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

The following is my Academic CV in the format requested by my employer for promotions etc.

A. Personal information
1. Name: Thomas Allan House
2. Appointments held:
2021–: *University of Manchester.* Professor.
2017–21: *University of Manchester.* Reader.
2015–17: *University of Manchester.* Senior Lecturer.
2014: *University of Warwick.* Associate Professor.
2013–14: *University of Warwick.* Assistant Professor.
2006–13: *University of Warwick.* Research Fellow.
2002–05: *Sussex University.* Teaching Assistant.
3. Education:
2002-2005: Sussex University.
1998-2002: Oxford University.
1989-1998: Allerton Grange High School, Leeds.
4. Qualifications:
2013: Postgraduate Certificate in Academic and Professional Practice.
2005: DPhil, 'Aspects of Flux Compactification'.
2002: BA(Oxon), 1st class honours.
5. Visiting appointments: IBM Research; Alan Turing Institute for Data Science and Artificial Intelligence; Manchester University NHS Foundation Trust Clinical Data Science Unit; UK Health Security Agency Data, Analytics and Surveillance Division.

B. Research contributions
1. Publications
(a) Peer-reviewed
[95] K.-D. Vihta, K. B. Pouwels, T. E. A. Peto, E. Pritchard, **T. House**, R. Studley, E. Rourke, D. Cook, I. Diamond, D. Crook, P. C. Matthews, N. Stoesser, D. W. Eyre, A. S. Walker, "Omicron-associated changes in SARS-CoV-2 symptoms in the United Kingdom." Clinical Infectious Diseases (2022) ciac613
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[93] B. B. Yimer, D. M. Schultz, A. Beukenhorst, M. Lunt, H. L. Pisaniello, **T. House**; J. C. Sergeant, J. McBeth, W. G. Dixon, "Heterogeneity in the association between weather and pain severity among patients with chronic pain: a Bayesian multilevel regression analysis." PAIN Reports **7**:1 (2022) e963.
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A. Hunt, N. R. H. Stone, B. Kasstan, T. Chantler, S. Lal, C. H. Roberts, D. Goldblatt, M. Marks, R. M. Eggo, "Transmission dynamics of SARS-CoV-2 in a strictly-Orthodox Jewish community in the UK." Scientific Reports **12** (2022) 8550.
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[88] E. Pritchard, J. Jones, K. . Vihta, N. Stoesser, P. C. Matthews, D. W. Eyre, **T. House**, J. I. Bell, J. N. Newton, J. Farrar, D. Crook, S. Hopkins, D. Cook, E. Rourke, R. Studley, I. Diamond, T. Peto, K. B. Pouwels, A. S. Walker, "Monitoring populations at increased risk for SARS-CoV-2 infection in the community using population-level demographic and behavioural surveillance." The Lancet Regional Health – Europe **13** (2022) 100282.
[87] A. S. Walker, K. D. Vihta, O. Gethings, E. Pritchard, J. Jones, **T. House**, I. Bell, J. I. Bell, J. N. Newton, J. Farrar, I. Diamond, R. Studley, E. Rourke, J. Hay, S. Hopkins, D. Crook, T. Peto, P. C. Matthews, D. W. Eyre, N. Stoesser, K. B. Pouwels, Covid-19 Infection Survey Team. "Tracking the Emergence of SARS-CoV-2 Alpha Variant in the United Kingdom." New England Journal of Medicine **385**:27 (2021) 2582-2585.
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Susceptible-Infectious-Susceptible Infection Dynamics on Networks," PLOS Computational Biology **12**:12 (2016) e1005296.
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[1] **T. House** and A. Lukas, "G_2 domain walls in M-theory," Physical Review D **71** (2005) 046006. [arXiv:hep-th/0409114]

(b) Under review / To (re-)submit:

[R16] K.-D. Vihta, K. B. Pouwels, T. Peto, E. Pritchard, D. W. Eyre, **T. House**, O. Gethings, R. Studley, E. Rourke, D. Cook, I. Diamond, D. Crook, P. C. Matthews, N. Stoesser,

A. S. Walker, the COVID-19 Infection Survey team "Symptoms and SARS-CoV-2 positivity in the general population in the UK." [medRxiv:2021.08.19.21262231]
[R15] G. C. Marshall, R. Skeva, C. Jay, M. E. P. Silva, M. Fyles, **T. House**, E. L. Davis, L. Pi, G. F. Medley, B. J. Quilty, L. Dyson, L. Yardley, E. Fearon, "Public perceptions and interactions with UK COVID-19 Test, Trace and Isolate policies, and implications for pandemic infectious disease modelling [version 1; peer review: awaiting peer review]." F1000Research **11** (2022) 1005. [R14] K. Fong, Y. Mushtaq, **T. House**, D. Gordon, Y. Chen, D. Griffiths, S. Ahmad, N. Walton "Understanding Waiting Lists Pressures." [medRxiv:2022.08.23.22279117]
[R13] S. P. C. Brand, M. P. C. Cavallaro, J. Hilton, L. M. Guzman Rincon, **T. House**, M. J. Keeling, D. J. Nokes "The role of vaccination and public awareness in medium-term forecasts of monkeypox incidence in the United Kingdom." [medRxiv:2022.08.15.22278788]
[R12] K. A. Lythgoe, T. Golubchik, M. Hall, **T. House**, G. MacIntyre-Cockett, H. Fryer, L. Thomson, A. Nurtay, D. Buck, A. Green, A. Trebes, P. Piazza, L. J. Lonie, R. Studley, E. Rourke, D. Cook, D. Smith, M. Bashton, A. Nelson, M. Crown, C. McCann, G. R. Young, R. A. N. dos Santos, Z. Richards, A. Tariq, C. Fraser, I. Diamond, J. Barrett, A. S. Walker, D. Bonsall, Wellcome Sanger Institute COVID-19 Surveillance Team, "Lineage replacement and evolution captured by the United Kingdom Covid Infection Survey." [medRxiv:2022.01.05.21268323]
[R11] R. Cahuantzi, K. Lythgoe, I. Hall, **T. House**, L. Pellis, "Analysis and comprehensive lineage identification for SARS-CoV-2 genomes through scalable learning methods." [bioRxiv:2022.09.14.507985]
[R10] M.E. P Silva, M. Fyles, L. Pi, J. Panovska-Griffiths, C. Jay, **T. House**, E. Fearon, "The role of regular asymptomatic testing in reducing the impact of a COVID-19 wave." [arXiv:2207.08495]
[R9] M. E. P. Silva, R. E. Gaunt, L. Ospina-Forero, C. Jay, **T. House** "Comparing directed networks via denoising graphlet distributions" [arXiv:2207.09827]
[R8] R. Das, M. Muldoon, M. Lunt, J. McBeth, B. B. Yimer, **T. House** "Modelling and classifying joint trajectories of self-reported mood and pain in a large cohort study." [arXiv:2209.15553]
[R7] M. Fyles, K.-D. Vihta, C. H. Sudre, H. Long, R. Das, C. Jay, T. Wingfield, F. Cumming, W. Green, P. Hadjipantelis, J. Kirk, C. J. Steves, S. Ourselin, G. Medley, E. Fearon, **T. House**, "Diversity of symptom phenotypes in SARS-CoV-2 community infections observed in multiple large datasets." [arXiv:2111.05728]
[R6] **T. House**, L. Pellis, E. Pritchard, A. R. McLean, A. S. Walker, "Total Effect Analysis of Vaccination on Household Transmission in the Office for National Statistics COVID-19 Infection Survey." [arXiv:2107.06545]
[R5] Y. Han, Y. Sun, J. C. Hsu, **T. House**, N. Gent, I. Hall "Statistical Design and Analysis of PCR Tests for Fast Mutating Viruses" medRxiv 2021.04.07.21254917 [https://doi.org/10.1101/2021.04.07.21254917]
[R4] A. S. Walker, K.-D. Vihta, O. Gethings, E. Pritchard, J. Jones, **T. House**, I. Bell, J. I. Bell, J. N. Newton, J. Farrar, I. Diamond, R. Studley, E. Rourke, J. Hay, S. Hopkins, D. Crook, T. Peto, P. C. Matthews, D. W. Eyre, N. Stoesser, K. B. Pouwels, COVID-19 Infection Survey team, "Increased infections, but not viral burden, with a new SARS-CoV-2 variant." medRxiv 2021.01.13.21249721; doi: https://doi.org/10.1101/2021.01.13.21249721
[R3] S. Funk, S. Abbott, B. D. Atkins, M. Baguelin, J. K. Baillie, P. Birrell, J. Blake, N. I. Bosse, J. Burton, J. Carruthers, N. G. Davies, D. De Angelis, L. Dyson, W. J. Edmunds, R. M. Eggo,

N. M. Ferguson, K. Gaythorpe, E. Gorsich, G. Guyver-Fletcher, J. Hellewell, E. M. Hill, A. Holmes, **T. House**, C. Jewell, M. Jit, T. Jombart, I. Joshi, M. J. Keeling, E. Kendall, E. S. Knock, A. J. Kucharski, K. A. Lythgoe, S. R. Meakin, J. D. Munday, P. J. M. Openshaw, C. E. Overton, F. Pagani, J. Pearson, P. N. Perez-Guzman, L. Pellis, F. Scarabel, M. G. Semple, K. Sherratt, M. Tang, M. J. Tildesley, E. Van Leeuwen, L. K. Whittles, CMMID COVID-19 Working Group, Imperial College COVID-19 Response Team, ISARIC4C Investigators, "Short-term forecasts to inform the response to the Covid-19 epidemic in the UK" [https://doi.org/10.1101/2020.11.11.20220962]

[R2] F. Pagani, A. Chevallier, S. Power, **T. House**, S. Cotter, "The NuZZ: Numerical ZigZag Sampling for General Models." [arXiv:2003.03636]

[R1] T. M. Kinyanjui and **T. House**, "Generalised Linear Models for Dependent Binary Outcomes with Applications to Household Stratified Pandemic Influenza Data." [arXiv:1911.12115]

(c) Non peer-reviewed

[xvii] **T. House**, "Was lockdown necessary? – Details of SAGE advice." BMJ Rapid Response https://www.bmj.com/content/376/bmj.o776/rr-4

[xvi] S. Ahmad, B. Brown, A. Charlett, E. Davies, **T. House**, B. Kirkman, Machin, N., O'Hara, R., Paton, R., Pellis, L. and Ward, T., "Early signals of Omicron severity in sentinel UK hospitals." ResearchSquare (2021) https://doi.org/10.21203/rs.3.rs-1203019/v1

[xv] E. Fearon, I. E. Buchan, R. Das, E. L. Davis, M. Fyles, I. Hall, T. D. Hollingsworth, **T. House**, C. Jay, G. F. Medley, L. Pellis, B. J. Quilty, M. E. P Silva, H. B. Stage, T. Wingfield, "SARS-CoV-2 antigen testing: weighing the false positives against the costs of failing to control transmission," The Lancet Respiratory Medicine **9**:7 (2021) 685-687.

[xiv] E. Fearon, E. L. Davis, H. B. Stage, I. Hall, L. Pellis, L. Yardley, M. Fyles, R. Das, **T. House**, T. Wingfield, "A response to 'Covid-19: government must urgently rethink lateral flow test roll-out': lateral flow testing in contact tracing." BMJ Rapid Response https://www.bmj.com/content/372/bmj.n81/rr

[xiii] K. B. Pouwels, **T. House**, J. V. Robotham, P. Birrell, A. B. Gelman, N. Bowers, I. Boreham, H. Thomas, J. Lewis, I. Bell, J. I. Bell, J. Newton, J. Farrar, I. Diamond, P. Benton, S. Walker, "Community prevalence of SARS-CoV-2 in England: Results from the ONS Coronavirus Infection Survey Pilot." [medRxiv:2020.07.06.20147348]

[xii] L. Pellis, F. Scarabel, H. B. Stage, C. E. Overton, L. H. K. Chappell, K. A. Lythgoe, E. Fearon, E. Bennett, J. Curran-Sebastian, R. Das, M. Fyles, H. Lewkowicz, X. Pang, B. Vekaria, L. Webb, **T. House**, I. Hall, "Challenges in control of Covid-19: short doubling time and long delay to effect of interventions." [arXiv:2004.00117].

[xi] J. Middleton, S. L. Walker, **T. House**, M. G. Head, J. A. Cassel, "Ivermectin for the control of scabies outbreaks in the UK," The Lancet, **394**:10214 (2019) 2068-2069.

[x] **T. House**, "Fast Non-Parametric Estimation of Outbreak Growth from Cumulative Incidence Applied to the Current Ebola Epidemic" (2018) [bioRxiv:340067].

[ix] E. M. Hill, M. J. Tildesley and **T. House**, "How predictable are flu pandemics?", Significance **14**:6 (2017) 28-33.

[viii] **T. House**, "Hessian corrections to Hybrid Monte Carlo" (2017) [arXiv:1702.08251].

[vii] **T. House**, "A general theory of early growth?: Comment on: 'Mathematical models to characterize early epidemic growth: A review' by Gerardo Chowell et al.", Physics of Life Reviews **18** (2016) 109-111.

[vi] **T. House**, "Hessian corrections to the Metropolis Adjusted Langevin Algorithm" (2015) [arXiv:1507.06336].

[v] M. J. Keeling, M. Tildesley, **T. House** and L. Danon, "The Mathematics of Vaccination," Mathematics Today **49**:1 (2013) 40-43. Awarded the 2013 Catherine Richards Prize for the best article in Mathematics Today.
[iv] **T. House**, "Exact epidemic dynamics for generally clustered, complex networks," (2010) arXiv:1006.3483.
[iii] **T. House** et. al. (2009), "Can Reactive School Closures help critical care provision during the current influenza pandemic?" PLOS Currents Influenza.
[ii] **T. House**, G. Davies, L. Danon and M. J. Keeling, "Complex network structure and transmission dynamics," Proceedings of the European Conference on Complex Systems (2009).
[i] **T. House**, "Aspects of Flux Compactification," DPhil thesis, University of Sussex (2005).

2. Details of grants awarded

2022-24: EPSRC IAA with UKHSA. Co-I. £177,710.
2021-22: Manchester contribution to National Core Studies. Co-I. £460,000.
2021-23: DHSC support for work with ONS. PI. £217,011.
2020-22: MRC / UKRI JUNIPER consortium. Co-I. £3,811,889 with £521,165 to UoM.
2020-21: NIHR / UKRI COVID-19 grant. Co-I. £515,852.
2020-22: EPSRC / UKRI COVID-19 grant. PI. £444,951.
2020-21: IBM Corporate Social Responsibility award. Co-I. £15,000.
2019-22: Royal Society Industry Fellowship with IBM Research. PI. £137,052.
2018-20: Alan Turing Institute Funded Project. PI. £160,563.
2018-21: Wellcome Institutional Strategic Support Fund award. Co-I. £250,674.
2017-20: Autotrader Industrially Funded PhD Studentship. PI. £81,085.
2016-18: EPSRC Healthcare Technologies Impact Fellowship. PI. £396,583.
2013-16: EPSRC Responsive Mode. PI. £266,224.
2013-15: EPSRC New Directions Award. PI. £296,300.
2011: EPSRC Developing Leaders Award. PI. £43,201.
2011-16: EPSRC Career Acceleration Fellowship. PI. £790,668.
2010-13: EPSRC Responsive Mode. Co-I. £292,670.

3. Supervision

Mwandida Afuleni (PhD 2022-); Roberto Cahuantzi (PDRA 2020-); Bunlang Thatchai (PhD 2021-); Francesca Scarabel (PDRA 2021-22); Heather Riley (PDRA 2020-); Feng Xu (PDRA 2020-); Claire Little (PhD 2020-); Martyn Fyles (PhD 2019-); Hugo Lewkowicz (PhD 2019-); Marc Sune Simon (PDRA 2019); Jacob Curran-Sebastian (PhD 2019-); Alex Koch (PhD 2019-); Xiaoxi Pang (PhD 2019-); Rajenki Das (PhD 2018-); Luke Webb (PhD 2018-); Miguel Silva (PhD 2018-22); Bindu Vekaria (PhD 2017-); Jack Mckenzie (PhD 2017-21); Filippo Pagani (PhD 2016-20); Alex Bishop (PhD 2015-2019); Rob Eyre (PhD 2015-18); Tim Kinyanjui (PDRA 2014-2020); Liz Buckingham-Jeffery (PhD 2014-17, PDRA 2017-18); Ed Hill (PhD 2014-17); Ashley Ford (PDRA 2014-15); Sam Bilson (PDRA 2014); Lorenzo Pellis (PDRA 2012-16); Dan Sprague (PhD 2012-15); Matt Graham (PhD 2011-14); Sam Mason (MRes 2011).

4. Promotion of research

Invited seminar / plenary talks

These talks were externally funded. Plenaries at larger events are italicised.
(2022) University of Texas COVID-19 Modeling Consortium; Office for National Statistics; UK Health Security Agency; *Isaac Newton Institute event on Controlling COVID-19 in Schools: Lessons Learned and Open Questions*; **(2021)** *Fry Statistics Conference, Bristol* SIAM dynamical systems minisymposium; BAMC session on modelling COVID; *Discussant at the*

8th Nordic-Baltic Biometrics Virtual Conference, Helsinki; **(2020)** Manchester Academic Health Sciences Centre; Turing Health Programme; **(2019)** Stochastic modelling in Health & Disease, Leeds; *MATRIX Institute workshop on Influencing Public Health Policy with Data-informed Mathematical Models of Infectious Diseases, Australia*; Royal Society Meeting of Minds, London; British Applied Mathematics Colloquium (BAMC) Minisymposium on Dynamics of Complex Contagions, Bath; **(2018)** Probability in the North East (PINE) day, Leeds; **(2017)** Liverpool TB meeting; Galois Group, Manchester; **(2016)** Manchester stochastic networks day; *iLike workshop, Lancaster*; North West ESRC CDT methods seminar; **(2015)** North Manchester General Hospital; Manchester Royal Infirmary; *Royal Statistical Society Applied Probability Section meeting, London*; **(2014)** European Conference on Mathematical and Theoretical Biology: Spatial moment techniques for modelling biological processes minisyposium; Newton Institute, Cambridge; **(2013)** *Newton Institute, Cambridge*; Leeds Mathematical Biology and Medicine; UCL Computational Inference Group; **(2012)** *EpiNet 2012 meeting in Girona, Spain*; Manchester Complexity Centre; Leeds / Bradford Royal Statistical Society; Leicester Student Union Mathematics Society; **(2011)** KEMRI-Wellcome centre, Kenya; Bath University, Centre for Mathematical Biology; York University, Complexity Science; Nottingham University, School of Mathematical Sciences; University of Oxford, CABDyn; *SIMID workshop in Antwerp, Belgium*; **(2010)** Liverpool University, Department of Mathematical Sciences; Imperial College, Department of Infectious Disease Epidemiology; University of Sussex, Department of Mathematics; London School of Hygiene and Tropical Medicine, Infectious Disease Epidemiology; **(2009)** University of Cambridge, Department of Applied Mathematics and Theoretical Physics; **(2008)** DIMACS working group, Rutgers University, USA; Imperial College, Department of Infectious Disease Epidemiology; **(2005)** University of Oxford, Theoretical Physics.

Contributed international conference talks

Royal Statistical Society (2016); Society for Mathematical Biology (2007); European Conference on Mathematical and Theoretical Biology (2008, 2011, 2014, 2016, 2022); the European Conference in Complex Systems (2009); Epidemics (2008, 2009).

C. Other evidence of academic and professional standing

Coronavirus pandemic

Member of the SPI-M modelling sub-committee of SAGE. Academic collaborator for the ONS Coronavirus Infection Survey. Visiting position at the NHS at the Manchester University Foundation Trust. Attended SAGE full meeting and task & finish groups on Transmission, Children and Schools.

Events

Organising committee for events at CIRM, France and Fields Institute, Canada. Organiser of week at the International Centre for Mathematical Sciences in Edinburgh on Stochastic spreading 2016. Held a four-week visiting fellowship at the Newton Institute in Cambridge to participate in the 'Infectious Disease Dynamics' 2013 programme and a one-week fellowship for the 2014 follow-up meeting.

Membership of learned societies

Society for Mathematical Biology. European Society for Mathematical and Theoretical Biology.

Promotions

Referee for promotions at University of Melbourne.

External examining

External examiner on MSc in Modelling for Global Health at the University of Oxford. External PhD examiner for University of Liverpool, University of Nottingham, University of Warwick, Australian National University, London School of Hygiene and Tropical Medicine, University of Melbourne, and University of Edinburgh. PhD upgrade committee member at the London School of Hygiene and Tropical Medicine. External MPhil examiner for the University of Adelaide.

Grant reviewing

Member of the EPSRC Peer Review College. Reviewed grants for EPSRC, the Royal Society, the Medical Research Council, Public Health England, the Swiss National Science Foundation, Public Health England, the Wellcome Trust, the Belgian Fonds de la Recherche Scientifique – FNRS, the PRISM Network in Australia, Cancer Research UK, the Royal Society Marsden Fund in New Zealand, the International Centre for Mathematical Sciences, Edinburgh.

Editorial

Associate Editor of The Journal of Theoretical Biology. Founding Editorial Board member of Foundations of Data Science. Associate Editor of The Institute of Mathematics and its Applications (IMA) journal Mathematical Medicine and Biology. Member of the Editorial Board of Theoretical Biology and Medical Modelling. Founding Editorial Board member of Infectious Disease Modelling. Guest Editor for PLOS Computational Biology.

Paper reviewing

Americal Journal of Epidemiology; Applied Mathematical Modelling; Biostatistics; Biosystems; BMC Public Health; BMC Infectious Diseases; BMC Research Notes; BMJ Open; Bulletin of Mathematical Biology; Chaos, Solitons & Fractals; Discrete and Continuous Dynamical Systems Series B; EBioMedicine; Electronic Journal of Differential Equations; Epidemics; Epidemiology and Infection; Foundations of Data Science; Health Policy; IEEE Access; Infectious Disease Modelling; Journal of Complex Networks; Journal of Epidemiology and Global Health; Journal of Mathematical Biology; Journal of Theoretical Biology; Journal of Physics A; Journal of the Royal Society Interface; Journal of Statistical Physics; The Lancet Infectious Diseases; Mathematical Biosciences; Mathematical Modelling of Natural Phenomena; Nature Communications; Physica A; Physical Review E; Physical Review Letters; Physical Review X; PLOS Computational Biology; PLOS ONE; PNAS; Proceedings of the Royal Society A; Proceedings of the Royal Society B; Royal Society Open Science; Science; Scientific Reports; SIAM Journal on Applied Dynamical Systems; Theoretical Population Biology; Transboundary and Emerging Diseases;

Awarded a 'certificate of excellence in reviewing' by Mathematical Biosciences for 2013.

Conference reviewing

Advances in Data Science.

Book reviewing

Academic book outlines reviewed for Taylor and Francis and CRC Press.

D. Teaching and Learning

1. Teaching duties

Modules led

2018-: Multivariate Statistics for MSc Statistics.
2018-19: Statistics and Machine Learning 1 and 2 for MSc Data Science.
2017-18: Multivariate Statistics for MSc Statistics and 3rd/4th year UG.
2016-17: Engineering Mathematics 1 for 1st year UG students.

2013: Networks, Self-Organisation and Emergence for Complexity Science MSc.
2010-12: Topics in Mathematical Biology for 3rd/4th year UG.

Other Ongoing

MSc supervision. MMath and BSc UG project supervision. Academic advising.

Previous

Applied Mathematics MSc Transferable Skills Module. 1st year supervisions in Calculus and Vectors and Differential Equations. 2013: Networks, Self-Organisation and Emergence; 8 2-hour-long lectures; written assignment + viva exam; around 20 postgraduate students. Warwick. Module leader. 2010-12: Topics in Mathematical Biology; 30 hour-long lectures, one 3-hour exam; around 80 Undergraduate and 5 Postgraduate students. Warwick. Module leader. MMath and MSc supervision, marking and vivas at University of Warwick. Lectures on "Dynamics of the infectious process, and the impact of vaccination" and "How to Read a Modelling Paper," as well as a practical "Estimation of vaccine coverage target" to the "Communicable Diseases and Immunisation" module, Warwick Medical School. Lecture on "Statistics used for surveillance" for Public Health England MSc students in Warwick Life Sciences on the module "Food & environmental borne disease diagnosis, surveillance & outbreak investigation". Lectured on the Birmingham University Masters in Public Health. Convened support classes in Foundation Year Mathematics and Physics at the University of Sussex.

2. External teaching

Invited lecturer at Bridges PhD School Warwick September 2016. Invited lecturer for PhD school – the Helsinki Summer School on Mathematical Ecology and Evolution 2014: Dynamics of Infectious Diseases. Invited lecturer at the Warwick Winter PhD School on Networks 2011.

E. Leadership and/or management roles

Research lead for Statistics and Probaility Group within Department of Mathematics. Internal peer review for Faculty, particularly fellowship applications. RRE assessment. Member of the Management Board for Manchester's Data Science Institute. Committee membership of the Manchester Institute for Mathematical Sciences (MIMS).

F. Knowledge and Technology Transfer

Seconded to UKHSA DAS as Joint Chief Data Scientist 2021-22. Working with IBM Research, including Royal Society funding. Supervised multiple industrially funded MSc theses and an industrially funded PhD by Autotrader plc. Extensive record of engagement with Public Health England, Government, and the NHS – particular details for coronavirus pandemic at the start of section C above. Participation in the 2015 European Study Group with Industry 107, and the 2018 KTN study group on AI in Health.

G. Outreach and public engagement

Extensive press coverage of work on coronavirus, including on Panorama and the BBC 6 O'Clock news, The Guardian, The Times and many other national newspapers. Will appear in upcoming film by the Royal Society on coronavirus scientific response. Pre-pandemic research, in particular [60], [57], [47], [42], [24] and [5], has been press-released, leading to coverage in national newspapers (such as the Guardian, Mail, and Telegraph) as well as internationally (such as The Atlantic, To Vima, and CBS). Membership of the Science Media Centre, making regular contributions on research papers carried in the national press. Talks

about my research given in schools and to undergraduate societies. Consulted by the Science Museum in London for information on the use of Mathematics in Health. Spoke at Cafe Scientifique at the Barbican Centre, London.

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-MO** – visitor in January and February 2020 then member from Mar 2020 to April 2022.
- **SAGE** – attended once in 2020.
- **SPI-M** – member from May 2022 onwards.
- **ONS CIS** – academic collaborator from April 2020.
- **CT&FG** – Children's Task and Finish Working Group – Participant from April 2020 to November 2020.
- **JMT** – Joint Modelling Team at UKHSA (former PHE) – occasional visitor from January 2020 to July 2022.

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;
b. The number of meetings you attended, and your contributions to those meetings;
c. Your role in providing research, information and advice.

- **SPI-MO**
    a. I was invited to visit and later join by the Chair due to expertise in epidemic modelling. The forms I filled in to join formally are dated 10 March 2020.
    b. I attended almost all meetings, and regularly produced documents in response to commissions, as well as more open responses to other requests and topics for discussion. I contributed to wider discussion of the meeting agenda, e.g. scrutiny of other models. The most important contribution is arguably formulation of the *consensus* statements.
    c. My role was to produce modelling results, and in addition to this I played a role in linking SPI-M in with other activity, most prominently the ONS CIS.
- **SAGE**
    a. I was invited by the secretariat.
    b. I visited one meeting (SAGE 73) on 17 December 2020. I also attended SAGE-organised briefings on working with the Media and Security.
    c. I presented work on evidence that high-Ct infections in the ONS CIS were less infectious within households.
- **SPI-M**
    a. I was invited by the chair to participate after membership of SPI-MO.
    b. I attended all meetings from May 2022 onwards.
    c. The main work so far has been on procurement and stockpiling.

- **ONS CIS**
    a. I was invited as one of the only authors on a paper on design of longitudinal household studies of infections.
    b. I attended daily meetings to provide statistical / academic support to the project.
    c. My focus was particularly on household transmission and variants.
- **CT&FG**
    a. I was invited as a member of SPI-M and the ONS CIS to feed in information.
    b. I attended a small number of meetings from April 2020 to November 2020.
    c. Presentation mainly concerned results on children and schools from the ONS CIS.
- **JMT**
    a. I was invited as a known modeller with a track record of collaboration with PHE and later UKHSA.
    b. I attended occasional meetings from January 2020 to July 2022.
    c. My main contributions were on hospitals, households and the ONS CIS as would be expected.

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 obtained this information mainly from searching my Sent Mail and so it may not be comprehensive. All documents are for SPI-MO unless indicated otherwise.

- 18 March 2020: A Document "Household Isolation Model for COVID-19" considering periods of isolation of household contacts that might have the most benefit on transmission for the least harm. The model behind this was eventually written up in publication [89] above.
- 20 March 2020: Documents "UK covid-19 predictions" and "Doubling Time Analysis" with others where we note that the doubling time is likely closer to 3 days than 4.5 and so we were much closer to overwhelm of the health service than was previously realised.
- 30 March 2020: Document "Assessment of European Doubling Times, Efficacy of Measures, and Delays" with other Manchester colleagues summarising our analysis of the speed of spread and time taken for non-pharmaceutical interventions to have an noticeable impact on transmission. This work would eventually become publication [79] above.
- 1 April 2020: Document "Household Surge Model" considering whether within-household transmission might prolong the time needed for lockdown to cause a reduction in prevalence.
- 8 April 2020: Documents "Analysis of Historic Respiratory Hospitalisation Data at MFT" and "Household Plateaus" with Manchester and IBM research colleagues. The former was looking at how other respiratory diseases behaved in a large NHS trust historically, and the latter developing the 1 April document work.

- 17 April 2020: Full code and approach for the hospital length-of-stay model that we developed was sent for rapid review and "Scenario Planning for COVID at MFT: 17 April 2020" document written that would form one part of paper [83] above.
- 19 April 2020: Helped introduce "An Analysis of the Duration of ICU and Hospital Stays of Covid-19 Patients Admitted to Intensive Care Units in England in January - April 2020. Preliminary report" by colleagues in Social Science that would go on to be another part of the paper [83] above.
- 20 April 2020: Papers in last two bullet points discussed at SPI-MO meeting.
- 1 May onwards: Regular presentations on results from the ONS CIS.
- 6 May 2020: Contributed to consensus statement on "bubbles". Fuller analysis would be done in publication [89].
- 11 May 2020: Estimate of the R number from ONS CIS as indistinguishable from 1 presented. Methodology for extraction of R number appeared in [76] above and associated preprint.
- 18 May 2020: Began submission of R and growth rate estimates from ONS CIS. This methodology was developed and became part of the regular reporting of
- 4 June 2020: "Household structured contact tracing: Branching process model" paper from Test and Trace modelling project led by Liz Fearon based on model that was published as [80] above.
- 4 June 2020: Ad-hoc confirmation from ONS CIS that $R < 1$ presented to SPI-MO.
- 10 June 2020: "Backwards Contact Tracing, Recall, and Testing Delays: Report for SPI-M on 10 June 2020" from test and trace modelling project, looking at whether TTI should try to look for infectors of cases as well as infectees.
- 15 June 2020: Document "Assessing the Extra Footprint of COVID Patients: Report for SPI-M" estimating that a typical COVID patient spent about 10% of their time in hospital pre-pandemic.
- 17 June 2020: "Hospital length of stay for COVID-19 patients: Data-driven methods for forwards planning" substantially complete version of paper [83] sent to SPI-MO.
- 24 June 2020: Figure showing prevalence in ONS CIS fell from around 0.4% to under 0.05% presented.
- 26 June 2020: Chaired SPI-M meeting on: Nosocomial Transmission; Missingness in e.g. CHESS data; Length of Stay (and associated censoring); Readmission; Variability of clinical practice by site and time.
- 1 July 2020: Document "Probability of ICU Admission Conditional on Hospitalisation (SPI-M Commission)" estimating proportions of COVID hospitalisations needing intensive care by age and nosocomial status.
- 8 July 2020: Submission of latest length of stay in hospital estimates in response to commission.
- 15 July 2020: Document "Household clustering and False Positives" showing that positives in households are much more clustered than would be consistent with a significant false positive rate. This analysis presented to SPI-M and also included in ONS CIS slides.
- 29 July 2020: Symptoms clustering results that would eventually appear in [R7] above first presented showing patterns of co-occurrence of symptoms in diverse datasets.

- 29 July 2020: updated analysis of household clustering of ONS CIS positives indicating over 99.9% specificity in tests.
- 10 August 2020: Document "Times to Extinction" on how long it would be expected to get to a true zero of COVID prevalence in the UK (Explained at more length at https://personalpages.manchester.ac.uk/staff/thomas.house/posts/why-zero-is-so-hard.html)
- 26 August 2020. Three papers:
    - "Household Adult-Child Analysis Preliminary Results" looking at relative susceptibility of children to within-household infection showing this is possibly lower than for adults. Would eventually be formalised for ONS CIS data in [86] and ongoing analysis at https://github.com/thomasallanhouse/covid19-housefs
    - "Modelling out-of-household isolation as a COVID-19 mitigation strategy" using methods eventually in publication [89] to look at potential for out-of household isolation (OOHI)
    - "Preliminary analysis: Out of household isolation of the index case vs out of household quarantine of a vulnerable individual" using methods published as [80] to look at OOHI.
- 2 Sept 2020: Re-analysis of Fishing Boat data to estimate relative susceptibility of previously infected versus immunologically naïve as very likely under 20% (this is for wildtype and recent infection)
- Throughout September: ongoing work to
- 13 October 2020: Document "Prioritising testing when capacity is limited: considering trade-offs in the proportion of infections detected against the speed tests are processed and returned for TTI efficacy"
- 21 October 2020: Documents "Potential for Future Nosocomial Transmission– Insights from Greater Manchester" on what role we might expect for hospital transmission in Wave 2; "Considerations towards optimising allocation of testing across areas" and "Time series of testing, positive tests, demand for tests across local areas" and a document on testing effort, which between them considered existing and potentially improved use of testing.
- 28 October 2020: Document "Integrating Mental Health Considerations into Pandemic Modelling". Note, many have asserted that modellers did not consider wider implications – this was one of several documents that were presented to SPI-MO offering to consider wider impacts of measures alongside
- 10 November 2020: Contribute to the document "Mass testing of the whole population – note from SPI-M"
- 17 November 2020: "Bubbles During the Festive Season" document.
- 25 November 2020: Document "Older and Younger Adult infection patterns in households" from ONS CIS
- 2 December 2021: "Symptom Phenotypes amongst SARS-CoV-2 PCR-positive community cases" with many results from [R7] above included.
- 2 December 2021: Document "Multi-Household Groupings over the Holidays" looking at possible Christmas policies.
- 9 December 2021: Updated Christmas policy presentation "Modelling household bubbling over the Christmas period".

- 16 December 2020: Document "Risk Perception and Behaviour" on spontaneous behaviour change in response to epidemics. Like the mental health document on 28 October above, this was ruled as not within the scope for SPI-MO. It is therefore important to note that we offered to include such things in models and were told not to.
- 23 December 2020: Document "Results from ONS CIS on PCR Pattern of New Variant" on what we would now call "alpha" variant in households, included in JUNIPER slides on new variant.
- 30 December 2020: Untitled slides on spread of alpha variant through devolved nations and English regions.
- 4-14 Jan 2021: Various papers leading up to https://www.gov.uk/government/publications/emgspi-bspi-m-reducing-within-and-between-household-transmission-in-light-of-new-variant-sars-cov-2-14-january-2021 - "EMG/SPI-B/SPI-M: Reducing within- and between-household transmission in light of new variant SARS-CoV-2, 14 January 2021"
- 3 Feb 2021: "Vaccine impact on Care Homes in England", updated by Ian Hall on 17 Feb and 24 Feb. End of Feb "Projecting the impact of staff vaccination in care homes" modelling results presented.
- 10 Feb 2021: "Within- and Between-Household Transmission in the ONS Survey by Time, Age, CT Pattern and Patient-Facing Work" preliminary results that would become [86]. Showed healthcare workers at risk, and schools open associated with infection being brought into homes.
- 24 March 2021: "Importation of Variants and Border Control" document on risks from what we now call the Beta variant. Updated on 20 April 2021, then 10 May 2021 in document "Latest Analysis of B.1.351 Variant Data". I assessed that there was some signal for growth in this variant, however the Delta variant made any advantage Beta might have had over Alpha as vaccination progressed a moot point.
- 24 March 2021: "Social Care vaccine and testing modelling response to recent commissions" updating February care home work.
- 28 April 2021: "S-positivity and tracking new variants" technical note on reliability of the OR+N+S PCR gene positivity pattern for detection of what we now call the Delta variant.
- Over summer 2021, SPI-MO moved to much less frequent meetings and
- 3 November 2021: Document "Assessment of AY.4.2 Lineage in ONS CIS Data" showing that this "Delta Plus" lineage had ambiguous growth advantage in the ONS CIS. Updated on 26 November 2021 and 1 December 2021 when the evidence for a growth advantage of Delta Plus was convincing, but the Omicron wave had made that of less interest.
- 1 Dec 2021: "Analysis of SGTF for Omicron Detection" seeing if PCR gene pattern was a good proxy for Omicron.
- 8 Dec 2021: "Assessment of Omicron from SGTF in Scotland" predicting an Omicron sweep by the end of 2021.
- 15 Dec 2021: Documents "Update on transmission within care home settings", "Omicron hospital admissions trend –Greater Manchester", JUNIPER "Briefing note: Early S-gene trends in England: Omicron surveillance"

- 22 Dec 2021: "Impact of shielding on care homes during wave 2:Considerations for Omicron" considering what might be possible to protect the vulnerable in social care during the Omicron wave.
- 22 Dec 2021: "NPIs and household generation structure" thinking about protecting the vulnerable within households, showing that noticeable but not huge improvements in outcomes were possible.
- 5 Jan 2022: Presentation of genomically confirmed lineage replacement in the ONS CIS that would become [R12] above.
- 9 March 2022: Document "Inferring Risks of Coronavirus Transmission from Community Household Data:Tranche 11 Update" on the BA.2 Omicron wave and household transmission.

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 not appeared before any formal bodies for interview yet, although I did participate in events hosted by the Royal Statistical Society (RSS) in preparation for the formal Inquiry.

I have written some somewhat formal journal opinion pieces / commentaries on policy issues such as [xiv] and [xv] above, and participated in the BMJ "COVID Unknowns" series as well as other academic forums that are likely to feed in to evidence.

In terms of speaking to the press, my position was to speak to any mainstream media outlet that I had time to and where I could contribute meaningfully. A lot of this work was via the Science Media Centre. The most prominent appearances were on Newsnight, an early Panorama, and I also provided comment to many different local, national and international news sources. I did not keep detailed records of every such interaction.

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;
b. The way in which the groups were commissioned to work on the relevant issues;
c. The resources and support that were available;
d. The advice given and/or recommendations that were made;
e. The extent to which the groups worked effectively together;
f. The extent to which applicable structures and policies were utilised and/or complied with and their effectiveness.

I did not participate for long enough in the other groups to comment, and so all of my thoughts pertain to SPI-MO, in which I was a regular participant. Overall, I cannot speak

highly enough of the typical calibre of participants, visitors and secretariat involved in SPI-MO, but also whom I met and worked with throughout the pandemic. The UK is incredibly fortunate to have such excellent people working for it across Government, academia, industry, and charities. It was not at all clear to me why smaller profit-making consultancies without much track record were used to extensively early in the pandemic when excellent advice was freely available.

The main negative comments I could make about the process are that where certain individuals and groups are too dominant, this makes effective consensus based on having multiple independent groups working on the same problem impossible.

Also, while hundreds of scientists did contribute to SAGE, given the scale of the enterprise I also wonder if more could have been done to coordinate and expand the overall scientific effort as organisations like the Royal Society did.

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.

If there were three things I could change about our pandemic response they would be:

i. Avoiding a situation where one group of scientists is overwhelmingly dominant, making the independently scrutiny and peer critique that science depends on impossible. This was true for the Imperial College modelling group at the start of the pandemic. Then, for a brief moment in the middle of the pandemic, there was more equity and this led to vastly improved scientific advice, but it is now the case again that this one group dominates. The level of control that this group asserts over publication, funding and data means that they can produce work that no-one else is in a position to check, and this led to multiple serious errors in models and estimates presented to Government both early and late in the pandemic.

ii. Clearer rules enabling data sharing. SPI-M is currently preparing documentation on this matter, but in the early weeks of the pandemic in particular we would often turn up at SPI-MO meetings to find that Imperial College had or claimed to have unique access to data on China, Italy or the state of NHS hospitals etc. so that we could not attempt to reproduce their conclusions. There were other datasets it would be good to ensure were available to modellers, and ideally any expert quantitative scientist who could be expected to follow appropriate directions on data use, which would include most academics with statistical training – the 'crowd-sourced' work on the data that were fully public was wonderful.

iii. Encouragement of more "Blue skies" thinking in emergency preparedness. Prior to COVID, there was a lot of thinking that coronavirus pandemics would proceed like SARS1 or MERS and plans were not made. People previously dismissed the possibility of orthopox virus spread in rich countries before we had the recent monkeypox outbreak, and Ebola in East Africa before the present Ugandan outbreak. We must start to plan for scenarios that seem unlikely but which can be envisaged as scientifically possible.

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.

Having had no administrative support, I hold documentation on these on a combination of different physical computers, paper notes and remote / cloud systems. I have not knowingly deleted or destroyed any records, and am trying to document and tidy as best I can given other commitments.