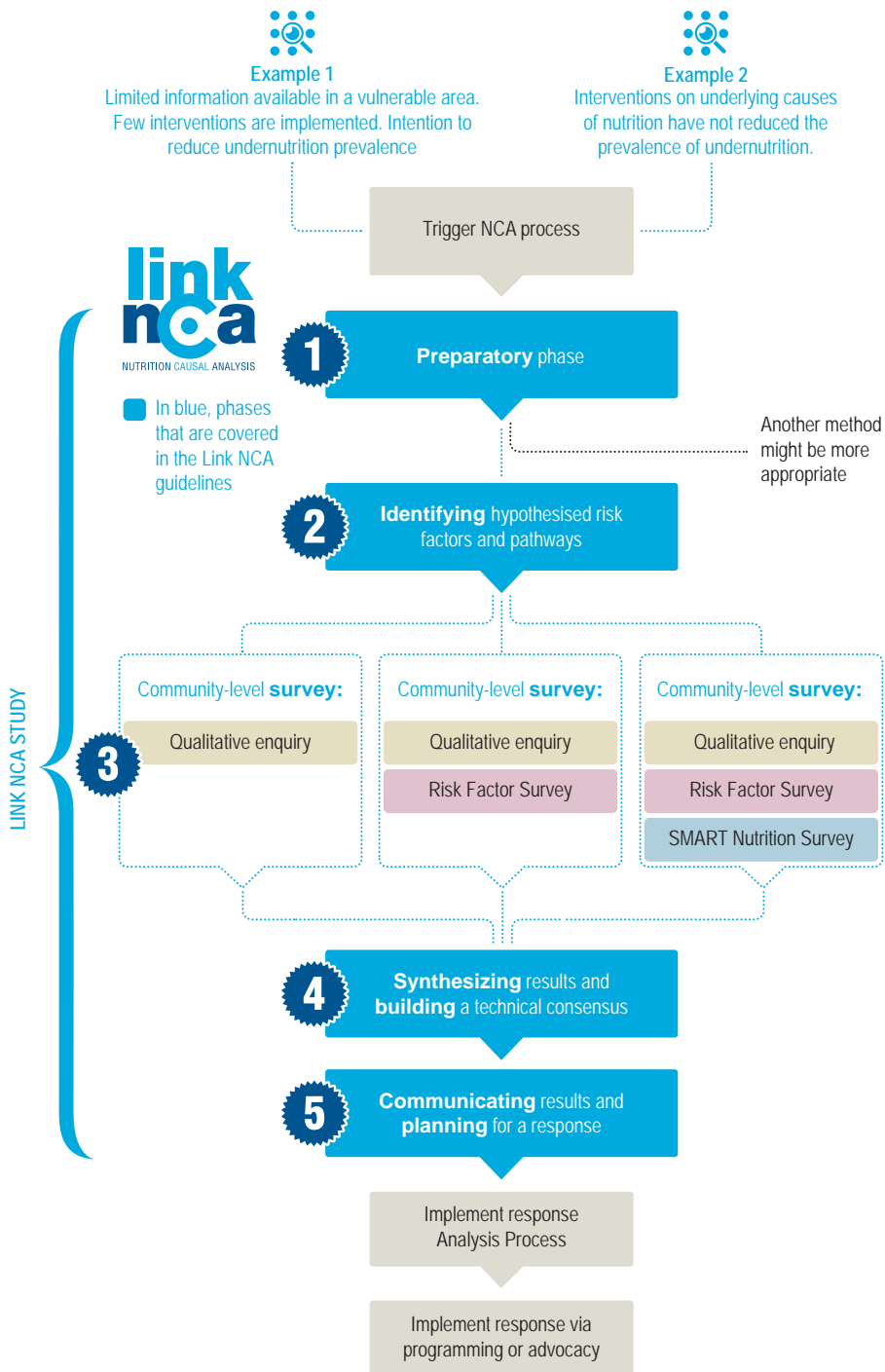


Figure 2 Steps in the Link NCA process
Source: Action Contre la Faim (2015)

study is made, technical experts then determine other key parameters such as nutrition problem (will the focus be on stunting, wasting, or both?), specific study objectives, target group and geographic coverage, timing and resources needed.

Prior to conducting the Link NCA study, ethical approval is obtained from the appropriate local or national authority. Also, informed consents are obtained from all participants in the Link NCA studies.

In the second step of the process, a Link NCA analyst is recruited to carry out an in-depth review of secondary data sources (official statistics, reports, academic studies, and locally available grey literature), organize interviews with key informants and, if necessary, conduct field visits. After acquiring a good understanding of the overarching environment, the Link NCA analyst generates a set of preliminary hypotheses about the risk factors and pathways, suggesting possible mechanisms of association between risk factors and undernutrition in the study context.

The following is an example of one preliminary hypothesis:

Hypothesis P (Figure 3): Inadequate access to safe drinking water due to surface water being the main source of water, and long distance (and time) to collect water. Description of the hypothesis: Inadequate and/or poor access to safe drinking water is directly related to high prevalence of diseases and can impact negatively children's nutritional status. The major source of water (pond, 42%) is surface water, which might be easily contaminated due to various pollutants. Besides, surface water is directly depending on the climate condition and from time to time the water sources are getting dry. Almost 31% of the population in the targeted area take 1h30 to 3h00 to fetch water, meaning that they are most likely to collect less water than needed to satisfy basic water needs (Action Contre la Faim/USAID/ECHO, 2016).

The preliminary hypotheses are then presented and debated in a one-day workshop with technical experts chosen for both their knowledge of the local context and expertise in one of the nutrition security pillars (nutrition, health, care practices, food security and livelihoods, WASH, anthropology, sociology, economy). The objective of this technical experts' workshop is to review, reject, or validate preliminary hypotheses on risk factors and pathways to undernutrition proposed by the Link NCA analyst as well as to reach a consensus around the hypotheses to be field-tested and further explored during the community-level data collection. The workshop also provides an opportunity to formulate new hypotheses on risk factors and pathways to undernutrition that might have been missed in the previous stage of the process.

The next step in the process involves community-level data collection. This component of the Link NCA methodology aims at going beyond technical data by exploring the specificities of a local context, the challenges vulnerable and marginalized groups are facing, and unique factors that are contributing to the community's nutritional vulnerability. All data collection at the community level includes a qualitative enquiry, focused on:

- understanding how communities define and perceive undernutrition;
- exploring communities' perceptions of the causes and consequences of poor food security, WASH, health, and care in relation to undernutrition;

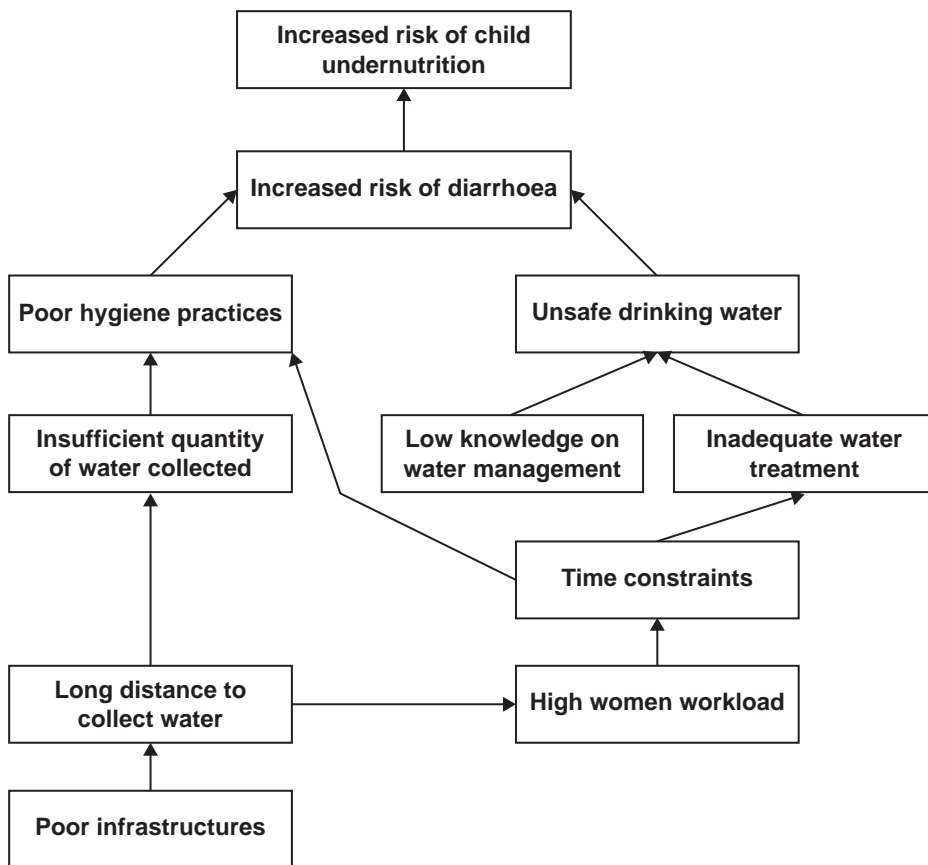


Figure 3 Hypothesized causal pathway of inadequate access to safe drinking water to undernutrition
 Source: Action Contre la Faim/USAID/ECHO (2016)

- identifying seasonal and historical trends of undernutrition and risk factors;
- understanding how communities prioritize these risk factors.

This qualitative component is mainly based on pretested, semi-structured research instruments. Clusters (in the Link NCA guidelines typically used to refer to a village in a rural setting) are randomly selected within the study area. In some studies, the Link NCA analyst starts by zoning the area to better understand key parameters and then randomly selects the clusters (e.g. random selection of the clusters close to the market versus clusters that are more isolated). Within the clusters, participants are purposively selected. Four types of participants, namely community leaders, key informants (e.g. community health workers, traditional healers), mothers and fathers of children under five, and caregivers of positive and negative deviant children are intentionally chosen, based on the usefulness of information they are likely to provide. Depending on the study objectives and the context, the Link NCA analyst may choose to interview other participants such as adolescents and grandparents.

If recent, representative, and good quality secondary data is available, the quantitative component of the community level data collection is optional. If secondary data is not available or sufficient to draw firm conclusions, this step of the Link NCA process may include a SMART nutrition survey, used to estimate the prevalence of undernutrition among children under five, and/or a risk factor survey, a cross-sectional survey used to estimate the magnitude and severity of key risk factors.

All Link NCA studies are looking at several WASH indicators: household access to safe water source and water management, quantity of water per capita per day, use of hygienic and safe sanitation facilities, presence of soap or ashes in the household, and hygiene practices. According to the hypotheses identified, Link NCA studies can include some other context-specific WASH indicators such as animal waste management or child body cleanliness.

Once the data collection is complete, the Link NCA analyst works on synthesizing various outputs and evidence gathered throughout the Link NCA process in order to assign a preliminary rating to the hypothesized risk factors. The hypothesized risk factors are rated as 'rejected', 'minor', 'important', or 'major' based on their relative contribution to undernutrition. The risk factors can also be deemed 'untested' when not enough information was gathered to reach a conclusion.

During the fourth step of the Link NCA study, technical experts from funding agencies, NGOs, universities, and government representatives from different sectors are invited to the final workshop to discuss the findings, decide which factors are the most relevant for explaining undernutrition in the study area, validate or update risk factor ratings proposed by the Link NCA analyst, and generate consensus about the plausible causes of undernutrition. As part of the process, these stakeholders are also asked to provide confidence notes on each result of the Link NCA study. The confidence note is a temperature tool assessing how reliable stakeholders deem the findings related to a particular risk factor to be (high, medium, or low). The confidence notes are based on the perceived strength of the information and evidence gathered for each risk factor and pathway. A high confidence note is not scientific proof of causality but rather conveys that a large majority of stakeholders, after reviewing the quality of the data triangulated from several sources, are similarly convinced of the causal relevance of the risk factor.

Following this final workshop, the Link NCA results are presented to operational stakeholders and to the communities that participated in the study. The Link NCA study concludes with a set of agreed recommendations and steps forward to improve multisectoral nutrition security programming. Subsequently, the operational team might also implement a response analysis to decide which recommendations to implement and how to implement them.

Human and logistic resources needed to conduct the Link NCA study vary greatly from one context to another and depend on certain key study parameters, such as whether or not a SMART nutrition survey and/or a risk factor survey will be included in the process. Some rough estimates, based on the past experiences, show that it takes between four and five months to complete the study, involving a team of five (if secondary data is available and no additional surveys will be included

in the process) to approximately 29 people (if SMART/risk factor surveys are to be conducted). The Link NCA study in Burkina Faso took four months to complete and cost a total of €45,000 in 2012 (Action Contre la Faim, 2015).

Since 2010, Action Against Hunger has produced 23 Link NCA studies all around the world and, at the time of writing this article, seven were ongoing. This article discusses the results of 12 most recent Link NCA studies, conducted from the beginning of 2014 until the end of 2016, in the following countries: Bangladesh (Sathkira district, 2014), Cambodia (Choam Ksant district, Preah Vihear province, 2016), Chad (Abdi district, Ouaddai region, 2015), Democratic Republic of Congo (DRC- Kasai Occidental, 2014), Ethiopia (Sidama, 2014), Ethiopia (Harargue, 2014), Ethiopia (Borena, 2016), India (Khaknar block, Bhuranpur district, 2014), Kenya (West Pokot county, 2015), Mauritania (Guindimakha, 2016), the Philippines (Province of Masbate, 2014), and Uganda (Karamoja, 2016).

Results presented in this article have been jointly analysed by independent research consultant, WASH, and Link NCA technical experts from Action Against Hunger. Descriptive statistics have been used to summarize the results per Link NCA study. Studies are then grouped according to the region where they were conducted (Africa or Asia) and results are compared between the regions. Graphic analyses have been used to present the overall (total) results from 12 Link NCA studies as well as segregated results by sector/risk factor category and region.

In each of these 12 studies, the risk factors of undernutrition have been grouped into five categories:

- *Food security and livelihoods (FSL)*, including risk factors such as household access to enough foods, employment opportunities and sources of income, agricultural production, access to markets, and resilience to climate change.
- *Mental health and care practices (MHCP)*, including risk factors such as infant and young child feeding practices, maternal health and well-being, psychosocial care, time for childcare, quality of diets of children under five, and nutritional status of women of childbearing age. In the humanitarian domain, the term 'mental health and childcare practices' covers a broad area of issues that are often related. Grouping them in one cluster and addressing them in an integrated manner is part of Action Against Hunger's global strategy for fighting against malnutrition and hunger.
- *Health*, including risk factors such as access to health services and quality of care, prevalence of diseases in children under five, community health seeking behaviour, and immunization coverage.
- *Water, sanitation and hygiene (WASH)*, including risk factors such as access, quality and quantity of water, access and use of sanitation facilities, disposal of child faeces, hygiene practices (hand washing at critical times, use of soap, child cleanliness), and environmental hygiene (presence of open defecation in the community, presence of animal or human faeces in the household, waste disposal and management).
- *Other risks* such as discrimination based on gender, educational opportunities, tradition and beliefs.

With regard to the WASH sector specifically, results are analysed for the sector as a whole (WASH total) and for each sub-component individually, namely water, sanitation, personal hygiene, and environmental hygiene. Even though the Link NCA method rates risk factors based on the strength of their association with undernutrition as 'minor', 'important', or 'major', this article is only looking at the risk factors identified as 'major'. Major WASH risk factors that proved to be interdependent (e.g. hygiene practices and access to water) are studied together as a mechanism in which one risk factor is leading to another and jointly create a pathway to undernutrition.

Results

Table 1 shows the occurrence of risk factors that appeared as major contributors to undernutrition across 12 Link NCA studies. As can be seen, the occurrence of WASH (23), FSL (22.5), MHCP (21) and Health (18) related risk factors is approximately equal, confirming a strong presence of multiple and diverse determinants of undernutrition in the study areas. The occurrence of 'Other risks' is notably lower (9.5). Although the share of major risk factors is almost even, the proportion of WASH-related risk factors is slightly higher than for any other sector (Figure 4). However, it should be noted that mechanisms to undernutrition are often closely interrelated and that risk factors from one domain might have significant impact on the risk factors from another domain.

Results from eight studies implemented in western, central, and eastern Africa (Figure 5) show that the share of major risk factors is approximately equal: 23.1 per cent Health, 22.4 per cent WASH, 21.6 per cent FSL, 21.6 per cent MHCP, and 11.2 per cent 'Other risks'. However, the proportion of FSL and WASH-related risk factors identified as major contributors to undernutrition (29.6 per cent for each sector) in four studies implemented in South and South-east Asia (Figure 6) is larger compared with other sectors (24.1 per cent MHCP, 9.3 per cent Health, and 7.4 per cent 'Other risks').

Looking at different WASH sub-components individually, water-associated risk factors (37 per cent) seem to be the greatest concern across 12 studies, followed by sanitation and personal hygiene, which rank equally (28 per cent), and environmental hygiene (7 per cent). Nevertheless, the results from 12 Link NCA studies show notable differences between the regions. In the studies conducted in Africa (Figure 7) water-associated risk factors (40 per cent) appear to be more present when compared with the studies conducted in South and South-east Asia (31.3 per cent), in which sanitation-associated risk factors are more dominant and account for half of the WASH-related risk factors (Figure 8). Furthermore, personal hygiene appears to be of greater concern in eight African studies (36.7 per cent) than in four Asian studies (12.5 per cent), while the share of risk factors related to environmental hygiene is approximately the same in both regions, varying between 6 and 7 per cent.

Finally, it should be noted that the results from three studies conducted in Ethiopia (Sidama, Harargue, and Borena) appear to differ in the number and types of major risk factors identified, indicating the sensitivity of the Link NCA method to local context and location-specific determinants of undernutrition.

Table 1 Occurrence of the risk factors rated as 'major' in 12 Link NCA studies

Risk factor / occurrence per study	Region												Mean	Standard deviation
	Africa						Asia							
	Chad	DRC	Ethiopia (Harague)	Ethiopia (Sidama)	Ethiopia (Borena)	Kenya	Uganda	Mauritania	Bangladesh	Cambodia	India	Philippines	Occurrence sum	Occurrence proportion (%)
FSL	1	0	2	3	2	3	1	2.5	1	0	3	4	22.5	23.9
MHCP	1	2	2	2	3	1	3.5	0	2.5	0	2	2	21	22.3
WASH (total)	2	2	0	3	1	2	2	3	1	1	1	5	23	24.5
Water	1	1	0	1	1	1	0	1	0.5	0	1	1	8.5	37.0
Sanitation	0.5	0.5	0	1	0	0	0.5	0	0.5	0.5	0	3	6.5	28.3
Personal hygiene	0.5	0.5	0	1	0	1	1.5	1	0	0	0	1	6.5	28.3
Environmental hygiene	0	0	0	0	0	0	0	1	0	0.5	0	0	1.5	6.5
Health	3	2	2	2	1	1	4	0.5	1.5	1	0	0	18	19.1
Other risks	0	0	0	4	1	0	1.5	1	0	0	2	0	9.5	10.1
Total	7	6	6	14	8	7	12	7	6	2	8	11	94	100.0
														7.8
														3.2

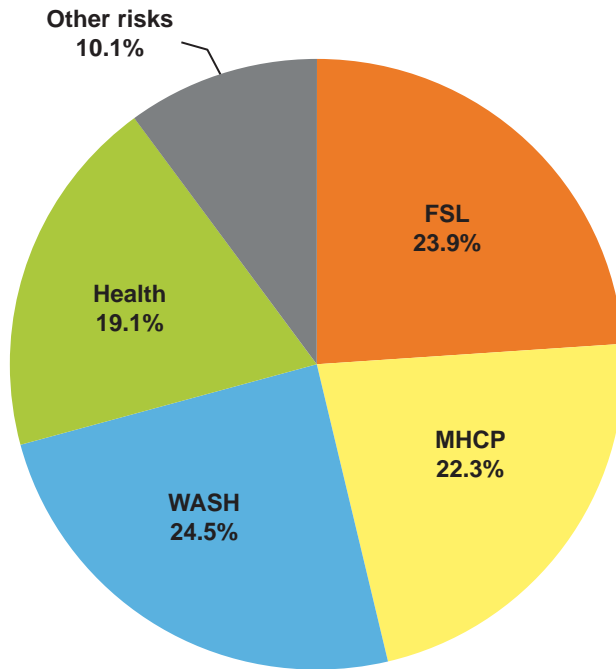


Figure 4 Proportion of risk factors identified as 'major' in 12 Link NCA studies

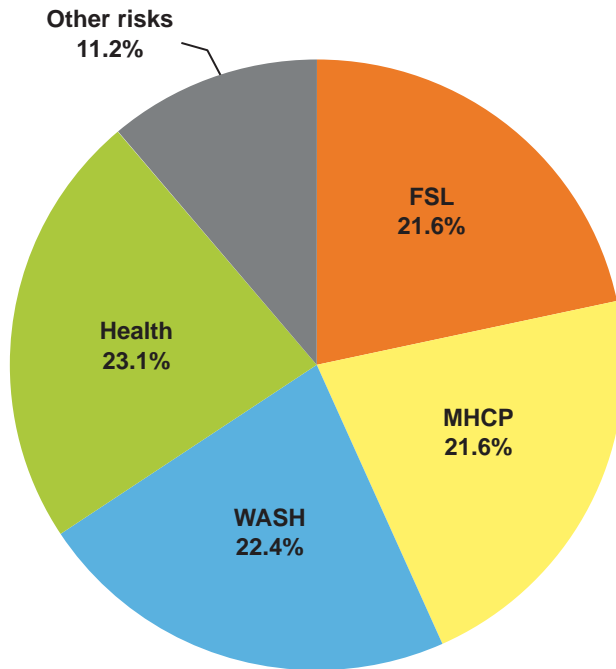


Figure 5 Share of 'major' risk factors per sector in eight African studies

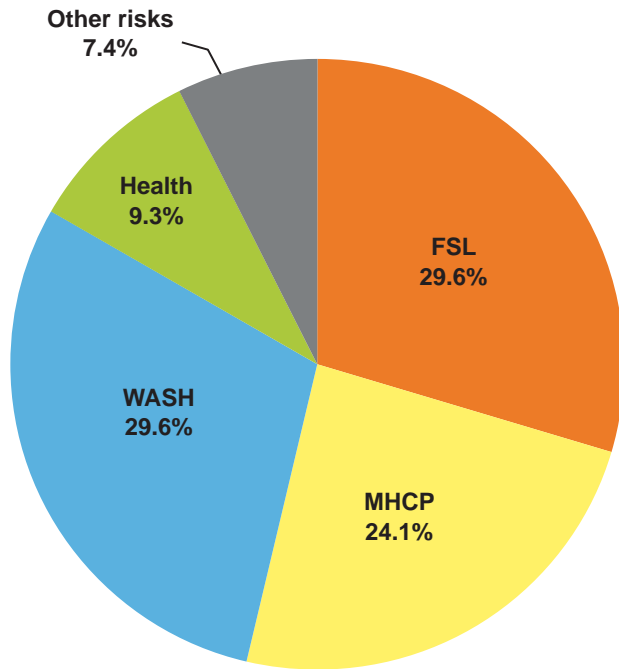


Figure 6 Share of 'major' risk factors per sector in four Asian studies

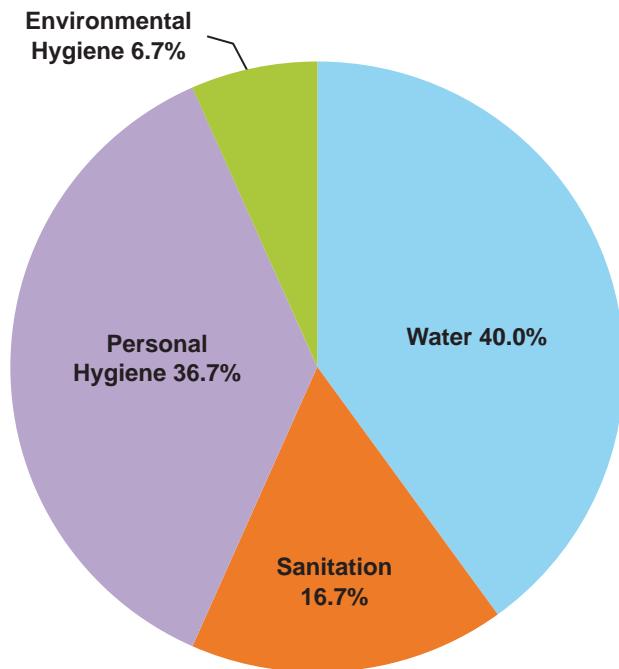


Figure 7 Proportion of different WASH components appearing as 'major' risk factors for undernutrition in African studies

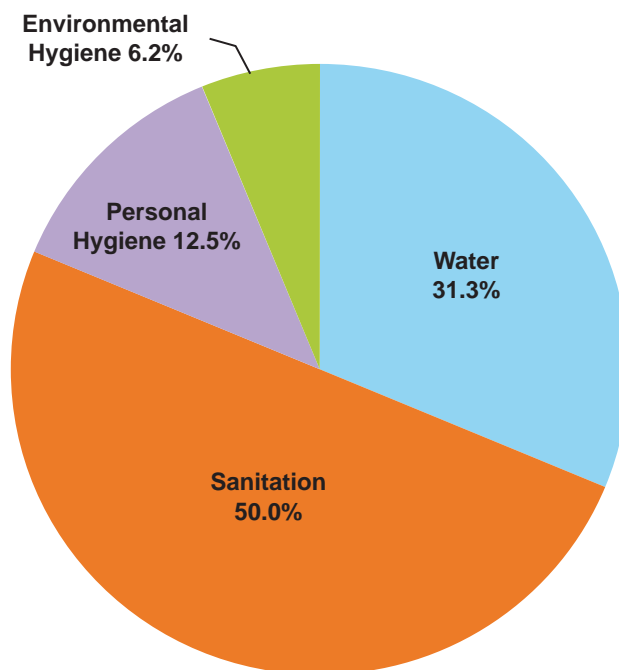


Figure 8 Proportion of different WASH components appearing as 'major' risk factors for undernutrition in Asian studies

Discussion: how to read these results

The Link NCA methodology presents a detailed, contextualized, and local model of the undernutrition causes and as such is only valid for the population studied. Consequently, the results cannot be generalized to other areas in the country where study is conducted without complementary analysis. Dissimilar findings from three Ethiopian studies, conducted in different localities within the country, confirm this.

The Link NCA methodology aims to be operationally feasible, balancing scientific rigour with field time, expertise, and resource realities. The methodology is flexible enough to be context-adapted; however, the overall process is following a sequential approach based on standardized tools and uniform protocol. Therefore, the content of the outputs is context-specific and differs for each Link NCA study, but the structure of the outputs should be consistent among studies. The steps of the method are precisely defined and have all been tested in the field. Guidance and tools are available for each step in the process. A dedicated unit of experts (Link NCA Unit) is responsible for the quality of studies and respect of the overall protocol during their implementation.

The Link NCA is built as a mix-method approach, meaning that study results should be only read considering both the findings from a qualitative enquiry and the findings from quantitative data analysis. Information derived from the

quantitative part of the study complements the qualitative information and both are equally important and necessary for obtaining an in-depth picture of diverse causes and mechanisms leading to undernutrition in a local context. Important work has been done to mitigate the risk of bias in the Link NCA studies. However, there is no zero-risk bias and the qualitative enquiry could still potentially be subject to a sampling or selection bias when choosing villages, participants or when distributing participants into different sub-groups. Self-reporting biases related to sensitive questions can happen during the quantitative assessment (e.g. on hygiene practices), where respondents tend to choose the socially desirable behaviours. As for the SMART/risk factor survey (quantitative component of community-level enquiry), data are collected at a specific point in time and present a snapshot of a situation. It is therefore important to consider overall study results according to the year when the study was conducted as well as the season, because there are seasonal variations of risk factors and undernutrition itself (e.g. seasonal peaks of diarrhoea prevalence, seasonal lack of water, seasonal peaks of wasting).

When interpreting the results, it should not be overlooked that the Link NCA study does not include statistical analyses of causality and cannot possibly lead to a causal conclusion (e.g. concluding that high undernutrition rates in the community are the result of inadequate sanitation only). Instead, it is designed to test the strength of association between different risk factors and undernutrition and to provide a strategic prioritization of risk factors with an inference of causality, relying on the triangulation of evidence from multiple sources, experts' validation, and consensus building that takes place in the final stage of the process during the stakeholders' workshop.

Drawing some general conclusions from the data out of 12 studies is challenging because of the significant differences between the regions, populations, sample sizes, and level of representativeness. Nevertheless, the authors' view rests on the assumption that aggregated results from these 12 Link NCA studies highlighted some specific priorities and patterns.

WASH plays a major role in undernutrition across multiple settings. Association between poor WASH conditions and poor nutritional status has been widely perceived by the communities. The findings show that WASH-related risk factors such as presence of open defecation practices in the community, unhygienic environments (including inadequate waste management), inconsistent access to safe water, insufficient domestic water supply, and poor hygiene practices are consistently identified as one of the main causes of undernutrition across 12 Link NCA studies.

In addition to the direct relationship perceived between WASH conditions and nutritional status, it is also important to consider the role that WASH plays within each cluster of the underlying causes of undernutrition: food security and livelihoods, health, and mental health and care practices. To illustrate, WASH affects access, availability, stability or resilience, and utilization of food resources, and significantly impacts food security (Alderman et al., 2013). Several Link NCA studies reported that water access is a common constraint for good crops, growing vegetables, and for keeping livestock. Likewise, deficient WASH is partially responsible for poor health among the populations studied. There are frequent reports of

stomach ache and intestinal problems in children, which could be symptomatic of nematode infections and environmental enteric dysfunction, both caused by a chronic exposure to faecal pathogens (Brown et al., 2011; WHO, 2014a). Frequent observations were that children are exposed to domestic animal faecal contamination (they often pick food up from the floor to eat) and that, in many instances, inadequate care practices are related to the lack of knowledge regarding environmental and personal hygiene. Poor hygiene coupled with inadequate care practices are threats to children's health and development (Mwase et al., 2016).

The Link NCA studies show that some of the major contributors to undernutrition are WASH-related issues, but also that poor WASH conditions are created by something else or included in a specific mechanism. For example, the study in Uganda (Karamoja, 2016) revealed that severe droughts forced many families to migrate from rural areas to the capital and women had to engage in income-generating activities. This, in return, decreased their time for breastfeeding and water collection from the safe source, which is far off, as well as for water treatment at home.

Therefore, the risk factors are often strongly related and dependent on each other. On that account, most of the mechanisms start from a large range of critical issues not specifically related to WASH, but combined together, those interrelated and complex issues are contributing to the creation of unhealthy environments in which specific WASH risk factors appear to be 'major' contributors to undernutrition.

Implications and recommendations for field practitioners

The multidimensional nature and causes of undernutrition call for coherent and coordinated responses that transcend traditional sector boundaries. Given the results presented, the authors recommend improving the WASH environment in all settings where exposure to faecal pathogens is an important threat to children's health and nutritional outcomes. This would require integrating different WASH components into nutrition programmes, adapting WASH interventions to include nutritional considerations; i.e. making them more nutrition-sensitive and impactful on nutrition as well as improving collaboration between WASH and nutrition actors.

There are several design characteristics that could make WASH interventions nutrition-sensitive: for instance, targeting on the basis of nutritional vulnerability. The first 1,000 days after conception have been identified as a critical point in a child's development because of the rapid process of linear growth, which mirrors brain development (Victora et al., 2010). WASH programmes targeted to this age group are therefore more likely to achieve nutritional outcomes and prevent the developmental deficits associated with early growth faltering. Likewise, WASH interventions can be implemented in a manner that protects women's time; reducing the time women spend fetching water can affect the time they have available for childcare. The Link NCA methodology emphasizes the fact that the causes of undernutrition often differ from one location to another and the main purpose is to go beyond generic interventions. Therefore, recommendations regarding the WASH interventions to be implemented are context-specific and will depend on the Link

NCA study results and risk factors identified as major contributors to undernutrition in the study area. For example, in the settings where sanitation is revealed to be a major concern, focus could be placed on reducing open defecation, latrine construction, safe disposal of children's faeces, and cleaning up environments. In some other contexts, interventions may prioritize improvement of drinking water quality, promotion of handwashing at critical times, reducing animal waste contamination, and similar.

From the operational point of view, there are several recommendations for aligning and integrating WASH and nutrition interventions in the areas where both WASH conditions and undernutrition are a concern:

- *Joint situation analysis and planning.* Conducting joint assessments by WASH and nutrition technical sectors is more likely to foster a comprehensive understanding of the situation and encourage an integrated response. The Link NCA methodology is a suitable tool to be used in this regard as it engages multidisciplinary stakeholders in causal analysis and transfers the results into multisectoral programme planning and response.
- *Co-ownership of the results.* Conclusions from the Link NCA studies indicate that a participatory process is essential for establishing accountability and co-ownership of the results. One way to incentivize sectors to work together to achieve shared objectives is to incorporate one or more specific indicators (e.g. *70 per cent of the target population demonstrate adequate and hygienically safe child feeding practices*) into the project objectives of another sector and/or to set a common specific objective for both sectors.
- *Geographical co-location of WASH interventions in nutritionally vulnerable areas.* The Link NCA outputs, among others, include visual examples of interaction among different risk factors; that is, pathway diagrams, which demonstrate where certain key interventions would be likely to have the greatest impact on undernutrition. These pathway diagrams can help the WASH sector in the selection of geographical area, level, and type of intervention. The use of relatively low-cost and easy-to-apply mapping techniques to overlay various key indicators to better understand the relationship between WASH conditions and undernutrition rates can also help improve decision-making. Mapping can be used at any geographical level (household, community, district, region) as an assessment, programme design and/or monitoring tool, but primarily, it could help ensure good geographical concentration of WASH projects in the areas with high prevalence of undernutrition.
- *WASH and nutrition co-messaging.* Several findings from the Link NCA studies suggest that timing, location, and potential synergies among interventions should be carefully thought out to ensure that activities have maximum participation without overburdening women. When communicating with the community, WASH and nutrition actors often target the same beneficiaries and aim at similar results: for example, increasing knowledge and practice of handwashing with soap at critical times among mothers/caretakers of children under five. Yet their efforts are often poorly coordinated and interventions poorly harmonized. Delivering key WASH and nutrition messages in an integrated

manner can help save resources, identify areas of overlap (e.g. discussing food hygiene practices when promoting healthy and nutritious foods), and reinforce them through joint communication channels.

- *Communication and coordination between WASH and nutrition stakeholders.* A good number of programme and policy recommendations from the Link NCA studies have highlighted the need for ensuring regular communication and information sharing among key stakeholders as well as establishing a well-coordinated management and reporting structure, if improvements in nutritional outcomes are to be achieved. The level of integration should be decided on the basis of sector capacities and context-specific conditions. Even when strong synergies are not possible, due to, for example, funding constraints or activity timetables preventing different sectors from operating as a single programme, there are still options for aligning interventions as long as there is good coordination, communication, and collaboration between actors.

For concrete guidance and examples of good practice from the field, we recommend consulting *WASH' Nutrition: A Practical Guidebook on Increasing Nutritional Impact through Integration of WASH and Nutrition Programmes* (Action Against Hunger/ UNICEF/ECHO, 2017). Any organization planning to conduct a Link NCA study can receive support from the Link NCA Technical Unit (for more information, please consult <http://linknca.org/support.htm>).

Conclusions

Factors and pathways leading to undernutrition are diverse, complex, and most of the time interconnected. The key broad factors that influence nutritional status are food, care practices, access to health care, and healthy environment, including the access to water, sanitation, and hygiene. Achieving a long-term, sustainable, and at-scale impact on undernutrition requires a multisectoral approach and addressing both direct and indirect causes of poor nutritional status.

The Link NCA methodology is a reliable tool for providing a multisectoral overview of factors affecting nutritional status within a given area, and can stimulate in-country multi-stakeholders' dialogue and trigger appropriate actions. One of the strengths of the Link NCA method is a participatory approach, which offers the opportunity for a wide range of stakeholders (from community members to technical experts) to express their opinions and perceptions regarding the causes of undernutrition as well as to discuss, review, and finally validate study conclusions. In addition, the Link NCA studies are usually followed by a response analysis exercise, which aims to ensure that the key findings are transferred into locally tailored interventions and programming.

The aggregated results from 12 Link NCA studies show that inadequate WASH conditions are often identified as a major contributor to undernutrition. WASH environment appeared to be an essential determinant of children's nutritional status both in Africa and Asia and a core enabler for other sectors such as food security and livelihoods, health, and care practices. The authors' view rests on the

assumption that the evidence is sufficient to justify and support the integration of nutrition and WASH interventions in the contexts where both poor WASH conditions and high prevalence of undernutrition are a concern.

References

Action Against Hunger/UNICEF/ECHO (2017) *WASH' Nutrition: A Practical Guidebook on Increasing Nutritional Impact through Integration of WASH and Nutrition Programs* [online] <www.actioncontrelafaim.org/fr/content/wash-nutrition-practical-guidebook-increasing-nutritional-impact-through-integration-wash> [accessed 12 February 2017].

Action Contre la Faim (2011) *Water, Sanitation and Hygiene* [pdf], ACF-International Policy, Paris: ACF <www.actioncontrelafaim.org/sites/default/files/publications/fichiers/exe_bd_wash_policy_-_eng.pdf> [accessed 12 February 2017].

Action Contre la Faim (2014a) *Greater Investment in Water, Sanitation and Hygiene is Key to the Fight against Under Nutrition* [pdf], Paris: ACF <www.coalition-eau.org/wp-content/uploads/WASH-Advocacy-En.pdf> [accessed 6 February 2017].

Action Contre la Faim (2014b) *Nutrition Security Policy* [online], Paris: ACF <www.actioncontrelafaim.org/en/content/acf-international-nutrition-security-policy> [accessed 6 February 2017].

Action Contre la Faim (2014c) *Factsheet: WASH in Nutrition* [online], Paris: ACF <<http://www.actioncontrelafaim.org/en/content/factsheet-wash-nutrition>> [accessed 10 June 2017].

Action Contre la Faim (2015) *Link NCA – Nutrition Causal Analysis Guidelines* [pdf], Paris: ACF <http://document.linknca.com//30/30/supports/2351/catDoc26/nca_guidelines_en_web-low2.pdf> [accessed 6 June 2017].

Action Contre la Faim (2017) *Link NCA – Nutrition Causal Analysis Overview* [pdf], Paris: ACF <http://document.linknca.com//30/30/supports/2353/catDoc26/nca_overview_en_web-low_170601.pdf> [accessed 6 June 2017].

Action Contre la Faim/USAID/ECHO (2016) *Link NCA report, Borena Zone, Ethiopia* [pdf], Paris: ACF <http://linknca.org/fiche/borena_zone_oromia_region1.html> [accessed 6 June 2017].

Alderman, H.H., Elder, L.K., Goyal, A., Herforth, A.W., Hoberg, Y.T., Marini, A., Ruel-Bergeron, J., Saavedra Chanduvi, J., Shekar, M., Tiwari, S. and Zaman, H. (2013) *Improving Nutrition through Multisectoral Approaches*, Working Paper, Washington, DC: World Bank <<http://documents.worldbank.org/curated/en/625661468329649726/Improving-nutrition-through-multisectoral-approaches>> [accessed 9 December 2016].

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R., Uauy, R., the Maternal and Child Nutrition Study Group (2013) 'Maternal and child undernutrition and overweight in low-income and middle-income countries', *Lancet* 382(9890): 427–51 <[http://dx.doi.org/10.1016/S0140-6736\(13\)60937-X](http://dx.doi.org/10.1016/S0140-6736(13)60937-X)>.

Blössner, M. and de Onis, M. (2005) *Malnutrition: Quantifying the Health Impact at National and Local Levels* [online], WHO Environmental Burden of Disease Series, No. 12, Geneva: World Health Organization <www.who.int/quantifying_ehimpacts/publications/eb12/en/> [accessed 7 June 2017].

Brown, J., Cairncross, S. and Ensink, J.H.J. (2011) 'Water, sanitation, hygiene and enteric infections in children', *BMJ* 98(8): 629–34 <<http://dx.doi.org/10.1136/archdischild-2011-301528>>.

- Cairncross, S., Cumming, O., Jeandron, A., Rheingans, R., Ensink, J., Brown, J., Cavill, S., Baker, S., Schmidt, W.P., Amery, J., Bibby, S., Harvey, M., Howard, G., Mulligan, J., O'Connor, H., Ryan-Collins, L., Swann, P., Wijesekera, S. and Woolnough, D. (2013) *Water, Sanitation and Hygiene Evidence Paper* [pdf], London: UK Department for International Development <<https://www.gov.uk/government/publications/water-sanitation-and-hygiene-evidence-paper>> [accessed 21 December 2016].
- Checkley, W., Gilman, R.H., Black, R.E., Epstein, L.D., Cabrera, L., Sterling, C.R. and Moulton, L.H. (2004) 'Effect of water and sanitation on childhood health in a poor Peruvian periurban community', *Lancet* 363(9403): 112–8 <[http://dx.doi.org/10.1016/S0140-6736\(03\)15261-0](http://dx.doi.org/10.1016/S0140-6736(03)15261-0)>.
- Curtis, V. and Cairncross, S. (2003) 'Effect of washing hands with soap on diarrhoea risk in the community: a systematic review', *The Lancet Infectious Diseases* 3(5): 275–81 [online] <<https://www.ncbi.nlm.nih.gov/pubmed/12726975>> [accessed 10 May 2017].
- 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 nutrition status of children', *The Cochrane Database of Systematic Reviews* 8: CD009382 <<http://dx.doi.org/10.1002/14651858.CD009382.pub2>>.
- Fewtrell, L., Kaufmann, R.B., Kay, D., Enanoria, W., Haller, L. and Colford Jr, J.M. (2005) 'Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis', *The Lancet Infectious Diseases* 5(1): 42–52 <[http://dx.doi.org/10.1016/S1473-3099\(04\)01253-8](http://dx.doi.org/10.1016/S1473-3099(04)01253-8)>.
- Humphrey, J.H. (2009) 'Child undernutrition, tropical enteropathy, toilets, and handwashing', *The Lancet* 374(9694): 1032–5 <[http://dx.doi.org/10.1016/S0140-6736\(09\)60950-8](http://dx.doi.org/10.1016/S0140-6736(09)60950-8)>.
- International Food Policy Research Institute (2016) *Global Nutrition Report 2016: From Promise to Impact: Ending Malnutrition by 2030* [pdf], Washington, DC: IFPRI <<http://ebrary.ifpri.org/utills/getfile/collection/p15738coll2/id/130354/filename/130565.pdf>> [accessed 12 May 2017].
- Luby, S.P., Agboatwalla, M., Feikin, D.R., Painter, J., Billhimer, W., Altaf, A. and Hoekstra, R.M. (2005) 'Effect of handwashing on child health: a randomised controlled trial', *The Lancet* 366(9481): 225–33 <[https://doi.org/10.1016/S0140-6736\(05\)66912-7](https://doi.org/10.1016/S0140-6736(05)66912-7)>.
- Mwase, I., Mutoro, A., Owino, V., Garcia, A.L. and Wright, C.M. (2016) 'Poor infant feeding practices and high prevalence of malnutrition in urban slum child care centres in Nairobi: a pilot study', *Journal of Tropical Pediatrics* 62(1): 46–54 <<http://dx.doi.org/10.1093/tropej/fmv071>>.
- Prüss-Ustun, A., Bonjour, S. and Corvalan, C. (2008) 'The impact of the environment on health by country: a meta-synthesis', *Environmental Health* 7 <<http://dx.doi.org/10.1186/1476-069X-7-7>>.
- Rodríguez, L., Cervantes, E. and Ortiz, R. (2011) 'Malnutrition and gastrointestinal and respiratory infections in children: a public health problem', *International Journal of Environmental Research and Public Health* 8(4): 1174–1205 <<https://dx.doi.org/10.3390%2Fijerph8041174>>.
- Spears, D. (2013) *How Much International Variation in Child Height Can Sanitation Explain?* [online], Policy Research Working Paper, Washington, DC: World Bank <<http://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-6351>> [accessed 9 December 2016].
- Strunz, E.C., Addiss, D.G., Stocks, M.E., Ogden, S., Utzinger, J. and Freeman, M.C. (2014) 'Water, sanitation, hygiene, and soil-transmitted helminth infection: a systematic review and meta-analysis', *PLOS Medicine* 11(3): e1001620 <<https://doi.org/10.1371/journal.pmed.1001620>>.
- UNICEF (1990) *Strategy for Improved Nutrition of Children and Women in Developing Countries* [pdf], New York: UNICEF <www.ceecis.org/iodine/01_global/01_pl/01_01_other_1992_unicef.pdf> [accessed 7 June 2017].

UNICEF/WHO/World Bank Group (2015) *Levels and Trends in Child Malnutrition* [pdf], New York: UNICEF; Geneva: WHO; Washington, DC: World Bank <https://www.unicef.org/media/files/JME_2015_edition_Sept_2015.pdf> [accessed 13 January 2017].

Victora, C.G., de Onis, M., Hallal, P.C., Blössner, M. and Shrimpton, R. (2010) 'Worldwide timing of growth faltering: revisiting implications for interventions', *Pediatrics* 125(3): e473–80 <<http://dx.doi.org/10.1542/peds.2009-1519>>.

WHO (2014a) *Preventing Diarrhoea through Better Water, Sanitation and Hygiene: Exposures and Impacts in Low- and Middle-Income Countries* [pdf], Geneva: WHO <www.who.int/water_sanitation_health/publications/preventing-diarrhoea/en/> [accessed 13 January 2017].

WHO (2014b) *WHA Global Nutrition Targets 2025: Wasting Policy Brief* [pdf], Geneva: WHO <www.who.int/nutrition/topics/globaltargets_wasting_policybrief.pdf> [assessed 10 May 2017].

WHO (2016) *Preventing Disease through Healthy Environments: A Global Assessment of the Burden of Disease from Environmental Risks* [pdf] Geneva: WHO <www.who.int/quantifying_ehimpacts/publications/preventing-disease/en/> [accessed 9 December 2016].

Wolf, J., Prüss-Ustün, A., Cumming, O., Bartram, J., Bonjour, S., Cairncross, S., Clasen, T., Colford, J.M. Jr, Curtis, V., De France, J., Fewtrell, L., Freeman, M.C., Gordon, B., Hunter, P.R., Jeandron, A., Johnston, R.B., Mäusezahl, D., Mathers, C., Neira, M. and Higgins, J.P. (2014) 'Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression', *Tropical Medicine and International Health* 19: 928–42 <<http://dx.doi.org/10.1111/tmi.12331>>.