Engineering controls for long term care facilities to prevent and manage infectious diseases such as COVID-19

By William (Bill) Benbow, MSW

COVID-19 has uncovered the innate weakness of congregate living, especially in Long-Term Care Homes.

An International Study of data from 20 countries reports that Canada has the highest proportion of COVID related deaths in care homes at 82% **(Comas-Herrera, 2020)**. Carole Estabrooks, a professor in the Faculty of Nursing at the University of Alberta, calls it "benign neglect".

Ontario's Minister of Long-Term Care, Merrilee Fullerton, admitted that the province's system is "broken" and has endured years of neglect **(Osman, 2020)**.

The Provincial Infection Control Network of British Columbia, of which the Provincial Health Officer, Dr. Bonnie Henry is a member, published a study in 2012 that identified the gaps in infection prevention and control resources in long-term care facilities. They found that the vast majority of facilities have little or no access to Infection Control Specialists **(ICS)** and that this has adversely impacted their preparedness to defend against infectious diseases.

(Gamage, 2012)

Engineering Controls

Infection control specialists have developed terminology for planning and analyzing infection control measures.

Engineering Controls form part of three lines of defense against infectious diseases, along with Administrative and Work Practice Controls, and Personal Protective Equipment.

These three types of controls are a hierarchy with *Engineering Controls* through facility design being the most effective because they are built into the facility infrastructure and do not rely primarily on individuals to implement them correctly.

Engineering Controls are physical and mechanical measures put in place to reduce the risk of infection to staff, residents and visitors. They are designed to remove the hazard or place a barrier between the hazard and the human.

Occupation Safety and Health Administration (OSHA)

This article will focus on six elements of ***Engineering Controls*** that are critical to preventing/managing infectious outbreaks, such as COVID-19, in LTC facilities:

1. Private resident rooms with ensuites
2. Zones of resident rooms
3. Hand washing stations
4. Physical barriers particularly for visitors
5. Spatial separation for group interaction
6. Ventilation

1. PRIVATE RESIDENT ROOMS WITH ENSUITES

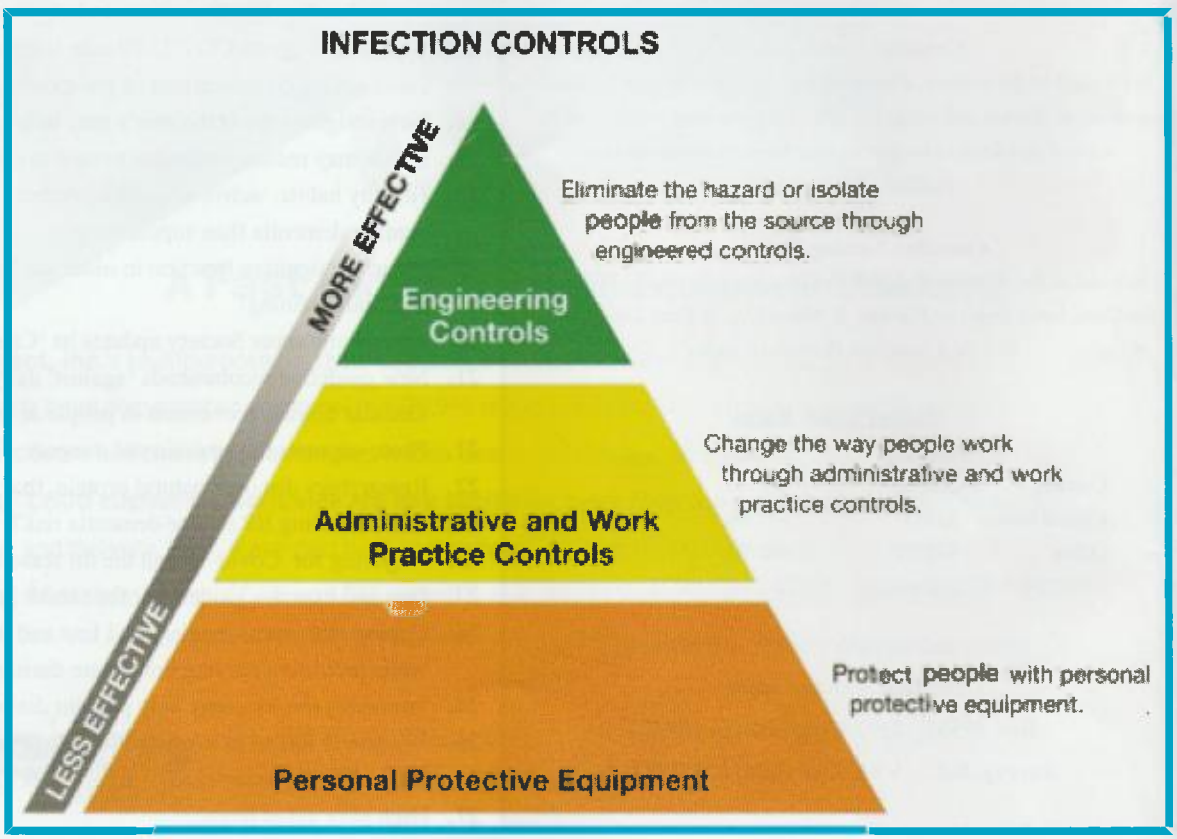
Viruses love 'shared accommodation' and they especially love 'shared washrooms.'

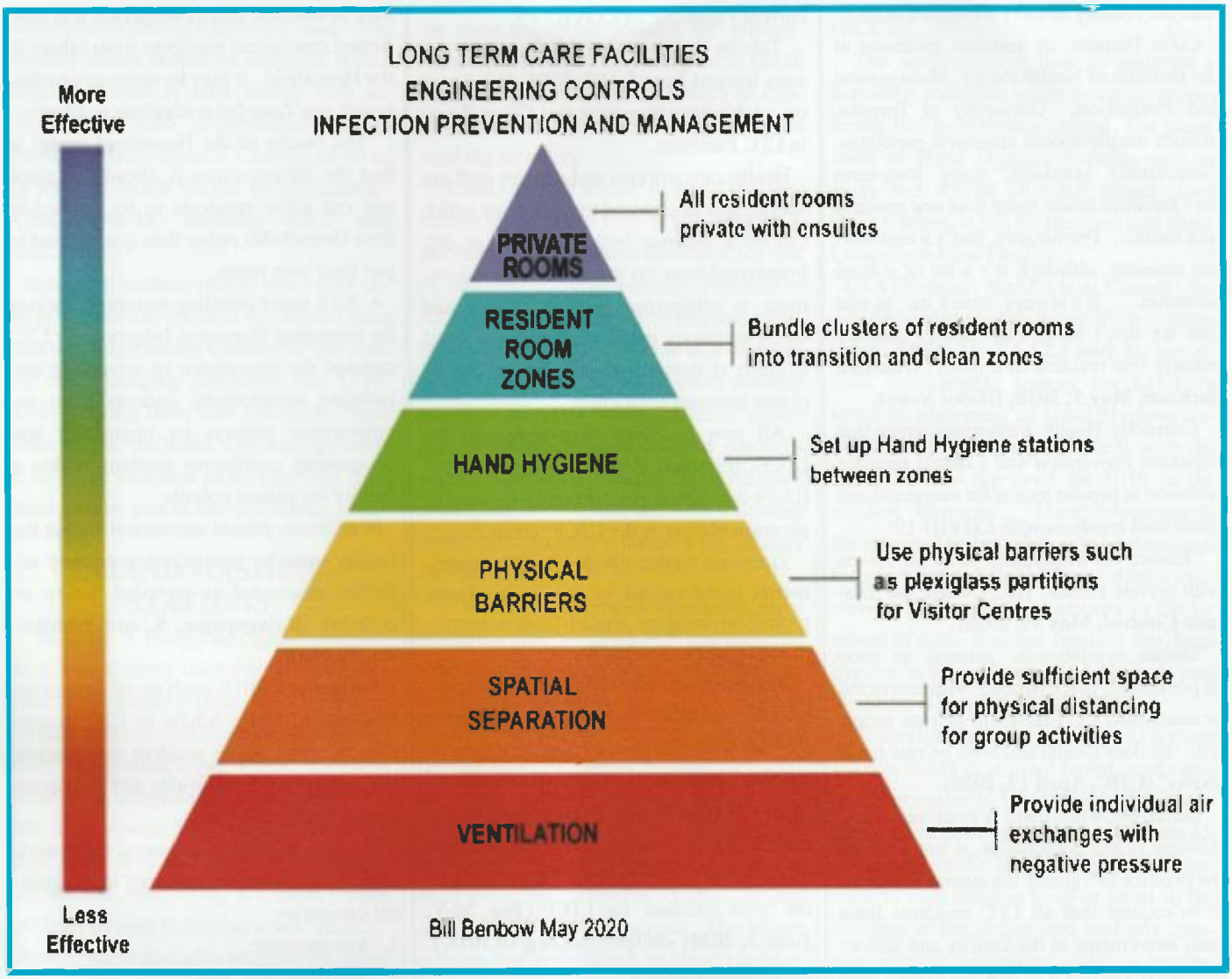
One hundred years ago, a disgruntled patient of Chicago's Presbyterian Hospital complained to the Superintendent, Asa Bacon: *"When I return, put me in a closet rather than in the ward."*

Bacon published an article, ***"Efficient Hospitals,"*** in *The Journal of the American Medical Association* in which he advocated for private rooms, noting that this would mitigate the serious problem of contagion.

Bacon's vision included a private toilet and lavatory in each room. His dream is yet to be fully implemented **(Noskin & Peterson, 2001).**

More recently, in 2003, in the midst of a SARS outbreak, Dr. Stan Feinburg, Chief





of Surgery at North York General Hospital in Toronto, urged the same:

"Since March, 28, 2003, SARS - ***Severe Acute Respiratory Syndrome*** - has been the focus of my professional life... The epicentre of the 2nd outbreak (in the Greater Toronto Area) is my hospital. My hospital will be extensively studied by Health Canada and the CDC - Centres for Disease Control - to answer why this happened. . .

"There is no doubt that the answer will relate to environmental issues. Part of the answer is going to be simple - the standard for healthcare is going to be private rooms for every patient. . .

"Many of our rooms have 2 to 4 patients. Tell me if you would check into a hotel where you shared a bedroom with strangers and shared a toilet with strangers and had to walk down the hall for a shower. Why do we accept this standard in hospitals?" **(Chaudhury, H., 2005).**

The CSA Group has issued a *"National Standard of Canada Z8000-18"* for Canadian health care facilities. Under the Long-term Care section this specifies that all residents should be accommodated in an "individual resident room with private washroom" **(CSA Z8000-18: 8.9.2.1.4).**

This follows the same requirement for Class A Health Care Facilities (Acute Care) which notes: "Single-patient room occupancy has been shown to reduce the potential for transmission of organisms and therefore decrease the risk of infection, decrease medication errors and improve safety, for both patients and health care providers overall" **(CSA Z8000-18, 4.5.3.1).**

Research supports the provision of all private rooms: The American Institute of Architects (AIA) and the Facility Guidelines Institute (FGI) have adopted single-bed private rooms as a minimum standard for new hospital construction. Although this pertains to acute care, it is instructive and will set the direction for complex care as well.

A study conducted by Simon Fraser University in Vancouver, British Columbia shows that private rooms are the trend in hospital planning and design. The advantages of single occupancy rooms are cited as improvements in patient care, enhanced infection control, and greater flexibility in operation **(Chaudhury, H., 2005).**

This is becoming the standard as well for Long Term Care facilities in much of the developed world including Canada, with the exception of some provinces, particularly Ontario, which continues to show a bias for shared accommodation in its funding formula.

Not surprisingly, Ontario and Quebec

lead the country in COVID related deaths.

Colin Furness, an assistant professor at the Institute of Health Policy, Management and Evaluation, University of Toronto, blames deeply-rooted structural problems: "structurally speaking, many long-term care facilities house more than one resident to a room... Presumably, that's a cost-saving measure, although it's a bit of a head scratcher... It's always struck me as odd that we don't build LTC homes that are entirely one resident to a room" **(Hannah Jackson, May 5, 2020; *Global News*).**

Currently Health Authorities agree that Infection Prevention and Control requires isolation in private rooms for suspected and confirmed residents with COVID-19:

- "Ensure the availability of single rooms with private toilets" **(BC Centre for Disease Control, May 19, 2020).**
- "Isolate symptomatic patients as soon as possible... place patients with suspected or confirmed COVID-19 in private rooms with the door closed and with private bathrooms" **(CDC, April 13, 2020).**

Moreover, when there is sustained transmission in the community, it has become the practice in fighting the current Pandemic to request that all LTC residents limit their movements in the facility and restrict themselves as much as feasible to their own room which, preferably, is a private room.

The conundrum for LTC facilities without all Private Rooms is how to isolate residents during an Outbreak.

Catherine Cohen in a 2016 Ph.D dissertation found that isolation-based infection control practices in Nursing Homes were severely impacted by the dearth of private rooms **(Cohen, 2016).**

Private accommodation for residents in Long Term Care facilities is the most effective ***'Engineering Control'*** for preventing and managing outbreaks of infections such as COVID-19.

2. ZONES OF RESIDENT ROOMS

A Taiwanese study recommends ***'enhanced traffic control bundling' (eTCB)*** for the protection of Long Term Care facity residents and staff in outbreaks such as the current Pandemic of COVID-19.

Taiwan developed **eTCB** based on lessons learned from SARS 2003. It is based on establishing transition and Clean Zones in LTC Facilities.

Health care workers and support staff are specifically designated to each Zone which can be a separate building, floor, or differentiated ones on the same floor. Movement is minimized between Zones and when necessary must involve proper hand hygiene at designated disinfection checkpoints between each Zone.

All new residents must reside in the LTCF 'transition Zone' for the full COVID-19 incubation period before moving to accommodation in the LTCF 'clean Zone'.

Zones are further divided into **Compartments** (subdivisions of rooms or private rooms) to mitigate spread from asymptomatic residents and staff.

Residents who exit the facility for hospitalization or other reasons must quarantine for two weeks upon returning to the facility. If an outbreak is discovered within the facility a **Quarantine Zone** should be established for the index cases and residents of the same compartment. This should be the 'gold standard' for LTCF **(Yen, M-Y, June 3, 2020; <https://doi.org/10.1016/j.jmii.2020.04.003>).**

This is remarkably like the ***Household Model*** which has developed over the past few years in progressive LTC Facilities.

The ***Household Model*** (or Small Group Model) usually has 6 to 15 residents in a self-contained cluster of private rooms with its own dining, lounge and designated staff.

Sometimes Activity Areas are shared between Households in a 'Neighbourhood' **(Benbow, W., 2012; Nelson, Gaius, 2009).**

The enhancement developed by Yen is the strict protocol of PPE, environmental disinfection, and prevention of cross-contamination through checkpoints of Hand Hygiene stations between Zones and Compartments.

Facilities composed of several distinct Households readily lend themselves to isolating residents in cohorts to prevent the spread of infectious diseases. Of course, some relocation of residents will be necessary to sort and cohort suspected and confirmed contagious residents from others in the Household. It may be necessary to designate one Zone for contagious residents.

The beauty of the Household model is that the infrastructure is already in place and can allow residents to be isolated in their Households rather than quarantined to just their own room.

A 2016 paper detailing recommendations for managing Norovirus Infections in LTC stressed the importance of separating and isolating symptomatic patients from asymptomatic patients by organizing and designating contiguous sections within a facility for patient cohorts.

In addition, patient movement within the facility must be minimized and group activities suspended or curtailed during an outbreak **(Rajagopalan, S. and Yoshikawa, T., 2016).**

Similarly, a 2018 analysis of Infectious Diseases in Older Adults in LTC recommended minimizing resident movements, suspending group activities and restricting access to affected wards.

The authors suggest a general framework of grouping residents and staff into 3 clinical categories:

1. symptomatic,
2. asymptomatic, and
3. potentially exposed, and unexposed **(Jump, R., 2016).**

Health Authorities recommend isolating symptomatic residents as soon as possible in private rooms with private bathrooms by dedicating space in a facility to monitor and care for residents with possible COVID-19; this could be a floor, unit or wing in the facility, or a group of rooms with specific staff to work only in that area.

A transition area is recommended for new residents and readmissions whose COVID-19 status is unknown. Residents should remain in this observation area for fourteen days if they remain symptom free. **(CDC, April 13).**

The Canadian Standards Association (CSA) actually provides such a standard for LTC: "This includes the capacity to establish and maintain separate zones for

patients in pandemic situations;" and "The resident rooms should be clustered within neighbourhoods. A total facility may include many such neighbourhoods with shared common areas... Clusters of 10 to 12 resident rooms should be considered," **(CSA-Z8000-18, Sections 4.5.2 and 8.9.2.1.3)**.

Grouping resident rooms into small cohorts of rooms or zones is the second most effective Engineering Control for preventing and managing infections like COVID-19 in Long Term Care Facilities. These zones are like the water-tight compartments of an ocean liner that protect the ship from sinking when part of the hull is breached.

3. HAND WASHING STATIONS

In 1846, a Hungarian, Ignaz Semmelweis, was a young doctor at the maternity clinic of the General Hospital in Vienna.

Many women were dying from 'childbed fever' in the clinic's two wards. 'Childbed Fever' is an infection after childbirth.

Dr. Semmelweis found that women in the clinic, staffed by all male doctors and medical students, were dying at a much greater rate than women in the midwives' clinic.

A pathologist died after pricking his finger while performing an autopsy on a woman who had died from childbed fever.

This gave Dr. Semmelweis a decisive clue. He surmised that cadaverous particles were getting on the hands of students from cadavers they dissected; and when they delivered babies, these particles would get inside the women who would develop the disease and die.

He ordered his medical staff to clean their hands and instruments with soap and chlorine. The rate of childbed fever fell dramatically.

But Semmelweis was unable to convince his colleagues: they resented the implication that they were responsible for infecting their patients.

The doctors gave up the chlorine handwashing and Semmelweis lost his job **(Davis, Rebecca, 2015)**

Things have not changed much. Despite general acceptance that Hand Hygiene is the most important practice for preventing the transmission of pathogens in health care settings, it has been difficult to convince health care workers to take hand washing seriously.

A 2015 French review of Hand Hygiene studies reported that 63% of reviewed studies found Hand Hygiene decreased the risk of infections in nursing homes. This rose to 80% for studies focusing on respiratory infections or influenza **(Hocine and Temine, 2015)**. However, studies of hand washing practices in LTCF have generally shown that adherence to hand hygiene practices is poor. One study found 27% compliance prior to resident contact and 63% following interaction. Another reported a rate of only 14.7% in two LTCF.

A 2013 study undertook a comprehensive education program in a LTCF and achieved a 54% rate. The authors attribute this to the installation of easily accessible Alcohol Based Hand Rub (ABHR) dispensers and the increased awareness resulting from the education program **(Schweon, 2013).**

A British review strongly recommends access to Hand Hygiene facilities at the workspace for infection control in the current COVID-19 pandemic. The report stresses that compliance to Hand Hygiene infection control measures depends upon the equipment's immediate availability in the work area, and line manager's support.

One barrier to use is skin sensitivity or damage. This report references a study that found an effective strategy to improve compliance combined education, reminders, and each staff member being given a pocket-sized hand sanitizer **(Koshkouei, 2020).**

The initial US outbreak of COVID-19 in a Washington Nursing Home is attributed in part to poor infection control practices due to inadequate supplies of personal protective equipment and hand sanitizer. **(McMichael, 2020).**

The British Columbia Centre for Disease Control (BCCDC): "Hand hygiene, sinks, liquid soap dispensers, paper towel holders, hand sanitizer dispensers and no-touch waste bins with lids ... should be readily available throughout the facility." **(BCCDC, 2020).**

The conundrum is how to maintain a homelike ambiance while ensuring proper health facility infection control. The placement of Hand Hygiene fixtures, such as sinks and ABHR (Alcohol Based Hand Rub) stations, is left for the most part to the Long-Term Care Facility.

CSA (National Standards of Canada) has detailed guidance for Acute Care settings **(CSA Z8000-18, 7.5.12.2 and 3),** but allows considerable leeway for LTCF in terms of placement of Hand Hygiene fixtures: the planner shall confirm with the facility owner the need for HHS in the resident bedroom... These requirements are intended to provide a safe environment for residents and staff by providing a convenient HHS in close proximity to the location of care. It is not implied that hand hygiene is less important in long-term care facilities. **(CSA Z8000-18, 8.9.3.2)**

Minimally there should be Hand Hygiene stations (sinks or alcohol-based hand rubs) at the entrance to the facility, at the entrance and exit of each Zone or Household, in the path of the Health Care Worker enroute to each resident wing or room, at the entrance to the dining area and any common amenity or activity space, in any assisted tub bathing area or other therapeutic space, in every soiled and clean utility area, in every food preparation area, in each nursing or medication station, and in any public or visitor area.

The availability and easily accessible location of Hand Hygiene stations is the third most effective Engineering Control for LTC facilities to defend against the invisible enemy. They are like sprinkler systems installed in buildings to wash away outbreaks of fire.

4. PHYSICAL BARRIERS

Necessity is the mother of invention. With contact between families and residents curtailed by Care Homes during a Pandemic, families have resorted to visiting through closed windows where possible and via tablets and phones.

However, creative Physical Barriers are being utilized as never before to shield hu-

mans from COVID-19. Plexiglass screens, once seen only as sneeze guards at buffets, are being used to protect cashiers in grocery and other retail outlets, to separate tables and place settings in restaurants, to enhance cubicles for office workers, and most significantly, for LTC facilities, there are interesting innovations for Visitors cropping up around the world.

My mother-in-law who resides in an Assisted Living facility operated by Laurens Group in the Netherlands now has the option to entertain visitors in a recently installed "Visiting House". An enterprising entrepreneur had developed portable hotel rooms ***(Flexotels)*** that could be set up in 15 minutes for concert and festival venues. They measure 6 by 2.5 metres.

With COVID-19 he found he had 500 such temporary rooms out of commission and stored in a warehouse. He had to look for an alternative use: he converted his 'hotel rooms' into ***'Visiting Houses'*** by installing a plexiglass wall in the middle. Both sides have a door so that Visitors and the Resident have separate entrances. Conversation between the resident and visitor can be accomplished with a Baby Monitor. The Visiting House is cleaned after each visit. Units are available for about $3000 Euros.

This group of facilities is also utilizing *"Come on Visit Carts"* where the vistor sits in an enclosed mobile cart and is wheeled to visit a resident. **(Laurens, 2020)**

A much less expensive Visiting enclosure has been erected by *Amica Senior Living* in Toronto and several of its other facilities: it cost less than a hundred dollars and took just a couple of hours to erect. The four metre square box is built from a few panes of Plexiglas, some plywood and some two-by-fours. It allows visitors to be safely distanced but up close to loved ones. **(DiManno, May, 2020)**

Clearly, there is a need for a permanent solution to Visitor Access during infection outbreaks in LTC facilities - something that allows some physical screening between the visitor and the resident.

Permanent Visitor Centres should be part of facility design. Visitor rooms ought to be in the public area of facilities: i.e., there should be a continuum from a Privacy Zone of resident rooms, to a semi-private area of small resident-only lounge and dining areas, to a semi-public meeting/activity area and a full public area, perhaps at the entrance to the facility. **(Nelson, 2009)**

Visitors should not be meeting in resident rooms or anywhere in the Privacy Zone of the Household. Visitor rooms could be designed to be flexible with double entrances and moveable plexiglass screens for usage during infection outbreaks.

Physical barriers could also be used in dining areas, e.g., a plexiglass screen across the middle of dining tables which could be reduced from 4 residents per table to just two during outbreaks. Two sittings would accomplish less crowding and greater physical distance.

There are also commercially available portable Environmental Containment Units (ECU), partitions and Construction Wall systems designed for temporary isolation in health care settings to help prevent the spread of dust and airborne infection during construction and public health emergencies. These are designed to meet and exceed infection control guidelines. They could be useful to temporarily create zones within a facility. At least one US manufacturer is producing "instant isolation rooms" **(Grainger, 2020; STARC, 2020).**

There is scant research on the use of Physical Barriers in LTC facilities. A 2009 systematic review of 138 papers did conclude that many simple and low cost interventions could be useful in reducing the spread of respiratory viruses. Studies reviewed included school closures, triage and barrier traffic flow into hospital, zoning of risk, isolation, Quarantine. **(Jefferson, 2009)**

The British Columbia Centre for Disease Control (BCCDC) National Collaborating Centre for Environmental Health has issued guidance to ensure proper design and installation of rigid barriers: "Partitions are proposed to serve three critical functions:

1. Intercepting the respiratory droplets that are thought to transmit the virus,

2. Re-enforcing physical distancing requirements, even when users are unwilling or forgetful;

3. Reducing reliance on masks, both due to the shortage of such items, and comfort."

Key Points re. Physical Barriers:

- Choose dimensions that protect the breathing zone of the tallest person using the partition. The breathing zone can be thought of as a bubble with a radius of 30 cm extending out from the mouth and nose.
- Pass-throughs or openings should be as small as possible and not located in the breathing zone of either user; do not include speaking ports or grates.
- Install the partition securely, such that it cannot tip or fall; do not block or impede emergency egress.
- Surface-mounted partitions with small openings and wings/surrounds are preferred over hanging partitions that can swing or waft air.
- Clean the partition at least daily with mild soap and water or a compatible disinfectant; discard or launder the cloths used for cleaning. **(Eykelbosh, 2020)**

WorkSafe BC suggests barriers may be superior to masks because:

- Their effectiveness doesn't rely on correct usage - as in the case with masks.
- They don't need to be continually supplied.
- They protect people on both sides from breathing the other person's droplets.
- They can serve as a visual reminder of physical distancing requirements. **(WorkSafe BC)**

Installation and placement of physical barriers need to comply with Provincial building life safety regulations of Building Fire codes. These requirements refer to:

- Flame-retardant and non-combustible materials;
- Fire detection and suppression systems;
- Structural capacities of barriers, guards, and dividers;
- Exit path widths & travel distances;
- Accessibility requirements for persons with disabilities. **(City of North Vancouver)**

Physical Barriers are the fourth most ef-

fective Engineering Control for shielding residents of LTC facilities from the virus. They are like the firewalls installed between fire protection zones in buildings to limit the spread of fires; and like computer firewalls, they are designed to block incoming viruses.

5. SPATIAL SEPARATION

The virus loves crowds, especially if they are indoors

Physical distancing is one of the most effective means of thwarting the spread of infectious diseases: but it demands adequate Spatial Separation. This is particularly difficult to achieve within the current Space Allowances for resident rooms and amenities in Long Term Care facilities.

A Nova Scotia LTC provider has adapted their dining rooms for Spatial Separation: "Dining rooms and meal service have been adapted to ensure physical distancing standards. For our licensed long term care homes, measures that have been taken to expand the size of the dining room, distance people sitting at the same table and temporarily schedule two times for meal service.

For retirement living communities, we have moved to a system of delivering meals to residents' suites" (**Shannex, June, 2020**).

The Registered Nursing Association of Ontario (RNAO) suggests the following for Social distancing during meals:

- Staggered meal times,
- Serve breakfast in bed,
- Develop a take-out menu (RNAO).

The Government of Canada has issued Guidance for LTC facilities regarding activities:

If group activities take place, the number of residents should be limited to the smallest feasible groups, and residents spaced as far from one another as possible, maintaining a minimum distance of 2 metres between them. Group activities should, wherever possible, be restricted to a single unit and floor. **(Canada, 2020)**

Physical Distancing is not likely to be a short-term remedy: a recent study suggests it may be necessary as far into the future as 2025 **(Kissler, 2020)**. The Engineering Control of adequate Spatial Separation needs to be factored into permanent facility design.

Thirty years ago the British Columbia Ministry of Health mandated increased dining space to ensure wheelchair and walker accessibility: i.e. the then standard of 2 square metres per resident was increased to 3 square metres. Unfortunately, the guideline for lounge and activity space allowances was not increased.

To enable Spatial Separation, common areas such as lounges and multi-purpose activity rooms need to be enlarged to 2.5 and 3 square metres per resident **(CSA Group).** One suggestion is for two or three Households or Zones to share adjacent Activity Space on rotation with disinfection cleaning between uses.

Resident rooms, which may become isolation and quarantine areas for residents, also need to be of a size for accessibility and comfort: an area of 17 to 20 square metres of usable space, plus 5 to 6 square metres for an ensuite, is not unreasonable. **(Benbow, 2013; CSA Z8000-18 Table 8.9)**

A case can be made for additional space for a sitting area in the resident's room given the requirements for isolation and quarantine during infectious disease outbreaks such as annual influenza and regularly occurring Pandemics.

Outdoor access and adequate area allowances are critical as well. The COVID-19 virus has a transmission rate estimated between 1.5 to 3: i.e. one contagious person on average infects 1.5 to 3 other persons. This is called the R0 ***(R-naught)***. However within the confined spaces of the Built Environment (BE) the R0 of COVID-19 has been estimated to be a great deal higher: ranging from 5 to 14 persons, based on the experiences of passengers onboard the Diamond Princess cruise ship **(Dietz, 2019)**. Hence the current wisdom that infection is much less likely outdoors. This is due in part to bright Sunlight with Ultraviolet light, and the movement of air diluting and dispersing droplets and aerosols. So, ample opportunity for outdoor access with adequate Spatial Separation is highly recommended for Long Term Care residents.

Adequate Spatial Separation is the fifth most effective Engineering Control for Long Term Care facility designers to use in defending residents from the invisible enemy. This limits the virus' ability to traverse the gap between possible hosts: it is like blowing up bridges and creating moats to defend against the foe. Each resident needs sufficient room to maintain their own personal space or bubble.

6. VENTILATION

Florence Nightingale developed her ideas about hospital design from her experiences in the Crimean War. She said: "depriving patients of appropriate ventilation is nothing but manslaughter under the garb of benevolence." She favoured open windows with good cross ventilation of outside air **(Noskin, 2001).**

Victorians and Edwardians believed that infections were contracted from foul air. They were not mistaken. We now know that a sneeze can introduce 40,000 droplets laden with the virus, a cough can generate 3000, the same number as talking for 5 minutes. Normal breathing over time actually generates more virus aerosols than either a cough or a sneeze **(Memarzadeh, 2012)**.

A 2019 study on the Role of Ventilation in the transmission of infectious agents concluded that there was strong evidence showing the association between ventilation rates, airflow pattern, and the transmission of airborne diseases like influenza and SARS **(Leung, 2007)**. Airborne aerosols of COVID-19 can remain stable for at least 3 hours **(Lynch and Goring, 2020).**

Modern buildings have evolved a centralized ventilation systems (HVAC) with mixed recirculated air delivered as part of heating and air circulation. This has resulted in many cases of "sick" buildings due to poor maintenance and inadequate filtration.

A study in Lima, Peru compared eight older, naturally ventilated, hospitals with 12 post-2000 mechanically ventilated ones and found that opening windows and

doors provided median ventilation of 28 air changes per hour which was significantly more than double that of the mechanically ventilated ones. They concluded that in settings where respiratory isolation is difficult and climate permits, windows and doors should be opened to reduce the risk of airborne contagion **(Escombe, et al., 2007)**.

The American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) points out that infectious aerosols can be disseminated throughout buildings by air distribution systems and interzone airflows. They recommend personalized ventilation systems that provide local exhaust source control and/or supply 100% outdoor, highly filtered, or UV-disinfected air. The main thing is to eliminate or mitigate the recirculation of air.

In addition, the Society endorses Negative Pressure for resident rooms containing contagious residents as this minimizes leakage from the room to other parts of the facility **(ASHRAE, 2020)**.

The Facility Guidelines Institute (FGI) guidelines developed by a Canadian Architect recommend providing resident rooms with individual air exchange **(Wrobowsky, 2018).** This is becoming the Building Code standard with split heat pumps providing heat and air conditioning and Energy Recovery Ventilators (ERV) - part of individual room outside air exchanges.

Exhaust air is no longer recirculated to the rest of the building. Unfortunately, many older facility systems are based on a Central HVAC system of mixed air.

The number of Air Exchanges an hour impacts airborne-contaminant dilution and removal. Older facilities often have only 2 air exchanges an hour which means it takes 138 minutes to remove 99% of potential infectious aerosol particles. The CSA standard is a minimum of 4 exchanges per hour for resident rooms in LTC facilities which shortens this to 69 minutes **(CSA Z317.2:19)** Six exchanges reduce this to 46 minutes which is the recommendation for highly infectious diseases in acute care patient rooms **(ASHRAE, 2020)**. Duration is an important factor in a human host acquiring airborne viruses so these figures are important in determining staff susceptibility to infection when they enter a contagious resident's room to provide care services or cleaning.

'The Summit,' the most recent LTC facility built in Victoria, B.C., which opened in June, has 4-6 ACH, 100% outdoor Air, a 10% differential between supply and return to provide negative pressure, and 80 _ 85% heat recovery with MERV 14 -15 filtration for resident rooms **(Personal Email).**

For existing facilities, Lynch and Goring have provided practical steps to improve air flow and negative pressure in LTC resident rooms. He provides detailed information on installing supplemental exhaust ventilation through bathroom or kitchenette exhaust fans with the aid of an HVAC contactor **(Lynch, 2020)**.

Caution does need to be exercised since increasing the air exchange rate can increase air turbulence and affect the dispersion of infectious particles and the subsequent deposition of these on various surfaces, which in one study increased the ventilation risk to some regions of the room **(Sze-To, 2014).** A recent blog references a CDC research letter that showed how air flow directed by an air-conditioner in a restaurant could disperse the virus from a contagious host to several diners seated downwind at other tables. The author suggests that extended time spent in any environment that is enclosed, with poor air circulation, is risky **(Bromage, 2020; Lu, 2020).**

So Proper Ventilation to ensure clean fresh air is the sixth Engineering Control critical to the infrastructure of LTC facilities in the battle against the virus adversary. Breathing dirty air is like eating a sandwich of stale bread and moldy cheese.

Not an exhaustive list

Please note this list of six Engineering Controls is not all-inclusive. We could add Technological infrastructure with such installations as the temperature taking device recently installed in the entrance vestibule of a local private school in Greater Victoria. This sets off an alarm for anyone entering with a temperature of 38 degrees Celsius or more. Or smart TV's in resident rooms could be adapted to be used for face time or skype much like the vestibule cameras connected to resident TVs in apartment buildings to enable interchanges between visitors and residents. Creativity and innovation will no doubt add many more infrastructure adaptations to better prepare the battlefield for engagement during virus outbreaks.

Overlooked is the tremendous impact that an Outbreak imposes on the Quality of Life of LTC facility residents. We do not want to build in infrastructure that diminishes the homelike environment that seniors crave. Isolation, boredom and lack of contact with families and friends is devasting and exacerbates loneliness and depression. Infection Control Specialists designing Engineering Controls need to take this into account and balance infection control with Quality of Life.

The Long-Term Care crisis uncovered by COVID-19 demands our attention and response. Premier Ford of Ontario has called it 'Gut-Wrenching' and has even raised the prospect of criminal charges.

Infrastructure deficits

Underfunding, insufficient and poorly trained staff, inadequate infection control policies and practices, and lack of Personal Protection Equipment all need to be addressed in the short term; but if infrastructure deficits are not tackled, the ship will surely sink.

Even the best trained and equipped crew cannot hold back the deluge if a poorly designed hull is holed. Engineering Controls are an essential bulwark for the long-term solution.

Private Resident Rooms, Distinct Compartmentalized Zones of resident rooms, well placed Hand Hygiene Stations, Physical Barriers for staff, residents and visitors, sufficient Space Separation for Physical Distancing, and Personalized Ventilation are all necessary shields against the virus.

Health facility design needs to ensure that the risk for infection is minimized. Infection Prevention and Control specialists need to be part of the planning process for

LTC facility development and most importantly steer the strategic planning and implementation of our response to the current and future pandemics.

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