Frugal Engineering

Medical devices and infection prevention and control practices for low-resource settings

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About me..

Dr Davide Piaggio

Assistant Professor of Biomedical Engineering, University of Warwick, UK

Co-Director, Applied Biomedical Signal Processing and Intelligent eHealth lab

Academic Co-Lead for Biomedical Engineering and Biotechnology, Health GRP, University of Warwick

Steering committee member, WICID, University of Warwick

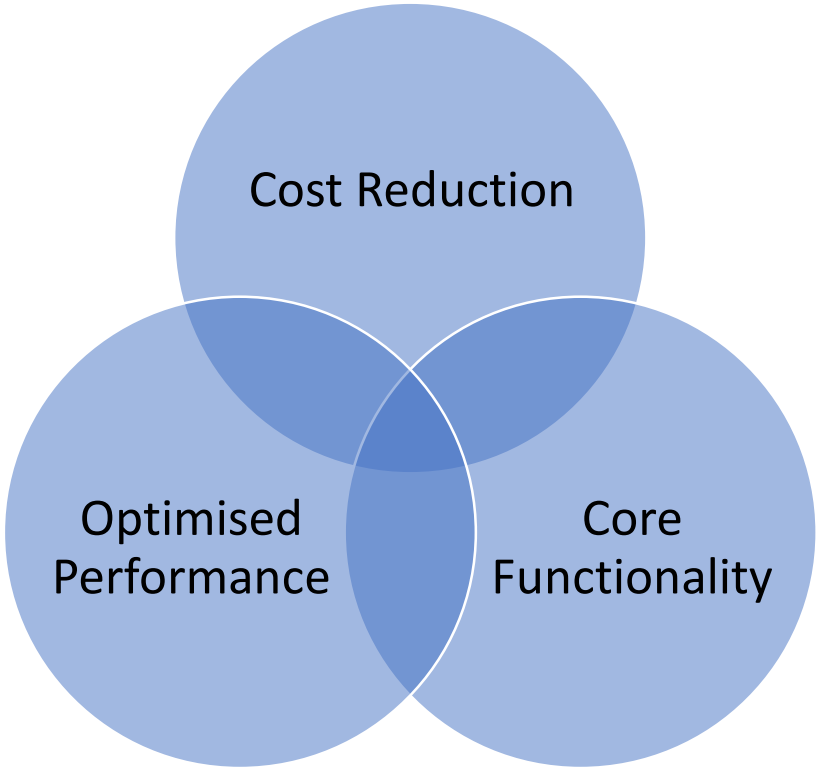
Collaborator member, IFMBE HTAD

Research interests: medical device design, management, assessment and regulations, frugal engineering, mHealth, additive manufacturing, IPC, ethics, preparedness and governance

GATE KEEPER

Frugal design of medical devices

- **Frugal** is defined as "**simple and plain and costing little**" – Oxford Languages.
- **3 pillars** being: cost reduction, optimized performance, and core functionality
- Extremely **values** the **contexts** and the **end users**



Major challenges?

Major challenges being:

- Lack of **funds**
- Lack of **expertise** (specialized doctors and biomed. Engineers)
- Poor **supply chain**
- Poor **infrastructures** (electrification rate)
- Harsh **environmental conditions** (humidity, temperature)

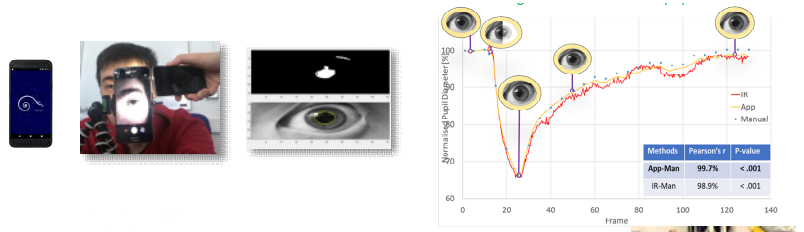
Possible solutions?

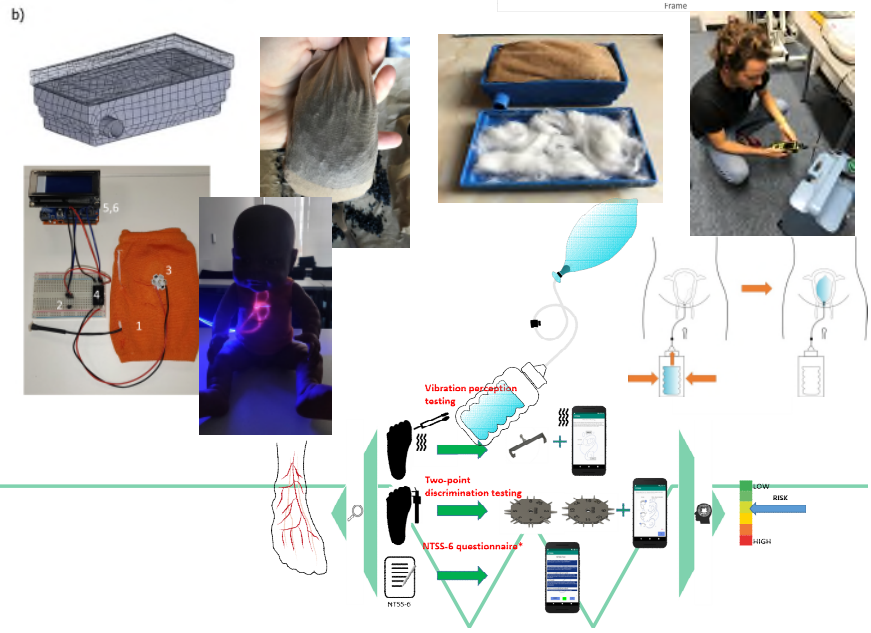
General level:

- A framework for designing medical devices resilient to low-resource settings
- A framework for assessing healthcare locations in low-resource settings
- A framework for promoting a more universal regulatory approach for medical device and healthcare locations

Particular level:

mHealth, 3D printing and protocycling as possible ways forward





Why focus on low-resource settings?

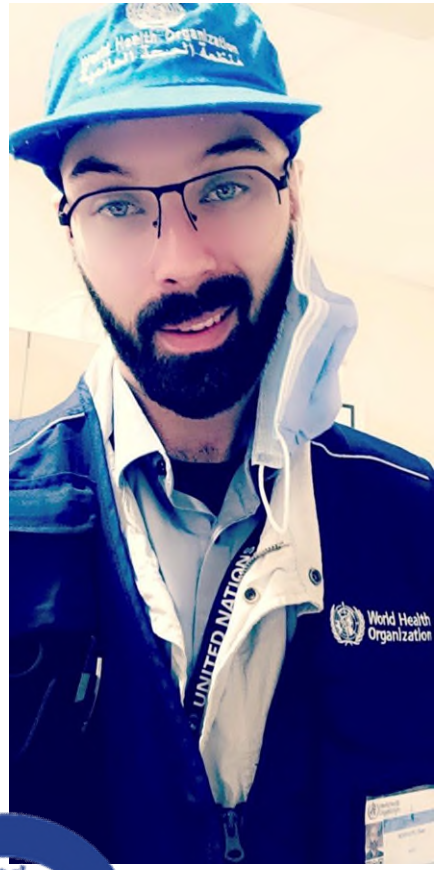
- **Inequitable access to healthcare**: less than 15% of the global population accounts for over 75% of the global medical device use in favour of higher-resource settings
- For example, up to 80% of **medical devices** in SSA are **donated**, and up to 90% of them are **not working**
- **Health emergencies** highlighted severe conditions also for higher resource settings

COVID-19 influence on our work

Focus on:

- Local **perception** (Benin) of **protective measures** and **vaccination** campaign
- **Infodemic** and the relation between scientists, policymakers and bioethicists
- Research priorities in **Infection prevention and control** practices

About me..



Dr Madison Moon

Technical Officer (Country Support) - World Health Organization
Health Emergencies Programme – Infection Prevention and Control

Current projects: IPC standard operating procedures during outbreaks (Acute Watery Diarrhea, Crimean-Congo Haemorrhagic Fever), Classification of Emergency Medical Teams for Highly Infectious Diseases, Healthcare Associated Infection Investigation Handbook, IPC and WASH Innovations during Health Emergencies, Integrated Outbreak Analytics

Current response operations: Sudan Crisis, Northern Ethiopia Humanitarian Response, Multi-Region Cholera outbreak, Iraq and Afghanistan Crimean-Congo Haemorrhagic Fever Outbreaks, Yemen Humanitarian Response

IPC Preparedness Readiness Response

World Health Organization
HEALTH EMERGENCIES programme

Scope of WHE IPC PPE R&D projects (2020-2022):

R&DBlueprint
Powering research to prevent epidemics

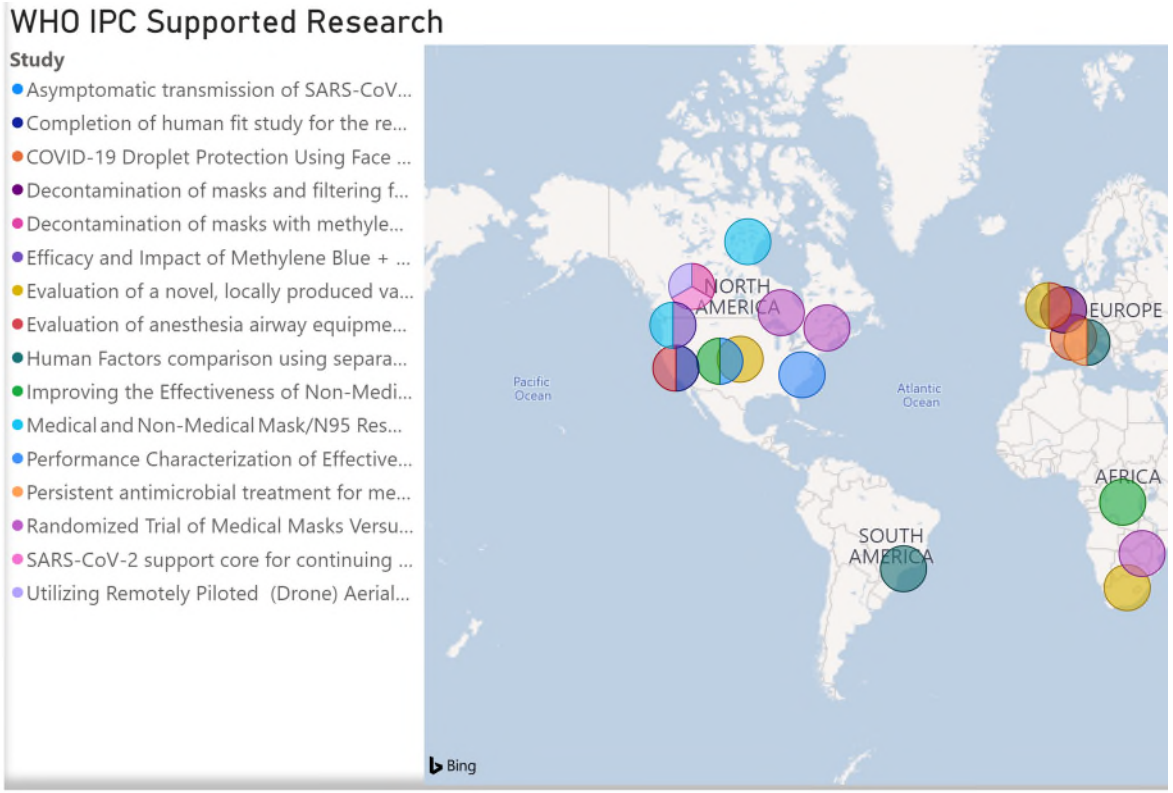
Optimal PPE selection and human factors in healthcare (4 studies, 3 with multiple sites): Randomized control trial of medical masks and respirators, human factors studies of health workers using combination PPE (respirator and face shield vs. PAPR), contamination of environment and PPE associated with anaesthesia/airway procedures

PPE Decontamination (6 Studies): Examining low-cost novel decontamination methods to allow for PPE reuse particularly for community masks and respirators, but also for other PPE (gowns, medical masks). Determining relative decontamination potential of different low-cost methods. Multiple studies evaluating multifaceted approaches necessary to build scientific evidence for the introduction of Methylene Blue + Light as a novel decontamination method.

Community Masks [textiles] (4 studies): Evaluating the effectiveness of textiles used in non-medical masks, evaluating the use of safety/efficacy of antimicrobial treatments on community masks, evaluating novel vacuum sealed masks, evaluating the relative respiratory pathogen reduction capabilities of an international sampling of face shields.

Surveillance (1 study): Evaluating the use of test strips embedded in masks capturing the wearers exhaled breathe as a form of asymptomatic surveillance.

Transport of PPE (1 study): Evaluating the use of drone delivery for PPE and medical devices to low-resource settings

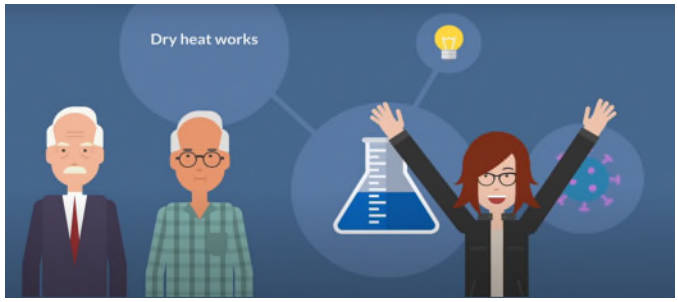


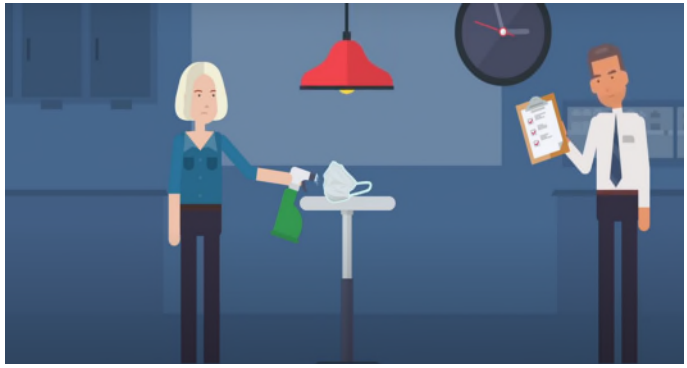
World Health Organization

HEALTH EMERGENCIES programme

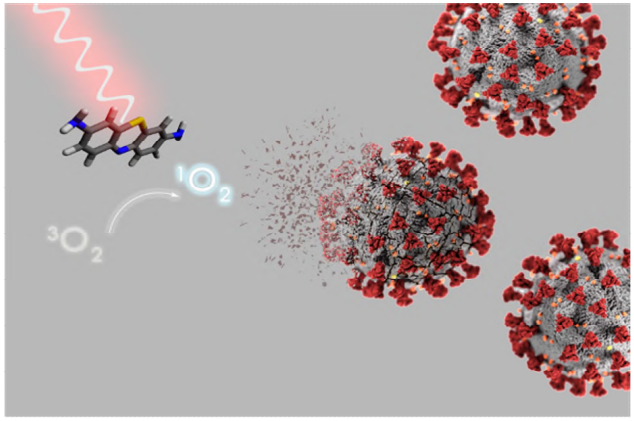
Focus - Decontamination of Personal Protective Equipment

During severe shortages, research efforts made to evaluate methods for **reusing PPE designed for single-use.**





- → **Multiple methods were laboratory and field tested**
  - → dry and moist heat, methylene blue + light decontamination
- → **Some methods have been granted emergency use authorization**
  - → vaporized hydrogen peroxide, ultraviolet germicidal irradiation
- → **With appropriate technologies and standard operating procedures in place, PPE can be reused when decontamination is performed** while maintaining its functional performance integrity
- → **Methylene Blue** has been validated under **FDA Class-1** registration for **medical masks and respirators**
  - → Gowns and gloves under evaluation
  - → **Effectiveness against other pathogens of concern (current research gap)** - needed for widescale implementation



Promising **decontamination methods** are also being investigated for **surface** decontamination (during cleaning and disinfection)

- → May also provide residual preventative **antimicrobial effect**, which can rapidly deactivate pathogens which contaminate surfaces after initial application

Future outlook

Cholera outbreak and healthcare facilities (very urgent)

→ Current multi-region Vibrio Cholerae outbreak

→ Frequently insufficient water, sanitation, and hygiene infrastructure to provide safe and quality care to patients presenting with diarrheal illness; or to mitigate the risk of spreading diarrheal infections within health facilities in low-resource settings.

→ Additional resource mobilization, capacity building, and innovation needed to enable WASH engineering to meet baseline standard for quality of care

Ventilation of rooms in healthcare facilities (urgent engineering control)

→ Techniques enabling assessment of the current rate of ventilation, particularly natural ventilation assessment for low-resource settings where HVAC engineering expertise may be limited and where mechanical ventilation systems may not have reliable maintenance schedules.

  → Applicable to range of infections, important that laypersons are able to action engineering controls to mitigate inhalation of infectious aerosols

O_2 access

→ Oxygen concentrators provide a simple means of delivering clean concetrated oxygen from room air. Several challenges: short duration of the filters and of the zeolite cylinders, which are hard to retrieve due to the lack of supply chain. Need to research novel frugal ways of filtering and frugal ways of regenerating the zeolite cylinders in house.