Communicating Water, Sanitation, and Hygiene under Sustainable Development Goals 3, 4, and 6 as the Panacea for Epidemics and Pandemics Referencing the Succession of COVID-19 Surges

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**ABSTRACT:** WASH (water, sanitation, and hygiene) has become the most crucial amenity in the past decade for every individual on the planet. In the UN agenda for 2030, which created 17 Sustainable Development Goals (SDGs), SDGs 3, 4, and 6 directly correlate with WASH practices and management for creating a good health hygiene environment for all. The dearth of WASH facilities has created barriers for averting the transmission of COVID-19, motivating the concept of WASH as the primary step of precaution and prevention, which includes WASH practices, communication for literacy, and positive behavioral changes primarily in developing and low-income countries. This Review deals with the complex concept of correlation of WASH and SDGs 3, 4, and 6 while defining elaborate WASH practices, including the prominence of clean water, the need for sanitation facilities, and health hygiene for good health and immunity for preparedness for and during epidemics and pandemics. Certain risk factors explain the sectors in which the gaps exist, creating a gap for implementation of WASH practices in epidemics and pandemics across the globe. Further, COVID-19 surge succession is presented along with data of different variants that have occurred. The need of WASH understanding is required using different tools (audio-visual, social media, print media, and mass media) and strategies (communication, advocacy, and positive behavioral changes) for every individual as an act to counter consequences during and after the COVID-19 pandemic and as a routine practice for future preparedness. This Review gives a detailed concept of WASH understanding for every sector from community to government agencies and research professionals to act immediately for the sustainable future of humanity.

**INTRODUCTION**

Water, sanitation, and hygiene communities under the United Nations (UN) Sustainable Development Goal (SDG) like SDG 3 (good health and well-being), SDG 4 (quality education), and SDG 6 (clean water and sanitation) have upgraded earlier goals from decontamination of water sources and sanitation systems to well-managed Water, Sanitation, and Hygiene (WASH), including health hygiene literacy for all. Continued efforts are made to focus on SDGs 3, 4, and 6, creating major innovations providing impartial accessibility of WASH facilities, including access to clean water equally in quantity and quality, primarily to those who are marginalized or socially discriminated. Conversely, the available data highlight the dissimilarities among countries varying between rural and urban areas, vulnerable clusters, and other general sections of society. Under SDGs, focusing on "sustainability for all" and "leaving no one behind" requires continuous monitoring and detection of the types of discrimination at different levels for water, sanitation, health hygiene, and education, emphasizing the most suffered part of society, and should be counted as fundamental human rights to be maintained and nourished by all for all. Continuous recommendations from the World Health Organization (WHO) emphasize good health hygiene, WASH practices, and updated scientific literacy for communicators and WASH practitioners providing information on impacts and the severity of infections and viruses to encourage involvement in improving the overall health structures of humanity. Together these lead to knowledge up-gradation for WASH awareness, to providing literature and tools to understand in regional languages where needed, and to continuous monitoring, assessing, and focusing on the gaps in WASH, confirming equal accessibility to all.

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Unfortunately, within the current state of the guidelines, it requires more wide accessibility, including translation to regional languages, trained communicators at the regional level, people’s participation, and regulating bodies in regions with minimum health care systems, education, and WASH facilities.\textsuperscript{11,20,28,40,108} WASH practices and communication for good hygiene could reduce death and disease by ubiquitous infections.\textsuperscript{24} SDGs clearly define WASH facilities, and services are conveyed by communication for awareness and increasing literacy during epidemics and pandemics, which could initiate positive and long-lasting behavioral changes in the society.\textsuperscript{24} A win–win strategy could apply to a management plan for improved WASH services within the time frame to respond to epidemics and pandemics. The prominence of WASH practices responding to epidemics and pandemics is recognized by several world leaders, prioritizing it while investing in implementation and management.\textsuperscript{68} In light of the number of outbreaks in the last three decades, long-term planning is essential for sustainable WASH services, including communication to educate, as part of Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs).\textsuperscript{24}

Epidemics and pandemics are the regional and global outbreak of diseases, spreading rigorously like COVID-19 (declared a pandemic by WHO in March 2020), causing an increase in morbidity and deaths either in a geographic region or in multiple continents, severely impacting economy, social, political, and in some cases environmental aspects.\textsuperscript{13,55} WASH practices, including education through communication, are counted as the first step for precautions and preventions to control the spread and transmission of disease in treatment facilities\textsuperscript{109} as scarcity of services can increase the risk of transmission of infectious diseases like coronavirus, including other diseases like cholera, typhoid, and hepatitis during epidemics and pandemics.\textsuperscript{21,27} Ensuring good and consistently applied WASH practices in communities, homes, schools, marketplaces, and health care facilities helps in the prevention of human-to-human transmission of any bacteria or virus-like in the COVID-19 pandemic.\textsuperscript{34} Hence, focusing on continuous improvement and implementation of WASH practices could help combat the epidemics and pandemics while providing the essential infrastructure for drinking, hand washing, maintaining good hygiene, cleaning, and education for good health.\textsuperscript{18}

Focusing on SDGs 3, 4, and 6 for WASH practices and communication, this Review describes the following vital contributions for improvisation in WASH literacy positive behavioral changes to fight against endemics, epidemics, and pandemics. Further, this Review presents a brief history of epidemics and pandemics and significant causes behind them. The second section of this Review provides detailed information on SDGs 3, 4, and 6 correlating with WASH while elaborating the importance of clean water, sanitation facilities, and health hygiene, including potential risk factors during epidemics and pandemics. Further, this Review clearly defines the different surges of COVID-19 while giving a detailed comparison of COVID-19, COVID-20, COVID-21, and COVID-22. To minimize the impact of COVID-19, the role of WASH practices and WASH communication for positive behavioral changes is well-described while mentioning the recommendations based on WHO and United Nations guidelines and clearly explaining, on the basis of literature assessment, that marginalization and discernment are consistent across the world. This Review is restricted to SDGs and the need for attention to the most underprivileged segments of humanity in accessing WASH services and for targeting them more efficiently for WASH illiteracy. Overall, this Review demonstrates and describes the need for WASH communication regarding WASH literacy and a basic understanding of regional and global health hygiene practices.

### EPIDEMICS AND PANDEMICS

Epidemic occurs “worldwide, or over an extensive area, crossing international boundaries, including many individuals or whole communities,”\textsuperscript{40} whereas “pandemic” is a word initially originated from the Greek word pan “all” and demos “the people” and refers to “a widespread epidemic of transmissible disease across one or more countries or continents at the same time frame.”\textsuperscript{29,42} Initially, a pandemic is classified as an epidemic, the quick spread of disease in a particular region like the 2014 Zika virus outbreak in Brazil and the Ebola virus in West Africa. COVID-19 affected China as an epidemic, but after crossing the boundaries and severely affecting other parts of the globe, it was declared a pandemic.\textsuperscript{20,28}

Epidemics and pandemics generally originate through the “zoonotic” transfer of viruses or bacteria from animals to humans (Figure 1). Thus animals play a significant role in maintaining zoonotic diseases in natural forms like bacteria, viruses, or parasites.\textsuperscript{7,93} History indicates the increase in human–animal interaction with hunting and consuming wild animals, the animal trade, or other contacts with wild animals, whereas pathogens like Ebola emerged from wildlife reservoirs and entered human populations\textsuperscript{109} (Figure 2 and Table 1). From records, several outbreaks like the plague, smallpox, dengue, HIV, influenza, severe acute respiratory syndrome (SARS), flu, tuberculosis, and others created periodic events causing humanity to struggle for survival.

**Figure 1.** Transfer of zoonotic diseases from animals to human beings. Reproduced from https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html.
in 2012, more than 122,000 individuals died from measles; in the same year, typhoid fever killed around 216,000 individuals, and tuberculosis, an infectious bacteria, killed 1.5 million people; West Africa faced the major Ebola virus epidemic in 2014, killing a record of 11,300 individuals and remaining active until 2016; the 2016 Ebola virus was declared a public health emergency by WHO along with the Zika virus, impacting 3–4 million people in one year including the Zika outbreak in the USA (Table 2).

### Table 2. History’s Epidemics and Pandemics, Time Period, and Death Toll per the Records

| name              | time period | type/prehuman host                          | death toll |
|-------------------|-------------|---------------------------------------------|------------|
| Antonine Plague   | 165–180     | smallpox or measles                        | 5M         |
| Japanese smallpox epidemic | 735–737     | Variola major virus                         | 1M         |
| plague of Justinian | 541–542     | Yersinia pestis bacteria/ rats, fleas       | 30–50M     |
| Black Death       | 1347–1351   | Yersinia pestis bacteria/ rats, fleas       | 200M       |
| New World smallpox outbreak | 1520 onward | Variola major virus                         | 56M        |
| Great Plague of London | 1665        | Yersinia pestis bacteria/ rats, fleas       | 100,000    |
| Italian Plague    | 1629–1631   | Yersinia pestis bacteria/ rats, fleas       | 1M         |
| cholera pandemics 1 6 | 1817–1923    | Yersinia cholerae bacteria                  | 1M+        |
| third plague      | 1885        | Yersinia pestis bacteria/ rats, fleas       | 12M (China and India) |
| yellow fever      | late 1800s  | virus/mosquitoes                            | 100,000–150,000 (U.S.) |
| Russian flu       | 1889–1890   | believed to be H2N2 (avian origin)          | 1M         |
| Spanish flu       | 1918–1919   | H1N1 virus/pigs                             | 40–50M     |
| Asian flu         | 1957–1958   | H2N2 virus                                  | 1.1M       |
| Hong Kong flu     | 1968–1970   | H3N2 virus                                  | 1M         |
| HIV/AIDS          | 1981 to present | virus/chimpanzees                          | 25–35M     |
| swine flu         | 2009–2010   | H1N1 virus/pigs                             | 200,000    |
| SARS              | 2002–2003   | coronavirus/bats, civets                    | 770        |
| Ebola             | 2014–2016   | ebolavirus/wild animals                     | 11,000     |
| MERS              | 2015 to present | coronavirus/bats, camels                   | 850        |
| COVID-19          | 2019 to present | coronavirus/unknown (possibly pangolins) | 2.65 million per WHO |

In 2003, the SARS (severe acute respiratory syndrome) pandemic increased the risk posed by avian influenza, forcing many countries to develop pandemic plans. During the first SARS cases, much delay happened in providing the information to the World Health Assembly and the International Health Regulations (IHR) to share it with other WHO member states to follow precautions and guidelines to respond quickly to outbreaks. After events like the influenza pandemic in 2009 and the number of outbreaks in 2014 in Africa by the Ebola epidemic, pressure was added to update IHR guidelines, asking for more coordination of member states.

security”. Humanity must fight for a healthy and clean environment and see a more comprehensive rejuvenation toward a living example that values nature as the foundation for a healthy society. According to WWF reports, 60–70% of the new epidemics and pandemics that emerged in humans since 1990 came from wildlife. Jointly definite by Elizabeth Maruma Mrema, Head, United Nations (UN) Convention on Biological Diversity, Maria Neira, Director for Environment and Health, WHO, and Marco Lambertini, Head, WWF International, “many diseases were seen by the humanity in last few decades, like Zika, Aids, Sars and Ebola, commonly originated by animal populations facing severe environmental pressures.”

Looking into recent pandemics, unsustainable developments with minimum focus on WASH facilities created intensified worries about health hygiene issues and expanded sustainable development activities with regular monitoring, awareness, and upgrading technological development for future events. In the last two decades, around eight epidemics severely affected the entire human race: SARS (Severe Acute Respiratory Syndrome) in 2003 had more than 8000 cases and more than 774 reported deaths; in 2009, a Swine Flu pandemic was impacted by a new strain of H1N1 with the origin pointing to Mexico and affected 1.25 billion individuals in just one year with the expected approximate death of 75,000 people; the cholera epidemic killed around 10,000 people in Haiti in 2010;
Figure 3. Map showing Choropleth Maps of Pandemic COVID-19 cases (a), deaths (b), and vaccination (c) across the globe. Reprinted from https://COVID-19.who.int/.

Open Source: WHO (https://covid19.who.int/)
Figure 4. continued
while increasing the investment in the improvisation of WASH, health, and disaster management facilities. Coordination was needed not only in our own countries but also in other low-income countries or neighboring countries to develop health capacities, including WASH and scientific literacy. Unfortunately, with all the efforts and preparedness, many countries cannot meet even the basic requirements for survival, ignoring the mandatory need for clean water, sanitation, and health

Figure 4. Above image showing (a) cumulative confirmed cases, (b) incidence rate, (c) case-fatality ratio, (d) global vaccinations. Reproduced from COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU), https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6$113$

Source: COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6$^{112}$
hygiene facilities and communication for WASH literacy, increasing the gap in the fight against epidemics and pandemics.45,91 In 2020, the world was fighting with COVID-19 or coronavirus, affecting more than 4 million people and killing 263,000 individuals by third July 2021 in over 215 countries, areas, or territories with cases.37 With no availability of vaccination, the rise in the number of infections and death increases41 (Figures 3 and 4).

The COVID-19 pandemic has put humanity’s health at high risk, along with the need to understand the origin, medication, vaccinations, and implementation of precautions and prevention measures to thwart and resist the spread of the virus.48 After facing the sternness of COVID-19 with new variants in 2020, 2021, and 2022 as COVID-20, COVID-2021, and COVID-22 and many more expected in the future, humanity continues unsustainable practices, destruction of environmental resources, and lack of WASH facilities and education; the only hope in the future to fight epidemics and pandemics is WASH and science communication.

SDGs 3, 4, AND 6 AND WATER, SANITATION, HYGIENE (WASH)
The 2030 Agenda for SDG, espoused by all UN Member States in 2015, provides a blueprint for peace and prosperity for humanity today and tomorrow. The 17 Sustainable Development Goals (SDGs) require an urgent call for action by all developed and developing countries while supporting low-income countries as a global sustainable partnership. SDGs focus on ending poverty and other scarcities with strategies to improve education and health hygiene, reduce inequality, and spur economic losses—all while tackling environmental destruction, WASH and climate change, and work oceans and forests. Although the goals are broad and interdependent, the UN Resolution adopted by the General Assembly made SDGs more actionable. The resolution identified specific targets under each goal and indicators used to measure progress toward each target. From good health to quality education and WASH, the SDGs pay attention to multiple cross-cutting issues, like climate change, epidemics, and pandemics like COVID-19.26 For continuous monitoring, tracking, and understanding the progress toward SDGs, various tools exist, and much data are available in online publications (Figure 5).

SDG 3 focuses on good health and well-being to ensure healthy living and promote well-being for humanity at all ages without any regional or other discrimination. SDG 3 focus on different aspects of a healthy life and health hygiene. SDG 3 has 13 points, including ending all preventable deaths under five years of age, struggling with communicable diseases, ensuring minimization in mortality rate from noncommunicable diseases, promoting mental health, accomplishing universal health coverage, reducing disorders and deaths from hazardous chemicals and pollution, and many more. Most of them are concerned with health hygiene practices, including communication, positive behavioral changes, and continued education. SDG 3 aims to accomplish universal health coverage that seeks equitable access to healthcare services to humanity, making a check and end to preventable deaths in every age group and epidemics. Healthy living and practicing WASH is essential to sustainable development and the 2030 Agenda, focusing on economic and social inequalities, unsustainable urbanization, climate crisis, and the continuing burden of infectious diseases and not forgetting emerging challenges such as noncommunicable diseases and, in the COVID-19 pandemic, the urgent need to give significant consideration toward understanding good health through hygiene practices on a global scale.

SDG 4 targets quality education with an elaborative objective to ensure equitable education and promote lifelong learning opportunities for all.
Table 3. Classification of Patterns of Pandemics

| patterns                  | explanation                                      | pandemic name                                                                 |
|--------------------------|--------------------------------------------------|-------------------------------------------------------------------------------|
| 1. originality           | new or novel variants of existing organisms      | SARS and avian influenza arising from Asia                                    |
| 2. geographical          | extend over large geographic areas               | H1N1 pandemic affecting around 178 countries in 2009                           |
| distribution             |                                                  |                                                                               |
| 3. disease               | unexpected disease movement or outbreak via       | pandemic influenza A (H1N1), widespread transmission in both hemispheres in   |
| movement                 | transmission, to be traced at different places   | 2009                                                                           |
| 4. severity              | pandemics with high mortality and morbidity      | Ebola, most cases die within 10 days of their initial infection               |
|                          | affected by a new viral strain                  |                                                                               |
| 5. high attack rates     | outbreak of pandemics with very high rates       | H1N1 and Ebola                                                                 |
| 6. minimal population    | pandemics affect populations with low immunity   | because H7N9 was a new variant of the influenza virus, it                     |
| immunity                 | against microbial infection and transmission;    | affected the population in a very short span of time showing no immunity     |
|                          | population immunity can be a powerful antipandemic force |                                                                               |

learning opportunities. It has a total of 10 targets, including free primary and secondary education; affordable technical, vocational, and higher education; elimination of all discrimination in education; universal literacy; and education for sustainable development and global citizenship, including science literacy for all during any regional or international disaster like COVID-19. SDG 4 aims to educate young people with quality education, including universal literacy and knowledge for valuable skills from sustainable development, WASH practices, education for living, and survival. At the same time, we are focusing on the current status of the global literacy rate, requiring more educational institutes and also an upgrade to the present ones to educate in terms of environment, hygiene, and learning to survive in conditions of epidemics and pandemics or any other disastrous diseases.64

SDG 6 is about the most vital need to survive on the planet, clean water, sanitation availability ensuring health hygiene, and sustainable development. SDG 6 has eight targets to achieve, including safe and affordable drinking water; ending open defecation and providing access to sanitation and hygiene; water quality; wastewater treatment; safe reuse; and increased water-use efficiency, ensuring freshwater supplies and restoring water-related ecosystems. All these focus directly and indirectly toward health hygiene to expand water and sanitation support to developing and low-income countries and to support local connections in WASH practices and management. According to the reports, 2.2 billion individuals lack safely managed drinking water and 4.2 billion lack safely managed sanitation in 2017,62 whereas more than 3 billion people globally lack handwashing facilities.62 Fighting the COVID-19 pandemic, WASH practices play a significant role and have made SDG 6 an essential focus of the United Nations Economic and Social Council (2020).79 However, some studies show that strains of the pandemic have been found in wastewater, affecting the ability of water treatment facilities because improved management plans are not applicable quickly because of increased revenue losses. During the COVID-19 phase in April 2020, United Nations Secretary-General António Guterres said: “Sustainable Development Goal 6 is badly off track” and “it is hindering progress on the 2030 Agenda, the realization of human rights and the achievement of peace and security around the world.”6

SDGs 3, 4, and 6 are closely interlinked and are very much needed for survival against all current events and those that may occur in the near future because rapid population growth causes significant climate changes, environmental destruction, and increased severity of epidemics and pandemics. For example, taking the COVID-19 pandemic as a comparative example, SDG 3 concentrates on good health and SDG 4 concentrates on education including communication about SDG 6, i.e., WASH practices against the severity of infections.

A report by the WHO/United Nations International Children’s Emergency Fund (UNICEF) Joint Monitoring Programme (JMP) assessing the progress of WASH programs clearly states that over 4.2 billion people lack clean water and safe sanitation services, impacting the health hygiene of humanity. This affects children, increasing the mortality rates for children under age five when they are infected with a disease that presents with diarrhea, because of poor sanitation, poor hygiene, or unsafe drinking water. In the World Water Development Report 2019, the United Nations clearly defines the importance of clean water, health, and sanitation as a basic human need to sustain a healthy life, livelihood, community growth, and society to fight any epidemic or pandemic. International human rights laws state and focus on the work done for health hygiene for all, including universal access to clean water and sanitation for all, prioritizing those in need, and the facilities are available, affordable, accessible, and culturally acceptable.81,106

The availability of fresh water for drinking and of sanitation adheres to acceptable hygiene practices with immediate advantage to people—collectively known as WASH—with an enormous impact on socio-economic aspects of the society. During the current COVID-19 pandemic, the necessary precaution is sanitation and washing hands with clean water; unfortunately, in many regions, no awareness can increase many diseases and infections. However, if the people know good hygiene behaviors, even if they do not have access to clean water, soap, and other washing or sanitation facilities, specific locally available resources per WHO guidelines and sharing the awareness with others can make a positive change to protect themselves and their community. Considering detection of infection or diseases, quarantine and isolation facilities, postinfection medication and awareness, WASH practices, infrastructure to communicate with society to increase scientific understanding and awareness, and technological development to coordinate with other counties, resources must increase for localized epidemics or for fighting a global pandemic (Table 3).

Today, the world is in the midst of the COVID-19 pandemic, and after more than one year of severity a number of new stains were identified in 2020, 2021, and 2022, severely impacting all humanity from ill-health to death, economic to social life, and scarcity of basic needs even for vaccination. All the preparedness, robust health care systems, and technologies worldwide failed, and no country was left untouched by the global health crisis. In reviewing WHO82 guidelines, the first step of precautions and prevention is to wash hands to be safe.
from infection and prevent us from infecting others at the usual critical moments (cooking food or eating and after use of toilets) and especially when coming in touch or contact with an infected person or when there is a risk of exposure to any virus or bacteria. In the current scenario of the COVID-19 pandemic, without WASH services and practices, it is tough to fight against a pandemic like COVID-19, risking the development of hotspots in many regions with many infections that are hard to treat and put all humanity at risk.

**PROMINENCE OF OBTAINABILITY OF CLEAN WATER**

Water is the most critical and limited resource on earth, continuously moving from different freshwater bodies to the ocean. Considering the amount of availability, freshwater is the size of a bubble in comparison with the amount on the entire earth. With the uncontrolled rise in population, urbanization, and industrialization, many parts of the world face water scarcity. The situation worsens, leading to environmental degradation and excessive use of water resources throughout the world, which increased the demand for water supply management systems. According to the United Nations report 2018, 6 billion people will suffer from water scarcity by 2050 with a continuously increasing population, the demand for clean water, the decline in freshwater resources, extinction of water resources like glaciers and springs, tremendous increase in pollution activities, and so-called population growth (Figure 6). On the basis of the current global health hygiene condition with a global water shortage, the situation in 2050 worsens.

Today, more than 60% of the global population suffers from water-borne diseases because of insufficient water hygiene and sanitation systems and has more than 4 billion cases of diarrhea per year, resulting in the death of more than 2 million people, including a significant portion of children below the age of five. Bacteria causing typhoid, hepatitis A, and cholera are the most common infections causing diarrhea as well as other illnesses such as dysentery caused by parasites living in water contaminated by sewage containing the feces of sick persons. Ponds, lakes, and streams, which people use for specific domestic water uses, are the most affected by domestic and commercial contaminants, especially before, during, and after monsoon periods (Figure 7). Not only this but also the food cooked, served, or packed by the person infected with any kind...
of water-based diseases, with no hygiene, infects the individual coming in contact.4

To compete with developed countries, demand for freshwater is continuously increasing in countries with emerging economies and in low-income countries. However, because of continued environmental destruction and climate change by various anthropogenic activities, severe complications are affecting societies mainly through water pollution: affecting the availability, quantity, and quality of freshwater for basic needs; threatening all living forms, including human beings, potentially billions of people; impacting health conditions of people, flora, and fauna. The United Nations in 2020, with its report on World Water Development, emphasized the current and future challenges and prospects and possible responses to climate change conditions, addressing improvisation in water management practices. Changes in the global temperature and water quality are severely affected, reducing the dissolved oxygen level and reducing the self-purification capacity of water bodies.11 Three major causes of the scarcity of clean water are toxic substances entering water resources, directly impacting humanity, and contaminants penetrating the groundwater, destroying entire aquatic ecosystems. Once the water is polluted, it is much trickier and more costly to purify it while removing all the contaminants; still more than 80% of the global wastewater from industrial, commercial, and domestic complexes, including agricultural runoff, goes untreated into freshwater bodies, containing toxic industrial wastewater and human excreta. Discharge of contaminants, including organic and inorganic components, increases the chances of developing bacteria and viruses in aquatic bodies and, when in excess, causes eutrophication or algae blooms, creating dead zones where aquatic life can no longer thrive. At the same time, in human health concerns, it can cause severe diseases, like in infants causing blue baby syndrome (Figure 9).
Unhygienic water supplies from sanitary systems may be one of the main reasons for infectious illnesses in water bodies, affecting at least 2 billion people. At the same time, drinking feces-contaminated water transmits severe diseases like cholera and typhoid, according to the WHO. A preliminary assessment of world rivers estimates that severe pathogenic pollution affects more than one-third of all the rivers and is one-seventh of organic pollution worldwide.

Pinning hopes on better-quality water access and quality of rights encompassing clean water access, communication and activities should increase the focus on democratic governance to realize human rights goals, especially in times of imposed states of emergency, resulting in limits on civil (and even political) rights. However, rather than acknowledging the importance of water access during a pandemic, recognizing the human right to water, coupled with practical and equitable democratic governance, should be an enduring priority.

**NEED OF SANITATION AMENITIES**

WASH is a dedicated target within the Sustainable Development Goals (SDG 6) to prove its importance and requirement for future sustainable development with good health for humanity. A clean water supply, necessary sanitation facilities, and good hygiene are essential practices for the survival and growth of human beings. According to UNICEF, in the convention on the Rights of a Child, every child has the right to clean water and basic sanitation for good health and development. Access to clean water and sanitation are human rights recognized by the United Nations General Assembly in 2010. For universal fulfillment of these rights to become a reality, we need suitable systems: well-resourced, capable institutions delivering services and changing behaviors in resilient and appropriate ways.

Today, around 2.4 billion people have no access to improved sanitation, around 663 million lack access to clean water, and 946 million people defecate in the open. An estimate shows that 7 out of 10 people are without access to sanitation, and 9 out of 10 are living in open rural areas. With the scarcity of clean water, which is a basic need for survival, millions of children are at a significant risk of death, especially those who are under the age of five, as water hygiene infections are one of the biggest concerns with over 800 children dying from low water access and a lack of sanitation and hygiene. From 1990 to 2015, from 54% to 68% of sanitation facilities are increased, but still 2.4 billion people have no access to sanitation facilities, with a significantly growing population (Figure 10). Globally, comparing rural and urban areas, it is found that approximately 9% of people share their sanitation facility with other families and 51% of rural dwellers have access to improved sanitation compared with 82% of urban dwellers. Rates of upgraded sanitation facilities do not reveal the actual amount of domestic sewage treated safely; according to a study of 12 cities in low- and middle-income countries (LMICs), 98% of households’ toilets, only safely manage 29% of sewage (Figure 11).

However, the rural areas achieve sufficient water supply targets with availability of improved water quality, water use,
and management behavior education. In urban areas where an acceptable amount of water from different sources is already available, they also need the education to fight against pollution while sustaining the quality required for fulfilling all
immune deficiency, or suffering from chronic diseases or any kind of immune deficiency, indirect factors are the easy targets of epidemics or pandemics, affecting entire communities or generations.67

HYGIENE FOR HUMANITY

Hygiene is a combination of certain practices conducted and practiced for good health and sustainability. According to

Table 4. Classification of Water-Related Disease

| category | description of category                                                                 | type of water | subcategories                                                                 | disease/infections |
|----------|----------------------------------------------------------------------------------------|---------------|-------------------------------------------------------------------------------|--------------------|
| water-borne microorganisms disease | consumption of pathogen-containing water from human or animal fecal material | drinking water | •treated or untreated (raw) water<br>•public (municipal) supplies or private supplies | cholera, typhoid fever, viral gastroenteritis |
| water-borne chemical disease | ingestion of toxic substances in water | drinking water | •treated or untreated (raw) water<br>•public (municipal) supplies or private supplies | arsenicosis |
| water hygiene disease | incidence, prevalence, or severity reduction by using safe (clean) water to improve personal and domestic hygiene | water used for washing/personal hygiene | •disease related to variations in water quality<br>•disease related to water shortage | scabies, shigellosis, trachoma |
| water contact diseases | skin contact with pathogen-infested water or with chemical-contaminated water | recreational water | •freshwater sources<br>•marine waters<br>•rivers, streams<br>•small collections of stagnant water | schistosomiasis (bilharzia), cyanobacteria |
| water-based vector diseases | aquatic invertebrate organism living in or adjacent to a water habitat | untreated freshwater sources | •diseases related to human/animal waste in drinking water<br>•diseases related to direct/indirect contact with feces/urine | malaria, filariasis, onchocerciasis, schistosomiasis |
| excreta disposal diseases | unsanitary disposal of human waste (feces and urine) | drinking water and untreated water sources | •diseases related to drinking water<br>•diseases related to water resource management<br>•diseases related to water hygiene | ascariasis, fecal–oral infections (e.g., shigellosis), schistosomiasis, trachoma |
| water aerosol diseases | respiratory transmission, where a water aerosol containing suspended pathogens enters airway | drinking or raw water sources | •water used in industrial/residential buildings<br>•raw water sources | Legionellosis, Norwalk-like viral gastroenteritis |

Table 5. Disease Burden from Inadequate WASH for the Year 2016a,b

| disease | deaths | DALYs (‘000) | population attributable fraction |
|---------|--------|--------------|-------------------------------|
| diarrhea diseases | 828 651 | 49 774 | 0.60 |
| soil-transmitted helminth infections | 6248 | 3431 | 1 |
| acute respiratory infections | 370 370 | 17 308 | 0.13 |
| malnutrition | 28 194 | 2995 | 0.16 |
| trachoma | <10 | 244 | 1 |
| schistosomiasis | 10 405 | 1096 | 0.43 |
| lymphatic filariasis | <10 | 782 | 0.67 |
| subtotal drinking water, sanitation and hygiene | 1 243 869 | 75 630 | NA |
| malaria | 354 924 | 29 708 | 0.80 |
| dengue | 38 315 | 2936 | 0.95 |
| onchocerciasis | <10 | 96 | 0.10 |
| subtotal water resource management | 393 239 | 32 740 | NA |
| drownings | 233 890 | 14 723 | 0.73 (0.74 for LMIC, 0.54 for HIC) |
| subtotal safety of water environments | 233 890 | 14 723 | NA |
| total inadequate water, sanitation and hygiene | 1 870 998 | 123 093 | NA |

WHO, "Hygiene refers to conditions and practices that help maintain health and prevent the spread of diseases." Hygiene is, directly and indirectly, correlated with clean water supply, sanitation, cleanliness of the living environment, and acceptable health practices, following day-to-day hygiene practices

67

the needs. However, even with the use of many chemicals in domestic and commercial complexes for water purification, piped water does not guarantee the surety of a continuous water supply. 33 Understanding the importance of freshwater with the need and demand for survival, the improvisation of drinking water sources increased more than 75% from 1990 to 2015.39 According to the Millennium Development Goal (MDG) in the 2012 joint report of WHO and UNICEF (2012),94 global estimates mask regional disparities and inequities in access between urban and rural populations. Rural dwellers remain unserved compared with urban dwellers (16% and 4%, respectively).93

Contaminated water supplies, without managed sanitation systems, increase the chances of transmission of water-borne diseases through fecal matter, causing diarrhea, hepatitis, helminth infection, trachoma, and adenoviruses (e.g., conjunctivitis).95 Water-related infections are characterized by the sources and types of water exposure, for example, by contact with water causing the sickness, by the scarcity of clean water or water contamination during natural disasters, and by infections related to pathogens as part of their life cycle in water ecosystems (Table 4 and Table 5). Bacteria transmitted through urine are mainly from animal-to-human transmission. Health hygiene with contaminated water can cause fungal skin infections, and lack of handwashing can cause severe respiratory infection, even death in the case of infants.7,56 In terms of health hygiene factors such as water treatment and management, sanitation, disease transmission, and individuals underfed or suffering from chronic diseases or any kind of immune deficiency, indirect factors are the easy targets of epidemics or pandemics, affecting entire communities or generations.67

| disease | deaths | DALYs (‘000) | population attributable fraction |
|---------|--------|--------------|-------------------------------|
| diarrhea diseases | 828 651 | 49 774 | 0.60 |
| soil-transmitted helminth infections | 6248 | 3431 | 1 |
| acute respiratory infections | 370 370 | 17 308 | 0.13 |
| malnutrition | 28 194 | 2995 | 0.16 |
| trachoma | <10 | 244 | 1 |
| schistosomiasis | 10 405 | 1096 | 0.43 |
| lymphatic filariasis | <10 | 782 | 0.67 |
| subtotal drinking water, sanitation and hygiene | 1 243 869 | 75 630 | NA |
| malaria | 354 924 | 29 708 | 0.80 |
| dengue | 38 315 | 2936 | 0.95 |
| onchocerciasis | <10 | 96 | 0.10 |
| subtotal water resource management | 393 239 | 32 740 | NA |
| drownings | 233 890 | 14 723 | 0.73 (0.74 for LMIC, 0.54 for HIC) |
| subtotal safety of water environments | 233 890 | 14 723 | NA |
| total inadequate water, sanitation and hygiene | 1 870 998 | 123 093 | NA |

Table reproduced from Table 2 of ref 113, which was reproduced from ref 114. LMIC: low- and middle-income countries. HIC: high-income countries. DALYs: disability-adjusted life years. NA: not applicable. Disease burden estimates are for low- and middle-income countries. The estimates for diarrhea, acute respiratory infections, and drownings also include the disease burden in high-income countries. Includes disease burden from protein-energy malnutrition (PEM) and consequences in children under five only.

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with preventative measures to reduce the incidences of spreading any disease. Practicing hygiene with variations from culture to the region and resource availability and from the industrial sector to commercial complexes is very important for health and for product development to prevent the spread of any disease-causing agent. In the context of preventing an outbreak of infections and viruses, cleaning and clear water with proper sanitation facilities are primary factors for good health in addition to removing infectious microbes and dirt and changes in behaviors and mindsets in the society to keep the surroundings clean, stay healthy, and break down the chain of transmission and spread of any infection or disease.60 However, to be clear, knowledge sharing is not sufficient; using science through communication with an evidence support system while describing the case studies is more critical.52 Estimates state that cleaning hands using clear water and soap or sanitizing with alcohol-based sanitizers can reduce the chances of infection with many food-borne illnesses and other diseases.

The requirement of a safe, consistent, reasonable, and easily accessible water supply is crucial for good health. Yet, approximately a billion people in developing countries have not had a safe and sustainable water supply for several decades. Poor health and hygiene have multiple impacts on people at work, families, and children missing school and pose risks to the environment and other people.61

Regarding the need to avoid water stress, experts generally agree that about 1000 m$^3$ of freshwater per capita/year are needed.57 Although of such importance, health hygiene is one area that has been the lowest on the priority list in global development for many decades. However, theoretically, health hygiene from WASH has been a primary concern in the previous decade of various international organizations collaborating with multiple governments. A lack of understanding linking social, cultural, and economic aspects with health hygiene and without science, communication, and education are the main reasons for poor health hygiene and its facilities.

### POTENTIAL RISK FACTORS DURING EPIDemics AND PANDEMICS

The number of possible risk factors and unsafe practices affecting the health of humanity in developing and low-income countries is discussed in reviews.112 During epidemics and pandemics, several things can increase the severity:

- **Deprived sanitation system**: Practices like open defecation and flawed sanitation systems primarily in informal human settlements like slums, refugee camps, unapproved colonies, sanitation systems may be closely contrasted with weak or contaminated drinking water sources hardly impacting the health hygiene system of the entire population but becoming a risk factor especially in epidemics and pandemics.

- **Meager wastewater management**: Even in the 21st century, most parts of the world do not have sound wastewater management systems, and those regions have not continually upgraded. With overloaded old wastewater treatment systems, infectious raw wastewaters from domestic, commercial, industrial, and health care systems are directly discharged into open channels or the sewer system without any pretreatment,61,120 providing easy transmission of viruses and bacteria into freshwater bodies and increasing the severity of infections primarily during epidemics and pandemics.

- **Risk of co-infection**: Diseases like cholera, typhoid, malaria, and HIV/AIDS may prejudice humanity to the hostile health impacts of other infections or viruses during epidemics and pandemics like coronavirus. These coinfections may create fragile health conditions, generating a high-risk environment for an individual and the entire society.

- **Lack of WASH understanding and literacy**: In any epidemic and pandemic, societal awareness and literacy play the most prominent role in providing factual information. Limited knowledge of the cause, impact, and modes of transmission can lead to high health risks for infections, which has been a primary factor during COVID-19. The risk factor is specifically noted for the current pandemic but must be overcome soon under SDGs 3, 4, and 6 for emerging infections.

- **Unhealthy food handling**: One of the most significant causes of being infected is unhygienic food or food mishandled because of poor water quality at the time of cultivation or cleaning. Even in most food markets, food transportation or storage does not have food safety and hygiene practices, primarily in developing and low-income countries. Even retailing of food in open markets and streets puts the food at high risk of contamination by air-borne diseases and, in some cases, can be one of the causes of endemics, epidemics, and even pandemics.

- **Lack of infectious solid waste management**: In light of the COVID-19 pandemic faced by humanity in 2020, 2021, and 2022, it is clear that all the countries from developed to developing are lacking in managing the infectious solid waste from research facilities, health care centers, isolation centers, and domestic complexes with infected residents. Infected solid waste contributes directly and indirectly by contaminating the nearby water bodies, soil, and biodiversity near dumping sites. In most places, it is ubiquitous that infected solid waste mixed with common waste increases the rate of high risk contamination in all parts of society, even animals and plants.

- **Lack of social responsibility**: Most of the time, during disastrous events in epidemics and pandemics, the social responsibility of individuals in different sections of society is communicated by scientists, researchers, health workers, and even motivational speakers. All of these could motivate their audiences to follow the precautions and preventions of any infectious outbreak from social distancing to following health hygiene in public places. Lacking understanding of social responsibility, most people do not even know how to behave and act during such situations. Epidemics and pandemics have many contrary effects on incomes and food security of...
vulnerable communities, creating a long-lasting impact on the mindset and creating a worse situation in society.  

- **Weak policies and regulations**: From inadequate WASH policies and environmental laws to un-understandable climate change policies, the formality of occupational and public health policies and not having guidelines for social responsibility provide much space for easy impacts of harsh consequences for living forms. Unfortunately, humanity creates such situations and needs laws to control them. Most regulatory agencies create many policies, but they are not being transferred to the common masses because of lack of proper communication or linguistic barriers. These gaps create high risk with certain anthropogenic activities, leading indirectly to disasters generated by humanity with unsustainable development. An urgent need has risen to redefine and implement the policies and regulations to check and counter climate change and to address the lack of WASH practices and environmental degradation. Most importantly, creating an environment to address science illiteracy for all with communication tools.

## SUCCESSION OF PANDEMIC COVID-19 SURGES

Like in the 1918 flu pandemic, a pandemic in a susceptible population makes a worst-case scenario for the preplanning and management during and after the pandemic to limit the spread of disease. Epidemic and pandemic concerns have increased because of continuous incidences that occurred in last two decades, disease outbreaks such as the SARS coronavirus (SARS-CoV) in 2002, pandemic H1N1 in 2009, MERS coronavirus (MERS-CoV) in 2012, and novel coronavirus (COVID-19) in 2019. Coronavirus is a paradigm of this phenomenon, severely impacted in the last 18 years, causing three new alarming diseases: SARS, MERS, and COVID-19 with diversified variants.  

Coronavirus or family Coronaviridae includes variants that can infect humanity with various clinical symptoms, from the common cold to potentially lethal respiratory syndromes. Earlier, researchers and scientists addressed the environmental circulation of viruses, highlighting the potential new pandemic threats posed by a coronavirus.

Health pandemics are constantly exposed to uncovered weaknesses in community health hygiene, like in societies facing the challenge for clean water, sanitation, and hygiene conditions that worsening global health crises. Looking back into epidemics that occurred in the last three decades and comparing them with the current COVID-19 global health crisis, the similarities are unhygienic conditions and the environment in the society, causing human-to-human transfer of the infections through direct contact of body fluids by any means. Unfortunately, the poor and the marginalized populations are first to suffer from any pandemic or epidemic, which is always a shortfall in health hygiene facilities, like the Ebola crisis (Guinea, Liberia, and Sierra Leone which are among the lowest 25% of introductory water access rates globally). However, bacteria or viruses are transmitted via close contact, droplets, and contaminated water or wastewater.  

During the COVID-19 pandemic, in a recent study, Yeo et al. (2020) confirmed the fecal elimination of coronavirus. Because of lack of sanitation facilities or other reasons, one reason behind the transfer of coronavirus contamination could be through wastewater, including infecting freshwater bodies (surface and groundwater) required for entire WASH practices.

Tissues flushed from medical centers and health care complexes led to the nasal secretions identified in wastewater, indicating that COVID-19 would infect wastewater systems sooner or later. Like COVID-19, SARS-CoV was identified in wastewater while persisting in fecal material from domestic complexes up to 2 days at 20 °C and 14 days at 4 °C and could survive for 4 days in diarrheal stool samples with an alkaline pH at room temperature in spiked samples. However, we know that the COVID-19 virus is an enveloped virus that is predicted to be more sensitive to decontamination than nonenveloped diseases such as coxsackievirus, Hep A, and adenovirus. Although the chances of transmission of coronavirus from the feces of an infected person are 50%–60%, as found in recent studies, it clearly shows that it was indirectly causing diarrhea or intestinal infections that weaken a person’s immunity, making it easier for COVID-19 infection and severity. Improving wastewater treatment infrastructure and services, including skilled workers, is essential to implement an effective decontaminator. Still, not all viruses or bacteria spread via sewage during an outbreak or at other times. COVID-19 is a new virus to humanity. With its new strains found at the end of 2020 and starting in 2021 (Table 6), researchers are still trying to understand its origin, migration, adaptation possibilities, transmission, and development of exact vaccination. However, the necessary precautions and prevention are hygiene conditions and a clean environment. The most commonly used disinfectants are chlorine-based media, UV radiation, and ozonation, with advantages and certain limitations. The problem of wastewater was addressed by WHO on water, sanitation, hygiene, and waste  

### Table 6. List of All primari Variants Occurring to Date during the COVID-19 Pandemic

| WHO label | Pango lineage | GISAID clade/lineage | next strain clade | earliest documented samples | date of designation |
|-----------|---------------|----------------------|------------------|-----------------------------|---------------------|
| Alpha     | B.1.1.7       | GRY (formerly GR/50Y.V1) | 20V (V1) | United Kingdom, Sep-2020 | 18-Dec-2020         |
| Beta      | B.1.351       | GH/50Y.V2             | 20H (V2) | South Africa, May-2020  | 18-Dec-2020         |
| Gamma     | P.1           | GR/50Y.V3             | 20J (V3) | Brazil, Nov-2020        | 11-Jan-2021         |
| Delta     | B.1.617.2     | G/478K.V1             | 21A             | India, Oct-2020          | VOI: 4-Apr-2021     |
| Epsilon   | B.1.427/B.1.429 | GH/452R.V1           | 21C             | United States of America, Mar-2020 | 5-Mar-2021       |
| Zeta      | P.2           | GR/484K.V2            | 20B/S.484K      | Brazil, Apr-2020         | 17-Mar-2021         |
| Eta       | B.1.525       | G/484K.V3             | 21D             | multiple countries, Dec-2020 | 17-Mar-2021    |
| Theta     | P.3           | GR/1092K.V1           | 21E             | Philippines, Jan-2021    | 24-Mar-2021         |
| Iota      | B.1.526       | GH/253G.V1            | 21F             | United States of America, Nov-2020 | 24-Mar-2021   |
| Kappa     | B.1.617.1     | G/452R.V3             | 21B             | India, Oct-2020          | 4-Apr-2021          |
| Lambda    | C.37          | GR/452Q.V1            | 20D             | Peru, Dec-2020           | 14-Jun-2021         |
management for COVID-19 (March 3, 2020).<sup>87</sup> not only focusing on the COVID-19 pandemic but also targeted to focus on all epidemics and pandemics. A significant need for WASH communication is required in every aspect, from social to scientific and from common masses to high-end researchers, with various approaches that could be very useful for risk assessment and management.<sup>10</sup>

### WASH AND PANDEMIC COVID-19

From time to time, agencies like WHO recommend public health measures like handwashing with water and soap or sanitization with alcohol-based sanitizers, covering the mouth and nose with a mask in public places, physical distancing of at least 6 feet between individuals, adhering to good respiratory hygiene practices primarily at the time of sneezing or coughing by covering the nose and mouth, and avoiding visiting social gatherings and crowded places. Along with WHO, some countries initiated specific stratagems and guidelines to restrain the COVID-19 outbreak like lockdowns, closing regional, national, and international boundaries, isolation, and quarantine facilities. WASH practices are crucial in preventing human-to-human transmission of COVID-19.<sup>93</sup> Documented evidence that coronavirus extracted in feces and viral RNA fragments has been recovered throughout the illness and after the recovery of patients.<sup>14</sup> However, handwashing with water and soap is not a new intervention in developing and low-

| Table 7. Hygiene and Waste Management Guidelines per WHO WASH Program<sup>42</sup> |
|-----------------------------------------------|
| I. In Health Care Centers                      |
| 1. perseverance of virus in clean water       | many possibilities of coronavirus in untreated fresh water, requiring primari attention in current global health crisis |
| 2. safely managing wastewater and fecal waste  | although there is no such evidence to date of virus fragments found in feces of COVID-19 infected patients, it could increase the high risk factor of other potential infections, requiring regular checks and treatment of wastewater using disinfectants |
| 3. keeping water supplies safe                 | protecting from the water source, using recommended treatment before distribution, regularly checking, monitoring, and cleaning of containers and storage units are most important to avoid any kind of contamination even after treatment |
| 4. hand hygiene practices                      | important for fighting any disease, and most important in the COVID-19 pandemic, are initiating regular programs with science communication and social awareness and providing all health care facilities with access to all public platform; hand washing with clean water or hand sanitation with alcohol-based sanitizers is one basic solution to fight the health crisis |
| 5. sanitation and plumbing                     | people with infection or suspected infection with COVID-19 should be provided with a separate toilet system, which must be cleaned and sanitized by a trained cleaner wearing PPE from cleaning to sanitation to plumbing with regular checks and following the guidelines of WHO guidelines, including the wastewater piping system before it reaches the disposal site |
| 6. toilets and the handling of feces           | diapers or clean bedpans with immediate disposal procedures at the time of severity of the patient; healthcare workers doing all the procedure must be trained with WHO contact and droplet precautions, while being equipped with PPE during the procedure, and must be sanitized again before coming to patients |
| 7. safe management of health care waste        | per the WHO guidelines, management of health care waste, which must be segregated and disposed of safely; waste produced during the patient care, including used masks, sanitizer bottles, used PPE kits, medical equipment waste, and pathological waste should be collected safely and disposed of following proper precautions; along with waste from the waiting areas and from inside the campus, toxic and nontoxic waste should be separated and disposed of with much care during the current coronavirus global health crisis |
| 8. environmental cleaning and laundry          | regular cleaning and sanitization procedures for patient wards, ICUs, and chambers must be done along with the patients once a day and patient clothing must be washed separately; workers performing environmental cleaning and changing clothes and bedsheets should wear PPE kits and must follow the hand hygiene practice after the cleaning work and after removing PPE kits; excreta if on clothes or bedsheets must be taken care of per the norms |
| 9. disposal of greywater or wastewater         | reusable medical gear should be cleaned with soap and clean water and decontaminated with 0.5% sodium hypochlorite solution every time; wastewater out or the graywater must be disposed in sewer system for further treatment before reuse |
| 10. safe management of dead bodies             | standard procedures must be followed in handling a deceased person's body; health care workers or mortuary staff must wear the PPE kits; after completion of the procedure including disposal of infectious waste and disinfection of used equipment, hand hygiene and sanitation procedures must be followed; the deceased body must be transferred to a mortuary area as soon as possible after wrapping in cloth or fabric or a bag (during the excessive body fluid leakage, etc.) |

II. At Home and at Community Level

| 1. hand hygiene general recommendations        | hand hygiene is the most important precaution to fight against any infection, especially in the COVID-19 health crisis, from taking care of patients, coming from public places, before preparing food and eating, after using the toilet, after touching animals, etc.; WHO recommends hand hygiene facilities for all from public to private places, with proper installation, supervision, and maintenance of equipment, water supply and soap and/or alcohol-based hand rubs and regular supply management should be under public health authorities |
| 2. hand hygiene materials                       | ideal hand hygiene materials for communities and homes in order of effectiveness are clean water and soap, alcohol-based hand sanitizers, ash or mud, and water alone |
| 3. water quality and quantity requirements for handwashing | supply of clean water in sufficient amounts for all is very important to disinfect the hands and other things during washing and sanitization; an estimate suggests that 0.5−2 L per person is a required amount of water for reduction of fecal contamination while washing; minimum of 20 s of hand washing is recommended normally as prevention during the COVID-19 health crisis; water should be free flowing in the drainage system to minimize the increase or settlement of contamination |
| 4. handwashing facility options                 | water taps are sensor based, have a large handle, or are foot pump based; soap dispensers or sanitizer dispensers should be sensor based or have a large handle to be operated with the elbow; it is very important to discharge gray water into the septic or sewer system, completely avoiding open flow; to dry the hands, only tissues should be used, placed in a covered bin, and disposed of properly when the bin is filled; facilities must be available to all without any kind of discrimination in all public and private places |
| 5. treatment and handling requirements for excreta | when suspected patients of COVID-19 quarantine at home, instant precautions must be taken to avoid the risk of transmission of infection to other family members; frequently touched places and used things must be sanitized regularly, and clothes and utensils must be washed separately and not shared with anyone else; toilets must also be separated with regular cleaning done using disinfectants while wearing PPE kits etc.; precautions must be given to safely manage the human fecal material with proper treatment, good flow of water, proper functioning of toilets, and even separate disposal (if possible) |
| 6. management of waste generated at home       | during the home quarantine, waste generated while caring for and during recovery of a suspected COVID-19 patient, must be put in a black bag and completely closed and handed over to municipal waste service while giving the information about the patient; proper hygiene measures must be taken after the full process is complete |

“Table reproduced from ref 87.”
human coronaviruses are found to be sensitive to chlorination, pointing for the COVID-19 virus because, according to studies, procedures for water treatment plants following standard guidelines and required, including regular water monitoring and supply management, several measures are treatment methods like filtration, boiling, and appropriately dosed free chlorine can help lower or completely remove the risk of infection.25,35,63

Focusing on the crucial role of handwashing in preventing infection highlights the need for clean water, sanitation, and hygiene to fight COVID-19. Not only is the resource availability important, but it is also essential to understand the need and use of the practice for changes in behaviors and to share these actions with others, especially with children. With the spread of the coronavirus pandemic, an increase in health hygiene activities is advised and intensified. The recommendation is critical, but it is challenging in developing countries where the proportion of scarcity with an increasing population, even for the exact water supply, is lacking by 40%. In low-income countries, for between 50% and 80% of the entire population, it is estimated that certain water-borne diseases and infections spread by water and sanitation facilities take the lives of an estimated 4.3 million people. In the current ongoing health crisis of COVID-19, it has been estimated that approximately four million people will die in 2020 because of a lack of clean water, sanitation, and hygiene facilities. Even the medical centers do not have much preparedness for a clean water supply, sanitation facilities, and disposal of medical waste in such a large amount in the current pandemic. Minimum WASH practices and services are counted as barriers and as critical factors for planning and preparedness for animal-to-human or human-to-human transmission of infection or diseases like COVID-19 in communities, medical centers, public places, and academic institutes.

The Infection Prevention and Control (IPC) report, summarizing WHO guidance on WASH and solid waste relevancy with viruses, including coronaviruses, focuses on WASH workers, practices, and services. Simultaneously, the emphasis is on sharing the knowledge and understanding risks and precautions for WASH and self-hygiene.87 Centralized water treatment plants following standard guidelines and procedures for filtration and disinfection can act as a stopping point for the COVID-19 virus because, according to studies, human coronaviruses are found to be sensitive to chlorination and decontamination with ultraviolet (UV) light.19,39 In addition to adequate water treatment, including water quality monitoring and supply management, several measures are required, including regular water—water quality testing and laboratory maintenance with standard methods, stocks of spare parts, electricity backup plans, and emergency plans required to supply safe drinking water. There are also places in rural areas of many developing countries and in low-income countries where centralized wastewater treatment facilities are not available; several domestic measures for home water treatment methods like filtration, boiling, and appropriately dosed free chlorine can help lower or completely remove the risk of infection.87

Despite all efforts of international agencies and national governance from social distancing to lockdown, quick response for health care facilities improvements, development of isolation and quarantine centers, and sanitation and science communications, across the globe four million likely to die this year from the lack of WASH facilities. The maximum number of deaths by clean water scarcity is from the lower segment of the community, who never travel internationally. In being prepared for any pandemic and having an increase in medical infrastructure, equipment, and technological enhancement, WASH is one major factor that needs to be addressed. The future of the COVID-19 virus is still much unknown with significantly less understanding. The is no exact vaccination or standard medical cure; just the prevention and precautions in hygiene and sanitation are the only way to fight against COVID-19 and its new strains.35,63

In health care systems, especially during an epidemic or a pandemic like COVID-19, it is imperative to understand the impact of water, sanitation, and hygiene measures to provide appropriate care to patients from any type of water-based infection risk.89 When events like COVID-19 occur, health care facilities should include hygiene programs and medical facilities, especially if they are in rural areas and places like slums or where people live in huge masses, should be reevaluated and strengthened. It requires many hygienic and cleansing material supplies, which are hard to acquire in light of challenges from lockdowns by respective governments. According to WHO, there are certain precautions that can be managed and applied, like cleaning hands using clean water and soap or, if available, an alcohol-based hand rub, even if the hands do not look dirty; washing the hands with soap and water for 20−30 s is an appropriate technique, and if visibly soiled, washing with soap and water for 40−60 s.87,90

Several measures can effectively plan for protecting the water from contaminants as well as removing contaminants:

- regular monitoring
- treatment before distribution
- following standard methods for treatments
- cleaning of water storage tanks
- science education for common masses in cleaning and managing the freshwater at home.

On the basis of the WHO, WASH, and waste management guidelines for COVID-19, some aspects also need to address fighting and surviving COVID-1978 (Table 7). To keep municipal and wastewater managers and workers safe from contaminated solid waste and wastewater, existing guidelines and procedures must be followed strictly for the COVID-19 virus, whereas the healthcare workers who are in direct or indirect contact with COVID-19 infected individuals must take all the precautions related to putting on medical gear, eating, or drinking before and after coming in contact with patients with suspected or confirmed COVID-19 infection. All workers must wear PPEs and avoid touching their eyes, noses, and mouths with unwashed hands.25,35,63,100

## WASH COMMUNICATION

Communication is an essential tool for sharing specific aspects of information, primarily during a global outbreak like COVID-19. For situations like epidemics and pandemics, to communicate accurate information, counter fake news, share science and WASH information for better understanding of precautions and preventions, and increase scientific literacy is the essential aspect learned by humanity during the last two decades. There are different ways to communicate among societies and age groups, different levels of trust in science and research practices, and different languages. WASH communications comprise aims, strategies, target communities, and government—public—private partnerships, including scientists and researchers. During this conceptual work, standard tools are described for creating societal trust in science sharing accurate water, sanitation, and hygiene (WASH) information. Earlier, the most common science communication methods were person-to-person, radio, television, and newspapers, out
of which person-to-person verbal communication was the most used method of communication.

The ultimate target for communicating WASH is to create a positive behavior-changing environment for humanity regarding health hygiene, sanitation, water conservation, and understanding how to act positively during epidemics and pandemics. Detailed objectives of WASH communication are

- increase societal understanding of hygiene, sanitation, and safe water to create a favorable environment for community mobilization
- ensure the residents in rural areas have a link between safe water and sanitation for health hygiene
- to encourage the society to build and use toilets and other sanitation facilities, ending open defecation
- to increase the literacy for continuous assessments and need to timely check whether WASH facilities are working correctly
- to minimize the gap in the society through promotional campaigns for continued use of clean water practices and to check water-polluting actions primarily in rural areas
- to minimize linguistic barriers and reach all the communities, primarily to disabled or illiterate communities at national, state, and district levels, by strengthening coordination among locals and NGO partners working for such gatherings.

To achieve the objectives of WASH communication, continuous use of science communication tools is required under three categories, viz., communication stratagems, advocacy, and behavioral changes, as a mixture of old and new communication tools for promoting WASH practices among the masses.

- Mass media: Tools can be used to effectively communicate to larger masses while minimizing the linguistic and regional barrier with a powerful image. Mass media can help in promoting positive behaviors for health hygiene through multiple products like radio and television announcements, print media, and live TV shows and in training of nonprofessionals from society to work as communicators to communicate reliable information from authenticated sources and to convey critical information on WASH services and practices especially during epidemics and pandemics. However, it requires a significant check through internal departments and government agencies that information shared through mass media has authenticated information and that translation into any regional language does not change the meaning or alter the public health guidelines.

- Public media: There are some places and individuals from society who are not to used to mass media, such as public media, viz., wall paintings, signs, and banners, and traditional modes of communication, like through folk art. Public media could help communicate through images and regional languages and could be recorded and shared on mass media platforms.

- Public appeals: Encouraging and motivational messages, without barriers of language or region, from public celebrities, motivational speakers, and spiritual leaders could be developed to educate the millions of their followers on clean water, hygiene, and sanitation practices and could be broadcast on various mass media formats.

- Mobile campaign: In the 21st century, the easiest way to communicate with the maximum number of people is to use different text and multimedia applications available on mobile phones. Voice messages and small videos, pictorial messages and text, and changing languages using converters are all readily available to contribute to WASH literacy for cleanliness and hygiene and to reach the citizens of respective countries. Further, it could be possible by involving network providers, telecom ministries, and trained communicators to share authenticated information during an epidemic or pandemic.

- Social media platforms: From Twitter to Facebook, YouTube channels to WhatsApp, campaigning on different social media platforms has become the most critical communication source and connecting with an educated and trained communicator to promote WASH literacy and awareness. It was crucial during the COVID-19 pandemic when millions of people were infected and thousands were isolated and quarantined. With social media platform open discussions, authentic information was shared and fake news was countered regarding clean water, sanitation, and hygiene.

## ADVOCACY OF WASH

Urgency in advocacy for strategic communication for planning and management involving government, media, people from society, implementing agencies, private organizations, and NGOs is needed to fortify the WASH system and continually upgrade the policies for preparedness. Bringing these entities together enables effective implementation with people’s participation and with communicators for the government programs, yielding fact-based advocacy for concrete actions including the following:

- Society representatives and policymakers are encouraged to work together and continuously nurture the issues of WASH practices and literacy with individuals of the society and in the various government agendas for policymaking and implementation.

- Different social groups pledge to hold dialogues to check and contribute to implementing WASH practices involving certain government bodies like municipal corporations and to discuss upcoming issues of various platforms as part of government–public partnerships.

- Traditional and modern modes of communication are promoted and facilitated to raise awareness, improving the behavior patterns toward the initiatives of government agencies for WASH practices.

- Newly trained communicators are encouraged to raise health hygiene issues and sanitation at the regional level while minimizing linguistic and regional barriers and facilitating the availability of literature and other informative materials and recognitions after analyzing the outcome to promote their efforts and motivate others to take an interest in such practice.

- In light of the epidemics and pandemics faced in the last two decades, there is an urgent need for advocacy for continued planning, research, and development for WASH facilities, to support the existing establishments to make clean water, sanitation, and hygiene a top priority. This includes continuous training of new communicators from society, increasing the number of...
WASH facilities and health care systems, and primarily educate citizens and others to adjust their mindsets during epidemics and pandemics.

COMMUNICATING WASH FOR BEHAVIORAL CHANGES

To create positive behavior in the communities, a significant awareness and increasing science and WASH understanding is required for every age group, including creating a stable environment for future preparation. Continued WASH communication practices contribute to changing the behavior of masses in society using various modes and tools of communication. Clustering the target stakeholders and communities can better implement the management plan identifying the needs and levels of understanding and to help indirectly address the communities for positive behavioral changes for WASH practices and literacy. Continuous methods of WASH communication, including science communication, have contributed much during the COVID-19 pandemic to the implementation of precautions and preventions while helping others in the society, including creating the understanding for environmental conservation.46

Understanding existing WASH facilities and societal literacy of various platforms could help implement COVID-19 preventive measures. For continuous modifications and upgrades in WASH management (improving adequate availability of water services, installing WASH facilities in public places), communication requires knowledge and awareness among the society of proper health hygiene practices such as critical times for handwashing, appropriate steps of health hygiene practices, and promoting positive behavioral changes in the communities.30,82,104 To ensure sustainable behavioral changes, continuous efforts are required to increase the level of understanding, and WASH communication should be done by the government to inspire communities (researchers, scientific communicators, health care workers) to adopt new behaviors using various tools of science communication.45 ensuring current WASH interventions are expanded to reach communities where such services are nonexistent. Practicing hygiene with washing hands while using soap is not a worldwide phenomenon—just a minor percentage of society uses soap or ash to wash hands. Before cooking or eating, handwashing is more of a ritual—just a few drops of water used to wet and “purify” the hand symbolically. Improving domestic hygiene through WASH communication is one of the potential and most effective ways to reduce the global burden of diarrheal diseases in children. With continued efforts for WASH, understanding the seriousness of the problem for lack of health hygiene and hostile behavior toward WASH practices, it must be stressed that the curative measures must be at a regional level. Solutions for positive behavior must be found at the grassroots level. Key behavioral changes can improve cleanliness, leading to good hygiene and health conditions, directly impacting society:1,51,86

- healthy childcare
- regular monitoring and maintenance
- health hygiene education

According to the UNICEF Hygiene Programming Guidance Note for the COVID-19 emergency response, capacity assessment of behavioral changes is done by Communication for Development (CfD), a joint program between CfD capacity and WASH workers based on the past epidemics and pandemics79 (Figure 12). Promoting health hygiene during epidemics and pandemics like COVID-19 is one of the most cost-effective practices for public health interventions for COVID-19 prevention.

Figure 12. Capacity Assessment. Reproduced from UNICEF 2020.78

CONCLUSIONS

With growing population and development, climate change and environmental destruction have increased the scarcity of resources like water, which are the primary and vital factors to fight against any epidemic or pandemic like novel coronavirus or the COVID-19 pandemic primarily targeting the SDGs 3, 4, and 6. COVID-19 has shaken humanity by affecting the lives of millions of people on health, social, and economic survival levels. Each day, the migration challenge of food and clean water to increase transmission has increased since December 2019. With the identification of a new strain of coronavirus with more severity and no exact availability of vaccines for even the first identified strains, precautions and prevention are the solutions with WASH practices and services, playing a significant role in putting a brake on virus transmission. WASH systems must be organized and provide service to all the groups and communities, including those living in informal settlements, creating facilities for literacy and WASH for good health under the SDGs. Clean water and sanitation services must be well-taken care of in all the health care centers, public places, and isolation and quarantine centers under SDG 6. In developing countries, the responsibility of governance is to fight COVID-19 and identify the communities lacking in necessary facilities like WASH and food for survival like...
homeless people, people living in informal settlements, older adults, and migrants. It is imperative to understand the need for WASH for these people; if the COVID-19 transmission spreads within such communities, it is tough to control, and the entire humanity is at risk. With NGOs and assistance from local administrations, under SDG 3, reviewing existing facilities of water hygiene, WASH, and necessary supplies of precautionary equipment must be conducted regularly and the information must be shared to increase the understanding of the need for health hygiene in the current crisis. WASH communication contributes to changes in people’s behaviors, especially those with less education living in rural areas; for this, under SDG 4, regional language experts or communication modes like audio-visual are helpful. For WASH communication, strategies include communication, advocacy, and positive behavioral changes for health hygiene using science communication tools without community or language barriers. Clean surroundings help fight against the COVID-19 pandemic, but the world needs to understand the importance of water, sanitation, and health hygiene; otherwise, humanity should be prepared for more frequent pandemics.

Global organizations like WHO, United Nations, UNICEF, and respective governance must identify those communities or specific groups that are at more risk without facilities like clean water and sanitation services and ensure WASH availability to fight against the global health crisis. Further, it is essential to be aware of and make available the facility requirements of precautionary gear to one’s own country and support others who lack the ability to fight against a pandemic. With WASH for all and at every place, the need for WASH science communication using various tools and science communicators to communicate to the common masses of society can also contribute in improvisation in understanding in terms of WASH.

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**Notes**

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