World Health Organization

WHO R&D Blueprint

COVID-19

Infection prevention and control (IPC) pillar

Achievements

February 2020 – January 2021

R&DBlueprint

Powering research
to prevent epidemics

Contents

Introduction

As part of WHO's response to the COVID-19 pandemic, the WHO Research and Development (R&D) Blueprint was activated to improve coordination between scientists and global health professionals, accelerate the research and development process, and develop new norms and standards to learn from and improve upon the global response. In collaboration with the Global Research Collaboration for Infectious Disease Preparedness and Response, in February 2020 the WHO R&D Blueprint developed a global research roadmap to accelerate research that can contribute to containing the spread of this epidemic and to facilitate receipt of optimal care by those affected. Infection prevention and control (IPC) is one of the pillars of the WHO COVID-19 R&D Blueprint, which is supported by a group of international experts convened by WHO in the COVID-19 IPC R&D Expert Group (see Annex 1). Three primary objectives for IPC research were identified:

- to understand the effectiveness of public health and social measures (movement control, mask-wearing, physical distancing and so on) and IPC strategies to prevent secondary transmission in health care and community settings;
- to optimize the effectiveness of personal protective equipment and its usefulness in reducing the risk of transmission in health care and community settings;
- to minimize the role of the environment in transmission.

The global research roadmap also includes detailed knowledge gaps and research priorities identified by the IPC pillar.

The aim of the WHO COVID-19 IPC R&D Expert Group is to work in concert with the WHO Secretariat, other experts and other COVID-19 research pillars and working groups, with the purpose of facilitating coordination and collaboration of research and innovation, and boosting synergy in the field of IPC during the response to the COVID-19 pandemic. This group has met regularly since February 2020, with the following objectives:

- to promote, support and engage in research into all aspects of IPC of relevance to the COVID-19 pandemic, according to the research questions and priorities identified;
- to continue to review and update the global IPC R&D agenda according to the emerging evidence;
- to enhance timely sharing of IPC research results and evidence interpretation;
- to contribute to the development and implementation of evidence-based IPC recommendations and documents during the COVID-19 pandemic;
- to enhance and provide COVID-19 global outbreak response through provision of evidence-based technical advice;
- to dedicate special focus on research areas aimed at improving knowledge and tools to avoid health care-associated transmission of SARS-CoV-2 and to better protect health workers from becoming infected with SARS-CoV-2;
- to contribute to the research agendas of other areas such as social science, environmental health science and epidemiology, in particular for the understanding of SARS-CoV-2 modes of transmission;

- to explore and understand the impact of the COVID-19 pandemic on health care-associated infections (HAIs) and antimicrobial resistance (AMR);

- to ensure that the needs of low- and middle-income health care settings and countries are taken into consideration in the development of protocols and designs.

Research priorities and questions

In July 2020, the WHO COVID-19 IPC R&D Expert Group reviewed the progress of the previously identified priorities within the global research roadmap, and agreed on ongoing and newly identified research needs in the following areas.

1. SARS-CoV-2 modes of transmission

Main research question:

- What is the role of airborne transmission and what are its implications for IPC (specifically distance and ventilation)?

Research priority and questions	Research focus and objectives	Types of study
What is the role of **droplet versus airborne transmission** of SARS-CoV-2?	• Determining the aerosol-generating procedures (AGPs) that are able to generate aerosolization of viable SARS-CoV-2 (potentially transmissible) • Determining the presence of viable virus and its concentration in droplet nuclei versus respiratory droplets (distinction of droplets by size) • Exploring effective and innovative ways of communicating airborne and droplet transmission to health workers and the general public	• Randomized controlled trials (RCTs) and observational studies engaging multiple disciplines • Modelling based on available evidence • Systematic reviews • Testing communication and discussion platforms
What **distance** can infective SARS-CoV-2 droplets travel?	• Determining the maximum distance travelled by respiratory droplets/droplet nuclei containing SARS-CoV-2 • Searching for both RNA and viable virus in different situations, such as: ○ indoor versus outdoor	• RCTs • Experimental design at discrete distances (e. g. 0.5 m versus 1 m, versus 1.5 m, versus 2 m or greater)

	○ with patients with and without respiratory etiquette ○ with patients breathing normally versus sneezing versus coughing	• Modelling based on available evidence • Systematic reviews
What is the **role of ventilation** in spreading SARS-CoV-2?	• Determining the effectiveness of the use of negative pressure according to the setting (e.g. in the presence of AGPs, in operating rooms) • Determining the impact of ventilation rates, temperature and humidity on droplet size and transmission of SARS-CoV-2 in different settings (health care facilities and public spaces)	• RCTs • Systematic reviews • Observational studies

2. Personal protective equipment (PPE)

Main research questions:

- What is the effectiveness and what are the adverse events associated with non-medical masks, medical masks, respirators and face shields?
- What are the effectiveness, compliance, sustainability of masking for the general public and in specific populations?
- Are there safe and effective methods for PPE decontamination that could also be suitable for low-income countries?

Research priority and questions	Areas of focus	Types of study
Non-medical masks • What are the **effectiveness, compliance and sustainability** of universal masking for the general public? • What are the **risks and adverse events**, including in the context of prolonged and repeated use?	• Assessing the effectiveness of universal masking as a public health measure to reduce the spread of SARS-CoV-2: ○ in countries/areas with limited capacity to implement containment measures ○ in countries/areas with higher capacity • Identifying the risks and adverse events of non-medical mask use, including in the context of prolonged and repeated use • Improving comfort through fit and breathability, in addition to filtration	• RCTs • Ecological studies • Observational studies • Modelling based on available evidence • Systematic reviews • Surveys • Testing different communication strategies on the public • Laboratory testing

• What is the effectiveness of the **materials and their properties for source control and for protection**?	efficiency, so that the general public can be best protected while using masks • Determining the filtration efficiency and fit of non-medical masks as protective equipment for the wearer • Determining the effects on integrity and performance of prolonged and repeated use of non-medical masks • Determining and comparing the effectiveness of different methods of decontamination of non-medical masks • Exploring effective and innovative ways of communicating recommendations on the use of non-medical masks among the general public	
Medical masks and respirators • What is the **effectiveness** and what are the **adverse events** in the context of combination with other PPE, prolonged use and repeated use? • What are the most effective methods for **decontamination**?	• Determining the effectiveness of medical masks compared to respirators in combination with other PPE (e.g. face shields) in different settings (e.g. screening, triage, AGPs in emergency care, COVID-19 rooms with and without AGPs, home care, long-term care facilities (LTCFs)) • Determining the effects on integrity and performance of prolonged use and repeated use of medical masks and respirators • Identifying the adverse events associated with use of medical masks and respirators, including in the context of prolonged use and repeated use • Determining and comparing the effectiveness of different methods of decontamination of medical masks and respirators	• RCTs and observational studies engaging multiple disciplines • Modelling based on available evidence • Systematic reviews
Face shields • What are the **effectiveness and compliance**, and the **advantages**	• Assessing the effectiveness of use of face shields alone in the general public (e.g. in schools, colleges, shops) compared to non-medical masks • Assessing the effectiveness of use of face shields with medical masks compared to	• RCTs • Observational studies • Systematic reviews • Surveys

and adverse events associated with using face shields?	respirators with eye protection in health care (especially in the context of shortages) • Determining the level of compliance and adverse events when using face shields compared to other PPE	
Masks in specific populations • What are the **effectiveness, compliance and sustainability**, and what are the **adverse events** in specific populations and contexts (e.g. children, people with special needs, elderly people, people with hearing impairment or cognitive impairment)	• Assessing the effectiveness of use of masks to reduce the incidence of COVID-19 within specific populations and contexts • Assessing the adverse events associated with use of masks in specific populations • Determining the compliance and long-term sustainability of the use of masks in specific populations	• RCTs • Observational studies • Systematic reviews • Surveys

3. Role of the environment in transmission and control

Main research questions:

- What is the role of fomites and contaminated water, sanitation and hygiene (WASH) environments in SARS-CoV-2 transmission?
- What are innovative methods and technologies for decontamination of the environment and PPE?

Research priority and questions	Areas of focus	Types of study
What is the presence of **viable SARS-CoV-2 in**	• Determining the presence and concentration of viable SARS-CoV-2 in faeces, sewage/wastewater, biosolids and	• Observational studies • Laboratory testing

different WASH environments?	sludges, latrine wastes, greywater and other environmental waters	
What is the **role of fomites in SARS-CoV-2 transmission** in health care and community settings, and how can the risk of transmission be mitigated?	• Determining the presence and concentration of viable SARS-CoV-2 on surfaces (e.g. household surfaces) • Determining the role of fomites in SARS-CoV-2 transmission compared to other transmission routes • Determining effective and cost-effective ways of decontamination of surfaces, particularly exploring new technologies for low-resource settings	• RCTs • Cost–effectiveness studies • Observational studies • Laboratory testing
What are cost-effective novel approaches and technologies for **environmental decontamination** (surfaces, air, water)?	• Determining effectiveness and cost–effectiveness of mobile decontamination devices (e.g. ultraviolet lights) and other novel technologies, including foggers, misters and gasses using disinfectant and chemicals such as free chlorine, chlorine dioxide, peroxides and ozone	• RCTs • Cost–effectiveness studies • Laboratory testing

4. Other areas

Main research questions

- What are the drivers of SARS-CoV-2 transmission and the IPC requirements in LTCFs?
- What are the most effective and cost-effective ways of implementing quarantine and isolation, particularly in the community?
- What are innovative approaches to monitor the status of IPC implementation, particularly in low-resource settings?
- What is the most effective surveillance approach to understand, detect and reduce health care acquisition and outbreaks?
- What is the impact of the pandemic on AMR and HAIs?

Research priority and questions	Areas of focus	Types of study

What are the **drivers of SARS-CoV-2 transmission** and the **requirements for IPC in LTCFs**?	• Determining the risk factors for SARS-CoV-2 transmission in LTCFs and other special settings, including the role of health workers working in several LTCFs, and other factors (e.g. presence of alcohol-based handrub/WASH, training, guidelines) • Assessing the WHO IPC minimum requirements in LTCFs and their role in containing the transmission of SARS-CoV-2	• RCTs and observational studies engaging multiple disciplines • Modelling based on available evidence • Systematic reviews
What are the most **effective and cost-effective ways of implementing quarantine and isolation**, particularly in the community?	• Comparing the effectiveness and cost–effectiveness of different approaches to ensure quarantine of contacts and/or returning travellers, and isolation of mild cases of SARS-CoV-2 (health care facilities, dedicated hotels, home or other settings) • Determining the acceptability, feasibility and cultural factors involved in different approaches	• RCTs and observational studies • Cost–effectiveness studies • Modelling based on available evidence • Systematic reviews
What are **innovative approaches to monitor the status of IPC implementation**, particularly in low-resource settings?	• Exploring novel survey platforms for rapid assessment of IPC implementation • Exploring innovative methods for IPC monitoring at the facility level, in particular related to behaviour compliance with best practices • Exploring novel methodologies for translating monitoring and evaluation in rapid (low-cost) IPC action planning and improvement	• Observational studies • Systematic reviews • Surveys
What is the most effective surveillance approach to understand, detect and reduce **health care acquisition and outbreaks**?	• Understanding amplification and super-spreading events within health care facilities and LTCFs • Exploring appropriate surveillance models and their adoption as a component of health care resilience and “recovery” strategies	• Retrospective studies • Systematic review • Implementation studies

What is the **impact of the pandemic on AMR and HAIs**?	• Assessing the risk of HAIs due to resistant pathogens (including the impact of AMR on clinical management) in COVID-19 patients • Assessing the impact on antibiotic use and access • Exploring AMR national or local incidence in 2020 and the correlation with implementation of public health and IPC measures, as well as antibiotic consumption	• Retrospective studies • Ecological studies • Modelling based on available evidence

IPC research projects according to the R&D Blueprint roadmap objectives

Many studies have been initiated by members of the WHO COVID-19 IPC R&D Expert Group, in line with the objectives for IPC research identified in the R&D Blueprint global research roadmap and the related research priorities areas and questions. The tables below present summaries of these projects, including the types of study, objectives, leading institution and related publications so far. It is by no means a comprehensive list of all the studies the members of the group have contributed to. It encompasses most of the studies that relate to the objectives set out by the group when this list was assembled, and members contributed to it until February 2021.

Objective 1 – Understand effectiveness of movement control and other public health strategies to prevent secondary transmission in health care and community settings

Project	Institution	Objectives	Link to publication
Systematic reviews			
Physical interventions to interrupt or reduce the spread of respiratory viruses	Oxford University, United Kingdom	To assess the effectiveness of physical interventions to interrupt or reduce the spread of acute respiratory viruses	DOI: https://doi.org/10.1002/14651858.CD006207.pub5
Physical distancing, face masks and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis	COVID-19 Systematic Urgent Review Group Effort (SURGE)	A rapid review commissioned by WHO to investigate the optimum distance for avoiding person-to-person virus transmission and to assess the use of face masks and eye protection to prevent transmission of viruses	DOI: 10.1016/S0140-6736(20)31142-9
COVID-19 evidence lacking for 2-metre distancing	Oxford University, United Kingdom	Expression of concern regarding the assessment of the distance measures in the SURGE study review	Report available here

Project	Institution	Objectives	Link to publication
Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review	Danube University, Austria	A rapid review commissioned by WHO to assess the effects of quarantine (alone or in combination with other measures) of individuals who had contact with confirmed cases of COVID-19, who travelled from countries with a declared outbreak, or who live in regions with high transmission of the disease	DOI: https://doi.org/10.1002/14651858.CD013574
Physical interventions to interrupt or reduce the spread of respiratory viruses. Part 2 – hand hygiene and other hygiene measures: systematic review and meta-analysis	King Saud University, Saudi Arabia; Bond University, Australia	To assess the effectiveness of hand hygiene, surface disinfecting and other hygiene interventions in preventing or reducing the spread of illnesses from respiratory viruses	DOI: https://doi.org/10.1101/2020.04.14.20065250
Does cleaning hands with ash stop or reduce the spread of viral and bacterial infections compared with soap or other materials?	Cochrane, United Kingdom	To discover whether people who use ash for hand cleaning are more likely to catch infectious diseases than people who use soap, water, mud or soil, or who do not clean their hands; and whether using ash causes unwanted effects, like sore hands or a rash	DOI: 10.1002/14651858.CD013597
Epidemiology of and risk factors for coronavirus infection in health care workers: a living rapid review	Oregon Health & Science University, USA	To examine the burden of SARS-CoV-2, SARS-CoV-1, and Middle East respiratory syndrome (MERS-CoV) on health care workers and risk factors for infection, using rapid and living review methods	DOI: https://doi.org/10.7326/M20-1632
Primary studies			

Project	Institution	Objectives	Link to publication
Cost–effectiveness of interventions to reduce the spread of SARS-CoV-2 in health care facilities	Organisation for Economic Co-operation and Development (OECD) and WHO	To define the methodological framework for estimating the cost–effectiveness of interventions to reduce the spread of SARS-CoV-2 in health care facilities including hand hygiene, use of PPE and vaccination, and to apply it to the analysis of some specific countries	Study ongoing
Study 1 – Investigating the burden of hospital-onset COVID-19 infection (HOCI) and developing implementable surveillance systems to inform interventions and enable recovery and resilience of acute health care: • Development and delivery of a real-time hospital-onset COVID-19 surveillance system using network analysis Study 2 – Understanding, monitoring and mitigating the impact of COVID-19 on HAIs and AMR in acute care for both COVID-19 and non-COVID-19 patient populations: • Understanding the role of bacterial and fungal infection in COVID-19 • COVID-19 and the potential long-term impact on AMR	Imperial College London, United Kingdom	• To synthesize evidence in the existing literature and consensus from international experts to inform the expansion of the HOCI surveillance system to include standardized definitions and data collection methods for potential international implementation • To identify potential international adopter sites and estimate the capacity and resources required for HOCI surveillance implementation • To estimate the impact of HOCI surveillance systems on HOCI incidence and data utilization as aligned to core component 4 (HAI surveillance) of the WHO IPC Programme through modelling and simulation	• DOI: https://doi.org/10.1093/cid/ciaa892 • DOI: https://doi.org/10.1016/j.cmi.2020.09.025 • DOI: 10.1093/cid/ciaa530 • DOI: https://doi.org/10.1093/jac/dkaa194 • DOI: https://doi.org/10.1038/s41579-020-0395-y • DOI: https://doi.org/10.1016/j.cmi.2020.09.025

Project	Institution	Objectives	Link to publication
• Antimicrobial use, drug-resistant infections and COVID-19 • Investigating the impact of COVID-19 on primary care antibiotic prescribing in north-west London, United Kingdom, across two epidemic waves • Supervised machine learning to support the diagnosis of bacterial infection in the context of COVID-19			• DOI: https://doi.org/10.1016/j.cmi.2021.02.007 • DOI: https://doi.org/10.1093/jacamr/dlab002
Study 1 – Assessing the impact of the COVID-19 pandemic on nosocomial carbapenem resistant organisms (CRO) using integrated whole genome sequencing (WGS), clinical epidemiology and environmental surveillance • SARS-CoV-2 seroprevalence and transmission risk factors among high-risk close contacts: a retrospective cohort study Study 2 – Nosocomial infections among COVID-19 patients: an analysis of prospective intensive care unit (ICU) surveillance data	Department of Infectious Diseases, Tan Tock Seng Hospital, National University of Singapore	Study 1 • to assess the impact of COVID-19 on incidence of CRO incidence rates and transmission cluster sizes • to conduct WGS on retrospective and prospective clinical CRO isolates to identify clusters of nosocomial transmission of CRO within the hospital using clonality as a guide • to identify the routes of transmission of CRO in these clusters by correlation of clonal transmission with clinical epidemiology and environmental sampling Study 2 - to assess the difference in device-associated infections and secondary bacteraemia among COVID-19 and non-COVID-19 ICU patients	Study 1 ongoing DOI: https://doi.org/10.1016/S1473-3099(20)30833-1 Study 2 ongoing Study 3 ongoing Study 4 DOI: https://doi.org/10.1038/s41467-020-16670-2 Study 5 DOI: 10.1017/ice.2020.91

Project	Institution	Objectives	Link to publication
Study 3 – Compliance of the general public to the appropriate use of face masks during the COVID-19 pandemic – a community observational study in Singapore Study 4 – Detection of air and surface contamination of SARS-CoV-2 in hospital rooms of infected patients Study 5 – Absence of contamination of PPE by severe acute respiratory syndrome SARS-CoV-2		Study 3 - to evaluate the proportion of face mask usage, the extent of correct face mask usage and face mask-related hygiene practices among the general public in Singapore Study 4 - to understand particle size distribution in the air and the impact of environmental contamination of SARS-CoV-2 particles by screening environmental samples from airborne isolation rooms Study 5 - to evaluate the safety of extended PPE use and ascertain the risk of PPE contamination with SARS-CoV-2	
Impact of non-pharmaceutical interventions against COVID-19 in Europe: a quasi-experimental study	University of East Anglia, United Kingdom	A quasi-experimental study of the impact of various interventions for control of the outbreak – data on case numbers and deaths taken from the daily published figures by the European Centre for Disease Prevention and Control and dates of initiation of various control strategies from the Institute of Health Metrics and Evaluation website and published sources	DOI: https://doi.org/10.1101/2020.05.01.20088260
Policy implementation and communication lessons from Alberta's acute and primary care (a mixed IPC/ social sciences study) Rapid conversion of an inpatient hospital unit to accommodate COVID-	University of Calgary and Alberta Health Services, Canada	To study how policies are being formed, transmitted, interpreted and implemented at clinical front lines, and studying how context and culture are shaping the way policies and protocols are being put into action in Alberta's health system	https://www.w21c.org/portfolio/assessment-of-albertas-covid-19-preparedness-and-response-policies/

Project	Institution	Objectives	Link to publication
19: an interdisciplinary human factors, ethnography and IPC approach			DOI: https://doi.org/10.1371/journal.pone.0245212
WHO and International Labour Organization (ILO) Global Survey on Health and safety of health workers in COVID-19	WHO and ILO	To assess the risks for health and safety at work and existing preventive measures	Study report here
International Society of Antimicrobial Chemotherapy (ISAC) Infection Control Africa Network (ICAN) global survey on perceptions of health care workers on the current IPC preparedness measures for COVID-19: • Perceived challenges of COVID-19 infection prevention and control preparedness: a multinational survey	ISAC-ICAN	To assess the perceptions of infection preventionists on the current global IPC preparedness measures for COVID-19	DOI: 10.1016/j.jgar.2020.07.002
WHO international case control multicentre study – Assessment of risk factors for COVID-19 in health workers	WHO headquarters	• To characterize and assess the IPC risk factors for SARS-CoV-2 infection in health workers with exposure to COVID-19 patients • To describe the range of clinical presentations for SARS-CoV-2 infection in health workers, including the duration and severity of the disease	Study ongoing Protocol available here

Project	Institution	Objectives	Link to publication
		• To determine serologic responses in health care personnel with confirmed SARS-CoV-2 infection and in those attending patients but without COVID-19	
WHO surveillance protocol for SARS-CoV-2 infection among health workers	WHO in collaboration with the WHO Regional Office for Europe, Italian National Public Health Institute and European Centre for Disease Prevention and Control	To describe the epidemiology of COVID-19 among health care workers, including their exposure characteristics and risk factors, as part of case investigation	Protocol available here
Study assessing health care worker readiness for COVID-19	WHO headquarters; Oxford University, United Kingdom	To understand health care worker perceptions of IPC measures implemented within their respective organizations to prevent COVID-19 transmission	Study ongoing
Repeated cross-sectional survey assessing health care worker infections in high-risk facilities (prevalence of seropositivity, compliance with IPC measures)	Robert Koch Institute, Germany	To assess the prevalence of SARS-CoV-2 infection and seroprevalence among health care workers and associated risk factors in a repeated cross-sectional survey over the course of the pandemic	Study ongoing Study information available here
Study 1 – Retrospective analysis of effects of Israeli national protective strategy (PPE guidelines for care of COVID-19 patients, masking of all	National Center for Infection Control,	Study 1 - to determine whether Israeli national measures succeeded in reducing COVID-19	Study 1 under review for publication

Project	Institution	Objectives	Link to publication
health care workers in hospital, masking of general public entering hospital) on prevalence of health care workers infected and health care workers out on post-exposure quarantine Study 2 – Point prevalence study of undetected health care worker infection and possible relationship to PPE use and work practices – multi-institutional cross-sectional survey in COVID and non-COVID wards (questionnaire on exposures and work practices, and swab for SARS-CoV-2 polymerase chain reaction (PCR)): • Extremely low prevalence of asymptomatic COVID-19 among health care workers caring for COVID-19 patients in Israeli hospitals: a cross-sectional study	Ministry of Health, Israel	infections and exposures requiring quarantine among health care workers in general hospitals Study 2 - to compare the prevalence of asymptomatic COVID-19 among clinical staff in designated COVID-19 units versus that among staff in similar units with no known or suspected COVID-19 patients	Study 2 DOI: 10.1016/j.cmi.2020.09.040
Seroprevalence of SARS-CoV-2 antibodies in health care workers and administration employees: a prospective surveillance study at a 1400-bed university hospital in Germany	Jena University Hospital, Germany	To compare SARS-CoV-2 immunoglobulin G seroprevalence and compliance with wearing PPE between health care workers working within (high-risk) or outside (intermediate-risk) units treating suspected or confirmed COVID-19 patients; also including administration staff (low-risk)	DOI: https://doi.org/10.1101/2020.09.29.20203737

Project	Institution	Objectives	Link to publication
Estimating the cost–effectiveness of selected IPC interventions in the context of COVID-19	OECD Public Health Team	To assess the cost–effectiveness of selected IPC interventions to prevent health care-associated SARS-CoV-2 infections in health care settings in selected IPC interventions, including: • promoting best practices in hand hygiene • IPC training and education of health workers • scaling up the use of PPE	Study ongoing
Multicentre cross-sectional survey of Israeli hospitals: • Extremely low prevalence of asymptomatic COVID-19 among health care workers caring for COVID-19 patients in Israeli hospitals: a cross-sectional study	National Center for Infection Control, Israel	To compare the prevalence of asymptomatic COVID-19 among clinical staff in designated COVID-19 units versus that among staff in similar units with no known or suspected COVID-19 patients	DOI: 10.1016/j.cmi.2020.09.040
Cross-sectional survey regarding health care worker perception of their IPC preparedness and trust in health care organization Study 1 – The experience of European hospital-based health care workers on following infection prevention and control procedures for COVID-19	Oxford University, United Kingdom	To assess the perceptions of European hospital health care workers of local IPC procedures during the COVID-19 pandemic and the impact on their emotional well-being	Study 1 under review for publication Study 2 preprint DOI: https://doi.org/10.1101/2020.12.23.20248793 Study 3 ongoing Study 4 ongoing; protocol available here

Project	Institution	Objectives	Link to publication
Study 2 – Perceptions of health care workers on IPC procedures for COVID-19 in Canada Study 3 – Perceptions of health care workers on IPC procedures for COVID-19: State of São Paulo, Brazil Study 4 – Cellulle d'Analyses de Science en Sociaux (CASS) and guidance for health care worker surveys in humanitarian contexts in low- and middle-income countries Study 5 – Perceptions of health care workers regarding local IPC procedures for COVID-19: research protocol			Study 5 protocol available here
Asymptomatic and pre-symptomatic transmission in a community congregant setting – assessment of environmental and behavioural factors associated with asymptomatic transmission. Pilot prospective study evaluating conditions of infection in high-exposure groups	Colorado School of Public Health, USA	To understand how infection control practices can mitigate exposure risks by: • conducting a pilot prospective study in COVID-19 high-exposure groups to identify conditions in which a person is infective • describing the demography, environment and behaviours associated with asymptomatic transmission to improve IPC practices and guidance	Study ongoing

Project	Institution	Objectives	Link to publication
Impact of indoor air handling on transmission of respiratory viral infections	University of East Anglia, United Kingdom	Systematic review of the benefits of air management systems on controlling the spread of respiratory viral infections in buildings	Study ongoing
IPC monitoring portal	WHO	To develop and launch a portal for data entry, download and improvement processes to monitor IPC programmes at the national and health care facility levels	N/A
Hand hygiene in health care research agenda	WHO	To identify gaps and priorities for hand hygiene within the health care research agenda in the light of the COVID-19 pandemic	N/A

Objective 2 – Optimize the effectiveness of PPE and its usefulness to reduce risk of transmission in health care and community settings

Project	Institution	Objectives	Link to publication
Systematic reviews			
Physical interventions to interrupt or reduce the spread of respiratory viruses	Oxford University, United Kingdom	To assess the effectiveness of physical interventions including eye protection and face masks to interrupt or reduce the spread of acute respiratory viruses	DOI: https://doi.org/10.1002/14651858.CD006207.pub5
Facemasks and similar barriers to prevent respiratory illness such as COVID-19: a rapid systematic review	University of East Anglia, United Kingdom	To better understand the value of wearing facemasks, a rapid systematic review of existing scientific evidence about development of	DOI: https://doi.org/10.1101/2020.04.01.20049528

Project	Institution	Objectives	Link to publication
		respiratory illness, linked to use of facemasks in community settings	
Masks for prevention of respiratory virus infections, including SARS-CoV-2, in health care and community settings	Pacific Northwest Evidence-based Practice Center and Oregon Health & Science University, USA	To examine the effectiveness of N95, surgical and cloth masks in community and health care settings for preventing respiratory virus infections, and effects of reuse or extended use of N95 masks	DOI: https://doi.org/10.7326/M20-3213 DOI: https://doi.org/10.7326/L20-1067
Primary studies			
Absence of contamination of PPE by SARS-CoV-2	Tan Tock Seng Hospital, Singapore	To determine whether PPE of health workers caring for COVID-19 patients gets contaminated and would pose a risk of contamination if used for extended periods	DOI: https://doi.org/10.1017/ice.2020.91
Introduction to and spread of COVID-19 in care homes in Norfolk, United Kingdom	University of East Anglia, United Kingdom	Secondary analysis of care homes in Norfolk, England (United Kingdom), to assess potential of transmission through PPE, staffing and COVID-19 infections: the number of non-care workers, staff and more severe PPE shortages were significantly linked to higher COVID-19 rates	DOI: https://doi.org/10.1101/2020.06.17.20133629
DeMaND studies Study 1 – Research on masks: development of methods for mask and N95 decontamination and reuse	Colorado School of Public Health, USA	Study 1 - • to identify cheap and effective decontamination of SARS-COV2 on masks and respirators	Study 1 preprint DOI: https://doi.org/10.1101/2020.12.11.20236919 Study 2 ongoing

Project	Institution	Objectives	Link to publication
• Addressing PPE decontamination: methylene blue and light inactivates SARS-CoV-2 on N95 respirators and masks with maintenance of integrity and fit • The use of germicidal ultraviolet light, vaporized hydrogen peroxide and dry heat to decontaminate face masks and filtering respirators contaminated with a SARS-CoV-2 surrogate virus Study 2 – A suite of studies to expand DeMaND findings Study 3 – Improving effectiveness of non-medical masks		• to ensure the decontamination method does not impair performance integrity of the masks and respirators • to utilize representative masks and respirator types most commonly worn as distributed by WHO (with the addition of a community mask in the study) Study 2 - • to collect methylene blue (MB) toxicity and photobleaching studies to determine limits of biological dose and the longevity of the MB effect on surfaces (PPE, environment) • to examine the MB effect on pathogens of outbreak concern including Ebola, Lassa and noroviruses • to determine the usability and impact on human factors of the long-term use of PPE, AGP equipment and masks/respirators Study 3 - • to identify the materials most accessible and suitable for non-medical mask construction • to improve the effectiveness of non-medical masks	Study 3 ongoing

Project	Institution	Objectives	Link to publication
		• to develop and design better fitting non-medical masks for public use	
A proof-of-concept study on detection of SARS-CoV-2 in exhaled air in symptomatic/asymptomatic people using innovative, non-invasive embedded polyvinyl alcohol (PVA) strips in face masks	Colorado School of Public Health, USA	To explore a new way to test whether someone can potentially transmit SARS-CoV-2 involving placement of a strip made of PVA inside a face mask to capture SARS-CoV-2 DNA and potentially live virus exhaled by the person wearing the mask	Study ongoing
SARS-CoV-2 support core for continuing study and expansion of DeMaND study	University of Alberta, Canada	Following up on previous studies, and mainly the DeMaND study, which have established that MB activated by light is an effective and low-cost method to disinfect PPE while keeping their integrity: • to assess MB longevity and optimal time between re-application for maintaining its efficacy • to develop methods and experimental settings for visualizing and quantifying interactions between singlet oxygen and coronavirus surrogate • to inactivate surrogate virus using sunlight as a substitute for dry heat	Study ongoing
Household materials selection for homemade cloth face coverings and	Colorado School of Public Health,	To evaluate the filtration efficiency and pressure drop of common household materials of natural and synthetic origin using a modified version of	DOI: https://doi.org/10.102

Project	Institution	Objectives	Link to publication
their filtration efficiency enhancement with triboelectric charging	University of Colorado, USA	the National Institute for Occupational Safety and Health standard test procedure	1/acs.nanolett.0c02211
Aerobiology of cloth masks sourced from countries to evaluate their protective effects and breathability – improving the effectiveness of non-medical masks and face coverings	Colorado State University; University of North Carolina, USA	To improve the effectiveness of non-medical masks for community use by: • linking material properties to key performance metrics (i.e. aerosol filtration efficiency and breathability) • identifying and minimizing risks associated with prolonged and repeated mask use, investigating how the performance of masks and their component layers changes with repeated use and following available decontamination methods • developing design and use guidelines that minimize flow bypass (leakage) due to poor mask fit	Study ongoing
Non-inferiority randomized trial of medical masks versus N95 respirators in preventing COVID-19 in health care workers	McMaster University, Canada	To provide evidence on the safety and efficacy of medical mask use compared to N95 respirators in clinical settings	Study ongoing
Efficacy and impact of MB with light decontamination and its potential uses in the field setting	George Washington University, USA	To evaluate the potential for light-activated MB treatment to inactivate pathogens on durable PPE items (masks, goggles, gowns), assessing the duration of MB effect (hours, days) to develop procedures for PPE reuse and developing light-	Study ongoing

Project	Institution	Objectives	Link to publication
		activated MB treatment for PPE in the Democratic Republic of the Congo	
Study measuring the perceived workload of carrying out clinical tasks, using different PPE combinations as well as the difference in number of readjustments and physiological signals between separate PPE and integrated PPE.	University of São Paolo, Brazil; Universita' di Bologna, Italy; Stanford University USA	Since hospitals facing a shortage of disposable respirators (N95, FFP2) have sometimes chosen to use power-assisted air purifying respirators to protect medical staff from exposure to aerosols containing SARS-CoV-2 during direct patient care, and in these situations the design of PPE may affect overall well-being and may be perceived to hinder or facilitate clinical work: • to measure the perceived workload of carrying out clinical tasks, using different PPE combinations, in simulated working scenarios, for baseline assessment and reproducibility purposes, and then in two COVID-19 care sites (Bologna and São Paolo) • to measure the difference in number of readjustments and physiological signals between separate PPE and integrated PPE	Study ongoing
Human fit study for the reuse of disinfected of N95, medical and community masks	Stanford University, USA	To examine the fit of the respirators, medical and community masks before and after disinfection by heat, HPV and MB as directed by WHO, Centers for Disease Control and Prevention and National Institute for Occupational Safety and Health, all of which are working on additional aspects of this work, and	Study ongoing

Project	Institution	Objectives	Link to publication
		to explore the human factors around the research question, surveying the experiences, preferences and human factors of mask-wearing among health professionals and the general public	
Evaluation of a novel, locally produced vacuum-formed mask in the community-oriented primary care programme in Pretoria, South Africa	University of Leicester, United Kingdom	A pseudorandomized trial comparing Mayku masks (study arm) versus a standardized local source of cloth masks (control arm) to evaluate the effectiveness of Mayku masks in relation to community acceptability, appropriate use and infection prevention – acceptability and appropriate use to be determined by questionnaires and infection prevention by SARS-CoV-2 antibody testing	Study ongoing
COVID-19 droplet protection using face shields: development of methods to measure effectiveness of face shields for local production and adoption in low-resource settings	University of East Anglia, United Kingdom	To acquire data on why people choose face shields (sometimes called visors), which are being used extensively during the COVID-19 pandemic, especially in low- and middle-income countries, and on how they are worn, to inform how face shields can be best designed to minimize transmission of COVID-19 or other influenza-like illness	Study ongoing
Medical and non-medical mask/N95 respirator inhalational MB profile study	University of Washington, USA	Since application of MB to decontaminate face masks yields a constant amount of MB residuum on the masks, but the quantity of MB inhaled from the pre-treated or decontaminated mask over the course of an 8–10-hour mask-wearing	Study ongoing

Project	Institution	Objectives	Link to publication
		shift or event is unknown, and the data safety sheet for MB suggests that, to mitigate any inhalational health risks, a dose lower than 700 ppm must be maintained: • to identify the quantity of MB that comes off masks during the course of a 10-hour wearing shift through physiological inhalation and exhalation • to test multiple masks treated with MB and measure the ppm of MB that comes off masks during course of a 10-hour shift, using spectroscopy	
Utilizing remotely piloted (drone) aerial systems (RPAS) operating beyond line of sight (BVLOS) to deliver medical supplies and PPE to remote first nation communities during the COVID-19 Pandemic	University of Calgary, Canada	• To define a procedure for using drones for delivering PPE to remote areas in Canada, which requires clearing relevant regulatory frameworks – e.g. flying authority authorization for BVLOS operations • After clearing the required authority approvals, to perform flights to demonstrate the feasibility of this approach and pave the way to further discussion and partnerships with local community representatives	Study ongoing
Decontamination of masks and filtering facepiece respirators inoculated with an infectious norovirus via MB photochemical treatment	University of Liege, Belgium	Since inactivation of a norovirus – the most resistant of the respiratory and oral human viruses – can predict the inactivation of any less resistant viral contaminant and will provide	Study ongoing

Project	Institution	Objectives	Link to publication
		important information regarding safe decontamination and re-use of typically single-use only PPE items: • to investigate MB decontamination of murine norovirus (MuNoV)-inoculated masks and respirators, which will provide an opportunity to improve LED light box efficiency via optimization of physical and environmental parameters (wavelength, light type, exposure frequency, temperature, ventilation, spacing) that may affect MB activation, considering MB photobleaching in correlation to viral inactivation	
Persistent antimicrobial treatment for medical face mask, respirators and community masks	Universita' Campus Biomedico Roma, Italy	To review the scientific literature for effective antimicrobial treatments for medical face masks, filtering facepiece respirators (i.e. N95, FFP2 or FFP3 standard or equivalent) and community masks (i.e. non-medical face mask)	Study ongoing
Performance characterization of effective community face masks and methods for their rapid, onsite decontamination by physical and chemical processes for reuse	University of North Carolina, USA	• To conduct laboratory studies on the effectiveness of sunlight, dry and wet heat, hydrogen peroxide and detergents to inactivate SARS-CoV-2 by using surrogate viruses aiming for 5–6 log10 reductions • Based on the results of these studies, to develop technical protocols and communication products to support communities to decontaminate face masks	Study ongoing

Project	Institution	Objectives	Link to publication
		as a COVID-19 prevention and control measure • To quantify reductions in the infectivity of enveloped viruses – specifically bacteriophage Phi6 and animal coronaviruses such as mouse hepatitis virus and/or transmissible gastroenteritis virus of swine	

Objective 3 – Minimize the role of the environment in transmission

Primary studies			
Project	**Institution**	**Objectives**	**Link to publication**
• Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients • Air, surface environmental and PPE contamination by SARS-CoV-2 from a symptomatic patient • Lack of viable SARS-CoV-2 among PCR-positive air samples from hospital rooms and community isolation facilities • Environmental contamination in a COVID-19 ICU – What is the risk?	National Centre for Infectious Diseases, Singapore	To identify potential patient-level risk factors for environmental contamination by SARS-CoV-2 by sampling the air and surfaces surrounding hospitalized COVID-19 patients at different stages of illness	• DOI: https://doi.org/10.1038/s41467-020-16670-2 • DOI:10.1001/jama.2020.3227 • DOI: https://doi.org/10.1017/ice.2021.8 • DOI: https://doi.org/10.1017/ice.2020.1278

Primary studies			
Project	**Institution**	**Objectives**	**Link to publication**
Survival of Coronavirus Surrogates on Meat and Fish Products	Texas Tech University and the University of North Carolina, United states.	Evaluate the survival of various coronavirus surrogates including enveloped and non-enveloped bacteriophage viruses as well as animal coronaviruses such as Transmissible Gastroenteritis Virus (TGEV) and Murine Hepatitis Virus (MHV) on meat and fish products.	Study ongoing
Investigating SARS-CoV-2 surface and air contamination in an acute health care setting during the peak of the COVID-19 pandemic in London	Imperial College London, United Kingdom	To assess potential role of environmental and air contamination but no demonstration of transmission	DOI: https://doi.org/10.1093/cid/ciaa905
Study on room sanitization using MDU/Rx™ units in hospital rooms of patients infected with SARS-CoV-2	University of Calgary, Li Ka Shing Institute of Virology, University of Alberta and Alberta Health Services, Canada	• To confirm the efficacy of the MDU/Rx against SARS-CoV-2 in a laboratory setting • To determine whether MDU/Rx is effective against SARS-CoV-2 in COVID-19 patient care rooms	Study ongoing
Study on methods to detect cultivatable virus in the clinical environment of the SARS-CoV-2 patient	University of Calgary, Li Ka Shing Institute of Virology, University of Alberta and Alberta Health Services, Canada	To determine successful methods for sample collection and transport of specimens from the environment in patients infected with SARS-CoV-2	Study undergoing review for publication An additional study ongoing

Primary studies			
Project	**Institution**	**Objectives**	**Link to publication**
Electrolysed water for hospital cleaning: pilot study in Nigeria	London School of Hygiene & Tropical Medicine, United Kingdom	To test the effectiveness of electrolysed water on hospital surfaces compared to standard products through a pilot laboratory study and a cluster RCT in Nigeria. Pilot objectives: • to assess the feasibility of product application • to select high-touch surfaces • to adapt the procedures for outcome measurement (aerobic colony counts and presence of *Staphylococcus aureus*) • to estimate the baseline microbiological cleanliness for standard cleaning products • to assess the potential effectiveness of hypochlorous acid • to refine the procedures for allocation concealment	Study ongoing
Use of carbon dioxide (CO_2) sensor to assess the potential infectious risk of SARS-CoV-2 in indoor settings	University of Hong Kong, China	• To provide required ventilation rates for minimizing long-range airborne (aerosol) transmission of SARS-CoV-2 • To estimate CO_2 threshold concentrations in different indoor settings such as classrooms,	Study ongoing

Primary studies			
Project	**Institution**	**Objectives**	**Link to publication**
		offices, restaurants, buses, gym, supermarket, cruise ships etc. • To assess the adequacy of some available CO_2 sensors in the market and to provide specifications, including technical specifications, sensors placement and measurement recommendations, enabling the use of CO_2 sensors to assess ventilation and the potential infectious risk of SARS-CoV-2 in indoor settings	
Cough droplet sampling methods and PCR testing	University of Alberta, Canada	• To directly sample exhalations, report size-selection and culture the virus reported. • To select by size and analyse exhaled (breath, speak, cough) droplets for qPCR and culture.	Study ongoing

Implications of the SARS-CoV-2 variants of concern for IPC recommendations

On 14 January 2021 the WHO Secretariat convened a consultation with members of the WHO COVID-19 IPC Guideline Development Group and the WHO COVID-19 IPC R&D Expert Group to discuss the implications of the SARS-CoV-2 variants of concern for current IPC recommendations.

The experts noted that knowledge gaps that have a direct impact on relevant questions for IPC of the new variants of concern pertain to several, including but not limited to:

- the level of increased transmissibility of the different variants;
- whether there are any relevant changes in the SARS-CoV-2 modes of transmission, survival time of variants in the environment, incubation period and virus shedding durations, and infectious dose;
- whether the new variants cause more reinfections or affect vaccine effectiveness; and
- whether immunocompromised patients are disproportionately affected by the new variants.

Knowledge gap	Reason it is critical	Other remarks
Actual increased transmissibility	Increased transmissibility has been reported with a wide variation of the estimated attack rates depending on the variant, geographical areas and modelling.	Each of the new major variants of concern (associated with the United Kingdom, Brazil, South Africa and mink farming) will need to be evaluated in this context.
Modes of transmission (MOT)	Any **significant** changes with relevance to any of the routes of transmission may affect current IPC recommendations – in particular, PPE recommendations.	This includes emphasis on asymptomatic and pre-symptomatic cases and transmission dynamics, which are important in both health care and community settings.
Incubation period	This may affect public health recommendations on quarantine, contact tracing and so on.	Any differences in incubation would affect many of the public health and IPC recommendations.
Shedding duration	The duration of shedding of viable virus may affect the duration of isolation recommendations and PPE use in health care and community settings.	This may have a greater effect on immunocompromised individuals, which will need to be assessed.

Knowledge gap	Reason it is critical	Other remarks
Infectious dose	A lower dose may lead to more infections.	Assessment is needed of whether and how this would affect current PPE recommendations.
Hospital outbreaks	These are affected by differences in modes of transmission or recommended measures to prevent transmission.	Assessment of the type and duration of use of PPE is needed.
Reinfection	Potential for reinfection is increased because the new variants of concern may behave differently.	N/A
Impact on vaccine effectiveness	The impact on the health care worker population and high-risk population, as well as the impact on relaxation of measures post vaccine, giving a false sense of security, could be significant.	Health care workers are of high relevance for the pandemic response.
Immunocompromised patients	If this population is disproportionately affected by new strains, they may require different recommendations.	Questions surrounding whether immunocompromised patients are more vulnerable to variants or are sources of super-spreading events.
Exposure/close contact definition	It is important to know whether the definition of close contact needs to be modified for current variants of concern or future variants during preliminary investigations.	N/A
Viruses with variants – higher survival rates and duration in environment/on surfaces	The implications for cleaning/decontamination methods need to be assessed.	N/A

The experts also identified further key research questions and proposed methods to be used to investigate them.

Key research question	Proposed methods to address it	Other remarks
Is there a significant increase in transmissibility? To what extent are the increased attack rates observed with the new variants influenced by Public Health and Social Measures (PHSM) measures?	• Case control and prospective cohort study designs • Assessment of outbreaks in the hospital setting	Priority question
Are there any alterations to the MOT? If so, do these have any impact on IPC measures: distance, PPE requirements and other non-pharmaceutical measures (NPM) (e.g. masking)? Is there a difference in infectious large respiratory droplets/droplet nuclei ratios (measured as intact virions per plaque) expelled by cases infected with the new variants? If so, does this have any impact on the respiratory protection needed? Is there a difference in survival on surfaces and susceptibility to disinfectants, and does this have any impact on decontamination practices?	• Health care worker review of exposures and those not meeting criteria – testing and genomic sequencing of both groups to assess exposure and efficacy of PPE and other intervention methods • Survival studies of the new variants versus variants of concern versus wild type SARS-CoV-2	Priority question
Should IPC efforts be enhanced until more data are available on variants?	N/A	Priority question
Is there any impact of shedding duration on isolation period requirements?	N/A	Priority question
Do the variants of concern have a lower infectious dose (which could explain more infections)? If so, does this have an impact on the isolation period?	• Animal model studies • Human challenge experiments if ethically approved	Priority question
Is there increased transmission in asymptomatic patients?	Cohort and population-based ecological studies	Priority question
Is there a difference in shedding among immunocompromised patients?	Longitudinal shedding duration studies of viable virus	N/A

Key research question	Proposed methods to address it	Other remarks
Does the circulation of new variants affect the effectiveness of the vaccines (at any stage of vaccination)? Would this have an impact on the possibility of relaxing IPC measures for those who have been vaccinated and on the ability to lift restrictions of movement (e.g. passports for vaccinated people)?	• Cohort and population-based ecologic studies • Phase 4 vaccine-based studies	N/A
Are there infectivity assays or experimental animal assays that would make it possible to determine whether these variants are more infectious or have different dose responses?	Animal model studies	N/A
Are LTCFs a hot spot for the new variants to spread?	Cohort and population-based ecological studies	N/A
Should there be any changes in defining close contact time (i.e. 15 minutes)?	N/A	
Are immunocompromised patients at risk of novel variants (e.g. patient zero)?	Assessment and screening of patients who have received monoclonal antibodies, convalescent plasma therapy or antivirals	N/A
How does the mutation rate for SARS-CoV-2 compare to other human coronavirus strains?	N/A	N/A
How can existing studies be leveraged using serology to type for new variants and evaluate the impact on infection or risk factors?	Leveraging any other funded studies by WHO or within countries that are relevant to the IPC research agenda: an example would be the WHO international case control multicentre study – Assessment of risk factors for COVID-19 in health workers, which could utilize existing samples and send them for typing	N/A

Annex 1. Members of the WHO COVID-19 IPC R&D Expert Group

Member	Affiliation
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