



**PULTE INSTITUTE**  
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# **Measuring Transformative WASH: A New Paradigm for Designing, Monitoring, and Evaluating Water, Sanitation, and Hygiene Interventions**

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## ABOUT THE AUTHORS

**Justin Stoler** is Associate Professor of Geography and Sustainable Development, and Public Health Sciences, at the University of Miami. He is trained in geospatial science and infectious disease epidemiology, and his research explores health disparities using social, environmental, and spatial epidemiological methods. He has more than a decade of experience studying drinking water and infectious diseases in Ghana, and he co-leads the Household Water Insecurity Experiences Research Coordination Network (HWISE-RCN), an international community of interdisciplinary water researchers. He also directs the Social & Health Inequities Research & Education (SHIRE) Lab, where social and environmental justice are front-and-center.

His research with the Pulte Institute seeks to re-conceptualize “successful” water, sanitation, and hygiene (WASH) projects and recommend a pathway toward more holistic evaluation of safe water interventions. Many WASH programs are still evaluated using a narrow notion of health that focuses on indicator bacteria and water quality, thereby missing opportunities to demonstrate the breadth of how water interventions improve people’s lives. The potential benefits span physical, environmental, and psychosocial health; socio-economic standing and social capital; political empowerment; increased time for education and livelihood activities; gender equity; and more. The ultimate goal is to strengthen global WASH commitments by transforming how we measure, evaluate, and communicate the success of water interventions.

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### Author Contributions

**Justin Stoler:** Conceptualization, Writing – Original Draft, Writing – Review & Editing

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## ABSTRACT

Progress toward achieving Sustainable Development Goal 6, clean water and sanitation for all, is behind schedule and faces substantial financial challenges. Gold-standard water, sanitation, and hygiene (WASH) interventions have underperformed, casting doubt on their efficacy and potentially undermining confidence in WASH funding and investments. But these interventions have leaned on a narrow set of WASH indicators—linear growth and diarrhea—that reflect a 20<sup>th</sup>-century prioritization of microbiological water quality as the most important proxy for WASH intervention success. Even when water is microbiologically safe, hundreds of millions of people face harassment; assault; injury; poisoning; anxiety; exhaustion; depression; social exclusion; discrimination; subjugation; hunger; debt; or work, school, or family care absenteeism when retrieving or consuming household water. This paper summarizes factors that perpetuate the status quo in WASH program assessment, and outlines a new paradigm for designing, monitoring, and evaluating WASH interventions. We recommend a sample set of alternative metrics that can be incorporated immediately into WASH monitoring and evaluation programs by practitioners in government agencies, non-governmental organizations (NGOs), and academic institutions; a framework for linking these metrics to human impacts using the WASH theory of change; and a shift to participatory implementation designs that promotes inclusivity.

## INTRODUCTION

Water, sanitation, and hygiene (WASH) insecurity affects billions globally<sup>1</sup> and has been increasingly acknowledged as a cause and consequence of low socioeconomic development.<sup>2,3</sup> The WASH-attributable disease burden is estimated to be 3.3% of global deaths and 4.6% of global disability adjusted life-years (DALYs)—over half of which is in sub-Saharan Africa alone—and 13% of deaths and 12% of DALYs among children under 5.<sup>4</sup> Even before the coronavirus pandemic we were not on track to meet Sustainable Development Goal (SDG)<sup>6</sup>, which aspires to provide universal access to safely managed water and sanitation services by 2030.<sup>5</sup> One estimate priced the investments needed to achieve SDG<sup>6</sup> at \$114 billion per year through 2030, or \$28.4 billion annually for universal basic WASH services, both of which offer compelling cost-benefit ratios.<sup>6</sup> But the coronavirus pandemic created a global debt boom that will present ongoing challenges to WASH infrastructure financing.<sup>7</sup>

Amid these challenges, WASH continues to have an existential crisis—billions of dollars are spent annually implementing, monitoring, and evaluating WASH projects, yet SDG<sup>6</sup> seems out of reach. There were already questions about whether foreign aid for WASH interventions was effective.<sup>8</sup> Then, in 2018-2019, a series of studies from the WASH Benefits and SHINE trials in

Bangladesh, Kenya, and Zimbabwe reported no effect on child linear growth and only mixed effects on diarrhea.<sup>9-11</sup>

These primary outcomes of diarrhea and stunting are traditional measures of WASH effectiveness. But in retrospect, they seem like remarkably narrow evaluation criteria for such ambitious projects. Even when water is microbiologically safe, hundreds of millions of people face harassment; assault; injury; poisoning; anxiety; exhaustion; depression; social exclusion; discrimination; subjugation; hunger; debt; or work, school, or family care absenteeism when retrieving or consuming household water.<sup>12-15</sup> By neglecting to regularly measure how WASH interventions address these wider challenges, the development community has tacitly endorsed a limited understanding of WASH program effectiveness.

## TRANSFORMATIVE WASH

WASH interventions have increasingly relied on randomized controlled trials (RCTs), despite their limitations in external validity and in capturing respondent heterogeneity.<sup>16</sup> In 2019, a group of WASH insiders convened to reconcile the WASH Benefits and SHINE RCT results. This team ultimately reaffirmed RCTs as the preferred tool for evaluating WASH interventions and called for more detailed studies to control for additional

<sup>1</sup>WHO/UNICEF. Progress on household drinking water, sanitation and hygiene 2000-2020: Five years into the SDGs. Geneva: WHO; 2021.

<sup>2</sup>Chenoweth J. Minimum water requirement for social and economic development. *Desalination* 2008; 229(1): 245-56.

<sup>3</sup>Flörke M, Kynast E, Bärlund I, Eisner S, Wimmer F, Alcamo J. Domestic and industrial water uses of the past 60 years as a mirror of socio-economic development: A global simulation study. *Global Environmental Change* 2013; 23(1): 144-56.

<sup>4</sup>WHO. Safer water, better health. Geneva: World Health Organization; 2019.

<sup>5</sup>Sadoff CW, Borgomeo E, Uhlenbrook S. Rethinking water for SDG 6. *Nature Sustainability* 2020; 3(5): 346-7.

<sup>6</sup>Hutton G, Varughese M. The costs of meeting the 2030 Sustainable Development Goal Targets on drinking water, sanitation, and hygiene. Washington, DC: World Bank Group; 2016.

<sup>7</sup>Kose MA, Ohnsorge F, Sugawara N. A mountain of debt: Navigating the legacy of the pandemic. CEPR Discussion Paper No DP16637: SSRN; 2021. p. 41.

<sup>8</sup>Wayland J. Constraints on foreign aid effectiveness in the water, sanitation, and hygiene (WaSH) sector. *Journal of Water, Sanitation and Hygiene for Development* 2017; 8(1): 44-52.

<sup>9</sup>Humphrey JH, Mbuya MNN, Ntozini R, et al. Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on child stunting and anaemia in rural Zimbabwe: a cluster-randomised trial. *The Lancet Global Health* 2019; 7(1): e132-e47.

<sup>10</sup>Luby SP, Rahman M, Arnold BF, et al. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: a cluster randomised controlled trial. *The Lancet Global Health* 2018; 6(3): e302-e15.

<sup>11</sup>Null C, Stewart CP, Pickering AJ, et al. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Kenya: a cluster-randomised controlled trial. *The Lancet Global Health* 2018; 6(3): e316-e29.

<sup>12</sup>Mushavi RC, Burns BFO, Kakuhikire B, et al. "When you have no water, it means you have no peace": A mixed-methods, whole-population study of water insecurity and depression in rural Uganda. *Social Science & Medicine* 2020; 245: 112561.

<sup>13</sup>Peloso M, Morinville C. 'Chasing for water': Everyday practices of water access in peri-urban Ashaiman, Ghana. *Water Alternatives* 2014; 7(1): 121-39.

<sup>14</sup>Ranganathan M. 'Mafias' in the waterscape: Urban informality and everyday public authority in Bangalore. *Water Alternatives* 2014; 7(1).

<sup>15</sup>Smiley SL, Stoler J. Socio-environmental confounders of safe water interventions. *WIREs Water* 2020; 7(3): e1438.

<sup>16</sup>Levy K, Eisenberg JNS. Moving towards transformational WASH. *The Lancet Global Health* 2019; 7(11): e1492.

pathways that were presumed to attenuate WASH intervention effects on linear growth and diarrhea, but the authors did not offer much of a roadmap.<sup>17</sup> One of the legacies of that discourse was the call for *transformative WASH*,<sup>17,18</sup> which has subsequently been referred to by others as WASH++<sup>19</sup> or transformational WASH.<sup>16,20</sup> Years later, it is still not clear what transformative WASH is, or how to achieve it.

The initial call for transformative WASH centered around fecal contamination and stronger governance.<sup>18</sup> The authors partially attributed the perceived ineffectiveness of the original trials to targeting particularly deep-seated public health challenges.<sup>17</sup> This call hit a nerve and generated two correspondences in *The Lancet Global Health* titled “Moving toward transformational WASH.” In one, Levy and Eisenberg<sup>16</sup> highlighted caveats of the study design and the non-representativeness of these trials’ rural sites in an increasingly urbanized world, but ended by affirming the need for new interventions “to reduce faecal contamination in the domestic environment,” again keeping the focus on microbial contamination. In the second correspondence, Kearns<sup>20</sup> explained how these trials could have been confounded by chemical pollution, as synthetic chemicals can dysregulate immune function and increase susceptibility to waterborne pathogens.

Pickering and colleagues responded to these letters,<sup>21</sup> but still seemed stuck in the same paradigm. They are not alone: recent reflections about the future of WASH continue to reinforce the pathogen-oriented paradigm.<sup>22,23</sup> The Lancet recently rewarded a group of WASH establishment leaders—many of whom were involved in the WASH Benefits and SHINE trials—with a new *Commission on water, sanitation and hygiene, and health*, ostensibly to reconcile many of these issues. The Commission’s stated priorities include “provid[ing] a comprehensive assessment

of the potential benefits [of achieving universal access to at least safely managed WASH services], encompassing public health gains, financial returns through improvements in human capital and productivity, and other benefits relating to social and environmental justice and gender equality.”<sup>24</sup> Yet the Commission’s first product doubled-down on microbiological water quality and diarrhea as WASH’s most pressing problem, with a mere two sentences about “other benefits.”<sup>25</sup> How did we get to this point? Two things stand out: inconsistent application of the WASH Theory of Change, and the WASH establishment’s preoccupation with a 20th-century water quality paradigm.

## THEORY OF CHANGE

Many WASH programs are guided by some version of the Theory of Change, which explicitly maps out how an initiative’s impacts will be achieved. The Theory of Change is often visualized and communicated using a logic model that starts with the desired impacts and works backwards through the causal logic that will lead to the desired outcomes and impacts. If we examine how leading global WASH programs operationalize the Theory of Change, it becomes clear that outcomes and impacts are often poorly articulated.

For example, UNICEF’s WASH-oriented *Goal Area 4* in its 2022-2025 Strategic Plan is that “Every child, including adolescents, has access to safe and equitable WASH services and supplies, and lives in a safe and sustainable climate and environment”.<sup>26</sup> Each Goal Area has multiple nested Results Areas, which in turn contain indicators. These indicators measure successful implementation activities, such as “4.1.3. Number of people reached with at least basic hygiene services through UNICEF-supported programmes,” or engagement, such as “4.2.5. Number of countries integrating a humanitarian-development-peace nexus approach on WASH programming through

<sup>17</sup>Cumming O, Arnold BF, Ban R, et al. The implications of three major new trials for the effect of water, sanitation and hygiene on childhood diarrhea and stunting: a consensus statement. *BMC Medicine* 2019; 17(1): 173.

<sup>18</sup>Pickering AJ, Null C, Winch PJ, et al. The WASH Benefits and SHINE trials: interpretation of WASH intervention effects on linear growth and diarrhoea. *The Lancet Global Health* 2019; 7(8): e1139-e146.

<sup>19</sup>Hussein M, Darboe MK, Moore SE, Nabwera HM, Prentice AM. Thresholds of socio-economic and environmental conditions necessary to escape from childhood malnutrition: a natural experiment in rural Gambia. *BMC Medicine* 2018; 16(1): 199.

<sup>20</sup>Kearns J. Moving towards transformational WASH. *The Lancet Global Health* 2019; 7(11): e1493.

<sup>21</sup>Pickering AJ, Arnold BF, Prendergast AJ, et al. Moving towards transformational WASH – Authors’ reply. *The Lancet Global Health* 2019; 7(11): e1494-e5.

<sup>22</sup>Howard G. The future of water and sanitation: global challenges and the need for greater ambition. *Journal of Water Supply: Research and Technology-Aqua* 2021.

<sup>23</sup>Mraz AL, Tumwebaze IK, McLoughlin SR, et al. Why pathogens matter for meeting the united nations’ sustainable development goal 6 on safely managed water and sanitation. *Water Research* 2021; 189: 116591.

<sup>24</sup>Amebelu A, Ban R, Bhagwan J, et al. The Lancet Commission on water, sanitation and hygiene, and health. *The Lancet* 2021; 398(10310): 1469-70.

<sup>25</sup>Wolf J, Hubbard S, Brauer M, et al. Effectiveness of interventions to improve drinking water, sanitation, and handwashing with soap on risk of diarrhoeal disease in children in low-income and middle-income settings: a systematic review and meta-analysis. *The Lancet* 2022; 400(10345): 48-59.

<sup>26</sup>UNICEF. Theory of Change, UNICEF Strategic Plan, 2022–2025. New York, NY: UNICEF, 2021.

the participation of affected populations.” These kinds of indicators do not measure how the services, or engagement in service provision, improved people’s lives. WASH indicators should measure what WASH interventions are accomplishing *through* improvements in quality, quantity, temporal availability, service predictability, etc., not these characteristics themselves.

Other major WASH project implementers are organized similarly. WASH Alliance International (WAI), a consortium of nine organizations, uses a Theory of Change built upon three pillars: affordable WASH markets, sustainable governance, and empowered citizens.<sup>27</sup> Very few of the activities described in these pillars are explicitly linked to a measurable improvement in people’s lives. IRC International Water and Sanitation Centre (a WAI member) is guided by their *Sustainable Services at Scale (Triple-S) Theory of Change* with expressed outcomes that comprise the adoption of a service delivery approach by donors, NGOs, and government stakeholders with adaptive, sustainable management.<sup>28</sup> Their 2020 annual report highlighted expenditure totals and staff, project, and donor counts in each partner country, rather than community- or household-level improvements.<sup>29</sup> A few organizations

do emphasize impact. Water for People’s Theory of Change explicitly culminates with *Impacts* including “improved health, education, economic options, and quality of life for generations”.<sup>30</sup> Splash International’s Theory of Change also differentiates between *Outcomes*, e.g., improved infrastructure or behavior change, and *Impact* such as better health and development.<sup>31</sup>

None of this is intended as a critique of these organizations’ structures and missions, all of which aim to improve WASH security around the world. But the “wicked” problem of global safe water and sanitation requires complicated integration of global health efforts with supply chain management, finance, governance, and many other sectors to implement the causal chain of activities that leads to desired impacts. Given this multi-sectoral complexity,<sup>32</sup> some practitioners have suggested the use of human-centered design of WASH interventions based on Behavior Centered Design Theory.<sup>33</sup> Outcomes and impacts need to reflect the full range of what WASH interventions can accomplish, as depicted in the sample logic model in **Figure 1**, and be measured systematically. But instead, WASH program evaluations continue to focus narrowly on water quality and waterborne diseases.

**Figure 1.** Hypothetical logic model of a WASH intervention with examples of human-centered impacts beyond microbiological indicators.



<sup>27</sup>WASH Alliance International. Theory of Change for accelerating sustainable WASH services. The Netherlands: WASH Alliance International, 2016.

<sup>28</sup>Schouten T, Moriarty P. The Triple-S Theory of Change. The Hague, The Netherlands: IRC International Water and Sanitation Centre, 2013.

<sup>29</sup>IRC. IRC Annual Report 2020. The Hague, The Netherlands: IRC International Water and Sanitation Centre, 2020.

<sup>30</sup>Water For People. Water For People theory of change. Denver, CO: Water For People, 2019.

<sup>31</sup>Splash. Theory of Change 2018-2023. Seattle, WA: Splash International, 2018.

<sup>32</sup>Rhodes-Dicker L, Brown NJ, Currell M. Unpacking intersecting complexities for WASH in challenging contexts: A review. *Water Research* 2022; 209: 117909.

<sup>33</sup>Burton J, Patel D, Landry G, Anderson SM, Rary E. Failure of the “gold standard”: The role of a mixed methods research toolkit and human-centered design in transformative WASH. *Environmental Health Insights* 2021; 15: 11786302211018391.

## THE WATER QUALITY PARADIGM

WASH evaluation strategy continues to focus on water quality, stuck in a 20th century paradigm of clean water that harkens back to John Snow, germ theory, and traditional sources of infant mortality. If you look at broad WASH literature over the past decade or two, one might reasonably conclude that if we could just provide everyone with “access” to water that is free of *E. coli*, the problem would be solved. But anyone working in this sector knows it is not that simple, and that even when safe water is provided, there are often substantial structural, behavioral, and institutional barriers to access.

This is not to say water quality doesn’t matter—of course it does. But there is a disproportionate outpouring of funding—from governments and NGOs—to drill wells, install pumps, and perfect all kinds of point-of-use and point-of-acquisition water safety technologies, which critics refer to as the “WASH industrial complex.” Few (if any) of these solutions have been sustainably scaled beyond local communities, and they often lack clear evaluation criteria. Researchers at UCL have piloted concept mapping in rural India to embrace and gain a more holistic view of the socio-environmental, cultural, and political-economic context around infant health, but again focused on enteric infections.<sup>34</sup> There are many confounders of the pathways and behavior changes associated with indicators like diarrhea and stunting.<sup>15</sup> More importantly, those enduring water insecurity face so many challenges to health and well-being that studies just focused on water quality-related outcomes seem to be missing the bigger picture.

Despite all we have learned, the development community is still doing many of the same old things. Perhaps the most high-profile ongoing WASH program is the RISE trials (“revitalizing informal settlements and their environments”) headquartered at Monash University in Melbourne. They integrate transformative WASH and planetary health with hopes of generating a new, empirically grounded conceptual model of health and environment in urban informal settlements. Their work is based on the traditional WASH Theory of Change: if we reduce child exposure to fecal-oral contamination, it will improve gastro-intestinal health and thus physical

development outcomes. Part of the innovation is using TaqMan Array Cards to screen 30+ pathogens simultaneously, but they are *still focused on microbiological water quality and enteric pathogens*. The project has a strong gender empowerment component, intent on creating resources for practitioners to improve gender-inclusive co-design of WASH infrastructure. Perhaps the most significant advance in this RCT might be the use of psychosocial impacts, such as validated measures of subjective wellbeing, depression, quality of life, and social cohesion. It pushes boundaries, but not nearly to the extent possible given all that we know about the impacts of WASH insecurity.

In fact, there is wide-ranging literature demonstrating how WASH insecurity disrupts people’s lives in *many* more ways than waterborne diseases. Many of these pathways demonstrate intricate links between resource insecurities, such as food, water, and sanitation securities, and likely exacerbate diarrheal diseases and child stunting.<sup>35</sup> To many interdisciplinary WASH scholars, the burden of diarrheal diseases is a drop in the proverbial bucket. But in the WASH establishment—which is dominated by civil and environmental engineers whose background and training has, for a century, focused on health impacts related to water quality—few are measuring a diverse set of socio-medical burdens, even though *all of these projects probably improve community well-being in unmeasured—perhaps even transformative!—ways*. What we need is a paradigm shift in the monitoring and evaluation of WASH projects. We have the tools to demonstrate to governments and funders just how overwhelmingly transformative WASH may be, end the narrative about ineffective WASH, and attract financing for transformative change. To do that, we have to measure transformative WASH.

## MEASURING TRANSFORMATIVE WASH

The WASH literature offers a growing set of tools for measuring different physical and biosocial outcomes related to WASH insecurity in diverse international contexts. These examples—summarized in **Table 1**—are far from comprehensive, but generally present opportunities for survey-based monitoring and evaluation programs to quantify how WASH projects transform lives. Most of these tools can, and should, be adapted to

<sup>34</sup>Vila-Guilera J, Parikh P, Chaturvedi H, Ciric L, Lakhanpaul M. Towards transformative WASH: an integrated case study exploring environmental, sociocultural, economic and institutional risk factors contributing to infant enteric infections in rural tribal India. *BMC Public Health* 2021; 21(1): 1331.

<sup>35</sup>Workman CL, Stoler J, Harris A, Ercumen A, Kearns J, Mapunda KM. Food, water, and sanitation insecurities: Complex linkages and implications for achieving WASH security. *Global Public Health* 2021: 1-16.

local contexts through community-based participation in intervention design and program evaluation, a theme we will return to below.

## Water insecurity experiences

The Household Water Insecurity Experiences (HWISE) scale is a screener for rapidly assessing household level water insecurity. This survey module asks how frequently, over the prior 30 days, a respondent encountered 12 disruptions to daily activities or to emotional well-being that.<sup>36</sup> The 12 items are related to access, use, and reliability of household water, and span topics such as hygiene, water worry, and quantity. These items represent universal, though not comprehensive, household experiences associated with water insecurity. The first-generation HWISE scale appears to be a significant improvement over traditional water security metrics used by the WHO JMP which focused on the type of water source as a proxy for quality. The HWISE scale is a plug-and-play tool with short-form<sup>37</sup> and individual-level<sup>38</sup> versions that can be used to assess intra-household disparities. Next-generation versions of this scale should ideally also capture the relative severity of these disruptions, and how people are adapting to them to help guide integration of resilience-building into WASH interventions.<sup>39</sup> Others have proposed similar experiential scales to measure sanitation and

hygiene insecurity.<sup>40</sup> At the very least, experience-based scales remind WASH practitioners of the breadth of impacts of resource insecurity.

## Mental health

Research on WASH insecurity's effects on mental health and well-being has flourished over the past 5 years, even if scholars are still scratching the surface of these pathways.<sup>41</sup> It is clear that water worry, and related forms of stress, anxiety, and depression, are incredibly disruptive to households and individuals, whether directly through inadequate WASH,<sup>42</sup> or indirectly through adaptations to inadequate WASH such as the distress generated by water sharing arrangements.<sup>43</sup> Mental ill health can also be shaped by the loss of dignity and autonomy over one's water situation, effects that demonstrate the far-reaching implications of the human right to water.<sup>44,45</sup> Researchers have adapted a variety of Western psychometric tools to measure WASH-related stress in international settings,<sup>46,47</sup> while also implementing biometric assessments such as blood pressure<sup>48</sup> or oxidative stress<sup>49</sup> during household surveys.

## Gender roles

Scholars have also long observed WASH gender disparities,<sup>50</sup> particularly imbalances in household responsibilities for water fetching<sup>51</sup> and participation in

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<sup>36</sup>Young S, Boateng G, Jamaluddine Z, et al. The Household Water InSecurity Experiences (HWISE) Scale: development and validation of a household water insecurity measure for low- and middle-income countries. *BMJ Global Health* 2019; 4(5): e001750.

<sup>37</sup>Young SL, Miller JD, Frongillo EA, et al. Validity of a four-item household water insecurity experiences scale for assessing water issues related to health and well-being. *The American Journal of Tropical Medicine and Hygiene* 2021; 104(1): 391-4.

<sup>38</sup>Young SL, Bethancourt HJ, Ritter ZR, Frongillo EA. The Individual Water Insecurity Experiences (IWISE) Scale: reliability, equivalence and validity of an individual-level measure of water security. *BMJ Global Health* 2021; 6(10): e006460.

<sup>39</sup>Sidote MN, Goodman ZT, Paraggio CL, Tutu RA, Stoler J. Measurement invariance of a household water insecurity metric in Greater Accra, Ghana: Implications for test-retest reliability. *International Journal of Hygiene and Environmental Health* 2022; 240: 113922.

<sup>40</sup>Caruso BA, Clasen T, Yount KM, Cooper HLF, Hadley C, Haardörfer R. Assessing women's negative sanitation experiences and concerns: The development of a novel sanitation insecurity measure. *International Journal of Environmental Research and Public Health* 2017; 14(7): 755.

<sup>41</sup>Kangmenaaang J, Elliott SJ. Linking water (in)security and wellbeing in low-and middle-income countries. *Water Security* 2021; 13: 100089.

<sup>42</sup>Wutich A, Brewis A, Tsai AC. Water and mental health. *WIREs Water* 2020; 7(5): e1461.

<sup>43</sup>Wutich A, Rosinger A, Brewis A, Beresford M, Young S, HWISE-RCN. Water sharing is a distressing form of reciprocity: Shame, upset, anger, and conflict over water in twenty cross-cultural sites. *American Anthropologist* 2022; 124(2): 279-90.

<sup>44</sup>Robina-Ramírez R, Sañudo-Fontaneda LS, McCallum S. Human dignity as a mediator effect for the rights and duties of accessing water and sanitation. *Transactions of the Royal Society of South Africa* 2020; 75(2): 203-12.

<sup>45</sup>Shreyaskar PP. Contours of access to water and sanitation in India: drawing on the right to live with human dignity. *Economic and Political Weekly* 2016; 51(53): 144-51.

<sup>46</sup>Stoler J, Pearson AL, Staddon C, et al. Cash water expenditures are associated with household water insecurity, food insecurity, and perceived stress in study sites across 20 low- and middle-income countries. *Science of The Total Environment* 2020; 716: 135881.

<sup>47</sup>Workman CL, Ureksoy H. Water insecurity in a syndemic context: Understanding the psycho-emotional stress of water insecurity in Lesotho, Africa. *Social Science & Medicine* 2017; 179: 52-60.

<sup>48</sup>Brewis A, Choudhary N, Wutich A. Low water access as a gendered physiological stressor: Blood pressure evidence from Nepal. *American Journal of Human Biology* 2019; 31(3): e23234.

<sup>49</sup>Lin A, Mertens AN, Rahman MZ, et al. Effects of drinking water, sanitation, handwashing and nutritional interventions on stress physiology, oxidative stress, and epigenetic programming in young children living in rural Bangladesh: A randomized clinical trial. *medRxiv* 2021: 2021.11.24.21266798.

<sup>50</sup>Caruso BA, Sevilimedu V, Fung IC-H, Patkar A, Baker KK. Gender disparities in water, sanitation, and global health. *The Lancet* 2015; 386(9994): 650-1.

<sup>51</sup>Geere J-AL, Cortobius M. Who carries the weight of water? Fetching water in rural and urban areas and the implications for water security. *Water Alternatives* 2017; 10(2): 513-40.

economic activities.<sup>52</sup> Generally speaking, transformative gender studies engage with agency, relations, and power dynamics to critically examine gender dynamics inherent in WASH service delivery.<sup>53</sup> For example, gender- and disability-inclusive designs have strengthened WASH programs in Cambodia and Timor-Leste by shifting awareness, roles, relationships, and attitudes.<sup>54</sup> Yet WASH data have traditionally not been sex-disaggregated, and this obscures intra-household dynamics, particularly related to gender roles.<sup>55</sup> Dickin et al.<sup>56</sup> recently filled an important gap in our ability to measure women's empowerment and gender outcomes in WASH, echoing earlier calls.<sup>55,57</sup> The Empowerment in WASH Index uses gendered indicators of agency, participation, and empowerment at multiple scales and can be used in tandem with other intra-household parity and autonomy measures.<sup>58</sup>

## Reproductive health

Inadequate WASH services are well-known to limit menstrual hygiene and cause other reproductive health problems.<sup>59,60</sup> Constraints on menstrual hygiene can, in turn, lead to a wide range of physical, mental, social, and economic consequences.<sup>61</sup> Efforts to measure menstrual hygiene experiences, such as the Menstrual

Practice Needs Scale (MPNS-36),<sup>62</sup> or other menstrual insecurity measures,<sup>63</sup> aim to measure the extent to which menstrual practices and environments meet women's needs. The MPNS-36, for example, is composed of 28 items answered by all respondents, and eight additional items related to washing and drying experiences during the reusing of menstrual materials.

## Violence

A growing body of work has documented the links between WASH access and gender-based violence<sup>64,65</sup> and intimate partner violence.<sup>12,66</sup> Recent work has connected water insecurity with community-level and intra-household conflict, and how these relationships may be shaped by regional conflict<sup>67</sup> and exacerbated by climate change.<sup>68,69</sup> While traditional water conflict metrics have tended to be implemented at regional scales, we can learn a lot about community and household conflict through short survey modules, with additional precautions for assessing physical and sexual violence.

## Injuries

Water carriage and management associated with WASH insecurity is widely known to lead to pain, fatigue,

<sup>52</sup>Indarti N, Rostiani R, Megaw T, Willetts J. Women's involvement in economic opportunities in water, sanitation and hygiene (WASH) in Indonesia: Examining personal experiences and potential for empowerment. *Development Studies Research* 2019; 6(1): 76-91.

<sup>53</sup>MacArthur J, Carrard N, Willetts J. WASH and Gender: a critical review of the literature and implications for gender-transformative WASH research. *Journal of Water, Sanitation and Hygiene for Development* 2020; 10(4): 818-27.

<sup>54</sup>Huggett C, Da Costa Cruz L, Goff F, Pheng P, Ton D. Beyond inclusion: practical lessons on striving for gender and disability transformational changes in WASH systems in Cambodia and Timor-Leste. *H2Open Journal* 2022; 5(1): 26-42.

<sup>55</sup>Caruso BA, Sinharoy SS. Gender data gaps represent missed opportunities in WASH. *The Lancet Global Health* 2019; 7(12): e1617.

<sup>56</sup>Dickin S, Bisung E, Nansi J, Charles K. Empowerment in water, sanitation and hygiene index. *World Development* 2021; 137: 105158.

<sup>57</sup>Kayser GL, Rao N, Jose R, Raj A. Water, sanitation and hygiene: measuring gender equality and empowerment. *Bulletin of the World Health Organization* 2019; 97(6): 438-40.

<sup>58</sup>Bisung E, Dickin S. Who does what and why? Examining intra-household water and sanitation decision-making and autonomy in Asutifi North, Ghana. *Journal of Water, Sanitation and Hygiene for Development* 2021; 11(5): 794-804.

<sup>59</sup>Mahon T, Fernandes M. Menstrual hygiene in South Asia: a neglected issue for WASH (water, sanitation and hygiene) programmes. *Gender & Development* 2010; 18(1): 99-113.

<sup>60</sup>Campbell OMR, Benova L, Gon G, Afsana K, Cumming O. Getting the basic rights – the role of water, sanitation and hygiene in maternal and reproductive health: a conceptual framework. *Tropical Medicine & International Health* 2015; 20(3): 252-67.

<sup>61</sup>Sommer M, Kjellén M, Pensulo C. Girls' and women's unmet needs for menstrual hygiene management (MHM): the interactions between MHM and sanitation systems in low-income countries. *Journal of Water, Sanitation and Hygiene for Development* 2013; 3(3): 283-97.

<sup>62</sup>Hennegan J, Nansubuga A, Smith C, Redshaw M, Akullo A, Schwab KJ. Measuring menstrual hygiene experience: development and validation of the Menstrual Practice Needs Scale (MPNS-36) in Soroti, Uganda. *BMJ Open* 2020; 10(2): e034461.

<sup>63</sup>Caruso BA, Portela G, McManus S, Clasen T. Assessing women's menstruation concerns and experiences in Rural India: development and validation of a menstrual insecurity measure. *International Journal of Environmental Research and Public Health* 2020; 17(10): 3468.

<sup>64</sup>Abu Sharekh Y. Relationship between gender-based violence and poor access to water, sanitation, and hygiene services. *English Language Institute* 2021: 131.

<sup>65</sup>Pommells M, Schuster-Wallace C, Watt S, Mulawa Z. Gender violence as a water, sanitation, and hygiene risk: Uncovering violence against women and girls as it pertains to poor WaSH access. *Violence Against Women* 2018; 24(15): 1851-62.

<sup>66</sup>Choudhary N, Brewis A, Wutich A, Bhushan P. Sub-optimal household water access is associated with greater risk of intimate partner violence against women: evidence from Nepal. *Journal of Water and Health* 2020; In press.

<sup>67</sup>Pearson A, Mack E, Ross A, et al. Interpersonal conflict over water is associated with household demographics, domains of water insecurity, and regional conflict: evidence from nine sites across eight sub-Saharan African Countries. *Water* 2021; 13(9): 1150.

<sup>68</sup>Caridade SMM, Vidal DG, Dinis MAP. Climate change and gender-based violence: Outcomes, challenges and future perspectives. In: Leal Filho W, Vidal DG, Dinis MAP, Dias RC, eds. Sustainable Policies and Practices in Energy, Environment and Health Research: Addressing Cross-cutting Issues. Cham: Springer International Publishing; 2022: 167-76.

<sup>69</sup>Mack EA, Bunting E, Herndon J, Marcantonio RA, Ross A, Zimmer A. Conflict and its relationship to climate variability in Sub-Saharan Africa. *Science of The Total Environment* 2021; 775: 145646.

perinatal effects, violence, stress, and disability from musculoskeletal disorders.<sup>70-73</sup> In one study, 13% of 6,291 households across 24 LMIC sites reported at least one lifetime water-fetching injury.<sup>74</sup> The study also proposed a survey module for assessing water-fetching injuries and symptoms. This tool allows for assigning multiple ICD-11 codes for injury or symptom, body location, mechanism/activity, and environmental context, while potentially capturing intersecting themes of safety and violence. Beyond SDG 6, injury prevention is also strongly aligned with several SDG priorities such as health and well-being, sustainable cities, gender equity, responsible consumption and production, and decent work and economic growth.<sup>75</sup>

### Life course non-communicable diseases

Inadequate WASH also leads to a wide range of health issues by interacting with poverty.<sup>76</sup> For example, water fetching by women was found to be associated with lower likelihood of giving birth in a healthcare facility, increased risk of childhood death, reduced utilization of antenatal care, and increased risk of leaving a young child unsupervised for an hour or more.<sup>77</sup> Recent studies have assessed how water insecurity is related to children's gut health,<sup>78</sup> and how WASH interventions may improve immune function.<sup>79</sup> At the other end of the life course, WASH access has implications for older adults and people living with disabilities, particularly with respect to

workforce participation.<sup>80</sup> Others have noted additional human biological relationships between water insecurity and non-communicable health issues such as nutrition, cognitive performance, hypertension, and kidney disease.<sup>81</sup> Although long-term chronic health issues are difficult to link to WASH interventions, changes in how they are experienced can be inexpensively surveyed. Measuring rates of maternal health complications and behaviors associated with child care are also opportunities for evaluating WASH project impact. Many of these health outcomes are regularly assessed by household surveys such as USAID's Demographic and Health Surveys (DHS), UNICEF's Multiple Indicator Cluster Survey (MICS), and WHO's Stepwise Approach to Surveillance (STEPS), and context-appropriate modules can be incorporated into WASH evaluations.

### Climate resilience and migration

Climate change is regarded as an increasingly important driver of migration.<sup>82</sup> In communities vulnerable to climate change, WASH improvements can build resilience by stimulating economic activity, social capital, education and training, and community health.<sup>83</sup> Emerging studies have begun to explicitly connect climate migration, traditional migration drivers, and WASH services.<sup>84,85</sup> A 2021 World Bank report estimated that water scarcity is now believed to be associated with 10% of the increase in global migration, with much of this

<sup>70</sup>Rosinger AY, Bethancourt HJ, Young SL, Schultz AF. The embodiment of water insecurity: Injuries and chronic stress in lowland Bolivia. *Social Science & Medicine* 2021; 291: 114490.

<sup>71</sup>Geere J-A, Bartram J, Bates L, et al. Carrying water may be a major contributor to disability from musculoskeletal disorders in low income countries: a cross-sectional survey in South Africa, Ghana and Vietnam. *Journal of Global Health* 2018; 8(1).

<sup>72</sup>Geere J-AL, Hunter PR, Jagals P. Domestic water carrying and its implications for health: a review and mixed methods pilot study in Limpopo Province, South Africa. *Environ Health* 2010; 9: 52.

<sup>73</sup>Geere J-AL, Cortobius M, Geere JH, Hammer CC, Hunter PR. Is water carriage associated with the water carrier's health? A systematic review of quantitative and qualitative evidence. *BMJ Global Health* 2018; 3(3): e000764.

<sup>74</sup>Venkataramanan V, Geere JA, Thomae B, et al. In pursuit of "safe" water: the burden of personal injury from water-fetching in 21 low- and middle-income countries. *BMJ Global Health* 2020; 5: e003328.

<sup>75</sup>Ma T, Peden AE, Peden M, et al. Out of the silos: embedding injury prevention into the Sustainable Development Goals. *Injury Prevention* 2020; injuryprev-2020-043850.

<sup>76</sup>Adams EA, Stoler J, Adams Y. Water insecurity and urban poverty in the Global South: Implications for health and human biology. *American Journal of Human Biology* 2020; 32: e23368.

<sup>77</sup>Geere J-AL, Hunter PR. The association of water carriage, water supply and sanitation usage with maternal and child health. A combined analysis of 49 Multiple Indicator Cluster Surveys from 41 countries. *International Journal of Hygiene and Environmental Health* 2020; 223(1): 238-47.

<sup>78</sup>Piperata BA, Lee S, Mayta Apaza AC, et al. Characterization of the gut microbiota of Nicaraguan children in a water insecure context. *American Journal of Human Biology* 2020; 32(1): e23371.

<sup>79</sup>Lin A, Mertens AN, Tan S, et al. Effects of drinking water, sanitation, handwashing, and nutritional interventions on immune status in young children: a cluster-randomized controlled trial in rural Bangladesh. *medRxiv* 2021: 2021.11.10.21266206.

<sup>80</sup>Wrisdale L, Mokoena MM, Mudau LS, Geere J-A. Factors that impact on access to water and sanitation for older adults and people with disability in rural South Africa: An occupational justice perspective. *Journal of Occupational Studies* 2017; 24(3): 259-79.

<sup>81</sup>Rosinger AY, Young SL. The toll of household water insecurity on health and human biology: Current understandings and future directions. *WIREs Water* 2020; 7(6): e1468.

<sup>82</sup>Kaczan DJ, Orgill-Meyer J. The impact of climate change on migration: a synthesis of recent empirical insights. *Climatic Change* 2020; 158(3): 281-300.

<sup>83</sup>Omasete J, Forster J, Geere J-A. Water, sanitation and hygiene: The foundation for building resilience in climate-vulnerable communities. New York, NY: WaterAid, 2021.

<sup>84</sup>Khan MA. Livelihood, WASH related hardships and needs assessment of climate migrants: evidence from urban slums in Bangladesh. *Heliyon* 2022; 8(5): e09355.

<sup>85</sup>Stoler J, Pearson AL, Rosinger AY, et al. The role of water in environmental migration. *WIREs Water* 2022; 9(3): e1584.

due to rainfall shocks.<sup>86</sup> But chronic water insecurity is theorized to spur migration through everyday disruptions to social and economic well-being.<sup>87</sup> One unpublished study found that 20% of 5,336 households from 23 LMIC sites around the world said they had considered moving at least once in the prior 4 weeks due to water problems (author's unpublished data). We know almost nothing about the thresholds of WASH inadequacy that shape migration decision-making, especially amid climate change. It is plausible that WASH security could yield some degree of migration security, or at least mitigate climate-induced displacement, but migration is rarely integrated into WASH interventions. Standard modules, such as the United Nations' standard questions on international migration,<sup>88</sup> could be adapted to capture migration push and pull factors related to environmental change, with focus on WASH insecurity.

### Emerging contaminants

There are many classes of emerging chemical toxicants in water include “halogenated organics, plasticizers such as phthalates and bisphenol-A, numerous pesticides including atrazine and chlordane, flame retardants, and PFAS,”<sup>20</sup> and usually without published health criteria.<sup>89</sup> All these compounds have demonstrated immunotoxicity; Kearns<sup>90</sup> summarized over a decade of literature about chemical exposures in Bangladesh, Kenya, and Zimbabwe that could confound projects such as the WASH Benefits and SHINE trials. We are unable to test most emerging contaminants in low-cost, rapid field conditions because testing procedures are expensive and limited to specialized laboratories. Innovations such as biosensors may one day enable low-cost diagnostic methods for many natural

and synthetic contaminants.<sup>91</sup> It is incumbent upon the WASH community to actively monitor advances in detection technologies and, when the opportunity arises, be ready to expand our toolkit beyond basic physico-chemical and microbiological monitoring.<sup>89</sup>

### TRANSFORMATION THROUGH DECOLONIZATION

Theories of change demonstrate that WASH interventions could improve people's lives in many measurable ways. The breadth of WASH's potential influence on so many domains of well-being warrants reconsideration of SDG 6 as a keystone goal. Without WASH, it is hard to imagine ending poverty and hunger; improving health, education, and gender equity; providing ample work opportunities and infrastructure for industrial development; achieving sustainable communities that promote climate action, oceanic life, terrestrial life, and global partnerships; and reducing global inequalities. Imagine rearranging the SDG icons as a pyramid with SDG<sup>6</sup> at the pinnacle; WASH remains a critical centerpiece toward transforming our world.<sup>92,93</sup> We might also rethink deeper integration with SDGs 10 (reduce inequality within and among countries) and 16 (promote peaceful and inclusive societies for sustainable development) to expedite the decolonization of WASH.<sup>94</sup>

The movement to decolonize global health—and WASH in particular—continues to decry the influence of insider elite circles who fail to adequately include minoritized voices.<sup>95-98</sup> For example, while Global North researchers retreated to online webinars, conferences, and trainings during the COVID-19 pandemic, Africans innovated and managed to greatly increase access to water for handwashing in some of the most difficult-to-reach

<sup>86</sup>Zaveri E, Russ J, Khan A, Damania R, Borgomeo E, Jägerskog A. Ebb and Flow, Volume 1 : Water, Migration, and Development. Washington, DC: World Bank; 2021.

<sup>87</sup>Stoler J, Brewis A, Kangmennang J, et al. Connecting the dots between climate change, household water insecurity, and migration. *Current Opinion in Environmental Sustainability* 2021; 51: 36-41.

<sup>88</sup>United Nations. Standard questions on international migration. In: Department of Economic and Social Affairs, editor. New York, NY: United Nations; 2018.

<sup>89</sup>Wutich A, Rosinger AY, Stoler J, Jepson W, Brewis A. Measuring human water needs. *American Journal of Human Biology* 2020; 32: e23350.

<sup>90</sup>Kearns J. The role of chemical exposures in reducing the effectiveness of water–sanitation–hygiene interventions in Bangladesh, Kenya, and Zimbabwe. *WIREs Water* 2020; 7(5): e1478.

<sup>91</sup>Thavarajah W, Verosloff MS, Jung JK, et al. A primer on emerging field-deployable synthetic biology tools for global water quality monitoring. *npj Clean Water* 2020; 3(1): 18.

<sup>92</sup>Boltz F, LeRoy Poff N, Folke C, et al. Water is a master variable: Solving for resilience in the modern era. *Water Security* 2019; 8: 100048.

<sup>93</sup>Marcos-García P, Carmona-Moreno C, López-Puga J, Ruiz-Ruano García AM. COVID-19 pandemic in Africa: Is it time for water, sanitation and hygiene to climb up the ladder of global priorities? *Science of The Total Environment* 2021; 791: 148252.

<sup>94</sup>Dietvorst C. Decolonising the WASH sector. The Netherlands: IRC; 2020.

<sup>95</sup>Gautier L, Karambé Y, Dossou J-P, Samb OM. Rethinking development interventions through the lens of decoloniality in sub-Saharan Africa: The case of global health. *Global Public Health* 2022; 17(2): 180-93.

<sup>96</sup>Kapur D. Decolonisation of WASH knowledge: addressing institutional bias. The Netherlands: IRC; 2020.

<sup>97</sup>Worsham K, Sylvester R, Hales G, McWilliams K, Luseka E. Leadership for SDG 6.2: is diversity missing? *Environmental Health Insights* 2021; 15: 11786302211031846.

<sup>98</sup>Irfan A, St Jean DT. COVID-19 & sociocultural determinants of global sanitation: An aide-mémoire and call to decolonize global sanitation research & practice. *Annals of Global Health* 2021; 87(1): 91.

places.<sup>99</sup> Recent panels with high-level donors continue to share the same stories of WASH intervention failures, such as the typical tale of equipment installation by an international NGO with unsustainable maintenance structures.<sup>94</sup> These failures demonstrate the flaws of an approach which focuses only on immediate access to water—and its quality—rather than system sustainability through equitable partnership and co-production of knowledge.<sup>100</sup> Influential global WASH entities might reconsider how their funding of, and commitment to, traditional WASH paradigms inhibit their broader goals. The WASH community might be better served to focus on inclusivity and accelerate the integration of participatory research designs into future interventions.<sup>101</sup>

These issues underscore why there is contradictory evidence from the past two decades over whether WASH foreign aid actually expands access to WASH services and improves human health.<sup>8</sup> Any messages that undermine the value proposition for WASH projects risk sowing seeds of doubt in the development community, particularly with donors and investors. To be clear: we certainly do not support suppressing null findings for fear of worrying donors. Rather, we urgently call for the expansion of WASH evaluation criteria to encompass a broader range of potential impacts. This wider lens can help implementers, donors, and researchers understand how vital WASH services are for human well-being and development. This is crucial in light of new challenges for achieving SDG 6 related to the COVID-19 pandemic,<sup>102,103</sup> and with the feasibility of universal safe water again being called into question.<sup>104</sup>

## CONCLUSION

There are many valid criticisms of the SDG<sup>6</sup> indicators,<sup>105-108</sup> and by chasing them, we have perhaps been lured into counting project implementations (i.e., households “with access”) rather than explicitly assessing if and how WASH projects transform lives. Focusing disproportionately on the microbial impact of WASH projects risks missing a big part of the picture if such interventions can transform communities and individuals in the ways described here. Broadening our set of indicators can help donor communities more fully understand the impact of their investments. Let’s start using the full set of measurement tools at our disposal—even if some seem unfamiliar.

Transformative WASH may be at our fingertips, but we must promote multiple-indicator, dashboard-type approaches to the monitoring and evaluation of WASH interventions to know for sure. This implies a commitment to transdisciplinary WASH research, particularly between the engineering and social sciences, which fortunately has substantial precedent.<sup>109</sup> Through participatory research that evaluates a fuller set of WASH impacts, we can gain much deeper insights into how WASH interventions change lives, i.e. “what works,” and improve our ability to convey the WASH value proposition. In doing so, we can bolster community trust, convene more equitable partnerships, strengthen ties with funders, improve project sustainability, incentivize supporting governance structures, and otherwise reinforce the deployment ecosystems that can help us regain momentum toward achieving SDG 6.

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<sup>99</sup>Luseka E. Initiating de-colonisation of WASH sector knowledge. San Francisco, CA: Medium; 2020.

<sup>100</sup>Carrard N, Willetts J, Mitchell C. Placing sustainability at the centre of water, sanitation and hygiene: Knowledge co-production for sectoral transformation. *Current Research in Environmental Sustainability* 2022; 4: 100154.

<sup>101</sup>Roque A, Wutich A, Quimby B, et al. Participatory approaches in water research: A review. *WIREs Water* 2022; 9(2): e1577.

<sup>102</sup>Ekwebelem OC, Ofielu ES, Nnorom-Dike OV, et al. Threats of COVID-19 to Achieving United Nations Sustainable Development Goals in Africa. *The American Journal of Tropical Medicine and Hygiene* 2020; 104(2): 457-60.

<sup>103</sup>The Lancet Public Health. Will the COVID-19 pandemic threaten the SDGs? *The Lancet Public Health* 2020; 5(9): e460.

<sup>104</sup>Taing L. Is safe water, sanitation, and hygiene a pipe dream? *One Earth* 2022; 5(2): 126-8.

<sup>105</sup>Cassivi A, Tilley E, Waygood EOD, Dorea C. Evaluating self-reported measures and alternatives to monitor access to drinking water: A case study in Malawi. *Science of The Total Environment* 2021; 750: 141516.

<sup>106</sup>Herrera V. Reconciling global aspirations and local realities: Challenges facing the Sustainable Development Goals for water and sanitation. *World Development* 2019; 118: 106-17.

<sup>107</sup>Guest JS. Editorial Perspectives: we need innovation for water, sanitation, and hygiene (WASH) in developing communities. *Environmental Science: Water Research & Technology* 2019; 5(5): 819-20.

<sup>108</sup>Guppy L, Mehta P, Qadir M. Sustainable development goal 6: two gaps in the race for indicators. *Sustainability Science* 2019; 14: 501-13.

<sup>109</sup>Workman CL, Cairns MR, de los Reyes FL, Verbyla ME. Global water, sanitation, and hygiene approaches: Anthropological contributions and future directions for engineering. *Environmental Engineering Science* 2021; 38(5): 402-17.

**Table 1. Summary of select survey tools for measuring physical and biosocial outcomes of WASH interventions.**

Domain	Description	Measure
Water Insecurity Experiences	New survey screeners assess universally-experienced disruptions to daily activities or to emotional well-being.	<ul style="list-style-type: none"> <li>Household Water Insecurity Experiences (HWISE) Scale<sup>56</sup> – measures frequency of 12 water-related disruptions</li> </ul>
Mental Health	WASH insecurity can product water worry, and related forms of stress, anxiety, and depression, that are incredibly disruptive to households and individuals.	<ul style="list-style-type: none"> <li>Perceived Stress Scale (PSS-4)<sup>110</sup> – measures perceptions of psychological stress</li> <li>General Anxiety Disorder (GAD-7)<sup>111</sup> – measures severity of anxiety</li> <li>Depression Anxiety Stress Scale (DASS-21)<sup>112</sup> – measures depression, anxiety and tension/stress</li> <li>Patient Health Questionnaire depression scale (PHQ-9)<sup>113</sup> – measures degree of depression severity</li> </ul>
Gender Roles	WASH gender disparities include imbalances in household responsibilities for water fetching and participation in economic activities	<ul style="list-style-type: none"> <li>Empowerment in Water, Sanitation and Hygiene Index<sup>56</sup> – measures women’s empowerment and other gendered outcomes</li> </ul>
Reproductive Health	Inadequate WASH services are well-known to limit menstrual hygiene and cause other reproductive health problems.	<ul style="list-style-type: none"> <li>Menstrual Practice Needs Scale (MPNS-36)<sup>62</sup> or other menstrual insecurity tools<sup>63</sup> – measures the extent to which respondents’ menstrual practices and environments meet women’s needs</li> </ul>
Violence	WASH insecurity often leads to gender-based violence and intimate partner violence whether intra-household or community-based.	<ul style="list-style-type: none"> <li>DHS module on domestic violence<sup>66</sup> – collects self-reported data on women’s experiences of physical and emotional violence from family members</li> <li>Individual survey items about conflict<sup>67</sup> – measure WASH-related conflict within the household, community, and potentially other scales</li> </ul>
Injuries	Water carriage and management associated with WASH insecurity can lead to pain, fatigue, perinatal effects, violence, stress, and disability from musculoskeletal disorders.	<ul style="list-style-type: none"> <li>Water-fetching injuries and symptoms module<sup>74</sup> – assigns multiple ICD-11 codes to injury or symptom, body location, mechanism/activity, and environmental context</li> </ul>
Non-Communicable Disease	Inadequate WASH often interacts with poverty and leads to a wide range of health issues including material and child health, immune function, malnutrition, and complications for people living with disabilities.	<ul style="list-style-type: none"> <li>Assessments of maternal health, nutrition, and other leading non-communicable diseases are regularly captured by population health household surveys (e.g., DHS, MICS, STEPS) and can be incorporated into WASH evaluations.</li> </ul>
Migration	WASH improvements can build resilience to displacement by stimulating economic activity, social capital, education and training, and community health.	<ul style="list-style-type: none"> <li>Standard questions on international migration<sup>88</sup> – reasons for migration should be expanded to capture dimensions of environmental change</li> </ul>

