

Review

Resilient built environment: critical review of the strategies released by the Sustainability Rating Systems in response to the COVID-19 pandemic

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Supplementary material: strategies addressed by the SRS

1. WELL Health-Safety Rating

1.1. Cleaning and Sanitization Procedures

Coronaviruses and noroviruses, among other pathogens or bacteria (i.e., Salmonella), are transmitted via respiratory droplets, fomites (i.e., infected surfaces) or direct contact (i.e. handshake). Maintaining good cleaning protocols can support organizational resilience by helping reduce the risk of infection [1].

1. Support Handwashing

Ensure support of hygienic hand washing practices. NOTE: soap has been found to be more effective at removing germs than hand sanitizer, as sanitizers' effect is impeded by dirty or greasy hands. Bathrooms must be designed and furnished to ease hygiene because sinks may harbor pathogenic bacteria that can migrate onto hands during washing and soap containers often remain contaminated after use [1–3].

2. Reduce Surface Contact

Reduce the amount of hand contact on high-touch surfaces. NOTE: reducing the instances where occupants touch surfaces can help minimize one of the vectors of disease transmission (e.g., touch-free faucets, voice-activated elevators, ticketless entry, transparent partitions, etc.) [1].

3. Improve Cleaning Practices

Provide effective cleaning through protocols and practices. NOTE: develop cleaning and disinfection plans that include instructions, training and recordkeeping to protect the health of occupants and cleaning staff and increase the overall efficiency of the process, while reducing environmental damage [1,4].

4. Select Preferred Cleaning Products

Minimize potential health effects to occupants by selecting less hazardous products. NOTE: commercial cleaning products may contain ingredients suspected to be hazardous to human health and the environment. Low-hazard cleaning products and cleaning practices reduce impacts in Indoor Air Quality (IAQ) and in the health of those performing these duties, while protecting occupants from respiratory and dermal symptoms [1,5].

5. Reduce Respiratory Particle Exposure

Implement strategies to reduce human contact with respiratory particles. NOTE: establish physical distancing among people (e.g., marks in elevators, meeting rooms, etc.), provide barriers to

prevent respiratory particles and improve circulation strategies (e.g., one-way hallways and corridors) [1,6–8].

1.2. Emergency Preparedness Programs

Even if they are not directly referred to the built environment, emergency preparedness and resilience plans are critical to ensuring that organizations are equipped to immediately handle unforeseen events, as well as to recover successfully from it, minimize occupant confusion, productivity loss and stress and improve coordination and safety [1,9–11].

6. Develop Emergency Preparedness Plan

Enable organizations, families and individuals to prepare and respond to diverse emergency situations. NOTE: undertake a risk assessment, create an emergency management plan for natural, human-caused, technological and health-related emergencies and educate occupants on the plan to support emergency preparedness and response with proper mitigation strategies [1].

7. Create Business Continuity Plan

Prepare organizations to operate under disruptive circumstances. NOTE: create a business continuity plan to help manage business disruption, restore business operations, minimize risk to employees and mitigate financial loss when emergencies occur. Establishing organizational remote work readiness can help operations run smoothly and support employee well-being and productivity when an emergency makes remote work imperative [1,12,13].

8. Plan for Healthy Re-Entry

Ready spaces for re-occupancy following situations requiring them to be vacant. NOTE: create and implement a re-entry plan that includes re-evaluation of existing policies, protocols and programs, risk inspections of building systems, frequent occupant communications, and flexible re-entry options to meet occupant needs [1].

9. Provide Emergency Resources

Provide resources, personnel and training to help organizations, families and individuals respond to emergency situations. NOTE: offer resources like first aid kits and automated external defibrillators, coordinate with emergency response teams and provide emergency preparedness and occupant response trainings [1].

10. Bolster Emergency Resilience

Better enable individuals and communities to help maintain health and well-being, and organizations to maintain business function, during and after emergencies. NOTE: facilitate resilience during and recovery after an emergency (e.g., through spaces designed for emergency public use or through employer-funded employee relief assistance) [1].

1.3. Health Service Resources

As for the Emergency Preparedness Programs, Health Service Resources are not directly referred to the built environment, but they are strategies that focus on way to foster individual actions that support health and safety for all in a space [1].

11. Provide Sick Leave

Improve recovery from and reduce transmission of diseases by enabling and encouraging employees to stay home when sick. NOTE: organizations must provide access to paid sick leave to reduce contagion in the workplace, improve employee productivity and reduce turnover since studies show that employees go to work sick if they lack sick leave or if their sick leave does not offer sufficient wage replacement [1,14].

12. Provide Health Benefits

Support the health and well-being of individuals and their families by offering comprehensive health benefits, policies and services. NOTE: provide access to essential and on-demand healthcare services (e.g., medical, dental, vision, mental health, preventive screenings, disease management or on-site flu vaccines) [1].

13. Support Mental Health Recovery

Enable families and individuals to access mental health services and resources that provide support during and after emergencies. NOTE: offer supportive resources (i.e., psychological first aid) to facilitate recovery after an emergency and avoid psychological distress, depression, anxiety, feelings of hopelessness, fatigue, irritability or anger) [1,15].

14. Promote Flu Vaccines

Promote flu vaccinations to reduce incidence of seasonal influenza. NOTE: flu vaccinations also reduce the quantity and duration of visits to intensive care units, freeing up medical capacity for other needs such as pandemics and natural disasters [1,16].

15. Promote a Smoke-Free Environment

Prevent the use, sale and advertisement of tobacco products. NOTE: in addition to the most common health risks, smoking can increase comorbidities for influenza such as chronic obstructive pulmonary disease (COPD) and COVID-19. The only way to protect people from secondhand and thirdhand smoke (residual chemicals left on indoor surfaces by tobacco smoke) is to implement a 100% smoke-free environment both inside and in the vicinity of building entrances, operable windows and building air intakes. Restricting the sale and advertisement of tobacco on-site is a key strategy for preventing or curbing use of tobacco products as well as providing support to those trying to quit [1,17–22].

1.4. Air and Water Quality Management

Depending on their specific properties, pathogens can enter our system through breaks in the skin or through our body's natural openings, such as our mouth, nose, and eyes via the air we breathe, the food we ingest and the water we drink. Air and water quality monitoring, together with operational strategies to improve the ventilation and filtration in an indoor space, is critical to identifying and mitigating infection risks for occupants [1].

16. Assess Ventilation

Minimize IAQ issues through the provision of adequate ventilation. NOTE: assess the amount of fresh air supplied from the outside in order to dilute human- and product-generated air pollutants (i.e., particulate matter and volatile organic compounds (VOCs)) [23,24]. Increasing ventilation rates is also a recommended strategy to mitigate the transmission of COVID-19 and other airborne contagious diseases [1].

17. Assess and Maintain Air Treatment Systems

Mitigate risks from indoor contamination and pollution sources through air filters and other treatment devices. NOTE: carbon filters remove VOCs and ozone from the passing air [25]. High-efficiency particulate air (HEPA) filters can remove virus particles since the virus often travels as part of larger particles [26]. Also ultraviolet germicidal irradiation (UVGI) systems are effective towards airborne virus both when irradiating the upper portion of the room or when placed in the air ducts [27]. For optimal performance, air filtration systems need to be maintained according to the manufacturer's instructions [1].

18. Develop Legionella Management Plan

Implement protocols to reduce risk of Legionella colonization. NOTE: Legionella bacteria is naturally present in water at low concentrations, but it may colonize recirculated water systems and can cause lung disease and even death if contaminated water aerosols are inhaled. Legionella may spread in domestic potable and hot water systems, cooling towers, humidifiers, misters, decorative

fountains, spas and hot tubs [28]. A proper Legionella management plan should reduce the risk of exposure to pathogenic bacteria [1].

19. Monitor Air and Water Quality

Assess IAQ and water quality. NOTE: monitor air quality (e.g., VOCs, ozone, particulate matter, carbon monoxide and radon) and water quality levels (e.g., chemical and microbiological characteristics like turbidity, residual chlorine and pH) to identify potential issues and minimize risk to human health through building design and operation strategies [1,29].

20. Manage Mold and Moisture

Limit the potential for bacteria and mold growth within buildings. NOTE: verify through inspections that design and operations work properly against mold growth that, together with other biological pests, can increase the risk of developing respiratory infections for those within the building [1,30,31].

1.5. Stakeholder Engagement and Communication

During emergencies, stakeholder engagement and communication is critical to instilling confidence, improving coordination and supporting actions that can help protect safety [1]. Therefore, the following preventive strategies are presented even if they are not directly related to the built environment.

21. Promote Health and Wellness

Promote adherence to collective wellness and sustainability goals and a deeper occupant understanding of the features pursued by the project and of how building operations and policies impact health and well-being. NOTE: enhance the health literacy, defined as a person's cognitive and social ability to access, interpret and understand basic health information, as well as the ability to act on that understanding to maintain health [1,32–35].

22. Share Food Inspection Information

Mitigate foodborne illness and increase consumer knowledge of food inspection results. NOTE: restaurants and other food service areas should display letter grades or sanitary inspection reports resulting in increased public awareness of restaurant cleanliness and quality, as well as incentivizing food establishments to uphold and maintain sanitary measures and hygiene practices [1].

2. *Fitwel Viral Response Module*

2.1. Enhance Indoor Environments

This section focuses on mechanical systems and policies that impact viral transmission while also benefiting other chronic conditions, such as asthma within the indoor environment [36].

1. Enhanced Indoor Air Quality Policy

Establish and implement an enhanced IAQ policy. NOTE: a qualifying IAQ policy must outline the implementation of management and maintenance (source control and housekeeping); ventilation and filtration (assessment, enhancement and maintenance); management of closures and significant reductions in occupancy; procurement of products, materials and testing standards; management of IAQ during any construction and major renovations [36].

2. Humidity Control Policy

Establish a Humidity Control Policy. NOTE: a Humidity Control Policy supports optimal air quality. Not too dry environments promote physiological defense against viral infection, while not too humid environments prevent mold growth. The policy includes strategies for controlling the relative humidity (RH), and outlines strategies for microbe and mold control in applicable areas [36].

3. Enhanced Indoor Air Quality Testing and Monitoring Protocol

Establish an Enhanced IAQ Testing and Monitoring Protocol. NOTE: an Enhanced IAQ Testing and Monitoring Protocol sets benchmarks to identify ventilation and filtration issues and ensure air quality remains high over time, contributing to mitigation of viral transmission and promotion of respiratory and mental health [36].

4. Legionella Water Management Plan

Establish a Legionella Water Management Plan. NOTE: a Legionella Water Management Plan supports the monitoring and maintenance of a water system to address risks and prevent Legionella growth reducing exposure to harmful bacteria [36].

5. Enhanced Cleaning, Disinfecting, and Maintenance Protocol

Establish an Enhanced Cleaning, Disinfecting, and Maintenance Protocol. NOTE: regular cleaning, disinfecting, and maintenance significantly reduces surface-to-person and person-to-person transmission of contagious diseases by removing microbial and viral pathogens from the environment [36].

6. Enhanced Green Purchasing Policy

Establish an Enhanced Green Purchasing Policy. NOTE: a Green Purchasing Policy can ensure that materials brought into the building conform to standards that preserve high IAQ and sustainability, contributing to enhanced respiratory and mental health [36].

2.2. Encourage Behavioral Change

This section offers a variety of tactics proven to motivate behavioral change and increase compliance with new norms and practices proven to effectively reduce contagious disease transmission [36].

The occupants' behavior indirectly impacts on the built environment and, therefore, fall under the scope of the review.

7. Surface Hygiene Stations

Establish a Plan for Surface Hygiene Stations. NOTE: surface hygiene stations placed in common areas enable regular disinfection of high-touch areas which supports the frequent removal of microbial and viral pathogens from the environment [36].

8. Personal Protective Equipment (PPE) Guidelines

Establish Personal Protective Equipment (PPE) Guidelines. NOTE: Personal Protective Equipment (PPE) Guidelines establish clear expectations for where and when PPE needs to be worn, increasing compliance and decreasing community spread of respiratory infections. For instance, the correct use of masks is described by experts as one of the best available defenses against infectious respiratory diseases [36].

9. Personal Protective Equipment (PPE) Provision Plan

Establish a Personal Protective Equipment (PPE) Provision Plan. NOTE: a Personal Protective Equipment (PPE) Provision Plan increases access to masks and other relevant PPE that comply with guidance from national, regional, and/or local public health authorities, improving compliance and reducing community spread of respiratory infections [36].

10. Hand Hygiene

Support Hand Hygiene. NOTE: a hand hygiene standard supports improved handwashing practices, reducing contagious disease transmission, increasing sense of safety and contributing to feelings of well-being. Currently, the majority of the population does not practice recommended hand hygiene practices, indicating the severe need for additional supports to adopt them broadly [36].

11. Health Promotion Signage

Provide Select Educational Health Promotion Signage. NOTE: educational health promotion signage provides effective prompts that increase awareness of new building policies and expectations

supporting improved compliance and reducing person-to-person spread of contagious diseases. Health promotion signage is a proven communication method and is essential for the successful implementation and adoption of new policies and the establishment of new norms within a community [36].

12. Specialized Health Programming and Services Plan

Establish a Specialized Health Programming and Services Plan. NOTE: a Specialized Health Programming and Services Plan provides consistent access to preventative healthcare services and stress support as well as programs targeting increased physical activity and nutrition, preventing disease morbidity [36].

13. Social Support Groups

Establish Social Support Groups. NOTE: social support groups provide a safe space to discuss challenges or celebrate achievements, contributing to increased social interaction and participation in available health programming [36].

2.3. Build Occupant Trust

This section focuses on policies and procedures to maximize trust in the built environment, increasing occupants' sense of safety and promoting mental health [36].

Company policies indirectly impact on the built environment and, therefore, fall under the scope of the review.

14. Contagious Disease Outbreak Preparedness Plan

Establish a Contagious Disease Outbreak Preparedness Plan. NOTE: a contagious Disease Outbreak Preparedness Plan strengthens pandemic response and ensures awareness of protocols minimizing uncertainty and supporting sustained occupant trust. Without a contagious Disease Outbreak Preparedness Plan, the likelihood of experiencing degradation of occupant trust and a failed response increases considerably in a time of crisis [36].

15. Business Continuity

Establish a Business Continuity Plan. NOTE: a business continuity plan establishes expectations in the event of a contagious disease outbreak and reduces uncertainty increasing preparation and occupant confidence [36].

16. Mental Health First Aid

Establish a Mental Health First Aid Responder Training Plan. NOTE: a mental health first aid responder training expands capacity to address proven increases in anxiety, stress, depression, substance use disorders, suicidality or self-harm, and abuse or neglect associated with contagious disease outbreaks and other crisis situations [36].

17. Viral Response Design Guidelines

Establish Viral Response Design Guidelines. NOTE: viral response design guidelines ensure that tactics aimed at supporting physical distancing and proper hygiene are in place and ready to implement in the event of a contagious disease outbreak, mitigating risk of person-to-person transmission [36].

18. Enhanced Stakeholder Collaboration Plan

Establish an Enhanced Stakeholder Collaboration Plan. NOTE: a stakeholder collaboration plan establishes a framework to engage and prioritize stakeholder concerns and insights, strengthening preparedness and response efficacy in the event of a contagious disease outbreak [36].

19. Communication Plan

Establish a Communication Plan. NOTE: a communication plan increases awareness of new policies and enhances transparency, contributing to enhanced trust and a strengthened relationship between operators and occupants. Strong communication practices improve compliance with new

policies, ensure access to all relevant information and also increase acceptance of the implemented standards [36].

20. Paid Sick Leave Policy

Establish a Paid Sick Leave Policy. NOTE: a paid sick leave policy ensures all employees are able to stay home when sick without fear of negative retribution or retaliation, increasing the likelihood that sick individuals do not go into work when contagious. This significantly reduces the transmission rate of contagious diseases at workplace [36].

21. Family Support Policy

Establish a Family Support Policy. NOTE: a family support policy ensures all employees are able to work with their employers to adjust their schedule as needed if they need to care for a family member due to the impacts of a contagious disease outbreak, promoting occupant trust and employee retention [36].

3. *LEED Safety First Pilot Credits*

1. Re-Enter Your Workspace

Promote best practice requirements in operations and human behavior. NOTE: create a re-occupancy assessment and requirements for an operations plan; create a management and operations plan; keep a daily journal with building management and occupants with all data transparent [37].

2. Cleaning and Disinfecting Your Space

Provide effective cleaning and disinfecting relative while minimizing adverse health impacts on cleaning personnel, building occupants, visitors and the environment. NOTE: create and implement policy and practices that focuses on a healthy environment. This includes the procurement of cleaning and disinfecting products, procedures and training for cleaning personnel, occupant education, and services that are within the project and site management's control [38].

3. Managing Indoor Air Quality during COVID-19

Promote precautionary best practices for managing air quality in buildings. NOTE: determine temporary adjustments to the ventilation approach that assume infected people will be in the building (e.g., increase total airflow supply and percentage of outdoor air, disable demand-control ventilation (DCV), improve central air filtration, use portable HEPA fan/filtration systems and UVGI). Recommendation is appropriate for the specific building, location, and season [39].

4. Building Water System Recommissioning

Reduce occupant exposure risks associated with degraded water quality in community and building water systems due to stagnant or low water use. NOTE: Develop and implement a water quality management plan for the building water system and all devices that use water, engage a qualified professional independent from the water utility to conduct the testing, communicate to building occupants the status of the building's water systems [40].

5. Pandemic Planning

Prepare for, control and mitigate the domestic spread of a pandemic. NOTE: Convene and facilitate an interdisciplinary team to identify risk and vulnerabilities to the health and assess the existing pandemic preparedness and response. Based on the capacity assessment and existing gaps, develop a comprehensive pandemic preparedness and response plan for the city or community, and provide public health preparedness and response training and guidance to stakeholders [41].

6. Social Equity in Pandemic Planning

Consider equity implications across all phases of the pandemic preparedness, planning and response process. NOTE: The local government or development authority must have in place a local equity officer responsible for building and ensuring equity into the structure of the emergency command and response system through plans, policies and procedures [42].

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