PANDEMIC PREPAREDNESS GUIDE FOR LABORATORIES

A guide to help laboratories keep playing their vital role during the next pandemic

SUSTAINABLE LABS CANADA
LABORATOIRES ÉCOLOGIQUES DU CANADA

October 2021

Dedicated to the memory of Philip James Wirdzek, Jr., founder and executive director of the International Institute for Sustainable Laboratories (I^2SL).

An idea is like a seed that grows into a tree

But it takes a Gardner to generate a grove

With each sprout and sprig, he breeds

He builds a treasure trove

With each single tree he nourishes

His green thumb labours long and hard

And as his garden grows and flourishes

It soon becomes an orchard

- *James A. Dykes, FSLCan,*
  Founding President of SLCan

Phil was truly the Master Gardner for I^2SL and SLCan, and is responsible for the growth of so many branches on this magnificent Sustainable Lab tree.

Pandemic Preparedness Guide for Laboratories
- A guide to help laboratories keep playing their vital role during the next pandemic.

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FOREWORDS

By failing to prepare, you are preparing to fail.

- Benjamin Franklin.

The outbreak of a new coronavirus was reported by the health authorities of China on 31 December 2019. The World Health Organization (WHO) became aware of this information and an epidemiological watch was activated. On 11 March 2020, concerned about both the alarming levels of spread and severity of the disease, the WHO Director-General declared that COVID-19 could be classified as a pandemic.

The journey of a year and a half has been a human experience that none of us will soon forget. Lives have been changed, many have lost loved ones or are still suffering from the effects of COVID-19 long after they have been declared cured. Businesses had to be closed overnight, some permanently. Studies show that distancing and containment measures have had significant impacts on people's mental health.

The world of laboratories has not escaped this. First, there was an initial reaction of generalized closure imposed by the authorities, with rare exceptions mainly for test labs, for obvious reasons. Then we saw a gradual, slow, and cautious reopening of the majority of research laboratories. Despite the urgency of the situation, it was an exciting time as resources were pooled to identify new practices to be put in place.

By their very nature as places where the environment is controlled against the backdrop of the need to ensure the safety of occupants and operations, our laboratories are in a privileged position. And also, what a moment of great science, when an unprecedented spirit of collaboration in research led to the development in a record time of vaccines that today give hope.

One year on and nothing is the same as before. At the same time, the arrival of the vaccines has brought an immense wave of hope to the population, to the point where some are already ready to turn the page and forget everything, at the risk of creating or amplifying a new wave through lack of patience. One might be led to believe that everything is over.

Just as one might think that publishing a pandemic response guide is now unnecessary, that the window of opportunity and relevance has closed and that soon everything will return to normal.

But this is not the case. Nothing must go back to the pre-pandemic situation. We need to change. We must prepare for the next time.

The previous H1N1 pandemic in 2009 provoked reflection and awareness of the dangers of a pandemic and the need to prepare, but since this pandemic turned out to be (fortunately) relatively mild, it did not have such a catastrophic impact on people's lives and few jurisdictions followed through and transformed their practices and activities. Even with the COVID-19 crisis having had such far-reaching consequences as we have experienced so far, one wonders whether the lessons will be learned and whether we will be better prepared next time.

For there will certainly be a next time. An article in the Journal of the Royal Society in 2014 noted that we were then seeing an increase in infectious disease outbreaks in humans. We also know that many zoonotic diseases (diseases transmitted to humans by insects, birds, rats, and other animals) remain unknown. At the June 2020 IPBES conference on biodiversity and pandemics, it was reported that there are about 1.7 million unknown viruses in mammals and birds, of which an estimated 631,000 to 827,000 have the potential to affect humans. The likelihood of a pandemic caused by zoonotic diseases in the near future should not be overlooked.

This is without taking into account the very real risks that are present within the laboratories themselves. The hypothesis that the origin of SARS-CoV-2 is linked to an incident in the Wuhan research laboratory is disputed by many and to date, the WHO's statements do not point in this direction. But we know, and this is part of their rationale, that many research laboratories possess and handle highly virulent pathogens, SARS-CoV-2 not being the most dangerous (this virus is classified as a Risk Group 3 Human Pathogen by Health Canada). Laboratories are complex instruments with many interlocking devices requiring precise operations. And they are manned and operated by humans. Despite the efforts made in their design, despite the existence of strict and demanding standards, despite the protocols and good practices put in place, it cannot be excluded that one day an incident could occur.

Our labs must therefore be prepared for a future pandemic, to avoid the worst, to remain operational, and to contribute in the effort to contain and a virus that we still don't know.

This guide is therefore LÉCan / SLCan's response not only to the present situation but also, and more importantly, the foundation for preparing for the next event. So that our laboratories are prepared and so that scientists can play their leading role when the world calls on their talents, in the hope of saving lives.

This guide should also be a reminder that ecology must be more and more at the heart of our concerns every day. Those little creatures mentioned above could be seen as vectors of disease, all this biodiversity is now being made sick by the pressure of human activities on the environment. The large predators are disappearing because their territory is shrinking and this is causing an imbalance in the rest of the species, including those most likely to carry these famous viruses that can make the bridge to humans. The solution is not to eliminate them, these animals are themselves a link in the essential biodiversity. A single little brown bat is capable of eating the equivalent of its weight in insects, i.e. about 600 grams per hour, in the space of a single night - how can you not love this insectivore! The solution lies in the regeneration of damaged ecosystems, which requires innovative and bold approaches to our built environment.

Even in times of pandemic, laboratories have an ethical obligation to be green. We invite all SLCan members and users of this document to make this their goal and mission.

DISCLAIMER

This document is not intended to provide codes or standards. This document does not supersede or negate the requirements for safe practices and procedures in laboratories, particularly in the case of biosafety laboratories licensed to handle pathogens. This document does not provide guidance specific to the direct handling of viruses or pathogens in a laboratory environment.

This document is intended for an informed public able to interpret and adapt its content to specific situations and needs, it does not constitute professional advice. The authors freely offered their expertise to raise awareness of the various aspects of managing laboratories and related facilities under the situations of pandemics. Neither SLCan nor any other party involved in the preparation of material contained in this publication warrants that the information contained is accurate or complete

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DOCUMENT OVERVIEW

This document is structured in two main sections. First at high level, the document describes what pandemics and infectious diseases are, understanding the issues at stake, how they come to exist, and their main transmission mechanisms. This first section will help set the place for understanding how diseases evolve, how they affect health, and the spread mechanisms that could be of interest for us in the world of laboratories. The second part of the document will explore how lab planners and operators can prepare for pandemics by reviewing three major aspects of lab operations: workforce, infrastructure, and procurement

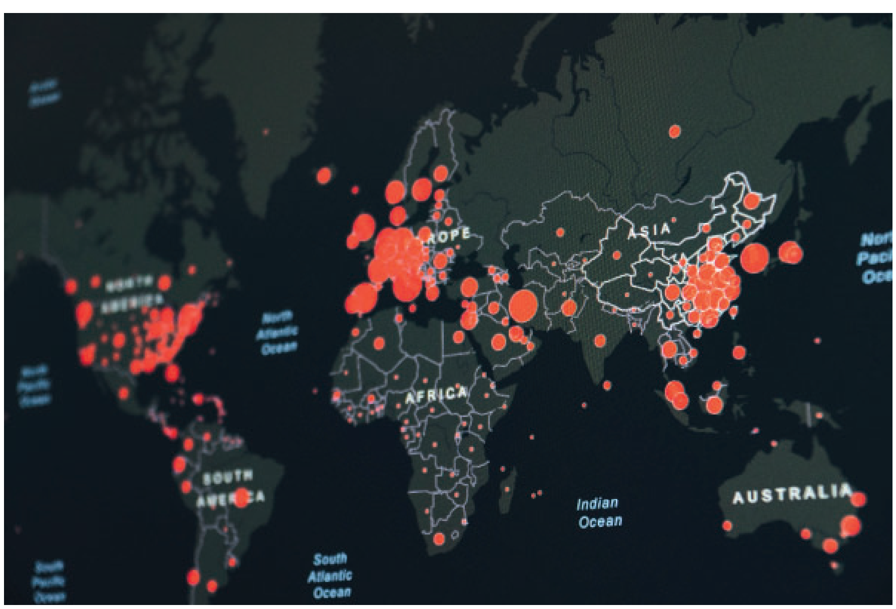
PART 1 – BRIEF INTRODUCTION TO PANDEMICS

The first use of the word pandemic is attributed to the Dutch-born English physician Gideon Harvey who uses it in the first chapter entitled *On the original, contagion, and frequency of consumptions* of his work *Morbus Anglicus* published in 1666 in London. In French, the word pandemic appears in the 1752 edition of the *Dictionnaire universel françois et latin*, also known as the *Dictionnaire de Trévoux*. The word Pandemic draws its origin in two Greek words, pan meaning “all” and demos meaning “people, population”. The word, therefore, refers to the extent of a disease, one that would span all the world and could affect all the population.

The word origin clearly means that it is a major epidemic, one of great scale, but it does not specify whether it is severe, explosive, or even new. For the World Health Organization, however, the novelty of the epidemic is of primary importance. According to the WHO, “a pandemic is defined as the worldwide spread of a new disease”.

The importance of the novelty aspect to the eye of the WHO might have to do with the role of this organization and the difficulty it is faced with when a new infectious disease spreads worldwide (or in a large region) from person to person before most people could develop immunity for lack of previous exposure to the disease of before any cure can be developed to help health carers with the tools they would need.

Novelty adds to the uncertainty in the case of a disease. Contrary to seasonal influenza which is also a disease that affects a large portion of the world population, vaccines and antiviral medications are not readily available as the pathogens are new, the transmission mechanism is still being investigated and the disease consequences on people’s health are unknown. Pandemic planning is therefore vital.



MONITORING, DECLARING, AND MEASURING PANDEMICS

Pandemics are public health emergency situations. Government agencies such as Health Canada or the Center for Disease Control (CDC) in the United States in conjunction with international organizations such as the United Nation's World Health Organization (WHO) are responsible for the surveillance and assessment of latent diseases. Various international agencies, governments, national health agencies, and laboratories have formed several global disease surveillance and response networks. These organizations are experts in the fields of virology and epidemiology and have developed surveillance and response mechanisms to monitor, investigate and warn the world of the emergence of a pandemic.

The WHO is an organization of the United Nations with an international presence. It coordinates a large network of partners and as such, is the leading source of information and the center of decisions when comes the time to call a pandemic. The WHO uses a series of six phases of pandemic alert to inform the world about an outbreak and the need to launch progressively more intense preparations and measures. The six-step pandemic alert scale is based on the geographic spread of a new virus to which people have little or no immunity, and not on its severity.

The WHO pandemic alert scale says a pandemic will be declared at phase 6 when it is clear such a virus is spreading in communities in countries in two different WHO regions. This is a warning system that advises on the spread of a virus. It does not address the severity of the disease.

Table 1 presents an outline of WHO's alert phases system:

TABLE 1 - WHO alert phases system

Phases 1 to 3 – Predominantly animal infections; few human infections:

- Phase 1: No reports of human infections from influenza viruses circulating naturally among animals and birds;
- Phase 2: Some infections in humans from influenza viruses in animals show the virus is a potential pandemic threat;
- Phase 3: Sporadic cases or small clusters of infection in people, but not enough to result in sustained human-to-human transmission.

Phase 4 – Sustained human-to-human transmission: The virus is spreading from person to person causing outbreaks at the level of communities, indicating an increased risk but not a certainty that it will turn into a pandemic.

Phases 5 and 6 – Widespread human infection/pandemic

- Phase 5: Human-to-human spread of the virus in at least two countries in one region. Most countries are not yet affected but a pandemic is imminent. Health authorities have little time left to finalize measures to deal with the outbreak.
- Phase 6: The virus is spreading in at least two regions, indicating a global pandemic is underway.

Assessment of the severity of an outbreak is important when planning for measures to be implemented. In 2007, the United States Department of Health and Human Services (HHS) introduced the pandemic severity index (PSI). Developed by the Centers for Disease Control and Prevention (CDC) and using the Case Fatality Rate (CFR) as its criterion, the PSI index ranges from 1 to 5, with Category 1 pandemics being most mild (equivalent to seasonal flu) and level 5 being reserved for the most severe "worst-case" scenario pandemics (such as the 1918 Spanish flu).

Table 2 presents the CDC Pandemic Severity Index:

TABLE 2 - CDC Pandemic Severity Index Chart

Category	Case fatality rate	Example(s)
1	Less than 0.1%	Seasonal flu and 2009 A(H1N1) pandemic
2	0.1–0.5%	1957 A(H2N2) and 1968 A(H3N2) pandemics
3	0.5–1.0%	
4	1.0–2.0%	COVID-19 (SARS-CoV-2) pandemic in Canada
5	2.0% or higher	1918 A(H1N1) influenza pandemic

As of September 30, 2021, the reported CFR in Canada stands at around 1,7% which would place COVID-19 at category 4 of the PSI scale.

Unfortunately, and as the current pandemic has made obvious in many regions, the CFR calculation has serious limitations as it relies heavily on each country's capacity (or willingness) to accurately measure and report cases and deaths. Deaths may lag several weeks behind cases, resulting in an underestimated CFR. Also, establishing the CFR for an entire population may obscure the view on impacts among sub-groups such as children, the elderly, those with pre-existing conditions, urban or country populations, and provinces. Public policies and political influences may also affect the accurate calculation of the CFR.

The CDC continued to further revise and upgrade its tools and in 2014 adopted the Pandemic Severity Assessment Framework (PSAF), an evaluation framework featuring six intervals (investigation, recognition initiation, acceleration, deceleration, and preparation) based on events occurring during the development and outbreak of a pandemic. To counter the limitations of the measurement of CFR alone, the PSAF rates the severity of a disease outbreak according to two measures: transmissibility and clinical severity.

The CDC framework includes additional tools such as the Influenza Risk Assessment Tool (IRAT), a tool used to evaluate influenza A viruses that are not circulation in the human population but that shows a potential pandemic risk and likelihood that these viruses acquire the ability to spread in humans.

The WHO has also developed a severity assessment tool that uses three indicators to measure the pandemic severity: transmissibility of the virus among the population, the seriousness of the resulting disease when people get sick, and impact on healthcare systems and the society in general.

BRIEF OVERVIEW OF PATHOGENS AND VIRUSES

The human body contains trillions of microorganisms — outnumbering human cells by 10 to 1. Because of their small size, however, microorganisms make up only about 1 to 3 percent of the body's mass (in an 80-kilogram adult, this represents 800 grams to 2.4 kilograms of microorganisms). They usually don't do us any harm; in fact, they play a vital role in human health.

But under certain conditions, some organisms may cause disease, in which case these are called pathogens. A pathogen is a microorganism, nucleic acid, or protein capable of causing disease or infection in humans and/or animals. Examples include bacteria, viruses, fungi, parasites, prions, and toxins. Most human infections are caused by bacteria and/or viruses. Some infectious diseases can be passed from person to person. Some are transmitted by insects or other animals. And some could be transmitted by consuming contaminated food or water or by being exposed to organisms in the environment.

To cause disease, a pathogen must successfully achieve four steps or stages of pathogenesis: exposure (contact), adhesion (colonization), invasion, and infection. The pathogen must be able to gain entry to the host, travel to the location (human cells) where it can establish an infection, evade or overcome the host's immune response, and cause damage (i.e., disease) to the host.

The ability of a microbial agent to cause disease is called pathogenicity, and the degree to which an organism is pathogenic is called virulence. Highly virulent pathogens will almost always lead to a disease state when introduced to the body, and some may even cause multi-organ and body system failure in healthy individuals. Less virulent pathogens may cause an initial infection, but may not always cause severe illness. Pathogens with low virulence would more likely result in mild signs and symptoms of disease, such as low-grade fever, headache, or muscle aches. Some individuals might even be asymptomatic.

Viruses are microscopic strands of ribonucleic acid (RNA) or deoxyribonucleic acid (DNA) wrapped in proteins that can latch on and infect a host. Once an individual is infected with a virus, it can effectively use its replicating machinery of the host cells to produce copies of its genetic material. Viruses are classified by their replication strategy and by the organization of their genome (i.e., double-stranded deoxyribonucleic acid [DNA], single-stranded DNA, etc.).

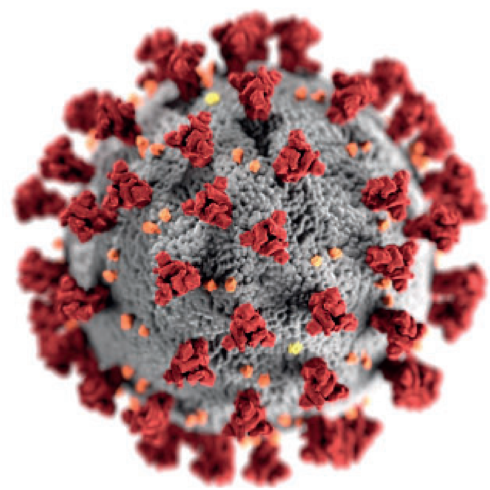
A viral protein is an antigen specified by the viral genome during replication in the host cells. A virus antigen is a toxin or other substance given off by a virus that causes an immune response in its host. The human immune system produces antibodies in response to the presence of antigens.

Viruses can produce a latent (e.g., delay of months or years between infection and appearance of symptoms) or persistent infection (e.g., the host remains alive while shedding the virus over a period of time). Some viruses may alter the host genome by integrating (e.g., integration of a retrovirus into the host genome). Examples of pathogenic viruses include influenza, human immunodeficiency virus (HIV), herpes, rabies, and Ebola (CBH, 2nd Ed., 2015).

All viruses change over time and continuously evolve as mistakes (genetic mutations) occur during the replication of the genome. The term variant is used to describe a subtype of a microorganism that is genetically distinct from the main strain but not sufficiently different to be termed a distinct strain. Many variants will be of particular importance due to their potential for increased transmissibility, increased virulence, or reduced effectiveness of vaccines against them. The CDC classifies virus variants in four groups based on their attributes and prevalence: Variants Being Monitored (VBM), Variant of Interest (VOI), Variant of Concern (VOC), and Variant of High Consequence (VOHC).

Several national and international health organizations such as the CDC or the Canadian COVID Genomics Network (CanCOGeN) use some or all of the following criteria to assess variants:

- Increased transmissibility
- Increased morbidity
- Increased mortality
- Increased risk of long term impacts
- Ability to evade detection by diagnostic tests
- Decreased susceptibility to antiviral drugs (if and when such drugs are available)
- Decreased susceptibility to neutralizing antibodies, either therapeutic (e.g., convalescent plasma or monoclonal antibodies) or in laboratory experiments
- Ability to evade natural immunity (e.g., causing reinfections)
- Ability to infect vaccinated individuals
- Increased risk of particular conditions such as multisystem inflammatory syndrome or long-haul COVID.
- Increased affinity for particular demographic or clinical groups, such as children or immunocompromised individuals.



EXPOSURE TO AND TRANSMISSION OF INFECTIOUS DISEASES

As mentioned earlier, pandemics are declared when an infectious disease is spreading in large populations. Diseases that do not feature high transmissibility might not evolve into pandemics. Understanding the transmission mechanism is of particular interest to lab operators and planers as this will need to be addressed not only during an outbreak but also well before in a planning stage.

For a pathogen to infect a person, it needs to be able to gain access into host tissue. Major portal of entry includes the skin, mucous membranes, or by injection. Mucosal surfaces are the most important portals of entry for pathogens; these include the mucous membranes of the respiratory tract, the gastrointestinal tract, and the genitourinary tract. Although most mucosal surfaces are in the interior of the body, some are contiguous with the external skin at various body openings, including the eyes, nose, mouth, urethra, and sphincter. Pathogens can also enter through a breach in the protective barriers of the skin and mucous membranes (wounds, insect or animal bites, needles).

Multiple factors must be considered as they can influence the probability of transmission of infectious diseases and must be addressed when planning for pandemic preparedness in laboratories. These factors include, but are not limited to:

- The number and proximity of infected to susceptible individuals;
- The emission and propagation of droplets and aerosols;
- The contact of direct and indirect pathways;
- Environmental parameters, such as temperature and humidity;
- The ventilation within a building;
- The mitigation measures from personal protection equipment (PPE); and
- The Health status and the inherent vulnerability of the exposed party.

PART 2 –PANDEMIC PLANNING IN LABORATORIES

Laboratories are certainly the most resilient space type when it comes to mitigating pathogenic transmission. Labs are working spaces specifically thought of and operated with increased health security measures in mind. Infrastructure and procedures are already addressing a large spectrum of risks; laboratory ventilation requires 100% fresh air and is usually the primary means of ensuring safe levels of contaminants in the air. Personnel is trained regarding manipulation, cleanliness, and use of personal protective equipment. Protocols exist on how to handle and dispose of contaminated material.

With all this already in place, the probability of new infectious diseases spreading within the facility could be assessed as being low, a pandemic seen as “just another risk” to add to a somewhat long and intricate list of threats to be considered in daily operations. But it would be a mistake not to address pandemics with more consideration as these events are caused by new and novel pathogens and will impact the whole society simultaneously. Labs can not operate in isolation and therefore, they must prepare.

And on top of that, a large portion of lab facilities in Canada and the United States have a direct relation to the health and hospital sector. Labs will be at the frontline of everything needed urgently during a pandemic, from the basic understanding of the pathogen and disease to diagnostic and testing of cases and to the development of vaccines and other antiviral drugs that will be needed to save people and contain the outbreak. In a time of crisis, labs will play a key role and must be ready to operate in this disruptive environment.

Pandemics affect society as a whole and have far outreaching impacts. They usually have a prolonged duration that could last many months or even several years as is the case with the current COVID-19 pandemic. This is partly because the virus and the disease are not yet well known and that vaccines and other drugs are not yet developed to control the outbreak. This duration aspect of pandemics is a key element to be considered in planning. Another aspect will be the evolution of the situation during the outbreak as knowledge and data become available. Again, COVID-19 provided some examples of such situations where information and health directives needed to be revised and adapted sometimes every week as a result of evolving knowledge and environmental factors. Adaptability, flexibility, and resilience will be key to this exercise.

For labs, we can regroup the challenges to be overcome in three categories for which many aspects could be considered: workforce challenges, infrastructure challenges, and procurement challenges. These three main categories will each be subdivided into various subcategories. Obviously, all of these considerations are linked together and the whole of them must be addressed simultaneously for a pandemic plan to work as intended.

Pandemic planning is not only required for existing and running labs but shall also be addressed as one component of future lab planning and we will discuss some aspects of programming and design approaches for future labs throughout this section.

LAB WORKFORCE CONSIDERATIONS

Pandemics impact human health and will therefore have an impact on the lab workforce. Protecting and safeguarding lab personnel has to be the main focus of lab pandemic planners. People could become infected and become severely ill, or even die. Daycare and school closures will force some to stay home which could impact operations for those jobs that could not be transferred to working remotely. Some could have to isolate following exposure or to take care of infected family members. The government-imposed measures could affect or even shut down part of operations.

ASSESSMENT OF ROLES AND RESPONSIBILITIES

The first step in pandemic risk assessment for operators will be to map the role and responsibilities, and create and maintain contact lists for anyone closely or even remotely related to their operations, from lab technicians themselves to operation, custodial, suppliers, and outside service providers.

Both Exposure Risk and Strategic Importance of each role and task must be evaluated and mitigation strategies are developed in case the associated personnel become unable to work. Lab personnel will likely have a very high potential of exposure if they are involved or exposed during medical, post-mortem, or diagnostic procedures. Various tasks might need minimum staffing to be accomplished safely or in the correct sequence.

Labs should conceive staffing plans to manage varying degrees of pandemic risks, severity, and duration. Strategies for knowledge transfer and sharing shall exist for very specialized and essential tasks, equipment, and material in the lab so that any temporary leave could be compensated. Training for current and future staff must include cross-training for personnel to be able to be transferred to other tasks within the lab if needed.

TRAINING

Training is a critical element of any integrated lab and biosafety management program, as it provides the understanding, technical knowledge, and tools that the individuals need to practice and improve safe laboratory practices. Training should include but is not limited to, laboratory safety practices, biosafety, chemical safety, bloodborne pathogens, emergency response, such as spills, and hazardous waste operations. Site-specific training should also be provided for any specific procedures and processes, such as building emergency response plans.

COMMUNICATIONS

Efficient and clear messaging and communication is essential during a pandemic. Rapidly changing situations, rumours, and misrepresentations encountered during pandemic conditions may foster uncertainty. If not already in place, lab operators would benefit from setting up a communication group to manage the flow of information that needs to circulate during events. Pandemics are stressful events and the last thing managers want is rumors and false or inaccurate information among staff and users of the facility. New procedures and protocols will be implemented and the communication team has the responsibility to get the message to everyone concerned.

Also, this group shall monitor and track pandemic alert information from WHO, CDC, and Health Canada and inform upper management of any signals or warnings published by these organizations as soon as they become available.

The communication group will also be responsible for posting information and messages at relevant locations throughout the building, mainly at entrances, lobby areas, elevators, and public communication boards. There might also be the need to set up a pandemic-specific web page for personnel and users to get the most current information, fill logbooks, and report outbreaks.

BASIC PREVENTION IN LAB

The first measure to protect staff is to limit and control exposure to the pathogen. At the outbreak of a pandemic, a prudent approach will be to implement all mitigation methods until a better understanding of the transmission process is known and measures could be focused on the specific mechanisms that are at play. Also, until diagnosis and testing are fully put in place, caution shall be exercised when operating the lab.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) refers to any devices and clothing designed to minimize the risk of exposure to chemical, biological, radiological, physical, electrical, mechanical, or other hazards.

PPE is considered a safety mitigation strategy that acts as the last line of defense to protect individuals by providing a barrier between the individual and the hazardous material. PPE should be the last form of control considered as it provides an additional barrier to protect against exposure to hazardous materials in the event of a failure in the administrative or engineering controls. PPE does not reduce the hazard itself, nor does it guarantee permanent or total protection.

PPE can be classified into five categories: mouth and respiratory protection; eye and face protection; hand protection; body protection; and hearing protection. Refer to Annex A for more details on the first four types of PPE that are the most relevant for pandemic situations, their use, and storage. PPE should only be used as a short-term measure before other safety controls are implemented, where other controls are not available or adequate, during activities such as maintenance, clean up, and repair where pre-contact controls are not feasible or effective, and/or during emergency situations.

Once the need for PPE has been established, the next task is to select the proper type. Two criteria need to be determined: the degree of protection required and appropriateness of the equipment to the situation, including the practicality of the equipment being used and kept in good repair. All personal protective equipment should be safely designed and constructed and should be maintained clean and reliable.

Individuals should always wear PPE in situations where an exposure can occur with hazardous materials. Inspect the PPE for damage before use and replace any damaged or contaminated items. Follow all normal rules and procedures such as removing the PPE before leaving the work area, decontaminate, or clean your reusable PPE after use and store appropriately. Appropriately dispose of non-reusable PPE after use. Ensure to wash hands with soap and water for 20 seconds after removing PPE.

PPE requirements are legislated on the provincial, territorial, and federal levels, and are incorporated into a relevant occupational health and safety program. The employer is responsible for ensuring that appropriate PPE is available, properly maintained, used, and that personnel is appropriately trained on how to use it.

Pandemic situations will likely put a strain on the procurement, see the procurement chapter of the guide for more on this aspect.

Annex A of this document provides information on PPE use, storage requirements and reuse potential.

PERSONAL HYGIENE

Personal hygiene is critical during a pandemic. In addition to standard good laboratory practices, the following measures might be required to be implemented following public health authorities' recommendations: practice physical distancing at work, avoid physical contact such as handshakes, remain at least two meters (six feet) apart from others, do not leave assigned workspaces for visits throughout the facility – your approved access is only for your work area.

Follow proper hand hygiene and respiratory etiquette, including proper and frequent washing of hands (back of hands, palms, nails, etc.) with soap

and water. The best cleaning agent for washing hands –over alcohol-based formulas– and the most ecological is soap.

Scrub for a minimum of 20 seconds. Use hand sanitizer when hands are not visibly dirty and handwashing is not available. Only use hand sanitizer approved by Health Canada (look for DIN or NPN on the bottle). Avoid touching your face, mouth, nose, and eyes as these are entryways for viruses and pathogens. Cover your coughs and sneezes, then wash hands with soap and water. And wash hands after touching communal surfaces, computers, doorknobs, pens, and such. Avoid sharing office supplies, if not feasible thoroughly disinfect between each person's use.

OTHER HYGIENE MEASURES

In addition to the COVID-19 specific conditions listed above, the following are general hygiene practices that shall be followed by all individuals working in laboratory environments:

- Follow laboratory access procedures and PPE requirements;
- Do not smoke (includes e-cigarettes), drink, chew gum, eat or store food or drinks in laboratories including those where hazardous materials are handled or stored;
- Avoid contacting yourself with contaminated hands;
- Wash hands regularly after removing PPE and before leaving the laboratory, and before eating, drinking, smoking, or going to the washroom. Use soap and water and wash for a minimum of 20 seconds;
- Practice good housekeeping - regularly wash/ decontaminate work surfaces;
- Do not wear laboratory coats or protective clothing outside laboratory areas;
- Ensure you clean up completely and store materials before leaving the lab;
- Remove and clean contaminated clothing before wearing it again, or dispose of it following your lab's waste disposal procedures;
- Immediately report to your supervisor if you have been exposed to hazardous materials, or if you are experiencing adverse medical symptoms that may have resulted from work activities in the laboratory.
- To prevent the spread of infectious diseases, it is mandatory that all lab users and visitors self-monitor for the development of symptoms. Screening and monitoring checklist shall be developed, made available, and filled out by lab personnel.

WORK SHIFTS AND SCHEDULE CHANGES

Reducing the workforce to a minimum level ensuring proper delivery of work safely will reduce risks of transmission. Considerations shall be given to establishing a flexible schedule, or accommodate multiple work shifts (day, evening, night, weekend). Authorities might impose curfews during a certain time during the day or the night which might render this approach unpracticable.

Such approaches shall be well studied for their whole impact as they would result in an increased need for housekeeping, security and equipment use. For instance, make sure to stop any unoccupied period ventilation programs that would interfere with the work shifts added that were not part of the design parameters.

REMOTE WORK

In a pandemic, one key element to consider to contain spread of the pathogen is implementing remote work whenever this is possible. A plan must be developed beforehand to identify which tasks and jobs can be moved from the lab areas. Obviously, some lab manipulations could not be performed remotely, nor would be any animal facility care and maintenance. But all administrative and clerical work should get careful consideration toward implementing virtual work measures. This will need to be carefully planned with IT and the lab manager or lab management.

Increased IT demand will require additional support and maintenance for both the in-lab infrastructure but also for individual at-home workstations. IT support will play an integral role in the lab business continuity plan and shall be sufficiently staffed. Security software might need to be installed on personal laptops and computers before allowing connections to the network.

Refer also to the "Information Technologies" section of the Procurement chapter of this paper for other IT considerations.

AUTOMATION AND ROBOTICS

Automation, and lab robotics. are gaining ground for repetitive or dangerous tasks. Analytical labs already use continuous sampling devices. The cost of such equipment is sometimes prohibitive and many lab procedures are not well suited for automation. Development in this field is accelerating and the possibility to have more robots in labs in the future needs to be considered.

LAB INFRASTRUCTURE CONSIDERATIONS

Laboratory infrastructure is expected to be robust and efficient, but the novelty brought to processes and operating parameters by the outbreak of a pandemic can put pressure on systems not designed for change, adaptation, or resilience from the beginning. Some changes introduced with the good intention of protecting people health can have a negative results to occupiers of the space. Each change to conditions in which buildings and systems operate could lead to unwanted consequences if not well planned.

This section will focus on ideas, strategies, and concepts that would likely improve a lab space, existing or new, to be better prepared for pandemic events.

ADAPTABLE LAB

A well-designed lab should be able to be modified to answer pandemic security issues and good hygiene practices. Labs could require reconfiguration of parts or of the whole room to adapt to new pandemic-oriented procedures, or to accommodate physical distancing measures.

Flexibility of labs will be beneficial for some areas and might not be appropriate for others. Planners and operators must assess where reconfigurable benching would be beneficial without falling to the temptation to have everything reconfigurable if not necessary.

FLOW PATTERNS

Flow patterns in laboratories must be conceived to avoid or minimize occurrences of lab users crossing paths with others. Dead-ends should be avoided and if not feasible at the moment, allowing reconfiguration of benches to open new circulation path shall be made possible. A clear, ideally one-way workflow between stations shall be established to minimize circulation and to accommodate for physical distancing.

HAND HYGIENE AND PPE STATIONS

Biological labs, especially those that are designed from BSL2 and above according to Health Canada Biosafety Standards and Guidelines, have to provide hand washing stations at all entry and exit points. As a good practice in preparation for pandemics, all other lab types should implement handwashing stations at lab entrances, if it's not already the case,. These stations shall ideally feature a touchless faucet and paper, plus a PPE / gowning station with enough storage capacity to hold additional material.

VENTILATION

Ventilation is one of the primary safety systems of a laboratory and in the event of a pandemic, proper understanding and maintenance of these systems will be central to maintain operations and prevent possible airborne transmission. Early in the SARS-CoV-2 pandemic, the laboratory environment was considered low risk for aerosol transmission because these facilities are already designed with the safety of occupants as a key performance indicator; typically, through the use of 100% outside air (i.e., no recirculation) supply systems, higher air change rates, and exhaust systems designed to minimize re-entrainment of contaminated air.

However, these same systems provide unique operating conditions that require distinct mitigation strategies to minimize the risk of transmission of aerosolized particles. Several recommended mitigation strategies that may be prudent for other building types should not be employed in a lab environment because they may adversely impact the airflow patterns within the lab and/or the performance of existing containment devices. This is the case with translucent screens such as those that have been recommended in commerce during the SARS-CoV-2 pandemic; they might interfere with airflow patterns in labs that are designed to protect occupants.

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) set up the Epidemic Task Force (ETF) to provide its members and authorities with insights and recommendations on the proper measures to be implemented during this specific pandemic. ASHRAE ETF's Laboratory Subcommittee has published its Guidance Document on November 12, 2020, to address the mitigation strategies that are unique to the laboratory environment and to define those strategies that may apply to non-lab environments that should not be implemented within a laboratory or to its HVAC systems.

Please refer to the ASHRAE's Guidance Document and consult qualified professional advice before implementing changes to any of the air handling and ventilation systems within a laboratory.

HUMIDIFICATION

Although optimal relative humidity levels for the purpose of infection control continue to be an area of research, ASHRAE ET Lab Guidance Document recommends maintaining the space relative humidity between 40% and 60% RH when not in conflict with experiments or equipment operation. Laboratories typically have temperature and humidity requirements that are not only for human comfort but also for maintaining consistency in experiments and or processes.

Canadian laboratories are faced with special concerns when dealing with such relative humidity levels in a northern climate. Unless the lab building envelope is designed to account for such RH levels, any change or increase in humidity levels needs to be reviewed with architects, engineers, and envelope consultants before any change to avoid condensation during the heating season and eventual formation of mold and other degradation. Careful consideration is to be given to this situation. Future laboratories shall consider implementing high-performance envelope systems to cope with higher RH demands.

LAB CLEANING AND DISINFECTION

During a pandemic, normal lab cleaning and disinfection might need to be increased due to the potential transmission of pathogens from surfaces. Some viruses can survive for several days on different surfaces and objects, and therefore laboratories must implement enhanced environmental cleaning to prevent transmission and exposure. Users shall be made responsible for this cleaning and all completed disinfection practices must be documented using a disinfection log posted in the laboratory/work area.

Sharing of material and workstations shall be avoided whenever possible. At a minimum, high touch surfaces in the area must be disinfected at the end of each day, or the end of the work procedure, and before the space is used by a different group or user. This will be of particular importance in multi-users labs. In case of an outbreak, complete disinfection of the space and equipment will need to be performed.

Common disinfectants will usually be sufficient to kill most viruses. These include bleach solutions, quaternary ammonium (QUAT), alcohol (70%), and hydrogen peroxide. Some disinfectants will have an 8-digit Drug Identification Number (DIN). These products are approved for use by Health Canada and must be used according to the manufacturer's directions. Wear the recommended PPE including gloves while using disinfectants. After cleaning, remove and dispose of gloves and/or immediately wash hands.

Certain equipment may be damaged by spraying disinfectants directly onto components or by harsher disinfectants such as bleach. This includes not only computer keyboards and mice but also key-style equipment touchpads, on/off switches, power tools, and other research equipment that need manipulation during operation. If you have approved quaternary-ammonium (QUAT) disinfectant or 70% ethanol wipes, use them for these more delicate tasks. If you do not have disinfectant wipes, these items can be disinfected by soaking a dry wipe or clean soft cloth in the disinfectant until it is wet but not quite dripping, and then using it to wipe the keyboard/switch/etc., being careful to avoid getting liquid into any openings. The surface should be visibly wet after you wipe it, and the disinfectant should be left to evaporate from the surface. In any case, check with the manufacturer or product manual for specific instructions on cleaning and disinfecting specialized equipment.

STORAGE OF ALCOHOL-BASED HAND SANITIZER

As discussed in the workforce section above, people will require frequent hand washing and sanitation during a pandemic. One item that could easily be overlooked is the safe storage of hand sanitizer. Alcohol-Based Hand Rub (ABHR) is an alcohol-containing preparation designed for application to the hands for anti-micro bacterial or other medicinal purposes and containing ethanol or isopropanol in an amount ranging from 70-95 percent by volume. ABHRs are typically identified as Class 1B or 1C as per NFPA 30 Flammable and Combustible Liquids Code depending on alcohol concentration.

The quantity of ABHR on the premises will need to be considered in conjunction with other chemicals of this class in the lab space, and some laboratories are already stocking large quantities of such material for their research and experiment needs. Changes in quantities of flammable liquids might result in a change of the fire classification of the space or lab unit, which in turn would require physical changes to building systems and construction. These need to be carefully planned.

The National Fire Prevention Code and other Provincial or municipal bylaws require owners to maintain a chemical product registry, which will need to take into account additional storage of flammable products in planning for a pandemic. NFPA 30 states the maximum allowable quantity per control area (spaces within a building where quantities of hazardous materials not exceeding certain parameters) and allows for an increase to these quantities if a building is equipped with an approved automatic sprinkler system and/or when hazardous material is stored in an approved storage cabinet.

PHYSICAL SECURITY

Security involves safeguarding and protecting facilities and personnel. During a pandemic, the level of uncertainty, stress, and fear in the population might increase risks or even generate unrest in the population. Security concerns are particularly acute for lab facilities. Laboratories could be vulnerable to a variety of threats and lab operators will need to increase security levels to deal with the risk of vandalism or theft.

Laboratories shall also assess how workforce reduction might affect the security of its operations. Some activities will require minimum staff and will not be able to be performed unless personnel is reassigned. Bringing new staff to certain areas or to perform tasks for which they have not been trained could result in higher risk.

Controlled access to lab areas must still be restricted to authorized personnel, management of access rights will require careful coordination between security personnel and lab managers. New access protocols might need to be implemented as part of pandemic response management. Security staff may have to keep entry logbooks and instigate new entry procedures (such as vaccine passport validity verification or temperature reading. These activities will require space before the entrance to the lab facility and shall be planned.

PLANNING FOR RESILIENCE

In May of 2021, the International Institute for Sustainable Labs (I^{2}SL) published the Laboratory Resilience Guide. From this work, we learn that resilience has emerged as a key concept in a world marked by evolving disruptors and increasing uncertainty. Resilience speaks to the ability to maintain continuity in the face of ongoing shocks and stressors. A transformational approach to resilience includes the ability to thrive amid uncertainty and change, rather than simply adapting. Pandemic preparedness and planning shall therefore be part of resilience planning, with an approach to maintain continuity even when coping with uncertain and undefined disruptive events such as a pandemic.

LAB PROCUREMENT CONSIDERATIONS

Procurement of goods and services will take careful planning and management during a pandemic. Labs rely and depend on large quantities and a great variety of goods to operate. Pandemics are long-time events and will disrupt the whole society, making it more difficult to obtain all material needed for regular operations. The following section addresses some aspects of supply chains that are most relevant for laboratories.

SUPPLIERS PREPAREDNESS AND SUPPLY CHAIN FAILURE MITIGATION

Pandemics could disrupt a supplier's capability to provide goods or services. Laboratories rely on many suppliers that provide material goods (such as chemicals, PPE, lab consumables, etc.) as well as service providers (waste collection, equipment maintenance, etc.). Proper preparation for a pandemic should start by identifying services and supplies that are vital to the lab operations, assess the procurement delay (if any) that can be tolerated before the lab gets delivery of ordered goods, and evaluate its storage capacity. List all critical suppliers and equipment service that needs to be maintained.

Strategies should be considered to minimize the risk associated with supply chain disruptions of all goods and most particularly for those that will have been deemed essential or on a short supply schedule. A first step would be to determine if good and service suppliers have themselves set up a pandemic response program to ensure a constant flow of products and services, ensuring they could still operate during that time. Diversification of supply sources focusing on getting local ones would reduce the risk associated with having a sole provider that could either become inoperant during a pandemic, be faced with a surge in demand, or be subject to foreign governments' decisions to limit or shut down exportations.

Negotiate service contracts for equipment and service levels agreements on key material and equipment that would ensure the lab gets a certain level of performance during pandemics. Consider establishing priority arrangements with main vendors and suppliers to help meet needs and expectations.

INVENTORY MANAGEMENT

Stockpiling key material or hard to get replacement pieces would also be a good strategy to put in place.

If a lab pandemic strategy includes some kind of storage or stockpiling of goods, a strategy to organize and keep track of the inventory will need to be implemented and maintained. A significant number of lab consumables and chemicals that come with a best before date or short shelf life and a stock rotation process (were previously purchased units in inventory so they are used before the newer ones) will be required to avoid or mitigate stock losses caused by expiration.

Labs shall be careful in their preparation plan if they intend to increase the storage of chemicals on the premises as building and fire codes govern the quantity (volume or weight) of chemicals a given space can contain. Full assessment of quantities, container size and type, and fire characteristics of the lab shall be performed before deciding on additional chemical storage capacity.

Also, some activities might be downsized or even suspended for an extended period during a pandemic without compromising on other essential lab activities. Procurement and inventory management must be able to cope with the evolving situation and not only plan for an increase in demand but also a reduction.

WASTE MANAGEMENT

As much as other service providers could experience delays or a breach of services, Waste Collection could also face disruption and have severe consequences for lab operations. Soiled and contaminated material could need in-house autoclaving or require long-term on-site storage for many days or a few weeks. Handling and storage of waste will require sufficient and properly designed spaces.

PPE PROCUREMENT SPECIFICS

In pandemic situations, laboratories will be faced with specific challenges with personnel protective equipment (PPE). One key aspect to consider is that labs will likely require the same type of PPE as will hospitals and other care providers will do. A Health crisis will put pressure on the manufacturers and distributors of such equipment that could likely lead to shortage or delay in acquisition for an extended period. Strategies must therefore be implemented in advance to acquire, store and manage inventory, as some PPE might feature expiration dates.

INFORMATION TECHNOLOGIES

Information technologies play a vital role in most contemporary laboratories. Pandemics will bring new and higher demands on the IT infrastructure since new remote work models are being considered to help stop the transmission of infectious diseases and remote monitoring of processes and experiments.

Research or testing activities directly related to the pandemic will likely require the safe exchange of information allowing for privacy to be maintained. Voice and video communication are also essential; sufficient and reliable bandwidth capacity needs to be available. Support for remote working staff must be provided, often outside regular business hours.

Pandemics might also be a time when the security of IT infrastructure gets tested by hackers or even foreign actors in case of laboratories involved in the research of a cure, or with any sensitive operations. There will be new and untested systems that will connect to the network and controlling traffic and access rights might get overwhelming.

A pandemic will see an increase in IT equipment demand and there will be difficult to acquire technology solutions from the beginning of the outbreak and probably for an extended time. Storage capacity and backup capabilities shall be assessed and future needs are evaluated in advance to allow for IT team to implement solutions before an outbreak.

See also “Remote Work” section in the “Lab Workforce Considerations” chapter for other considerations concerning IT.

ALTERNATIVE AND SUSTAINABLE STRATEGIES

Planning for a pandemic might be a good time to review lab processes and assess if everything that is currently used or planned to be used in the lab is necessary if it could be replaced with alternatives or even discarded (do you really need this?).

Reuse of material could also be a strategy during a pandemic or even before. Such strategies will need to be carefully planned to ensure that reused material is safe and equivalent to new. If material needs to be cleaned or sterilized, a review of cleaning procedures including an evaluation on chemical consumption might inform the need for the lab to acquire additional material to allocate for this increased demand.

ANNEX A – PERSONAL PROTECTIVE EQUIPMENT

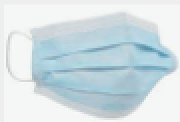
TABLE A.1 – HAND PROTECTION

Type/Use	Storage	Reuse/Extended Use

Disposable Gloves (e.g., nitrile, vinyl)

Note: Latex gloves are not recommended as they can cause allergy sensitization.
• Protects hands when working with certain hazardous materials
• Inspect gloves for holes, cracks, and other damage prior to each use
• Remove all rings prior to putting on gloves
• Change gloves if they develop holes, cracks, or any other damage
• Avoid touching face while wearing
• Avoid touching unnecessary surfaces while wearing
• Ensure gloves are removed/replaced or sanitized between activities to prevent contamination
• If doubled-gloved, remove and dispose of outer glove as required and sanitize inner glove with an appropriate disinfectant or alcohol-based hand sanitizer
• Wash hands after removal of gloves with spa and water for 20 sec.
	• Disinfect gloves before removal and storage
	• Ensure gloves are dry before they are stored
	• Store in a clean, labeled, container or bag
		• Clean, non-contaminated gloves can be reused and worn extended periods of time if:
		  o they are clean,
		  o not contaminated, and
		  o are not degrading (swelling, cracking, shrinking, or discolouration.
		• Reuse of disposable gloves is most feasible if thicker gloves (>6 mil) are used
		• Can decontaminate gloves with an appropriate disinfectant or alcohol-based hand sanitizer between activities
		• Grossly contaminated gloves must be disposed of in a hazardous waste container
		• Used, but non-contaminated gloves should be disposed of in the garbage
		• Monitor gloves routinely for signs of wear (including tears and holes) and replace as required
		• If doubled-gloved, remove and dispose of outer glove as required and sanitize inner glove with an appropriate disinfectant or alcohol-based hand sanitizer

TABLE A.2 – MOUTH AND RESPIRATORY PROTECTION

Type/Use	Storage	Reuse/Extended Use
Procedure/Surgical Mask/ Dust Mask  • Protects the face from splashes, droplets, and spit • Does not provide respiratory protection from small particles, such as viruses • Before and after use, inspect for any contamination, tears, rips, holes, elastic/straps ripped/stretched, and other damage • Ensure mouth and nose are covered • No fit testing is required • When donning and doffing, hold mask by the straps to prevent contamination • Ensure hands are clean or use a pair of clean gloves when donning a used mask. Always clean hands after donning a used mask.	• Masks can be stored for reuse in a clean, breathable, labeled container or bag, or hung by the straps in a dust-free, low traffic location until the next use • Store masks so that they do not touch each other • If using a reusable container or bag for storage, ensure it is disposed of or disinfected regularly	• Reuse and extended use of disposable masks is appropriate, unless contaminated or degraded • In circumstances where there is a high risk of the mask becoming contaminated, workers can wear a face shield over the mask • When donning and doffing, hold mask by the straps to prevent contamination • Avoid touching the inside of the mask • Ensure hands are clean or use a pair of clean gloves when donning a used mask. Always clean hands after donning a used mask.
Respirator (e.g., N95) (Disposable)  • Fit testing is required before first use and biennially afterwards to ensure respiratory protection • Before and after use, inspect for any contamination, tears, rips, holes, elastic/straps ripped/stretched, and other damage • Always perform a seal check to ensure respiratory protection When donning and doffing, hold	• Masks can be stored for reuse in a clean, breathable, labeled container or bag, or hung by the straps in a dust-free low, traffic location until the next use • Store respirators so that they do not touch each other • If using a reusable container or bag for storage, ensure it is disposed of or disinfected regularly	• **Reuse of disposable N95 is limited to <u>five uses</u> (as per CDC guidance)**, unless contaminated or degraded • In circumstances where there is a high risk of the respirator becoming contaminated, wear a face shield or a surgical mask over the respirator • Discard respirator if it becomes difficult to breathe through • <u>Do not</u> reuse respirators if working with high-risk hazardous materials (e.g., cytotoxic drugs, risk group 3 pathogens) • When donning and doffing, hold mask by the straps/ties to prevent contamination

mask by the straps/ties to prevent contamination • Avoid touching the inside of the respirator • Ensure hands are clean or use a pair of clean gloves when donning a used respirator. Always clean hands after donning a used respirator. • **Reuse of disposable N95 is limited to <u>five uses</u> (as per CDC guidance)**, unless contaminated or degraded		• Avoid touching the inside of the respirator • Ensure hands are clean or use a pair of clean gloves when donning a used respirator. Always clean hands after donning a used respirator.

TABLE A.3 – EYE AND FACE PROTECTION

Type/Use	Storage	Reuse/Extended Use
Safety Glasses, Goggles, and Face Shields (Disposable)   • Provides protection of the eyes and face, and can extend the life of masks and respirators • Clean with soap and water or spray with a chemical disinfectant, as needed • After use, decontaminate with appropriate disinfectant on the inside and outside of the safety glasses, face shield, goggles, and straps • Do not set safety glasses on surfaces, except for in designated storage areas • Ensure gloves are removed before eye/face protection is doffed • Ensure hands are clean and straps do not become contaminated when doffing	• Before and after use, inspect for any contamination, scratches to lenses/shield, bent or twisted frames, ripped/stretched headbands, and other damage • Store for reuse in dust-free, dedicated area • After use, wash with soap and water and allow to dry before placing in a storage container, bag, or dedicated area	• Disposable safety glasses, goggles, and face shields can be reused and worn for extended periods of time • After use, decontaminate with appropriate disinfectant on the inside and outside of the safety glasses, face shield, goggles, and straps • Do not set safety glasses on surfaces, except for in designated storage areas • Ensure gloves are removed before eye/face protection is doffed • Ensure hands are clean and straps do not become contaminated when doffing

TABLE A.4 – BODY PROTECTION

Type/Use	Storage	Reuse/Extended Use

Lab Coats, Coveralls, Head Covers, Aprons, Sleeves, Gowns, Boot Covers (Disposable)
 
• Protects the worker from contaminating their clothes/shoes/hair with certain hazardous materials
• Should be changed between rooms/zones to prevent accidental contamination of other areas
• Clean, non-contaminated lab coats, coveralls, head covers, aprons, sleeves, gowns, and boot covers can be reused and worn extended periods of time if:
    o they are clean,
    o not contaminated, and
    o are not degrading
• Frequently inspect for tears, missing buttons/clasps, cuffs that have lost their elasticity, and contamination
	• For aprons, lab coats and coveralls, hang on designated hook (one per hook) or in a clean, dust-free storage space
	• For sleeves, head covers, and boot covers, label and store in **separate** clean, breathable bags for reuse
	• Store items so that they do not touch each other
		• Clean, non-contaminated lab coats, coveralls, head covers, aprons, sleeves, gowns, and boot covers can be reused and worn extended periods of time if:
		    o they are clean,
		    o not contaminated, and
		    o are not degrading
		• Frequently inspect for tears, missing buttons/clasps, cuffs that have lost their elasticity, and contamination

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ANNEX C – LIST OF CONTRIBUTORS

Yvon Lachance, architect, OAQ, MRAIC, FCSC, Principal at BGLA Architecture; SLCan President (2021-present)

John Alberico, Strategic Director - Healthcare, Principal at RWDI Inc.; SLCan Vice-President (2021-present)

Kevin Belusa, President, AirGenuity Inc.; SLCan immediate Past-President (2021-present)

Peggy Theodore, OAA, AIBC, FRAIC. LEED AP, Principal, Diamond Schmitt Architects, SLCan Board Member

Liam Brown, OAA, MRAIC, PMP, Associate, mcCallumSather, SLCan Board Member

Mary On, P.Eng., CPHD, LEED AP, Associate, Integral Group

Andrea Smida, Biosafety Officer, University of Saskatchewan

Sylvain Letarte, President, Phytronix Instruments.

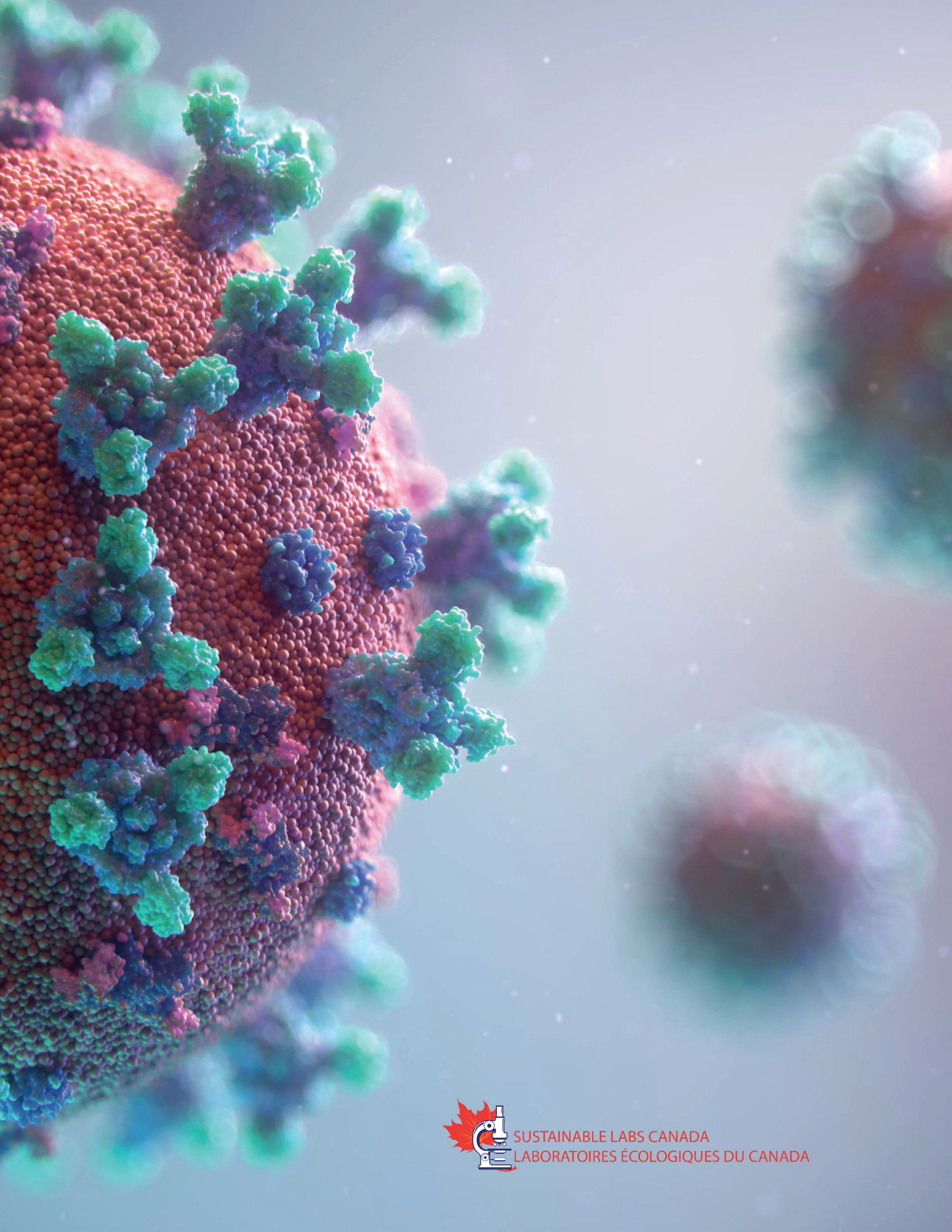
Justin Berquist, Research Officer, National Research Council Canada

Stephen Ginsberg, OAA, MRAIC, NFPA, Technical Principal, NXL Architects

Doug Ross, Business Development Manager, M.K. Plastics Corp

Paul Bozek, BASc MEng MBA ROH CIH PEng, Senior Consultant - Occupational Hygiene & Safety Engineering, Resource Environmental Associates; OHAO President

Kim Lan Sauer, Manager (EHS), Chemicals and Controlled Products, Ryerson University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