

Reducing the risk of COVID-19 transmission in hospitals

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ACADEMIC



HEALTH



POLITICAL



SOCIAL



TECHNOLOGICAL

SUMMARY

The impact of the COVID-19 pandemic on hospitals resulted in many non-critical procedures being cancelled or postponed.

Dr Nolan's research studied various procedures to reduce or eliminate the risk of aerosols (liquid droplets in the air) spreading across the hospital. This included looking at the effectiveness of face masks, aerosol leaks during keyhole surgery, infection control during ophthalmic procedures, aerosol spread when critical COVID-19 patients are placed on oxygen, and mask effectiveness during exercise and speech and language therapy.

The research has led to changes in practices in the Mater hospital, protecting patients and clinicians from COVID-19. The findings – shared via peer review publication, the media and social media – have illustrated the importance of social distancing and wearing a mask, helping slow the spread of the disease.

“Dr Nolan’s work has had immediate and direct clinical impact. It has informed design of medical equipment and has been highly informative regarding patient and personnel protection from airborne viral transmission. It has also enhanced public awareness of how COVID is transmitted and the need to socially distance.”

Prof Conan McCaul, Consultant at the Mater Hospital

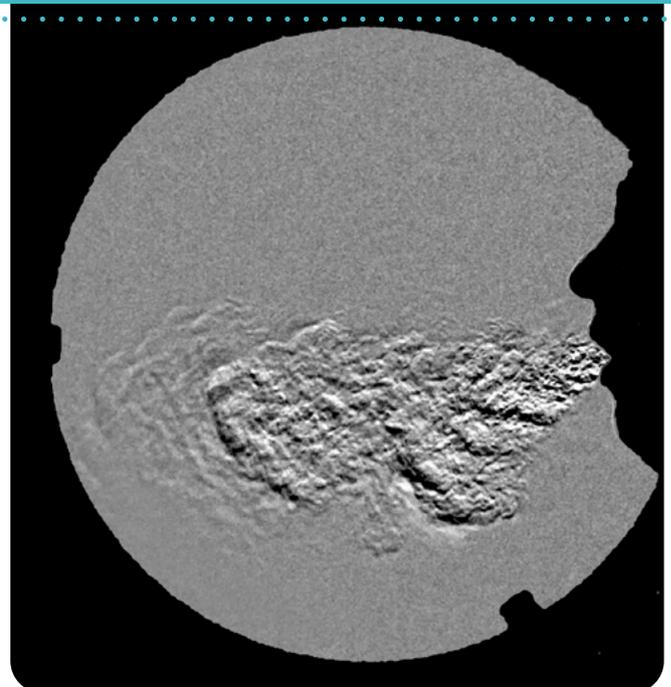
RESEARCH DESCRIPTION

In the early stages of the COVID-19 pandemic, it became apparent that the spread of the virus via aerosol and limitations in the supply and effectiveness of PPE were critical contributors to the infection rate. All non-essential surgery was halted due to risk of spreading aerosols, and the need for solutions was clear.

In April 2020, Professor Cahill therefore began investigating the problem of aerosol dispersion during surgery. Dr Nolan volunteered his time and expertise to this investigation, and his custom Schlieren facility was relocated to the old operating theatres of the Mater Hospital.

Schlieren is a real-time optical technique, whereby local changes in the refractive index of air are made visible. In other words, by looking at how rays of light bend, this technique visualises human breath in the air in a striking way (see adjacent image).

What began as a short-term project grew in scope as the effectiveness of Schlieren in diagnosing sources of aerosol became apparent. The Schlieren facility remains in place in the Mater and is in continuous operation helping specialists understand how best to design their varied medical procedures to eliminate aerosol risk.



A cough captured with Schlieren optical technique.

Examples include:

- Exploring the effectiveness of a device called an 'intubation box', a clear plastic box that is placed over a patient's head and shoulders before they are intubated, in an attempt to reduce risk of infection.
- Examining leaks of CO₂ gas that occur from the abdomen during a procedure known as a laparoscopy - an operation to examine the organs in the abdomen. These jets of gas contain bodily fluids in aerosol form and present an infection risk. Dr Nolan's expertise in fluid flow was invaluable in accelerating the development of a device to target the leaks.
- Conducting a study, involving volunteers from hospital staff, to mitigate risks associated with high-flow nasal oxygen. This is often given to critical COVID-19 patients and generates a significant jet of gas from the airway, creating environments with high amounts of aerosol.
- Working with Periodontists from Trinity College Dublin, performing a study on aerosol generation during dentistry.
- Measuring the effectiveness of different facemasks during exercise. This was expanded to include a number of designs, including commercial and homemade masks, of interest to UCD Sport. Work on novel mask designs in ongoing, in collaboration with the National College of Art and Design (NCAD).
- Investigating, in collaboration with Speech and Language Therapists, how the tools they use can be made safe from aerosols. Research in PPE strategies for ophthalmologic procedures was performed as well.

RESEARCH TEAM, COLLABORATORS AND FUNDING

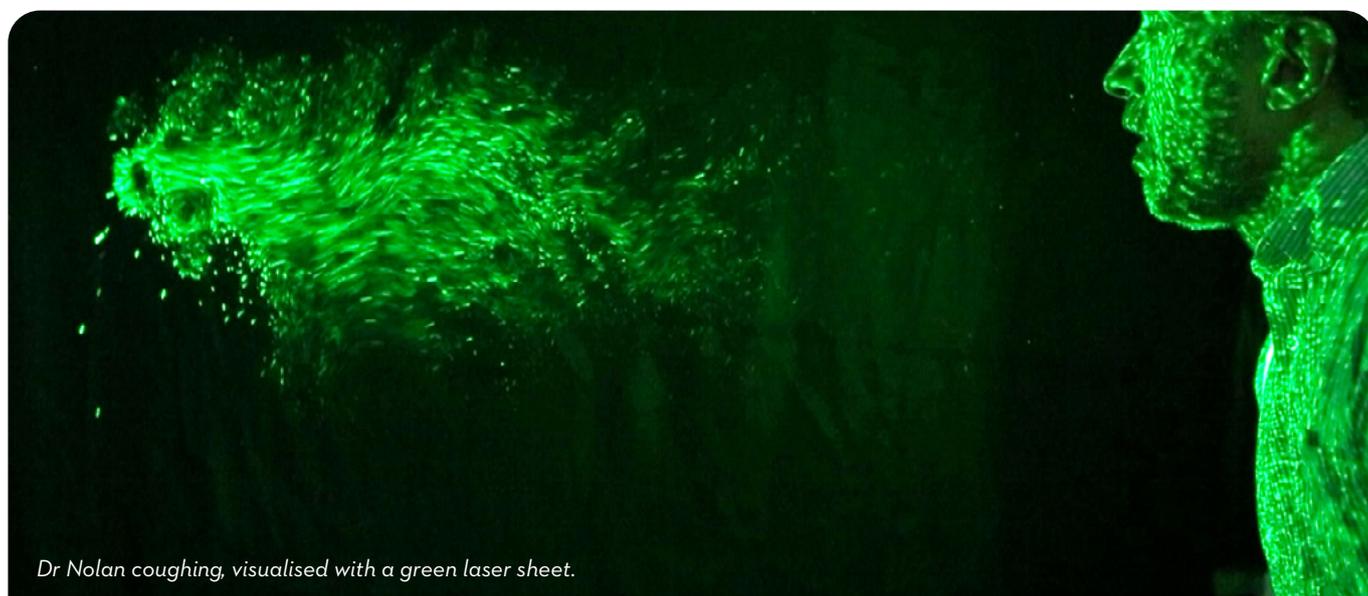
Research team and collaborators

- Dr Kevin Nolan, Assistant Professor/Lecturer, UCD School of Mechanical & Materials Engineering.
- Professor Ronan Cahill, Professor of Surgery, Mater Misericordiae University Hospital (MMUH) and UCD School of Medicine & Medical Science.
- Professor Conan McCaul, Consultant Anaesthetist, Rotunda Hospital Dublin & MMUH; Clinical Professor, UCD School of Medicine.
- Dr Brian Murphy, Anesthesiology Fellow, Rotunda Hospital.
- Dr Jeffrey Dalli MD, PhD Candidate, UCD School of Medicine.
- Dr Mohammad Faraz Khan, Specialist Surgical Lecturer / Senior Colorectal Registrar, UCD & MMUH.
- Louise O'Toole, Consultant Ophthalmologist, Mater Private.
- Dr Patricia Gillivan-Murphy, Department of Speech and Language Therapy, MMUH.
- Louise Groeger, Senior Physiotherapist, Surgical Respiratory, Physiotherapy Department, MMUH.
- John O'Dea, Director, Pallaire.

Funding

Owing to the extremely rapid nature of this work, funding was not initially obtained, and all team members volunteered their time, expertise, and equipment. The team have since applied for funding from various organisations.

The work now continues under the H2020 funded PORSAV project, where Dr Nolan will develop a novel imaging technique tailored to rapid deployment in the surgical environment.



Dr Nolan coughing, visualised with a green laser sheet.

RESEARCH IMPACT

Health and social impact

This research has contributed to the health and wellbeing of a wide range of people, not just in hospitals but across society. A campaign of education across traditional and social media used the research to illustrate the importance of social distancing and the need to wear facemasks, contributing to greater adherence to guidelines. It also showed ongoing work in hospitals to develop evidence-based PPE practises so that patient care could recommence.

This campaign reached many thousands of people across various demographics, through channels including RTÉ News, PrimeTime, Irish Times, Irish Independent, the Sun, Wexford People, LinkedIn, LadBible and German RTL. (See links in References section.)

Similarly, many tweets have been sent via @Matersurgery that show the effectiveness of facemasks. This has also facilitated engagement with clinicians across the world to help better understand the data published.

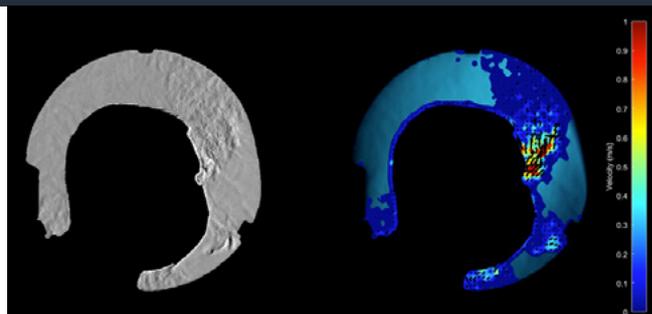
The collaboration with UCD Sport will aid the reopening of sports facilities in UCD and elsewhere, and the research will ensure these environments are as safe as possible, protecting those within. A manuscript has been drafted with physiotherapists and is awaiting publication.

Policy impact

Ophthalmology research conducted by Dr Nolan and colleagues revealed that wearing facemasks under surgical drapes actually increases the risk of aerosol exposure. This finding has been communicated via a Webinar for the Irish College of Ophthalmologists, resulting in revision of hospital policy in three centres. This is directly protecting surgeons and patients in these hospitals. A publication is being prepared, so that the findings can inform policy in other centres as well.

The work on high-flow nasal oxygen therapy provides important real-time lessons on how aerosol can be mitigated with facemasks. This work will directly impact policy and practice in COVID-19 wards, and will significantly reduce viral load. The findings have already been communicated at conferences and a detailed analysis is underway for publication.

In May 2020 the US FDA gave a blanket approval to use the so-called intubation box. Citing two studies carried out by Australian researchers published in June 2020, the approval was withdrawn in August. These papers cite and build upon the work carried out by Dr Nolan and colleagues published in May 2020 illustrating the limited effectiveness of this device.



Visualisation of mask leak test performed for UCD Sport, illustrating the consequences of a poorly fitting mask. Leaks are apparent at the bridge of the nose and under the chin.

Technological impact

Dr Nolan and colleagues have engaged with industry partners to develop technologies that mitigate or eliminate jets of gas containing aerosols from the hospital environment. This includes work with Pallaire on insufflation technologies (where gases are blown in body cavities).

Work is also planned with NCAD on novel facemask design, and with the Construction Industry Federation on mask and visor testing for the construction industry.

Academic impact

From this research, Dr Nolan and colleagues have rapidly published a number of papers, and several more are planned. The team's academic papers since the summer have already been cited more than 30 times. An evaluation of the intubation box showing how to mitigate its shortcomings has been cited more than 20 times in just seven months. Work on gas leaks and insufflation revealed unanticipated behaviours and provoked a robust social media discussion between industry and surgeons.

“Dr Nolan has been involved with multiple clinical teams on the Mater Misericordiae University Hospital since the start of the COVID 19 epidemic. His work has had immediate and direct clinical impact. It has informed design of medical equipment and has been highly informative regarding patient and personnel protection from airborne viral transmission. It has also enhanced public awareness of how COVID is transmitted and the need to socially distance as a primary protective measure.”

Prof Conan McCaul, Consultant at the Mater Hospital

REFERENCES

Research references

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Dalli, J., Khan, M.F., Nolan, K. and Cahill, R.A., 2020. Laparoscopic pneumoperitoneum escape and contamination during surgery using the Airseal Insufflation System—a video vignette. *Colorectal Disease*.

McInerney, N., Gilligan, C., Manojlovich, L., Khan, M.F., Nolan, K. and Cahill, R.A., 2020. Airflow during clinical examinations with and without protective face masks. *British Journal of Surgery*.

Dalli, J., Khan, M.F., Nolan, K. and Cahill, R.A., 2020. Gas leaks through laparoscopic energy devices and robotic instrumentation—a video vignette. *Colorectal Disease*.

Media and social media

[The science behind the effectiveness of face masks](#), The Irish Times.

[Can businesses survive the two metre social distance rule?](#), RTE Prime Time.

[Study Shows Importance of Social Distancing](#), Wexford People and Gorey Guardian.

[Airflow video shows how easily coronavirus can be spread by coughing](#), Medical Express, David Kearns, UCD.

[Coughing video reveals the best face masks to prevent spread of coronavirus](#), The Irish Sun.

[Mater Misericordiae University Hospital Surgery YouTube Channel](#).

[UCD COVID-19 Rapid response](#).



Simulation of face-to-face coughing (subjects were socially distanced, standing 2m apart shoulder to shoulder).