Infection Prevention & Control (IPC) Research during the Pandemic: An Opportunity for Saving Lives and Avoiding Costs

Dr John Conly on behalf of the WHO COVID-19 IPC R&D Expert Group
Introduction: R&D Objectives for IPC

1. understand the effectiveness of public health and social measures and IPC strategies to prevent SARS-CoV-2 transmission in health care and community settings
2. optimize the effectiveness of personal protective equipment (PPE) in reducing the risk of transmission in health care and community settings
3. identify the role of the environment in transmission of SARS-CoV-2

45 IPC research projects coordinated, funded, or led by WHO, in collaboration with the COVID-19 IPC R&D Expert Group. Results provided innovative solutions and helped to inform WHO IPC guidelines for COVID-19
OECD/WHO Joint Project Cost-effectiveness of IPC Interventions to Reduce Transmission of SARS-CoV-2 Among HCWs

- Analysis with **global coverage**, during the first 180 days of the pandemic
- Using the **OECD Strategic Public Health Planning COVID-19 model**, that predicts disease outcomes by inputting **health impacts** - attributable morbidity and mortality, and **economic impacts** - medical costs of treatment, productivity loss due to absence from work and premature mortality and **effectiveness of IPC interventions** based on meta-analyses of scientific evidence
Cost-Effectiveness OECD/WHO Joint Project - Results

Combining increased access to PPE with IPC training yields the greatest global health and economic gains.

> 50% of new infections among HCWs in South-East Asia, Europe and the Americas, and approximately one third of new infections in other regions, could have been averted.

- $7.2 billion USD net savings globally
- Hand hygiene also cost-effective in most regions
WHO Multicenter Case Control Study to Assess Risk Factors for COVID-19 in Healthcare Workers (HCWs)

Objectives

1. To characterize and assess the IPC risk factors for SARS-CoV-2 infection in HCWs with exposure to COVID-19 patients
2. To describe clinical presentation, including serologic responses, duration and disease severity for SARS-CoV-2 infection in HCWs

Interim findings

• 2285 HCWs from 97 health facilities in 19 countries participated (~80% low-middle income)
• Risk factors for COVID-19 in HCWs identified so far
  ➢ Prolonged close contact (>15min within 1 meter) [OR 1.4, 95%CI 1.0-1.8, P=0.05]
  ➢ Inconsistently wearing a respirator or a surgical mask or both compared to consistently wearing a respirator during AGPs [OR 4.8, 95%CI 2.3-9.7, p<0.01]
  ➢ Not always appropriately performing hand hygiene during prolonged patient contact [OR 2.7, 95%CI 1.7-4.2, P<0.01]
Understanding the Burden of Hospital-onset COVID-19 Infection (HOCl) and Developing Implementable Surveillance Systems

- **Living rapid review** on existing HOCl systems initially published in the Journal of Hospital Infection; **9 sets of definitions** and surveillance systems identified. Proportion of **HOCl cases varied from 0% to 15.2%**. A new definition was developed.

- **Network analysis of COVID-19 transmission** in healthcare settings using **patient movement data** and a risk **prediction algorithm** based on patient and specialty characteristics, and development of a real-time and automated **HOCl surveillance** and individual risk prediction system (not yet published).


Understanding the Impact of the Pandemic on Healthcare-associated Infection (HAIs) and Antimicrobial Resistance (AMR)

- **Study 1 (London):** of 1,047 bloodstream infections (BSI), 38% were HAIs, with **bloodstream HAI rate increased to 132.3** during the Wave 1 and to **190.9 per 100,000 patient-days** during Wave 2, compared to 100.4 across the pandemic (with significant increases in elective inpatients). Patients with HAI had longer hospital stays (≈20 days) and 26.7% higher mortality rates.

- **Study 2 (Singapore):** decreasing trends of incidence of HAIs in intensive care units and of carbapenem-resistant organisms in 2020 compared to previous years.

Optimize PPE Effectiveness: Addressing PPE Shortages Through Innovative Decontamination Processes

Rapid, On-Site Decontamination of Facemasks in Low-Resource Settings (M. Fisher, M. Sobsey et al.)

<table>
<thead>
<tr>
<th>Method</th>
<th>Cloth Mask</th>
<th>Dry Heat</th>
<th>Rice Cooker</th>
<th>Sunlight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time (min)</strong></td>
<td>5.1 ± 0.3</td>
<td>10.8 ± 4.4</td>
<td>7.7 ± 4.8</td>
<td>33.6 ± 2.9</td>
</tr>
<tr>
<td><strong>Wet Heat</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dry Heat</strong></td>
<td>13.6 ± 4</td>
<td>15 ± 6</td>
<td>33.1 ± 15.8</td>
<td>152.8 ± 107.6</td>
</tr>
<tr>
<td><strong>Rice Cooker</strong></td>
<td>19.6 ± 12</td>
<td>21.3 ± 5.8</td>
<td>24.9 ± 8.9</td>
<td>171.5 ± 93.1</td>
</tr>
<tr>
<td><strong>Surgical Mask</strong></td>
<td></td>
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</tbody>
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Florine Scholte et al., Exploring inactivation of SARS-CoV-2, MERS-CoV, Ebola, Lassa with methylene blue
Optimize PPE Effectiveness - Addressing PPE Shortages: Pre-treatment, Antimicrobial Treatment, Delivery

DeMaND-2 Project: Pretreatment with Methylene Blue:

Respirators’ pretreatment + ambient light
• remained effective for up to 3 weeks against SARS-CoV-2 Delta and MERS on N95s and KN95s

Surgical masks pretreatment + ambient light
• effective at fully inactivating (>99.9%) SARS-CoV-2 Beta variant within 5 minutes at concentrations of 5µM or higher.

Community masks pretreatment + ambient light
• inactivated >99.9% of SARS-CoV-2 Beta variant within 30 minutes for concentrations of 2.6 µM or higher
• Full inactivation to limit of detection occurred for concentrations of 50 µM (Mask 5) or higher.

https://doi.org/10.1017/ice.2021.230

The Use of Drones for the Delivery to Remote First Nations Communities During Covid-19 (J Conly, W Hawkins, et al.)

The Use of Drones for The Delivery of Diagnostic Test Kits and Medical Supplies to Remote First Nations Communities During Covid-19, American Journal of Infection Control (Under revision)

Enhanced Medical and Community Face Masks with Antimicrobial Properties: A Systematic Review
“ […] antimicrobial treatment is a promising route to extending the life and improving the safety of face masks. In order to reach significant achievements, shared and precise methodology and reporting is needed” https://doi.org/10.3390/jcm10184066
Optimize PPE Effectiveness: Improving Design and Human-Experience

Perceived Workload using combination of PPE (e.g., respirators + visors) vs PAPR (Padoveze et al., unpublished)

Field testing procedure of N95 mask + face shield (left) vs Light PAPRs (right). PAPRs reduced perceived workload (NASA Task Load Index) and increased usability (System Usability Scale score) & communication among HCWs.
Lessons Learned: Research on IPC Interventions

- on the **cost-effectiveness of IPC interventions**
  - enhanced PPE use, IPC training and hand hygiene could have **prevented millions of infections among HCWs and billions of associated costs** on a global scale
  - sustained **IPC programmatic support** and **training** among all HCWs and **budgeted and operational plans for rapid PPE procurement scale-up** at the start of a pandemic must be prioritized to save lives and costs

- on **HCW infections**, research has yielded **identification of risk factors** for SARS-CoV-2 infection among HCWs, and **capability to assess high-risk breaches** in IPC practices

- patient **hospital-onset COVID-19 infection (HOCI)** posed significant harm to patients; **real-time surveillance and risk prediction systems must be in place and be maintained**, allowing early identification of HOCI and informing **local IPC practices** to prevent spread to patients and HCWs. The methods can be translated to monitoring transmission of **other pathogens**
Lessons Learned: PPE

- Severe PPE shortages at pandemic arrival demonstrated that pre-COVID models for manufacturing, logistic and disposal of PPE was not sufficient, sustainable nor resilient - there is a need for decentralized/regional approaches in context of a pandemic
- HCW and population perceptions are critical to PPE uptake, adherence and extended use
- Need for a paradigm shift regarding PPE of the future in context of climate change – focusing on reusable/biodegradable PPE given waste generation from PPE
- The increased attention on PPE should not hinder the attention on other IPC measures; the combined use of PPE with other measures is significantly more effective than PPE alone
- Gaps exist among research outputs and the actionable outcomes required for writing evidence-based cost-effective IPC global measures. Further collaboration is required
- More well-designed, timely, robust studies (e.g., multicentric RCT) are required to generate high-quality evidence on PPE efficacy and safety
Priorities to Expand Research Capabilities for Future Pandemic Preparedness Related to IPC Interventions

- **Understanding HCW infections**: surveillance with standardized methods for reliable estimation of HCW cases and outcomes and identification of occupational vs community acquisition and exposure settings; understanding the role of working conditions (e.g., overload, excess working hours, variations in post-infection return-to-work criteria; understanding the epidemiology of reinfection.

- **Assessing HCW behaviour following vaccination**: impact of mandatory vaccination on HCWs behaviours and outcomes; impact of the COVID-19 vaccination on PPE/IPC measures (de-escalation).

- **Understanding HOCI among patients**: effectiveness of innovative real-time surveillance and WGS to detect transmission in health care and understand the dynamics; assessing the impact of tailored IPC measures implemented according to real-time HOCI surveillance data; applicability of these methods to other pathogens.

- **Assessing the impact of the pandemic on AMR and HAI**: in COVID-19 and other patients; assessing impact on antibiotic use and access; understanding emerging and re-emerging pathogens associated with surges of COVID-19 cases.
Priorities to Expand Research Capabilities for Future Pandemic Preparedness Related to PPE

- High-quality evidence on medical masks vs respirators effectiveness and adverse events in the context of prolonged use, repeated use and in combination with other PPE
- Effectiveness of PPE decontamination methods and need for standardised protocols
- Human factors: effective & safe PPE use; does PPE use affect compliance with IPC measures?
- Non-medical masks: adequate standards for manufacturing, mass-production, optimal use, performance assessment, decontamination and communication strategies to public
- Improve PPE international standards, design processes, taking into consideration physical differences, as well as gender (e.g., female) and ethnicity
- Lifecycle of PPE and non-medical masks: optimising logistics, management, surveillance, waste management, minimizing the environmental impact, need for innovative solutions
- Exit strategy for PPE use in the context of the pandemic scaling back