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Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science

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The coronavirus disease 2019 (COVID-19) pandemic is having a profound effect on all aspects of society, including mental health and physical health. We explore the psychological, social, and neuroscientific effects of COVID-19 and set out the immediate priorities and longer-term strategies for mental health science research. These priorities were informed by surveys of the public and an expert panel convened by the UK Academy of Medical Sciences and the mental health research charity, MQ: Transforming Mental Health, in the first weeks of the pandemic in the UK in March, 2020. We urge UK research funding agencies to work with researchers, people with lived experience, and others to establish a high level coordination group to ensure that these research priorities are addressed, and to allow new ones to be identified over time. The need to maintain high-quality research standards is imperative. International collaboration and a global perspective will be beneficial. An immediate priority is collecting high-quality data on the mental health effects of the COVID-19 pandemic across the whole population and vulnerable groups, and on brain function, cognition, and mental health of patients with COVID-19. There is an urgent need for research to address how mental health consequences for vulnerable groups can be mitigated under pandemic conditions, and on the impact of repeated media consumption and health messaging around COVID-19. Discovery, evaluation, and refinement of mechanistically driven interventions to address the psychological, social, and neuroscientific aspects of the pandemic are required. Rising to this challenge will require integration across disciplines and sectors, and should be done together with people with lived experience. New funding will be required to meet these priorities, and it can be efficiently leveraged by the UK's world-leading infrastructure. This Position Paper provides a strategy that may be both adapted for, and integrated with, research efforts in other countries.

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Introduction

It is already evident that the direct and indirect psychological and social effects of the coronavirus disease 2019 (COVID-19) pandemic are pervasive and could affect mental health now and in the future. The pandemic is occurring against the backdrop of increased prevalence of mental health issues in the UK in recent years in some groups.[1,2] Furthermore, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19, might infect the brain or trigger immune responses that have additional adverse effects on brain function and mental health in patients with COVID-19.

Research funders and researchers must deploy resources to understand the psychological, social, and neuroscientific effects of the COVID-19 pandemic. Mobilisation now will allow us to apply the learnings gained to any future periods of increased infection and lockdown, which will be particularly important for front-line workers and for vulnerable groups, and to future pandemics. We propose a framework for the prioritisation and coordination of essential, policy-relevant psychological, social, and neuroscientific research, to ensure that any investment is efficiently targeted to the crucial mental health science questions as the pandemic unfolds. We use the term mental health sciences to reflect the many different disciplines, including, but not limited to, psychology, psychiatry, clinical medicine, behavioural and social sciences, and neuroscience, that will need to work together in a multidisciplinary fashion together with people with lived experience of mental health issues or COVID-19 to address these research priorities.

The UK has powerful advantages in mounting a successful response to the pandemic, including strong existing research infrastructure and expertise, but the research community must act rapidly and collaboratively if it is to deal with the growing threats to mental health. A fragmented research response, characterised by small-scale and localised initiatives, will not yield the clear insights necessary to guide policy makers or the public. Rigorous scientific and ethical review of protocols and results remains the cornerstone of safeguarding patients and upholding research standards. Deploying a mental health science perspective[3] to the pandemic will also inform population-level behaviour change initiatives aimed at reducing the spread of the virus. International comparisons will be especially helpful in this regard. In this Position Paper, we explore the psychological, social, and neuroscientific effects of COVID-19 and set out clear immediate priorities and longer-term strategies for each of these aspects.

We also surveyed the public and people with lived experience of mental ill-health (panel 1). The general population survey, done by Ipsos MORI,[4] revealed widespread concerns about the effect of social isolation or social distancing on wellbeing; increased anxiety, depression, stress, and other negative feelings; and concern about the practical implications of the pandemic response, including financial difficulties. The prospect of becoming physically unwell with COVID-19 ranked

Panel 1: Methodology

This Position Paper summarises the priorities put forward by an interdisciplinary group of 24 world-leading experts, including people with lived experience of a mental health issue, from across the bio-psycho-social spectrum of expertise in mental health science in March and April, 2020. The experts were convened by the UK Academy of Medical Sciences and the mental health research charity, MQ: Transforming Mental Health. Members participated in an individual capacity, not as representatives of their organisations. A coordinating group of seven experts met daily over a period of two weeks to develop the research priorities, informed by input from the expert advisory group. Given the need to develop the research priorities rapidly to inform immediate funding priorities, extended evidence gathering and consultation was not possible. However, we are confident that the wide breadth of expertise on the expert group and their leading roles in their respective fields provide a wide-ranging and comprehensive view of the mental health and neuroscience research priorities now; priorities which should be reviewed and should evolve with the pandemic.

Lived experience of a mental health issue was incorporated by four mechanisms. First, three representatives with lived experience provided input as part of the expert advisory group. Second, an online survey collected data on people's two biggest concerns about the mental health and wellbeing implications of the coronavirus disease 2019 (COVID-19) pandemic and the coping strategies used by patients. The survey was promoted via email to MQ's supporter network and via social media. In total, 2198 people completed the survey, submitting 4350 concerns about the mental health effects of the COVID-19 pandemic and 1987 responses about what has helped to maintain mental health and wellbeing during the pandemic. A thematic analysis of the full dataset was done. Third, two questions were asked on Ipsos MORI's online Omnibus survey to collect data on people's concerns about the effect of COVID-19 on mental wellbeing and what is helping people's mental wellbeing at this time. In total, 1099 interviews were completed with adults aged between 16 and 75 years from across England, Wales, and Scotland. Quotas were set and data were weighted to the offline population to ensure a nationally representative sample by gender, age, and region. Statistical analysis was done and any subgroup differences included are statistically significant at a 95% confidence interval unless stated otherwise. A summary report of the findings of both surveys and further methodological details can be found online.[4] The Ipsos MORI tabular data can be found on its website.[5] Finally, the manuscript was peer-reviewed by a reviewer with lived experience of a mental health issue. We acknowledge the limitations of our surveys, including the representativeness of the MQ sample, the short timescale for input, and the representativeness of online populations. We also acknowledge the restricted evidence gathering and opportunity for wider consultation of people with lived experience. However, combined, these four mechanisms of collecting input from people with lived experience provide important insight into people's concerns about the effect of COVID-19 on mental health and coping strategies within the very short timeframe.

A living systematic map[6] is tracking emerging empirical studies, systematic reviews, and modelling on COVID-19. As of April 1, 2020, 643 records were identified in the databases MEDLINE and Embase. Only ten of these were on mental health effects of the pandemic.[7–16]

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lower than these issues related to the social and psychological response to the pandemic. The MQ: Transforming Mental Health stakeholder survey of people with lived experience of a mental health issue likewise highlighted general concerns about social isolation and increased feelings of anxiety and depression. More specifically, stakeholders frequently expressed concerns about exacerbation of pre-existing mental health issues, greater difficulty in accessing mental health support and services under pandemic conditions, and the effect of COVID-19 on the mental health of family members, especially children and older people. Both surveys are reported online.[4] These findings, combined with the published scientific literature, informed the development of our research priorities. The surveys represent a snapshot of the current situation, but they will need to be repeated more rigorously over the course of the pandemic, and the research priorities reviewed.

Psychology and individual factors: researching the effect of COVID-19 on mental health

In this section, we focus on the psychological processes and effects in individual people related to COVID-19, such as cognition, emotion, and behaviour, that affect mental health (table 1).

What is the effect of COVID-19 on risk of anxiety, depression, and other outcomes, such as self-harm and suicide?

Although a rise in symptoms of anxiety and coping responses to stress are expected during these extraordinary circumstances, there is a risk that prevalence of clinically relevant numbers of people with anxiety, depression, and engaging in harmful behaviours (such as suicide and self-harm) will increase. Of note, however, is that a rise in suicide is not inevitable, especially with national mitigation efforts.[17]

The potential fallout of an economic downturn on mental health is likely to be profound on those directly affected and their caregivers. The severe acute respiratory syndrome epidemic in 2003 was associated with a 30% increase in suicide in those aged 65 years and older; around 50% of recovered patients remained anxious; and 29% of health-care workers experienced probable emotional distress.[18–20] Patients who survived severe and life-threatening illness were at risk of post-traumatic stress disorder and depression.[19,20] Many of the anticipated consequences of quarantine[14] and associated social and physical distancing measures are themselves key risk factors for mental health issues. These include suicide and self-harm, alcohol and substance misuse, gambling, domestic and child abuse, and psychosocial risks (such as social disconnection, lack of meaning or anomie, entrapment, cyberbullying, feeling a burden, financial stress, bereavement, loss, unemployment, homelessness, and relationship breakdown).[21–23]

A major adverse consequence of the COVID-19 pandemic is likely to be increased social isolation and loneliness (as reflected in our surveys),[4] which are strongly associated with anxiety, depression, self-harm, and suicide attempts across the lifespan.[24,25] Tracking loneliness and intervening early are important priorities. Crucially, reducing sustained feelings of loneliness and promoting belongingness are candidate mechanisms to protect against suicide, self-harm, and emotional

problems.[26,27] Social isolation and loneliness are distinct and might represent different risk pathways.

To inform management of COVID-19, it is vital to understand the socioeconomic effect of the policies used to manage the pandemic, which will inevitably have serious effects on mental health by increasing unemployment, financial insecurity, and poverty.[28,29] Involvement of people with lived experience and rapid qualitative research with diverse people and communities will help to identify ways in which this negative effect might be alleviated. Achieving the right balance between infection control and mitigation of these negative socioeconomic effects must be considered.[30]

The immediate research priorities are to monitor and report rates of anxiety, depression, self-harm, suicide, and other mental health issues both to understand mechanisms and crucially to inform interventions. This should be adopted across the general population and vulnerable groups, including front-line workers. Monitoring must go beyond NHS record linkage to capture the real incidence in the community, because self-harm might become more hidden. We must harness existing datasets and ongoing longitudinal studies, and establish new cohorts with new ways of recording including detailed psychological factors.[26,31] Techniques assessing moment to moment changes in psychological risk factors should be embraced.

Given the unique circumstances of COVID-19, data will be vital to determine causal mechanisms associated with poor mental health,[31,32] including loneliness and entrapment. To optimise effectiveness of psychological treatments, they need to be mechanistically informed—that is, targeting factors which are both causally associated with poor mental health and modifiable by an intervention.[31] A one-size-fits-all response will not suffice because the effectiveness of interventions can vary across groups.[26,33–36] Digital psychological interventions that are mechanistically informed, alongside better understanding of the buffering effects of social relationships during stressful events, are required in the long term. The digital response is crucial,[37–39] not only because of social isolation measures but also because less than a third of people who die by suicide have been in contact with mental health services in the 12 months before death.[40] Digital interventions for anxiety, depression, self-harm, and suicide include information provision, connectivity and triage, automated and blended therapeutic interventions (such as apps and online programmes), telephone calls and messages to reach those with poorer digital resources (digital poverty),[41] suicide risk assessments, chatlines and forums, and technologies that can be used to monitor risk either passively or actively. The digital landscape extends beyond apps and requires an evidence base. Artificial intelligence-driven adaptive trials could help to evaluate effectiveness, while digital phenotyping could be helpful to ascertain early warning signs for mental ill-health.[42]

Looking beyond digital interventions (as not everyone has access to them), and ascertaining what other mechanistically based psychological interventions are effective and for whom is important.[31,43] Risks and buffers for loneliness should be a focal target in interventions to protect wellbeing. The longer-term consequences of COVID-19 for the younger and older generations (and other groups at high risk, including workers, those with existing mental health conditions, and caregivers) are also unknown and must be a priority.

How do individuals build optimal structures for a mentally healthy life that works for them in the wake of COVID-19 and social and physical distancing?

The optimal structure of a mentally healthy life for individuals in the wake of COVID-19 needs to be mapped out. Structure will vary as a function of background and individual circumstances. Changes in sleep and lifestyle behaviours influence our mental health and stress response. Understanding the effective, individualised ways of coping in such a situation is of paramount importance.[44–46] The social and personal resources (eg, seeing family and getting sufficient sleep) available to individuals can be important resilience-related factors for mitigating mental health difficulties under particularly stressful circumstances.[47] We need

	Immediate actions	Longer-term strategic programmes
What is the effect of COVID-19 on risk of anxiety, depression, and other outcomes, such as self-harm and suicide?	Improve monitoring and reporting of the rates of anxiety, depression, self-harm, suicide, and other mental health issues; determine the efficacy of mechanistically based digital and non-digital interventions and evaluate optimal model(s) of implementation	Determine the mechanisms (eg, entrapment and loneliness) that explain the rates of anxiety, depression, self-harm, and suicide; understand the role of psychological factors in buffering the effect of social context on mental health issues; ascertain the longer-term consequences on wellbeing of COVID-19 for the young and older generations (and vulnerable groups)
What is the optimal structure for a mentally healthy life in the wake of COVID-19 and social or physical distancing?	Determine what psychological support is available to help front-line medical and health-care staff and their families; understand the psychological (eg, coping), physiological (eg, sleep and nutrition), and structural (eg, work rotas and daily routines) factors that protect or adversely affect mental health	Develop novel interventions to protect mental wellbeing, including those based on positive mechanistically based components, such as altruism and prosocial behaviour and understanding of online life; understand how we optimise positive social resources and enhance resilience in the face of stress; establish the effects of altruism on mental health and wellbeing in the wake of COVID-19

COVID-19=coronavirus disease 2019.

Table 1: **Psychology and individual factors: the effect of COVID-19 on mental health**

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	Immediate actions	Longer-term strategic programmes
What are the mental health consequences of the COVID-19 lockdown and social isolation for vulnerable groups, and how can these be mitigated under pandemic conditions?	Determine the best ways of signposting and delivering mental health services for vulnerable groups, including online clinics and community support; identify and evaluate outreach methods to support those at risk of abuse within the home; ascertain which evidence-based interventions can be rapidly repurposed at scale for the COVID-19 pandemic, and identify intervention gaps requiring bespoke remotely delivered interventions to boost wellbeing and reduce mental health issues; swiftly provide interventions to promote mental wellbeing in front-line health-care workers exposed to stress and trauma that can be delivered now and at scale	On the basis of the intervention gaps identified, design bespoke approaches for population-level interventions targeted at the prevention and treatment of mental health symptoms (eg, anxiety) and at boosting coping and resilience (eg, exercise); develop innovative novel universal interventions on new mechanistically based targets from experimental and social sciences (eg, for loneliness consider befriending) that can help mental health; assess the effectiveness of arts-based and life-skills based interventions and other generative activities including exercise outdoors
What is the effect of repeated media consumption about COVID-19 in traditional and social media on mental health, and how can wellbeing be promoted?	Understand the role of repeated media consumption in amplifying distress and anxiety, and optimal patterns of consumption for wellbeing; develop strategies to prevent over-exposure to anxiety-provoking media, including how to encourage diverse populations to stay informed by authoritative sources they trust; mitigate and manage the effect of viewing distressing footage	Inform evidence-based media policy around pandemic reporting (eg, clearly identify authoritative sources, encourage companies to correct disinformation, and policies on traumatic footage); mitigate individuals' risk of misinformation (eg, improve health literacy and critical thinking skills and minimise sharing of misinformation); understand and harness positive uses of traditional media, online gaming, and social media platforms
What are the best methods for promoting successful adherence to behavioural advice about COVID-19 while enabling mental wellbeing and minimising distress?	Understand how health messaging can optimise behaviour change, and reduce unintended mental health issues; track perceptions of and responses to public health messages to allow iterative improvements, informed by mental health science	Synthesise evidence base of lessons learned for future pandemics, tailored to specific groups as required; motivate and enable people to prepare psychologically and plan practically for possible future scenarios; understand the facilitators and barriers for activities that promote good mental health, such as exercise; promote people's care and concern for others, fostering collective solidarity and altruism

COVID-19=coronavirus disease 2019.

Table 2: **Social and population factors: the effect of COVID-19 on mental health**

research to foster positive social resources, resilience, and altruism.

The immediate research priorities are to understand how front-line health and social care staff and their families can be supported to optimise coping strategies to mitigate symptoms of stress, and facilitate the implementation of preventive interventions in the future.[14,48] During the COVID-19 pandemic, it is important that health and social care workers are supported to stay in work, the health, personal, social, and economic benefits of which are vast. Personalised psychological approaches are likely to be a key component to address complex mental health conditions, coping mechanisms, and prevention.[31] Given the association between sleep disturbance and mental health,[49] and the effect of sleep disturbance on the risk of suicide,[50] research on mitigating the effect of such changes on mental health and stress response is required.

The longer-term strategic research programmes are to develop novel interventions to protect mental wellbeing, including those based on positive mechanistically based components (ie, causal, modifiable factors), such as altruism and prosocial behaviour. This could include increased opportunities to elicit community support,[51,52] exercise,[53] social activities,[54] training in assertiveness and conflict resolution,[55] and group interventions that provide support through peers.[56]

The inclusion of altruism in UK Government health messages has likely had a positive effect on wellbeing compared with compulsory orders to stay at home.[14] Key research questions include "What positive mechanistically based psychological interventions can be developed for mental wellbeing derived from theories of altruism and prosocial behaviour?" and "What can be learned from the large-scale roll-out of volunteer-based psychological interventions that will optimise the benefits to individuals and society?"

Working from home, loss of employment, and social and physical distancing have abruptly interrupted many social opportunities important to physical and psychological health. It is important to research the mental health dimension of online life and investigate how changes in engagement with gaming and online platforms might inform interventions aimed at improving mental health. We must rapidly learn from successful existing strategies to maintain and build social resources and resilience and promote good mental health in specific populations moving forward.

Social and population factors: the effect of COVID-19 on mental health

Population-level factors, such as the effect of social distancing measures (more recently being redescribed as physical distancing)[57] and other necessary public health measures, affect mental health within a syndemics approach (table 2). By syndemics we mean intersecting global trends among demographics (eg, ageing, rising inequality) and health conditions (eg, chronic diseases and obesity) that yield resultant comorbidities. These

interacting health effects and societal forces that fuel them combine to form syndemics, or complex knots of health determinants.[58] Research priorities around COVID-19 require us to embrace complexity by deploying multidimensional perspectives.

What are the mental health consequences of the COVID-19 lockdown and social isolation for vulnerable groups, and how can these be mitigated under pandemic conditions?

We do not yet know the acute or long-term consequences of the COVID-19 lockdown and social isolation on mental health. Although worries and uncertainties about a pandemic are common, for some they can cause undue distress and impairment to social and occupational functioning.[14,59,60] Across society, a sense of loss can stem from losing direct social contacts, and also range from loss of loved ones, to loss of employment, educational opportunities, recreation, freedoms, and supports. Existing evidence suggests some measures taken to control the pandemic might have a disproportionate effect on those most vulnerable (panel 2).

Vulnerable groups include those with pre-existing mental or physical health issues (including those with severe mental illnesses), recovered individuals, and those who become mentally unwell (eg, in response to anxiety and loneliness surrounding the pandemic; panel 2).[14,61,62] Therefore, loss of access to mental health support, alongside loss of positive activities, might increase vulnerability during COVID-19 lockdown. Increased feelings of anxiety and depression in response to the outbreak have been highlighted already.[63] Health workers who come in close contact with the virus and are exposed to traumatic events, such as death and dying, while making highly challenging decisions, are particularly at risk of stress responses.[15]

The pandemic intersects with rising mental health issues in childhood and adolescence.[2,64,65] Ascertaining and mitigating the effects of school closures for youth seeking care is urgent and essential, given that school is often the first place children and adolescents seek help,[64,66] as is considering vulnerabilities, such as special educational needs and developmental disorders, and finding therapeutic levers.[67] For the older population, promoting good mental health is important during self-isolation, which can be compounded by lifestyle restrictions, exacerbated loneliness, comorbidities (such as dementia), and feelings of worry and guilt for using resources.[68] There is an acute need to identify, in consultation with people with lived experience, remotely delivered interventions that support those at risk of abuse.[69,70]

The immediate research priorities are to reduce mental health issues and support wellbeing in vulnerable groups in particular. A coordinating mechanism for pandemic mental health interventions is required for the agile identification of interventions that can be repurposed, alongside the identification of intervention gaps that will require bespoke de novo design, and the evaluation and roll-out of remotely delivered interventions. By the term intervention, we mean interventions of all sorts that make a difference to mental health, including population-level policy, occupational guidelines, and psychological interventions.

We need to gather high-quality data rapidly to ascertain the effects of lockdown and social isolation over time. Innovative research is needed to establish ways to mitigate and manage mental health risks and inform interventions under pandemic conditions.

Research to support vulnerable groups needs to consider cross-cutting themes (such as the physical absence of schools and clinics) to create methods to provide connectivity and support; promote rapid innovation in mental

***Panel 2*: Populations of interest, including vulnerable groups**

Although the whole population is affected by the coronavirus disease 2019 pandemic, specific sections of the population will experience it differently.

Children, young people, and families will be affected by school closures. They might also be affected by exposure to substance misuse, gambling, domestic violence and child maltreatment, absence of free school meals, accommodation issues and overcrowding, parental employment, and change and disruption of social networks.

Older adults and those with multimorbidities might be particularly affected by issues including isolation, loneliness, end of life care, and bereavement, which may be exacerbated by the so-called digital divide.

People with existing mental health issues, including those with severe mental illnesses, might be particularly affected by relapse, disruptions to services, isolation, the possible exacerbation of symptoms in response to pandemic-related information and behaviours, and changes in mental health law.

Front-line health-care workers might be affected by fears of contamination, moral injury, disruption of normal supportive structures, work stress, and retention issues.

People with learning difficulties and neurodevelopmental disorders might be affected by changes and disruption to support and routines, isolation, and loneliness.

Society might experience increased social cohesion and communitarianism, but also be negatively affected by increased health inequalities, increased food bank use, increased race-based attacks, and other trauma. Rural communities might also be affected differently to urban communities.

Socially excluded groups, including prisoners, the homeless, and refugees, might require a tailored response.

People on low incomes face job and financial insecurity, cramped housing, and poor access to the internet and technology.

health services that can be remotely signposted and delivered (including online clinics and community support); identify and evaluate means to support those at risk of abuse within the home (eg, online outreach); and swiftly provide interventions to promote mental wellbeing in front-line health workers. By identifying cross-cutting research themes, interventions to help specific vulnerable populations should be leveraged to help other vulnerable groups.

With regard to the longer-term priorities, health services research must reliably and iteratively inform remotely delivered mental health resources, such as digital clinics, to efficiently manage mental health issues in an adaptive and flexible manner.[71] This requires a coordinating mechanism to prioritise and streamline efforts, working with service users to optimise signposting and delivery and define therapeutic targets that matter from a user perspective (eg, loss, loneliness). Such a mechanism requires a range of disciplines, including psychology, digital science, and social sciences.[31,72] International collaboration will ensure the necessary research skills and expertise. Research should harness internet-based social media and gaming using existing platforms and be cognisant of the so-called digital divide, which leaves 15% of Britons without internet access.[73]

Research for population-level interventions will require rapid evolution of approaches, starting with testing whether existing digital interventions can be repurposed, such as physical activity, sleep, and stress management programmes, as well as targeted approaches for the prevention and treatment of established mental health symptoms (eg, anxiety and worry).[31,74] Tailoring of such universal interventions will need to be informed by experimental and social science (eg, for loneliness, befriending, and physical activity).[75,76] The effectiveness of arts-based interventions also needs to be assessed[77] as do other generative activities that boost positive coping and resilience throughout society, from community-based activities, to life-skills classes, to exercising outdoors.[4] The effectiveness of all interventions requires rigorous evaluation and implementation to avoid recommending a plethora of apps with no evidence base.[78] Interventions at the population level should be repurposed, developed, and tested in a virtuous loop to create the necessary evidence base.

What is the effect of repeated media consumption about COVID-19 through traditional media and social media on mental health, and how can wellbeing be promoted?

People seek trusted information via the media, which can provide swift, critical guidance regarding the pandemic. Media consumption can be adaptive and positive for mental health. However, reports of infectious diseases often use risk-elevating messages, which can amplify public anxiety.[79] Social media can be a source of rapidly disseminated misinformation,[80] amplifying perceptions of risk.[81] Repeated media exposure to information about an infectious disease particularly can exacerbate stress responses, amplify worry, and impair functioning.[82] Anxiety and uncertainty can drive additional media consumption and further distress, creating a cycle that can be difficult to break.[83] Media-fuelled distress can promote behaviours that negatively affect the health-care system (eg, visits to emergency departments and hoarding of face masks), with downstream mental and physical health consequences.[84]

The immediate research priority is to better understand the role of repeated media consumption around COVID-19 in amplifying distress and mental ill-health in various groups, and the optimal patterns of consumption to promote wellbeing. Research is needed to inform future approaches, including strategies to help individuals to stay informed by authoritative sources, prevent over-exposure to media, and mitigate and help manage the effect of viewing images with traumatic content.

Longer-term research priorities should inform evidence-based guidelines for media around pandemic reporting (eg, clearly identifying authoritative sources, limiting graphic footage, and encouraging social media companies to flag or correct disinformation and rumours). Research should also help to develop strategies to mitigate an individual's risk of exposure to misinformation and amplification of anxiety by minimising sharing of misinformation, and promoting strategies for managing the emotional consequences. Adaptive and positive uses of traditional media and social media, such as influencers, should be understood and harnessed. Understanding the effect of pandemic media on various vulnerable groups is essential.

What are the best methods for promoting successful adherence to behavioural advice about COVID-19 while enabling mental wellbeing and minimising distress?

Behavioural change—such as the three personal protective behaviours of handwashing, not touching the T-zone of the face, and tissue use, and social or physical distancing required to control the pandemic—necessitates ensuring people know what to do, are motivated to do it, and have the skills and opportunity to enact the changed behaviours.[85,86] Messaging is key for good knowledge,[86] but public health messaging needs to draw on behavioural science if it is to be effective and avoid unintended consequences. We know that the more concerned people are in pandemics, the more likely they are to adhere to advice.[59] However, increasing concern experienced by the public might heighten distress, which could undermine adherence or exacerbate existing mental health issues. Anxiety can be fuelled by uncertainty and by fears of risk of harm to self or others. For example, feelings of paranoia[87] can be heavily influenced by anxiety, and symptoms of obsessive compulsive disorder[88] can be associated with fear of contagion and rigid handwashing.[89] Increasing people's confidence and clarity in what they need to do fosters

adherence to health behaviours,[90] and can help people to manage psychological distress.

Immediate research on COVID-19 health messaging is urgently required to both optimise health behaviour change and to reduce unintended mental health issues, which will be required in the event of a second wave of infection. Research should prioritise message content, format, and delivery modes and behavioural change alongside risk communication, and consider how this might need to vary for diverse groups. A virtuous cycle that tracks perceptions of and responses to public health messages during this pandemic will enable iterative improvements. It must be informed by mental health science[3] to close the knowledge-to-implementation gap (eg, between effective behaviour messages and maladaptive consequences).

Longer-term research priorities are to create an evidence base of lessons learned to plan for future pandemics—that is, detailing how to foster a rapid and coordinated response regarding health messaging from governments[91] and simultaneously to develop effective systems embedded in communities to reach out and access the most vulnerable groups in our society, including how to motivate and enable people to prepare psychologically and plan practically for possible future scenarios, and how to promote people's care and concern for others, fostering a sense of collective solidarity and altruism. The optimal messaging should be tailored (including digitally) to different social groups to connect diverse segments of the population to appropriate mental health information resources.

Neuroscience: effects of the virus on brain health and mental health

Almost nothing is known with certainty about the effect of SARS-CoV-2 infection on the human nervous system. SARS-CoV-2 is a zoonotic virus and a review from 2005 suggested that about half of zoonotic virus epidemics have been caused by neurotropic viruses that invade the CNS.[92] The closely related coronaviruses responsible for the severe acute respiratory syndrome epidemic in 2003 and the so-called Middle East respiratory syndrome in 2012 are biologically neurotropic and clinically neurotoxic, causing mental health and neurological disorders.[93–95] SARS-Cov-2 has a similar receptor-binding domain structure to SARS-CoV and probably shares its neurotropism and neurotoxicity (panel 3).[96]

Neurological symptoms of COVID-19 infection are common, diverse, and often severe. In a retrospective study of 214 patients in Wuhan, China 36% had CNS symptoms or disorders and the subgroup of 88 patients with severe respiratory disease had significantly increased frequency of CNS problems (45%).[97] The problems reported include dizziness, headache, loss of smell (anosmia), loss of taste (ageusia), muscle pain and weakness, impaired consciousness, and cerebrovascular complications. Similar reports have begun to emerge from Italy.[98] Some of these acute neurological presentations could reflect systemic aspects of infection, such as disseminated intravascular coagulation causing strokes or intense inflammation and hypoxia causing delirium.

SARS-CoV-2 infection of the brain could be a contributor to the core medical syndrome of respiratory distress and failure in patients with COVID-19.[99] Viral infection of the lung alveoli is the immediate cause of severe acute respiratory syndrome; but viral infection of key brainstem nuclei could disrupt the normal rhythms and homoeostatic control of respiration. This idea needs to be tested rapidly[99] because if brainstem infection does contribute to the severity of SARS and the need for treatment in an intensive care unit, it could be directly relevant to the immediate COVID-19 crisis in the NHS and other health-care systems.

In the longer term, it is possible that SARS-CoV-2 will have persistent direct neurotoxic effects and immune-mediated neurotoxic effects on the brain. The Spanish flu epidemic of 1918–19 was linked to a spike in incidence of post-encephalitic Parkinsonism.[100] Currently, it is not known if SARS-CoV-2 infection could cause mental health or neurodegenerative disorders immediately or years after the acute respiratory phase of COVID-19 has passed, but action is needed now to build the research capacity to test these potentially important biological causes of COVID-19-related mental illness.

Immediate actions include the development of a neuropsychological database of COVID-19 cases to bring together standardised, longitudinally repeated data at scale both from the clinic for those needing hospital

***Panel 3*: Neuroscience: effects of the virus on brain health and mental health**

Immediate actions

- Build a neuropsychological database of UK coronavirus disease 2019 cases (standardised, longitudinally repeated, data at scale) which is clinically and geographically inclusive
- Expand facilities for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infected tissue handling

Longer-term strategic research programmes

- Understand how SARS-CoV-2 might enter and propagate through the brain and how the immune response to SARS-CoV-2 infection contributes to mental health and neurological symptoms
- Investigate the long-term relationship between SARS-CoV-2 infection and post-infective fatigue or depressive syndromes
- Validate clinical biomarkers of SARS-CoV-2 brain infection using MRI and other methods
- Develop interventions to interrupt or prevent the adverse biological effects of SARS-CoV-2 on brain function and mental health, including repurposed drugs

treatment and by online assessments for patients in isolation at home. Following the progression of clinical symptoms over time will be key to understanding and predicting the effects of infection on the CNS.

Facilities for SARS-CoV-2-infected tissue handling need to be expanded to examine human brain tissue post mortem, which is crucial to understanding the neurotropic and neurotoxic properties of the virus. Facilities equipped to safely handle human (or animal) brain tissue infected with SARS-CoV-2 are currently very few in number. We recommend building pathology and molecular neuroscience networks to enable brain and other tissue to be collected at autopsy and examined for viral infection and damage. This will require protocols for tissue collection and examination in appropriate laboratory facilities to protect researchers and other staff at all times.

The longer-term research priorities are to understand the mechanisms by which SARS-CoV-2 might enter the brain. There are two conceivable pathways: neuronal or vascular.[101] The neuronal pathway, used by other coronaviruses,[102,103] is to invade a specialist sensory receptor in peripheral tissue, travel by the axonal transport systems to the brainstem, and propagate between neurons by trans-synaptic mechanisms. It is not known whether SARS-CoV-2 can follow the same path to infect the human brain or whether it invades nerve cells by hijacking angiotensin converting enzyme 2 (ACE2),[104–106] despite neurons expressing low amounts of the protein, as described in a preprint[107] and two other published studies.[108,109] Alternatively, SARS-CoV-2 might invade the brain from the blood, if circulating particles of the virus were transported across the blood–brain barrier by binding to ACE2 receptors expressed by endothelial cells,[109] or if infected leucocytes could carry the virus with them as they migrate into the tissues as part of the immune response to infection.[110] Better understanding of how the intense systemic immune response to SARS-CoV-2 infection affects mental health and neurological symptoms,[97,111,112] and of the mechanisms of immune clearance of SARS-CoV-2, is also needed.[113,114]

Post-infectious fatigue and depressive syndromes have been associated with other epidemics, and it seems possible that the same will be true of the COVID-19 pandemic. Longitudinal studies, especially if commenced before or soon after the start of the current pandemic, will be crucial in establishing the often complex biological pathways between infection and mental health outcomes.[115–117]

Candidate biomarkers need to be evaluated to measure the effects of SARS-CoV-2 infection on the human brain and brainstem in living patients, including structural and functional MRI, diffusion-weighted MRI, quantitative cerebral blood flow imaging, and magnetic resonance spectroscopy. The 7 Tesla MRI technique has sufficient spatial resolution to measure functional connectivity between subcortical structures that constitute networks for respiratory control and distress.[118] Other methods could include sampling cerebrospinal fluid or use of PET to measure brain inflammation; patient self-reporting or behavioural testing of smell, taste, and other cranial or vagal sensory functions; electrophysiological methods to measure brainstem function; and computerised tests of cognitive and emotional processing.

Informed by greater understanding of the effects of viral infection on the nervous system and by more accurate biomarkers of brain function in patients with COVID-19, interventions need to be developed to interrupt or prevent the adverse biological effects of SARS-CoV-2 on brain function and mental health. Potential drug targets include putative mechanisms for neuronal invasion, interneuronal propagation, and immune clearance of SARS-CoV-2. Biological and clinical validation of these or other targets would enable experimental medicine studies or early clinical trials of repurposed drugs. For example, the ACE2 inhibitors already licensed for treatment of hypertension, and a licensed drug for reflux oesophagitis, camostat mesylate, that blocks the serine protease TMPRSS2[119] (which operates with ACE2 to facilitate viral entry into cells) have already been advocated as repurposable drugs. There are many other potential candidates for drug repurposing described in a preprint,[120] which could be a faster route to effective treatment for CNS infection than development of entirely new drugs or vaccines. Partnerships between researchers in academia and industry will be vital.

Infrastructure and opportunities

Many of the immediate priorities are for surveillance of general and specific populations for effects of SARS-CoV-2 infection on health, ranging from health behaviours, psychological symptoms, neuropsychiatric disorders, and mortality, including, but not limited to, suicide. The other immediate priority is to assemble cohorts to determine longer-term outcomes and provide a resource for nesting intervention studies, and a resource of interventions to monitor their effectiveness. We recommend three main routes. For each of these routes, there is a need to coordinate existing research infrastructure through shared protocols, research measures, and data assets, and to uphold the highest standards of scientific and ethical review. We urge the mental health science community to combine agility in initiating new or adapting existing research with collective scrutiny and collaboration.

First, administrative data assets principally derived from existing electronic health records, with systems in place to interrogate these for research purposes, provide a means of identifying health effects at scale. Health Data Research UK is coordinating national efforts. Examples include the Clinical Practice Research Database[121] and similar primary care databases; the Clinical Record Interactive Search[122] and other related systems for the

interrogation of mental health records; and CogStack[123] for general hospital settings, which provides near real-time information from health records (eg, to provide feedback on neurological consequences of severe COVID-19). These systems should be linked between mental health services, acute medical services, and community health services to identify patterns and trends both in clinical populations and in individuals with confirmed or suspected COVID-19.

Second, surveillance through recruitment platforms and existing cohorts has the benefit of embedding research on COVID-19 into studies where participants' mental or cognitive health has previously been ascertained. Existing cohorts or data platforms that can be rapidly deployed for COVID-19 research are likely to be particularly valuable. Examples include the National Institute for Health Research National Bioresource, a platform that already includes clinical and genetic data on participants, and could be deployed for rapid characterisation of mental health and neurological symptoms. UK Biobank has successfully done a web-based mental health survey of 160 000 individuals, and the ongoing neuroimaging studies of 100 000 individuals with some repeat imaging, provide an ideal opportunity to image the effect of SARS-CoV-2 infection on the brain and the brainstem via a before-and-after imaging comparison.

Third, novel population-based studies on mental health and COVID-19 should be established, using appropriate epidemiologically robust survey methodology for both the whole population and specific groups of particular interest (eg, children and young people, front-line staff in health and social care, and people who have survived severe COVID-19). Priority should be given to assembling representive populations using explicit sampling frames. Finally, many other disciplines will be establishing similar studies and it is vital that the ascertainment of mental health should be embedded wherever possible.

Whether using established or new cohorts, priority should be given to methods that can ascertain COVID-19 status, symptoms, and behaviours in as close to real-time as possible, providing a dynamic picture of change in illness status, social circumstances, and behaviours. Questions regarding COVID-19 and mental health symptoms and social stressors can readily be disseminated through smartphones. Passive data from smartphones can also give high temporal resolution to behaviours related to the pandemic. Cohorts should gain permissions for the linkage of records, including serological status, when mass testing becomes available, and consent for recruitment into nested substudies, including randomised trials of interventions.

Patient and public involvement in research is a critical underpinning component to research. Given that the entire population has lived experience of the COVID-19 pandemic, researchers will need to be particularly mindful of consulting and collaborating with patient and public groups that reflect the diverse groups being studied when developing protocols, conducting research, and interpreting results (panel 4).

Panel 4: **Principles of good research practice in COVID-19 research**

Study design
Researchers must continue to describe the patient group or population and the research question under study. A priori research questions are crucial. Sample size, sources of bias, participant characteristics (including sex, age, and ethnicity), and study design need to be carefully considered and must be appropriate to the research questions.

Ethics
Research on human participants should maintain high standards of ethical practice, including seeking research ethics committee approval.[124] Committees now have fast-track procedures to expedite study start up. Ethical considerations for doing coronavirus disease 2019 (COVID-19)-related research have been published.[125,126]

Vulnerable groups
Researchers should recognise the capacity of the pandemic to exacerbate health inequalities within populations, particularly affecting people with established mental health issues (including severe mental illnesses) and physical disability. Those with precarious or no employment or housing, or other forms of social inequality, such as digital poverty,[41] should also be considered.

Involvement of patients, people with lived experience, and the public
Researchers should continue to engage and involve patients, people with lived experience, the public, and service providers in their work by mutually setting research questions, testing the acceptability of protocols and questionnaires, and interpreting results. Researchers should ensure that they discuss their research findings with participants.

Harmonised data and measures
There is an obvious need for researchers to use and share full study protocols and measures, where possible. This will facilitate comparisons between data and projects. The urgency of the research effort should be a strong driver for the principles of open science, reproducibility, and data sharing. The ready availability of analysis code and data is essential to verifying findings. Broad adoption of the registered reports publication model,[127] including rapid peer review of study protocols before data collection, will help to minimise waste and ensure conclusions are empirically sound.

Interdisciplinary working
The challenge of the COVID-19 pandemic requires imaginative collaborations between disciplines, including, but not limited to, psychology, psychiatry, neuroscience, virology, intensive care medicine, and respiratory medicine. Previous experience with epidemics has shown the "essential role that the humanities and social sciences play in information, reduction of fear and stigma, prevention, screening, treatment adherence, and control policies".[128]

Collaboration and coordination
Where possible, research protocols should be deployed at scale harnessing existing research infrastructures, including the Clinical Research Networks, Biomedical Research Centres, Mental Health Translational Research Collaboration, MQ Data Science group, charities, service user groups, and professional bodies. To avoid waste and protect against participant fatigue, it is essential that there is national coordination across research groups. International collaboration and a global perspective would also be beneficial.

Call for action

Multidisciplinary mental health science research must be central to the international response to the COVID-19

***Panel 5*: Rapid learnings to apply to future infection waves or pandemics**

The outputs of immediate research could help to inform responses to future infection waves or pandemics by identifying:

- Mechanisms (eg, coping strategies and preventive interventions) to support vulnerable groups under pandemic conditions, such as front-line health and social care staff, those with pre-existing mental health issues, young people (aged ≤18 years), and older adults (aged ≥65 years)
- Interventions that can be delivered under pandemic conditions to reduce mental health issues and boost wellbeing, including those that can be repurposed
- Solutions to the effect of repeated media consumption about coronavirus disease 2019 (COVID-19) on the mental wellbeing of the population, to help individuals stay informed by authoritative sources while also preventing over-exposure and mitigating the effect of viewing traumatic content
- Methods for promoting more successful adherence to behavioural advice about COVID-19 while enabling mental wellbeing and minimising distress

pandemic, given the potential effects on individual and population mental health, and its potential effect on the brain function of some of those affected by the disease. There are important immediate insights to be gained, which could provide evidence-based guidance on responding to this pandemic and on how to promote mental health and wellbeing, and safeguard the brain, should future waves of infection emerge (panel 5).

The research priorities across the social, psychological, and neuroscientific aspects of this pandemic should be coordinated at a national and international level. We urge UK research funding agencies to work with researchers, people with lived experience, and others to establish a high-level coordination group to ensure that the mental health science research priorities are addressed swiftly, and that a firm evidence base is established for long-term studies. We need rigorous, peer-reviewed, ethically approved research codeveloped with people with lived experience that can be translated into effective interventions, rather than the current uncoordinated approach with a plethora of underpowered studies and surveys.

The immediate priority is the collection of high-quality data on the mental health and psychological effects of the COVID-19 pandemic across the whole population and in specific vulnerable groups, and on brain function, cognition, and mental health for patients with COVID-19 at all clinical stages of infection and illness. These datasets must be brought together under a national data portal for rapid access and use.

There is an urgent need for the discovery, evaluation, and refinement of mechanistically driven interventions to address the psychological, social, and neuroscientific aspects of this pandemic. This includes bespoke psychological interventions to boost wellbeing and minimise mental health risks across society, including in vulnerable groups, and experimental medicine studies to validate clinical biomarkers and repurpose new treatments for the potentially neurotoxic effects of the virus. There is an urgent need for research to address the effect of repeated pandemic-related media consumption and to optimise health messaging around COVID-19. Rising to this challenge will require integration across disciplines and sectors, including industry and health and social care.

New funding will be required to meet these priorities, and it can be efficiently leveraged by the UK's world-leading neuroscience and mental health research infrastructure. The UK must connect with international funders and researchers to support a global response to the mental health and neurological challenges of this pandemic. In these challenging times, mental health science should be harnessed to serve society and benefit both mental and physical health in the long term.

Contributors

EB, EAH, MH, RCO'C, VHP, IT, and SW contributed to the literature review, conceptualisation, design and interpretation of surveys, and writing and editing of the manuscript as part of the core advisory group. CC contributed to and coordinated the writing and editing of the manuscript. KC analysed the qualitative data gathered via the stakeholder survey. LA, CB, HC, RCS, IE, TF, AJ, IM, SM, AKP, RS, CMW, and LY contributed to the drafting and formulation of the manuscript as part of the expert advisory group. TK, KK, and AS contributed to the drafting and formulation of the manuscript as part of the expert advisory group and by including lived-experience expertise. All authors approved the final version for submission.

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