Module 2 of the UK Covid-19 Public Inquiry
Request for Evidence under Rule 9 of the Inquiry Rules 2006
Reference for Request - M2/SAGE/01/MXG1
Professor Michael Gravenor

Professor of Epidemiology and Biostatistics, Swansea University Medical School

1. A brief overview of your qualifications, career history, professional expertise and major publications.

Qualifications

1988 – 1991	*University of Cambridge* BA(Hons) Natural Sciences, First Class
1991 – 1995	*University of Oxford* DPhil, Department of Zoology NERC Studentship Award
1999 – 2001	*University of Reading* MSc Biometry, Department of Statistics, with Distinction

Career History

1995 – 1998	Medical Research Council (MRC) Personal Fellowship Award *Institute of Molecular Medicine (now Weatherall Institute), University of Oxford* Developed models to predict total parasite load in cerebral malaria patients
1998 – 2003	Mathematical Modeller, BBSRC Award *Institute for Animal Health, Compton* Part of large BBSRC TSE programme designing UK scrapie control plan, providing mathematical modelling, statistical support, and extensive field data collection.
2003 – 2007	Senior Lecturer in Epidemiology *Swansea University Medical School* Medical School foundation appointment, promoted to Reader 2006
2007 – present	**Professor of Epidemiolgy and Biostatistics** *Swansea University Medical School* Head of Data Science (2022-)

My professional expertise is the application of mathematical and statistical methods to research problems in the medical and biological sciences. I have 30 years experience in the application of mathematical models to the study of infectious disease.

Selected Relevant Publications:
I have published over 150 peer reviewed journal papers since 1993. Google Scholar link: https://tinyurl.com/gravenor. Selected outputs are highlighted here, as exemplars of projects in a wide range of disciplines, and having significant impact through fundamental or policy driven science.

Wells, K., M. Lurgi, B. Collins, B. Lucini, R. R. Kao, A. L. Lloyd, S. D. Frost and M. B. Gravenor (2020). "Disease control across urban–rural gradients." Journal of the Royal Society Interface **17**(173): 20200775.

Gravenor, M. B., D. Cox, L. J. Hoinville, A. Hoek and A. R. McLean (2000). "Scrapie in Britain during the BSE years." Nature **406**(6796): 584-585.

Kao, R., M. Gravenor, M. Baylis, C. Bostock, C. Chihota, J. Evans, W. Goldmann, A. Smith and A. McLean (2002). "The potential size and duration of an epidemic of bovine spongiform encephalopathy in British sheep." Science **295**(5553): 332-335.

Baylis, M., C. Chihota, E. Stevenson, W. Goldmann, A. Smith, K. Sivam, S. Tongue and M. Gravenor (2004). "Risk of scrapie in British sheep of different prion protein genotype." Journal of General Virology **85**(9): 2735-2740.

GBR Working Group (2007). "Opinion of the Scientific Panel on biological hazards (BIOHAZ) on the revision of the Geographical BSE risk." EFSA Journal **5**(3): 463.

GBR Working Group (2004). "Scientific Report of the European Food Safety Authority on the Assessment of the Geographical BSE Risk (GBR) of the USA." EFSA Journal **2**(8): 3r.

Harris, D., D. Thayer, T. Wang, C. Brooks, G. Murley, M. Gravenor, N. Hill, S. Lister and J. Halcox (2021). "An observational study of INR control according to NICE criteria in patients with non-valvular atrial fibrillation—the SAIL Warfarin Out of Range Descriptors Study (SWORDS)." Eur Heart J Cardiovasc Pharmacother **7**: 40-49.

Hollinghurst, J., J. Lyons, R. Fry, A. Akbari, M. Gravenor, A. Watkins, F. Verity and R. A. Lyons (2021). "The impact of COVID-19 on adjusted mortality risk in care homes for older adults in Wales, UK: a retrospective population-based cohort study for mortality in 2016–2020." Age and ageing **50**(1): 25-31.

Davies, G., S. Jordan, C. J. Brooks, D. Thayer, M. Storey, G. Morgan, S. Allen, I. Garaiova, S. Plummer and M. Gravenor (2018). "Long term extension of a randomised controlled trial of probiotics using electronic health records." Scientific Reports **8**(1): 1-8.

Hinder, S. L., G. C. Hays, M. Edwards, E. C. Roberts, A. W. Walne and M. B. Gravenor (2012). "Changes in marine dinoflagellate and diatom abundance under climate change." Nature Climate Change **2**(4): 271-275.

Hinder, S. L., M. B. Gravenor, M. Edwards, C. Ostle, O. G. Bodger, P. L. Lee, A. W. Walne and G. C. Hays (2014). "Multi-decadal range changes vs. thermal adaptation for north east Atlantic oceanic copepods in the face of climate change." Global Change Biology **20**(1): 140-146.

Haydon, D., D. Randall, L. Matthews, D. Knobel, L. Tallents, M. Gravenor, S. Williams, J. Pollinger, S. Cleaveland and M. Woolhouse (2006). "Low-coverage vaccination strategies for the conservation of endangered species." Nature **443**(7112): 692-695.

Hays, G. C., T. Bastian, T. K. Doyle, S. Fossette, A. C. Gleiss, M. B. Gravenor, V. J. Hobson, N. E. Humphries, M. K. Lilley and N. G. Pade (2012). "High activity and Lévy searches: jellyfish

can search the water column like fish." Proceedings of the Royal Society B: Biological Sciences **279**(1728): 465-473.

Hays, G. C., S. Fossette, K. A. Katselidis, G. Schofield and M. B. Gravenor (2010). "Breeding periodicity for male sea turtles, operational sex ratios, and implications in the face of climate change." Conservation Biology **24**(6): 1636-1643.

Harris, D., A. Lacey, A. Akbari, M. B. Gravenor and J. Halcox (2018). "Early discontinuation of p2y12 antagonists and adverse clinical outcomes post percutaneous coronary intervention." Journal of the American College of Cardiology **71**(11S): A74-A74.

Harris, D. E., A. Lacey, A. Akbari, F. Torabi, D. Smith, G. Jenkins, D. Obaid, A. Chase, M. Gravenor and J. Halcox (2021). "Achievement of European guideline-recommended lipid levels post-percutaneous coronary intervention: A population-level observational cohort study." European journal of preventive cardiology **28**(8): 854-861.

Brophy, S., R. Cooksey, M. B. Gravenor, R. Mistry, N. Thomas, R. A. Lyons and R. Williams (2009). "Risk factors for childhood obesity at age 5: analysis of the millennium cohort study." BMC public health **9**(1): 1-7.

Charlton, R., M. B. Gravenor, A. Rees, G. Knox, R. Hill, M. A. Rahman, K. Jones, D. Christian, J. S. Baker and G. Stratton (2014). "Factors associated with low fitness in adolescents–a mixed methods study." BMC public health **14**(1): 1-10.

Jones, S., M. James-Ellison, S. Young, M. Gravenor and R. Williams (2005). "Monitoring trends in obesity in South Wales using routine data." Archives of disease in childhood **90**(5): 464-467.

Kosakovsky Pond, S. L., D. Posada, M. B. Gravenor, C. H. Woelk and S. D. Frost (2006). "GARD: a genetic algorithm for recombination detection." Bioinformatics **22**(24): 3096-3098.

Kosakovsky Pond, S. L., D. Posada, M. B. Gravenor, C. H. Woelk and S. D. Frost (2006). "Automated phylogenetic detection of recombination using a genetic algorithm." Molecular biology and evolution **23**(10): 1891-1901.

Kosakovsky Pond, S. L., S. D. W. Frost, Z. Grossman, M. B. Gravenor, D. D. Richman and A. J. L. Brown (2006). "Adaptation to different human populations by HIV-1 revealed by codon-based analyses." PLoS computational biology **2**(6): e62

Allen, S. J., K. Wareham, D. Wang, C. Bradley, H. Hutchings, W. Harris, A. Dhar, H. Brown, A. Foden and M. B. Gravenor (2013). "Lactobacilli and bifidobacteria in the prevention of antibiotic-associated diarrhoea and Clostridium difficile diarrhoea in older inpatients (PLACIDE): a randomised, double-blind, placebo-controlled, multicentre trial." The Lancet **382**(9900): 1249-1257.

Halcox, J. P., K. Wareham, A. Cardew, M. Gilmore, J. P. Barry, C. Phillips and M. B. Gravenor (2017). "Assessment of remote heart rhythm sampling using the AliveCor heart monitor to screen for atrial fibrillation: the REHEARSE-AF study." Circulation **136**(19): 1784-1794.

Plebanski, M., E. A. Lee, C. M. Hannan, K. L. Flanagan, S. C. Gilbert, M. B. Gravenor and A. V. Hill (1999). "Altered peptide ligands narrow the repertoire of cellular immune responses by interfering with T-cell priming." Nature medicine **5**(5): 565-571.

Flanagan, K. L., E. A. Lee, M. B. Gravenor, W. H. Reece, B. C. Urban, T. Doherty, K. A. Bojang, M. Pinder, A. V. Hill and M. Plebanski (2001). "Unique T cell effector functions elicited by Plasmodium falciparum epitopes in malaria-exposed Africans tested by three T cell assays."

Stallard, N., M. B. Gravenor and R. N. Curnow (2006). "Estimating numbers of infectious units from serial dilution assays." Journal of the Royal Statistical Society: Series C (Applied Statistics) **55**(1): 15-30.

Sazonov, I., M. Kelbert and M. B. Gravenor (2011). "A two-stage model for the SIR outbreak: Accounting for the discrete and stochastic nature of the epidemic at the initial contamination stage." Mathematical biosciences **234**(2): 108-117.

Moller, M., M. B. Gravenor, S. E. Roberts, D. Sun, P. Gao and J. M. Hopkin (2007). "Genetic haplotypes of Th-2 immune signalling link allergy to enhanced protection to parasitic worms." Human molecular genetics **16**(15): 1828-1836.

Kosakovsky Pond, S. L., K. Scheffler, M. B. Gravenor, A. F. Poon and S. D. Frost (2010). "Evolutionary fingerprinting of genes." Molecular biology and evolution **27**(3): 520-536.

Gravenor, M. B., M. B. Van Hensbroek and D. Kwiatkowski (1998). "Estimating sequestered parasite population dynamics in cerebral malaria." Proceedings of the National Academy of Sciences **95**(13): 7620-7624.

Saunders, N. J., E. R. Moxon and M. B. Gravenor (2003). "Mutation rates: estimating phase variation rates when fitness differences are present and their impact on population structure." Microbiology **149**(2): 485-495.

2. A list of the groups (i.e. SAGE and/or any of its sub-groups) in which you have been a participant, and the relevant time periods.

SPI-M-O (Scientific Pandemic Influenza Group for Modelling)

3. An overview of your involvement with those groups between January 2020 and February 2022, including:

a. When and how you came to be a participant

August 2020 by invitation from the Chairs of SPI-M-O following my involvement with the Welsh Government Technical Advisory Cell covid response. I continued to serve until end of the census period (February 2022), and beyond. I am a current member of SPI-M.

b. The number of meetings you attended, and your contributions to those meetings

Attended the vast majority of SPI-M meetings during the time period. Approximately 80 meetings (1 per week). Contributions to general discussions on most topics, and specific models (see below).

c. Your role in providing research, information and advice.

My main role was to contribute to general discussion on modelling work being presented, and to provide research information and advice specific to the modelling of the evolving epidemic in Wales.

4. A summary of any documents to which you contributed for the purpose of advising SAGE and/or its related subgroups on the Covid-19 pandemic. Please include links to those documents where possible.

I contributed to numerous SPI0M-O Consensus Statements. These were published weekly at peak times. See repository at: https://www.gov.uk/government/collections/scientific-evidence-supporting-the-government-response-to-coronavirus-covid-19

Within the papers are regular "SPI-M-O Consensus Statement on COVID-19" submissions. I also contributed model projections as part of the ensemble model summaries for Wales included in the regular "SPI-M-O: Medium-term projections". For example: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1055473/S1511_SPI-M-O_MediumTermProjections__9_February.pdf

Modelling to support discussion on the Wales Firebreak: https://www.gov.uk/government/publications/welsh-government-tag-fire-breaks-19-october-2020

Modelling Reasonable Worst Case Scenarios in Wales: An October 2020 update to the SPI-M-O July 2020 Models, see: https://www.gov.uk/government/publications/spi-m-o-uk-reasonable-worst-case-scenario-weekly-metrics-30-july-2020

Other specific modelling analyses included work subsequently published with co-authors in peer reviewed journals, in particular several studies of care home transmission and transmission within schools.

Emmerson, C. et al. (2021). "Risk factors for outbreaks of COVID-19 in care homes following hospital discharge: A national cohort analysis." Influenza and Other Respiratory Viruses **15**(3): 371-380.

Hollinghurst, J. et al. (2021). "The impact of COVID-19 on adjusted mortality risk in care homes for older adults in Wales, UK: a retrospective population-based cohort study for mortality in 2016–2020." Age and ageing **50**(1): 25-31.

Hollinghurst, J., et al. (2022). "Intensity of COVID-19 in care homes following hospital discharge in the early stages of the UK epidemic." Age and ageing **51**(5): afac072.

Lyons, J., et al. (2020). "Understanding and responding to COVID-19 in Wales: protocol for a privacy-protecting data platform for enhanced epidemiology and evaluation of interventions." BMJ open **10**(10): e043010.

Hollinghurst, J. et al. (2022). "COVID-19 infection risk amongst 14,104 vaccinated care home residents: a national observational longitudinal cohort study in Wales, UK, December 2020–March 2021." Age and Ageing **51**(1): afab223.

Hollinghurst, J. et al. (2022). "SARS-CoV-2 infection risk among 77,587 healthcare workers: a national observational longitudinal cohort study in Wales, United Kingdom, April to November 2020." Journal of the Royal Society of Medicine: 01410768221107119.

Thompson, D. A., et al. (2021). "Staff–pupil SARS-CoV-2 infection pathways in schools in Wales: a population-level linked data approach." BMJ paediatrics open **5**(1).

5. A summary of any articles you have written, interviews and/or evidence you have given regarding the work of the above-mentioned groups and/or the UK's response to the Covid-19 pandemic. Please include links to those documents where possible.

I have written numerous research publications on COVID and contributed interviews and written advice on many occasions to a number of agencies in Wales (Public Health Wales, Wales Technical Advisory Cell, NHS Wales Trusts), but not specifically regarding the work of SAGE sub-committee SPI-M-O, other than those listed above.

6. Your views as to whether the work of the above-mentioned groups in responding to the Covid-19 pandemic (or the UK's response more generally) succeeded in its aims. This may include, but is not limited to, your views on:

a. The composition of the groups and/or their diversity of expertise;
The group had outstanding expertise, was large and diverse.

b. The way in which the groups were commissioned to work on the relevant issues;
Generally very good in the mid to later stages of the period. I joined in August 2020. Focus was on the most pressings issues at most times.

c. The resources and support that were available;
The SPI-M secretariat were outstanding.
The Chairs were outstanding.

d. The advice given and/or recommendations that were made;
Given the uncertainties at many key points in the epidemic the advice given was generally good and as in-depth as it could be. The speed at which much of the work was generated was remarkable.

e. The extent to which the groups worked effectively together;
Very good collaboration across institutions, with early sharing of results and tools.

f. The extent to which applicable structures and policies were utilised and/or complied with and their effectiveness.
Generally good, though uncertainties thoughout impacted on the effectiveness of applicable structures.

7. Your views as to any lessons that can be learned from the UK's response to the Covid-19 pandemic, in particular relating to the work of the above-mentioned groups. Please describe any changes that have already been made, and set out any recommendations for further changes that you think the Inquiry should consider making.

An important lesson is how quickly SPI-M could generate state-of-the-art modelling support for decision making. The group's working methods could be used as a template for response in other relevant scientific disciplines.

Lessons learned for improvements could include structures for early data access and sharing.

Support should have been made available for all the time that was given by so many volunteers, many of whom had no time off their usual duties. For example, university academics were dealing with the consequences of the epidemic in their institutions (staff shortages, moving teaching to online at short notice, extra student support, all on top of usual duties). On top of these challenges they were working very long extra hours providing pressing analysis leading to the advice. This was an exceptional burden of work that was offered for free. Very few individuals were on secondment from their normal duties.

8. A brief description of documentation relating to these matters that you hold (including soft copy material held electronically). Please retain all such material. I am not asking for you to provide us with this material at this stage, but I may request that you do so in due course.

I have documentations of model development and scenario runs supporting advice. In particular Reasonable Worst Case and weekly Medium Term Projections for Wales, and other research projects. Most other documentation was held centrally by the SPI-M secretariat.