Health emergency preparedness

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What were the lessons learned from the last pandemic? The point of view of a biomedical engineer.

Dr Davide Piaggio
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Hosted by Jim Gauthier

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Applied Biomedical Signal Processing and Intelligent eHealth Lab , a multidisciplinary team

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PhD Students

3-4th y

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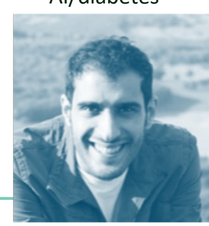

Abdulaziz Almuhini
Medical Engineering
Robots in surgery

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Wanzi Su
Computer scientist
Digital health for neurological/ophthalmological diseases and rehab

Zeeshan Raza
Medical doctor
Robots in surgery

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James Wallace
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Frugal engineering

Muhammad Farooq Shaikh
Computer scientist
Digital health for learning disorders

1st y

About me

Dr Davide Piaggio

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Collaborator member, IFMBE HTAD, IFMBE Africa Biomedical Engineering Working Group, and IFMBE Publicity Committee
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Research interests: medical device design, management, assessment and regulations, frugal engineering, mHealth, additive manufacturing, IPC, ethics, preparedness and governance

Research interest

- Applied *Biomedical signal processing, Internet of Things, Artificial Intelligence*
- Early-stage *Health Technology Assessment* (HTA) and User Need Elicitation methods
- Medical Device design, regulation, assessment and management (Clinical Engineering)

Main applications:

- Active/healthy ageing, prevent disease or worsening and adverse events in later life
- Disease Management Programs, patient monitoring and telemedicine
- *Medical devices and medical locations* in low-resource settings and LMICs

Main Projects

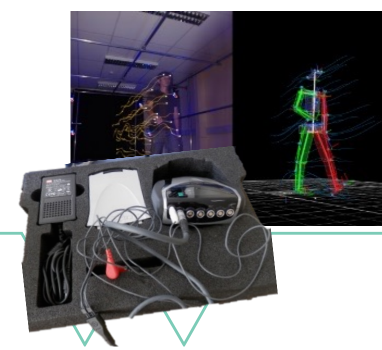
Current projects

1. *2023/2027, WIF, "Novel medical app for the early screening of learning disorders in children"*
2. *2022/2024, Innovate UK, "Intelligent Multimodal Digital Ophthalmic Measuring Device with enabled AI Tele-Ophthalmology"*
3. *2022/2023, Policy support fund, "Pandemic Preparedness: Best and Worst Practices from COVID-19"*
4. *2022/2023, Health GRP, Sustainability across the medical device lifecycle*
5. 2020/2024, *H2020, ODIN Smart Hospital (AI/Robots for Hospitals, COVID-19)*
6. *2020/2023, H2020, GATEKEEPER (AI/IoT for Home Care, COVID-19)*

Former projects

1. *2021/2021. Edwards Lifescience, "HTA of AI-based Medical Devices"*
2. *2021/2021, BT, "5G and well-being monitoring"*
3. *[2020/2022, PandeVita, H2020 call on COVID, EAMBES proj]*
4. 2020/2021, EPSRC, Hypoglicemia via AI and ECG in controlled environment
5. 2020/2022, Wellcome Trust, NoHypoglicemia
6. 2018/2020, GCRF, Medical devices design for Sub-Saharan Africa
7. *2018/2019, EPSRC, Closed-loop control for optimising chemotherapy*
8. *2016/2020, EPSRC IAA, HTA&Design of medical device in low-resource settings*
9. *2015/2016, The Royal Society, Sleep quality & balance*
10. *2014/15, European Commission, MAFEIP tool*



Learning outcomes

- **Understand** what preparedness means
- **Explain** the best and worst practices related to COVID-19 pandemic management and IPC
- **Understand** the importance of interdisciplinarity
- **Understand** the state of the art related to the use of robotics for IPC purposes and contact tracing technologies
- **Understand** the importance of contextualization (low-resource settings) and education

Parts of lecture

- Evidence generation in science
- Preparedness
- Best and worst practices during COVID-19
- Robots and automation for infection prevention and control

Hierarchy of evidence

Systematic literature review process

1) Define the research question

2) Search for relevant articles (search string, db selection, incl/excl. Criteria)

3) Exclusion of non-coherent, inconsistent, repeated studies

4) Synthesis methods (qualitative VS quantitative)

5) Quality appraisal/risk of bias assessment

Systematic literature review process

Let's see a case using Scopus:

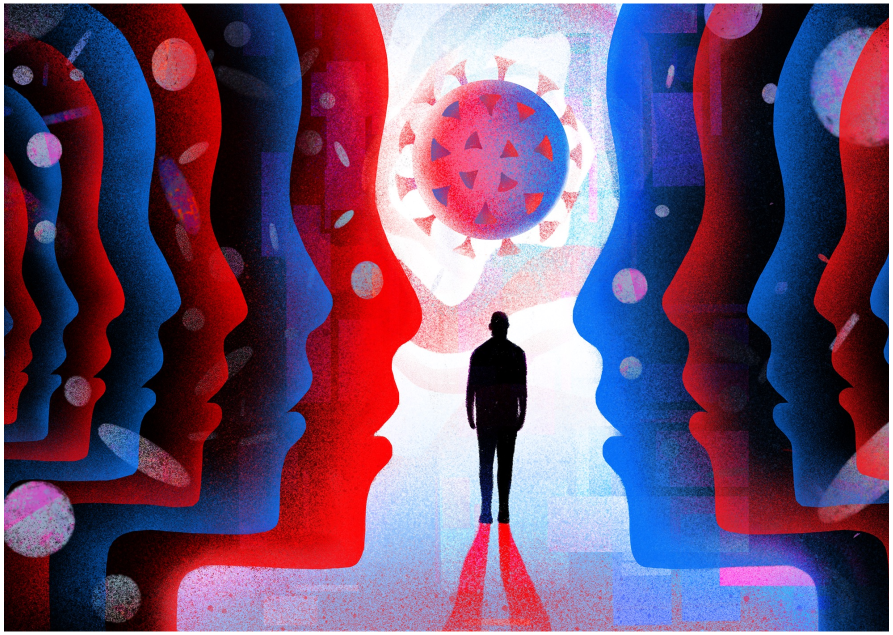
- Scopus: https://www.scopus.com/search/form.uri?display=basic#basic

- Recommendations for a systematic literature review:
  - Start reading few papers on the topic, in order to acquire the language and familiarise with key keywords
  - Once you are familiar with the topic and the keywords define your search
  - Once you have a clear idea of what are you looking for, start playing with the advanced search tool
  - Keep track of your search strategy, you may need it in future.
  - Write in the review report the method you used to do your review. This will make the difference between a review and a good review
  - Once you have collected results and knowledge, make links. Your contribution is not just to collect, but now that you have done, help the reader to see what you think emerges from pooling together different articles.

Preparedness - Introduction

- Future pandemics are inevitable*
- How can the global community best prepare for this?

- Findings presented here**:
  - Outcomes of discussions at the European Health Tech Summit (March 2023)
  - Scoping review of pandemic preparedness and governance strategies from COVID-19



Q&A: Future pandemics are inevitable, but we can reduce the risk | Research and Innovation. https://ec.europa.eu/research-and-innovation/en/horizon-magazine/qa-future-pandemics-are-inevitable-we-can-reduce-risk (accessed 2023-06-29).

**https://www.mdpi.com/2227-9032/11/18/2572

Disaster management phases

Mitigation: To <u>prevent</u> future emergencies and take steps to minimize their effects

- Clearing space around buildings to create a defensible space against fires

Preparation: To <u>take actions ahead of time</u> to be ready for an emergency

- Training and exercises

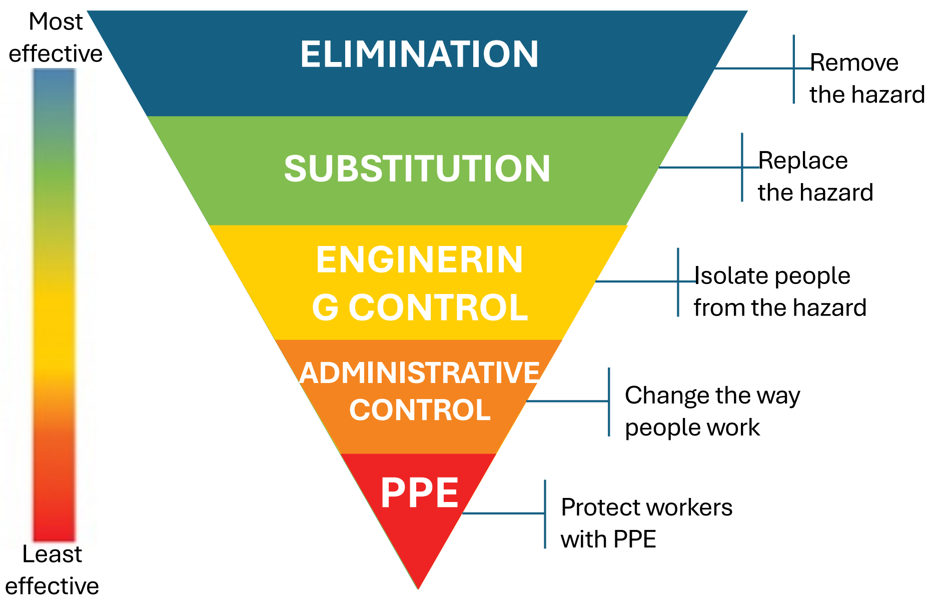
Response: To <u>protect</u> people and property in the wake of an emergency, disaster, or crisis

- Temporary lockdowns, development of vaccines

Recovery: To <u>rebuild</u> after a disaster in an effort to return operations back to normal

- Economic recovery, guidelines and protocols for the future

Preparedness



Elimination:

- removing the hazard.
- In the case of COVID-19, produce sterilizing vaccines (*i.e.,* vaccines that could prevent the infection).
- While the results achieved with the vaccination campaigns are unprecedented for safety and effectiveness, none of the vaccines resulted sterilizing.
- COVID-free wards…

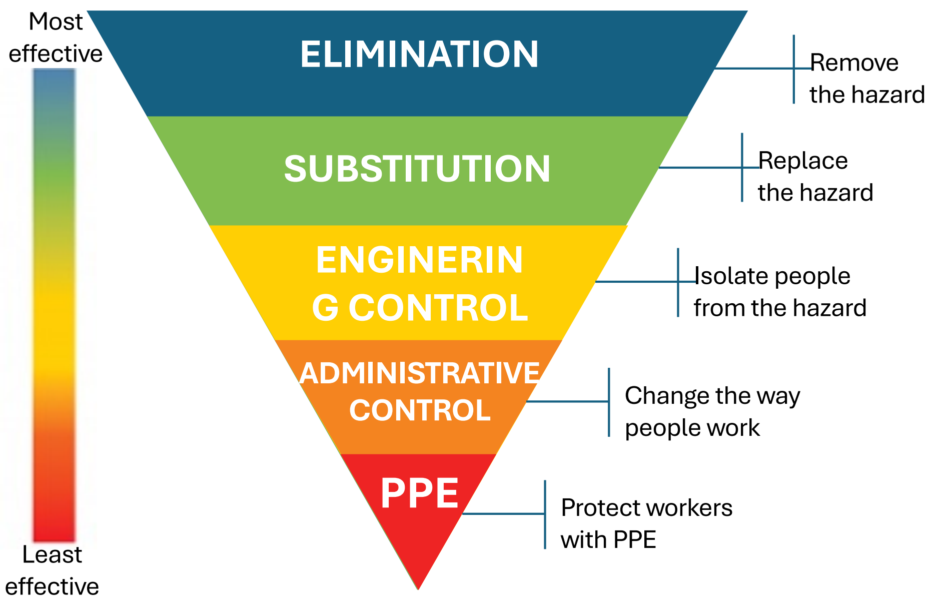
Substitution:

- replacing clinical procedures and interventions with less risky ones
- COVID-19:
  - social measures such as remote work, distance learning and prioritization of outdoor/non-crowd activities, as well as
  - health measures such as choosing non-aerosol-generating surgical procedures as explained later in this section

Engineering Control:

- minimizing unnecessary exposure (people and fomites) to the hazard with engineering measures.
- This involves hospital engineering measures such as pressure control (e.g., inverted pressure), ventilation, filtration, water management, filtering rooms,
- COVID-19: Social measures: increased use of barriers/partitions and an increased attention to those measures also beyond the hospital setting (e.g., public transport)

Preparedness



Administrative Controls:

- changing the way people work, when a residual exposition is still present, acceptable or unavoidable.
- reorganization of (healthcare) working processes in order to ensure the minimization of exposition, the enforcement of clean/dirty paths.
- COVID-19: administrative control was also extended beyond the hospital with social measures such as restricting indoor shopping/dining, reduced indoor density.

PPE:

- protecting the workers with dedicated equipment (masks, gloves, face-shields) when exposition with residual risk factors is unavoidable.
- COVID-19,
  - this opened completely novel scenarios including
    - universal masking (i.e., using PPE as a social measure),
    - prolonged masking (i.e., using PPE in healthcare settings during the whole working shift)
  - and the introduction of novel equipment
    - PPE (e.g., FFP/N95),
    - medical devices (e.g., surgical masks),
    - community-masks (completely novel!!)

COVID-19 and PPE shortage

Every month, frontline health responders around the world need these supplies (and more) to protect themselves and others from #COVID19

- 89 million masks
- 30 million gowns
- 1.59 million goggles
- 76 million gloves
- 2.9 million liters hand sanitizer

#COVID19
#coronavirus

World Health Organization

Grave Shortages of Protective Gear Flare Again as Covid Cases Surge

Five months into the pandemic, the U.S. still hasn't solved the problem. The dearth of supplies is affecting a broad array of health facilities, renewing pleas for White House intervention.

REUTERS World Business Markets Breakingviews Video More

HEALTHCARE & PHARMA APRIL 22, 2020 / 6:14 PM / UPDATED A YEAR AGO

In Britain's COVID-19 wards, doctors say they do not have enough gowns

By Alistair Smout 5 MIN READ

World Health Organization

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Shortage of personal protective equipment endangering health workers worldwide

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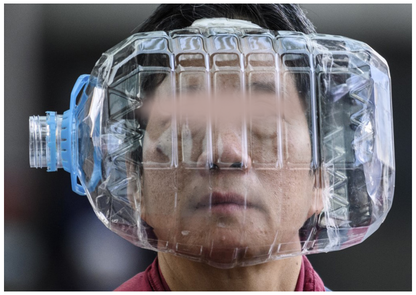
Coronavirus: The NHS workers wearing bin bags as protection

By Claire Press
BBC News

5 April 2020

Coronavirus pandemic

Responsibilities of science and technology - *Responsible thinking, responsible actions, responsible silence*



- COVID-19 created a **global lack of essential medical devices and PPE**
- As a consequence, **myriads of DIY solutions** were proposed and fomented on media worldwide (using the hoover filters as a mask, 3D printing respirators using cotton filters etc.)
- **This approach is unsustainable and very dangerous:** critical sectors as MDs or PPEs require postgraduate education, years of experience and deep knowledge of relevant international standards to ensure safety, efficacy and resilience.
- The virtuous example came from Italy (SIARE, FIAT and FCA, Ferrari and the Italian Government) should be expanded to other critical sectors.
- Much of this chaos could have been avoided if decision-makers had consulted with domain experts, e.g., biomedical and clinical engineers

Inadequacy of regulatory frameworks in time of crisis and LRSs: PPE and COVID-19

- Regulations require that PPE comply with tests and parameters set by international standards in order to be marketed/distributed
- Those standards are:

  too generic;
  mainly written be sellers with the aim at covering the wider possible market (e.g., getting the mask into any working place: hospital, foundry, sawmill…)
- For instance:

  Visors have to pass the bullet test. While this is reasonable for sawmill, this is not for hospital
  Masks have to pass heating test ad very high temperature (e.g., 75 degrees). Reasonable for a founder, not for hospitals
- We systematically analysed the needs and requirements for PPE in hospitals proposing a frugal set of essential tests that masks and visors should have been tested against, in order to be safe and effective.
- E.g., for Mask, only 3 tests are required (compared to the 20+ required by relevant standards):

  Filtering
  Breathability
  Fitting

Pecchia L, Piaggio D, Maccaro A, Formisano C, Iadanza E. The inadequacy of regulatory frameworks in time of crisis and in low-resource settings: personal protective equipment and COVID-19. Health and technology. 2020 Nov;10(6):1375-83.

"Wild" innovation…

The New York Times

The Coronavirus Pandemic › | Map and Cases | Updated Boosters: What to Know | New C.D.C. Guidelines, Explained | Covid F.A.Q.

Trump Resists Pressure to Use Wartime Law to Mobilize Industry in Virus Response

Seat detiene la producción de re…
lavanguardia.com/vida/20200411/48413026980/seat-detiene-produc...

LA VANGUARDIA

CRISIS SANITARIA

Seat detiene la producción de respiradores de emergencia por la descongestión de las UCI

UK cancels order for simple venti…
reuters.com/article/idUKKCN21U0UI

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HEALTH NEWS APRIL 12, 2020 / 10:19 PM / UPDATED 2 YEARS AGO

UK cancels order for simple ventilators, needs more complex ones: source

Financial Times
@FT

Johnson calls on business to help tackle ventilator crisis

Coronavirus: Government orders
bbc.com/news/business-52043767

Business | Market Data | New Economy | New Tech Economy | Companies | Entr…
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Coronavirus: Government orders 10,000 ventilators from Dyson

Coronavirus : 8 500 respirateurs p…
radiofrance.fr/franceinter/coronavirus-8...

france inter

SANTÉ

Coronavirus : 8 500 respirateurs produits... pour rien ?

Par Jacques Monin, Cellule investigation de Radio France

Mis à jour le jeudi 23 avril 2020 à 12h35 | Publié le jeudi 23 avril 2020 à 06h01 | 6 min | Partager

COVID-19 infodemic

An infodemic is too much information including false or misleading information in digital and physical environments during a disease outbreak.

"Drinking bleach can cure COVID-19"

"COVID-19 can be spread through 5G networks"

"Eating garlic prevents COVID-19 infection"

...any home-made concoction as COVID-19 treatment..

...any dubious claim (e.g., microchips in vaccines) that increased vaccine hesitancy....

Best and worst practices during COVID-19

Open Access Review

Pandemic Preparedness: A Scoping Review of Best and Worst Practices from COVID-19

by Alessia Maccaro [1,*], Camilla Audia [2], Katy Stokes [1], Haleema Masud [3], Sharifah Sekalala [4], Leandro Pecchia [1,5] and Davide Piaggio [1]

The article aims:

- To collect the evidence available in literature relative to COVID-19 pandemic **preparedness** and **governance**, focusing on **lessons learned** for future policies, and worst and best practices.
- To anchor our review in **ongoing praxis** around **learning from COVID-19** and reflecting on practices to be better prepared, and more resilient, in the event of future health

Methods

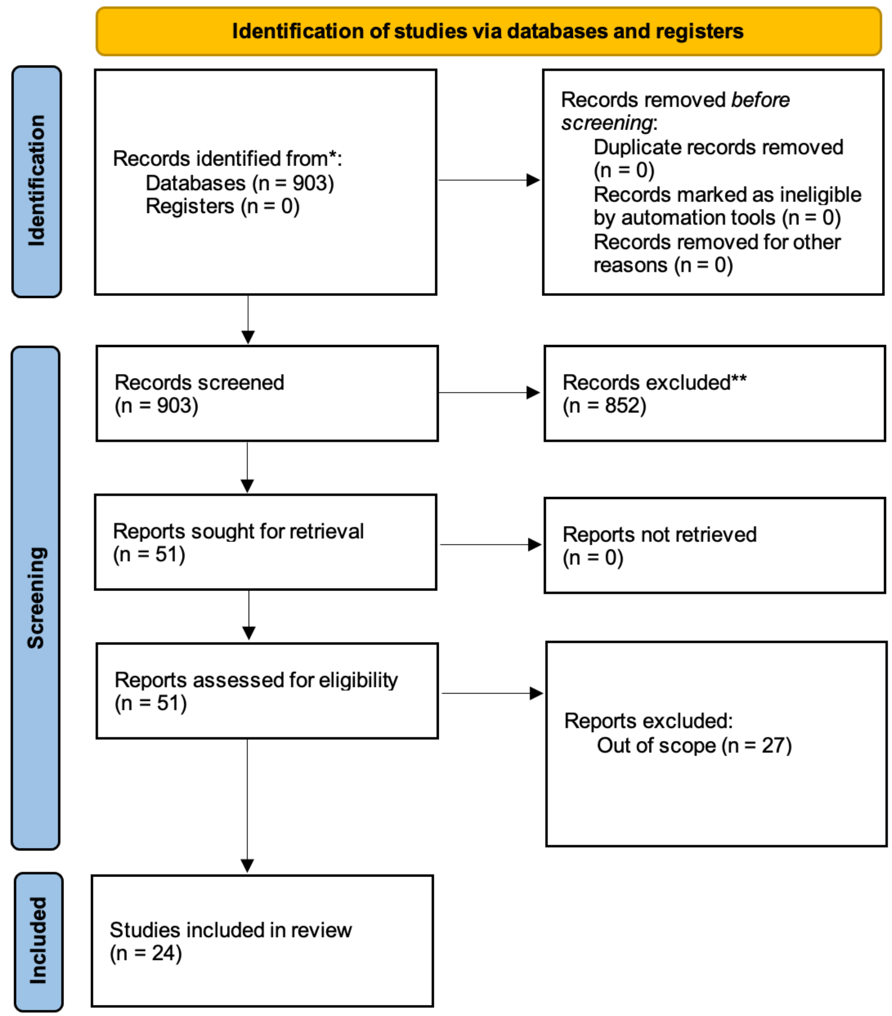
- **String** generated and searched on Scopus (Jan 2019 to Feb 2023)
- **Screening**: by title, abstract, and full text.
- **Inclusion criteria**: Only scientific articles focusing on the management of the COVID-19 health emergency were included.
- **Exclusion criteria**: Languages other than English, full text was not accessible, or published before 2019, or if letter to editors, editorials, commentaries, or review articles. Furthermore, studies that were not referring to the political management of pandemics (perhaps military lessons or focus on clinical setting and interventions), those that were reporting on very specific case studies (e.g., geriatric patient management) or those that were modelling studies were excluded.

Core Topic	Search String
Pandemic	(TITLE-ABS-KEY ((pandemic OR epidemic OR emergenc* OR disaster) AND (covid* OR "sars cov 2" OR coronavirus OR sars-cov-2))
Policies	TITLE-ABS-KEY (((preparedness OR governance OR management OR prevention OR control) AND (polic* OR polit* OR guidelin* OR regulat* OR law OR decree) OR (governmental AND response) OR ((containment OR prevention) AND strateg*)))
Best worst practices	TITLE-ABS-KEY ((best OR worst) AND practice*))


LESSONS FROM COVID
Pandemic Management and Preparedness and the Role of Technology in Securing a Safer Future
21 March 2023, 09:00–11:00 am CET
European Parliament 60 Rue Wiertz, Room 6Q1
Hybrid Event
Hosted By MEP Stelios Kympouropoulos (EPP, Greece)


EUROPEAN
HEALTH TECH
SUMMIT
Hosted by
Stelios Kympouropoulos MEP
Tuesday 21 March 2023
09:00-11:00 Pandemic Management and Preparedness:Telemedicine and the Role of Innovative Technologies in Securing a Safer Future
15:00-17:00 Future-proofing health professionals' skills for digital transition
Wednesday 22 March 2023
09:00-13:00 Showcases of the digital technologies in the health sector: how can technology help detect or tackle a disease?
Thursday 23 March 2023
09:00-11:00 Better Decision-Making for Better Outcomes: Harnessing the Power of RWE
European Parliament

Scoping review – Results



Results

- Most studies gave **narrative analysis of practices** relating to preparedness or pandemic response strategies
- **Great coverage of world regions** from all continents
- Broad range of practices addressed, from **specific containment measures** (e.g., social distancing, contact tracing) to **overall governance strategies** (e.g., the political ideology, high-level coordination of practices, etc.)

	Location	Study Type*	Practices Addressed
Herstein et al., 2022[1]	Global	Narrative analysis of practices	Pre-existing network as a platform for emergencies
Irwin, 2020[2]	Sweden	Case-study	COVID-19 response and media represe
Jegede et al., 2020[3]	Nigeria	Narrative analysis of practices	Measures: COVID-19 and previous epidemics/pandemics
Lee, Lim, 2021[4]	ASEAN	Data envelopment analysis	Efficiency of performance of IPC measu
Mersha et al., 2021[5]	Ethiopia	Cross-sectional study	Precautionary measures by health pro sanitizing, etc.)
Min, Lee, 2022[6]	OECD countries	Data envelopment analysis	Relationship between a nation's cultur and its COVID-19 control measure's eff
Moeenian et al., 2022[7]	Iran	Grounded Theory strategy	Social innovations
Ngoy et al., 2022[8]	AFRO WHO region	Retrospective policy tracing and descriptive statistical analysis	COVID-19 response strategies, plans, r press releases, government websites, reviewed literature
Pennestrì et al., 2021[9]	Lombardy (Italy)	Narrative data analysis	Regional response
Prajitha et al., 2021[10]	Kerala (India)	Quantitative descriptive study	Regional response
Saleh et al., 2022[11]	Nigeria	Narrative analysis of practices	NCDC learning mechanisms from Lassa outbreaks
Agnew, 2021[12]	USA	Narrative analysis of practices	Political ideology
Ansah et al., 2021[13]	Singapore	Narrative analysis of practices	Mitigation vs containment
Atsawarungruangkit et al., 2020[14]	Global; Asia, Europe, North America	Narrative analysis of practices	Case identification
Bartels et al., 2021[15]	North Carolina	Qualitative	Message testing, rapid design, COVID- distancing, emergency preparedness
Braithwaite et al., 2021[16]	Global; 36 OECD, Singapore, Malaysia, Taiwan and Iran	Cross-sectional study	Governance approaches
Canario Guzmánet al., 2022[17]	Central America, Dominican Republic	Qualitative	Governance approaches, ethics
Chowdhury, Jomo, 2020[18]	Asia, South America	Case study	Containment measures (physical dista tracing)
Coral et al., 2022[19]	Ecuador	Narrative analysis of practices	Governance practices
Evans, 2022[20]	UK	Narrative analysis of practices	Use of evidence in policy decisions
Goodyear-Smith et al., 2022[21]	Australia, South Africa, Egypt, Nigeria	Narrative analysis of practices	Primary healthcare policies
Halfmann et al., 2022[22]	Europe, Africa	Narrative analysis of practices, including SWOT analysis, surveys, interviews	Innovation governance
Upadhyay et al., 2022[23]	13 ITEC countries	Qualitative analysis, including workshops, Delphi survey	Various pandemic preparedness and r
Zhang et al., 2021[24]	China, Germany	Narrative and statistical analysis of practices	Non-pharmaceutical interventions

Results – Practices

- ***Need to improve Science-policy-society communication***
  - Media not always distinguishes between expertise, data, facts and science, which is key for building trust; lack of awareness in public is a major issue; time between evidence gathering, policy making and policy enactment.
- ***Institutional fragmentation: from local responses to global outcomes***
  - Local, flexible policies were found to be the most successful (e.g., China VS Germany different non-pharmaceutical approaches; high political engagement and layered coordination were successful in the AFRO region, etc.).
- ***Health practices***
  - Integrated response between primary care and public health services is crucial; documenting of and learning from practices applied during previous pandemic

Results – Practices and Principles

- ***Innovation technology***
  - Health technologies offer an opportunity to provide remote healthcare and contact tracing and coordination
- ***Building trust and ways of communication with the general public***
  - Policy decisions must be transparent, coordinated across bodies and clearly communicated in order to demonstrate trustworthiness
- ***Ethical guidelines to mediate the relationship between science and policy making***
  - Strong ethical frameworks and guidelines underpin effective pandemic response

Conclusions

Need for:

- More alignment and collaboration among different countries
- Increased and improved communication between scientists, policymakers and the wider public
- More focus on each peculiar context (e.g., local culture and challenges)
- Increased focus on ethics and ethics of responsibility…

However, need to accept our limits and leave behind our "Promethean dreams", and shift towards "technologies of humility", fostering more inclusive and diverse decision-making (citizens and experts) (see Jasanoff).

The use of smart environments and robots for infection prevention control: A systematic literature review

Review > Am J Infect Control. 2023 Oct;51(10):1175-1181. doi: 10.1016/j.ajic.2023.03.005. Epub 2023 Mar 15.

The use of smart environments and robots for infection prevention control: A systematic literature review

Davide Piaggio [1], Marianna Zarro [2], Silvio Pagliara [3], Martina Andellini [3], Abdulaziz Almuhini [4], Alessia Maccaro [3], Leandro Pecchia [5]

The article aims:

- To Investigate the current use and role of robots and smart environments in infection prevention and control (IPC) systems within nosocomial settings.
- Explore advancements in hand hygiene and personal protective equipment (PPE) compliance, automatic infection cluster detection, and environmental cleaning technologies from January 2016 to October 2022.

Methods

Search Strategy:

Utilized OvidSP database from January 2016 to October 2022.

Study selection based on PRISMA statement guidelines.

Study Selection:

Screened titles, abstracts, and full texts for eligibility.

Inclusion criteria: Scientific articles focusing on COVID-19 pandemic preparedness and governance strategies.

Data Extraction:

Essential information extracted included IPC device used, study aim, participants, and hospital department.

Search Strategy	Details
Database	OvidSP
Time Period	Jan 2016 to Oct 2022
Study Selection	PRISMA guidelines
Screening Criteria	Title, abstract, full text
Inclusion Criteria	Scientific articles on robots and automation for IPC
Exclusion Criteria	Non-English articles, inaccessible full texts, letters, editorials, reviews

Methods

Quality Appraisal:

- Used Mixed Methods Appraisal Tool (MMAT) for quality analysis.
- Evaluated criteria such as study design, sample representativeness, and confounder consideration.

Grouping Results:

- Results grouped into five macro areas: hand hygiene compliance, infection cluster detection, environments cleaning, air quality control, and correct use of PPE.

Discussion:

- Identified points for discussion, including focus on traditional IPC methods, lack of HCW involvement in technology co-design, and need for contextualized solutions in low-resource settings.

Areas	Examples
Hand Hygiene Compliance	Wearable sensors, RFID technologies
Infection Cluster Detection	Automated alert systems, AI-based surveillance
Environment Cleaning	Cleaning robots, air quality monitoring systems
Air Quality Control	Fuzzy inference systems, AI algorithms
Correct PPE Use	AI-based donning and doffing systems, real-time feedback

Scoping Review - Results:

Systematic search returned 1520 citations; 17 papers included.

Three main areas of interest identified: hand hygiene and PPE compliance, automatic infection cluster detection, and environments cleaning.

IPC practices primarily relied on traditional methods, limited integration of automation and robotic technology observed.

D. Piaggio et al. / American Journal of Infection Control 51 (2023) 1175–1181

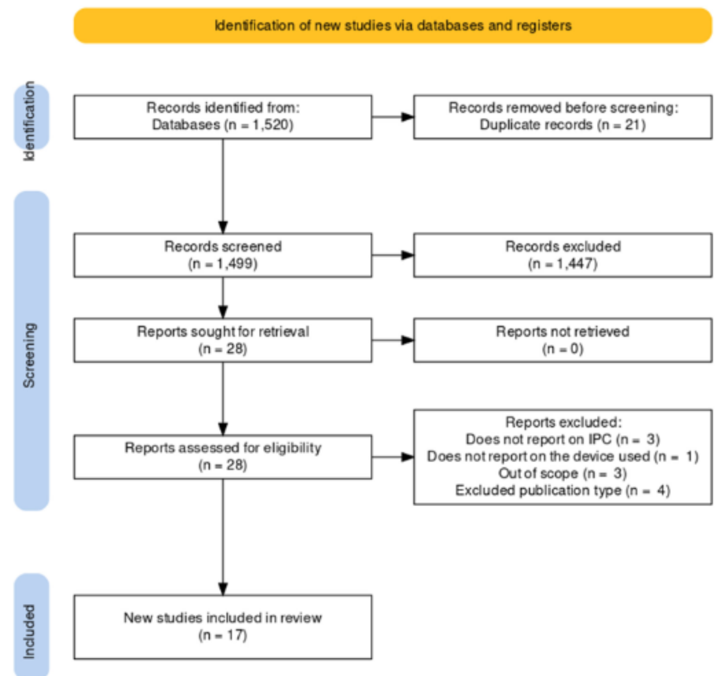


Fig 1. PRISMA flow diagram. Study selection process used, divided into 3 phases: identification, screening, included.

Results:

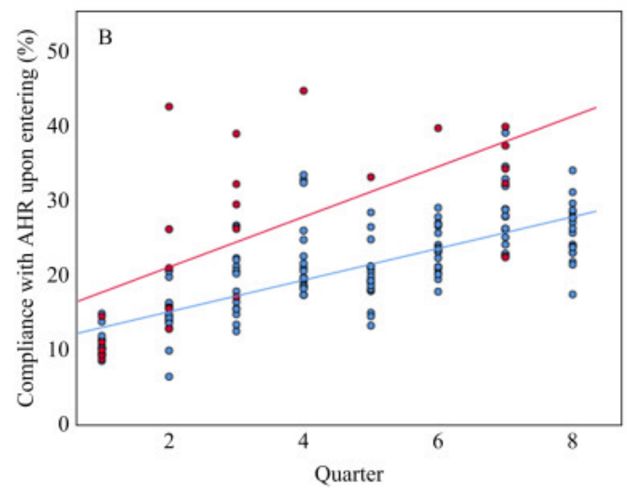
Table 1
Study characteristics

Study	Macro area	IPC device	One-sentence aim of the study	Participants	Hospital department/area
Xu 2021[17]	Hand hygiene compliance	IOT hand hygiene compliance monitoring device	Evaluation of IPC device impact on hand hygiene (HH) compliance and health care-associated infection rates	Hospital staff (54): specialized doctors, doctors, nurses, and cleaners Patients (697)	Electronic Intensive Care Unit (EICU)
McCalla 2017[18]	Hand hygiene compliance	Hand hygiene compliance system - Biovigil Healthcare Systems Inc	Evaluation of IPC device impact on HH compliance	Hospital staff: nurses, nurse technicians, respiratory therapist, care managers, dietary aides, housekeeping staff Patients (4,070)	Intensive Care Unit (ICU)
McCalla 2018[19]	Hand hygiene compliance	Hand hygiene compliance system - Biovigil Healthcare Systems Inc	Evaluation of IPC device impact on health care-associated infection rates	Hospital staff: nurses, nurse technicians, respiratory therapist, care managers, dietary aides, housekeeping staff Patients (36,890)	Whole hospital
Edmisten 2017[20]	Hand hygiene compliance	Electronic HH monitoring system, based on radiofrequency	Report on IPC device implementation, challenges, and success	Hospital staff (2,830)	Three community hospitals
Dufour 2017[21]	Hand hygiene compliance	Electronic HH monitoring system, based on radiofrequency	Report on HH compliance	Hospital staff (42): 23 medical doctors, 8 residents, 12 medical students, 3 senior doctors, 6 nurses, 9 assistant nurses and 4 housekeepers	Seven patient rooms, unit not specified
Iversen 2020[22]	Hand hygiene compliance	HHC automated monitoring system (Sani nudge)	Evaluation of HH compliance	Hospital staff: 42 nurses	Orthopedic surgery department, oncology department
Xu 2021[23]	Hand hygiene compliance	Electronic HH system - Sanibit	Validation of IPC device	Hospital staff (15): 12 nurses, 2 patient care assistants and 1 secretary	Surgical intensive care unit
Xu 2022[24]	Hand hygiene compliance	Electronic HH system - Sanibit	Evaluation of HH individual behaviors	Hospital staff (15): 12 nurses, 2 patient care assistants and 1 secretary	Surgical intensive care unit
Akkoc 2021[25]	Hand hygiene compliance	Electronic hand hygiene reminding and recording systems (EHHRRSs)	Validation of IPC device	Hospital staff: nurses, physicians, transporters, and other staff Patients (248)	Anesthesia and reanimation intensive care unit
Huang 2021[26]	Hand hygiene compliance	automatic hand hygiene monitoring system (MediHandTrace), based on radiofrequency	Evaluation of IPC device impact on HH compliance	Hospital staff: 38 physicians, 13 interns, 37 nurses, 18 nursing assistants, and 5 housekeeping personnel	Infection unit
Durant 2020[27]	Hand hygiene compliance	Electronic hand hygiene monitoring systems (EHHMS)	Report on New York State hospitals' adoption of EHHMS. Evaluation of IPC device on C. Difficile infection rates	56 hospitals	Not relevant
Stachel 2017[28]	Infection cluster detection	Statistical software SaTScan and software for laboratory data management WHONET	Report on IPC device implementation	Patients	Two hospitals
Aghdassi 2021[29]	Infection cluster detection	automated cluster alert system (CLAR)	Report on IPC device implementation and on cluster detected	Patients	Whole hospital
Colella 2022[30]	Air quality control	Operating room air quality monitoring system based on fuzzy logic (FL)	Report on IPC device development	Hospital staff, Patients	Operating room (OR)
Preda 2022[31]	Correct use of PPE	Artificial intelligence- personal protective equipment (AI-PPE) compliance system	Validation of IPC device	Hospital staff (74): 6 nurses, 14 medical students, 3 physicians, 9 junior medical officer, 3 surgeons, 31 laboratory staff and 8 administrative staff	Not specified
Wang 2022[32]	Cleaning and disinfection of hospital environments	RNN neural networks with the addition of PDCA cycle related element	Evaluation of IPC device impact on workers' satisfaction and standardization rates	Hospital staff: 17 room nurses	Supply room
Khan 2020[33]	Cleaning and disinfection of hospital environments	Different types of robotic technologies are used in hospital setting to dry vacuum and mopping to remove germs and pesticides. - intelligent navigating vacuum pump - ultra-violet radiation based device - highly dynamic robotic gripper and sensing system - autonomous heavy-duty cleaning robot	Report on robot utilization to menage the COVID-19 pandemic	Not relevant	Not relevant

Hand Hygiene and PPE Compliance Example

Study Example: Huang, 2021. Three-year hand hygiene monitoring and impact of real-time reminders on compliance. Journal of Hospital Infection.

- **Aim:** Evaluate the effectiveness of an automated hand hygiene compliance system in a hospital setting.
- **Method:** Implemented a system utilizing passive RFID sensors to monitor hand hygiene compliance among healthcare workers (HCWs). Tested on 111 HCWs and 500K+ activities observed.
- **Findings:** Significant improvement in hand hygiene compliance rates observed after the implementation of the automated system (with increased performance for rooms with activated reminders).
- **Implications:** Automated monitoring systems can enhance hand hygiene practices and contribute to infection control efforts. A randomised reminder approach can be a potential solution (avoids users' fatigue).



Environmental Cleaning Example

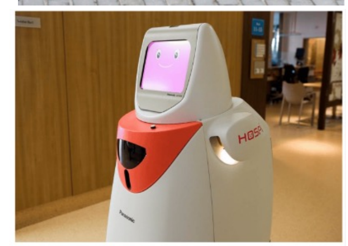
Study Example: Khan, 2020. Robotics utilization for healthcare digitization in global COVID-19 management. International journal of environmental research and public health.

- **Aim**: Evaluate robot utilization to manage the COVID-19 pandemic, in particular for cleaning and disinfection
- **Method**: Review.
- **Findings**: Significant reduction in HAIs observed in wards where robotic cleaning was implemented compared to standard cleaning practices…
- **Implications**: Robotic cleaning systems offer a promising solution for enhancing environmental hygiene and minimizing the risk of HAIs in healthcare settings.

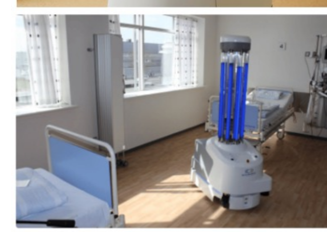
Nurse

Ambulance

Serving



Disinfecting



Conclusion

Limited integration of automation and robotic technology observed in IPC practices within nosocomial settings.

Emphasizes the necessity of increasing HCW awareness and involvement in technology co-design and training.

Research priorities should focus on implementing contextualized solutions for low-income countries to address diverse healthcare system needs globally.

- Meanwhile in Europe…

- ODIN is a European **multi-centre pilot study** focused on the **enhancement** of **hospital safety**, **productivity** and **quality**. This project will contribute to the implementation of the European Smart Hospitals of the Future.

- ODIN aims to demonstrate the **effectiveness** and **cost-effectiveness** of **Robots**, **Automation**, **AI**, **big-data** and **IOT**.

ODIN Consortium

				Philips Electronics Nederlands (PEN)	Universidad Politécnica de Madrid (UPM)	Inetum (IECISA)	Università Campus Bio-Medico di Roma (UCBM)
Medtronic Ibérica (MDT)	Centre for Research and Technology Hellas (CERTH)	Foundation for Research and Technology Hellas (FORTH)	University of Warwick (UoW)	Universitair Medisch Centrum Utrecht (UMCU)	Servicio Madrileño de Salud (SERMAS)	Charité Universität Medizin Berlin (CUH)	Amiens Picardie University Hospital (APUH)
Sant'Anna School of Advanced Studies (SSSA)	Robotnik Automatic SLL (ROB)	My Sphera SL (MYS)	TWI Hellas Astiki Mi Kerdoskopiki Etaireia (THL)	Medical University of Lodz (MUL)	Minds and Sparks GMBH (MS)	UDG Alliance (UDGA)	Università degli Studi Firenze (MEDICT)

Some Hospital with Implementation:

University hospital in Utrecht, Netherlands

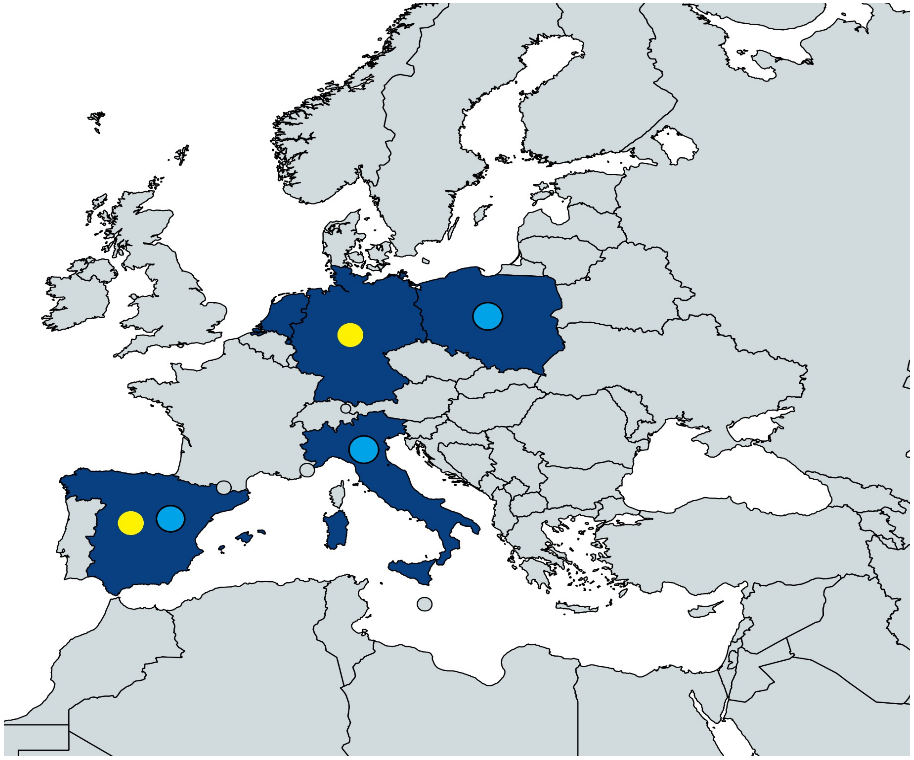
Università Campus Bio-Medico di Roma, Italy

The Charité – Universitätsmedizin Berlin, Germany

Medical University of Lodz, Poland

Andalusian Health Service (SAS), Spain

Servicio Madrileño de Salud, Spain



Objectives

1. ODIN:	2. ODIN:	3. ODIN:	4. ODIN:
Digital platform empowered by robotics, IoT and AI	Co-creation space between healthcare suppliers and providers	Reference of a new generation of digital care service	Business model supported by innovation and value-based healthcare

Odin Smart Hospitals

Impact

1. The emergence of European-led AI based pilots for the smart hospitals of the future.

2. The demonstration of effectiveness of AI based technologies, such as smart robots, in a broad range of healthcare tasks.

3. ODIN as an ecosystem for engagement among healthcare policy makers, investors, stakeholders and through the pilot.

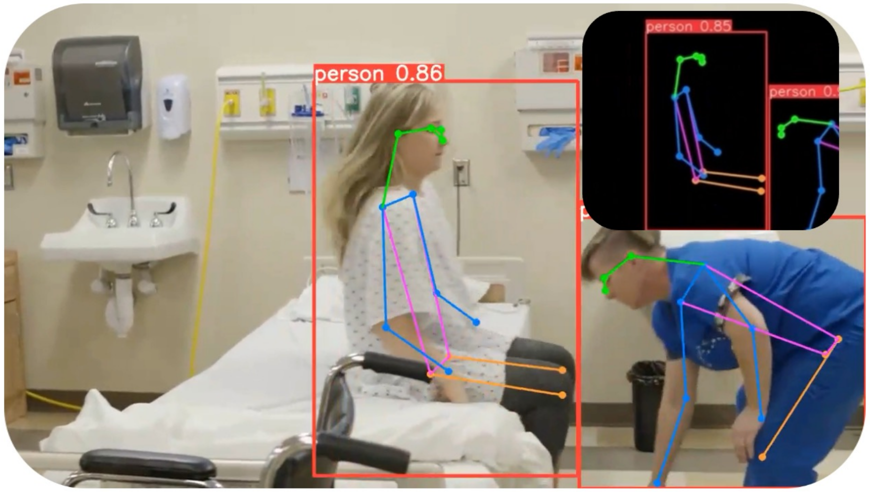
4. Ease of deployment and scalability of ODIN.

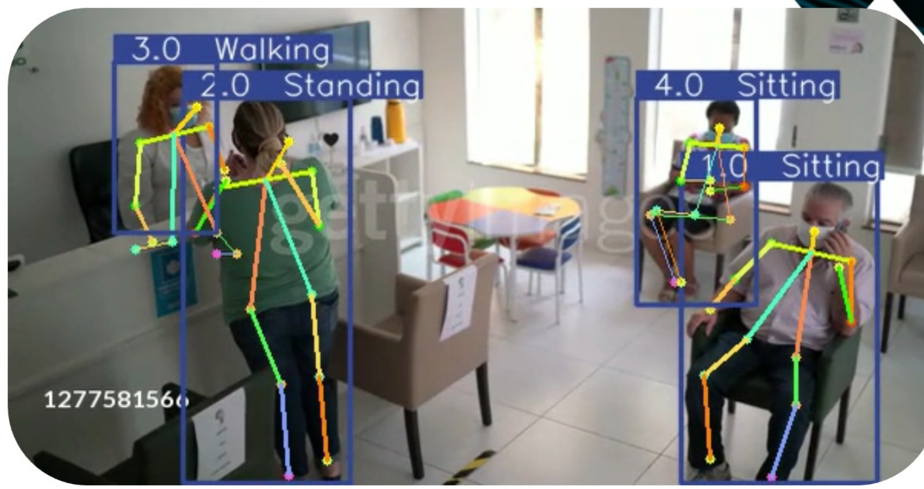
5. Reaching a high leveraging effect on the other sources of funding, in particular regional and national funding.

6. Contributing to trust and acceptance of AI technology.

Odin Smart Hospitals

AI for the hospital (of the future)






MOSAICΩ
UCBM
Operating room
Swab #1 - Ultrasound keyboard


MOSAICΩ
UCBM
Operating room
Swab #1 - Ultrasound keyboard


MOSAICΩ
UCBM
BostonDynamics


MONITORAGGIO INTEGRATO
acuson


MOSAICΩ
UCBM
BostonDynamics

Some ODIN-related further readings:

- Luschi A, Petraccone C, Fico G, Pecchia L, Iadanza E. Semantic ontologies for complex healthcare structures: a scoping review. IEEE Access. 2023 Feb 24.
- Luschi A, Iadanza E. OHIO-Odin Hospital Indoor Compass for Empowering the Management of Hospitals. InMediterranean Conference on Medical and Biological Engineering and Computing 2023 Sep 14 (pp. 142-149). Cham: Springer Nature Switzerland.
- Plati DK, Konstantakopoulos FS, Kalatzis T, Manousos D, Kassiotis T, Di Luzio FS, Tagliamonte NL, Zollo L, Tsiknakis M, Fotiadis DI. The Smart Hospital: Data and AI Challenges. In2023 IEEE EMBS Special Topic Conference on Data Science and Engineering in Healthcare, Medicine and Biology 2023 Dec 7 (pp. 1-2).
- IEEE. Luschi A, Petraccone C, Fico G, Pecchia L, Iadanza E. Semantic ontologies for complex healthcare structures: a scoping review. IEEE Access. 2023 Feb 24.Gandah S, Chiurazzi M, Domina I, Dei NN, Spreafico G, di Luzio FS, Tagliamonte NL, Sanz SG, Fico G, Pecchia L, Zollo L. An Integrated Sensorized Platform for Environmental Monitoring in Healthcare. IEEE Sensors Letters. 2023 Aug 4.
- Rondoni, C., Scotto di Luzio, F., Tamantini, C., Tagliamonte, N. L., Chiurazzi, M., Ciuti, G., & Zollo, L. (2024). Navigation benchmarking for autonomous mobile robots in hospital environment. Scientific Reports, 14(1), 18334.
- Zondag, A. G., Hollestelle, M. J., van der Graaf, R., Nathoe, H. M., van Solinge, W. W., Bots, M. L., ... & UCC-CVRM study group. (2024). Comparison of the Response to an Electronic Versus a Traditional Informed Consent Procedure in Terms of Clinical Patient Characteristics: Observational Study. Journal of Medical Internet Research, 26, e54867.
- ...

Thank you!

MAY

5 ... It Might Be Gloves. It's Always Hand Hygiene *(Special Lecture for World Hand Hygiene Day)*
With Miranda Deeves and Dr. Benedetta Allegranzi, World Health Organization

15 ... Non-Ventilator Hospital Acquired Pneumonia
With Prof. Michael Klompas, US

22 ... COVID-19 Preparedness – What Went Wrong? What Are the Next Steps? The Point of View of a Biomedical Engineer
With Prof. Davide Piaggio, UK

JUNE

2 ... IPAC Considerations in Global Emergencies *(Broadcast live from the IPAC Canada conference)*
With Dr. Bois Marufov, Canada

3 ... Persuasive Conversations *(Broadcast live from the IPAC Canada conference)*
With Ryan Mullen, Canada

12 ... IFIC Teleclass
With Terri Lee, Dr. Maria Clara Padoveze and Dr. Enrique Castro-Sánchez

Australasian Teleclass
18 ... Oral Care Practices and Healthcare-Acquired Pneumonia
With Prof. Brett Mitchell, Australia

19 ... Carbapenem Resistant *A.baumabnii* Outbreak on a Burn ICU in a Non-Endemic Setting
With Prof. Peter Werner Schreiber, Switzerland

26 ... Do We Still Need to Talk About Antibiotic Resistance
With Prof. Jean-Paul Zahar, UK

JULY

10 ... Challenges to Maintaining Asepsis in Patient Care Settings Beyond the Operating Department
With Prof. Dinah Gould, UK

Afro-European Teleclass
22 ... Proposal for a Screening Protocol for *Candida auris* Colonization
With Juliette Severin, Netherlands

Thanks to Teleclass Education

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