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Perspective: The Importance of Water Security for Ensuring Food Security, Good Nutrition, and Well-Being

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PERSPECTIVE

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ABSTRACT

Water security is a powerful concept that is still in its early days in the field of nutrition. Given the prevalence and severity of water issues and the many interconnections between water and nutrition, we argue that water security deserves attention commensurate with its importance to human nutrition and health. To this end, we first give a brief introduction to water insecurity and discuss its conceptualization in terms of availability, access, use, and stability. We then lay out the empirical grounding for its assessment. Parallels to the food-security literature are drawn throughout, both because the concepts are analogous and food security is familiar to the nutrition community. Specifically, we review the evolution of scales to measure water and food security and compare select characteristics. We then review the burgeoning evidence for the causes and consequences of water insecurity and conclude with 4 recommendations: *1*) collect more water-insecurity data (i.e., on prevalence, causes, consequences, and intervention impacts); *2*) collect better data on water insecurity (i.e., measure it concurrently with food security and other nutritional indicators, measure intrahousehold variation, and establish baseline indicators of both water and nutrition before interventions are implemented); *3*) consider food and water issues jointly in policy and practice (e.g., establish linkages and possibilities for joint interventions, recognize the environmental footprint of nutritional guidelines, strengthen the nutrition sensitivity of water-management practices, and use experience-based scales for improving governance and regulation across food and water systems); and *4*) make findings easily available so that they can be used by the media, community organizations, and other scientists for advocacy and in governance (e.g., tracking progress towards development goals and holding implementers accountable). As recognition of the importance of water security grows, we hope that so too will the prioritization of water in nutrition research, funding, and policy. *Adv Nutr* 2021;12:1058–1073.

Keywords: water insecurity, food insecurity, individual, household, indicator, experience-based

Introduction

The role of water in food security, nutrition, and overall well-being has been underappreciated in the nutrition literature. Traditionally, the field of nutrition has been attentive to the role of water in sanitation and hygiene (WASH) in the context of diarrheal diseases and child growth (1) and, more recently, in environmental enteropathy (2). Hydration status (3), especially apropos of sports nutrition (4), has also received significant attention. Both enteric infections and body water homeostasis are important for nutrition and health, but water has been underexamined as an essential nutrient compared with other key nutrients (5, 6). Further, access and use of this essential nutrient affect many other nutrition-related phenomena, such as agricultural productivity, food-preparation practices, eating behaviors, dietary diversity, infant and young child feeding practices, and energy expenditure.

Water security, a broad term that is commonly used to describe myriad water challenges (7), should be of interest to the global nutrition community both because of the prevalence and severity of water issues worldwide and the many interconnections between water and nutrition. A global water crisis has developed and is worsening, with an increasing number of humans experiencing problems with water being insufficient, excessive, and/or polluted (8, 9). This crisis is occurring in high-income countries (HICs)

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and low- and middle-income countries (LMICs), and the recognition of its globality led to the foundation of both the Global Water Partnership and the World Water Council in 1996 (10). Currently, at least 4 billion people—more than half the global population—experience severe freshwater scarcity at least 1 mo per year (11). At the same time, several hundred million people experience deleterious water excess, both in riverine and coastal areas, from rising bodies of water and excess rains, and the frequency of such episodes is also increasing (12, 13). Further, chemical contaminants (e.g., heavy metals, pharmaceuticals, plastic residues) and biological contaminants (e.g., parasites, bacteria, viruses) are found in water around the world (14, 15). This water crisis is driven by rapid population growth, economic growth, and urbanization that, in turn, increase domestic and irrigation water demands. Global warming and changes in precipitation patterns as well as aging infrastructure and underinvestment in operations and maintenance in the water sector, including on sewerage, further exacerbate these challenges (16).

Much of the previous work on water security focused on physical measurements of water at the level of population or hydrological units (e.g., river basins, watersheds) or on the adjacent field of sanitation (i.e., sewage disposal). This meant that assessments of water resources and risks were at a fairly large scale, often reported by country or state. The first in-depth discussion of water security at the household level appeared in a report by Patrick Webb and Maria Iskandarani in 1998 (17). Approximately a decade later, social scientists began to pay greater attention to lived experiences with(out) water security among individuals and households, investigating and eventually quantifying how water access and use shaped people's lives and their well-being (18–22). This research was done by asking about the frequency of experiences with anticipated or experienced problems with access and use. Linkages between water and well-being are best understood when exposure (i.e., water security) is measured as close to the level of the outcome (i.e., food security, nutrition) (23). Therefore, this consideration of water security experiences at the household and individual levels represented an important development for the public health nutrition community.

Our purpose in this Perspective is to make the case to the nutrition community for the powerful but overlooked role of water security for global food security, nutrition, and human well-being. By giving household water security attention commensurate with its importance to human nutrition and health, we can better understand drivers of nutrition and health inequities and gain new insights into how they can be reduced, as well as mobilize public and political will.

To that end, we first discuss the conceptualization of water security and how it has been measured, with an emphasis on household and individual metrics. Parallels to the food-security literature are drawn throughout, both because the concepts are analogous and food security is already a familiar concept to the nutrition community. We then review the burgeoning evidence for the causes and consequences of household and individual water insecurity, concluding with recommendations for action by the nutrition community, including for research, funding, and policy.

Current Status of Knowledge

Conceptualizing water security

There are numerous definitions of the terms "water security" and "water insecurity" because they are used by many communities, from practitioners to scholars to politicians, as well as across many disciplines (24). These definitions have varied in regard to their emphasis on ecosystem well-being, sustainability, governance, (defense of) infrastructure, production and agricultural needs, human capabilities, and sociocultural relations with water (7, 25, 26). Further, some definitions consider human water needs only, while others consider human populations and the environment in their definition [cf. Table 1 in reference (25)].

The operationalization of these definitions has also varied widely [cf. Tables 2 and 3 in reference (25)]. For example, the unit of analysis may be the individual, household, community, basin, watershed, or country. The measurements may be objective (e.g., using satellite data) or subjective, based on human recall. The recall period may be a few days, a month, or a year.

Definitions of water security tend to consider 1 or more of these 4 domains: availability, access, use, and stability (**Figure 1**) (23, 27). These domains are similar to those used in the conceptualization of food security; to this point, Figure 1 is adapted from a review on food security (28).

"Availability" refers to the physical existence of water "out there" to be had. Water security can also be conceived of in terms of access (i.e., can I get to it?). Availability is necessary, but not sufficient, for access. Access, in turn, is necessary but not sufficient for use (do I have enough acceptable and safe water for all my needs?). Finally, stability (sometimes referred to as reliability), which refers to the continuity of availability, access, and use without change across time, is necessary to

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Abbreviations used: COVID-19, coronavirus disease 2019; EBIA, Brazilian Food Security Scale; ELCSA, Latin American and Caribbean Household Food Security Measurement Scale; FIES, Food Insecurity Experience Scale; HIC, high-income country; HWISE, Household Water Insecurity Experiences; IFPRI, International Food Policy Research Institute; LMIC, low- and middle-income country; SDG, Sustainable Development Goal; SMART, Specific, Measurable, Achievable, Relevant, and Time-bound; WASH, water, sanitation, and hygiene.

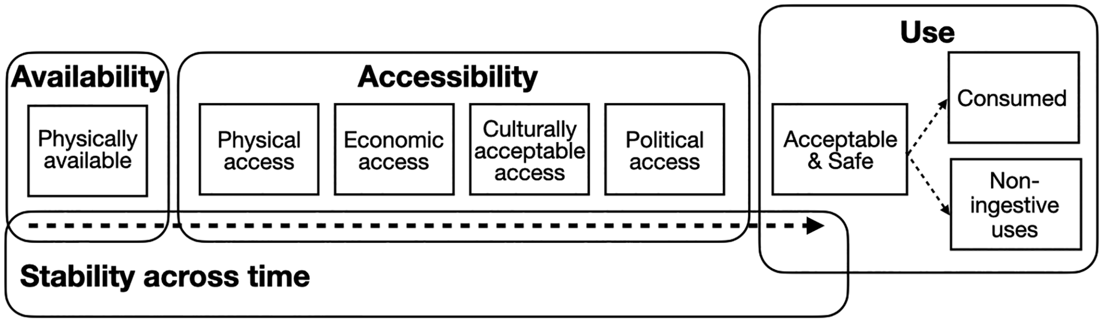

FIGURE 1 The 4 domains of water security are availability, accessibility, use, and stability. Household water insecurity occurs when any of these domains are not present. Stability (or reliability) is represented by the arrow spanning availability, access, and use. Adapted from references 23, 27, and 28 with permission.

ensure consistent availability, access, and use. In most cases, the domains to the right in Figure 1 are predicated on those to the left, which means that measuring phenomena towards the right captures those to the left.

While water availability is a fairly straightforward physical phenomenon, access is more complex and is shaped by structural and individual characteristics. For example, physical access may be hampered by age, pregnancy status, or physical fitness, even when water is physically available at a 10-min walk. Infrastructural problems can also be a barrier to physical access; water may be physically available 8 m underground, but a broken pump, stolen bucket, or power shortage may mean it is not physically accessible.

Economic access, or water affordability, can be hampered by poverty and/or inflated water prices (29, 30). Sometimes cultural proscriptions prevent water from being accessed. For example, women in South Asia may be physically able to fetch water but are prevented from doing so by norms about women not being unaccompanied outside the home or excluded because of their (lower) caste (31). Finally, water may be in close proximity, but unequal access occurs through sociopolitical processes, exclusion, biases, and discrimination (32–34). For example, in North America, inequity in water access is predominantly experienced by indigenous people and people of color (35, 36).

"Use" is also a multifaceted domain, in part because water serves so many purposes. A further complexity in the concept of use is that acceptability can differ by purpose. We have therefore distinguished acceptability for consumptive and noningestive uses (Figure 1). Acceptability is based on myriad factors, including objective and/or subjective safety, organoleptic properties, spiritual and cultural beliefs, and the intended use for the water (37–39). For example, in Lebanon, tap water is considered safe for bathing but not consumption because it is too saline, and tanker truck water is considered safe for cooking, but not drinking, because of bacterial contamination (40). Water can also be considered unacceptable because of its providence. The water of Lake Atitlan was disdained by some Tz'utujil Maya because of terrible events associated with the Guatemalan Civil War, and its chlorination was considered unpleasant to smell and taste (41). In Appalachia, some people trust "city water" far less than the more "natural" water from abandoned mines (42). Additionally, water that is considered suitable for irrigation may not be suitable for consumption because of salinity or other contaminants (43, 44).

Consumption-related water use includes water that is drunk as well as eaten. Water is found in all foods, and some cooking techniques (e.g., boiling, steaming) substantially increase their water content. The noningestive uses of water are far more numerous. These include practices for sanitation and hygiene—for example, washing hands, dishes, and foods; bathing; laundry; and sewage disposal. Water is also integral to the economic productivity of households and individuals; it is used for irrigation of crops that are eaten or sold and integral to job functions like food stalls, hair salons, gardening, and car washes, as well as to industrial processes and products. For all of these reasons, the domain of use in water insecurity is more complex than that in food insecurity.

The fourth domain of water security is stability (or reliability). Social, economic, environmental, and political instability all can affect the stability of water security. Stability can vary across seasons; it can also fluctuate within the week or even the day. For example, seasonal shortages in rainfall can limit availability, and flooding (seasonal or otherwise) can lower water quality when flood waters contaminate water for human use with, for example, manure, oils, and pesticides. On a shorter timescale, water access can be shaped by fluctuations in health, income, and relationships with those who control water delivery. Diurnal stability can be shaped by queues for water—they are often far shorter after dark—or citywide cuts in power that prevent pumps from delivering water, thereby creating further disparities in access by storage capacity in the home.

A final complexity in conceptualizing water insecurity is that there are several terms that are related to, but not synonymous with, water insecurity (**Figure 2**). Sometimes they are explicitly defined, such as in the case of water stress, water scarcity, and water risk (45) as well as plumbing poverty (46), but sometimes they have no explicit definition. These

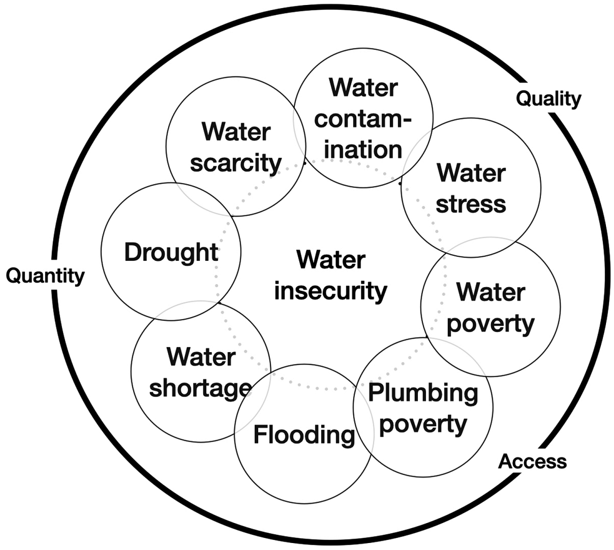

FIGURE 2 There are many overlapping terms used in discussions of water insecurity.

terms touch on aspects of water security including quantity, access, and quality, and are included here so that the reader can see where there is overlap with the domains of water security (Figure 1).

Empirical grounding for assessing water insecurity: measures and indicators across 4 domains

Many measures and indicators are used to assess these 4 domains of water. Most of these are at the level of physical availability. Water availability is typically assessed objectively—for example, using satellite data or hydrological flow gauges (47). This assessment is usually done across a large spatial area, such as the level of a country, state, or basin. These values are sometimes divided across a population to estimate per capita water availability, which is useful for projecting changes across time (48). In the same way that food balance sheets do not capture the heterogeneity of food distribution (49), per capita water availability does not capture information about access, use, stability, or disparities within populations.

There are fewer ways to measure the various types of access. Physical access to drinking water is most commonly measured by the drinking water service ladder, developed by the WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation, and Hygiene (50). With 6 questions, the proportion of the population using safely managed drinking water services can be calculated (51). This measure is indicator 6.1.1 for the Sustainable Development Goal (SDG) on safe water and sanitation. Because this measure captures only population-level data related to drinking water, however, it does not capture information on intrahousehold variation in access or use for cooking and the many noningestive purposes. Economic access to water is typically measured based on the proportion of income spent on water, with suggested affordability thresholds ranging from 2% (52) to 5% (53) of a household's income. We know of no measures or indicators of cultural acceptability or political access—that is, how the distribution of water has been shaped by relations of power (54).

Water use has several measures and indicators, almost all of which pertain to measuring aspects of water quality, especially safety, objectively. There are scores of tests for assessing physical characteristics (e.g., turbidity) as well as chemical characteristics and biological contaminants. Several contaminants are of great relevance to nutrition-related health—for example, fluoride levels for bone and tooth health, salinity for blood pressure, and campylobacter for diarrhea. These tests require a range of expertise, equipment, time, and financial resources (55); some of these are field-friendly, but most are not (56).

Hydration status, or the process of body water homeostasis, can be considered as a proxy measure of consumptive water intake. However, in the same way that body composition is shaped by many factors beyond food consumption, hydration is also shaped by factors beyond water consumption (57), which makes it less valuable for assessing water security. For example, beyond water intake, differences in environmental conditions and exposures, physical activity, medications, and body composition all affect hydration status (58). Further, hydration status can vary widely over the day, changing in response to water intake and expenditure. Hydration status can be noninvasively measured using urinary biomarkers such as urine-specific gravity, urine osmolality, or urine color (59).

Experience-based measures of human water security can capture many of the domains shown in Figure 1. Most experience-based scales ask about access and use, such as the frequency of being unable to bathe or prepare foods because of problems with water. Most of these measures also ask about the frequency of fear of insufficiencies of water of necessary quantity and acceptable quality. Because availability is necessary for access and use, availability is indirectly measured by these scales. Acceptability and safety are implicit in some items in experience-based scales, such as the frequency of insufficiency of enough water to drink. Stability across time can be captured depending upon the recall period in cross-sectional studies, or by asking about the uncertainty of water supply or using repeated measures.

Household and individual food- and water-insecurity scales

Because household and individual water insecurity are analogous constructs to household and individual food insecurity, and the latter are familiar to many in the nutrition and public health communities, it is illustrative to discuss the various scales available for measuring both constructs (**Table 1**).

The research and policy on household and individual food security are far more advanced than that for water security, in large part because the field is older and there are more ways of measuring household and individual

TABLE 1 Similarities and differences between the Household Food Insecurity Access Scale, the Food Insecurity Experiences Scale, and the Household Water Insecurity Experience Scale[1]

	HFIAS (60)	FIES (61)	HWISE (62)
Date published	2007	2013	2019
Number of items	9	8	12
Response type	Likert: never, rarely, sometimes, often	Yes, no	Likert: never, rarely, sometimes, often/always
Range	0–27	0–8	0–36
Categorizations and cutoffs	None, mild, moderate, severe; cutoffs established using an algorithm	None, moderate, severe; cutoffs vary by population, determined using Item Response Theory (63)	Dichotomous; ≥12 indicates water insecurity (62)
Applicable to households	Yes	Yes	Yes
Applicable to individuals	An individually focused scale has been developed (64)	Yes	Individually focused items are being implemented by Gallup World Poll
Recall period	Month	Month or year	Month for HWISE, year for individually focused items implemented by Gallup World Poll
Dimensionality	Unidimensional	Unidimensional	Unidimensional
Equivalence established	No	Yes	Yes, in LMICs; untested in HICs
Guttman ordering	Yes	Yes	No
Suitable in HICs	Yes	Yes	Untested
Suitable in children	Untested	Used for ages ≥15 y	Untested
Short form	The Household Hunger Scale (65) assesses only household hunger	No	Yes, HWISE-4 (66) is highly correlated with full scale and correctly classifies water-insecure households

[1] FIES, Food Insecurity Experience Scale; HFIAS, Household Food Insecurity Access Scale; HIC, high-income country; HWISE, Household Water Insecurity Experiences; LMIC, low- and middle-income country.

food security (28, 67–69). Measures include household consumption and expenditure surveys (70), dietary diversity (71), and the food-consumption score (72). The Coping Strategies Index (73) and the Household Economy Approach (74) are 2 participatory methods for the measurement of household food insecurity.

Several direct, experience-based measures of household and individual food insecurity have been developed (Table 1). Four constructs are important for understanding experiences of food insecurity: quantitative, qualitative, psychological, and social aspects (75). The first experience-based scales for food insecurity were developed from in-depth qualitative research and experiential learning through engagement in communities in the United States in 1992. Items developed from this work were eventually adapted for the USDA Household Food Security Survey Module in 1995 (76). At this point, several site-specific measures of food insecurity were developed, such as those for Bangladesh (77) and Burkina Faso (78).

Interest in using experience-based questionnaires quickly expanded globally, eventually resulting in 3 frequently used questionnaires: the Household Food Insecurity Access Scale (HFIAS), the Latin American and Caribbean Household Food Security Measurement Scale (ELCSA), and the Food Insecurity Experience Scale (FIES). These 3 measures of food insecurity are composed of similar sets of items assessing 4 subconstructs of food insecurity: uncertainty, compromised dietary quality or preferences, eating less, and going hungry (75). The psychological subconstructs of lack of choice and need to make compromises are not assessed; neither are the 2 social subconstructs of accessing food in socially unacceptable ways and socially or culturally nonnormative patterns of eating.

The HFIAS was developed in 2007 to assess the impact of interventions and programs on household food security (60). In response to national and provincial anti-hunger programs in some Latin American countries (e.g., Brazil in 2003 and Colombia in 2004), a number of country-specific experience-based scales were adopted, modified, and validated (79, 80). The regional experiential scales converged in the ELCSA in 2007 (81, 82). This scale was proposed to provide equivalent assessment of the prevalence of household food insecurity in the region across contexts. ELCSA was subsequently incorporated in national surveys such as Living Conditions and Nutrition and Health surveys (e.g., in Guatemala in 2011 and Bolivia in 2018). In Mexico (83) and El Salvador (84), data collected using a related scale became part of a multidimensional poverty assessment by the National Evaluation Council. Because the HFIAS was created for program evaluation, equivalence in assessing prevalence was not a priority. The Household Hunger Scale (85), which is composed of a subset of 3 HFIAS items, was developed to have a scale that was equivalent across settings but only assesses severe food insecurity.

Supported by the evidence gathered using these previous scales, especially the ELCSA, the FIES was established by the FAO to provide cross-context equivalent assessment of the prevalence of individual food insecurity globally. This questionnaire has been fielded in ∼150 countries through the Gallup World Poll and is the basis for SDG indicator 2.1.2, the proportion of people experiencing moderate or severe food insecurity (61).

Questionnaires leading to scales for measuring food insecurity were initially developed to be answered by adults under the assumption that adults, especially women, were most knowledgeable about the household food situation. Subsequent research has shown that individuals within households can experience food insecurity differently (86–88), that children are aware of and take responsibility for food insecurity (i.e., actions like reducing food intake, earning money to pay for food) (89–91), and that parents often do not know about their children's experiences (92). These insights have led to the development and validation of scales for measuring experiences of food insecurity among school-age children and adolescents in the United States (93), Venezuela (94, 95), and Lebanon (96, 97). It has since been shown that children's reports of their food insecurity more accurately predict child outcomes than adults' reports of their children's food insecurity (95). These investigators, in collaboration with others and UNICEF, are currently testing a scale for measuring child experiences of food insecurity for global use.

Experiences with water insecurity have been measured for a much shorter time. The first effort at quantifying experiences of water insecurity was led by Amber Wutich (18) with Kathleen Ragsdale in Bolivia in 2008 (19). Since then, a number of site-specific scales have been developed to measure either household or individual experiences with water insecurity [cf. Table 3 in reference (18)]. Typically, these scales ask about the frequency of 10–20 water-related activities in a specified time frame, usually the prior month. The first cross-culturally suitable scale is the Household Water Insecurity Experiences (HWISE) Scale (62, 98). It was finalized in 2019 and has been validated for use in LMICs (Table 1).

The HFIAS (60) and FIES (61) are the most widely used experience-based measures of food insecurity globally. The HWISE scale is currently the sole globally suitable measure of water access and use (62). These 3 scales are described and compared in greater detail in Table 1.

Drivers and consequences of household- and individual-level food and water insecurity

Given the extensive history of using validated food-security scales in both high- and low-income settings, the determinants of household and individual food insecurity have been well documented. Household access to adequate quantities and qualities of food, land ownership, production of food for one's own consumption, poverty, education, employment, income, and psychosocial factors have been regularly identified as shaping household- and individual-level food insecurity (28, 99, 100).

Water security is now emerging as critical for food security via multiple pathways (101–103). Similar to food security, predictors of water security have included socioeconomic and demographic characteristics (e.g. education, size of family, urban residence, poverty, income, and assets) (17, 62, 104). Although wealthier families are likely to be more water secure because they have resources to spend on buying water and storage systems (105–107), water insecurity has been observed across the wealth gradient—that is, not all households are able to "buy" themselves out of water insecurity (29). Household and individual determinants of water security distinct from food security include those related to the nature of the water system (quality, quantity, and reliability of the supply, water source, and the time required to collect water) as well as factors related to social identity and status. Because the measurement of household and individual water insecurity is in its early days, more determinants are likely to emerge.

Food insecurity has serious and pervasive consequences for human health and well-being. These well-established consequences of food insecurity result through both nutritional and non-nutritional mechanisms (108). For example, food insecurity can compromise food intake and thereby lead to malnutrition. Food insecurity is also a profound stressor. Distress, adverse family and social interactions, worry, anxiety, deprivation, and alienation can occur well before any changes in nutritional status. These, in turn, lead to poor health outcomes in adults and children, including poor mental health (e.g., depressive symptoms, risk of suicide, poor subjective well-being); poor physical health resulting from development and poor management of chronic diseases; and impaired learning, social developmental delays, and behavior problems in children (108).

To date, the evidence for the health and economic consequences of water insecurity (23) is much scarcer than that for food insecurity (109). Some of the best evidence we have of the consequences of water insecurity is that it is a critical psychosocial stressor detrimental to mental health; poor mental health can, in turn, impact nutrition in a variety of ways. Some of the first work on the mental burdens of problems with water described people as "suffering from water" as well as suffering for water (110). This local idiom of distress signified the holistic toll that water insecurity had on people's well-being, with implications that extend into nutrition, such as expending extra calories to acquire water. Water insecurity has since been linked with heightened worry, anger, frustration, and distress (19, 20, 33, 62, 110–114) as well as increased depressive symptoms (101, 112, 113, 115, 116). Increased psychosocial stress arising from water insecurity, as with other stressors, can also increase appetite, cause overeating, and be deleterious to body fat metabolism (117).

Water insecurity is undoubtedly directly associated with nutritional outcomes. Water insecurity is deleterious for child feeding and nutrition (33, 118–121) and is associated with food insecurity (62, 103, 112); the sole longitudinal study on individual food and household water insecurity found that water insecurity precedes food insecurity (101). It will be important to understand if water insecurity leads to micronutrient deficiencies such as anemia and vitamin D deficiency, as has been the case with food insecurity (122, 123). Further, households and individuals that experience both water and food insecurity face a higher risk of the dual burden of malnutrition (121) as well as higher odds of dehydration (124). For all these reasons water insecurity is also a source of stress, as discussed above.

One of the key nutritional consequences of water insecurity is increased risk of diarrhea among both children and adults (120, 125–127). Diarrheal diseases can undermine growth and development and are a leading cause of mortality particularly among children under 5 y in LMICs.

Additional tolls of water insecurity include bodily harm. Water fetching entails increased risk of falls and other accidents, which can cause bone breaks, bruising, and other musculoskeletal injuries (128, 129). There can also be risk of physical or sexual assault while fetching or queuing for water in some areas (129, 130) as well as violence from male partners when there is insufficient water in the household (33).

Water insecurity has serious economic consequences by necessitating a larger portion of income to be spent on water and undermining health and livelihood strategies (29, 30, 131). When individuals and households do not have enough water to cook, irrigate crops, or water livestock, economic subsistence strategies fail (33, 102, 104). For example, in parts of coastal Bangladesh, increased salinity of groundwater and soils has impeded farmers' ability to grow crops. As a result, many move to urban centers and change livelihood strategies (132). Severe drought and water scarcity, as well as extremely wet growing seasons in India, are associated with higher risk of suicide among farmers, particularly those in poverty, due to economic ramifications of crop loss (133, 134). Water-related avertive water expenditures (i.e., spending to compensate for the loss of a resource or facility) can be significant. For example, in many urban areas, the lack of stability of piped water has led many better-off households to develop back-up water systems, such as storage tanks that can be filled when piped water is working and wells that tap into groundwater below their dwellings; poorer households must rely on borrowing water from neighbors, walking long distances, or other non–cash-dependent strategies (135, 136). In the United States, purchasing bottled water after water quality violations is a fairly common and sometimes very costly avertive strategy (137).

Water-security strategies that rely on groundwater withdrawal also have deleterious economic consequences. Groundwater removal contributes to land subsidence (sinking) in cities all over the world, including Mexico City (138), Tehran (139), and Jakarta (140). Subsidence has caused billions of dollars of infrastructure and property damage; this is caused by shifting land and increased flooding from subsidence, as well as the resultant loss of property value (141).

Finally, water insecurity can have major political consequences, from local conflicts about water access and use to political crises and even wars between countries (8, 142). These conflicts can, in turn, have economic and health consequences.

In sum, water insecurity has detrimental impacts on mental, nutritional, physical, economic, and political well-being, but the extent of the damage has yet to be documented. There is therefore an important role for the nutrition community to play in helping to uncover the burden of water insecurity on well-being and elucidating the mechanisms by which this harm occurs.

Advancing water insecurity in nutrition research

Four key actions can significantly advance our understanding of water insecurity and its role in inequities in public health nutrition. The following actions can also reduce inequities in water and food security, nutrition, and well-being.

Collect more water-insecurity data.

The incorporation of experience-based questionnaires about food insecurity into small- and large-scale studies catalyzed a large body of research that established that food insecurity is widespread and that even mild food insecurity plays a harmful role in people's lives (143, 144). The plausibility that water insecurity is prevalent and has major impacts on health is high, but far more data are needed from household and individual studies until this can be stated definitively. The development of the HWISE scale has made possible the collection of such data on the role of water insecurity in health outcomes around the world in studies done by scientists, multilateral agencies [e.g., International Food Policy Research Institute (IFPRI)], and nongovernmental organizations (e.g., Oxfam, Innovations for Poverty Action). It has also been implemented within Demographic Health and Survey sites in Bangladesh and Ethiopia.

Data on the prevalence of water-insecurity experiences are currently being collected in the Gallup World Poll, in collaboration with United Nations Educational, Scientific, and Cultural Organization (UNESCO) and Northwestern University (145). This work means that water-insecurity experiences will be benchmarked in more than half of the world's population by 2021, including in China, Brazil, India, and much of Africa. By modifying HWISE items to ask about individual experiences over the prior year, the items are consistent with Gallup phrasing and can be compared across seasons, populations, and geographies. This set of items will allow a better understanding of individual experiences of water insecurity among adults and how they vary by a variety of sociodemographics. These data can also be merged with other nationally representative datasets (e.g., the India Comprehensive National Nutrition Survey) to investigate relations with a variety of nutritional outcomes.

Childhood water-insecurity experience indicators have yet to be developed. Children's experiences with water insecurity are expected to differ from those of parents, similar to differences found between children's and parents' assessment of children's food-insecurity levels (91, 94, 95).

Having nationally-representative data from the Gallup World Poll will be highly valuable for benchmarking water security across nations (146), but cross-sectional data should be complemented by data from other designs to assess the potential consequences of water insecurity. The incorporation of measures of experiences with water insecurity in studies in which health and economic outcomes are carefully measured is crucial. One example of such a study is Oxfam's use of the HWISE scale in the Democratic Republic of Congo and Zambia, concurrent with measures of diarrhea, resilience to cholera, life satisfaction, and governance (126).

More data on water insecurity are also needed from impact assessments (146). Far too often, water-security interventions are assessed based on the infrastructure built, rather than how that infrastructure impacts daily lives. The HWISE scale provides a simple and direct way of measuring differences in experiences with access and use. For example, HWISE was implemented by Oxfam in control and intervention villages in Sierra Leone to assess the impact of a water intervention on water access and use, and revealed a dramatic decrease in HWISE scores between intervention and comparison sites (Jaynie Vonk, personal communication 2020). The HWISE scale could also be useful in designing and evaluating the impact of multiple-use water services interventions, such as those described by Winrock International and others (147). The recent availability of a short form of the HWISE scale, the HWISE-4 (66), facilitates the collection of water security in surveys where questionnaire space is limited, such as telephone surveys. The implementation of the HWISE-4 in an 8-country study of the short-term impacts of coronavirus disease 2019 (COVID-19) on rural women by IFPRI and others has revealed positive correlations between water- and food-insecurity severity (148). Because data will be collected across several waves, it will also be possible to detect changes in water security over time.

Experiential measures of water insecurity could become a useful tool (146) in the suite of global monitoring indicators that are measured as part of the SDGs (149). This would allow greater comparison across countries and regions and the measurement of improvement in outcomes following investments in water security. By giving global recognition to the importance of monitoring experience-based water security, this indicator could complement other water-monitoring indicators being collected, such as those by the Joint Monitoring Program (50), and would provide benchmarks for resource allocation and for the development of coordinated policies across government actors in charge of water and food security.

To facilitate the collection of these types of data globally, it will be imperative to make (translations of) water-insecurity scales easily available. To that end, the HWISE scale is freely available for implementation and we are currently housing translations into other languages (150). As more groups translate the HWISE scale, we will be posting them to the website; dozens more languages will become available upon completion of the 2020 data collection by Gallup World Poll. Further, publishing findings about water insecurity in languages besides English will also be important for dissemination and awareness of this issue. The many publications in Spanish and Portuguese about food-insecurity experiences surely helped these indicators to be adopted throughout Latin America (e.g., 151, 152).

Collect better water-insecurity data.

We have several recommendations about how these various types of water-security data (i.e., on prevalence, causes, consequences, intervention impacts) should be measured. For one, we encourage food insecurity and its sister concept, water insecurity, to be measured jointly (23, 103, 146). Measuring water insecurity concurrently with other potentially germane nutritional outcomes, such as dietary diversity, will help disentangle the contributions of either or both to key nutrition outcomes, such as stunting, undernutrition, and overnutrition, as well as other outcomes of public health interest, including mental and physical health outcomes (114).

Measuring individual variation in food and water insecurity within the same households will allow us to understand differential nutritional effects of each on various household members. Doing so using instruments that yield data that are comparable across space and time will help us understand how water and food insecurity covary, as well as how trends change in both the general population and in subgroups (146).

Studies in which both water and food insecurity are measured repeatedly across time will provide information on causal relations between these two frequently associated phenomena (62, 101, 103, 112). A longitudinal design will also allow for evaluations of both short- and long-term effects of water insecurity on a range of outcomes, from growth to cognitive performance and educational attainment (23). Further, longitudinal studies in the first 1000 days of life will provide critical information about how water and food insecurity and their consequences may affect health trajectories intergenerationally (23).

In terms of monitoring and evaluation, establishing baseline indicators of both water and food security before water (and nutrition) interventions are designed, developed, and implemented, and monitoring changes in these indicators as these interventions mature, can provide empirical evidence of the synergies in nutrition and water security (153, 154). A particular focus needs to be placed on marginalized households and marginalized individuals within households in order to reveal and reduce disparities in nutrition and well-being (155).

Consider food and water issues jointly in policy and practice.

For far too long, the nutrition and water sectors have been siloed (146). For example, the UN General Assembly designated 2016–2025 the UN Decade of Action on Nutrition and 2018–2028 the UN International Decade for Action on Water for Sustainable Development. These two Decades and the SDGs they support (SDG 2 and SDG 6) are intimately intertwined. To date, however, collaboration by these two landmark initiatives has been lacking. They can, however, be brought together by interdisciplinary exchanges across international, national, and local levels.

At the highest level, interactions can be improved within UN agencies. The exploration of linkages or possibilities for joint interventions is nascent, with no systematic programs in place (102, 156). A recent report, however, lays out three specific actions for integrating across the SDGs beyond closer collaboration between the work programs of the UN Decade of Action on Nutrition and the International Decade for Action on Water for Sustainable Development. These include *1*) implement nutrition-sensitive agricultural water management, *2*) ensure the environmental sustainability of diets, and *3*) address social inequities in water–nutrition linkages (102).

A further opportunity for international, cross-disciplinary interactions is the Community of Practice on Water and Nutrition Linkages under the aegis of the FAO's Global Framework on Water Scarcity and Agriculture Partnership (WASAG) (157). This community is composed of academics, practitioners, and policymakers from both the water and nutrition communities. This group exchanges ideas on cross-sectoral linkages, develops research and insights, and aims to advance policy action.

One example of an arena in which food and nutrition issues should be considered jointly is the water footprint of nutritional guidelines. Improved food security and nutrition can carry substantial costs in terms of increased pressures on water systems and ecosystems. Further, because food production, processing, and transportation can carry enormous burdens in terms of water use and water pollution (e.g., fertilizer and pesticide run-off, slaughterhouse drainage), similar diets can have vastly different water, biodiversity, and climate change footprints, depending on where and how they are produced and consumed (158, 159). It is urgent that nutrition strategies become more water and environmentally sensitive; food-based dietary guidelines must focus on diets that are less environmentally destructive while meeting nutritional needs (160).

Strengthening the nutrition sensitivity of agricultural water-management practices, especially irrigation, is also key to integration across disciplines (161). Given that >80% of all water withdrawn by humans is used for crops and livestock, doing so could dramatically improve nutrition outcomes. Strategies to increase the nutrition sensitivity of agricultural water-management practices include developing irrigation infrastructure in locations where diets are poor, developing irrigation systems that integrate fishponds, irrigating more nutrient-dense crops, and linking irrigation development with nutrition messages (153, 162). Irrigation practices should, of course, consider water availability and sustainability—for example, boreholes should not be drilled where water tables cannot support them. Finally, these strategies should involve women throughout the entire process and consider water needs for multiple purposes, beyond irrigation, including domestic use. The recent focus on multiple-use water services or systems that interlink water provision for WASH and irrigation purposes provides a useful basis upon which water–nutrition linkages can be further developed (163).

Ultimately, experience-based scales should be considered for improving governance and regulation across food and water systems because there is a strong influence and interdependence between these two systems. As an example, the food industry is deeply embedded in water systems. The large amounts of water used by soda and infant formula companies (e.g., 4000 L of water are used for every 1 kg of powdered milk produced) have potentially enormous consequences for water access and use by private citizens. Transboundary water agreements between governments, such as those between Mexico and the United States (164) or Israel and Palestine (165), can also adversely shape individual access and use of water, sometimes for better, sometimes for worse.

The best way to bring together the food- and water-security worlds is through building and sustaining strong coordination among the key stakeholders responsible for food and water systems governance. Identifying who the key stakeholders are and how to design an intersectoral governance structure at international, national, and local levels will require multilevel community participatory implementation research based on sound implementation science frameworks (166).

Make our findings available to shape advocacy and governance.

An important lesson from experience-based food-security scales is that they can yield indicators that are easy to explain to, and be understood by, lay people. This means they can garner attention from the media, which, in turn, shapes public opinion, which, in turn, pressures decision makers to take action (167). For example, in Mexico, media coverage of the first application of ELCSA led to the term "food insecurity" becoming part of the lexicon of Mexican journalists, government officials, and policymakers (168). It also led the president to establish an intersectoral commission for understanding the causes and potential solutions to the problem of food insecurity. The scale can also be used to show governmental negligence. In Brazil, heavy media coverage of increases in food insecurity was used to contradict the assertion by the sitting Brazilian government that there was no hunger (168). These data and media coverage were also used by the then former president, Luiz Inácio Lula da Silva, to illustrate how the achievements of his government in dramatically reducing, poverty, inequalities, and food insecurity between 2003 and 2010 had been undone by the subsequent administration.

The measurement of global food insecurity by the FAO is another example of data presented simply but sufficiently rigorously to attract the attention of many types of stakeholders. As the name of the project, "Voices of the Hungry," implies, it gives expression to those experiences of the vulnerable that might have otherwise been invisible (169). This voice, in turn, can shape advocacy, governance, and regulation. For example, with these data, it is possible to track global progress towards the commitment to food as a human right (170). The use of valid and reliable food-insecurity scales to measure people's experiences of food insecurity is also an important way for local authorities and community organizations to better understand their own situation and act accordingly.

Experience-based water-security tools can also help us to track progress towards stated human rights and other development goals. In 2010, a resolution was approved by the UN General Assembly recognizing the access to safe and clean drinking water and sanitation as a human right, followed by a resolution by the Human Rights Council (171, 172). Like the recognition of the right to access to adequate food and the right to be free from hunger, such resolutions represent an important platform for the promotion of public policy and programs. Global commitments are much easier to made had for issues that can be quantified.

It is early days, but we are already seeing how the quantification of experiences of water insecurity can be used for advocacy. For example, the HWISE scale was used to assess water insecurity in the Six Nations reserve in southern Canada just prior to the outbreak of COVID-19. The evidence that this generated about the high prevalence of water insecurity was used to convince the Band Council (local government) to pay for outstanding water bills and avoid water shutoffs (Sarah Duignan, personal communication 2020).

Experience-based food-security scales have helped advance food-security governance because they provide indicators that can help address the four conditions needed for sound food-security governance (173). These are as follows: *1*) clear, participatory, and responsive planning, decision making, and implementation; *2*) efficient, effective, transparent, and accountable institutions; *3*) respect for the rule of law, and equality and fairness in resource allocation and service delivery; and *4*) coherent and coordinated policies, institutions, and actions. Hence, it is likely that a similar outcome could be obtained for water-systems governance using scales such as HWISE.

Experience-based food-security scales have also likely advanced food-security governance because they have SMART properties (i.e., Specific, Measurable, Achievable, Relevant, and Time-bound). They are specific, because they closely measure the construct of interest; they are achievable as their measurement can occur at a relatively low cost; they are relevant because they are sensitive to economic crises or growth changes; and they provide rapid feedback for timely decision making and action (167). The SMART properties of experience-based water-security scales are likely to be confirmed given the similarities in their conceptual basis and instrumentation (109). Hence, it is likely that decision makers will select scales such as HWISE for tracking targeting, implementation progress, and impact of water interventions targeting households. Indeed, at the 2020 Stockholm Water Week, Lord Zac Goldsmith, the British Minister of State for Foreign Affairs, called out the HWISE scale as a "smarter indicator" that quickly and reliably "promotes accountability and transparency" (174).

Much can also be learned about the widespread adoption of experiential scales based on lessons learned from food security. For one, a top-down approach is not always the most effective for the adaptation, adoption, and incorporation of water-security scales in diverse national representative surveys that are repeated over time or in routine monitoring systems. The likelihood that water-security scales will be embraced by governments and international organizations tracking the SDGs will likely be greater if a bottom-up approach is also followed.

The Brazilian Food Security Scale (EBIA) is a notable case in illustrating how powerful a bottom-up approach can be (175). The efforts that culminated with the national adoption of the EBIA began in 2013, with the adaptation and validation of mixed-methods studies of the US Household Food Security Survey Module in urban and rural areas throughout Brazil (167). This process was steered by a coalition of academics, civil society, international organizations, and the Ministries of Health and Social Development (81). In less than 1 y, the government of Brazil had scaled up the use of EBIA and invested over \$1 million US dollars in administering the EBIA to >130,000 households through the 2014 National Household Sample Survey (167). This allowed the country to develop a national baseline to start tracking household food insecurity through repeated household expenditure surveys as well as health and nutrition surveys. The process followed with the EBIA was then disseminated and replicated in other Latin American countries, such as Mexico (79, 80), leading to the harmonized Latin American Food Security Scale (ELCSA) (82).

It is unlikely that national governments will take up the FIES or the HWISE scale to the extent that ELCSA (and the scales that led to it) has been adopted without similar specific bottom-up efforts to do so. For one, governments are often more responsive to local calls for data than they are to those by international organizations. Further, the relatively small sample sizes necessary for estimating the prevalence of food (or water) insecurity across countries and world regions, the primary reason for which FIES was developed (176), is only 1000 for most countries. Such a sample size precludes the level of data disaggregation needed for sound food- or water-security policymaking in countries where there is any heterogeneity.

In any engagement with advocacy and governance, it is important to recognize that data on food and water insecurity can be politically sensitive. Many countries, communities, and agencies are reluctant to share data that do not reflect positively and do not want to highlight unaddressed vulnerabilities. For this reason, stakeholders may not want to collect data in case it would reveal unflattering findings. If such data are collected, they might not be shared, and if they are shared, they may be aggregated across regions or even countries. Thus, it may be important to demonstrate the value of such data for effective policymaking, per the above, or to help make the case for infrastructural investment to, at least partially, override some of these concerns.

Better integration of water-security measurement, policies, and actions from the national to the local level is needed, and there is precedent for doing so in the realm of food security. There is also opportunity in the nutrition policy community for evaluating if linking household food- and water-insecurity information-management systems enhances governance across and within each system and/or improves health and well-being.

Conclusions

In summary, water security is a powerful concept that is still in its early days in the nutrition literature. This is important because stable availability, access, and use of water have intrinsic value as a human right and should be a goal in and of itself. Further, water security also likely plays critical roles in outcomes upon which the public health community has broadly agreed as important: nutritional, mental, physical, and economic well-being. Increased attention to the benefits of ensuring water security and best practices for doing so are therefore needed. As recognition of the importance of water security grows, we hope that so too will the prioritization of water in research, programming, funding, and policy.

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