Infection Control Issues and Responses

Health Monitoring & Metrics

During the pandemic, there were many parents at risk of infection at work who went home and stayed away from their families for months. Kids cried at the house windows when their mum or dad came home, but they did not enter the house, instead, spending the evening and night in the car, caravan or garage.

Health monitoring practices are not just for staff, but to keep staff (and their families) safe; these need to be communicated to families also.

The protocols for monitoring are changing rapidly and will continue to do so as research-learning filters out and become best-practices.

Clock-in

The infra-red thermal measuring of temple-temperature is fast, but fails to recognize an infected, asymptomatic carrier. This failure matters, because the numbers of carriers have been variously reported as between 30 and 44%. Missing this proportion of people coming into a work-place will create major cross-infection threats and potentially further distress and shut-down.

A more reliable and immediate test may be to measure blood oxygen proposed by Dr. Richard Levitan[1], which can be at half the normal 'saturation' levels due to 'silent hypoxia' which manifests in COVID-19 patients. Patients with such low saturation levels (with other respiratory crises) would typically be flat-out and distressed, but COVID-19 does not prevent carbon dioxide expulsion in the early stages of the disease and it is this difference that is thought to be the most critical novelty manifesting in patients with such low oxygen saturation levels.

The measurement of oxygen saturation takes a few seconds and is typically measured using a finger-clamp device. A similar oximeter is an earlobe probe; this is more accurate than the finger-tip devices except when the individual is very cold[2]. Normal oxygen saturation is c. 94+% at sea-level.

At the time of writing, the possibility of rapid-monitoring of coronavirus (SARS-CoV-2) infected people by screening for blood-borne antibodies (prick-test) is poorly-developed; there are also questions about fail-positive results (for example, in someone who is infected with a common cold coronavirus or, influenza). There is currently a lack of peer-review medical research to provide reliable data (the antibody-levels that may provide protection from the virus), and what proportion of individuals may have antibodies, but still be carrying a viral-load and infectious to others. Until the peer-review research is done, antibody tests offer no security to anyone working near someone with an antibody score.

Whatever policies we establish, the methods should help mitigate the potential for people to come into the work environment when infected. Communication must be more than announcing change, we must explain why and what the evidence is for improved screening.

---

[1] https://www.nytimes.com/2020/04/20/opinion/sunday/coronavirus-testing-pneumonia.html

[2] https://www.who.int/patientsafety/safesurgery/pulse_oximetry/who_ps_pulse_oxymetry_tutorial2_advanced_en.pdf

Clock-in may also lead to queuing and so if old-fashioned cards are being used, an upgrade to a fast, contactless system, or facial-recognition system at multiple points on the shop-floor itself can reduce lines completely.

Clock-out

The same factors apply to clocking out, where upgrading the technology with multiple points will reduce the potential for cross-infection in lines. Where possible, staggering entry and exit over a much longer period of time, will also mitigate the threat of cross-infection.

Infection Control Layer

The Infection Control Layer has two prime threats: proximal individuals who may breathe microscopic, virus-containing water-vapor from an infected person and, common surfaces that may be touched before any surface contamination has become inert or been sanitized. Such surfaces include handles, tools and totes.

Contaminated Surfaces

The CDC reference above also provides a wealth of surface-cleaning agents that, as active ingredients in commercial consumable products, can reduce virus-loading to under 1% on clean, non-porous surfaces. Some of these are designed to leave a disinfecting surface-film that in a clean environment, continues to kill germs for an unspecified time. However, in real work-environments, we should not depend on that virucidal activity. An example of a formulation that leaves an active film is povidone-iodine.

As we shall see later, contaminated breath can leave infected droplets and virus particles in the air circulating widely for hours. This underlines the importance of proper respiratory protection at all times (not surgical masks, but actual certificated respirators that fit properly. Personal hygiene is thus critically important.

At the time of writing, our team is working on timing-systems for totes. The aim is to alert users to the 'safe-time' before tote and contents can be safely handled. These systems vary from color-coded labeling to digital-alarms with color-coded red/green (do not touch and touch) indicators that can be re-programmed easily to conform to latest guidance.

Distancing: limited protective efficacy indoors, without other measures

The first line of defense-measures involves reducing airborne threats. Outdoors, distancing with short-term proximity to people within six feet or more (depending on air-flows, humidity and temperature), limits exposure to levels where the threat of infection is low. This can be especially low where infected persons are wearing masks (or better, respirators without exhaust-valves). As the New York Times reported[3] May 14th, 2020:

As more virus research has emerged, however, the outdoors has begun to look safer. It still brings risks (like those doorknobs). But they are fairly small. One study of 1,245 coronavirus cases across China found that only two came from outdoors transmission.

[3] The New 'get out' Push, https://www.nytimes.com/2020/05/14/briefing/coronavirus-michael-flynn-federal-reserve-your-thursday-briefing.html

Distancing: Reducing Contact Risk by Changing Shift Working Patterns

Eventually, there may be an antibody treatment for everyone and another treatment to reduce symptoms. Any pharmaceutical help is going to come long before an actual vaccine. It means that distancing is going to stick-around for many months, maybe a year or two. In the new normal, staff may be more agreeable then before, to fill a new shift pattern, to reduce health risks for themselves and their families. Having more shifts, including in offices and functions where people still have to be present, will help reduce the number of people at work at any one time.

Shift patterns are likely going to impact on office staff too. If not working from home (perhaps by rota), you may add an office shift to reduce numbers in that area. In Shanghai, l'Oriel is using this to reduce head-count at work and staff have to wear masks when outside the home and at work too.

Distancing: Technology

Ford has trialed a proximal, alerting wrist-band[4] (Samsung and Radiant RFID technologies) that uses Bluetooth to provide a vibrating and color-coded alert when anyone gets closer that six feet from another person. A similar trial is being undertaken as a joint-venture between Krannert School of Management's Dauch Center of Manufacturing Management Enterprise (DCMME). Vibration is likely important, since any light on the wrist-band could easily be missed.

When we look at the case for smart technological deployment on the shop-floor later, one consideration includes the use of cobots, working alongside an operative and so reducing the need for a part-time or full-time person within their safe zone. We provide much more on these subjects in the Technology links.

Distancing: Remote Working

A surprising number of working people can accomplish a lot, if not all, of their work from home. A small survey[5] of 1,004 people states that, 'on average, remote employees worked 1.4 more days every month, or 16.8 more days every year, than those who worked in an office'.

Few companies have taken advantage of home-working by operatives, but some have. Before bringing in order-kiosks and digital-app ordering, McDonalds had changed their telephone ordering system to home-working, several years before the pandemic; home-workers could be a thousand miles from any given McD's collection-point.

How much more non-machine work could blue-collar employees do from home?

Disposable Masks, Respirators and Gloves

The filter system in common disposable face-masks worn in health settings are particularly poor and massively different in filter-performance, due to the absence of test-standards and certification. Eight

[4] https://www.bloomberg.com/news/articles/2020-04-15/ford-tests-buzzing-distancing-wristbands-to-keep-workers-apart

[5] https://www.airtasker.com/blog/the-benefits-of-working-from-home/

different surgical mask filter-materials were tested by Weber and found[6] to vary from 20-100% effective for particles between 0.1 and 4 microns in diameter.

As a 'protection' for a wearer, they allow between 20 and 100% of particles of 1 micron, or smaller, to pass through the filter-layers[7]. That means that the efficacy of the filter materials is between zero and 20% but, does not include the additional threat from substantial leakage around the mask edges. Tuomi found[8] that a surgical mask that is taped/sealed to the face improves performance marginally compared to just wearing the mask as normal (between 33 and 67% less effective than the taped masks using particles of 0.2 to 10 micron diameters). It is widely accepted that such masks are somewhat better for reducing the expulsion of larger droplets/particles from an infected wearer (who may have symptoms or be asymptomatic).

Conventional, disposable, surgical masks will barely reduce the airborne **out-breath** or cough of the wearer[9]. By comparison, an N95 mask will remove 80-90% of droplets, including smaller droplets. This level of protection can be improved to 100% by greasing the edges of the N95 mask with petroleum jelly). The filter system in a properly fitted/sealed N95 is reported[10] as 99.5% for 0.75 micron particulate and 95% for 0.1-0.3 micron.

Breathing releases small and large (droplets that are visible as mist). Smaller droplets (5 micron diameter) can carry in the air for over an hour[11] losing moisture fast in drier air and so, even more likely to travel deep into the respiratory tract of an unsuspecting person. Larger droplets of 100 micron diameter (reported by Tellier, 2006) will fall faster and also present a surface-contamination hazard[12] (fomite route). Recent work by Stadnytskyi et al[13] (May 2020) substantiates the earlier work stating,

*'In a closed, stagnant air environment, they [*the droplets*] disappear from the window of view with time constants in the range of 8 to 14 min, which corresponds to droplet nuclei of* ca. *4 µm diameter, or 12- to 21-µm droplets prior to dehydration. These observations confirm that there is a substantial probability that normal speaking causes airborne virus transmission in confined environments.'*

The figure below is taken from a final report[14] on protecting health care workers:

---

[6] Weber, A., et al., *Aerosol penetration and leakage characteristics of masks used in the health care industry*. AJIC, 1993, 21 (4): P. 167-173.
[7] https://www.ajicjournal.org/article/0196-6553(93)90027-2/pdf
[8] tuomi, T., *Face seal leakage of half masks and surgical masks*. Am. Ind. Hyg. Assoc. J., 1985. 46 (6): p. 308-312.
[9] https://annals.org/aim/fullarticle/2764367/effectiveness-surgical-cotton-masks-blocking-sars-cov-2-controlled-comparison
[10] https://www.ncbi.nlm.nih.gov/pubmed/9487666
[11] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7115322/#bib0410
[12] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3372341/
[13] https://www.pnas.org/content/early/2020/05/12/2006874117
[14] http://www.phsa.ca/Documents/Occupational-Health-Safety/ReportProtectingtheFacesofHealthcareWorkers.pdf., Table 2.1., P. 16.

Behavior of Infectious Aerosols in Still Air and Route of Exposure

Diameter in μm	Time to fall 3 metres	Route of exposure
100	10 sec	Direct contact with skin or mucous membranes
40	1 min	Direct contact
20	4 min	Direct contact
10	17 min	Direct contact Some deposition in mouth or nose
6 - 10	Several hours	Deposition in nasal passages
0.06 to 6	Many hours	Deposition into lungs

These papers highlight problems both on the shop-floor and in offices where exposure to others, even with distancing, can very quickly lead to viral exposure loads, each day, much higher than is necessary to infect people wearing ordinary, disposable surgical masks (that may offer next to no protection from these smaller droplets) and inadequate protection against all droplets due to leakage around the mask. The table is for a distance of almost ten feet. Windage will extend the distance traveled and further complicate the infection threats in work-settings. Distancing and wearing surgical masks therefore, by themselves, are inadequate to protect workers in any indoor work-area.

On the shop floor, extraction and the use of boxed UV lamps (with internal fans to circulate air) overhead is reported[15] to reduce risks by reducing the virus load. Far UV is used in hospital settings without screening; these are Kr/Cl or Kr/Br lamps that are especially effective against the smaller droplets that tend to drift, rather than fall.

In offices, actual respirators, sealed with petroleum jelly at the edges, would appear to be essential, along with significant distancing and preventative hygiene measures. Additional measures include high levels of ventilation using fresh air are sensible.

Canteens are a special hazard since eating and drinking while wearing a respirator is impossible and speech will produce increased viral load into the environment. Speaking also produces larger droplets than in normal breathing and these larger droplets can fall quickly onto the plates and cutlery of others. At the time of writing, many manufacturing operatives are eating in their vehicles and this may need to continue for their safety and to reduce the number of people congregating in, or sharing, the same corridors and doorways.

[15] https://www.sciencedaily.com/releases/2009/03/090316201505.htm

Toilet areas are another concern. Fecal material from an infected person will likely contain the SARS-COV-2 virus and flushing without a toilet lid can send a plume of contaminated air up to fifteen feet into the air[16]. Single occupancy, timed access, removal of entrance doors, multiple air-changes per hour will all reduce risks. You may also want to install sensors that not only switch-on internal lighting, but also illuminate red lamps outside the facility for an extended period of time, so staff can avoid getting close to one another.

In offices and corridors, if you have doors without windows in them, you may want to change these also.

Office cleaning, whether by service, or staff doing their own areas, will be important, especially if any work-area is shared. Remember that a cloth, mop and sponge are great media for hosting and spreading billions of germs. The American Society of Microbiology reported[17] that 81% of hotel room surfaces sampled had some fecal bacteria[18].

On the shop-floor, some manufacturers are allowing a period of time for operatives to sanitize their own work areas.

Disposable Gloves

Disposable gloves may be even less useful than disposable surgical masks. Whether you have a contaminated finger or contaminated glove, the risk to respiration still remains; if the hand is in contact with the face, especially eyes, nose and mouth, infection is just as likely with or without a glove.

Whether on the shop-floor, offices, rest-rooms, changing-areas, corridors and door-ways, there are times when people, however careful, may be within the required proximity limit, whether six feet or, as we see above, considerably more distance than that. One-way markings for walking, separation floor-markings or circles, all help to keep people apart. In those areas where accidental proximity will occur, especially where the ventilation/extraction is poor, the use of far-ultra-violet lamps can again ameliorate the virus loading in the air[19], but the CDC writes that these will not work at full efficiency if the air has organic pollutants[20].

[16] Reported in, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4692156/
[17] https://aem.asm.org/content/78/21/7769
[18] Reported in: https://time.com/5135121/dirty-hotel-rooms-germs/
[19] https://www.crr.columbia.edu/research/using-power-light-preventing-airborne-spread-coronavirus-and-influenza-virus
[20] https://www.cdc.gov/infectioncontrol/pdf/guidelines/disinfection-guidelines-H.pdf