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Guidance Notes for commercial offices: Safe return to work during COVID-19

For: Savile Row Projects Ltd.

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UCL INNOVATION & ENTERPRISE

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1 Executive Summary

This report explores multiple strategies and control measures for preventing or limiting the transmission of the SARS-CoV-2 virus in indoor office workplaces. It has been commissioned by Savile Row Projects Ltd to ensure that, in collaboration with its clients and supply chain, its work on the design, installation and operation of office interiors is executed in light of what is known about the disease. The background study on which this report is based focuses on three areas of advice: clinical, behavioural and built environment, the evidence from which we use to draw the following advice:

The macro view and co-creating knowledge

As the human population of the world increases in size and wealth, we encroach upon and alter the natural world. The spread of SARS, MERS, Ebola and now SARS-CoV-2, the virus that causes the disease we call COVID-19, may be the result. The spread can be accelerated by both globalisation and population growth. A growing share of the increased global population now resides in cities and megacities where residents may be exposed to viral spread, by regularly encountering strangers in daily life – at home, while travelling, at work, in school, while shopping, or in leisure activities. As cities grow, activities tend to be packed more tightly into buildings, inadvertently providing a breeding ground for transmission of a virus or other infection. Most urban employees work in offices that are increasingly designed and fitted out for high occupancy, including shared use of rooms and 'hot desks' for 'activity-based working' or 'coworkspaces'. These trends raise the risk of viral infection unless evidence-based specification of materials and operational practices are followed.

COVID-19 has affected much more than our healthcare services. It has so far affected almost all aspects of human activity and in multiple and complex ways. This multiplicity and complexity generates conflicting issues that challenge rational approaches to knowledge creation. There are two key aspects that have influenced knowledge creation in this study: Firstly, is the transfer of knowledge from healthcare facilities to office facilities. The two workplaces are very different and often served by different academic and industry professionals, and yet the work done in this study has shown the importance of diverse disciplines sharing and transferring knowledge. This transfer of knowledge from one built environment sector to another is one of the important and original contributions of this report. Secondly, this report is not solely the transmission of knowledge from academics to practitioners. Much of the knowledge can be said to have been co-created from the dialogue between the Savile Row Projects' Steering Group and the UCLC team during three online video conferences. Creating knowledge by bridging the gap between academia and practice is an important contribution of this study.

We have identified seven key themes across the three areas of advice that investigated:

Vulnerability assessment and the workplace

COVID-19 requires the redefinition of vulnerability. Groups that we have considered as vulnerable in the past might not be as threatened as we initially thought. Equally, there are groups that would not have been considered as vulnerable in the past, but now need to be reconsidered. For example, children do not appear to be that vulnerable, compared to people who work in crowded spaces. Moreover, vulnerability might extend to members of families who are not adequately protected. Environments that until recently would have been considered as safe need to be revisited and adjusted. At the same time the economic pressure as a result of the various lockdowns makes these modifications a significant burden for employers and landlords. Therefore, the responsibility of supporting the health, safety and wellbeing of employees, particularly the re-evaluation of their particular needs, requires particular attention.

Employee mental wellbeing

COVID-19 has, for many people, taken away the pleasure derived from their work-environment. People might have enjoyed going to work and interacting with colleagues or enjoying amenities in their workplace that are now inaccessible to them. Under the current circumstances, affordances that enabled people to enjoy their work environments may no longer be available. Employee mental health may have been affected negatively during the lockdown, especially for people who have been in healthcare environments, suffer from anxiety or even from PTS. We know, for example from healthcare architecture research, how the environment can play an important role in supporting people’s mental health and contributing to their sense of coherence. The importance of the sallutogenic elements of our environments, i.e. those environmental traits that promote our sense of coherence and support our health and wellbeing, may therefore become an important part of the change process. Under the economic climate of the pandemic, investing in such elements might sound challenging, but worthwhile to avoid mental health problems causing persistent, serious and long-term effects. Providing psychosocially supportive environments should be considered to support people who are under immense pressure. Working from home may be an option for some, but not for everybody, nor for every job.

Interactions with surfaces

Contaminated surfaces pose a transmission risk that can rapidly spread the virus. SARS-CoV-2, the virus causing COVID-19, has been shown to survive and remain infective on surfaces for up to 3 days. High-touch surfaces, those that are touched frequently and by many people, pose the highest risk. This applies to surfaces in communal areas such as bathrooms, kitchens, printing facilities, lifts and staircases. In order to minimise the risk of transmission of spread via surfaces, it is imperative that these are cleaned thoroughly and frequently. SARS-CoV-2 does not require specialist cleaning products as it is easy to deactivate with detergents, disinfectants, bleach and alcohols.

During the pandemic, it is crucial that building occupants, facilities managers, and cleaning staff work together to address the risk that surfaces might pose. As well as a more thorough than usual cleaning regime, all staff need to understand SARS-CoV-2 transmission pathways so that they can adopt behaviours which will minimise risk. It is recommended that surfaces that are easily cleanable (smooth, non-porous) surfaces are used and soft furnishings are avoided where possible. There is a plethora of antimicrobial surfaces available on the market, however, their antimicrobial function tends to be quickly eroded due to build-up of dust, dirt and grease and frequent cleaning. Field studies in hospitals have shown them to be ineffective.

Building Services Systems

Whilst the available guidance from Public Health England (PHE) states that COVID-19 is assumed to be primarily transmitted through respiratory droplets or via contaminated surfaces, it is generally acknowledged that airborne transmission is also a route, particularly in poorly ventilated spaces. We have identified a number of operational and maintenance measures to be taken with ventilation systems and we provide the relevant operation and maintenance guidance available at this time. The overarching principle to mitigate the risk of airborne transmission of the virus is to enhance fresh air ventilation.

Behaviour change and trust

Many of the routines of organisations have been disrupted by lockdown and changing such engrained patterns of action, either purposefully or not, is never easy. Yet it is essential for a safe return to work during and after an epidemic. Employers, building owners and managers need to provide clear and compelling communication in order that new actions are understood and actioned. And this should be an ongoing activity as new information emerges over time. Varied forms of communication and training will help to reinforce actions such as frequent handwashing, no touch controls, social distancing, wearing of masks and so on for employees, visitors and especially for all the operational staff who conduct facility management services. Employees and all building users need to be able to trust that appropriate precautions have been implemented in order that they can work without undue risk to their health.

Economic costs

Operational costs to safely run office workplaces may need to increase during the pandemic, at a time when many businesses and employees are suffering economically as a result of lockdown. This represents a real challenge. However, limiting the spread of COVID-19 may require additional staff to control the flow of people at building entrances, stairways and lifts, and for additional, more frequent cleaning.

Offices worth the journey

Lockdown can be viewed as a social experiment testing home and remote working on a grand scale. For office workers with remote tools and good internet at home, plus space and time to concentrate, lockdown has reinforced the possibilities and benefits of home working, including time saved by not commuting. But the experiment has also clarified what is lost without face-to-face contact with colleagues. As buildings reopen, a new challenge is to ensure that journeys to work are worthwhile, that opportunities for teams and colleagues easily to connect are maximised, and that the workplace is the environment of choice for efficient, effective and pleasurable work.

Figure 1 has been developed to provide a clear, graphical image of some of the behavioural aspects of returning to work and the workplace.

Figure 1 - Behavioural summary chart

2 Acknowledgements

The main project contributors are listed below, although they have consulted significantly with colleagues with UCL, and offer thanks to all who have made an input.

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6 Introduction

This report explores multiple strategies and control measures for preventing or limiting the transmission of the SARS-CoV-2 virus in indoor office workplaces. It has been commissioned by Savile Row Projects Ltd to ensure that its work on the design, installation and operation of office interiors is executed in light of what is known about the disease. The study identifies and focuses on three areas of advice: clinical, behavioural and built environment.

Social distancing interventions during the COVID-19 outbreak have had an impact on reducing SARS-CoV-2 transmission across countries (J. Zhang et al., 2020). A recent modelling study addressing the non-pharmaceutical interventions needed in the post-COVID-19 outbreak has observed that sustained surveillance and temporary distancing measures may keep going long-term into 2022, even 2025 for possible infection recovery (Kissler et al., 2020). Limiting daily contacts resulting from physical distancing implementation has demonstrated its effectiveness in minimising the risk of SARS-CoV-2 transmission through airborne and ocular surface routes and person-to-person via small droplets. Enclosed spaces involving the associated indoor environmental quality and building characteristics is a major SARS-CoV-2 infection transmission risk (Qian et al., 2020). Therefore, we need to rethink how we share these environments. The different routes of virus infection transmission evidenced — airborne, close contact, fomite surface (Tellier et al., 2019) and ocular surface routes (Zhang et al., 2020)— have posed the indoor space adequacy as significant focus of SARS-CoV-2 transmission. Therefore, further protective measures are needed beyond hygiene practices and wearing of face masks; such as surface hygiene, building parameters and systems, contact tracing methods and testing. All of these need to be integrated as part of control strategies to face the COVID-19 outbreak in the workplace.

The perception of working in contagious high-risk environments and insufficient precautionary workplace measures predict poor mental health outcomes and post-traumatic stress symptoms (Brooks et al., 2018). Understanding how office layout and the ways people use shared spaces affects disease transmission could help in developing effective measures for when people get back to work and make them feel safe in their working environment as well.

Available knowledge on these matters is varied and emerging all the time. In this report, where there is knowledge resulting from research, we include the reference to the publication. When there is a suggestion, we have split it in two: suggestions that come from governmental guidance and suggestion from the industry. The former we call for the purposes of this study “top down” and tends to be what people should/must follow. The latter, we named “bottom up” and involves guidelines or suggestions that have been introduced by industry and which are likely to be implemented in practice. For both groups there is no hard evidence in such a short time, under lockdown. Equally, there are frequent changes in both top down and bottom up. In some cases, information may be contradictory, but chosen by those who propose it as a more realistic solution, either because it is easier to implement or because it helps people feel at ease. We have distinguished between them in the text.

The report is split into three main sections looking at interactions with surfaces, behavioural advice, and built environment advice. We have summarised the guidance in each of these sections. We close with a short summary. Appendix A sets out the methodology of the literature review.

7 Clinical advice

7.1 Surface interactions and virus viability

7.1.1 How do surfaces become contaminated?

Since the beginning of the COVID-19 outbreak in Wuhan Province, China, virus contaminated surfaces were identified as a route of transmission for SARS-CoV-2 (CDC, 2020). The surfaces can become contaminated by (Jiang et al., 2020):

- Large respiratory droplets settling directly onto them in the immediate vicinity of an infected person,
- Smaller respiratory droplets settling onto them having been moved some distance within a space,
- An infected person depositing mucus onto them after coughing onto their hand,
- Deposited mucus being moved around from one surface to another by touch and by inadequate cleaning.

We are still learning about the way that the virus is transmitted and there are many unknowns. Indeed, there is emerging evidence that airborne transmission does occur (Morawska et al., 2020, Kim et al., 2020, Shen et al., 2020), which links with thermal comfort and the impact of HVAC systems discussed in section 9.1.1 of this report. Furthermore, we do not yet know the infectious dose – the number of virus particles that someone must be exposed to in order to develop an infection. This is likely to be in the 10s or 1000s and to vary for different individuals. Without hard evidence, the assumption is that the risk of infection grows with more exposure to the more virus particles.

7.1.2 Virus viability on surfaces

A number of studies have been performed to investigate how long the virus remains viable, or capable of infecting human cells, on different surfaces. A study looking at various coronavirus types, including SARS-CoV-1 and MERS, but not SARS-CoV-2, showed these viruses could survive for up to 9 days on different surfaces (Table 1) (Kampf et al., 2020). A more recent study looking at SARS-CoV-2 viability in laboratory conditions showed that the virus particles remained viable for up to 3 days on stainless steel and plastic (Table 1). The virus also remained viable in air samples for 16 hours (Fears et al., 2020).

	SARS-CoV-2	SARS-CoV-1	MERS-CoV-1	HCoV
Air	16	>3	-	-
Paper	-	96	-	-
Cardboard	24	8	-	-
Wood	-	96	-	-
Copper	4	8	-	-
Glass	-	96	-	120
Ceramic	-	-	-	120
Plastic	72	216	48	144
Steel	72	48	48	120

Table 1 - Hours that human coronaviruses remain viable on surfaces. SARS-CoV-2 causes COVID-19; SARS-CoV-1 caused SARS outbreak in 2003; MERS-CoV-1 caused MERS outbreak in 2012; HCoV represents other human coronaviruses; "-"no data available. Data taken from Kampf et al., 2020 and van Dormalen et al., 2020, Fears et al., 2020.

Two recent studies have shown that virus genetic material was detectable on many surfaces in wards where infected patients were being treated and in air samples up to 4 m away from the infected person (Jiang et al., 2020, Zhou et al., 2020). However, the presence of the virus genetic material does not necessarily indicate that the virus is viable and infective.

A recent study by one of the report authors found that genetic material used as a surrogate for SARS-CoV-2 contamination in an outpatient ward spread from the bedrail of a patient isolation room to 41 % of surfaces tested within the ward within 10 hours (Rawlinson et al., 2020). This indicated a failure in hand hygiene and cleaning practice and highlights the importance of both.

7.1.3 Traditional and enhanced surface cleaning

SARS-CoV-2 is able to persist on surfaces and remain viable for some time, however, it is a relatively easy virus to inactivate. It is an enveloped virus, which means that soap and detergents disrupt the fat envelope and render the virus inactive. However, the detergents and soaps must be used as instructed by the manufacturer to achieve a high enough concentration. A recent study has shown that a low concentration of hand soap was not able to inactivate the virus after 5 minutes, but was successful after 15 minutes (Chin et al., 2020).

Alcohol, in the form of ethanol or propanol, have both been found to inactivate human coronaviruses successfully at high concentrations of over 60% (Kampf et al., 2020; Chin et al., 2020). Similarly, household bleach containing the active ingredient sodium hypochorite was also able to inactivate SARS-CoV-2 at concentrations as low as 1% (Chin et al., 2020). The common disinfectants chlorhexidine and benzalkonium chloride, contained in many household cleaning products such as surface wipes, have also been found to be effective against human coronaviruses at concentrations as low as 0.1% (Chin et al., 2020).

Globally, a number of organisations have released lists of products suitable for inactivating SARS-CoV-2:

- The United States Environment Protection Agency has published a list of recommended agents for cleaning during COVID-19 (https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2)
- The European Centre for Disease Prevention and Control (ECDC): (https://www.ecdc.europa.eu/sites/default/files/documents/coronavirus-SARS-CoV-2-guidance-environmental-cleaning-non-healthcare-facilities.pdf)
- Public Health England (https://www.gov.uk/government/publications/covid-19-decontamination-in-non-healthcare-settings/covid-19-decontamination-in-non-healthcare-settings)

As the virus is inactivated by cleaning products used by cleaning contractors, it is not necessary to make any changes to cleaning products. Some premises have opted to use cleaning agents that are specifically antiviral as well as UV light and fogging or misting. While these are beneficial in the healthcare setting where they are routinely used by trained staff and where contamination is known to be high, little benefit will be gained by bringing these practices into the office setting. The real benefit will come from implementing more frequent thorough cleaning regimes using the products already employed.

Globally, a number of organisations have published guidance for good cleaning practice during COVID-19 that is effective for eliminating SARS-CoV-2:

- The UK Government has produced some guidance on good cleaning practice in non-healthcare facilities: https://www.gov.uk/government/publications/covid-19-decontamination-in-non-healthcare-settings/covid-19-decontamination-in-non-healthcare-settings.
- The ECDC has also published guidance on the cleaning of non-healthcare settings: https://www.ecdc.europa.eu/en/publications-data/disinfection-environments-covid-19

- The US Centres for Disease Control have provided guidance for the cleaning of community settings: https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/cleaning-disinfection.html.

It is important for the facilities managers to identify contamination hotspots on high-touch surfaces and implement more frequent cleaning regimes for these sites. These will include shared spaces such as bathrooms, kitchens and meeting rooms. They will also include specific surfaces such as lift buttons, card swipers, printers, shared keyboards and mice, etc. These surfaces will vary depending on how the space is used and the business carried out and will need to be developed for each individual premises.

Furthermore, it is paramount that the office staff understand the transmission routes of SARS-CoV-2 so that they implement changes in behaviour to avoid spreading the virus.

7.1.4 Surface materials

SARS-CoV-2 is 50-200 nm in diameter and will be carried in the air in respiratory droplets smaller than 1 μm. Such droplets can settle onto surfaces. Surface topography is very different from a microscopic point of view to what we see with the human eye. Many surfaces which seem smooth with the naked eye are intricate and rough when viewed at the microscopic scale.

When it comes to avoiding the transmission of SARS-CoV-2 and other pathogens, the first consideration when thinking about surfaces is whether they are easily cleanable. Surfaces can be classified as hard and soft; porous (rough with holes) or non-porous (smooth without holes). The most easily cleanable surfaces will be hard and smooth; the least cleanable surface will be soft and porous (Detry et al., 2010). During COVID-19, it is advisable to remove soft furnishings where possible, or used soft furnishings that can be easily and frequently laundered. Furnishings made of glass, steel and hard plastic are easily cleanable and durable. It is also best to avoid surfaces with too many intricate folds, joins and spaces that dirt and microorganisms could get into.

The surfaces themselves can be coated with a material that somehow modifies their function. There are many antimicrobial products on the market – e.g. antimicrobial paint, textiles, coatings, etc. These products have shown to be effective in laboratory tests carried out on a selected number of microorganisms, as specified in the marketing materials. However, the real world is quite different from laboratory tests. For example, microorganisms grown in the lab and then applied to a surface will respond differently when they are suspended in mucus than when they are in growth media. A study performed on hospital bedrails showed that soil (i.e. dirt, grease, mucus) applied to the surface with microorganisms rather than the surface material itself resulted in lower levels of cleaning efficiency (Ali et al., 2012). The healthcare sector has assessed the effectiveness of such materials, however, very few have been adopted widely, indicating that they did not have an impact on the number of cases of infections as demonstrated by a systematic review (Muller et al., 2016).

There is some evidence that titanium and silicon oxide coatings can make some materials more easily cleanable (Houmard et al., 2011, Verran et al., 2010). This may incur a higher cost, and there is no specific evidence to show that the cost is worthwhile. Copper has also been demonstrated to provide a good antimicrobial effect on many pathogens (Muller et al., 2016), however it is costly.

A recent study by one of the report authors investigated the microbial contamination of over 50 surfaces in an outpatient hospital ward. The results showed that many factors are likely involved in how clean, or indeed dirty a surface may be. These include the surface material, but also the behaviour of staff and patients, and the perceptions of staff and cleaners (Rawlinson et al., 2019). Surface contamination and cleaning is a complex issue and cannot be solved by technology and design alone.

7.2 Spatial distribution of SARS-CoV-2 and intra-building transport

Virus-laden aerosol particles (< 5-10 μm in diameter) – expelled from normal breathing, talking and coughing activities (Lee et al., 2019; Asadi et al., 2020) both symptomatic and asymptomatic individuals (Zou et al., 2020) – can remain with long viability for up to 16 hours in the airborne (Van Doremalen et al., 2020; Fears et al., 2020) and travel long distances up to two meters in indoor environments from the infected individual (Santarpia et al., 2020). However, last studies indicate that the spatial distribution of SARS-CoV-2 aerosol may reach up to 4 meters of distance in rooms (Guo et al., 2020). Indoor environmental conditions and activity-related behaviour patterns can contribute to the intra-building transport and resuspension of SARS-CoV-2 particles:

- First, turbulent eddies in indoors due to movement patterns –foot fall, walking, and human thermal plumes– can influence on airflow patterns of SARS-CoV-2 droplets (Ong et al., 2020). Studies based on aerosol dynamics simulation in enclosed environments addressing the walking activities on infectious agent transmission and dispersion shown that: a) human movement may increase the infection risks by > 50% of the occupants in the same room (72 persons in a space of 68.85 m^3) (Han et al., 2014); b) walking may origin the downward transport behind the human torso and so, the fall down of suspended aerosol particles on surfaces and ground (Han et al., 2014); c) Normal walking (1.0 m/s) through a contaminated aerosol cloud may increase the aerosol particle levels in the breathing areas of the occupants seated in front (between 3 rows, a distance of approximately > 2.40 meters adopting airline seats of average 79 cm) and back (1 row of seats) the contaminated region, and so the average infection risk of those occupants (Han et al., 2014). The distance of 2-row rule for infectious agent transmission zone provided in the Centers for Disease Control and Prevention guidelines could not cover the risk of infection (Hertzberg and Weiss, 2016). Therefore, the preventive distancing between indoor walkability/traffic flow pathway (from the office entrance) and workstations and other siting areas should be applied in the spatial distribution and demarcated on surfaces and floors.

- Secondly, experiments based on multiphase turbulent gas cloud model have shown that the exhalations, sneezes, and coughs under specific environmental conditions (humidity, temperature and airflow) can contribute to the droplet half-life prolonged by a factor of up 1,000 and transport longer distances between 7-8 meters. So, SARS-CoV-2 droplets can settle on surfaces while others are floating over the moving cloud (Bourouiba, 2020).
- Thirdly, asymptomatic individuals who loud talk in an enclosed environment can generate 1,000 viral-containing droplet nuclei (4 μm in diameter) which mean between 8 and 14-min SARS-CoV-2 contaminated airborne that can reach the lower respiratory tract, suggesting that normal speech droplets could also contribute to the virus transmission. Due to their small size, these droplets can reach the lower respiratory tract and generate a new SARS-CoV-2 infection in a stuffy environment (Stadnytskyi et al., 2020).

7.3 Prevention and protective measures to control SARS-CoV-2 transmission

7.3.1 Hand hygiene practices

A rapid systematic review comparing the effectiveness of using ash for hand-hygiene against other materials including soap or mud to reduce the viral and bacterial transmissions found inconclusive results (Paludan-Müller et al., 2020). Similarly, chlorhexidine gluconate-based antimicrobial soaps for hand-cleaning have not provided more reduction of infections compared with materials including non-antimicrobial soap, triclosan and alcohol-based products, and also its use was associated with cutaneous reactions (Baraldi, et al., 2019).

Although the use of water and soap is the gold standard for handwashing, the alcohol-based sanitisers, mainly 62-95% n-propyl, isopropyl, ethanol-based products or combination, have become a first-line effective measure for virus prevention during COVD-19 period (Jing et al., 2020). Ethanol (60% - 82%) has been evidenced to be more effective than isopranol (60%-80%) and n-propanol (60-80%)-based sanitisers against SARS-CoV-2, even at low concentrations, as 42.6% was able to deactivate the virus by the phospholipid bilayer lysis, and moreover it produced less skin irritation (Jing et al., 2020).

However, recurrent hand-cleaning habits as preventive practice in response to COVID-19 outbreak may cause skin irritation and hand dermatitis associated with the exposure to irritant and antimicrobial detergents and disinfectants (Beiu et al., 2020; MacGibeny and Wassef, 2020). It has been shown that instant hand wiping via a wet towel soaked in water --consisting of 1% soap powder and 0.25% active chlorine from sodium hypochlorite-- can eliminate more than 98% of the coronavirus from hands in a safe way for skin (Ma et al., 2020).

7.3.2 Hand sanitisers

Quality and formula composition of commercial products as well as used techniques for hand hygiene need to be reviewed and analysed towards improvements in hygiene recommendations (Berardi et al., 2020; Emami et al., 2020; Schrank et al., 2020). Efforts to avoid those hand sanitisers containing undeclared products such as methanol acquired in the market which can exposure high risk of systemic toxicity among users should be priority in occupational settings (Chan and Chan, 2018). Indeed, significant differences in the effectiveness of using European standards certified hand sanitisers for the bacterial load reduction compared with those non-certified products have been found (Babeluk et al., 2014).

7.3.3 Face masks wearing

Although face mask wearing is recommended, filtering capacity of the face masks for SARS-CoV-2 is unclear. A recent experimental study comparing the filtering effectiveness of surgical masks with reusable cotton masks shown that none of these masks had a filtered adequate during infected individuals' coughs (Bae et al., 2020). This can be explained according to viral load concentration and aerodynamic size of aerosol droplets and particles. The surgical masks can reduce respiratory virus-containing aerosol droplets but not block the aerosol particles ≤ 5 μm from breathing (Leung et al., 2020). Further, the filter tests for surgical masks have evidenced that these do not reach the expected protection against droplets of size 0.9, 2.0 and 3.1 μm (Oberg and Brosseau, 2008) and particles between 0.04 and 0.2 μm in diameter (Lee et al., 2008). It has been observed that the filter performance of non-medical face masks with non-woven fabric material and three layers for blocking aerosol droplets >28 μm in diameter can reach similar values of filtration efficiency compared to medical face masks (Amendola et al., 2020). In contrast, although homemade masks made of cotton were able to block specially the largest droplet sizes, the filtration efficiency was three times lower than surgical masks against virus (Davies et al., 2013).

Inappropriate use of face mask leads to virus transmission, despite preventive measures, both before putting on and after wearing the face masks; as well as during routine decontamination using products used for reusable masks (Desai and Aronoff, 2020). Importantly, the use of decontamination techniques that are non-abrasive physically or chemically, such as steam over boiling water, are needed to preserve the filtration efficiency of face masks (Q. Ma et al., 2020).

7.3.4 Contact tracing and testing

Isolation, followed by tracing contacts, both symptomatic and asymptomatic, seems successful in the COVID-19 outbreak outcome (Valent et al., 2020) compared with case-finding and isolation of symptomatic subjects alone (H.-Y. Cheng et al.,2020). The mode of symptom-based surveillance has shown to detect mostly symptomatic infected individuals and in the timing of 5.5 days after incubation period while the contact tracing-based surveillance reduced this period by approximately 3.2 days and detected by 20% of the group being asymptomatic (Bi et al., 2020).

Recent predictive models have evidenced that: a) the viability of contact tracing and isolation as a control measure of SARS-CoV-2 found that this combined approach alone might not be sufficient to contain COVID-19 re-outbreak during next three months (Hellewell et al., 2020); b) mass self-isolation in high-practicability settings (> 75% of infected subjects in quarantine) compared with active monitoring of contacts has shown to have similarly effective capacity and contribute in a co-adjuvant pathway with physical distancing to mitigate the COVID-19 spread (Peak et al., 2020); c) physical distancing needs to be accompanied by the implementation of general testing and contact tracing measures to strongly increase impact on spread reduction (Giordano et al., 2020).

The application of SARS-CoV-2 serological analysis –such as PCR diagnostic and IgG serology tests– could assist in tracing the virus transmission and monitoring in a rapid and effective manner (Marcel et al., 2020; Okba et al., 2020; Yong et al., 2020) and in turn, mobile phone applications-based tracing may help to reduce the frequency of testing and long-term individual quarantine (Peto, 2020).

8 Behavioural advice

8.1 Return-to-work effects on psychological and mental health outcomes

8.1.1 Return-to-work during the lock-down and the post-COVID-19 era

The daily routine disruptions during the outbreak of the COVID-19 pandemic is having a strong psychological impact on general community who are living under confinement and restricting movements (Brooks et al., 2020). People who had been quarantined facing other coronavirus outbreaks reported a high prevalence of symptoms of psychological distress and disorder such as emotional disturbance, depression, stress, low mood and post-traumatic stress (Brooks et al., 2020).

Indeed, people who continued to work at the office or at home during the COVID-19 outbreak had better mental health and life satisfaction and suffered less psychological distress than those who stopped working one month into the lock-down (Zhang et al., 2020). Even workers who worked from home reported more limitations related to physical and emotional issues than those who worked in their offices (Zhang et al., 2020). Research shows that having contact with people that do not reside in the same indoor space is related to more psychological distress, but less loneliness, so personal resources also seem to be relevant for psychological well-being during the lock-down period of COVID-19 (Losada-Baltar et al., 2020)

Returning to work has been proposed as a relevant part of the psychoneuroimmunity preventive strategies, but the workplace can become a highly contagious setting for the SARS-CoV-2 infection transmission (Kim & Su, 2020). It has been reported that organisational resources including the workplace hygiene practices and concerns for staff from the company is associated with less anxiety, depression and psychological distress as well as less severe psychiatric symptoms for its workers (Tan et al., 2020). Overall, these measures can contribute to the experience of returning to work being as tolerable as possible for people, ensuring a feeling of job security in their employment.

8.1.2 Organisational measures to reduce psychological distress

Workplace mental health guidelines – both national and international – provide a series of recommendations with an integrated approach, encompassing advice at both organisational and a personal level to minimise risk factors, promote positive factors and primary prevention. However, most of them are focused on the detection and treatment of mental health concerns rather than on protection and prevention in the workplace and practical tools for its implementation (Memish et al., 2017).

Based on the comprehensive quality assessment of twenty international workplace mental health guidelines from Memish et al. (2017) across items and key domains, the findings were analysed to extract the list of best-practice workplace guidelines. The criteria for inclusion were focused on those descriptive elements and domains which strongly involve practical recommendations for employers and decision-makers. Guidelines were selected that were associated with the highest overall scores of the guideline quality and integrative approach for the practice. These guidelines met the following criteria:

- They had recommendations for the organisation to minimise risk factors and provided practical line of action; as well as
- A score higher than 50% -adopting the Canadian academic assessment cut-offs scores (Dewa et al., 2016)- for the applicability domain.

The latest version of each selected guideline was also searched and retrieved. Results were as follows:

- Psychological health and safety in the workplace – prevention, and guidance to stages implementation (Mental Health Commission of Canada, 2018) from Canada;
- Heads up: a guide for employers and employees from Australia; Managing the causes of work-related stress: a step-by-step approach using the management standards (Health and Safety Executive, 2007),
- Tackling work-related stress using the Management Standards approach: a step-by-step workbook (Health and Safety Executive, 2019) from the UK; and Psychological risk management excellence framework (PRIMA-EF Consortium, 2008) from the EU.

The guideline with the highest overall score regarding the quality and integrative approach for the organisational practice *'Psychological health and safety in the workplace – prevention, and guidance to stages implementation'* (Mental Health Commission of Canada, 2018) – indicates that the key common elements of the four selected guidelines have been collected and are presented as a summary in table 2.

Key elements	Description	Tools and resources
A. COMMITMENT, LEADERSHIP AND PARTICIPATION		
(a1) Secure commitment ***(a2) Establish a steering group*** ***(a3) Develop a communication strategy*** ***(a4) Develop organisational policy***	Incorporation of a systematic strategic development for managing psychological health and safety programme into existing policies. Reinforce the sustainability of programme based on ethical values. Active participation of stakeholders and support engagement of employees in all process stages.	**For leaders and representatives** Practical steps to build accountability and effective communications. Initial steering group meetings: senior management and employee representative(s), health and safety, human resource and occupational health manager(s). **For employees** Action plans to help outline strategies, expectations and tips. Meetings for initial explanations.
B. ACTION PLANNING		
(b1) Identification, preliminary analysis ***(b2) Evaluate the risks*** ***(b3) Develop an action plan*** ***(b4) Managing practice changes***	Hazard identification, preliminary action plans to achieve compliance with legal regulations, assessment for level of risk. Control and implementation of stepwise iterative mitigation process, including protective measures, modifications of organisational practices. Link the potential concerns to developing and agreeing solutions.	Effective and user-friendly practical tools and methodologies. Assessment tools: *Stress Management Competence Indicator Tool, Guardian Minds @ Work*. Focus groups (6-10 individuals); routine and/or informal talks (i.e. *HSE's talking toolkit*); performance appraisal. Self-reported and questionnaire-based surveys for larger organisations (i.e. *The HSE Management Standards Indicator Tool*). Digital survey method, telephone interviews, face-to-face interviews, or combination. Data sources including administrative data (rates of absenteeism, turnover, long/short-term disability), worker engagement indicators, productivity data.
C. IMPLEMENTATION		
(c1) Sustainable Infrastructures ***(c2) Preventive and protective resources*** ***(c3) Knowledge, training and communication***	Provide infrastructure and knowledge of psychological health and safety into management systems. Implement preventive and protective measures to reduce the risks (use of personal protective equipment) and resources to respond mental wellbeing impact. Provide information about factors, planning and action processes and ensure communication to all workplace parties. A timescale fitting the implemented solutions.	Consideration of specialised external supportive structures (experts, consultants, research); training programmes for key personnel. Incorporate and review guidelines, reports and investigations. Active involvement of staff and steering group in meeting, discussions, effective communication. Website with case-studies, multiple resources, programmes and tools (*www.workplacestrategiesformentalhealth.com*) Monitoring through the follow-up of questionnaire-based surveys.
D. EVALUATION AND MONITORING		

(d1) Monitoring and measurements ***(d2) Internal audits***	Performance monitoring and qualitative/quantitative measurements to determine whether targets are being met. Provide data, analysis and results to determine whether interventions are successfully operating. Action procedures to ensure the effectiveness of interventions and prevent recurrence of hazards.	Opinion survey results via digital or printed questionnaire (for larger organisations). Informal talks, meetings, or combination of evaluation methods. Disability claim statistics. Investigation outcomes. Internal audit group. Baseline assessment of psychological risk factors and environmental and physical determinants, return-to-work programmes.
E. MANAGEMENT REVIEW		
(e1) Detailed review and analysis ***(e2) Up-dated review process***	Maintain and up-date a scheduled management process including aims, action plans, assessments, key outcome data, review of findings and reporting requirements.	**Continual improvement process:** Repurposing/refreshing existing tools and resources for improvements. Supplementary training. Spotlight success stories; discussion of learned lessons. Programme summary and workplace reporting through communications: briefings, intranet bulletin, email, notice boards.
HSE, Health and Safety Executive. *The latest versions of the selected guidelines were revised based on the established eligibility criteria.*		

Table 2 - Summary of key common organisational elements of four selected guidelines for prevention and management of mental and psychological problems in the workplace.

8.2 Behaviour patterns and control measures

8.2.1 Social distancing

- WHO has prescribed maintaining a social inter-personal distancing of 1.5 or 2m (about 6 feet), even though recent publications highlight that this distance does not count the transport of aerosol droplets, and the effective protection distancing can only be achieved by using face masks in daily life activities (Nexø et al., 2018)

8.2.2 The 2m distance guidance

- Use of the recommended 2m guidance in rooms with shared amenities, such as printing rooms, kitchen, coffee/ tea island. The 2m radius could be used as a guide around a central point, so that it is possible to see on the floorplans the minimum safe working space each individual needs, the workspace that can be occupied, and that which cannot be occupied due to this restriction. [Bottom up]

8.2.3 Training and communication

- Engage with workers and representatives to explain and agree any working arrangements and make sure they are kept up to date with safety measures. [Top down]
- Train workers to the new protocols so that they are alert, but also feeling more confident that their working environment is safe. [Top down and Bottom up]
- Communicate to staff the steps that are going to be taken to protect them, as well as behavioural changes needed to keep everybody safe. [Top down and Bottom up]

8.3 Employer, equality and response plan

An employer has the legal responsibility to protect workers and others from risk to their health and safety, and has a duty to consult his people on health and safety and involving them in decision making. By that action employers show that they take their employees' health and safety seriously [Top Down]. The following should be considered:

- Flexible working hours to avoid rush-hour gatherings at bottle-necks such as lifts and access control points should be encouraged. [Top Down]
- Return people to work gradually, so that there is time available if needed to adjust space and protocols after first workers' initial return. [Bottom up]
- Equality: Making reasonable adjustments to avoid a) disabled workers being put in a disadvantage and b) having unjustifiable negative impact on some groups compared to others. [Top down]
- Response plan: Develop and agree a response plan in case someone at the office becomes ill with symptoms of COVID-19. It is recommended that the plan at least includes: a) an identified room where someone who is feeling unwell can be safely isolated and b) a way to that person can be safely transferred from the office to a health facility. How to respond in case a staff member or visitor is tested positive for COVID-19 should also be planned for (WHO, 2020 a).
- Hand hygiene practices: Comprehensive systematic reviews have evaluated the effectiveness of hygienic practices such as handwashing as personal protective measure to reduce the risk of virus transmission other than SARS-CoV-2 (Jefferson et al., 2011). Meta-analysis of case-control studies concluded that handwashing more than 10 times daily can prevent SARS virus spread (Jefferson et al., 2008). Contrarily, recent meta-analysis of randomised clinical studies evaluating the effect of handwashing (with and without face mask) on influenza virus infections in non-healthcare settings found no

statistically significant result on influenza transmission (Xiao et al., 2020). However, hand-hygiene interventions in office-based workplaces have shown that alcohol-based hand sanitiser is an effective measure to denature respiratory viruses, but hand-cleaning with soap and water may be more effective against gastrointestinal bacterial and viral pathogens than respiratory viruses (Zivich et al., 2018).

- The correct use of the EN1500 technique of hand-cleaning results in high decreasing of pathogens, therefore, delivering training on this routine hand hygiene practice can be a potential tool to minimise infectious transmissions (Babeluk et al., 2014; Hillier, 2020). This has been demonstrated to have an impact on hand hygiene behaviour among employees receiving educational programme in the office workplace (Thompson and Rew, 2015; Arbogast et al., 2016). Importantly, facilitating hand hygiene infrastructure in strategic locations has shown to enhance the adherence to hand-cleaning practices by influencing positive social pressure (White et al., 2020).
- Face masks wearing: A combined approach of face mask-wearing and hand hygiene practices has shown to be more effective than same measures used separately against virus spread (Wong et al., 2014; Ma et al., 2020). Regions where the general public adopted the use of face-masks early, such as Hong-Kong, the COVID-19 incidence was lower compared with those locations where was not a preventive measure at the initial period of outbreak such as Italy, Spain, France, United Kingdom and the United States (Cheng et al., 2020). A study modelling the face-mask usage of symptomatic individuals compared with the extended usage for general public –including also asymptomatic individuals and non-infected ones – found that universal use of the masks may contribute to COVID-19 spread control (Eikenberry et al., 2020). Additionally, research has suggested the adoption of wearing face masks both for the safety and protection of those essentials workers who cannot perform their daily job at home and universal public use to return-to-work at indoor spaces during COVID-19 (Cheng, Lam and Leung, 2020; Gandhi and Havlir, 2020). The alternative resource of cloth masks to surgical masks for general public is supported by the research community (Esposito et al., 2020). Moreover, face mask wearing can avoid self-inoculation route of SARS-CoV-2 transmission as individuals' face-touching behaviour is a habit leading to this action 3 times per hour on average for eye and nose and 4 times for mouth (Kwok et al., 2015; Cornell guidance). However, some considerations should be regarded: the continuous use of face masks for several hours daily can cause pressure, frictional forces and shear, moisture and heat on facial tissue, leading to skin injuries which may result in SARS-CoV-2 infection in turn (Gefen and Ousey, 2020; Recalcati, 2020). Although a prolonged period of time wearing face masks

has not resulted in significant physiological changes, it has been shown that due to the increased inhaled carbon dioxide concentration. individuals can experience symptoms such as increased shortness of breathing, headaches, feeling tired and difficulty communicating (Rebmann et al., 2013; Sinkule et al., 2013).

- Contact tracing and testing: The manual or app-based tracing of all contacts of a person affected with COVID-19, combined with self-isolation could reduce virus transmission when combined with limitation of daily contacts in work settings to 10-20 individuals and < 10 contacts, respectively (Kucharski et al., 2020). Indeed, an original study assessing the worker interaction on different floors in a commercial office building and the SARS-CoV-2 spread found that high-density work environments have a high-risk of transmission by contact route, suggesting strategies of tracing and testing of all contacts, and then early self-isolation to achieve a sustained virus control in the workplace (Park et al., 2020). Another modelling study combining different non-pharmaceutical strategies – self-isolation, tracing and testing measures and physical distancing – on UK population and demography resulted contact tracing and testing to be more effective in reducing SARS-CoV-2 transmission than mass testing or self-isolation alone, by 50-60% compared with 2-30% (Kucharski et al., 2020).

8.4 Preparing buildings to return-to-work

8.4.1 While you are away (before returning to work):

- Serosurveillance and antibody testing at the individual and community level could provide more safety for decision-making to return-to-work among workplace members (Jacofsky et al., 2020; Krsak et al., 2020).
- Provide comprehensive cleaning and disinfections to maintain the building readiness [Bottom up]
- Monitor and maintain each building's indoor air quality system [Bottom up]
- Strategically install touch-free hand sanitisers stations throughout the buildings (for example at the reception area, elevators, common areas, outside and inside restrooms, workstations) [Top down and Bottom up]
- Prepare and install strategically signage that provides guidance/instructions on hygiene and social distancing [Top down and Bottom up]
- Maintain Fire Life Safety procedures and drills by including social distancing measures. [Bottom up]

8.4.2 Journey to work

- If workers arrive by public transport, hand sanitiser should be used before entering the building. [Top Down]
- Provide additional parking or facilities such as bike-racks to help people walk, run or cycle to work, where possible. [Top Down]
- In case of corporate vehicles (such as minibuses), limit passengers and avoid sitting face to face. Pay attention to increase ventilation when possible and clean shared vehicles between shifts.
- Regular cleaning of vehicles that workers may take home. [Top Down]
- Staggering arrival and departure times at work to reduce crowding. [Top Down]
- The use of face masks into closed public transport vehicles is recommended. (Liu and Zhang, 2020)

8.4.3 Detection before entry into a workplace

- Capturing employee temperatures, via infrared camera, to determine who can access the building. [Bottom up]
- Establishing entry procedures for the workplace, including temperature re-checks, mandatory face masks and hand sanitiser use. [Bottom up]
- Documenting those with the infection. [Bottom up]

8.4.4 Entering the building

- Leave entry doors open to minimise touchable spaces. [Bottom up]
- Have more entry points to workplace if possible and introduce one-way flow at entry and exit points. [Top down]
- Provide building access guidelines for employees, visitors and vendor change. [Bottom up]

8.4.5 Delivering goods.

- Delivering goods and food only to lobby areas and not to office floors. [Bottom up]
- Restrict non-business deliveries, such as personal deliveries to workers. [Top Down]
- Minimise contact during payments and exchange of documentation, by using electronic payment methods and electronically signed instead. [Top Down]

8.4.6 Visitors

- Encourage visitors to remote connection/working where possible. In cases where this is not feasible and a site visit is required, site guidance on social distancing and hygiene office protocols should be explained to them before arrival. Also, is it important to limit the number of visitors per hour and maintain a record of the visitors [Top Down]
- Provide handwashing facilities when possible or hand sanitiser at entry/exit points without using touch-based security devices, such as keypads [Top Down]

8.4.7 Elevators

- Elevator lobbies **-** Have clear signage to emphasise the importance of distancing, hygiene, and sanitation. Signs on the floor where to stand and wait [Bottom up]
- Make sure people with disabilities can access lifts [Top down]
- Use touch-free sanitisers before entering the lift [Top down]
- Reduce maximum occupancy of lifts [Top down]
- Encourage use of stairs where possible. Perhaps recommending the use of lift to go up only [Top down & Bottom up]
- Use of key card readers for manoeuvring the lift is recommended. [Bottom up]
- Program lifts to open automatically to avoid touching call buttons. [Bottom up]

8.4.8 Reception area/Lobby

- Use of distance reminder floor stickers. Hygiene guidelines signage. [Bottom up]
- Put a Plexiglas shield for the concierge. [Bottom up]
- Keep touch-free sanitiser and wipe dispenser at the reception area. [Bottom up]
- Clearly mark the waiting area. [Bottom up]
- Lobby furniture should be re-arranged or removed to support social distancing. [Bottom up]

8.4.9 Common areas/lounges

- Reduce occupancy keeping in mind seat-to-seat distancing and the 2m distance guideline. [Bottom up]
- New lounge settings with appropriate seating signage and max people capacity at each space. Keep touch-free sanitisers along with wipe dispenser at lounges. [Bottom up]

- In case of multi-tenant sites/buildings, ensure consistency across common areas such as staircases and receptions [Top Down]

8.4.10 Work booths

- Although initially designed for close collaboration, now will have to be limited to one person per booth. As a shared workspace, wipe dispensers is recommended to be placed nearby so that members can clean surfaces before and after use. Appropriate signage should be placed nearby as friendly reminders of new capacity and hygiene standards [Bottom up]

8.4.11 Workstations

- Decrease the use of open workstations with no screen divisions. [Bottom up]
- A workplace scenario planning should be adopted (showing the new working positions that could be occupied), so as to help in the creation of a phased return-to-workplace strategy. [Top down and Bottom up]
- Should be assigned to an individual and not be shared. In case this is not possible, should be shared to the smallest number of people. Only where it is not possible to move workstations further apart, using screens to separate people from each other. [Top Down]
- Avoid use of hot desks and spaces such as call centres or training facilities. [Top Down]
- Use green markers to limit desk usage and maintain social distancing. [Top Down]
- Recommend to employees to not share desks, offices and equipment when possible. That way employees can be confident that their space is maintained, and they do not rely to others to follow cleaning protocols. [Bottom up]

8.4.12 Pantries and coffee islands

- Touch-free soap dispenser along with hygiene guidelines signage at the sink. [Bottom up]
- Solutions such as single-use cups and cutlery are recommended. [Bottom up]
- Seating should be modified to reduce capacity and heavy foot traffic Use of markers and signage with seating positions available. [Bottom up]

8.4.13 Canteens

- Reconfigure seating and tables. [Top Down]
- Provide packaged meals where possible to avoid fully opening staff canteens. [Top Down]
- Encourage workers to bring their own food. [Top Down]

- Access to a food outlet in a high-rise building could be adopted, so as to reduce the need for people to go outside. [Bottom up]

8.4.14 Print stations

- Maintain the cleanliness of this commonly used space, by using wipe dispensers, hand sanitiser, and office hygiene protocols signage at every print station. [Bottom up]

8.4.15 Phone booths

- Increase the availability of private phone booths, where workers can take a video call away from their offices. [Bottom up]
- Routine cleanings will take place frequently throughout the day and wipe dispensers will be placed nearby. [Top Down and Bottom up]
- Provision of wipes and touch-free sanitisers allowing members to clean surfaces before and after use. [Top Down and Bottom up]
- Signage will be placed in phone booths encouraging good hygiene and post-COVID-19 rules. [Top Down and Bottom up]

8.4.16 Meeting rooms

- Decrease high density, unassigned meeting rooms and spaces. New capacity guidelines will need to be posted at entrances (clearly stating max capacity per room) and recommended seating arrangements could be placed on tabletops. [Top Down and Bottom up]
- Use stickers on table to mark which seats can be occupied and floor signage to help people maintain social distancing. [Top down and Bottom up]
- Only absolutely necessary participants should attend meetings and maintain 2m separation throughout meeting. [Top Down and Bottom up]
- Avoid sharing pens and stationery. [Top Down]
- Additionally, office hygiene protocol could be displayed on TV monitors in the meeting room. [Bottom up]
- Wipe and sanitiser dispensers should be located nearby, in the room and before entering. [Top down and Bottom up]
- When possible, meeting rooms is recommended to be positioned closer to the entrance so as to minimise guest exposure. [Bottom up]

- Consider ways to improve air exchange to enhance air quality. [Bottom up]

8.4.17 Shared spaces

- Modifying shared spaces with staggered seating and buffer zones, so that teams can continue to operate in the workplace while still maintaining the required physical distance from their colleagues. [Bottom up]

8.4.18 Circulation spines

- Reduce movement by discouraging non-essential trips to buildings and sites. [Top Down]
- Conduct a visibility analysis using Space Syntax to determine the optimal locations for sanitising stations and identify less integrated corridors for traffic flow redirection. [Bottom up]
- Reduce job and location rotation, so as to minimise foot traffic. [Top Down]
- Adopt a one way only approach for circulations and indicating this with stickers/signs. [Bottom up]
- Directing office foot traffic, staging areas for elevators. Colour coding on the floors can be used so as to help where you walk and where you don't walk. [Bottom up]
  Although human walking at workplace may contribute to the airborne SARS-CoV-2 transmission, lifetime of infectious agent-containing droplets and longer remaining in the airborne seems to be strongly dominated by the indoor environmental conditions, especially the air quality (ventilation rate, air exchange and filtered systems), temperature and humidity. Beyond the use of face masks, intra-building transport and infiltration of aerosol particles might be also managed across short bursts of walking in a routine way at different timeslots for each office-based worker.

8.4.19 Storage

- Reduce the use of shared storage areas and unassigned lockers. [Bottom up]
- Avoid placing bags and personal belongings on the floor. [Bottom up]
- Regulate the use of locker rooms, changing areas and other facility areas to reduce concurrent usage. [Top Down]

8.4.20 Furniture

- Increase the size of primary work surface to create distance between co-workers. [Bottom up]
- Use back to back or side to side working (rather than face to face) where possible. [Top Down and Bottom up]
- Replace work surfaces with non-porous material and seamless edges. [Bottom up]
- Replace soft seating with hard tables and chairs that can be easily cleaned. Textiles such as antimicrobial, vinyl, copper infused textiles are also recommended. [Bottom up]
- Free-standing, hard surface space dividers in high density areas are recommended. [Bottom up]
- The use of tall laminate gallery panels to the end of each row of workstations or benching stations is suggested. [Bottom up]
- Replace arm caps on conference chairs with materials which are antibacterial and easy to clean. [Bottom up]
- Use of materials that are easy to clean and bleach cleanable. Preferable use of non-porous hard surfaces, antibacterial and antimicrobial. Avoid the use of products with a lot of seams or metal folds.
- Healthcare materials and surfaces should be applied to office products. [Bottom up]
- The use of bleach cleanable products that meet the office design aesthetics is recommended. [Bottom up]
- Add around 60 cm height surface screen to base panel to act as cough/sneeze barrier and allow privacy, ideally in a hard, cleanable material such as laminate or glass [Bottom up]
- Add tall divider screens between people when seating in a row from durable material or use upper storage (on desks) for separation between people (from around 1.27 m to 1.83m, standing height barrier) off the floor. [Bottom up]
- Remove all shared storage and replace with tall laminate gallery panel to the end of each row of furniture that is open with no pulls, or tall lockers assigned to individuals [Bottom up]
- The addition of a drawer to place keyboard and mouse when the station is not in use is suggested [Bottom up]
- Remove or reduce guest seating. If this is not physible, replace with a poly chair or a cleanable fabric [Bottom up]

8.4.21 Technology

- Invest in more touch-free technology, such as automatic doors, taps and sinks, touchless faucets, automated window shades and motion-sensor or voice-activated door hardware [Bottom up]
- Integrating antimicrobial technology in interior design elements - Including faucets, window shades, paint, and door hardware — applying coatings that work to keep them cleaner from multiplying bacteria.
- Minimise the number of high-touch actions through gesture and voice control technologies [Bottom up]
- Utilise proximity readers at garage entrances [Bottom up]
- Preferred use of hands-free adjustment features [Bottom up]
- Videoconference. Provide the necessary IT to allow workers arrange remote meeting instead of in person ones [Bottom up]
- Desk check-ins. Implement a smart desk reservation system which will allow users to know when a desk is available [Bottom up]
- Vending machines - Promote touchless payment if possible [Bottom up]

8.4.22 Tracing with technology

Tracing with technology has been proposed as feasible resource due to the high proportions of SARS-CoV-2 transmission. Mobile applications-based tracing that not only notify automatically and anonymous contacts of infection risk after reporting a SARS-CoV-2 diagnosis but also provide advice both on physical distancing for lower-risk contacts and the need of quarantine/isolation for higher-risk contacts in different settings (home-public transportation-workplace route) might be an efficient control measure (Ferretti et al., 2020). Actually, many mobile phone apps capable of supporting instantaneous contact tracing are being developed without using personal data and so, preserving user privacy (Abeler et al., 2020; Yasaka et al., 2020). Implementation of both technology-based contact tracing and serological testing at the nearest point-of-care in the workplace could help to the viral mitigation at the work environment and ensure the employee's perceived safety to return-to-work.

8.4.23 Hygiene

- **Sanitary products kits:** Expanded availability of hand sanitiser, sanitising wipes, alcohol sprays, masks and gels throughout the building working spaces. Additionally, touch-free sanitisers could be placed at entrances, lobby areas and receptions desks, elevator lobbies, print stations, phone booths, pantries, shared working spaces such as nooks, meeting rooms [Bottom up]

- **Sanitising stations:** Prioritise positioning sanitising stations within the floor plans. A limited zone at the entrance of the office as sanitation station to disinfection of personnel surfaces/objects may reduce the risk of outdoor-indoor virus transmission. Consider dedicating some of the unused meeting rooms for that use [Bottom up]
- **Shoe soles:** Research shown that the shoe soles are potentially contaminated objects and might transport the SARS-CoV-2 between different spaces, so disinfection of the soles has been highly recommended (Guo et al., 2020). However, there are conflictive results on the efficacy of different disinfectant strategies both chemical and non-chemical for microbiological agents, including chemical disinfectants, shoe covers, overboots, floor mats and contamination control floorings (Rashid et al., 2016). Although individuals not working in spaces with high viral load such as healthcare facilities have less risk of collecting virus on their shoe soles, preventive decontamination techniques should be provided in the office entrance before walking along indoor. Moreover, sharing public spaces and public transport vehicles (Liu and Zhang, 2020) as well as common spaces into the building such as internal stairs, lifts, doorways can be determinant factors for increasing the risk of the SARS-CoV-2 infection (Qian et al., 2020).
- **Waste disposal:** Provide safe waste disposal strategically placed within the indoor spaces that employees work and walk, such as meeting rooms, printing areas and kitchens/pantry islands [Bottom up]
- **Cleaning protocols:** Strategically placed signage and wayfinding (also for guests) as gentle reminders of new cleaning standards and capacity protocols - with post-COVID-19 rules used near areas such as entrance, receptions desks, elevator lobbies, meeting rooms.
- **Lifts:** Elevator call buttons should be sanitised in a frequent basis. [Bottom up]
- **Increase frequency** and scope of daytime and surface cleaning. Frequent cleaning of work areas and equipment between uses, as well as cleaning of objects and surfaces that are touched regularly, such as door handles and keyboards. [Top Down]
- **Clean workspace** and remove waste and belongings from the work area at the end of the shift. [Top Down] To keep the daily routine cleaning easy of workstations and desk' devices such as computers, keyboards, etc., and prevent virus transmission through touching contaminated surfaces, it is recommended to maintain the work areas free of personal

objects (bags, mobile phones, etc.) and avoid those non-essential devices to the work procedure from the work surfaces such as desks and tables (Olsen et al., 2020; Wu et al., 2020).

- Include sanitisers and wipe litter in every work setting. [Bottom up]
- Increase frequency of hand washing. [Top Down]
- **Delivering products:** Cleaning procedures for goods and merchandise entering the site should be introduced. [Top Down]
- **Restrooms:** Installation of touch-free soap dispensers and hygiene guidelines signage (such as the 20-second hand washing signage). Provide touch-free sanitisers in washrooms and before entering. Provide had drying facilities – either paper of towels or electrical dryers. [Top Down and Bottom up]
- In case **shower and changing facilities** are required, setting clear use an cleaning guidance for showers, lockers and changing rooms is necessary. [Top Down]
- Provide more **waste facilities** and more frequent rubbish collection. [Top Down]
- **Signage:** Use signs and posters to build awareness of good handwashing technique, Attention should be paid to use clear, simple messaging to explain guidelines using images and clear language. [Top Down and Bottom up]

8.5 Indoor environment parameters

8.5.1 Effect of natural lighting in daytime workers

People working indoors could benefit of daylighting as resource for a wide physiological-behavioural aspect. Timing of lighting exposure is important to synchronise biological processes and brain circuits having a systematic impact on the mood of people working indoors (Bedrosian and Nelson, 2017, Fostervold and Nersveen, 2008)

Daylight is preferred for visual comfort (greater tolerance for glare due to in certain cases to a pleasant view out of the window) in the office lighting scenarios compared with electrical lighting. Changes of photometric variables modulate changes in visual light perception and mood during the afternoon (Borisuit et al., 2015). A possible re-configuration of the office setting so as to allow more daylight and provide better views could be considered post COVID in office environments. Seasonal variation in terms of bright daylight is associated in mood and sleep-activity behaviour among office workers (Adamsson, Laike and Morita, 2018). Exposure to optimised daylight and views condition in office spaces had a positive effect on sleep-activity patterns, cognitive performance and productivity (Boubekri et al., 2014, 2020)

8.5.2 Effect of daylighting on indoor viruses

Lighting can be a mitigation strategy for controlling and managing the viability of some infectious agents in indoors environments. This role of lighting for controlling infection within healthcare facilities has been extensively investigated across full-spectrum light (Hobday and Dancer, 2013; Hessling et al., 2017). The patterns in infectious community abundances in indoor built environments are determined by exposure to light and variation in specific wavelengths (Fahimipour et al., 2018).

8.5.3 Effect of artificial lighting in daytime workers

- Daytime workers who spent most of their time in indoor work environments may be exposed to low lighting levels and differences in the colour temperature of light leading to individual states of psychological mood disturbances and alertness (Küller et al., 2006). Therefore, the evaluation of the effectiveness and safety of lighting interventions applied to daytime workers to improve their state of psychological stress and mood has become crucial in indoor environments. However, there is limited evidence around the full-time office workers in indoor workplaces during workday and their 24-hour ambient light exposure. Office workers receive more morning light on workdays both summer and winter than weekends as they wake earlier and commute to work by an average time of almost 60 minutes. Many workers arrived home for the last time closely sleep onset on workdays, suggesting that most of their light exposure came from artificial indoor lighting in office workplace (Crowley et al., 2015).
- Research has shown that the colour of white lighting and the type of light source can affect employees' feelings of alertness, self-reported performance, mental resources and their need for recovery during regular working hours (Crowley et al., 2015). Indeed, employees based in offices with low-brightness luminaires experience depleted psychological resources, leading to engage in less demanding tasks than those exposed to bright lighting in their offices, even causing glare and reflections on screens (Smolders et al., 2012). Overall, the Correlated Colour Temperature (CCT) and illuminance (lux) in office environments mainly correlate with occupational outcomes according to the International Classification of Diseases: physical and physiological health, mental health, eye health, sleep parameters and visual comfort (van Duijnhoven et al., 2019). Light source (daylight/electric light), illuminance (cd/m_2) and uniformity parameters influence on visual comfort, including glare, visual acceptance and luminous perception of darkness (van Duijnhoven et al., 2019).

- A recent systematic review of thirty-four original research papers assessed four types of lighting comparisons and its effect on office and hospital daytime workers around alertness and mood: (1) cool-white light --technically known as high CCT light versus standard illumination--; (2) heterogeneity in the proportions of indirect and direct illumination; (3) blue-enriched lighting versus no application; and (4) bright light in the morning versus bright light in the afternoon. It was found that high CCT light may improve alertness compared with standard illumination as well as cause less irritation, eye discomfort and headache. Blue-enriched light individually applied can enhance both alertness and mood (Pachito et al., 2018).
- High CCT fluorescent lights could provide a useful workplace intervention to improve employee wellbeing and productivity (less irritability, difficulty focusing for concentrating) in the corporate setting (Mills, Tomkins and Schlangen, 2007; Viola et al., 2008).
- Bright light exposure has effects on mental well-being and performance of healthy individuals as a function of their antecedent psychological state. This personnel sensitivity during daytime may depend on type and duration exposure of light at any time (morning or afternoon), so dynamic lighting solutions may enhance the vitality, performance and physiological arousal after a mental fatigue condition (Smolders and de Kort, 2014).
- The blue-enriched white light exposure during the daytime has effects on the workers' neurobehavioural performance at indoor workspaces, especially improving motivation, personnel safety, reaction time task and well-being, compared with standard white light (Vetter et al., 2011; Najjar et al., 2014).
- Evening exposure to blue-enriched polychromatic white significantly improves working memory (cognitive) performance the next morning compared to white light (Scheuermaier et al., 2018).
- Low- and high-intensity narrow-band blue light improve the most striking symptoms of seasonal affective disorder, including mood, energy levels, reduced fatigability and hypersomnia symptoms, is equally effective as bright standard white-light treatment (Meesters et al., 2011, 2016; Gordijn, 'T Mannetje and Meesters, 2012; Meesters, Duijzer and Hommes, 2018).

8.6 Movement patterns and sedentary behaviour

Sedentary patterns – especially screen time-based sedentary behaviour and mentally passive behaviours – are significantly associated with the risk of depression defined by clinical diagnosis (Wang, Li and Fan, 2019; Huang et al., 2020).

Therefore, the occupational activity-sedentary behaviours play a key role on mental health outcomes of setting-based workers. The occupational physical activity habits in terms of context-dependent repetition (action and setting) has been evaluated on office-based population across ten UK organisations (Smith et al., 2018). It has been reported that stair-climbing is a habit among office workers (Smith et al., 2018). Large number of workers' steps on office environments seems to be in workplace outside to working meetings or when they take breaks (Spinney et al., 2015) as well as in the time-slot between 12 p.m. and 2 p.m. during UK typical lunch hours (Smith et al., 2015). It has been shown that UK office-based workers spend more than 60% of their time at work sitting followed by standing, and then stepping (Clemes et al., 2014; Smith et al., 2015). This overall suggests that office environment norms and infrastructure should address the sedentary behaviours and promote workplace interventions that reduce the occupational sitting time and encourage to be more physically active, and thus improve mental health outcomes.

Workplace interventions addressing the physical activity behaviour of office workers have shown positive impacts on depressive symptoms, anxiety, stress and distress and psychological health (Conn et al., 2009; Chu et al., 2014; Tew et al., 2015; Torbeyns et al., 2017; Abdin et al., 2018; Edwardson et al., 2018; Hallman et al, 2018; Munir et al., 2018; Shrestha et al., 2018; Proper et al., 2019). These office-based workplace interventions aim to reduce total occupational sitting time while improves mental health outcomes through three main domains: changes in the workplace environment and design, changes in the organisational policy of work and counselling provision (table 3).

A multicomponent approach in the intervention programme has evidenced to be the greatest effective resource for the changes in employee’s sedentary patterns and psychological health. However, new control strategies to prevent SARS-CoV-2 transmission while promoting movement behaviour in the workplace must be integrated. Intra-building transport and infiltration of aerosol particles might be also managed across programmed short bursts of 10-15 min (walking in a routine way) at different time-slots for each worker. Incorporating this strategy into organisational measures during workday can improve employee’s sedentary-movement patterns, the work performance and psychological stress (Barr-Anderson et al., 2011) while reducing indoor traffic flows and infectious risk through airborne route. This may be complemented by viable design strategies in the setting location such as height adjustable (sit-stand and/or bike) desk and multi-user workstations approach to reduce journeys towards devices.

Author/study	Intervention	Description
Workplace environment and design		
(Alkhajah et al., 2012; Dutta et al., 2014)(Carr et al., 2016)	**Sit-stand desk/workstation**	Height-adjustable, allowing the user to adjust posture sitting-standing.
(Neuhaus et al., 2014; Healy et al., 2016; Edwardson et al., 2018)	**Sit-stand workstation and counselling**	Height-adjustable workstation with organisational-level (informative sessions and workshops with representatives and staff, etc.) and individual-level (health coaching, support, etc.) components.
(Torbeyns et al., 2017)	**Bike desk**	height adjustable bike desk, allowing the user to cycle at different cycling intensity.
Organisation policy of work		
(Gilson et al., 2009)	**Walking strategies, work breaks**	Route-based walking during work breaks and incidental walking on office environment such as walking/talking to colleagues, and walking/standing in work meetings.
(Thøgersen-Ntoumani et al., 2014)	**Walking strategies, lunchtime walking**	30-min lunchtime walking intervention
(Freak-Poli et al., 2014)	**Walking strategies, day step counts**	The user uses a step count pedometer (and website-based records) to achieve 10,000 steps per day walking into virtually world map.
(Hartfiel et al., 2011)	**Exercise programme, yoga training**	Attendance at 60-min lunchtime sessions of yoga training with instructor per week (delivered 3 sessions each week) + 35-min guided digitally home practice session.
(De Zeeuw et al., 2010)	**Exercise programme**	Supervised exercise classes during working hours in the organisation's fitness centre: 10-min warming-up, followed by 10-min of intense training and 10-20-min of cycling, walking, climbing stairs and then, 10-min gentle exercise.
(Hallman, Mathiassen and Jahncke, 2018)	**Activity-based offices (relocation)**	Relocating workers from traditional offices (cells, shared room/open-plan offices) to new offices designed around the activity-based concept: large open plan room(s) for > 24 workers, quiet zones, web-meeting rooms, project and meeting rooms, etc.
Support and counselling		
(Evans et al., 2012; Cooley, Pedersen and Mainsbridge, 2014; Swartz et al., 2014)	**Point-of-choice prompting software**	Computer-based prompts plus informative sessions (orientation workshops, general instructions) around how to decrease sitting time in office environments (standing and walking).
(Brakenridge et al., 2016)	**Prompts with or without an activity tracker**	Workplace health-related presentations around of tips to 'Stand Up, Sit Less and Move More', walking meeting, walking step count guide, taking the stairs instead of the lift.

Table 3 - Summary of workplace interventions for reducing occupational time

Many systematic reviews addressing the association between blue-green space exposure and mental health and psychological outcomes have been conducted. A recent mapping review found that by approximately 70% of the published research retrieved around this topic highlighted positive effects between green space exposure and general mental wellbeing (Wendelboe-Nelson et al., 2019). Strong associations between depressive mood and the lack and/or poor accessibility of green spaces in living built environment has been reported (Rautio et al., 2018).

Short-time exposure by 15 min viewing, walking or green exercise in natural environments results positive changes in depressive mood, reporting greater effects according to the type of nature (such as forests, urban parks and horticultural settings) compared with views of residential streets and building sites (Roberts et al., 2019). Similarly, short-termed walking and seated relaxation in natural environments compared with city/urban environments had positive effects on perceived psychophysiological stress, anxiety, vitality, mood states, stress recovery and general mental health post-exposure (Corazon et al., 2019; Mygind et al., 2019).

Nature-based interventions including walking and working environment in greenspaces have demonstrated to reduce risk for sleep disturbances such as short-time sleep and poor sleep quality (Shin et al., 2020). Therefore, short bouts of time sitting and/or walking in green spaces at the employee's rest time could have a positive impact. Time-slots between 10-30 min walking and seated and 10-50 min walking in nature had impact on the stress marker reduction through both physiological and psychological measures compared with urbanised settings (Meredith et al., 2020).

Visibility of green and blue spaces has shown to have a positive effect on health outcomes including psychological distress and mental wellbeing (Labib et al., 2020). Viewings of natural scenarios both display stimuli via simulations such as smart digital windows (forests, urban spacegreens and natural landscapes) and real stimuli within buildings (indoor green plants and wooden materials) influence on physiological response, decreasing activity in the brain and autonomic nervous system and systolic blood pressure and leading to changes in oxy-Hb concentrations in the prefrontal cortex (Jo, Song and Miyazaki, 2019). The employees' satisfaction with their green office window views and green space usage at workplace of some vegetation types, especially trees, lawns and/or flowering plants, has been associated with improvements in mental wellbeing levels (Gilchrist et al., 2015).

The overall background suggests that forest interior environments and short-termed immersion in nature can become a helpful tool implemented in work environments for promoting employees' physiological and psychological wellbeing. This positive association has been demonstrated through different nature-based solutions/interventions implemented in office work environments (Gritzka et al., 2020). Based on the eligibility criteria and quality assessment from Gritzka's systematic review (Gritzka et al., 2020), the original data was retrieved in the office-specific context and reported mental wellbeing improved as well as greater psycho-physiological restoration and then, additional primary references were added to provide more up-dated evidence (Table 4).

Author/study	**Intervention**					**Description**
	country	**type**	**min**	**freq.**	**length**	
(Brown et al., 2014)	UK	GE	20	2	8-week	Walks4Work programme. Nature lunchtime walking route, surrounding greenness with trees, grass and public footpaths.
(Calogiuri, Nordtug and Weydahl, 2015; Calogiuri et al., 2016)	Norway	GE	42	1	2-week	Bicycling and circuit-strength training in urban forest and green space.
(Gladwell et al., 2016)	UK	GE	(-) 1.8 km	2*	4-month	Nature lunchtime walking route through grassland, wooded zones and a small lake.
(Largo-Wight et al., 2017)	USA	NE	10	5	4-week	Nature work break sitting, surrounding natural elements (trees, grass, water elements, nature sounds, etc.)
(Nieuwenhuis et al., 2014)	UK; Netherlands	IGS	-	-	3/2-week	Introduction of green infrastructure with large-leafed plants of 90 cm within office and direct green visualisation.
(Evensen, Raanaas and Patil, 2013)	Norway	IGS	-	-	11-month	Introduction of plants at the workstation and installation of daylight simulation in office.
(Yin et al., 2019)	USA	IGS	13 x 8-sc.	1	-	Biophilic intervention of virtual versions of open and enclosed office space with natural elements, natural analogues and combination.
GE, green exercise; NE, nature experience; IGS, indoor green space; sc., scenario; min., minutes; freq., frequent per week.						
** occasions per participant in the whole intervention*						

Table 4 - Summary of nature-based office workplace interventions for improving employee's mental wellbeing and psycho-physiological restoration.

8.7 Indoor air quality and behaviour patterns

There is substantial research exploring the relationship between indoor air quality (IAQ) and physichemical symptoms, behaviour patterns and psychological wellbeing among workers in office buildings across different populations:

8.7.1 Irritating and physichochemical symptoms

The OFFICAIR study assessing the IAQ – target pollutants such as volatile organic compounds (VOCs), aldehydes, ozone (O_3), nitrogen dioxide (NO_2) and particulate matter $(PM)_{2.5}$ – in mechanically-ventilated office buildings across different European countries and the effects on irritating symptoms showed that indoor PM concentrations, particularly 2.5µm in diameter, exceed those recommended values in WHO Air quality guidelines (Mandin et al., 2017). In fact, a cross-sectional study observed that values below those specified by the IAQ guidelines for several irritating VOCs were associated with physicochemical symptoms among workers in office buildings with air-conditioning systems (Azuma et al., 2018).

Indoor office activities – printing and photocopying – and worker habits around cleaning processes can contribute to the increase in diurnal variations of air quality in office environments, particularly $PM_{2.5}$ and O_3, and human health risks (Othman et al., 2020), whereby the incorporation both higher ventilation rates and high-efficiency filtration could reduce $PM_{2.5}$ concentrations towards a safer, healthier and more productive work environment for officers (Fisk et a., 2012; Ben-David and Waring, 2018).

8.7.2 Movement behaviour patterns

Research shows a high level of influence between physical comfort related to air quality and the occupant behaviour and productivity in office environments (Al Horr et al., 2016). In fact, office environments having ventilation airflow rates by 50% higher than standard and monitoring systems for CO_2 have been associated with behavioural changes among employees leading to an increased productivity and decreased absenteeism compared with those working in office without fresh air ventilation component and CO_2 monitoring (Thatcher and Milner, 2014). At standard levels of air quality measures (O_3, VOCs, PM_{10}, $PM_{2.5}$, CO, CO_2 parameters) within office buildings, by 21% of workers experienced feelings of non-air fresh related to fatigue symptoms and headaches (Atarodi et al., 2018).

A study analysing naturally-ventilated office building through a chimney system (airflow from manually operable windows and across office traffic zones) revealed no significant difference in the air quality compared with mechanically-ventilated rooms (Wagner et al., 2007) but identified different occupancy behaviour patterns, specifically four working profiles affecting building energy performance (D'Oca and Hong, 2015; Schweiker et al., 2019). Therefore, intervention programmes by informing in the adequate habits context among employees have been suggested in these office environments (Schakib-Ekbatan et al., 2015).

8.7.3 Psychological wellbeing

A causal model found the temperature, humidity and air quality parameters to be independent factors having the highest direct effects of employee's psychological wellbeing and performance, compared with other environmental parameters such as noise and lighting (Realyvásquez et al., 2016). Moreover, it has been observed an increase in the employees' stress at lesser satisfaction levels of perceived office workplace-related indoor environmental quality (IEQ) parameters and AIQ individually, using validated OFFICAIR questionnaire (Thach et al., 2020).

The high performance sustainable-certified office buildings considering the physical and social dimensions in the design practice, including better ventilation systems and indoor air quality, results in improvements on employee psycho-environmental potential and workplace pro-environmental behaviours (Dreyer et al., 2018), as well as improvements in the Warwick-Edinburgh Mental Well-Being scores for psychological wellbeing among officers (Thatcher and Milner, 2014). However, the OFFICAIR study reported that besides the office building characteristics and layout influencing on occupant comfort, the workers reported the lowest satisfaction score for air quality (air movement and stuffy air) between the IEQ parameters analysed in their mechanically-ventilated offices (Sakellaris et al., 2016). Due to the increasing concern, guidance and standards for the assessment and management of office building-related IAQ and employees' wellbeing continue to emerge and review (Persily, 2015; Carrer and Wolkoff, 2018).

9 Built environment advice

Whilst the available guidance from Public Health England (PHE) states that COVID-19 is assumed to be primarily transmitted through respiratory droplets or via contaminated surfaces, it is generally acknowledged that airborne transmission is also a route, particularly in poorly ventilated spaces. The following sections provide guidance on what we currently understand from the literature.

9.1 Thermal and ventilation conditions (aerosol)

Generally, the following parameters can have an impact on stability and infectiousness of viral particles:

9.1.1 HVAC and air quality

- Protect building occupants with the maximum achievable delivery of fresh, clean air into all spaces;

9.1.2 Ventilation mechanisms

- Viral particles are too small to be blocked by MERV air filters used in most buildings, but ventilation strategies can still play a role in reducing disease transmission. Increasing the amount of air flowing in from outside and the rate of air exchange can dilute virus particles indoors. However, high air flow could also stir up settled particles and put them back in the air. The human-associated contribution to the total detectable airborne microbial community is less important than ventilation strategy and air source. The ventilation systems and strategies as well as human occupancy have shown to influence in the dynamics of indoor airborne infectious communities. In fact, vestige outdoor airborne microbial communities are detectable in the unventilated rooms (Meadow et al., 2014);

9.1.3 Airflow

- Required ventilation rates. Both natural and mechanical airflow patterns dynamic can directly deposit the small virus-laden droplets on surfaces/fomites and re-suspend them to resettle back onto fomites (Ong et al., 2020). Systematic review showed that a rate as high as 25 L/s per person may be needed. Fine droplets (1-5 µm) can remain airborne for several hours in still air. In unfiltered air conditioning systems, the SARS-CoV-2 droplets can persist for hours in aerosol until settling on surfaces (van Doremalen et al., 2020).

9.1.4 Temperature and Humidity

- Virus particles like drier air, so maintaining a high relative humidity can be an effective measure against most viruses. However, COVID-19 virus appears to be quite stable under the normal range of temperatures and relative humidifies expected in buildings and is susceptible only to a very high relative humidly above 80% (REHVA, 2020). Nonetheless, the relative humidity range of 40-60% has been recommended because of other considerations that dry mucosa may be more vulnerable to infection, and at low humidity levels respiratory droplets evaporate more quickly to particle sizes capable of remaining airborne for extended periods (Taylor, 2020).

9.2 Recommendations for building services

To avoid the risk of airborne transmission through small particles (< 5 microns), the following measures related to mechanical building services are recommended (REHVA, 2020; ASHRAE, 2020; BESA, 2020; CIBSE, 2020):

9.2.1 Increase the rate and duration of ventilation

- This measure applies to both naturally and mechanically ventilated buildings. It is recommended to improve the ventilation rate (exchange of air between outdoor and indoor) by keeping manually operated windows open and override the settings of automated vents to enhance ventilation where applicable. In mechanically ventilated buildings, the schedule of operation of the air handing units can be extended, through the Building Management System, to provide fresh air to the building a couple of hours before the start of occupancy and a couple of hours after occupancy ends. This is to facilitate purge ventilation and completely remove and replace the air inside the building. Where demand-controlled ventilation strategy is in place, the settings can be changed (e.g. by lowering the CO_2 setpoint to ambient level of around 400 ppm) during occupancy hours to ensure the air distribution system is operating close to its maximum capacity. It is also recommended not to switch off the ventilation system outside the ventilation schedule and run the system at a lower speed continuously. Generally, it is important to increase the rate and duration of fresh air ventilation as much as possible.

9.2.2 Avoid re-circulation of air in all air systems

- Where an all-air mechanical system is in place to satisfy the heating and cooling demand in addition to provision of fresh air, it is likely that air re-circulation strategy is used to save energy. It is important to close the re-circulation dampers in the mixing box installed in air handling units and shift to full fresh air mode in these circumstances. If there is an indoor source of contamination in a building, re-circulation of air can spread viral particles to other zones of the building and therefore it is important to avoid air re-circulation. This measure can be implemented most of the time when external conditions are not extreme. However, if outdoor temperatures are extreme (e.g. too low in winter), the system may not have been designed to operate under full fresh air (e.g. the heating coil may have been sized based on re-circulation scenario), and this may have implications for thermal comfort of building occupants. It is, therefore, recommended to evaluate the exiting all air systems to ensure they can shift to full fresh air mode as and when necessary and under all ambient conditions.

9.2.3 Review the heat recovery systems installed in mechanical air distribution systems to avoid the risk of cross contamination

- Heat recovery systems are installed in most mechanical air distribution systems to save energy. A heat recovery system is effectively a heat exchanger placed between supply and extract air flows in an air handling unit. The risk of air leakage and cross contamination between extract and supply air therefore needs to be considered. Notably, rotary heat exchangers (thermal wheels), widely used in mechanical ventilation systems, are especially prone to cross contamination. It is therefore important to carefully consider the installation and maintenance of these systems. Where possible, it is recommended to turn these systems off and use the by-pass mode to reduce the risk of cross contamination during the pandemic.

9.2.4 Review the operation of room-based fan coil units and split systems.

- Most non-domestic buildings use HVAC systems with terminal fans. Where possible it is recommended to turn off these systems to avoid resuspension of viral particles. This will be feasible when heating or cooling demand of a building is not high, especially if this is communicated with building users and they are content to tolerate slightly lower temperatures in winter and higher temperatures in summer. The dress code can also be relaxed to facilitate adaptive comfort. However, if the systems must be in use, it is recommended to run the fans continuously to increase the chance of extracting the viral particles from the building through the mechanical ventilation system. In any case, it is important to keep a source of outside air in the room through mechanical ventilation system and/or operable windows.

9.2.5 Consider advanced filtration

- It is important to consider improving the air filtration in the central air distribution systems especially when it is not possible to avoid re-circulation of air or avoid the use of rotary heat exchangers. The level of filtration often used in mechanical ventilation systems is not adequate to prevent virus transmission and should be enhanced if re-circulation of air is a possibility. It is recommended to consider HEPA filters in such applications, although these filters may not be fully effective due to the size of the virus particles. They can however capture droplets that contain the particles. HEPA filters should only be used in filter housings designed for HEPA. Otherwise, there is a possibility of air leakage around the filter (CIBSE, 2020). Ultraviolet germicidal irradiation (UVGI) filters that can damage the DNA structure of virus can also be installed in the air distribution systems, although these filters are currently not used in most but critical applications (e.g. clean rooms, some operating theatres) (CIBSE, 2020; Schoen, 2020).
- The use of room-based air purifiers with HEPA and/or electrostatic filters that can process substantial amount of room air may also be considered. Room based air cleaners should be positioned in a central location away from stagnant areas (CIBSE, 2020).

9.2.6 Use protective measures for maintenance and disinfect control interfaces.

- Regular maintenance of HVAC systems including air filter replacement should be carried out using common protective measures including respiratory protection.
- Disinfect on/off switches, thermostats and other high-touch control interfaces regularly.

9.3 Summary

In summary, the following guidelines can help prepare the building services systems in existing offices to respond to the COVID-19 challenge:

- The overarching principle to mitigate the risk of airborne transmission of the virus is to enhance fresh air ventilation.

- Extend the ventilation schedule to provide purge ventilation at least two hours before and after occupancy every day. For mechanical ventilation systems this can be done via the building management system. In naturally ventilated buildings this can be facilitated by the FM team opening windows.
- Disable demand-controlled ventilation settings and utilise the maximum amount of fresh air the ventilation system can provide to the building.
- Do not switch the ventilation system off outside the ventilation schedule set up for building occupancy and keep systems running at lower speed continuously.
- Avoid re-circulation of air in the ventilation system by closing any re-circulation dampers. Assess the effect of this strategy under extreme weather conditions to ensure the heating and cooling systems will be able to meet the fresh air load. Consider relaxing the dress code to facilitate adaptive comfort. If air re-circulation has to be used in certain conditions, consider mitigation measures such as advanced filtration (HEPA filters for droplets, UVGI filters for disinfection of viral particles).
- Turn off rotary heat recovery exchangers (thermal wheels) to mitigate the risk of cross contamination between extract and supply air flows. Assess the effect of this strategy under extreme weather conditions to ensure the heating and cooling systems will be able to meet the fresh air load.
- Review the operation of room-based fan coil units and split systems. Where possible, turn off these systems to avoid resuspension of viral particles. If the systems must be in use to meet heating or cooling loads, run the fans continuously to increase the chance of extracting the viral particles from the building through the ventilation system. In any case, it is important to keep a source of outside air in the room through mechanical ventilation system and/or operable windows.
- Room air cleaners that have HEPA filter efficiency and/or use electrostatic filtration and can process a substantial amount of room air can also help. It is important to put such devices in a central location and away from stagnant areas.
- Regular maintenance of HVAC systems such as air filter replacement should be carried out using common protective measures including respiratory protection.
- Disinfect on/off switches, thermostats and other high-touch control interfaces regularly.

10 Summary and next steps

In this section, we summarise the findings above from each of the main areas and provide advice on further next steps.

10.1 Clinical advice

SARS-CoV-2 has been shown to persist on surface and in air for long periods of time. The virus can remain infective on surfaces such as stainless steel and plastic for three days and in aerosolised droplets for up to 16 hours. Contaminated droplets will settle on surfaces and pose a risk to occupants. High touch surfaces (e.g. kitchen areas, bathrooms, lift buttons) pose the greatest risk as they are touched frequently by many people. SARS-CoV-2 is easily inactivated with the usual cleaning products such as detergents, alcohols and bleach. Smooth non-porous surfaces are most easy to clean and least likely to harbour the virus. Many antimicrobial materials (e.g. surfaces, fabrics) are available on the market, but these have not been shown to be particularly effective in real world contexts (e.g. hospitals).

It is imperative that occupants and facilities managers are well informed about transmission pathways and risk and collaborate to keep spaces clean and hygienic to reduce the risk.

10.2 Behavioural advice

The research on behavioural aspects of returning to work during the lock-down and the post-COVID-19 era could be related to psychological distress and mental health outcomes. Both scientific data evidence and international and national workplace/mental health guidance were analysed (Top Down) as well as guidance on the actual steps industry, companies etc. made to prepare their workspace and protect their people (Bottom up).

More specifically, behaviour patterns and control measures were researched. The importance of social distancing and the 2m guidance in spaces was highlighted, along with the importance of training workers to the new protocols and engaging with them so as they are up to date to any new actions taken. Research showed the legal responsibilities an employer should take into account so as to protect their workers, the importance of having a response plan in case of a COVID-19 emergency and making reasonable adjustments so as not to negatively impact your staff.

New behavioural habits such as hand hygiene practices and face mask wearing were also introduced, showing that a combined approach can have a higher effect against the virus.

Additionally, contact tracing and testing was introduced as a way in achieving a sustained virus control in the workplace (Park et al., 2020).

Apart from behavioural patterns, categories from preparing buildings to welcome back workers, to adjustments to the most intimate areas of workspaces were further researched. More specifically, measures such as comprehensive cleaning and disinfections to maintain the building readiness, strategically placing touch-free sanitiser stations and signage were included.

Regarding journey to work, guidance for workers related to using public transport or corporate vehicles were included, along with the proposition of providing additional parking spaces or bike-racks where possible, to promote cycling at work.

A series of preventive measures including temperature checks, mandatory usage of face masks and hand sanitisers and sanitising stations, to disinfection of personnel objects and shoe soles (Guo et al., 2020) were suggested as detection before entering the building.

To enter the building, doors open and one-way flow introduction at entry and exit points as well as the use of stairs where possible were recommended. Also, measures such as automatic door opening, key card readers for elevators and guidance on office protocols for visitors before the arrival, were introduced.

A wide range of strategies and resources were recommended to be integrated along different spaces into the office workplace. Common measures researched regardless of space usage were around: a) layout and/or seating reconfiguration to be aligned with the 2 meters physical distancing; b) hygiene practices; c) strategically located signage of measures and protocols and d) maintaining of appropriate ventilation rates and monitoring air quality.

More specifically, practices according to space function were analysed. Scientific findings and guidelines on hygiene, reduce unnecessary movement and protection of office workers on areas such as reception/lobby, common areas/lounges, work nooks, workstations, coffee islands, canteens, print stations, phone booths, meeting rooms, shared spaces, restrooms, storage as well as circulation spines were gathered and further analysed. Data on furniture selection was also analysed, highlighting among other findings on surface material selection easy to clean and the use of suitable surface screens. Integrating technology-based systems such as touch-free technology, hands-free adjustment features and desk check-ins were identified to be efficient control measures.

Lastly, systematic searches on indoor environment parameters such as daylighting, artificial lighting, green-blue spaces, air quality and movement patterns and their effect on indoor workers were produced, providing strong evidence on positive correlations with physiological-psychological wellbeing, sleep-activity patterns, sedentary behaviours, distress/stress recovery, cognitive performance and productivity among office workers

10.3 Built Environment advice

To minimise the risk of airborne virus transmission, it is necessary to increase the rate and duration of fresh air ventilation. Air re-circulation and heat recovery systems such as rotary heat exchangers that are prone to air leakage and cross-contamination between extract and supply air flows are often used in buildings primarily to save energy. It is important to review the operation of these systems during the pandemic and avoid re-circulation of air and air leakage as much as possible. Advanced filtration of air, through HEPA filters for droplets that contain virus and UVGI filters that can disinfect viral particles, can also help especially when re-circulation of air is a possibility during extreme weather conditions.

10.4 Next steps

The report has brought focus to the relationship between the individual and home and the organisation and work, within the wider context of the built environment. Information is emerging on COVID-19 as a virus and its implications for workspace is emerging all the time, most specifically as people start to return to work. This raises theoretical and methodological questions that need to be considered as next steps:

- This study has focused on three topic areas derived from the client's scope. Consideration needs to be given to which theoretical constructs and/or concepts might be best suited to explore the impact of COVID-19 on the workspace as a phenomenon. It is complex and there is much to learn. Selection of appropriate theories and concepts (or indeed combining different fields of study) will be important. It will impact on the type of knowledge that is generated and its relevance to organisations who work with workspace, and individuals who use it.
- Following on from this line of thinking, methodologies for connecting academics and practitioners will be equally important. Because the information is so emergent, co-creation becomes an important factor in the design of any future study. Steps forward on this were taken in this study with the video sessions being very productive for both practitioners and academics. More innovation can be done in this regard.

11 Appendix A

Two very different approaches were used in developing the material presented in the report: first, a review of the literature was conducted using both systematic and narrative approaches; second, a series of workshops with the client were held in which the main findings were presented and the implications for office workplaces were discussed. The research team then summarised the main issues and drafted this report.

The systematic review of relevant published studies identified the studies from four electronic databases: PubMed-Medline; Web of Science; Scopus; and Google Scholar (GS). Different search strategies were applied according to database-specific properties and limitations. The initial search strategy was designed for the Pubmed-Medline database using medical subject headings terms (MeSH) and free-text words. The database algorithms were prepared by applying search syntax (field, codes, parenthesis, and Boolean operators) with the search terms (keywords, free-text synonyms) prior to the advanced search of the databases.

Terms referring to the virus, “SARS-CoV-2” “2019-Ncov” “HCoV-19”, were used in combination with free-text words focused on the search topic of interest. To illustrate, the search strategy on the topic of virus survival used three terms for the virus ("SARS-CoV-2” or "2019-nCOV" or "HCoV-19") and ("search terms around the domain of interest”, including surface, material, persistence, stability, viability. The same search strategy was adapted as required for the different databases. For GS searching, the Boolean search query with constructed expressions and terms was entered into 2dsearch graphical editor (www.2dsearch.com) to formulate the search strategy from one source (Pubmed database) to a new equation for GS search. Each new equation was incorporated into Harzing’s Publish or Perish version 7 software (Harzing, A.W. (2007) Publish or Perish, available from https://harzing.com/resources) and limited to retrieve the first 200 records titles according the relevance ranking of GS. All set of resulting references were introduced into the Mendeley Reference Management Software, and were exported in *xml file format to offline Systematic Review Assistant-Deduplication Module (SRA-DM) application to remove duplicates using the automatic option.

The remaining references were checked with the duplication tool from Mendeley desktop and conflicting fields were resolved manually and then, merged. The records were imported into Rayyan QCRI, a Systematic Reviews web app (www.rayyan.qcri.org), to start the title/abstract screening process of the articles. Based on selection criteria, the relevant publications are retrieved and screened in full-text for the final inclusion, data extraction and descriptive analysis.

Reviewers update the search in databases to ensure the up-to-date results on the topic of interest. Figure 2 provides an overview of the search strategy.

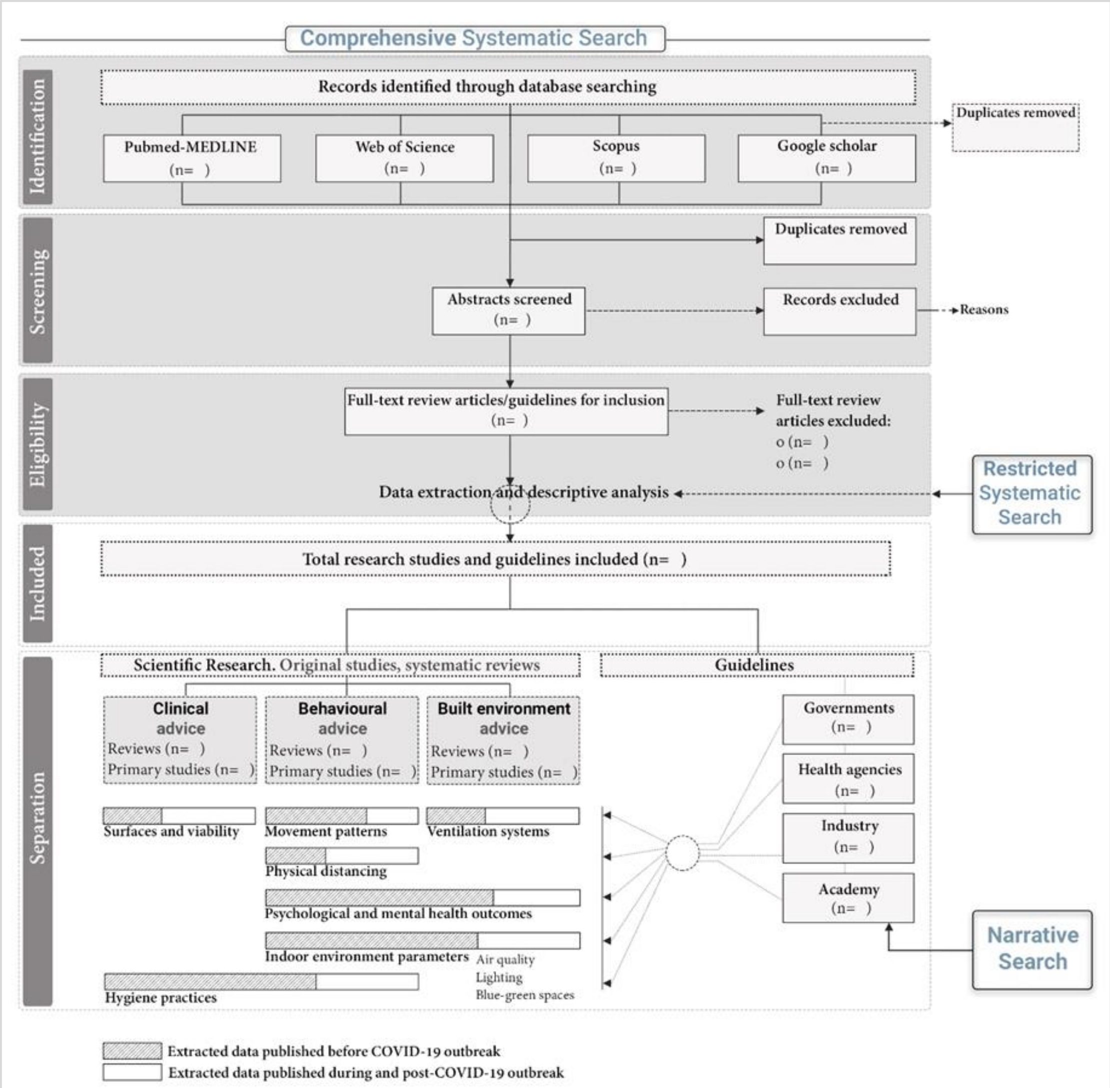

Figure 2 - An overview of search strategy for conducting the Guidance through flow diagram. Comprehensive systematic search methods through advanced electronic databases.

The research team applied the following methodological strategy for the restricted searches in order to turn the recovering items more operable and effective (Figure 3):

- No specific combination of databases and no specific searches of grey literature;
- On those topics with a large number of publications, the search was refined using validated filters from databases according the study design and so, restricted to "systematic review" filter
- Search terms may be restricted to the title and abstract instead of free-text words;

- Date limitations in the database filters may be applied to retrieve the most recent publications from COVID-19 research community;
- Additional searches for eligible primary studies from selected and reviewed references may be conducted to overcome specific items;
- Selection criteria for the inclusion of original publications and government, health agency and industry guidelines may be partially adopted of quality assessment and data analysis process conducted in systematic studies and/or meta-analysis;
- Preprint articles, full draft research papers before these has been peer reviewed may be used to search the alignment with the latest knowledge.

Narrative literature searches were conducted for the identification and retrieval of potentially eligible studies and guidelines from government, health agencies, academy and industry. Key terms and free-words were introduced into web search engines, university and governmental open databases, etc., and the eligibility was based on ad hoc selection, research experience. After each recommendation deriving from this search, inside brackets there is the phrase either 'Top Down' is case this is government guidance or 'Bottom up' if it comes from the industry, academia or regulatory bodies.

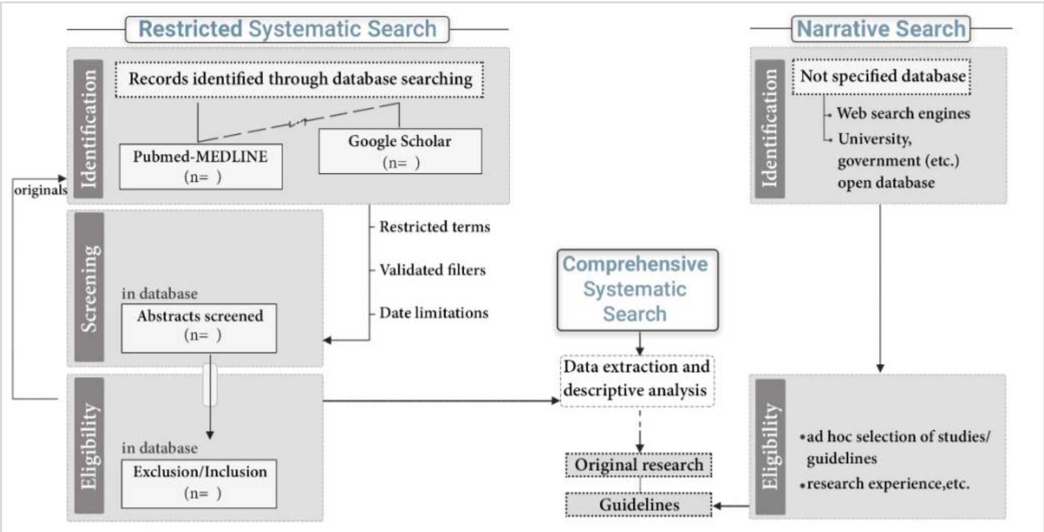

Figure 3 - Restricted systematic and narrative search strategy for conducting the Guidance through flow diagram. Restricted systematic search using advanced electronic databases.

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