Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

guide the rational design of host-directed therapies that reduce the incidence of superspreading for those virus classes. As these drugs act on host pathways, they can be evaluated beforehand for safety and then tested for efficacy in the early stages of a novel outbreak. Furthermore, many factors relevant to individual infectiousness, including how case characteristics affect the viability of the shed virus and the distributions of expelled respiratory particles, remain unclear. How behaviour, environment, host, and virus interplay to affect transmission modes or infection risk is also unclear. As seen over the past year,[6,11] cross-disciplinary interaction among researchers is needed to best understand these myriad matters.

Research into this nascent topic uncovers epidemiologically relevant biological insight and might provide key considerations for public health. When *k* is small, few cases transmit but are more likely to be superspreaders, meaning epidemics are infrequent but explosive. Overdispersion increases the likelihood of disease extinction when case numbers are low, and control measures targeting high-risk settings or individuals disproportionally curb transmission.[1,15] These measures can be particularly effective when implemented early in an overdispersed outbreak, as reflected in areas that have eliminated COVID-19, but have diminished effects on outbreaks with more uniform transmission. Currently, however, there is no way to predict the transmission patterns of novel viruses. Contact-tracing studies empirically characterise *k*,[2–4] meaning considerable spread must have already occurred before its estimation. Broadly understanding the factors that mediate overdispersion, from virological to clinical and environmental, might provide early, predictive correlates for transmission patterns—including superspreading—before widespread infection by novel viruses. In this case, a playbook of control strategies, each specified by transmission patterns, can be developed to then specifically address outbreaks.

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1 Lloyd-Smith JO, Schreiber SJ, Kopp PE, Getz WM. Superspreading and the effect of individual variation on disease emergence. *Nature* 2005; **438:** 355–59.
2 Sun K, Wang W, Gao L, et al. Transmission heterogeneities, kinetics, and controllability of SARS-CoV-2. *Science* 2021; **371:** eabe2424.
3 Lau MSY, Grenfell B, Thomas M, Bryan M, Nelson K, Lopman B. Characterizing superspreading events and age-specific infectiousness of SARS-CoV-2 transmission in Georgia, USA. *Proc Natl Acad Sci USA* 2020; **117:** 22430–35.
4 Hasan A, Susanto H, Kasim MF, et al. Superspreading in early transmissions of COVID-19 in Indonesia. *Sci Rep* 2020; **10:** 22386.
5 Brugger J, Althaus CL. Transmission of and susceptibility to seasonal influenza in Switzerland from 2003 to 2015. *Epidemics* 2020; **30:** 100373.
6 Greenhalgh T, Jimenez JL, Prather KA, Tufekci Z, Fisman D, Schooley R. Ten scientific reasons in support of airborne transmission of SARS-CoV-2. *Lancet* 2021; **397:** 1603–05.
7 Cowling BJ, Ip DK, Fang VJ, et al. Aerosol transmission is an important mode of influenza A virus spread. *Nat Commun* 2013; **4:** 1935.
8 Ip DK, Lau LL, Leung NH, et al. Viral shedding and transmission potential of asymptomatic and paucisymptomatic influenza virus infections in the community. *Clin Infect Dis* 2017; **64:** 736–42.
9 Zhang SF, Tuo JL, Huang XB, et al. Epidemiology characteristics of human coronaviruses in patients with respiratory infection symptoms and phylogenetic analysis of HCoV-OC43 during 2010-2015 in Guangzhou. *PLoS One* 2018; **13:** e0191789.
10 Zhu Y, Chew KY, Karawita AC, et al. Pediatric nasal epithelial cells are less permissive to SARS-CoV-2 replication compared to adult cells. *bioRxiv* 2021; published online March 8. https://doi.org/10.1101/2021.03.08.434300 (preprint).
11 Chen PZ, Bobrovitz N, Premji Z, Koopmans M, Fisman DN, Gu FX. Heterogeneity in transmissibility and shedding SARS-CoV-2 via droplets and aerosols. *eLife* 2021; **10:** e65774.
12 Westerhuis BM, Aguilar-Bretones M, Raadsen MP, et al. Severe COVID-19 patients display a back boost of seasonal coronavirus-specific antibodies. *medRxiv* 2020; published online Oct 12. https://doi.org/10.1101/2020.10.10.20210070 (preprint).
13 Yan B, Freiwald T, Chauss D, et al. SARS-CoV-2 drives JAK1/2-dependent local complement hyperactivation. *Sci Immunol* 2021; **6:** eabg0833.
14 Wang R, Simoneau CR, Kulsuptrakul J, et al. Genetic screens identify host factors for SARS-CoV-2 and common cold coronaviruses. *Cell* 2020; **184:** 106–19.e14.
15 Endo A, Centre for the Mathematical Modelling of Infectious Diseases C-WG, Leclerc QJ, et al. Implication of backward contact tracing in the presence of overdispersed transmission in COVID-19 outbreaks. *Wellcome Open Res* 2021; **5:** 239.

Lessons about COVID-19 vaccine hesitancy among minority ethnic people in the UK

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According to data collected by Public Health England, in the UK, minority ethnic groups were between two and four times more likely to die due to COVID-19 compared with those from a White ethnic background.[1] These outcomes are independent of age, sex, or socioeconomic factors. Moreover, at the start of the

national vaccine rollout, routinely collected clinical data in England showed that Black people older than 80 years were only half as likely as White people to have been vaccinated against COVID-19.[2] A UK-wide survey of 12 035 participants investigating attitudes towards COVID-19 vaccination showed that Black and Black British respondents had the highest rate of vaccine hesitancy (71·8%), followed by Pakistani and Bangladeshi respondents (42·3%), compared with White British or Irish respondents (15·2%) who were not likely or very unlikely to take a vaccine.[3]

Since the start of the COVID-19 vaccine programme, we, as health researchers, have sought to engage with over 200 community organisations that provide religious or social support for minority ethnic groups to offer information about available vaccines, answer questions, and encourage dialogue. We met with groups on online meeting platforms during the third national lockdown to answer questions and discuss concerns. The reasons for vaccine hesitancy are complex, multifactorial, and vary according to age, sex, and ethnic group. However, two broad themes were apparent.

The first theme relates to historical marginalisation, and this gap appears to have widened during the pandemic. Distrust of government and public health bodies has arisen due to ongoing discrimination (cited earlier this year by the independent National Health Service Race Observatory Board), previous unethical research (eg, in US Tuskegee syphilis study), and fears that groups are being misled about vaccines.[4–6] All have contributed to current hesitancy among minority groups in receiving a COVID-19 vaccine. We found organisations supporting asylum seekers and migrants raise concerns regarding deportation through registering for a vaccine. These communities, in addition to minority ethnic groups who live in the most socioeconomically deprived urban areas, also highlighted concerns about access barriers in receiving a vaccine.

The second theme identified a range of similar concerns across minority ethnic groups relating to safety and potential long-term effects on health, in which these groups felt that there was no clear guidance and advice. The speed of COVID-19 vaccine development and under-representation of minority ethnic groups in clinical trials exacerbated underlying hesitancy. In particular, older individuals discussed concerns regarding developing a rare blood clot after receiving the Oxford–AstraZeneca vaccine.[7] Younger women frequently stated concerns about infertility after receiving a COVID-19 vaccine. Misinformation, through social media channels accessed by different minority groups, have amplified these anxieties and reduced confidence in COVID-19 vaccines. Furthermore, messaging from central government (through television, social media, or written media) to address vaccine safety concerns had not reached various communities we had engaged with. This was due to several reasons, including communication only being delivered in English and by politicians or policymakers who did not appear relatable. Celebrity adverts promoting COVID-19 vaccination also provided only one-way communication and did not enable a dialogue to occur with individuals and groups whose concerns had not been addressed.

WHO noted a substantial increase in misinformation during the pandemic, which has been challenging and onerous to monitor.[8] It is, therefore, essential for information to be provided in different languages and is widely promoted through community champions. Local health-care providers and national policymakers should be encouraged to engage in a direct and two-way dialogue with communities to address specific concerns and ensure individuals have sufficient information to make evidence-based decisions regarding COVID-19 vaccines. Forging conversations with minority ethnic communities, with non-stigmatising language and focusing on listening to anxieties, would improve vaccine uptake and could also engender trust in governmental institutions. Practical solutions to make vaccination more convenient, including pop-up vaccine clinics in community centres, places of worship, and door-to-door administration, should also improve uptake. In the long term, quantitative and qualitative data will be required to monitor the uptake of vaccinations across all communities and understand the reasons for any decline.

The pandemic has disproportionality affected minority ethnic communities, causing some of the highest rates of hospitalisation and death. Developing and rolling out COVID-19 vaccines has been one of the biggest public health achievements in the current century. The success of the COVID-19 vaccine programme relies on ensuring all members of society can access and have confidence in receiving a vaccine. However, the increase of the

SARS-CoV-2 B.1.617.2 variant among non-vaccinated people means that ongoing surveillance in minority ethnic populations makes effective engagement an urgent issue.[9] This will also mitigate further worsening of disparities caused by the pandemic in minority ethnic groups.

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1 Public Health England. Disparities in the risk and outcomes of COVID-19. London: Public Health England, 2021.
2 MacKenna B, Curtis HJ, Morton CE, et al. Trends, regional variation, and clinical characteristics of COVID-19 vaccine recipients: a retrospective cohort study in 23·4 million patients using OpenSAFELY. *medRxiv* 2021; published online Jan 26. https://doi.org/10.1101/2021.01.25.21250356 (preprint).
3 Robertson E, Reeve KS, Niedzwiedz CL, et al. Predictors of COVID-19 vaccine hesitancy in the UK household longitudinal study. *Brain Behav Immun* 2021; **94:** 41–50.
4 de Figueiredo A, Simas C, Karafillakis E, Paterson P, Larson HJ. Mapping global trends in vaccine confidence and investigating barriers to vaccine uptake: a large-scale retrospective temporal modelling study. *Lancet* 2020; **396:** 898–908.
5 Independent. Institutional racism exists in UK and healthcare, says head of NHS race body. April 1, 2021. https://www.independent.co.uk/news/health/nhs-health-racism-commission-uk-b1825705.html (accessed May 14, 2021).
6 Reverby SM. Listening to narratives from the Tuskegee syphilis study. *Lancet* 2011; **377:** 1646–47.
7 Pottegård A, Lund LC, Karlstad Ø, et al. Arterial events, venous thromboembolism, thrombocytopenia, and bleeding after vaccination with Oxford–AstraZeneca ChAdOx1-S in Denmark and Norway: population based cohort study. *BMJ* 2021; **373:** n1114.
8 WHO. Call for action: managing the infodemic. Dec 11, 2020. https://www.who.int/news/item/11-12-2020-call-for-action-managing-the-infodemic (accessed May 14, 2021).
9 Wise J. COVID-19: UK cases of variant from India rise by 160% in a week. *BMJ* 2021; **373:** n1315.