# WELL V2:

## EVIDENCE BEHIND THE **WATER** CONCEPT

# FEATURE W01: WATER QUALITY INDICATORS

## OVERVIEW

**Part 1**: Water delivered to the project for drinking, cooking, dishwashing, handwashing, showering and other activities requiring human contact meets turbidity and coliform requirements.

## SCIENTIFIC BACKGROUND

- Turbidity and coliforms are common water quality indicators, which are simple-to-measure parameters used to assess the possible presence of contaminants.
- Turbidity describes the cloudiness created by particles suspended in water when light passes through. It is measured in nephelometric turbidity units (NTU), formazin turbidity units (FTU) or formazin nephelometric units (FNU), all of which measure the amount of scattering light and calibrate on the same scale. Although turbidity does not directly cause illness, it can indicate the close proximity of other harmful contaminants.[1]
    - Nephelometric, derived from "nephos", the Greek word for cloud, taken together with "metric" to mean measuring cloudiness.
- Coliforms refer to rod-shaped, non-sporulating (i.e., they do not produce spores) bacteria that can come from multiple sources in the environment. Their presence suggests that certain pathogens (i.e., viruses, bacteria and other disease-causing microorganisms) may be lurking in the water source.[2,3]
    - Escherichia coli (E. coli) is a well-known coliform that is included in total coliform measurements but is often tested separately.[4]
    - Most E. coli live in the human gut and are harmless producing vitamin K and defending the body against other disease-causing bacteria. But some strains excrete toxic chemicals and can lead to serious food poisoning.[5]

## KEY HEALTH AND WELL-BEING EFFECTS

- High turbidity is associated with the growth of pathogens that can cause digestive issues, such as cramps, nausea and diarrhea and also have been associated with headaches.[3]
- Low turbidity means the water appears clear making it more aesthetically appealing for washing and drinking and better for promoting water consumption and hydration.[6]
- If coliforms such as E. coli are present in drinking water, they may cause cramps, nausea, diarrhea (including bloody diarrhea) and potentially fever and vomiting.[3,4,7]

## HEALTH PROMOTION BENEFITS AND STRATEGIES

- Low turbidity levels indicate that water treatment systems are working properly and the water is free of sediment[6] and less likely to contain microbes.[4]
- Controlling for the absence of coliforms in drinking water, which include enteric pathogens, such as toxic strains of E. coli, can help people avoid becoming ill with waterborne diseases.[4]

# FEATURE W02: DRINKING WATER QUALITY

## OVERVIEW

**Part 1**: Through a performance test, confirm drinking water meets thresholds for water quality parameters, inorganic chemical contaminants and disinfection byproducts.
**Part 2**: Through either municipal water quality reports or a performance test, confirm drinking water meets thresholds for pesticides and organic contaminants.

## SCIENTIFIC BACKGROUND

- Drinking water treatment is a multi-stage process, with several stakeholders involved in the catchment, conveyance, treatment and delivery at the tap. External factors, such as construction, unplanned breakdowns or extreme weather events, may increase the risk of contamination of the water when delivered to buildings.[4,8]
- Buildings may also pose risks in the maintenance of good water quality due to conditions such as water stagnation, inadequate backflow prevention and corrosion of materials used in plumbing.[8]

## KEY HEALTH AND WELL-BEING EFFECTS

- Drinking water often is supplemented with disinfectants such as chlorine or chloramine at the treatment plant to prevent the growth of pathogens in the distribution system.
    - Trihalomethanes (THMs), such as chloroform, are formed in drinking water as byproducts of chlorination or disinfection by the combination of disinfectant with organic matter. TTHMs are suspected to increase the risk of colon, rectal and brain cancer.[9]
    - Haloacetic acids (HAAs) are also disinfection byproducts caused by the reaction of disinfectants with organic matter. Dichloroacetic acid (DCA) is classified as possibly carcinogenic to humans.[10] Long-term exposure is suspected to cause teratogenic effects.[11-13]
- Maximum allowable concentrations of many inorganic substances in drinking water – some of them naturally occurring, and others that may be nutrients or additives at lower concentrations – are regulated in a large proportion of the world's countries in an effort to prevent known or suspected adverse health effects upon chronic exposure:[14]
    - Arsenic is associated with increased risks of kidney, liver, bladder and lung cancer.[15]
    - Chronic exposure to cadmium is associated with kidney damage.[16]
    - Chromium may increase the odds of allergic dermatitis.[16]
    - Copper levels above guidelines have been linked with episodes of diarrhea, with acute exposure leading to more serious gastrointestinal damage.[17]
    - Fluoride commonly is added to drinking water to fortify teeth, but chronic exposure can lead to fluorosis (tooth discoloration).[18]
    - Lead can impair the neurological function of children. Exposure in adults may trigger an increase in systolic blood pressure.[4]
    - Chronic exposure to elevated levels of mercury in drinking water can result in kidney damage.[16]
    - Nickel may leach from water pipes and fixtures and can cause allergic contact dermatitis.[4]
    - Nitrate and nitrite can be particularly toxic for infants, who are susceptible to methaemoglobinaemia (haemoglobin disfunction) that in some instances can cause death.[4,16]
    - Chlorine compounds (measured as total chlorine) may cause eye or nose irritation.[16]
- The organic compounds listed in this feature, along with some of their metabolites, are suspected or confirmed human carcinogens.[4]
- 2,4,6-Trichlorophenol can be produced either by the chlorination of organic matter as well as by pesticide degradation. Hepatic toxicity has been shown in animal testing and is considered a possible carcinogen.[4]
- Some pesticides of widespread use in the past – such as DDT, Aldrin, Dieldrin, Chlordane, Lindane and Pentachlorophenol – are considered persistent organic pollutants (POPs) by the United Nations because of their widespread environmental and human toxicity, potential for long-term accumulation in fatty tissues and long lifetimes. Potential effects of exposure to POPs include cancer, endocrine disruption and allergies.[19]
- Prolonged exposure to high levels of 2,4-Dichlorophenoxyacetic acid (2,4-D) may cause problems with the kidneys and adrenal glands.[16]
- Chronic exposure to elevated levels of atrazine could lead to problems with the cardiovascular and/or reproductive systems.[16]

## HEALTH PROMOTION BENEFITS AND STRATEGIES

- The production, use and exposure to POPs are being phased out and enforced by law in more than 150 countries that have signed the Stockholm convention.[19]
- On-site testing verifies the quality of water at the point of delivery, confirming the proper functioning of sanitary barriers placed by water utilities, distribution networks and buildings to prevent contamination.[4]
- In some countries, and for some contaminants (such as lead and copper in the United States), regulations require drinking water testing at the consumers' taps.[20]
- Most countries regulate and enforce that the concentration of contaminants in drinking water is at or below country or state-determined thesholds.[14] Regular testing for contaminants at the water treatment plant is usually required by law.

# FEATURE W03: BASIC WATER MANAGEMENT

## OVERVIEW

**Part 1**: Sample specific water quality parameters at least once per year, including parameters found to be within 80-100% of thresholds listed in WELL Feature W02 Part 1.
**Part 2**: Provide and implement a Legionella management plan and submit documentation of activities and results annually.

## SCIENTIFIC BACKGROUND

- From a risk management standpoint, water testing in buildings verifies that the water treatment, disinfection methods and barriers (e.g., filters) are in place to achieve their intended outcome and to provide water of high quality.[8]
- Legionella species bacteria typically are found in water sources worldwide, both natural (e.g., surface water of rivers and lakes) and human-made (e.g., spas and cooling towers).[21,22]
    - An exception, Legionella longbeachae, is found in potting soil and is the leading cause of Legionella-related illness in Australia.[23,24]
- Legionella bacteria present in fresh water and other natural sources rarely cause disease. But these bacteria are best able to multiply in water pipes where water recirculates, such as in cooling towers, and hot water in large buildings and spas that are not properly monitored and maintained.[25]
- Legionella bacteria thrive in damp, warm places and, though they are present in water, transmission to humans occurs through aerosols. That means small droplets of water in the air containing the bacteria are breathed into the body. It is through aerosolization and aspiration, which affects the lungs, that disease may occur, not through drinking water.[21,26,27]
    - Legionella pneumophila, the strain most often implicated in cases of disease, optimally grows at 35°C [95°F], but can multiply in conditions between 25°C [77°F] and 42°C [107.6°F].[28]

## KEY HEALTH AND WELL-BEING EFFECTS

- pH is one of the most critical parameters for water treatment and delivery as it heavily influences the effectiveness of chlorine disinfection and corrosion control prevention.[29]
- High turbidity is associated with the growth of pathogens that can cause digestive issues, such as cramps, nausea and diarrhea and also have been associated with headaches.[3]
- Lower turbidity water means that water appears clearer, which makes it more aesthetically appealing for washing and drinking and may better promote water consumption and hydration.[6]
- If coliforms such as E. coli are present in drinking water, they may cause cramps, nausea, diarrhea (including bloody diarrhea) and potentially fever and vomiting.[3,4,7]
- Exposure to Legionella bacteria may cause Legionnaires' disease, which is a severe, rapid and potentially fatal form of pneumonia,[22] or a milder respiratory disease resembling a cold, known as Pontiac fever.[22]
    - A range of factors influence whether illness develops from exposure. The exact dose or extent of exposure necessary to trigger infection is unknown but suspected to be low, particularly for already susceptible people (e.g., smokers, elderly, immunocompromised individuals).[30,31]
    - Respiratory illnesses are the most common effects of exposure to Legionella bacteria, but the bacteria may spread and result in extrapulmonary infection.[22,32]

## HEALTH PROMOTION BENEFITS AND STRATEGIES

- Regular monitoring with reporting on an annual basis is a common best-practice that can help confirm that drinking water quality stays consistent throughout the year.[4]
- Best practices worldwide for preventing illness caused by Legionella bacteria are based in the development and implementation of a management plan[8,33]. The plan requires conducting a risk assessment of building water, identifying potential drivers for Legionella growth, determining strategies for monitoring, controlling and maintaining flows, temperatures and adequate levels of disinfectant (usually chlorine) in both cold- and hot-water systems plus independent assets, such as cooling towers, spa pools and water fountains, and preparing measures to correct the functioning of the system when monitoring variables are out of expected ranges.[22,33-35]

**ADDITIONAL NOTES**

- Legionnaires' disease outbreaks most often are associated with complex water systems, meaning places such as hospitals, hotels and cruise ships may be particularly susceptible, as are individuals responsible for maintaining water systems in such environments and other types of buildings.[31,36] Furthermore, reported legionellosis cases are most common in individuals over 50 years of age and men. Risk factors for legionellosis include smoking, being immunocompromised, heavy drinking history and having other illnesses, such as pulmonary-related, chronic respiratory, or renal illnesses.[30]
- Rates of Legionnaires' disease vary around the world. And in some places, the extent to which the disease actually affects a population is unknown if the tools and methods for diagnosing, testing, and surveilling the disease are not available in a given country, which can contribute to under-reporting.[30]

# FEATURE W04: ENHANCED DRINKING WATER QUALITY

## OVERVIEW

**Part 1**: Water for human consumption meets limits for contaminant levels that can affect taste, odor and appearance.

## SCIENTIFIC BACKGROUND

- Humans require an adequate amount of water to support basic body functions. Water is the most abundant component of the body and is needed to maintain cell integrity and health, eliminate body waste, regulate body temperature, lubricate joints and carry nutrients and oxygen to cells.[37]
- A daily recommended total water intake is about 2.7 L [91 oz] for adult women and 3.7 L [125 oz] for adult men, which can come from drinking water and other beverages, as well as consuming high-moisture foods such as fruits, vegetables and soups.[38]
- Small concentrations of some ions (e.g., zinc, iron) are widely accepted, if not essential parts, of a healthy diet. However, the presence of certain ions above detectable concentrations can deter water consumption and compromise adequate hydration:
    - Aluminum levels above concentrations as low as 0.05 mg/L and up to 0.2 mg/L can color water in a way that may make it less aesthetically appealing for consumption[39].
    - Sulfate, chloride, sodium and calcium may add a salty and/or mineral taste to water if any of these are present in concentrations above 200-400 mg/L.[40]
    - Manganese concentrations below 0.05 mg/L are usually are acceptable to most consumers, but higher concentrations may impart color and a bitter taste to water and may stain laundry.[39-41]
    - Taste thresholds for zinc, copper, iron and manganese are in the ranges of 4-9, 2-5, 0.04-0.1 and 4-30 mg/L, respectively.[40]
    - Elevated levels of silver may cause skin decoloration.[40]
    - Sulfide causes the “rotten egg” smell and is detectable at less than 0.1 µg/L.[40]
- Chlorine and chloramine (both measured in total chlorine) used for water disinfection have taste thresholds well below thresholds associated with health effects. Their odor seems more pungent upon reacting with organic compounds dissolved in water.[40]

## KEY HEALTH AND WELL-BEING EFFECTS

- The taste of water influences a person’s willingness to drink it and to select tap water as their primary source of hydration.[42]
- Chemical thresholds given in this feature address taste, odor and appearance considerations to promote palatable drinking water. Some of the chemicals listed in this feature can be toxic at significantly higher concentrations.[40]
- Lack of water intake can cause dehydration, which is discussed in detail in Feature W06. Mild dehydration refers to when there is a 1-2% loss of body water; moderate dehydration is defined as a loss between 2-5%; and severe dehydration occurs when there is a loss of more than 5% of body water.[43]

## HEALTH PROMOTION BENEFITS AND STRATEGIES

- Some countries have defined certain chemical thresholds to encourage drinking water consumption and reduce customers’ complaints based on non-health-based effects listed above. For instance, in the United States these limits are established for compounds categorized as “nuisance chemicals”, whereas in Canada thresholds for similar chemicals are known as “aesthetic objectives”.[39,41]
- Maintaining concentrations of total dissolved solids (TDS) below 500 mg/L can keep water from tasting unpalatable.
    - Water with too little TDS, on the other hand, may be found by some to taste flat.[42]
- Treatment techniques to remove these compounds from drinking water can vary depending on the chemical, the water source and point of treatment (e.g., treatment plant or within a building).
    - Corrosion control measures used at the treatment plant can reduce the concentration of dissolved metals (zinc, copper, iron).[39]
    - Reverse osmosis at the point of use is an expensive, yet efficient, way to remove salts and dissolved ions.[39,40]
    - Filtration with activated carbon may reduce most agents that cause color, foaming and odor.[39]

# FEATURE W05: DRINKING WATER QUALITY MANAGEMENT

## OVERVIEW

**Part 1**: Pre-test water prior to Performance Verification for listed parameters and monitor water quality on a quarterly basis.
**Part 2**: Display water test results and filter maintenance logs (if used) near sources of drinking water.

## SCIENTIFIC BACKGROUND

- The provision protection of water quality from its source to the tap involves multiple stages: sourcing, treatment, distribution to customers and distribution within a building. Multiple stakeholders may be involved in each of these stages.[4]
- By establishing health-based targets, municipalities and governments assess risk of contamination and determine water quality parameters, thresholds, monitoring requirements and barriers for contamination (e.g., water treatment processes) at every stage of the process.[4]
- The role of the building in maintaining water quality is often overlooked.[8] The building's pipe network and fixtures may negatively impact water quality due to factors such as poor design and maintenance, cross-connections between potable and non-potable water lines, building materials (such as lead in old buildings) and prolonged stagnation.[8]
- The water quality supplied to a building may be subject to fluctuations, some of them due to systemic failures and others associated with extreme events.[4,8]

## KEY HEALTH AND WELL-BEING EFFECTS

- Unproperly managed water can become a source of pathogens (such as some Escherichia coli strains) that can cause gastrointestinal diseases such as diarrhea.[4]
- Chronic exposure to chemical contaminants may increase the odds of experiencing long-term health effects, including endocrine disruption, impaired intellectual development in children and several types of cancer targeting organs such as the liver, bladder and lungs.[4,10,12,15,16,19]

## HEALTH PROMOTION BENEFITS AND STRATEGIES

- The World Health Organization (WHO) recommends a risk-based approach to address water quality in buildings.[8] This approach involves getting to know possible sources of risk – from both the water supply and within the building – implementing strategies to minimize risk (e.g., filters), monitoring water quality parameters and performing corrective actions (e.g., cleaning fixtures, changing fittings).
    - Pre-testing the water at the point of entry to the building and within the building's pipe system is a way to assess the risk of poor water quality and should inform the need for additional treatment, such as filters.
    - Periodic monitoring of water confirms its quality or may signal the need for maintenance or repair within the water pipes and fixtures.
- Documentation of water quality results and actions to correct any deviation from the target water quality parameters is essential to gain a better understanding of the building's water system and maintain its long-term performance.[8]

# FEATURE W06: DRINKING WATER PROMOTION

## OVERVIEW

**Part 1**: Provide readily accessible drinking water stations that can refill water bottles and are cleaned on a daily basis.

## SCIENTIFIC BACKGROUND

- Water is the most abundant component of the human body and is required for most body functions, including cell integrity and health maintenance, body waste elimination, body temperature regulation, joint lubrication and for carrying nutrients and oxygen to cells.[37,44]
- Water in our bodies helps to facilitate the transport of nutrients into the cells and bloodstream and serves several other essential functions, such as sweating, respiration, and absorbing shock for the spinal cord and brain.[45]
- The daily recommended total water intake is about 2.7 L [91 oz] for adult women and 3.7 L [125 oz] for adult men, which can come from drinking water and other beverages, as well as consuming high-moisture foods such as fruits, vegetables and soups.[46]
    - Mild dehydration refers to when there is a 1-2% loss of body water, moderate dehydration is defined as a loss between 2-5%, and severe dehydration occurs when there is a loss of more than 5% of body water.[43]

## KEY HEALTH AND WELL-BEING EFFECTS

- Chronic dehydration is associated with an increased risk of urinary tract infections and kidney stones, and potentially also with increased chances of stroke and high blood pressure.[47-51]
- Water consumption, even if people are not dehydrated, is associated with acute (i.e., short-term) improvements in subjective mood in adults, ranging from positive feelings of alertness to feelings of calmness and a reduced sense of fatigue.[52-55]
- Studies observing children typically living in hot climates report that improving hydration for students is associated with improvements in some cognitive functions and tasks, such as improved short-term memory and attention.[56,57]
    - In both children and adults, one study suggests that even as little as 25 mL [0.8 oz] of water may help improve things such as visual attention.[58]
- Older adults in particular may benefit from dehydration prevention efforts as they are more vulnerable to dehydration, which is associated with increased hospitalizations and deaths, as well as with certain other adverse health outcomes, such as impaired cognitive function and high blood sugar levels in diabetics.[59,60]

## HEALTH PROMOTION BENEFITS AND STRATEGIES

- The provision of free drinking water has been shown to be an effective strategy to re-direct caloric consumption away from sugar-sweetened beverages while also increasing water consumption rates for both children and adults.[51,61-64]
    - One study found that the risk of being overweight was reduced by 31% and water consumption increased by over 200 mL [6.7 oz] per day on average for students who were in schools where water fountains were installed and lessons were given on promoting water consumption.[63]
    - A systematic review of several studies reports that adults who drink sugar-sweetened beverages may consume 7.8% more energy (i.e., calories) at meals compared to adults who drink water at meals.[62]
- Lack of availability of free drinking water has been observed as a barrier to water access in schools as reported by students and staff.[65,66]
- Paying attention to the maintenance of drinking water fountains and other kinds of dispensers to maintain cleanliness and functionality can help remove a potential barrier to increased water consumption in schools.[65]

## ADDITIONAL NOTES

- Access to safe and easily accessible drinking water is a principal goal for protecting public health, particularly given that not all people live in places where there is easy access to any clean drinking water. The greatest opportunities for health promotion through the provision of safe drinking water that is more readily available is in developing nation contexts, where being able to have good access to drinking water often presents a serious challenge. Specifically, almost half of the 663 million people who do have access to an “improved water source” (i.e., a drinking water source protected against contamination) live in Sub-Saharan Africa.[67] Overall, estimates report that more than 800 million people worldwide lack a safe source of drinking water accessible within a 30-minute round trip. Potentially upwards

of 2 billion people use a drinking water source with fecal contamination. And by 2025, half of the world's population will live in an area considered water-stressed, wherein demand for safe drinking water exceeds availability.[68]

- There are also differences in water accessibility experienced by a given person depending on whether they live in an urban or rural environment. Eight in 10 of people who do not have access to an improved water source live in rural areas.[67] Access to safe water is usually greater in urban areas. But many urban locations nevertheless have been unable to keep up with the pace of urbanization. An estimated 156 million people living in urban environments around the world do not have access to an improved water source. It is estimated that the urban population will nearly double by 2050--from around 3.9 billion today to 6.3 billion.[67]

# FEATURE W07: MOISTURE MANAGEMENT

## OVERVIEW

**Part 1**: Design the build envelope to minimize moisture intrusion and accumulation.
**Part 2**: Use moisture-resistant materials and protect moisture-sensitive materials, manage condensation on cold surfaces and control water leaks on hard-piped fixtures and water treatment devices.
**Part 3**: Implement a moisture management plan, including period inspections of signs and sources of water damage, leaks and a system for occupants and tenants to notify the project about mold or water damage.

## SCIENTIFIC BACKGROUND

- Mold and other microorganisms can grow anywhere with moisture and a food source — including on any organic matter, wooden wall studs or sheetrock — and thrive particularly well in damp environments.[69,70]
    - Mold growth in buildings requires three components: oxygen, organic substances for food and moisture.[71]
- In the natural environment, mold and fungi are essential for breaking down dead plant material. However, they may become a health hazard in indoor environments.[70]
- Water brought into buildings for drinking, cooking, cleaning or irrigation passes through a system of pipes, sinks, showers and piped devices. Water leaks and damage, poor plumbing and poorly ventilated spaces can create moist, humid conditions that are sufficient for mold growth.[72]
    - Water can migrate through porous materials and cling as a thin film on surfaces in a process known as adsorption. Adsorbed water cannot be removed by drainage.[73]
    - The building materials most vulnerable to mold growth include cellulose, wood, jute, wallpaper, drywall and cardboard.[74]
    - Dampness can be visually identified by bubbles and discoloration of floors, walls and/or ceilings. Mold growth can be an indicator of water leakage or damage.[75]
- The porosity of common building materials and structures allows moisture to penetrate into buildings. As water in liquid and vapor form migrates from areas of high to low concentration, it may be withdrawn from damp soils, roofs or external walls to the inside of structures.[72,76]
- Improperly managed moisture can lead to damp environments that are conducive to bacterial and mold growth, attract insects and pests, create emissions and harm the overall performance and lifespan of a building.[72]
- Moisture problems may be more common in rooms that are not typically regularly occupied, such as basements or crawl spaces.[77] These types of rooms are also more vulnerable to problems related to moisture intrusion or plumbing leaks.[77]

## KEY HEALTH AND WELL-BEING EFFECTS

- Several studies in schools and homes demonstrate that excessive dampness poses a hazard to respiratory health in both children and adults, including the potential development or worsening of asthma, among other respiratory infections, such as bronchitis.[78-88]
- There may be a dose-response relationship between dampness and asthma, meaning that the greater the severity of dampness, the greater the risk of asthma.[89]
- The moisture content of wood has been studied and found to be implicated, among other moisture-related building factors, in triggering symptoms of Sick Building Syndrome, as well as with fungal growth and the attraction of insects, which may degrade building materials and lead to further problems.[90-93]
- Exposure to indoor environments that are moldy or damp is also consistently associated with allergy-related issues such as allergic rhinitis or eczema in children and adults.[78,94]
- Vulnerable populations for microbe and mold infestations include individuals living in poverty, those living in an area affected by a natural disaster (i.e., hurricane or flood damage), university students (via university-supplied housing) and healthcare workers and patients.[76,95] A European household survey of dampness showed that as rates of poverty increased, the prevalence of dampness-related adverse outcomes also increased.[96]

## HEALTH PROMOTION BENEFITS AND STRATEGIES

- Effectively controlling moisture intrusion into buildings requires consideration at the design and construction phase, as well as during operations and maintenance.[97]

- Per the U.S. Environmental Protection Agency (EPA), the three foundational aspects to address in the design and operation of a building are:
    - (1) Control liquid water.
    - (2) Prevent excessive flows of humidity and water vapor within the building and through its envelope to avoid condensation.
    - (3) Select appropriate materials for locations that are unavoidably wet.[72]
- Assessing and planning a building for moisture protection to determine sources and potential loads of moisture is recommended.[98] Items to consider include site drainage, vapor infiltration, condensation due to temperature differentials and the intrusion of liquid water due to rain events (in roofs and entrances) and capillarity (i.e., movement of water through pores due to a concentration gradient).[76,97]
- Correcting water damage or leaks can prevent the onset of building-related respiratory problems.[99] Limiting excess moisture in indoor spaces can also protect against the release of chemical emissions from building materials and furnishings.[76]
- Selecting water-resistant materials is critical for minimizing humid surfaces that are particularly hard to dry with even a small amount of moisture, such as composite wood and paper.[73,100]
- Design of plumbing systems should be such that leaks in pipes and appliances are easy to spot, isolate and repair.[72]
- Preventative maintenance and inspections verify the proper performance of barriers placed in the building design against moisture intrusion and mold growth.[97,98]

**ADDITIONAL NOTES**

- In homes and larger buildings, mold and moisture issues are common despite the availability of guidance on control strategies.[101] This may indicate a need for improved curricula and increased training for design and construction professionals on moisture control principles, including moisture-protective building techniques and materials selection and installation.[76]

# FEATURE W08: HYGIENE SUPPORT

## OVERVIEW

**Part 1**: Design accessible multi-user, single-user and family bathrooms with essential resources and safeguards available to accommodate diverse needs, providing signage and supplies to support handwashing.
**Part 2**: Design fixtures to reduce touchpoints in bathroom accommodations.
**Part 3**: Design sink dimensions to limit contact with wet surfaces during handwashing.

## SCIENTIFIC BACKGROUND

- According to data from 2017, 27% of the global population (approximately 2 billion people) still lack access to basic sanitation services.[102] Nine out of ten of people affected are from Central and Southern Asia, sub-Saharan Africa and Eastern and South-Eastern Asia.[102]
- Forty countries (out of 152 globally with <99% coverage for basic sanitation facilities) are expected to achieve nearly universal coverage for basic sanitation facilities by 2030 in urban areas. Progress estimates indicate that rates of change are significantly lower in rural areas, and particularly for the poorest areas within rural communities.[102]
    - Provision of sanitation needs to be accompanied with hygiene support to prevent the propagation of pathogens through fomites (i.e., contaminated surfaces).[103]
- In cases where fundamental sanitation facility access poses less of an issue, there are still key considerations in designing bathroom accommodations to support well-being and equity:
    - Empirical evidence shows that women typically require twice as much time in bathrooms compared to men.[104] The difference may relate to reasons both biological (e.g., internalized versus externalized urogenital systems, menstruation and related feminine hygiene tasks) and social (e.g., enclosed stalls versus unenclosed urinals, likelihood of being accompanied by small children).[105,106]
      On any given day, an estimated 300 million people around the world are menstruating and, on average, a woman menstruates for 3,500 days of her life, but feminine hygiene requirements often are overlooked in bathroom design.[107-109]
- Maintaining hand hygiene is a highly effective and low-cost measure to prevent illnesses and the transmission of infection-causing germs.[110,111]
- Although handwashing guidelines are often simple, compliance with proper handwashing practices is often poor (particularly as studied in healthcare settings), requiring that additional attention is paid to behavioral factors that can influence how strictly and consistently guidelines are followed.[112-114]
- Sinks and other environmental surfaces, particularly wet surfaces, can be sources of bacteria or viruses: Some germs can live on these surfaces for up to several hours in ambient conditions.[115]
    - Microorganisms can be transmitted from hands to surfaces and back to hands, and then again to surfaces, with some dilution effect but still within ranges that potentially can cause disease.[116]
- Seal traps (U-traps) provide a wet seal between sewage lines and the bathroom environment and are usually found under every bathroom sink and floor drain. The water in the bottom of the 'U' prevents sewage particles and gases to return through the drain.[117] Along with preventing unpleasant odors, they may prevent the spread of sewage aerosols that may pose a risk of disease.[118]

## KEY HEALTH AND WELL-BEING EFFECTS

- Inadequate access to sanitation, coupled with inadequate access to clean water and hygiene resources, is associated with increased risks of neglected tropical diseases (e.g., trachoma, intestinal worms, dengue), which affect more than 1.5 billion people across 149 countries.[119]
    - Shared sanitation facilities (e.g., public or community toilets, toilets shared across multiple households) are an interim solution towards eliminating open defecation and associated diseases, but may pose concerns related to dignity, privacy and safety, particularly for women, children and individuals with limited mobility.[102]
- Bathroom design is particularly important in fall prevention: Falls are a leading cause of fatal and non-fatal injuries among older adults, and injury-causing falls are more likely to occur on stairs and in bathrooms.[120-122] Overall, environmental design-related hazards are estimated to be attributable for up to 47% of falls.[123-125]
- Whether in developing or developed country contexts, women and girls are disproportionately affected by inadequate access to sanitation facilities.[106,109,126] Restricted access to toilets may restrict eating and drinking to delay

needs, increasing risks of related health problems.[127] Furthermore, perimenopause and pregnancy can compress or weaken the bladder, increasing women's needs for facilities.[128,129]

- Women, children and people living with disabilities are at greater risk from men of violence (sexual and otherwise physical) and harassment when forced to use unsafe or poorly located toilets.[130,131]
    - Sanitation-related tasks such as fetching water for post-defecation bathing and menstruation hygiene management are associated with both physical and mental stressors in rural India.[131]
    - Geographical variation affects relevance of accessing sanitation features. In one study examining sanitation stressors among 60 women, 100% of urban women report rape and sexual assault as a highly severe issue during sanitation compared to 64% of rural women, highlighting the nuance between geographical locations.[131]
- A robust body of literature illustrates that lesbian, gay, bisexual, transgender and queer/questioning (LGBTQ) youth are subject to significantly more violence and harassment (physical and verbal) from peers compared to other youth.[132-137] Surveyed students in the United States and Canada identify bathrooms and locker rooms as the least safe spaces in schools, making these prime areas for intervention to improve actual and perceived experiences of safety.[135,138,139] Whenever possible, LGBTQ groups should be consulted to consider whether separate, gender-neutral toilets in a given location or other context represents a preferred option that will not be likely to increase risks of violence.[140]
- Studies in developing countries indicate that proper handwashing in the community, which necessitates the availability of all related amenities such as soap and having access to clean water, can reduce the risk of both diarrheal diseases and severe intestinal infections by nearly 50%.[112]
- Bathrooms surfaces may constitute reservoirs of pathogenic microorganisms, particularly wet areas.[141]
    - A study showed the propagation of Salmonella species around wet areas of a toilet bowl. Hands-to mouth contamination, especially when kids touch toilet bowls, is possible.[142]
- Studies in both developing and developed countries indicate that improved hand hygiene (i.e., education and the use of nonantibacterial soap) in the community can reduce gastrointestinal illnesses by 31% and respiratory illnesses by 21%.[113]
- In hospital settings, suspension in the air of pathogenic bacteria present in sink drains, likely caused by the column of water directly impacting the sink drain, has been associated with intrahospital infection.[143,144]
- Dry seal traps, which allowed the dispersion of contaminated sewage aerosols into buildings, were thought to significantly contribute to the spread of SARS disease in a large outbreak in Hong Kong.[117,118]

**HEALTH PROMOTION BENEFITS AND STRATEGIES**

- The United Nations recommends providing access to private and accessible toilets accessible for all users and particularly for women and girls that cater for the use of feminine hygiene products in a culturally appropriate and dignified manner.[109]
    - In some cultural contexts, women and girls may be hesitant in seeking products from an attendant, and other solutions such as vending machines may be more appropriate.[109]
- Accessible toilets refer not only to distance or length of time to reach a toilet, but also to design that facilitates use by individuals of all physical abilities.[109] This may include handrails to support body weight or unobstructed and potentially non-slip paths to toilets.[109]
    - The recommended minimum stall size is 1.5 m [4.9 ft] wide and 2.2 m [7.2 ft] deep to accommodate wheelchair access.[145] For handrails, a galvanized iron pipe between 25-55 mm [0.9-2.2 in] diameter is considered suitable for utilization by many users.[146]
- The appropriate number of female toilets may vary between activity areas and other contexts, but typically facility design should recognize that women and girls require both more time and space compared to men (e.g., there may need to be more female toilets than urinals and male toilets).[109]
- Newly adopted amendments in the International Building Code scheduled for publication in the 2021 edition of the code will require signage on single-user stalls indicating they are open to any gender and provide guidelines to allow all-gender multi-stalls, featuring shared sinks but enclosed toilet stalls.[147] These amendments are designed to promote greater equity and efficiency in bathroom design for all genders, people living with disabilities and caregivers with small children.[147]
- Ideally, there should be one changing station (e.g., a free-standing table or folding table attached to a wall) for small children in both the women's section and in the men's section, or a gender-neutral cubicle available to all with a changing station that can be used to care for small children.[109]

- Bathrooms for children also should provide sinks and toilets designed accordingly (e.g., smaller toilet seats, lower urinals and sinks).[109]
- Individuals with various health conditions may require access to opportunities for the safe disposal of needles and other sharp objects.[148-150] Lack of safe disposal options can put others at risk of exposure to discarded, used needles. This can be avoided by providing puncture-resistant containers in bathrooms or other designated areas that can allow for private and safe disposal.[148]
    - Requirements vary based on country or locality on procedures for handling medical waste.[148,150]
- Using soap is a proven strategy for reducing bacterial levels on hands (count and types), the incidence of diarrhea in children, and gastrointestinal respiratory and illnesses in developed and developing countries.[110,151-153]
    - Many studies indicate an association between the chemicals that confer antibacterial properties to soap and the development of resistance to these compounds in certain pathogenic bacteria, such as E. coli and Salmonella, but there is some conflicting evidence on the relationship between antibacterial soap and antibiotic resistance overall.[154,155]
- The use of sealed soap refills is associated with less risk of bacterial contamination of soap compared to the use of open, refillable bulk soap dispensers (i.e., when new soap is poured into the dispenser).[110,154]
- Drying hands after washing reduces odds of bacterial re-colonization.[156] Cloth and paper towels may be more effective than other drying methods at removing residual moisture from hands to limit bacterial spread.[157-159]
    - Some studies indicate that environments where cloth and paper towels are in use have less airborne bacteria and/or a smaller radius of contamination compared to environments with air dryers, though findings are mixed across the literature.[158,160-162]
- Implementing touch-less fixtures in bathrooms may reduce the contamination of surfaces and exposure to the surface-to-person route of exposure.
    - Touch-less faucets must be designed to reduce internal water stagnation and subsequent microbial growth (including Legionella amplification).[163]

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