

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

Professional Expertise

I am an expert in the area of bioinformatics, pathogen genomics and genomic epidemiology. Like most bioinformaticians I have expertise across a range of areas. Bioinformaticians often play the role of the 'glue' that sticks projects together – and this is evidenced by the wide range of projects I have been involved in – from immunology to sequencer benchmarking.

I completed my PhD at Imperial College in the area of population genetics and molecular epidemiology, before moving to the Wellcome Sanger institute, and then to a permanent academic position in Cardiff. Since 2016 I have worked on secondment at PHW since 2016, where I have played a leading role in the development of new clinical genomics services. At the start of the pandemic, I therefore led both a research group within the University, who focused on the analysis of pathogen genomic data, and the bioinformatics activity within PHW in relation to pathogen genomics. In addition to this I have significant expertise in cloud computing / computational infrastructure. I have worked as co-technical lead for the MRC CLIMB project since its inception in 2014 and designed and led the deployment of a range of other computational infrastructures within Cardiff University. While working for PHW I led the development of, or wrote myself, all of the bioinformatics pipelines and processes that underpinned the pathogen genomics services that were in place within PHW prior to the pandemic.

My expertise can be summarised, therefore, as a deep theoretical and practical understanding of the genomics of microbial pathogens, how genomics data is generated, and how it can be applied within a public health system. I have published widely, with research outputs spanning multiple pathogen species, including work that is very highly cited. In 2022 I was included in the global highly cited researchers list, which is a list of the top 1% of researchers globally based on citations.

Prior to joining TAG, I played a key role in planning out the sequencing of the first Welsh SAARS-CoV-2 isolates in early March 2020 and performed the bioinformatics analysis to assemble the genomes for those samples. A week later, I was present at the meeting at Wellcome that planned out and established the COVID-19 Genomics UK consortium. As part of this I presented an outline proposal for sequencing samples in a tiered (local first, with central capacity) way, which formed the basis of the plan adopted by COG-UK. Subsequently, I contributed a significant amount of text, figures and ideas that summarised the model I was proposing, following the discussion at Wellcome. This, in addition to ideas I contributed with respect to the digital systems that would be needed (based on MRC CLIMB) then formed part of the proposal that was submitted for funding for that activity.

Professional History/Roles

2023 -	Head of Public Health Genomics Programme, Public Health Wales
2018 –2023	Bioinformatics Lead, Pathogen Genomics Unit, Public Health Wales*
2020 -	Professor, Cardiff University School of Biosciences
2016 – 2023	Honorary Consultant Bioinformatician, Public Health Wales*
2012-2020	Lecturer, then Senior Lecturer and finally Reader, Cardiff University School of Biosciences
2010-2012	Postdoctoral Fellow, Pathogen Genomics, The Wellcome Trust Sanger Institute, Cambridge
2005-2006	Research Assistant, Software Development, Department of Infectious Disease Epidemiology, Imperial College London

* I operated on secondment to PHW from 2016-2023, rising from 20% to 80% of my time between 2016 and 2020. I operated on a 90% secondment between 01/08/20 and 31/1/23.

Qualifications

2014	Fellow of the Higher Education Academy
2006-2010	PhD “The effects of metapopulation structure and recombination on bacterial populations”, Department of Infectious Disease Epidemiology, Imperial College London, supervised by Professor Brian Spratt, Dr Bill Hanage and Professor Christophe Fraser
2004-2005	MSc Bioinformatics, Imperial College London
2001-2004	BSc Biochemistry and Genetics, University of Nottingham

Publication overview and highlights

I have a total of 94 total publications, and Google Scholar reports my h-index as 48 and i10 index of 79. Papers I have authored have 16924 total citations. In 2022 I was included in the ‘Highly Cited Researchers’ list, comprised of researchers in the top 1% of researchers in the world by research citations. Below are a selection of some of my significant papers covering my areas of expertise:

- E. Volz, ...A. Rambaut*, **T. R. Connor*** “Evaluating the Effects of SARS-CoV-2 Spike Mutation D614G on Transmissibility and Pathogenicity” *Cell*, vol 184 no 1. pp 64-75. 2021
- A.J Mullins ... **T. R Connor**, J. Parkhill, G.L. Challis, E. Mahenthiralingam “Genome mining identifies cepacin as a plant-protective metabolite of the biopesticidal bacterium” *Nature microbiology* 4 (6), 996-1005 2019.
- **T. R. Connor*+**, N. J. Loman*, S. Thompson*, and others, “CLIMB (the Cloud Infrastructure for Microbial Bioinformatics): an online resource for the medical microbiology community,” *Microb. Genomics*, vol. 2, no. 9, 2016.
- V. K. Wong, S. Baker, **T. R. Connor**, and others, “An extended genotyping framework for *Salmonella enterica* serovar Typhi, the cause of human typhoid,” *Nat. Commun.*, vol. 7, p. 12827, 2016.
- **T. R. Connor*+**, C. R. Barker*, K. S. Baker*, and others, “Species-wide whole genome sequencing reveals historical global spread and recent local persistence in *Shigella flexneri*,” *Elife*, vol. 4, p. e07335, 2015.
- von Mentzer, **T. R. Connor**, L. H. Wieler, and others “Identification of enterotoxigenic *Escherichia coli* (ETEC) clades with long-term global distribution.,” *Nat. Genet.*, vol. 46, no. 12, pp. 1321–1326, 2014.
- S. Reuter*, **T. R. Connor***, L. Barquist, and others, “Parallel independent evolution of pathogenicity within the genus *Yersinia*,” *Proc Natl Acad Sci U S A*, vol. 111, no. 18, pp. 6768–6773, 2014.
- W. Knecht, **T. R. Connor**, A. Mutreja, and others, “Whole genome sequencing reveals potential spread of *Clostridium difficile* between humans and farm animals in the Netherlands, 2002 to 2011,” *Eurosurveillance.*, vol. 19, no. 45, p. 20954, 2014.
- L. Cheng, **T. R. Connor**, J. Sirén, D. M. Aanensen, and J. Corander, “Hierarchical and spatially explicit clustering of DNA sequences with BAPS software,” *Mol. Biol. Evol.*, vol. 30, no. 5, pp. 1224–1228, 2013.
- K. Okoro*, R. A. Kingsley*, **T. R. Connor**, and others, “Intracontinental spread of human invasive *Salmonella* Typhimurium pathovariants in sub-Saharan Africa,” *Nat. Genet.*, vol. 44, no. 11, pp. 1215–1221, 2012.
- Mutreja*, D. W. Kim*, N. R. Thomson*, **T. R. Connor**, and others, “Evidence for several waves of global transmission in the seventh cholera pandemic,” *Nature*, vol. 477, no. 7365, pp. 462–465, 2011.

* Contributed equally + corresponding author

- 2. A list of the groups (i.e. TAG and/or any of its subgroups) in which you have been a participant, and the relevant time periods. Please also confirm if you are or have been a participant in SAGE or other relevant groups.**

Please see the response to question 3 below for the list of groups that I think are relevant to the question, and the other details requested.

- 3. An overview of your involvement with those groups between January 2020 and May 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.**

Please note: I have grouped the answers to questions 2 and 3 above to put everything together. If anything is unclear, or needs clarification, please let me know. On account of my role and expertise I have been drawn into a large number of different meetings over the course of the pandemic, and so am reliant upon the information in my outlook calendar to identify which meetings I was at. In some cases, invites have been subsequently removed when the meeting series has been cancelled. In other cases, there may be meetings related to the groups below that occurred at other times that I haven't got any record of now, or which I might have missed when looking through my calendar. Hopefully, however, the list below should provide the background that you are looking for.

I asked Welsh Government to provide me with numbers of meetings attended from their records, but these have been provided to me and are incomplete. For example, of the 149 TAG meetings between January 2020 and May 2022 only 67 had attendance information. In a number of these cases the attendance information supplied by Welsh Government was incorrect – as evidenced by actions against my name from meetings, references to information (such as COG-UK reports) that I presented, or my participation/reference to participation in the sidebar, but where I am not listed as having attended the meeting in the meeting notes.

Therefore, I have opted to provide information that is approximate and based on my own estimate/recollection, drawing on the information provided by Welsh Government wherever possible, to provide an indication of the scale of my attendance and timescales over which the attendance occurred. If this is an issue, please let me know, but hopefully the information below should provide the context you need.

- I. TAG (originally called TAC when I was first invited)
 - a. I was invited by email following a conversation with Rob Orford (email invite received on 23rd March 2020).
 - i. Initial meeting frequency of 3 times per week, dropping to 2 times per week and then less frequently towards the end of the pandemic
 - b. Welsh Government did not record attendance at all TAG meetings in this time period. Of those where attendance was recorded, and following my invite to TAG, I attended at least 80% of meetings. although there are definitely cases where the attendance recorded in meetings isn't accurate. There were 149 TAG meetings in the period, and, based on the information provided by Welsh Government, reading over meeting notes and my own recollection, I would estimate that I attended 110-130 of those meetings.

- c. I believe I was present based on my expertise in bioinformatics/pathogen genomics/genomic epidemiology, my position within COG-UK and based on the fact I was leading the SARS-CoV-2 sequencing effort in Wales. This involved being an active participant in discussions, commenting on/offering edits to papers and providing updates/information/analysis based on the genomic data we (and others) were generating.
 - II. TAG Environmental subgroup
 - a. I joined the TAG Environmental subgroup on 14/10/2020
 - b. Welsh Government records place my attendance at 8 meetings in total, with 7 of those occurring between October 2020 and the end of January 2021, on a bimonthly basis. There may have been a few other occasions where I attended the group and my attendance wasn't noted, but my main engagement was in this time period.
 - c. I was present based on my expertise in genomics/genomic epidemiology and role within COG-UK and PHW, to contribute in a similar way to the main TAG group.
 - III. VT-TAG
 - a. I joined the TAG viral testing subgroup on 18/6/2020
 - b. I estimate, based on my recollection and records supplied by Welsh Government that I attended 22-26 of the ~35 VT-TAG/VT-TAG related meetings that took place between 18/6/2020 and 28/4/22
 - c. I was present based on my clinical pathogen genomics, bioinformatics and population genomics expertise. My role was similar to the main TAG group, although as the group was smaller and more focused, my expertise was more consistently required than in the main TAG.
 - IV. Policy modelling subgroup
 - a. I was originally invited to a meeting that came out of discussions in TAG on the 1st of May 2020 by Craiger Solomons and was then subsequently invited to meetings of the subgroup, when that was then established.
 - b. My engagement was greatest during 2020, with my attendance falling as the meeting became more focused on modelling/classical epidemiology. I would estimate I attended a total of 15-25 meetings as part of this group/related to this group, with the vast majority of these occurring between May 2020 and the end of January 2021.
 - c. I believe I was present based on my expertise in bioinformatics/pathogen genomics/genomic epidemiology. Early on, we certainly provided information derived from genomic data to help inform some of the model development/parameterisation. As this type of information started to become available through the UKHSA VTG, our involvement reduced.
 - V. TAG Children and Schools
 - a. I don't have records of this (because of diary invites being cancelled), but recall that I may have attended a small number of meetings of this group in the first half of 2020
 - b. I think I attended less than 5 of the meetings of this subgroup, although Welsh Government informed me they don't have records of the earliest meetings of this group.
 - c. I believe I was initially invited in case genomics could be of use in discussions of this subgroup, and there was certainly email correspondence in late 2020 around any genomics on Schools data (there wasn't any), although my expertise wasn't really needed, and I didn't attend these meetings regularly.

In addition, I was involved in other groups that have some role in providing advice in various places, all of which had outputs that would feed through to Welsh Government in some form/way. I have tried to summarise the ones below that are directly relevant to TAG / Welsh Government advice:

- VI. Welsh Government VAMC oversight group
 - a. Looking at my outlook calendar, the first meeting I was invited to was on the 10th of February 2021.
 - b. The meetings began at a frequency of once every week, before dropping to a rate of one meeting every two weeks. I attended most of the meetings held by the group, would estimate that this would be in the range of 20-30 meetings in the indicated period.
 - c. My role was to provide advice/expertise with respect to the genomics of SARS-CoV-2 and to provide information/advice in relation to SARS-CoV-2 variants.

- VII. Invited to a couple of SAGE Transmission subgroup meetings
 - a. I was nominated to join the group by Sharon Peacock on 30/11/2020 to ensure COG-UK representation. It then took quite some time to receive invites to join the group,
 - b. I attended less than 5 meetings.
 - c. I was invited based on my role/membership of COG-UK. I believe my role would have been to provide advice, with respect to genomic data on transmission.

- VIII. COG-UK analysis team/team responsible for generating COG-UK notes
 - a. I was a founding member of the group, in March 2020
 - b. I attended most of the weekly meetings from March to September/October 2020, and then subsequent meetings through to May 2021, which were more intermittent. I would estimate that there were at least 20 of these meetings that I attended.
 - c. I helped write reports, identify possible questions, discuss results, generate data and undertake analysis for COG-UK, which were then shared with SAGE and TAG (amongst others). I also provided a route between COG-UK and TAG.

- IX. COG-UK steering group
 - a. I was a founding member of the group in March 2020
 - b. I attended most of the monthly meetings through March 2020 – June 2021, I would estimate that there were 10-12 in total, allowing for holiday breaks etc.
 - c. As part of the steering group, we were collectively responsible for the management of COG-UK. I also had a specific responsibility to provide representation for Wales in COG-UK.

- X. UKHSA Variant Technical Group (originally the 'technical coordination meeting for new variants) and Horizon Scanning Group
 - a. I was invited to join, growing out of COG-UK and early work on the Alpha variant – first meeting in my outlook calendar was on the 4th of January 2021
 - b. I attended most of the meetings from its inception in 2021 through to the end of the specified time period. Initially the meeting was twice a week, dropping to once a week later.
 - c. I was present to contribute to discussions relating to variants, including offering my opinion/being involved in decision making on whether to classify variants as 'of concern' or 'of interest' based upon risk assessments of the available data.
 - i. I was present in the Horizon Scanning group to help join up horizon scanning activities across the UK, answer questions/look into questions relating to Welsh cases and provide a Welsh perspective. I ultimately handed this work

off to a member of my PHW team. This group wasn't about 'advice' per-se but does feed into the activities of the main VTG. The first Horizon Scanning meeting in my diary looks to be on the 22nd of January 2021.

- XI. UK 4 Nations COVID-19 Genomics Strategic Advisory Board
- a. I was invited to join by email on 14/12/2020, following a discussion with staff working for Professor Yvonne Doyle.
 - b. I attended all of the main advisory board meetings held in the specified time period. Meetings were monthly. I also attended working group meetings related to bioinformatics/data (which I co-chaired) taking place on a weekly/fortnightly basis when there was work to perform.
 - c. I was present to help represent PHW/Welsh SARS-CoV-2 genomics activity, expertise and experience. I believe my name may have been passed to UKHSA (PHE as was at the time) by Welsh Government.

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

- I. So, I just wanted to highlight an issue with the premise of this question. As I understand it, TAG was the group of experts that put together advice based on the consensus of discussion between TAG members. So, I don't think that, as a member, I was advising TAG. I was participating in TAG, and from that, TAG as a group was developing advice.
- II. Also, it was my understanding that there was a difference between TAC (the technical advisory cell) which was made up of staff/advisors from Welsh Government and TAG (the technical advisory group) which was comprised of invited experts. The question above appears to be treating TAG as a 'Welsh SAGE', but I don't think this is quite right, and so it is probably worth thinking about TAG was doing specifically, and how it was different to something like SAGE.
- III. With respect to the specific question, I contributed to numerous documents over the course of the pandemic. Most of these contributions were edits/comments/suggestions as part of the writing process, or contributions during discussions which then informed the ultimate document. These were generally linked to my specialist area, and as TAG documents were often quite broad, this means most of my contributions would be small, in terms of the overall word-count of the documents generated. The documents with comments were generally emailed to the TAC shared email inbox, and so there should be a record of my edits/involvement in documents within Welsh Government.
- IV. The documents generated by TAG were themselves intended to be consensus reports that reflected the opinions/expertise of the wider group, rather than one particular individual, so I would push back slightly on the premise of the question which could be taken to imply some sort of 'ownership' of particular documents. I don't think that this view reflects the way that TAG functioned, although there are certainly documents that I helped to pull together or wrote/contributed significant portions of. I think the key documents where I played a major role (there may be others – but these are the key ones I recall/know were published or specifically considered) would be:
 - a. Genomic insights paper: <https://www.gov.wales/sars-cov-2-genomic-insights-cover-statement-html>
 - b. Guidance for assessing new technologies for testing paper: <https://www.gov.wales/sites/default/files/publications/2020-10/technical-advisory-group-guidance-for-assessing-the-potential-for-new-technologies-to-improve-sars-cov-2-diagnostic-testing.pdf>
 - c. Places of worship evidence paper (for TAG-E) <https://www.gov.wales/sites/default/files/publications/2021-04/technical-advisory-group-covid-19-evidence-associated-with-transmission-and-potential-risks-associated-with-religious-activities-and-places-of-worship.pdf>
 - d. Variant technical brief https://www.gov.wales/sites/default/files/publications/2020-12/technical-brief-viral-variant-voc-20201201-23-december-2020_0.pdf
 - e. Delta technical brief <https://www.gov.wales/sites/default/files/publications/2021-05/technical-advisory-group-briefing-on-variant-of-concern-b.1.617.2.pdf>
 - f. UK Strategic advisory board paper – Digital building blocks for a federated pathogen genomics infrastructure in UK Public Health
 - g. UK Strategic advisory board paper - 4 Nations Pillar 2 data flows and data sharing
 - h. UK Strategic advisory board paper - Principles for development of pathogen genomics data integration and shared data processing and analysis
 - i. UK Strategic advisory board presentation – The Welsh Experience / PenGU journey

- V. In addition to documents that came out of TAG and were written by the group, there were pieces of summary information/reports/analysis that were presented during meetings. In my case, these fall into two major categories
- a. Outputs from COG-UK and my 'research' activities
 - b. Summaries/situation reports on the genomic data that were relevant to specific questions/issues at the time
- VI. All of the COG-UK outputs are public (<https://www.cogconsortium.uk/about/archive/>), as are all of our published papers (<https://scholar.google.com/citations?user=eTKwJysAAAAJ&hl=en>). I had major roles in COG-UK reports, including:
- a. Led the analysis/report on nosocomial transmission summarised in COG-UK report 2 (submitted on the 1st of April - these results were also communicated to members of Sage for discussion at the previous meeting)
 - b. Led the analysis on increased transmissibility of the D614G mutation (summarised in COG-UK report 6, submitted on the 14th of May, presented at TAG)
 - c. Led Two analyses, one focused on D614G and the other on hospital/community transmission (summarised in COG-UK report 9, submitted on the 25th of June, presented at TAG)
 - d. Co-authored a report on reinfection (considered at SAGE 55, shared with TAG)
 - e. Led the analysis examining imports into Wales from the UK and abroad (submitted to SAGE in November 2020, original version published by WG: <https://www.gov.wales/sars-cov-2-genomic-insights-cover-statement-html>)
 - f. Contributed to analysis in COG-UK report 11, submitted on the 8th of September (presented at/shared with TAG).
 - g. Contributed to an analysis of the genomic epidemiology of SARS-CoV-2 in the UK (summarised in COG-UK report 7, submitted on the 28th of May, shared with TAG)
 - h. Contributed to the importation analysis summarised in COG-UK report 8, submitted on the 11th of June (shared with TAG/presented at TAG).
- VII. I also contributed to a ECDC rapid risk assessment and threat assessment which would have fed through to TAG. These are online on the ECDC website. (<https://www.ecdc.europa.eu/sites/default/files/documents/COVID-19-risk-related-to-spread-of-new-SARS-CoV-2-variants-EU-EEA.pdf>, <https://www.ecdc.europa.eu/en/publications-data/threat-assessment-brief-rapid-increase-sars-cov-2-variant-united-kingdom>)
- VIII. The summaries/situation reports I provided to TAG are not public to my knowledge; however, they were provided to TAG, and should be stored on the TAG Objective Connect. There are also document(s) that I know that I contributed to, but which I am not sure went anywhere. Some of those document(s) may well have been cannibalised for summary documents by TAC/TAG, although I wouldn't know which ones those are.

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 Welsh Government's response to the Covid-19 pandemic. Please include links to those documents where publicly available.

- I. I can't recollect having written any articles or documents that directly comment on/critique the Welsh Government response.
- II. Over the course of the pandemic, I tweeted messages that related to the sequencing/genomic effort in Wales and in relation to aspects such as data sharing (<https://twitter.com/tomrconnor?lang=en>). I suspect my tweets are probably out of scope of the question, but for the sake of completeness, I am mentioning it here.
- III. I have also given public/academic lectures (virtually to an open event in Russia and another in Bahrain, both organised by the FCO, and to virtual events in the UK) that talk about the UK response with respect to sequencing and the way that sequence data has been used in Wales and the UK. (<https://www.youtube.com/watch?v=awaDIQDni5U> for my talk in Russia, from email exchanges with the FCO in Bahrain, the UK-Bahrain Covid-19 Phylogenetic Analysis Webinar was recorded, but I don't have a copy).
- IV. The COG-UK reports (<https://www.cogconsortium.uk/about/archive/sage-reports/>) mentioned above were publicly released and some of them contain information that relates to the Welsh Government response.
- V. I did some comms (recorded and released by Welsh Government -) and media work (interviews with the BBC (Radio and TV), C4, ITV, interview with Tom Whipple from The Times) in relation to the sequencing effort in Wales in 2020 (<https://www.bbc.co.uk/news/uk-wales-53579785>, <https://www.bbc.co.uk/news/uk-wales-56029034>), and did some media engagement via the science media centre in late 2020/2021 in relation to new variants (e.g. <https://www.bbc.co.uk/news/health-55413666> - I don't have a record of all the places where this work popped up, although I recall being quoted in most of the national newspapers at one point).
- VI. A couple of the research papers that I was involved in could possibly be seen to relate to the Welsh Government's response to the pandemic, as they look at aspects such as establishment/evolution of variants (<https://www.sciencedirect.com/science/article/pii/S0092867420315373>) and/or travel and spread/transmission within the UK at various levels (<https://www.science.org/doi/full/10.1126/science.abf2946> or <https://www.nature.com/articles/s41586-022-05200-3>) although I don't think that those papers actually comment on the response – they are focused on examining the data to understand what the virus was doing. Some of our work in healthcare settings identifies where the use of genomics has been beneficial, but I think this would be tangential to the specific question (e.g. https://scholar.google.com/citations?view_op=view_citation&hl=en&user=eTKwJysAAAAJ&sortby=pubdate&citation_for_view=eTKwJysAAAAJ:uJ-U7cs_P_OC or https://scholar.google.com/citations?view_op=view_citation&hl=en&user=eTKwJysAAAAJ&sortby=pubdate&citation_for_view=eTKwJysAAAAJ:evX43VCCuoAC)

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

- i. I want to highlight that early on in the process TAC/TAG agreed that we would operate under Chatham house rules. I think this was hugely important to understand. In a rapidly changing environment, scientists in particular are being asked to provide opinions based on incomplete information. There is also contentious information that has to be discussed and debated before a consensus is reached. Keeping the discussion 'in the room' and focusing on reaching a consensus position amongst the experts I think was really helpful in delivering advice to government, that had also been scrutinised. People feeling free to share their views was very important and a real strength of the process in Wales. From this, I think that the Inquiry needs to consider the risk that in future, if scientists/advisors feel that they are going to be judged later on with respect to advice/discussion provided in good faith during a pandemic, then this could have a chilling effect on future advice. This is especially true/important given the treatment of scientists on twitter and in other public spaces, where they are attacked for their views by those who disagree.
- ii. I think as part of this, it is also important to understand the scientific process, and that in order to provide rapid advice in real time, you have to push scientists (who are used to working studiously, generating solid evidence over a long period of time) to provide advice/interpretation/analysis quickly. That situation means that advice and opinions will need to change as the data changes. That is fine, and to be expected – but one thing to note is that any judgement on the rightness or wrongness of positions at a given point in time is also likely to be unhelpful.
- iii. I think it is also worth noting that the political and public health aims changed over the course of the pandemic, and I think you need to split that from the aim of the advisory groups which is simply to advise. My feeling is that the groups worked well to sift and integrate information, and that group members worked very well to produce Wales-specific outputs that were useful and timely. I also think the transparency of the groups in Wales was a real strength.
- iv. I also feel it is important to note that these are my feelings/perceptions, and those are obviously influenced by the pressure and intensity of the diverse work I was specifically delivering, and so some of how I feel is likely to be coloured by my. I appreciate and respect the enormous contributions from colleagues across the pandemic response, all of whom were working in uncharted waters, under immense pressure and scrutiny. Whatever the outcome of the inquiry I would hope that a key finding is that we are very lucky to have so many dedicated and hard working individuals who collectively came together to do their best in the face of a situation that is unprecedented in living memory. We may well be able to do things better next time – and indeed, I hope we learn the lessons that are there to be learnt – but overall, I think the response that was mounted was a remarkable achievement, delivered by a huge number of quietly brilliant people.

Overall, I felt that in TAG specifically, we had a large group of diverse individuals with very different areas of expertise and experience. I think TAG came together very well to work collectively to do what was asked of it in support of the pandemic response. I think given the size and diversity of the team we worked remarkably well together, and I had the sense of working very much as a 'team Wales' to collectively deliver the best quality advice that we could.

1. The composition of the groups and/or their diversity of expertise;

- I. My feeling is that in Wales we benefited from a number of pre-existing networks and that the initial group (which was reasonably public health heavy) was pretty effective early on, when the focus was very operational and on understanding what was happening in Wales. There were clearly a number of gaps, but I feel that these were largely filled as the pandemic developed, and by the end TAG had a significant membership with expertise covering the key areas.
 - a. One thing to note, which was a potential issue is that there were a small number of experts covering each area – I certainly felt pressure to attend TAG, to ensure genomics expertise was on hand, for example.
- II. Overall, I think the group was grown effectively, with the TAC team identifying the key expertise that was required and drawing in experts from inside and outside Wales. The group, while clearly being ‘invite only’ didn’t feel to me to be massively ‘exclusive’ and it felt to me as if when expertise was needed, it was found/added.
- III. In some cases, it was harder to get engagement, and in some groups (e.g., TAG-E) I think there was definite frustration around the fact there were important research questions to answer/evidence to generate, but there was no way to make this happen. The challenge in that case wasn’t the experience in the groups/their composition, it was more that these were groups that were advising on science, but the research hadn’t been done yet – and needed to be done.
- IV. I also think it is important to note that the scope of the group, certainly at the start, was, to my understanding, different to something like SAGE. Certainly, early on and at least part of the remit was to look at advice and evidence from places like SAGE and examine them/interpret them in a Welsh-specific way. In that sense, one possible weakness of the group (in that there are a small number of experts covering each area in TAG) is not such an issue, as the group was working off advice/evidence/information from elsewhere in many situations.

2. *The way in which the groups were commissioned to work on the relevant issues;*

- I. I felt as if one specific issue was the formulation of questions for TAG. I remember thinking on occasion the asking of questions was a problem, simply because the questions seemed to be asked by people who didn’t fully understand the biology they were asking about. In particular, when we were thinking about the evolution of variants and forecasting, I remember feeling as though some of the questions that were coming to us to answer weren’t the correct ones, although those areas are highly technical and complex. I think this points at a possible question in relation to commissioning, which in TAG, I felt was quite often based on questions from government, things that came up in discussion, or things that came out of other groups and there was a question of what the ‘Welsh’ dimension might be. Those may well be appropriate (and they certainly make sense to me when thinking about my understanding of the original objectives of the group), but I think it would be worth re-evaluating this, to make sure that things weren’t being missed, through a greater use of experts to proactively identify issues that needed to be dealt with, beyond the topics that were already being discussed.
- II. I also felt that at times there was, on occasion, a lack of coordination; with the same question being asked by multiple people from different places. I think this was more of a problem from individuals in Welsh Government seeking answers from different people/colleagues in PHW, particularly with respect to new variants etc, but in terms of ‘advice’ and TAG, I think this also relates to structure, and where/how advice is sought and where it comes from.

- III. I also felt that there was a clear challenge in the way that things were done, with government staff asking for advice, without having a clear understanding of what was possible, or the time to deliver the answer to their questions.
 - a. For specific examples of this - I remember discussions relating to analyses on the 5-mile rule in Wales with TAG in 2020 which were very research intensive/highly technical questions requiring both specialised expertise and significant amounts of computational resources to analyse. I remember the pressure in relation to pulling the 'genomic insights' paper together – which was only achievable because we were already working on research questions in that area. I also remember the short timescales pressure to look at questions such as imports when Delta began to spread in Wales, to generate analyses/information to inform TAG.
- IV. In addition, there were times when it felt to me as if the questions that were being asked weren't necessarily the right questions at that particular time. The process of commissioning questions seemed to have several possible starting points (e.g., suggestions from the group/out of discussions, questions from ministers, questions from advisors, advice/questions asked in other groups), which is understandable, but sometimes meant that valuable context was missing. Having access to papers (e.g. from SAGE) was helpful in this respect, but, particularly where a question had a genesis in a different advisory group elsewhere in the UK, I think it would have been very useful for those groups to have contained multiple (scientific/clinical) representatives who also sat on TAG to ensure that things weren't lost in translation – or to enable the process of analysing data to be kicked off more quickly. I suspect there are a number of semi-documented examples of this in the TAG papers, but a good example from early in the pandemic were the questions around modelling/forecasting (out of SPI-M/SAGE) which initially we couldn't answer in Wales partly resulted in the development of the policy modelling subgroup in Wales.
- V. Lastly, I think it important to highlight the work done by members of TAG, who were also having to deliver work operationally/in other areas at the same time as generating results/data to provide advice. There were times where there were a lot of questions etc in flight, and there didn't seem to be brilliant coordination across the different groups to manage the asks of experts.

3. The resources and support that were available;

- I. Overall, I was involved in quite a number of different groups, as well as performing my day-job (running the PHW Genomics Bioinformatics team, running the SARS-CoV-2 genomics in Wales etc). So, to me, at times support felt quite limited, the structure was setup to provide information to Welsh Government, I don't think it was especially brilliant for supporting members of the group. Throughout the pandemic my day job was intense, and while I managed to do it, I don't feel there were particular mechanisms to support me directly in providing advice. Providing advice as part of TAG and the other groups I was involved in meant lots of very short deadlines, and late nights, short turnarounds for comments on documents - all in addition to long hours elsewhere. It also required lots of analysis to be done – including redeploying people in my research group to do it, which in turn has had an impact on my research itself, which I think was never satisfactorily handled. The pandemic response was both the hardest and most rewarding thing that I have done in my professional career, and while I wouldn't change my involvement or effort, I think it is important to think about how experts are supported, and the potential for a small number of experts, spread across multiple groups, to be overwhelmed by asks from different sources.
- II. There were a number of occasions where I felt as though I was under a significant amount of pressure to bring together a report or document while other things were going on (e.g.,

being asked to finish putting together the places of worship paper so it could be sorted before Christmas in 2020 – while I was spending most waking moment working on the Alpha variant), and this sometimes felt a little de-humanising, with limited understanding/acknowledgement of the other work going on that was also of a high priority. There were also times when it felt as if government was almost ‘addicted to data’, and the machinery of government forgot that at the end of the reports, analysis and visualisations were a small group of people who had worked at a very high intensity for some time.

- III. There were some items of advice or outputs that generated negative responses from politicians/the press/the public. I think that the support in those situations was quite limited/there was no real playbook for how to handle that sort of situation. I think that previously, there was advice given that the membership of groups like SAGE shouldn’t be public, on account of the risk to members, which was/is clearly not a tenable situation. I think with respect to members of the public targeting members of the group, TAG generally got away without too much nastiness – certainly compared to colleagues on SAGE, but it was always a worry for me. On the political side, I was certainly caught up in a political response to the ‘genomics insight’ paper. The leader of the Welsh Conservatives described the report as ‘back of fag packet evidence’ (<https://www.walesonline.co.uk/news/politics/evidence-science-data-coronavirus-travel-19102724>) and it was suggested that there was ‘negative briefing from number 10’ in relation to the paper we had put together. Going forward I think that there needs to be better protection for scientists who advise government, especially those who are not part of the civil service/government machinery itself. The primary focus with respect to advisory groups to government in a pandemic should be ensuring that the best quality advice is available, and that advisors are free to speak what they believe the truth to be. While debate and discussion are to be expected and welcomed in a democratic society that values free speech, it also has to be understood that this should not be a licence to play the man, and not the ball as it were. Further, I think at times there was clearly not an option for free debate. I was certainly never contacted by any of the people who commented on our genomic insights paper, for example, to discuss our findings to actually understand it or engage with the substance of the analyses.

4. The advice given and/or recommendations that were made;

- I. I think in general the advice that was given in my area (can’t really comment outside of my expertise) made sense at the time and was consistent with the science/data that was available. My recollection of advice that was provided in my area was that there was a significant amount of discussion, both in meetings and by email, and by and large, I felt the group worked well together to deliver useful advice.

5. The extent to which the groups worked effectively together; and

- I. So, I think that the TAG and its subgroups generally worked effectively together. There were a number of members who sat across multiple groups, and I felt that the TAC/Welsh Government team did a good job joining the groups together
- II. I think there was more of a challenge in relation to some of the other groups that popped up. It was never wholly clear to me where the COG-UK group sat – I recall there being suggestions at one point that COG-UK would be classified as a SAGE subgroup, and I think the lack of clear structure in who reported to whom (and who could ask questions of whom) probably hindered the effectiveness of some of the groups working with others. In the case of COG-UK, I provided the link to TAG (sharing COG-UK reports with TAG); however, this was a single point of failure, and in future a lesson might be to have a clearer (published) governance structure enshrined for advisory group ‘air traffic control’.

6. *The extent to which applicable structures and policies were utilised and/or complied with and their effectiveness.*

- I. I don't actually understand the premise of this question; I don't have a complete picture of the various routes by which advice was provided to Welsh Government, and so can't really comment on this. I think the way in which the groups I was part of were used made a lot of sense – in that they were asked to respond to questions, synthesise advice etc in response to what was happening, and there were also cases where the future was considered, and advice sought for planning. In that sense, I think (especially in 2020/2021) they were well used, and they produced a range of valuable outputs. I think there is a challenge when one looks back – in the sense that it is difficult to look back through the lens of what we know now, without putting aside current knowledge. From a biological perspective we went, in a couple of years from a pathogen that we knew nothing about in early 2020 to a level of knowledge that exceeded the knowledge of something like Influenza, which has been intensively researched for more than 50 years. The pace of research, generation of understanding, synthesis of that information and generation of advice to government through the pandemic is, in my view, unprecedented. We may be able to do better next time, but I don't think that should detract from the fact that what we have seen from a research perspective has been incredible.

7. Your views as to any lessons that can be learned from the Welsh Government'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.

I will focus on TAG for the purposes of this response, as I have a few reflections with respect to the specific question of TAG. I think these reflections may be more useful than any specific ideas I might have – as I am an expert in the area of pathogen genomics/bioinformatics, rather than governance and the provision of advice. Hopefully these will be of some use and will help inform some of the work and recommendations of the inquiry.

Reflections and ideas for the future:

- i. Provision of advice
 - a. TAC/TAG was bought together quite rapidly and grew in an organic way. I think it would be great to both have a clear structure in place in future, and, in the area of health security, it may even be worth having a standing group that provides advice during 'normal' times and then can be expanded during times such as pandemics.
- ii. Expertise within the civil service
 - a. I interacted with quite a number of civil servants through the pandemic, and while they were all dedicated and hardworking, there were certainly cases where civil servants without a science background picked up on stories/information on twitter and the media. I felt a little as if it would be helpful for more civil servants to have science training/background to be able to evaluate information in a more scientific/critically informed way.
- iii. Thought about the split between advice and policy
 - a. One of the biggest challenges was, I think, that in a pandemic situation advice and policy are closely aligned – and it is easy for advice to drift into policy. There is a real challenge in balancing where advice stops and policy begins, especially when we are in uncharted waters, and an unprecedented situation. Where there is no clear play book on what to do, from a policy perspective, there is a risk that advice is taken and turned into policy rapidly. I think it will be important to understand how we can do this better in future. Advice being closer to policy may not be a bad thing, but with that comes responsibility, and I think we, as a society, need to think about that carefully. It is especially important to understand the perspective of people providing advice, and to think about balance in how that advice is generated. I don't have a solution to this but suspect that the inquiry is an opportunity to identify best practice and recommendations covering this in the future.
- iv. Group got quite big towards the end; think structure is important
 - a. TAC/TAG started off small and then grew significantly over time. I think one of the challenges is around the structure; clearly there are many lines of work/enquiry going on, and my feeling is that perhaps what is needed in future is a clearer structure of multiple subgroups that feed into a more central strategic/air traffic control group for advice. I think this began to happen towards the end of the pandemic, but it is something that needs to be thought about carefully.
- v. Transparency of advice and analysis
 - a. I think that TAG was very good at sharing its advice and being transparent with what the group was passing on to government. I think this should be codified and built upon; I took part in a number of media briefings, but think it is worth thinking about the ways in which a group like TAG can engage more widely so that the public and patients are aware of what is going on. Specific additional support in terms of

- scientific comms and engagement would be a capability that would be worth developing
- vi. How research is commissioned / how researchers are engaged over the longer term
 - a. TAG had limited ability to commission its own research, while things like the national core studies were initiated in England but covered the UK. It would be good, in the future, for similar initiatives to join up the advisory groups across the UK to ensure that local needs/questions are covered.
 - vii. Seeing outputs from advice, understanding why advice is or is not taken
 - a. Having provided advice to Welsh Government, and interacted with civil servants, on a personal level I think it would be nice to be able to understand the role our advice has played in the pandemic response, and also, in some circumstances, to understand how our advice has been taken. At points, it did feel like we were feeding data and advice into a massive governmental machine, without necessarily seeing where that was going, or how it was helping to move things forward.
 - viii. Support for members who may be attacked for political or other similar reasons
 - a. This wasn't such an issue in TAG, but I have seen cases of experts being attacked online for political or other similar reasons. I think a solution is needed covering both abuse from members of the public, and from politicians punching down at (paid or unpaid) experts who have said something they disagree with.
 - ix. How analysis capacity is resourced, and the process of requesting analysis
 - a. We undertook a number of analyses on request from TAG, and this was manageable because we had staff (research and PHW) who were funded for research that we could retask. I still don't think there was a proper process for supporting researchers who made use of (fixed term contract) researcher time to support the pandemic response, especially where the funding for these staff came from charitable sources. My research group certainly took a hit in terms of undertaking research/analysis in response to needs in Wales, as we didn't receive funding to replace that we had used when we retasked staff. This has had a longer-term impact in terms of our ability to go out and win new research funds, while my focus, working solidly on COVID, meant I simply didn't have the time/space to put together research grants – which is now impacting my research post-pandemic.
 - x. Intensity of effort and support for members
 - a. I served on TAG throughout the pandemic, and at times it contributed a significant additional workload for me. This had real effects on my own mental health, and I often felt that attendance was expected/required because of my area of activity and the fact there were a limited number of other experts in my area on the group. I would expect that other colleagues – such as those in PHW – may also have felt similar pressures, which are manageable over a few months, but are problematic when exerted over 2-3 years. I think the management and support for members of the group should be thought about in future, and specific measures put in place to help protect the health of experts who are contributing to TAG while also running parts of the pandemic response. It is also worth noting that in preparing this response I asked Welsh Government for information they held on my attendance at TAG. The fact that in most cases (82/149 meetings, according to the information supplied to me), attendance wasn't recorded, and in some cases where attendance was recorded, it wasn't recorded correctly is also not ideal, and points towards an impression that TAG itself did not 'look after' its people as well as it could have done. In some ways I wish I hadn't asked – as it actually makes me feel as though my time/contribution was under-appreciated/not recognised, despite TAG being a major draw on my time over the past three years.
 - xi. Better understanding of the scientific process and consideration of roles of key actors

- a. More generally, I think there is a challenge in the area of advice and evidence generation, in the sense that as the data changes, results change, and interpretation changes. That is science – and I make a similar point around judging rightness or wrongness of advice above, in an answer to a previous question. A key reflection going forward is how science feeds into advice, and what is the process for digesting, critically evaluating ‘science’ that exists (in un-peer reviewed and peer reviewed formats) to synthesise that information into advice. To my mind, advice requires critical thinking and evaluation, and that applies whatever the input material. As part of this, I think that there is probably a better level of understanding of the scientific process required more generally, and I think we probably also need to think carefully about what we want from advice and advisors, and if that is the same as what we want from researchers who are asked to generate evidence. I think you can have people who generate evidence and provide advice; but I also think you will have people who provide advice, but don’t generate evidence, and those who generate evidence, but are not suited to provide advice. I don’t think we really make that distinction explicitly or think about the skills/training/experience required for the different roles. I think considering this and baking it into advice generating structures would be helpful for the future. On the same point, I feel as though we have a conveyor belt for producing researchers, but I am not sure that we have as reliable a system for producing advisors who are able to critically evaluate the evidence and then provide clear advice that is understandable to policy makers. I think that is probably a need that should be thought about, given the scale and variety of advice that was required as part of the pandemic response.

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 don't hold any hard copies of documentation – everything would be in digital format.
- As far as I am aware, the vast majority of the documentation I hold or have access to that relates to these matters would be versions of documents shared via email (e.g., with comments, edits) or discussions that took place by email. Most of the documentation that specifically relates to TAG will have been copied into the TAG mailbox or the relevant secretariat for the other non-Welsh groups.
- Some of the documentation relating to some of the groups mentioned (e.g. COG-UK) is not held by me, but on shared systems (e.g. google drive) managed by others and editing of those documents was performed in those collaborative environments (COG-UK used a google drive managed by the University of Cambridge ; the UKHSA/PHE groups sometimes embedded documents into calendar invites, which may mean that they would have to be approached where these are overwritten). I don't think I myself hold local copies of many/most of those documents – other than the ones that I would have communicated onwards (e.g., COG-UK reports that I sent on to TAG, which are also public documents).
- I may have access to some relevant comments (effectively short message style communication between staff as they work) stored electronically within collaboration software (Slack, and possibly a google doc) in respect to certain analyses that my research team / PHW team undertook during the pandemic – I would have to search through the software to find anything that is specifically relevant/still stored. I expect that a lot of the information would be short comments which may not make sense without context, as they are generally task focused. It is also worth saying that these communications can also be discursive with detailed technical terms, and reflect the scientific process as different analyses were tried/refined/etc. Please note that these discussions are predominantly conversations between more junior staff members of the lab or PHW, and would not be complete because discussions were also taking place on calls/virtual group meetings/etc.