Unravelling How COVID-19 Mathematics Impact Behaviour Change

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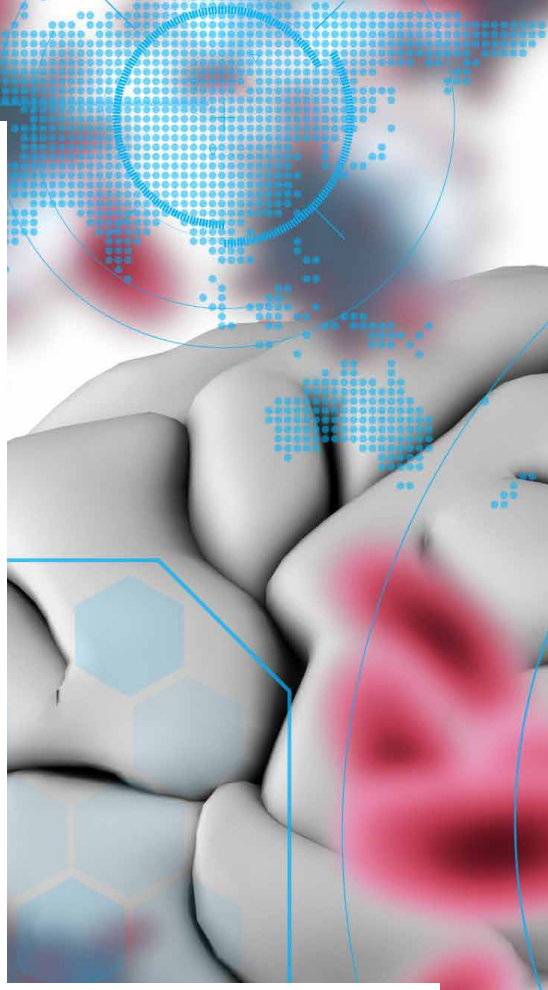
Scientia

UNRAVELLING HOW COVID-19 MATHEMATICS IMPACT BEHAVIOUR CHANGE

Mathematical models for predicting the spread of COVID-19 directly influenced public health measures around the world, significantly impacting everyone's day-to-day activities. At Kingston University, **Dr Cristina Oliva** and **Professor Giampiero Favato** are leading the way in COVID-19 research, looking at how complex statistical data is communicated to the general public. Their valuable work is helping drive changes in behaviour that could reduce the spread of COVID-19.



Flattening the Curve?

The COVID-19 pandemic changed how we live our lives – from our working habits to wearing masks in public to our contact with others, even close family members. Mathematical models were used to predict how the infection could spread and the public was bombarded with statistics about 'flattening the curve'. Measures including social distancing and lockdowns were put in place by governments across the world. Yet despite the severity of the situation, many people did not adhere to these measures.

During the pandemic, Dr Oliva and Professor Favato joined their research to better understand the spread of COVID-19, gathering vital data to help the fight against this infection. More specifically, they explored how the way in which mathematical information is explained to the public leads to changes in behaviour.

Simple, visual data were most commonly used to disseminate mathematical information about the spread of COVID-19 to the public. Line charts were used throughout the media to help communicate the importance of public health measures. It was proposed that flattening the curve was necessary to reduce the number of COVID-19 cases and stop hospitals from becoming overwhelmed. However, the researchers argue these line charts failed to effectively communicate to individuals the high risk of infection and thus, the importance of avoiding close contact with others was simply not heard by many.

The public health measures relied on people changing their behaviours and maintaining these changes over time. However, when asking such dramatic changes in how people behave, the researchers suggest that many factors need to be considered. In particular, they argue that how such messages are framed will play an important role.

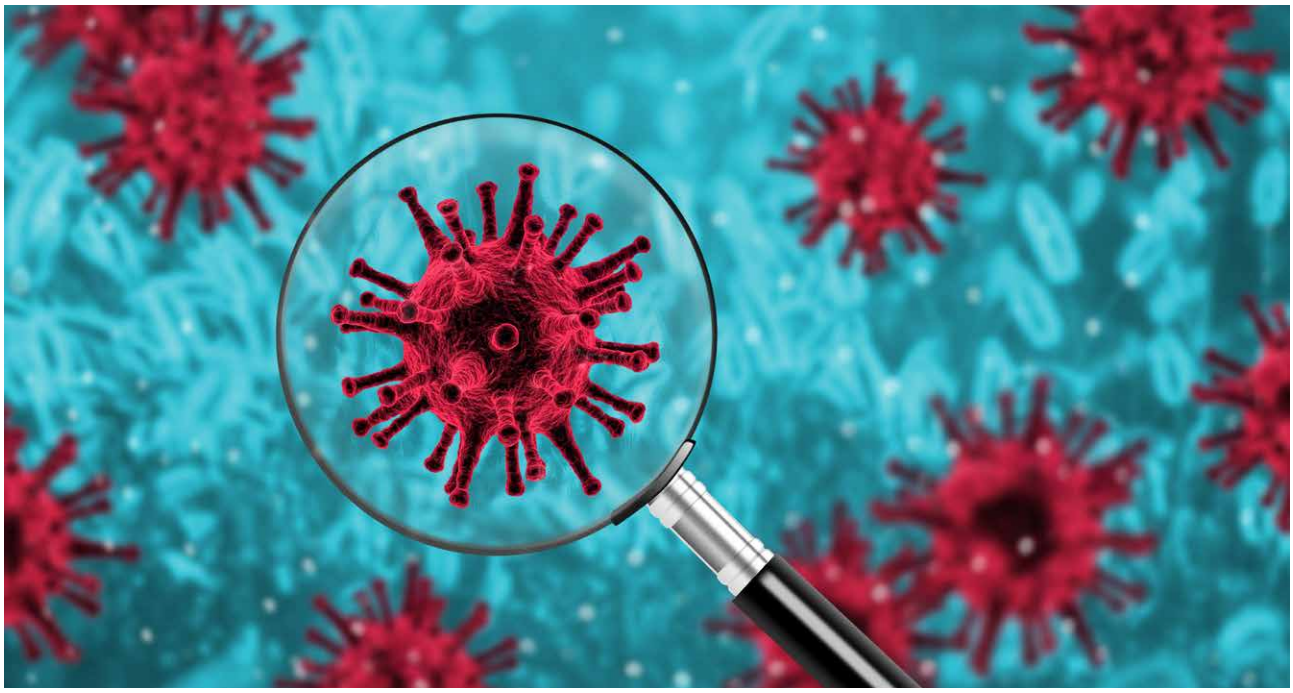
Using Behavioural Sciences to Tackle Health Problems

At the start of their research, the researchers turned to the behavioural sciences to explore how and why people make decisions about their actions, with one of the underpinning constructs

being the Health Belief Model. This model, adapted from behavioural science theories to health problems, is one of the most widely recognised models of health-related behaviour.

In essence, the Health Belief Model suggests that a person's belief in the personal threat of a disease (COVID-19 in this case) coupled with their belief in the effectiveness of the required behaviour (for example, wearing a mask and social distancing), will predict how likely they are to undertake that behaviour.

The researchers explored how this model might apply to the reasoning behind people's choices during the COVID-19 pandemic. They focused on four areas of perception (susceptibility, severity, benefits and barriers) that people consider and evaluate when making



health decisions, and linked this to the likelihood of them adopting a particular health behaviour relating to COVID-19 (such as wearing a mask).

The review of existing research led Dr Cristina Oliva to identify three key cognitive biases (which are subconscious errors in thinking that can affect the accuracy and rationality of decisions) directly relevant to health beliefs: identifiable victim effect, present bias and omission bias.

The researchers then applied these cognitive biases to the Health Belief Model. For example, they proposed that people responding more strongly to threats against themselves or people they care about (the identifiable victim effect) related to the concepts of perceived susceptibility and severity in the Health Belief Model.

For the researchers, this was an important opportunity to 'manage the meaning' of the COVID-19 data. The team then looked into paradoxically turning these cognitive biases into 'cues to action' – in other words, how to positively modify personal beliefs and, as a consequence, health behaviours.

Keeping the Elderly Safe

The relevant COVID-19 research was carried out in Italy. After the initial outbreak in China, Italy was one of the first countries to be hit by COVID-19, with over 25.5 million confirmed cases in the last three years, according to the World Health Organisation. The Italian Government set out new and urgent legally binding measures to contain the spread, which imposed restrictions on individuals to help mitigate the risk of exposure to the virus.

The researchers and their colleagues published the very first model to identify the elderly living in RSA as a primary target for COVID-19 mortality (Residenza Sanitaria Assistenziale is a type of nursing home, particularly for those requiring a higher level of care). The findings of this breakthrough study indicated that a significant reduction of social contact in metropolitan areas, along with the timely isolation of elderly and diabetic residents, could greatly impact the death toll in subsequent COVID-19 waves.

The researchers then coupled COVID-19 death statistics in different regions of Italy with determinants of health (factors that relate to how healthy people are) from a review of the current literature. They used mathematical methods to predict variations in mortality observed when the COVID-19 infection first swept through Italy.

As such, Dr Oliva and Professor Favato 'drew a face' on the maths. Using the Health Belief Model, they suggested that the 'flatten the curve' narrative does not convey perceived susceptibility and severity adequately because of the identifiable victim effect cognitive bias. Knowing the cumulative number of infections and deaths may fail to encourage people to change their behaviours – but knowing that an elderly relative is at high risk could help individuals make better choices.

Identifying Risky Activities

Dr Oliva and Professor Favato continued their ground-breaking COVID-19 research with a large-scale investigation into the risk of exposure to COVID-19 with day-to-day activities. They were the first researchers to use Google Maps data about visitation duration to estimate the exposure risk of different activities.

The researchers knew that COVID-19 spreads through close contact but when social restrictions were eased, new questions arose. Which activities posed a greater risk of exposure, and for

particular activities could the risk be reduced somehow? They explored the Health Belief Model concepts of perceived benefits and 'present bias' in thinking, relating them to how people chose activities during the pandemic. They suggested that people will tend to give priority to immediate gratification, such as eating out in restaurants, over larger future benefits like reducing the risk of being exposed to COVID-19.

Since there was no current information available to help people make informed decisions about their activities, the aim of this study was to make the risk versus benefits 'trade-off' more visible by estimating the exposure risk by activity and location in urban areas.

Professor Favato and Dr Oliva used new features on Google Maps to gather data about the average visit duration for over 500 activities in Genoa, such as grocery shopping, and bank and post office visits. They discovered there were significant variations in the risk of exposure amongst different activities as well as different locations for the same type of visit.

The authors presented their findings using an intuitive numeric form to define the exposure risk in order to help public health policymakers effectively communicate the urgency of containment measures. They believe that the most significant impact of this research was to make individuals aware of the absolute and relative risk of exposure to COVID-19. This knowledge then empowered them to make active choices about their behaviour.

The Second Wave and Beyond

Dr Oliva and Professor Favato teamed up again to investigate the Delta variant during the second wave of the pandemic. This COVID-19 variant was more easily spread with close contact durations going from minutes to only seconds for infection to occur.

The risk of exposure was vastly increased and so, the perceived barriers that the team identified as preventing changes in behaviour needed to be addressed. The researchers pointed to the role of omission biases supporting the erroneous thinking of 'why bother?' with behaviours such as mask-wearing and social distancing. This is consistent with the observation that people tend to prefer harm occurring due to failing to take action rather the taking preventative action that might not work at all.

This most recent study was the first of its kind to use game theory – a mathematical model of how interactions can occur – to model the most effective response to COVID-19 variants. The researchers utilised Google Maps data again, in a similar way to their previous study to track visit duration time in different activities, and found that the absolute risk of exposure to the Delta variant increased by sixfold compared to the ancestral form (original COVID-19 virus). In relative terms, however, the differences in exposure risk for various activities did not significantly differ from that of the ancestral form of COVID-19.

While the Delta variant represented an evolution of COVID-19, the researchers concluded that the best response was to commit to the original plan and continue to work on addressing psychological barriers that could influence the effectiveness of population-wide vaccination and social distancing. As the threat of the COVID pandemic still looms over us, Dr Oliva and Professor Favato's work may be key to mitigating its impacts in time to come.

Meet the researchers

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Cristina Oliva is a core member of the Institute of Leadership and Management in Health at Kingston University. She has been a practising oncologist for over 12 years at several national cancer institutes, treating a wide variety of oncology diseases. During her experience in clinical research, she has contributed to the development of new therapeutic approaches in gynaecological malignancies. Her experience ranges from early to late-stage clinical studies and as the lead of international teams, she has successfully brought several new compounds to their regulatory approval, across a variety of indications and mechanisms of action. Dr Cristina Oliva graduated as MD at the University of Genoa in 1988 where she also obtained her oncology board certification in 1991. She has authored more than 100 publications to date and is a member of the American Society of Clinical Oncology and the European Society of Medical Oncology, and holds registration with the General Medical Council in the UK.

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Professor Giampiero Favato is the Director of the Institute of Leadership and Management in Health at Kingston University. He is also a Fellow of the Royal Society of Public Health, the Royal Society of Medicine, and the European Cancer Organisation. Professor Favato's research has played an important role in public health policy, including Public Health England's gender-neutral human papillomavirus vaccination programme. His most recent work focuses on reducing the mortality risk of COVID-19 infection for the frail, elderly population. Before his academic career, Professor Favato undertook strategic and financial responsibilities in the life sciences industry. He received an MBA from the University of Chicago Booth School of Business in 1999, and a DBA from the Henley Management School, part of the University of Reading, in 2003.

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FURTHER READING

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