Response to UK COVID-19 Inquiry: Module 2 – Rule Request to Dr Trystan Leng

M2/SAGE/01/TL

This document is a response to the Request for Evidence under Rule 9 of the Inquiry Rules 2006 (Reference for Request - M2/SAGE/01/TL).

- A brief overview of my qualifications, career history, professional expertise and major publications is provided on **page 2.**
- A list of the groups in which I have been a participant, alongside the relevant time periods, is provided on **page 3**.
- An overview of my involvement with those groups between January 2020 and February 2022 is provided on **page 4**.
- A summary of any documents to which I contributed for the purpose of advising SAGE and/or its related subgroups on the COVID-19 pandemic is provided on **pages 5-7.**
- A summary of any articles I 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 is provided on **pages 8-10**
- My views as to whether the work of the above-mentioned groups in responding to the COVID-19 pandemic succeeded in its aims are provided on **page 11**.
- My views as to any lessons that can be learned from the UK's response to the COVID-19 pandemic are provided on **page 12**.
- A brief description of documentation relating to these matters that you hold (including soft copy material held electronically) is provided on **page 13**.

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

Qualifications:

- BSc honours degree (1st class) in Mathematics and Philosophy, University of Glasgow, 2011-2015
- MSc with distinction in Mathematics of Systems, University of Warwick, 2016-2017
- PhD in Mathematics of Systems, University of Warwick, 2017-2021

Career history:

- Postdoctoral Research Assistant, Zeeman Institute for Systems Biology and Infectious Disease Epidemiology Research, University of Warwick, January 2021 - April 2022
- Research Associate, Department for Infectious Disease Epidemiology, Imperial College London, May 2022 – present

Professional expertise:

My research focuses on the importance of including contact network structure in epidemiological models and designing models that incorporate appropriate levels of structure to answer questions for public health. During my PhD I considered a range of network approaches to modelling sexually transmitted infections. While a postdoctoral researcher at Warwick, my research focused on modelling SARS-CoV-2 transmission and interventions involving rapid testing in secondary schools. In my current role, my research focuses on modelling the potential impact of pre-exposure prophylaxis (PrEP) on HIV transmission among men who have sex with men (MSM).

Major publications:

- **Leng, T.,** Hill, E.M., Holmes, A., Southall, E., Thompson, R.N., Tildesley, M.J., Keeling, M.J. and Dyson, L., 2022. Quantifying pupil-to-pupil SARS-CoV-2 transmission and the impact of lateral flow testing in English secondary schools. *Nature communications*, 13(1), pp.1-11.
- **Leng, T.,** White, C., Hilton, J., Kucharski, A., Pellis, L., Stage, H., Davies, N.G., Keeling, M.J. and Flasche, S., 2020. The effectiveness of social bubbles as part of a COVID-19 lockdown exit strategy, a modelling study. *Wellcome Open Research,* 5(213), p.213.
- **Leng, T.** and Keeling, M.J., 2020. Improving pairwise approximations for network models with susceptible-infected-susceptible dynamics. *Journal of Theoretical Biology*, 500, p.110328.
- **Leng, T.** and Keeling, M.J., 2018. Concurrency of partnerships, consistency with data, and control of sexually transmitted infections. *Epidemics*, 25, pp.35-46.

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.*

I have been a participant for the Scientific Pandemic Influenza Group on Modelling (SPI-M-O). I attended SPI-M-O on two occasions, specifically on 03/03/21 and on 21/04/21. I contributed to work submitted to SPI-M-O from 06/05/2020 until 23/03/2022.

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.

   a. **When and how you came to be a participant;**
   I first contributed to SPI-M-O in May 2020, while a PhD student at University of Warwick. At this time, my research was focused on modelling the impact of social bubbles. I was invited to attend in March 2021, by the Principal Investigator of my research group (Professor Matt Keeling, University of Warwick). At this time, my research was focused on modelling the impact of secondary school control strategies on transmission and absences.

   b. **The number of meetings you attended, and your contributions to those meetings.**
   I attended two meetings in total, on 03/03/21 and on 21/4/21. For these meetings, I prepared documents explaining our modelling of secondary school control strategies. During these meetings, I briefly explained the key points from these documents, and did not contribute further to discussions during these meetings.

   c. **Your role in providing research, information and advice.**
   I performed scenario-based mathematical modelling of the potential impact of a) social bubbles on community transmission, and b) secondary school control strategies on within-school transmission and absences. I also assisted in collating weekly analyses of COVID-19 related absences in Primary and Secondary schools in England.

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.*

06/05/20	Potential Impact of Bubbles. Keeling & Leng	SPI-M
11/05/20	Short up-date on Modelling Bubbles. Flasche, Leng & Keeling	SPI-M
13/05/20	The effectiveness of extended social bubbles as a soft exit strategy from the COVID-19 lockdown. Leng, Keeling, Flasche	SPI-M SAGE 36
Summary. This body of work examines allowing additional social contacts through "bubbles". We note that clustering of additional contacts within a social bubble is a highly effective means of controlling the increase in *R* while allowing more contacts. Allowing all households to expand their social bubble may increase *R* above 1. However, some targeted approaches only generate a marginally increase in *R*, these include: Paring of single or dual occupancy households; pairing of households with primary school age children. Young children are at least risk and likely to benefit most from allowing close contact with peers because of their ineffective communication digitally or with a 2m distance. This was an early version of work published as: Leng, T., White, C., Hilton, J., Kucharski, A., Pellis, L., Stage, H., Davies, N., CMMID-Covid-19 WG, Keeling, M.J., Flasche, S. (2021) The effectiveness of social bubbles as part of a Covid-19 lockdown exit strategy, a modelling study. *Wellcome Open Res* **5**:213. https://doi.org/10.1268/wellcomeopenres.16164.2 SAGE link: https://www.gov.uk/government/publications/university-of-warwick-and-lshtm-the-effectiveness-of-extended-social-bubbles-as-a-soft-exit-strategy-from-the-covid-19-lockdown-13-may-2020		

27/01/21	Assessing the impact of secondary school reopening strategies on within-school transmission and absences: a modelling study. Leng, Hill, Thompson, Tildesley, Keeling & Dyson	SPI-M
03/03/21	The impact of uptake and adherence on transmission and absences resulting from secondary school reopening strategies involving rapid testing. Leng, Hill, Thompson, Tildesley, Keeling & Dyson	SPI-M SAGE 83
21/04/21	Exploring the impact of reopening secondary schools and the effect of mass testing. Leng, Hill, Stage, Klepac, Davis, Gog, Keeling, Tildesley, Dyson and members of the JUNIPER modelling consortium	SPI-M
11/08/21	Modelling within-school transmission in secondary schools in England in September 2021. Leng, Hill, Thompson, Dyson, Tildesley, Keeling	SPI-M
Summary. This body of work assesses the impact on transmission and absences resulting from school control strategies using lateral flow device tests (LFTs). - The first document quantifies the impact of reopening strategies assuming full uptake, finding that there is a trade-off between minimising infection and minimising school absence. - The second document quantifies the impact of uptake (pupils agreeing to participate in rapid testing), adherence (participating pupils actually taking tests at home), close contact group size, and transmission on within-school test days. We noted that mass testing, with isolation or serial contact testing, could result in high levels of absences – because more infections are detected.		

- The third document considers the impact of LFTs on within-school transmission in March, when models are calibrated to current levels of LFT uptake. We find that LFTs may have reduced infection within secondary schools and could be more effective at reducing transmission at higher levels of uptake.
- The fourth document considers within-school transmission upon secondary schools reopening in September 2021. We find that the level of immunity among secondary-school aged pupils at the start of term had a large impact on within-school epidemiological dynamics, demonstrating the importance of understanding the percentage of secondary school aged pupils who are immune to SARS-CoV-2 by the end of the summer holidays.

These were early versions of work published as:

1. Leng, T., Hill, E.M., Thompson, R.N., Tildesley, M.J., Keeling, M.J. and Dyson, L., 2022. Assessing the impact of lateral flow testing strategies on within-school SARS-CoV-2 transmission and absences: A modelling study. *PLOS Computational Biology*, *18*(5), p.e1010158. https://doi.org/10.1371/journal.pcbi.1010158
2. Leng, T., Hill, E.M., Holmes, A., Southall, E., Thompson, R.N., Tildesley, M.J., Keeling, M.J. and Dyson, L., 2022. Quantifying pupil-to-pupil SARS-CoV-2 transmission and the impact of lateral flow testing in English secondary schools. Nature communications, 13(1), pp.1-11. https://doi.org/10.1038/s41467-022-28731-9

SAGE link: https://www.gov.uk/government/publications/university-of-warwick-impact-of-uptake-and-adherence-on-transmission-and-absences-resulting-from-secondary-school-reopening-strategies-involving-rapi

08/09/21	Adherence to app-based notifications at 2 day and 5 day notification windows - Leng, Thompson, Tildesley	SPI-M

Summary. This document explores the effectiveness of app-based notifications at reducing transmission at 2-day and 5-day notification windows, reflecting the change made to the NHS app on 2/8/21 to reduce the number contacts asked to isolate through the app. We find that, assuming the same level of adherence to isolation for both window lengths, 5-day windows result in a greater reduction in transmission than 2-day windows. However, if 2-days windows are associated with higher levels of adherence to isolation, then they could lead to a greater reduction in transmission than longer windows.

This was an early version of work published as: Leng, T., Hill, E.M., Keeling, M.J., Tildesley, M.J. and Thompson, R.N., 2022. The effect of notification window length on the epidemiological impact of COVID-19 contact tracing mobile applications. *Communications medicine*, *2*(1), pp.1-7. https://doi.org/10.1038/s43856-022-00143-2

23/02/22	Reporting and information loss in education absences data - Leng, Dyson, Thompson, Hill, Keeling, Tildesley	SPI-M

Summary. This document explores trends in COVID-19 related school absence data, the impact of the data changing from a daily to a weekly data stream (which occurred on 7/3/22), and the potential impact of much lower levels of reporting from schools. We find that the proportion of schools submitting absences data had fallen through time, but that school-level absence data reported on a weekly basis remained informative of weekly pupil absences at the LTLA level.

From: 22/3/21 To: 23/3/22	Analysis of School Absences and Lateral Flow Test results following return of all pupils to school in England - Leng, Southall, Holmes. Dyson, Thompson, Hill, Keeling, Tildesley

Summary. An updated version of this document was submitted regularly to SPI-M-O from March 2021 to March 2022. These documents summarised trends in LFTs administered to children aged 10-19 years in England, and analysed school absences following the return of all pupils to schools in England during periods when schools were open.

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.*

Publications that I played a major role in:

First online: 17/06/2020 Published: 29/03/2021	Leng, T., White, C., Hilton, J., Kucharski, A., Pellis, L., Stage, H., Davies, N., CMMID-Covid-19 WG, Keeling, M.J., Flasche, S. (2021) "The effectiveness of social bubbles as part of a Covid-19 lockdown exit strategy, a modelling study" *Wellcome Open Res* **5**:213. https://doi.org/10.1268/wellcomeopenres.16164.2
Summary: Social bubbles have been proposed as a means of allowing extended contacts beyond the household while minimising the associated transmission risks. The concept is that members of one household are allowed to meet exclusively with members of one other household - while this increases the risk of transmission the premise is that the bubble remains relatively isolated. Our modelling work shows that social bubbles reduced cases and fatalities by 42% compared to an unclustered increase of contacts. Social bubbles may be extremely effective if targeted towards those small, isolated households with the greatest need for additional social interactions and support.	

First online: 16/07/2021 Published: 01/03/2022	Trystan Leng, Edward M Hill, Alex Holmes, Emma Southall, Robin N Thompson, Michael J Tildesley, Matt J Keeling, Louise Dyson. (2021) "Quantifying within-school SARS-CoV-2 transmission and the impact of lateral flow testing in secondary schools in England" *Nat Commun* **13**, 1106. https://doi.org/10.1038/s41467-022-28731-9
Summary: Here, we incorporated various data into the individual-based model of secondary schools in order to quantify SARS-CoV-2 transmission between secondary school pupils in England. We have used community swab testing data to inform community prevalence for schools according to their local area and to inform a school''s level of participation in lateral flow testing; we have used secondary school absences data to inform the size of group a school isolates upon identification of a positive case; and we have fitted this model to community swab testing data in 11-16 year olds and secondary school absences data. With this fitted model, we simulated outbreaks from 31st Aug 2020 - 21st May 2021 to quantify SARS-CoV-2 transmission in secondary schools in England. Doing so, we evaluated the impact of twice weekly lateral flow testing (LFT) of pupils on transmission, finding that twice weekly mass testing likely played an important role in controlling pupil-to-pupil transmission in secondary schools in England. We also considered the counterfactual impact of alternative strategies, finding that strategies involving mass testing have the potential to control within-school transmission while substantially reducing absences.	

First online: 09/11/2021 Published: 27/06/2022	Leng, T., Hill, E.M., Keeling, M.J., Tildesley, M.J. and Thompson R.N. (2022) "The effect of notification window length on the epidemiological impact of COVID-19 contact tracing mobile applications" *Communications Medicine* **2**:74. DOI: 10.1038/s43856-022-00143-2
Summary: The reduction in SARS-CoV-2 transmission from contact tracing applications (apps) depends both on the number of contacts notified and on the probability that those contacts quarantine after notification. Referring to the number of days preceding a positive test that contacts are notified as an app's *notification window*, we use an epidemiological model of SARS-	

CoV-2 transmission that captures the profile of infection to consider the trade-off between notification window length and active app-usage. We focus on 5-day and 2-day windows, the lengths used by the NHS COVID-19 app in England and Wales before and after 2nd August 2021, respectively. Short windows can be more effective at reducing transmission if they are associated with higher levels of active app usage and adherence to isolation upon notification, demonstrating the importance of understanding adherence to control measures when setting notification windows for COVID-19 apps.

First online: 21/02/2021 Published: 27/05/2022	Trystan Leng, Edward M Hill, Robin N Thompson, Michael J Tildesley, Matt J Keeling, Louise Dyson. (2022) "Assessing the impact of lateral flow testing strategies on within-school SARS-CoV-2 transmission and absences: A modelling study" *PLoS Comp. Biol.* **18**(5): e1010158. https://doi.org/10.1371/journal.pcbi.1010158
Summary: UK secondary schools have implemented a range of measures to control transmission within schools, including the isolation of close contacts of confirmed cases from September 2020 - July 2021, and twice weekly testing of staff and pupils since March 2021. We have developed an individual-based model to understand the impact of school control measures on pupil-to-pupil transmission, pupil absences and testing volume. Using an individual-based model of a secondary school implementing a bubbling strategy at the level of year-groups, and simulating infections over the course of a 7-week half-term, we evaluated a range of strategies with differing isolation and rapid test strategies. In particular, we found that a policy of daily contact testing resulted in a similar reduction in transmission to an isolation of year-groups policy, but markedly reduced absences.	

Publications that I played a minor role in:

First online: 11/05/2020 Published: 22/01/2021	Keeling, M. J., Hill, E., Gorsich, E., Penman, B., Guyver-Fletcher, G., Holmes, A., McKimm, H., Tamborrino, M., Dyson, L., and Tildesley, M. (2020). "Predictions of COVID-19 dynamics in the UK: short-term forecasting and analysis of potential exit strategies" *PLoS Comp. Biol.* **17**(1): e1008619. https://doi.org/10.1371/journal.pcbi.1008619
Summary: In this very early paper we develop the "Warwick model" for COVID-19 and consider how elements of quarantine and isolation can be included into the fundamental SIR-framework. From an applied perspective, we focus on potential exit strategies, such as different changes to the early lockdown restrictions, age-based easing of the lockdown and basing the lockdown on local ICU capacity. We conclude that any route out of lockdown that does not involve pharmaceutical interventions (such as vaccination) has to be very slow and measured.	

First online: 17/02/2021 Published: 07/06/2021	Emma Southall, Alex Holmes, Edward M. Hill, Benjamin D. Atkins, Trystan Leng, Robin N. Thompson, Louise Dyson, Matt J. Keeling, Michael J. Tildesley (2021) "An analysis of school absences in England during the Covid-19 pandemic" *BMC Medicine*, **19** (137). https://doi.org/10.1186/s12916-021-01990-x
Summary: This paper analysed data on pupil and staff absences due to confirmed COVID-19 infection during September-December 2020. During this early phase there is no significant evidence to suggest that schools are playing a substantial role in driving spread in the community. We conclude that careful monitoring was required as schools re-opened in 2021 to determine the effect upon community incidence.	

Media:

4/3/21	Plus Magazine Article – "Testing testing in schools" https://plus.maths.org/content/testing-testing-schools
27/4/21	Wellcome Open Research blog post: "Exiting lockdown– are social bubbles an effective strategy?" https://blog.wellcomeopenresearch.org/2021/04/27/exiting-lockdown-are-social-bubbles-an-effective-strategy/

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.*

SPI-M-O was comprised of researchers from a range of UK institutions, who used a range of approaches to answering modelling questions in line with their expertise/experience. In my opinion, this diversity (of institutions and modelling approaches) improved the effectiveness of SPI-M. As a group member, we were able to access the data required to produce modelling work relevant to the contemporary epidemiological situation. We had great support from the SPI-M-O secretariat throughout. In my personal experience, I found that different groups could work effectively together, and that collaborations between institutions could be facilitated through SPI-M-O (for example, the social bubbles work I was involved in also involved researchers from LSHTM and the University of Manchester).

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.*

At present, I have no strong views or keen insights on this matter.

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

I have copies of the documents outlined above, alongside the code of the models for the modelling work undertaken.