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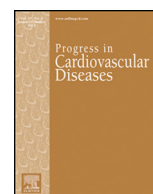
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# Progress in Cardiovascular Diseases

journal homepage: [www.onlinepcd.com](http://www.onlinepcd.com)



## Post pandemic research priorities: A consensus statement from the HL-PIVOT



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### ARTICLE INFO

#### Keywords:

COVID-19  
Research  
Priorities  
Health and wellbeing  
Collaboration exercise medicine  
Pandemic legacy  
Prevention

### ABSTRACT

We have been amid unhealthy living and related chronic disease pandemics for several decades. These longstanding crises have troublingly synergized with the coronavirus disease 2019 (COVID-19) pandemic. The need to establish research priorities in response to COVID-19 can be used to address broad health and wellbeing, social and economic impacts for the future is emerging. Accordingly, this paper sets out a series of research priorities that could inform interdisciplinary collaboration between clinical sciences, public health, business, technology, economics, healthcare providers, and the exercise science/sports medicine communities, among others. A five-step methodology was used to generate and evaluate the research priorities with a focus on broad health and well-being impacts. The methodology was deployed by an international and interdisciplinary team from the Healthy Living for Pandemic Event Protection (HL-PIVOT) network. This team were all engaged in responding to the Pandemic either on the 'front-line' and/or in leadership positions ensuring the currency and authenticity of the process. Eight research priorities were identified clustered into two groups: i) Societal & Environmental, and ii) Clinical. Our eight research priorities are presented with insight from previously published research priorities from other groups.

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Abbreviations: COVID-19, coronavirus disease 2019; CR, Cardiac Rehabilitation; HL-PIVOT, Healthy Living for Pandemic Event Protection; NBI, Nature-Based interventions; PA, Physical Activity; PH, Arterial Hypertension; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SB, Sedentary Behaviour.

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Longstanding health crises have affected global health for decades and have troublingly synergized with the coronavirus disease 2019 (COVID-19) pandemic.<sup>1,2</sup> Numerous studies have highlighted the impacts of living an unhealthy lifestyle,<sup>3–5</sup> related chronic diseases and co-morbidities, which can increase disease severity if infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus responsible for COVID-19. Recent data also highlights that unhealthy lifestyle behaviours have been increasing during the COVID-19 pandemic,<sup>6–11</sup> especially sedentariness, drug and alcohol consumption and social isolation. This is an ominous sign for the future and a challenge in the context of an accelerating incidence and prevalence of chronic disease, health care systems and public health status. As such, the need to establish research priorities in the global response to the unhealthy lifestyle, chronic diseases, and COVID-19 pandemics to address the broad health and wellbeing, social and economic impacts is clear. Several groups have previously set out areas for consideration that have mostly centered on the development of effective treatment, management strategies<sup>12–14</sup> and to address factors associated with living in forced isolation.<sup>15–18</sup> To date, there has been little attention directed to the lasting impacts of the COVID-19 pandemic and the additive effect of multiple ongoing public health crises.

Accordingly, this paper sets out a series of post-pandemic research priorities which were developed to inform interdisciplinary collaborations which has been championed previously by our group.<sup>19,20</sup> Collaborations must be enhanced between clinical sciences, public health, business, technology, economics, and the Exercise Science and Sports Medicine community, among others to determine diagnostic insight<sup>21,22</sup> and to mitigate against the longstanding impacts of COVID-19. Acknowledging the need and importance of rigour in achieving consensus,<sup>23</sup> a five-step methodology was used to generate and evaluate the research priorities related to broad health and well-being impacts and the results are reported here. The methodology was conducted by an international and interdisciplinary team from the Healthy Living for Pandemic Event Protection (HL- PIVOT) network.<sup>24</sup> This team were all engaged in responding to the Pandemic either on the ‘front-line’ and/or in leadership positions ensuring the currency and authenticity of the process. Eight research priorities were identified that could be clustered into two groups: i) Societal and Environmental; and ii) Clinical. These eight research priorities are compared against seven published research priorities from other international research groups and established organisations.

**Methods**

A robust, five-step methodology was used to generate and evaluate the research priorities reported here and a process that was informed

by existing literature to ensure an equitable process was adopted and incorporated the consideration outlined in a recent article by Blazey et al.<sup>23</sup> The process by which a consensus on what should be the post-pandemic research priorities is summarized below.

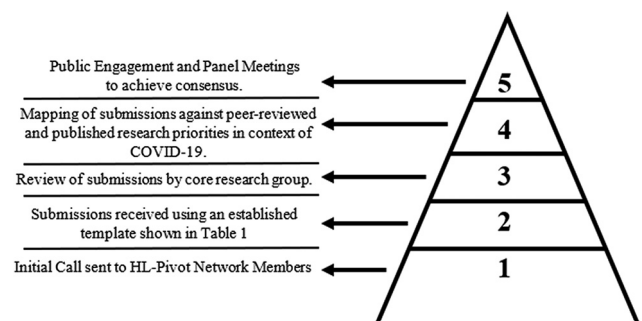
The text that follows details the methodology illustrated in Fig. 1 and in so doing covers how those involved in this process were: i) ‘selected’ and their demographics and ii) how the evidence and submissions were reviewed.

*Step 1: call for submissions*

To be as inclusive and open as possible, an invitation email was sent to all 125 members of the HL-PIVOT network, inviting expressions of interest, and requesting proposals for consideration. The HL-Pivot network is an international, multi-disciplinary network of academics, researchers, scientists, healthcare providers, health professionals, patient representatives and policymakers that are brought together by an interest in promoting human resilience and quality of life by increasing healthy living behaviours.<sup>25,26</sup> These demographics capture the much-needed interdisciplinarity and the global challenge of COVID-19. Network members who responded to the initial call ( $n = 11$ ) were invited to make a full submission using an itemised template as detailed in Table 1 below.

*The people*

As part of the process, all authors were asked about their professional experience during the Pandemic. Responses to this question included –



**Fig. 1.** The five step methodology adopted to reach consensus in the development of subsequent research priorities.

**Table 1**  
 Template provided to all respondents from the initial call to ascertain details important to research priority development.

Submission question	Commentary
What is your Profession?	This was asked to ensure that we had representatives from a variety of healthcare specialities and organisations.
State the research question that you think it is most important that Exercise Science and/or Sports Medicine addresses post-pandemic. Please make sure that your response is framed as a question	This was the most important question being designed to get a clear response.
What research methodology would you propose to investigate the question you pose above?	This question was asked so that we could classify the proposed methodologies as i) qualitative, ii) quantitative or iii) mixed methods and to enable us to report not only the research questions but also the proposed methodologies.
How was your research question shaped by your experience on the front line of the Pandemic?	This item was designed to enable us to link the research priorities to professional practice.
How would addressing your research question help us in the next Pandemic?	COVID-19 is not the first Pandemic, and it will not be the last. Therefore, it is important that Post Pandemic research priorities help us prepare for the next crisis.
Why is your research question one that could only be asked post-pandemic?	The purpose of this consensus statement was to identify post-pandemic research priorities that could not or would not have been addressed before COVID-19 Pandemic.
Is there an international dimension to your question?	As by definition, a pandemic is a global health emergency so some of the research questions that emerge from it need to have an international dimension.
Is there an interdisciplinary dimension to your research question or proposed methodology? If so, can you explain it?	The need for interdisciplinary research has been recognised.
Is there a social or contributive justice aspect to your research question? If so, please reflect upon it here.	Scientific and medical research does not take place in a cultural or political vacuum and this item was included to locate the research in a societal context.
If there are any existing publications that support giving priority to your research question, please cite up to 2 of them below.	This item helped locate the proposed research priorities within the existing literature.
Finally, and potentially most importantly please use the space below to make the case that your research question should be a global post-pandemic research priority. You can do so in any way you wish including summarising the points you have made above or introducing new arguments.	This open question was designed to ensure that responders had every opportunity to unpack their thinking.

*‘Being on the COVID-19 response team as a Nurse Practitioner from June 2020-now’*

*‘While working in the COVID-19 wards, I realized that patients who are athletes and physically active had a better clinical course. On the other hand, there were surprises when patients, despite good training had severe clinical pictures.’*

*‘Having seen COVID-19 survivors presenting with persisting dyspnoea and fatigue, there is a need to further evaluate what physiological systems are contributing to them.’*

*‘Observing the impact that the reduction in on-site CR services had on the lives of my patients with stroke who had been participating in the on-site program and transitioned to a program delivered by phone’*



Fig. 2. A word cloud developed using author submissions from the initial stages of the methodology.

during the pandemic. The program has not resumed due to lack of staff owing to redeployment.'

'We have seen that certain phenotypical and clinical metrics are correlated to risk and intensity of COVID-19 infection.'

'Our vulnerable populations have suffered immensely during this pandemic and our healthcare system's flaws have been exposed and highlighted'

'... been intimately involved in clinical trials for treatment of COVID-19 as well as prevention research efforts (e.g., we are a COVID-19 vaccine site for the Astra Zeneca vaccine).'

'Founding and leading the COVID-19 Special Interest Group for the British Association of Sport and Exercise Science.'

The following word cloud was generated from all the responses to the inquiry about the authors activities to the Pandemic (Fig. 2).

Step 3: review of submissions

Colleagues who responded to the call (n = 8) were asked to review each of the other submissions in a detailed, constructive, and collegial way. The purpose of this step was to i) review the submission against a set of criteria (outlined below); ii) add value to the proposals by using the submitted draft as a 'prompt' for additional thoughts and ideas, and iii) to consider if the submissions could be clustered into thematic areas. At this point authors of the submission were also sent a copy of their submission. This was to allow them to revise it in light of further reflection and developments in their professional practice and the research literature.

The criteria colleagues used to assess each other's submissions were as follows -

- ✓ Could the wording of the research question be improved?
- ✓ Could the proposed methodology be stronger?

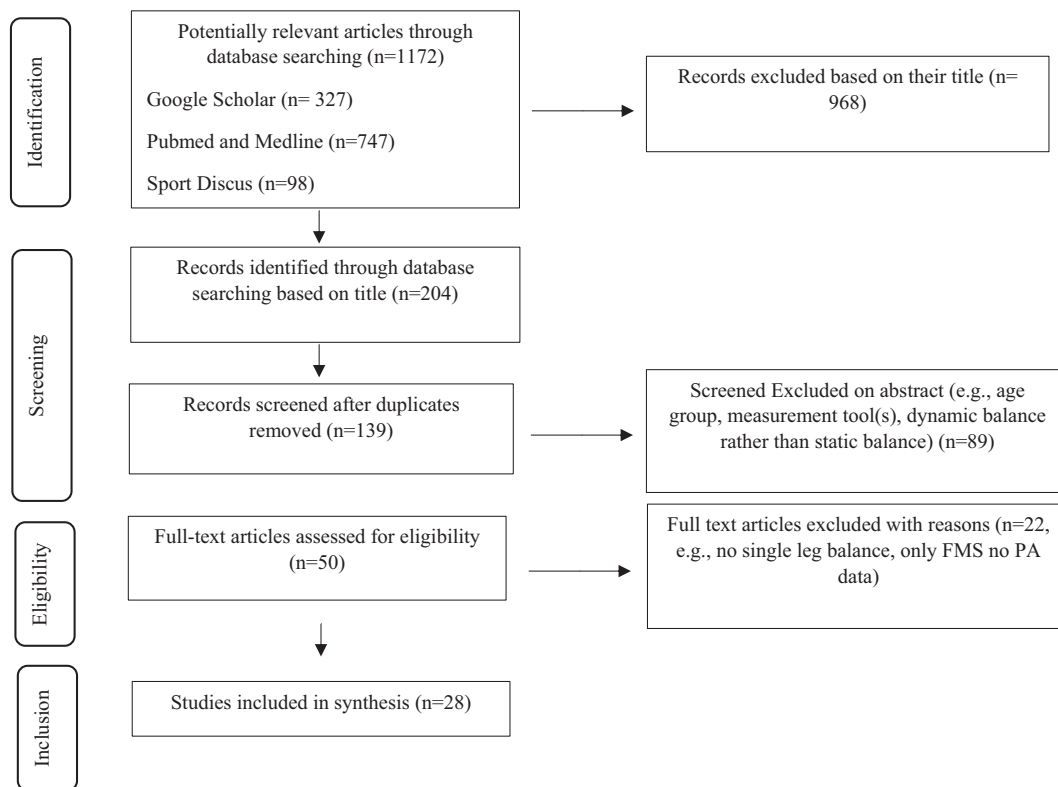
- ✓ How would addressing this research question impact professional practice and/or research?
- ✓ Were there any existing publications that support giving priority to the proposed research question?

Reviewers were also asked:

- ✓ What other comments would you like to make on this research priority?
- ✓ Do you think this research question stands in isolation from the others or could it be part of a thematic cluster?

Step 4: context against published research priorities

As highlighted in Table 2, research groups have previously established research priorities in response to COVID-19 which have been used in conjunction with policymakers and funding agencies globally. Whilst we provide an extension to this work, it is imperative to ensure that our work is positioned in context against those research priorities that have been previously published. As outlined in Fig. 3 and with published recommendations,<sup>23</sup> multiple searches of academic databases (Scopus, PubMed, and Google Scholar) were performed using the following search terms; research priorities, COVID-19, pandemic, and post-pandemic. Returning titles and abstracts were reviewed for suitability and those fulfilling the criteria had their data extracted. The following criteria were used to determine inclusion: i) relevant to COVID-19; ii) proposes research priorities in response to COVID-19; and iii) has relevance to public and global health priorities. The study methodology used to determine research priorities of all eligible papers (n = 7) were extracted, and a critical appraisal from the core research group to review the methodological rigour and established priorities and the relevance to the pandemic and post-pandemic situation was conducted.



**Table 2**  
Summary of published post pandemic and COVID 19 related research priorities.

References	Methodology	Research priorities	Evaluation
Carson, G., Long-COVID Forum Group., (2021)., Research priorities for Long Covid: refined through an international multi-stakeholder forum., <i>BMC Medicine</i> , 19(84). Text link: <a href="https://doi.org/10.1186/s12916-021-01947-0">https://doi.org/10.1186/s12916-021-01947-0</a> Published: 31st March 2021	Public forum to increase understanding of Long-COVID and define research priorities for funders and researchers to take forward.	<ol style="list-style-type: none"> <li>1. The need to establish Global patient voices, asymptomatic and younger groups</li> <li>2. Broader knowledge of Long-COVID and the implications for mild/-</li> <li>3. Global and country-specific responses.</li> <li>4. Reflecting on Chikungunya</li> <li>5. Psychological Health</li> </ol> <p>6. Consensus between ongoing Long-COVID research to understand the aetiology, identify treatments and develop holistic care pathway for rehabilitation, interventions, and social support systems.</p>	<ol style="list-style-type: none"> <li>1. The paper here sets out a list of priorities that have been informed and developed in conjunction with patient groups.</li> <li>2. The paper identifies several important areas for consideration in research and highlights the need for bespoke multi-disciplinary approaches to support patients.</li> <li>3. Whilst the paper acknowledges the complexity of the challenge, there is little insight offered from patients in the approaches that are needed and could be taken to inform the design and development of future research projects.</li> <li>4. There are limited details relating to the study methodology and how the research priorities were derived.</li> </ol>
UK Parliamentary Office of Science and Technology (POST) COVID-19 Areas of Research Interest Link: <a href="https://post.parliament.uk/covid-19-areas-of-research-interest/">https://post.parliament.uk/covid-19-areas-of-research-interest/</a> Published online: 6th October 2020	POST sent an online survey to members of its COVID-19 outbreak expert database and received 1100 responses. The survey included a question about what experts' most important concerns were relating to the impact of the COVID-19 outbreak beyond the next 9 months (long-term concerns). POST worked with David Ralph (University of Southampton) to identify the broad themes of these long-term concerns using machine-learning algorithms. The algorithm clustered responses into 20 themes based on the similarity of their content. After identifying 20 themes, POST surveyed select committee staff in the House of Commons and House of Lords. Committee staff rated each area on importance concerning the UK government's response to COVID-19 over the next year. In total, 33 different parliamentary teams contributed to the final COVID-19 research priorities.	<ol style="list-style-type: none"> <li>1. Lessons learned from the COVID-19 outbreak</li> <li>2. National and international preparedness for future pandemics</li> <li>3. Economic recovery and growth</li> <li>4. Social, economic and health inequalities</li> <li>5. Changes to viability and functioning of businesses</li> <li>6. Sustainable economic recovery and policies to address climate change</li> <li>7. International economy and global trade</li> <li>8. Supply chains and shortages of goods and labour</li> <li>9. Resilience of the economy to future shocks</li> <li>10. Communications strategy for public health messages</li> <li>11. Resilience of society to future shocks</li> <li>12. Changes to the availability of work, working conditions and types of employment</li> <li>13. Surveillance, data collection and data privacy</li> <li>14. Long-term mental health effects of COVID-19</li> <li>15. Changes to the role of education and the future of learning</li> <li>16. Population mental health and well-being</li> <li>17. Long-term physical health effects COVID-19</li> <li>18. Strategy for vaccine development, production, and distribution</li> <li>19. Future sustainability of the NHS and social care system</li> <li>20. Changes to crime, policing and the criminal justice system</li> </ol>	<ol style="list-style-type: none"> <li>1. POST as part of the UK Parliament sets out a comprehensive list of research priorities that are capable of directing future research and policy level activity and is cognisant of the broad and widespread impact of COVID-19. There is little detail relating to the interconnectedness of these priorities, which will be important in the design and delivery of future work in this area and resulting actions.</li> <li>2. It is encouraging that POST includes details relating to post-COVID preparedness for future pandemics, developing the sentiment by health researchers globally that COVID-19 will not be the last global pandemic. Seeing the learning from this work come to fruition is of great interest.</li> <li>3. The research priorities highlight the broad and international need for COVID-19 research and the report provides guidance on how this information will be used by UK parliament and by researchers with an interest in COVID-19 research. At the heart of this and what should be included here is the need to establish international collaboration between patients, clinical, academic, and governmental agencies to unify approaches and address the global impacts that have already and will continue to prevail in the COVID-19 legacy.</li> </ol>
The World Health Organisation and its R&D Blueprint is a global strategy that allows the rapid activation of research and development activities during epidemics and pandemics. It aims to fast-track the availability of effective tests, vaccines, medicines, and research that can be used to save lives and avert large scale crises. The R&D Blueprint is a global coalition of experts from medical, scientific, and regulatory backgrounds. There is no detail relating to the mythological process that was undertaken in the publishing of the report.	<p>The themes of activity are consolidated into key areas that are served by several established international working groups. Broadly these can be defined into the following areas:</p> <ol style="list-style-type: none"> <li>1. Vaccines</li> <li>2. Therapeutics</li> <li>3. Diagnostics</li> <li>4. Ethics</li> <li>5. Social Science</li> <li>6. Clinical Management</li> <li>7. IPC including HWs</li> </ol> <p>8. Epidemiological StudiesWHO also highlight further research and strategies are needed in the areas of:</p> <ol style="list-style-type: none"> <li>1. Addressing public health concerns</li> <li>2. Research with fair and equitable access</li> <li>3. Investment in research priorities with a long-term outlook</li> <li>4. Develop approaches that are broad in scope and maintain longitudinal focus.</li> </ol>	<ol style="list-style-type: none"> <li>1. The priorities set out a broad and international collaborative focus that can be utilised and adopted into practice by researchers, research funders and government agencies globally.</li> <li>2. The blueprint sets out a plan of action that can be broadly interpreted and tailored to suit the needs and or approaches to be taken by a global audience but little insight into the approaches taken as a collective international response is offered.</li> <li>3. The areas of activity are covered by many established international working groups but there is little detail in their membership and how these were used in the development of the recommendations for future research.</li> </ol>	
World Health Organisation: Research and Development (R&D) Blueprint and COVID-19 Text Link: <a href="https://www.who.int/teams/blueprint/covid-19">https://www.who.int/teams/blueprint/covid-19</a> Published online: 13th May 2021			

### 1. Groups, cohesion, and conflict:

- How does collective identification impact social responsibility and adherence to anti-pandemic measures?
- How can we nurture the development and persistence of mutual aid and pro-social behaviours?
  - What is the relationship between group membership, connectedness, and well-being?
- Under what conditions do unity and social solidarity give way to intergroup division and social conflict?

### 2. Work environment and working arrangements

- What is the impact of remote and flexible working arrangements on employee health, mental wellbeing, teamwork, performance, organizational productivity, and colleague/client relationships?
  - What is the impact of social distancing in the workplace on employee health, mental well-being?
  - teamwork, performance, organizational productivity, and colleague/client relationships?
- How can organizational resilience be developed to deal with the impact of COVID-19 whilst supporting employees and protecting jobs?

### 3. Children and families

- How will the COVID-19 pandemic affect children's development?
  - How will the COVID-19 pandemic affect family functioning?

### 4. Educational practices

- How do school closures influence children's educational progress and well-being?
  - What kinds of support improve long-term outcomes for children and young people?
  - How can support services be effectively delivered to vulnerable children and young people, families, and schools?

### 5. Mental health

- What are the immediate and longer-term consequences of COVID-19 for mental health outcomes?
- What changes in approaches resulting from the pandemic need to be harnessed for the future?
  - 6. Physical health and the brain

- Does COVID-19 have neurological effects on the brain with consequences for mental health?
- What are the psychological impacts of the COVID-19 pandemic on physical and mental health?
  - 7. Behaviour change and adherence

- How do we best apply existing theories and tools to promote sustained behaviour change among?
  - policymakers, key workers, and the public/patients?
- How do we develop new theories and tools to promote sustained behaviour change?

The British Psychological Society convened a core group of nine experts who met regularly over 4 weeks to develop the research priorities. The experts represented broad areas of the psychology discipline and were assisted by a wider advisory group of psychological scientists from a range of UK higher education institutions. The input was also received from international experts.

Following a survey of 539 psychological scientists, an iterative consensus procedure was used to elicit and distil the judgments of experts on the research priorities for psychological science. The consensus was achieved through discussion and meetings of the core group and experts were encouraged to discuss with the wider advisory group and their professional networks in between meetings.

O'Connor, D. B., et al. (2020), Research priorities for the COVID-19 pandemic and beyond: A call to action for psychological science, *British Journal of Psychology*, 111, 603–629.

Text link: <https://bpspsychub.onlinelibrary.wiley.com/doi/pdf/10.1111/bjop.12468>

Published: 19th July 2020.

1. O'Connor et al and the British Psychological Society set out a series of research priorities that broadly cover the discipline areas of psychology developed using a detailed methodological approach to support helping society recover.
  2. The areas of focus are closely linked to the priorities outlined by other groups and aligned to the expertise of the BPS but the detail of how the psychological priorities and non-psychological organisations/disciplines are not well established/detailed. The importance of the priorities that have been detailed will address some of the biggest global impacts of COVID-19, especially the mental health impacts of patients and the public are acknowledged here but greater consideration and detail of how this will be incorporated into developing resultant support mechanisms that are multi-disciplinary and collaborative are needed.
  3. The inclusion of behavioural approaches is important in the design and delivery of immediate support for the patient and broader society. It is acknowledged that pre-COVID health status was an effective strategy to prevent serious COVID-19 related illness and with future learning and pandemic preparedness, the role of behaviour change to promote improved health status and subsequent outcomes is pivotal to prevent a repeat of the COVID-19 is pivotal. Acknowledging this and establishing collaborative links with health scientists in clinical and non-clinical settings to develop efficacious health promotion strategies that can be championed by governments globally could lead to profound impacts in global health and wellbeing alongside broad societal and economical areas.

(continued on next page)

Table 2 (continued)

References	Methodology	Research priorities	Evaluation
		The research priorities highlighted are categorised as either immediate or longer-term strategic priorities.	
		<ol style="list-style-type: none"> <li>1. Mental health consequences of COVID-19 and associated lockdowns in the general population and for vulnerable groups and how these can be mitigated? Immediate actions: <ul style="list-style-type: none"> <li>• Determine ways of signposting and delivering mental health services for vulnerable groups.</li> <li>• Identify and evaluate outreach methods to support those at risk of abuse within the home.</li> <li>• Ascertain evidence-based interventions that can be repurposed for COVID-19.</li> <li>• Identify gaps requiring bespoke interventions to boost wellbeing and reduce mental health issues.</li> <li>• Provide interventions to promote mental wellbeing in front-line healthcare workers exposed to stress and trauma that can be delivered now and at scale.</li> </ul> </li> <li>Longer-term strategic priorities: <ul style="list-style-type: none"> <li>• Design bespoke approaches for population-level interventions targeted at the prevention and treatment of mental health symptoms and boosting coping and resilience.</li> <li>• Develop interventions from experimental and social sciences to help mental health.</li> <li>• Assess the effectiveness of arts-based and life-skills based interventions and other generative activities including exercise outdoors.</li> </ul> </li> </ol>	<ol style="list-style-type: none"> <li>1. The position paper from Holmes et al. is poignant and sets out a series of research priorities that address the mental health issues being felt globally during the COVID-19 pandemic. The iterative process used in determining the established priorities is rigorous and whilst there is a crossover to the paper by O'Connor et al., here the short and long-term considerations to guide research are outlined.</li> <li>2. The use of existing intervention approaches that can be repurposed and scaled to support the COVID-19 pandemic are suggested alongside the need to identify knowledge gaps that require bespoke approaches. The mental and physical challenges of the COVID-19 pandemic and its impacts are broad and have undoubtedly propagated mental health issues that were previously not widely recognised or as prominent (e.g., isolation and confinements imposed by lockdowns and social distancing, remote working and reduced social interaction and sustained uncertainty around transmission and emerging variants). These issues present a global challenge across the life span that must be addressed with bespoke COVID-19 approaches.</li> <li>3. The development of interventions that consider the knowledge and expertise of the social sciences will be imperative to addressing the mental health impacts of the pandemic. The paper highlights the role and importance of physical activity and being outdoors which are widely used but confounded by adherence, accessibility, and scalability.</li> <li>4. This creates the opportunity for the social and physical sciences to work collaboratively to create and deliver impactful and scalable intervention approaches to support patients in the post-COVID phase and more broadly the general public who have been impacted by the pandemic.</li> <li>5. There is a clear role for governing bodies and specific organisations to take responsibility for driving effective cross-disciplinary working and collaboration to address the global need.</li> </ol>
		<p>The research priorities were established in a three-part process:</p> <ol style="list-style-type: none"> <li>1. An interdisciplinary group of world-leading experts (<math>n = 24</math>), which incorporated people with lived experience of a mental health issue from across the bio-psycho-social spectrum of expertise in mental health science formed an expert advisory group.</li> <li>2. Thematic analysis was conducted on data from an online survey (<math>n = 2198</math>). The survey collected data on people's two biggest concerns about the mental health and wellbeing implications of the COVID-19.</li> <li>3. Two questions were asked on Ipsos MORI's online Omnibus survey to collect further data on people's concerns about the effect of COVID-19 on mental wellbeing. One thousand and ninety-nine interviews were completed using a representative sample from the UK.</li> </ol>	
<p>Holmes, E. A., et al. (2020), Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science., <i>The Lancet Psychiatry</i>, 7(6), 547–560. Text link: <a href="https://www.thelancet.com/journals/lanpsy/article/PIIS2215-0366(20)30168-1/fulltext">https://www.thelancet.com/journals/lanpsy/article/PIIS2215-0366(20)30168-1/fulltext</a> Published: 15th April 2020</p>		<ol style="list-style-type: none"> <li>1. Understand the role of repeated media consumption in amplifying distress and anxiety, and optimal patterns of consumption for wellbeing</li> <li>2. What is the effect of media consumption about COVID-19 in traditional and social media on mental health, and how can wellbeing be promoted? Immediate actions: <ul style="list-style-type: none"> <li>• Develop strategies and mitigate over-exposure to media, including encouraging diverse populations to stay informed by authoritative sources.</li> <li>Longer-term strategic priorities: <ul style="list-style-type: none"> <li>• Inform media policy on pandemic reporting.</li> <li>• Mitigate individuals' risk of misinformation.</li> </ul> </li> <li>• Understand and harness the uses of traditional media, online gaming, and social media platforms.</li> </ul> </li> <li>3. Promoting successful adherence to behavioural advice about COVID-19 and enabling mental wellbeing and minimizing distress? Immediate actions: <ul style="list-style-type: none"> <li>• Understand how health messaging can optimise behaviour change and reduce unintended mental health issues.</li> <li>• Track perceptions of and responses to public health messages to allow iterative improvements, informed by mental health science.</li> </ul> </li> </ol>	



- Synthesise an evidence base of lessons learned for future pandemics.
  - Understand the facilitators and barriers for activities that promote good mental health.
  - Promote people's care and concern for others, fostering collective solidarity and altruism.
4. Neuroscience: effects of the virus on brain health and mental health
- Immediate actions:
- Build a neuropsychological database of UK coronavirus disease 2019 cases that is inclusive.
  - Expand facilities for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infected tissue handling.
    - Longer-term strategic priorities:
  - 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 detailed methods.
  - Develop interventions to interrupt or prevent the biological effects of SARS-CoV-2 on brain function and mental health.

The research priorities were summarized in four themes:

1. Firstly, enabling efficient clinical decision-making and preventing delays in access to treatment, protecting overstretched healthcare resources and providing prognostic information that can be used to inform patient care.
2. Secondly, minimizing disruption to society and facilitating a return to pre-pandemic life, to reduce stigma and isolation associated with COVID-19.
3. Thirdly, protecting communities and highlighting the need for sensor technologies that can trigger contact tracing, establish safe environments, safeguard the vulnerable, gauge individual susceptibility to COVID-19, and mitigate the risk for healthcare workers.
4. Finally, preparedness for the next phase(s) of the pandemic' requires sensor technology to be relevant and responsive to the development of vaccines and patient support pathways over the longer term.

Forty-three participants completed an online survey. Participants included patients with COVID-19, family members, members of the public, scientists, engineers, health professionals, policymakers, industry representatives and research funders. Research statements were ranked in order of priority using a 9-point Likert scale. Statements that achieved a median of >7 were discussed at an online consensus workshop ( $n = 65$ ).

Tong, A., et al., (2021)., Research priorities for COVID-19 sensor technology., *Nature Biotechnology*., 39, pages144–147 (2021)  
Text link: <https://www.nature.com/articles/s41587-021-00816-8>  
Published: 18th January 2021

1. The role of sensor technologies in healthcare settings has dramatically increased this century and pioneering technologies exist broadly across healthcare services. The COVID-19 pandemic has further highlighted the role and the importance of integrating sensor technology to support patients and optimise healthcare provision is highlighted in the resulting research priorities in this paper.
2. The methodology used a broad range of participants from patients to clinical specialists and policymakers to research funders. An important omission is a representation from primary care settings (i.e., general practitioners, physiotherapists, physical therapists, and counsellors) who are likely to be at the forefront of the delivery of the long-standing issues associated with COVID-19 e.g., community-based support pathways. What is apparent if to address the complexity and global need is multi-disciplinary collaborations that consider and includes all stakeholders.
3. The idea of addressing the next phases of the pandemic is presented but little detail is provided to highlight what this includes. The current global picture presents a concerning and longstanding issue that must address sustained transmission, new variants, and mutation of COVID-19 and the legacy impacts for patients with profound symptoms profiles post COVID-19. On this last point, sensor technology and the associated innovation could provide useful tools and resources that can be integrated into COVID-19 specific support mechanisms and rehabilitation approaches to restore the functional status and quality of life.

(continued on next page)

Table 2 (continued)

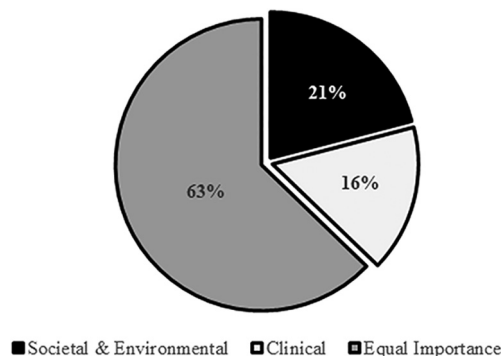
References	Methodology	Research priorities	Evaluation
	Existing priorities now requiring greater research emphasis: 1. Infection recurrence: Understanding infections and outcomes in vulnerable populations including children, persons living with disabilities, ethnic groups 2. Relationship between repeated viral exposure and disease severity in frontline workers 3. The effects of the disease on pregnant women 4. Effective use of personal protective equipment for frontline healthcare workers (emphasis on nurses) 5. Health systems research and strengthening to mitigate the impact of COVID-19 on capacity 6. The understanding zoonotic leap between humans and animals 7. The impact of redirecting resources and public health interventions toward COVID-19 on other disease burdens 8. Adherence to and trust in public health interventions such as quarantine and social distancing 9. Evaluation of public health interventions in varied settings 10. Public health messaging and addressing myths and mistrust 11. Engaging relevant stakeholders (including religious leaders) in research to enhance community sensitisation, adherence to public health measures, detection, and surveillance 12. Effective and feasible ways of community engagement during lockdowns and social distancing. New research priorities: 1. Virus natural history, transmission, and diagnostics 2. Epidemiological studies 3. Clinical management 4. Candidate therapeutics R&D 5. Candidate vaccines R&D 6. Ethical considerations for research 7. Social sciences in the outbreak response 8. Infection prevention and control 9. The environmental impact of the response to COVID-19 10. Preparing for the next pandemic 11. Cross-cutting		
	A mixed-method multi-stage process was used in the development of the subsequent research priorities. 1. An online survey ( $n = 1528$ ) was developed from an existing African Academy of Science project. Seventy- three potential priorities were arranged under the nine headings used in the Research World Health Organisation roadmap. Participants ranked three options for both short-term and long-term priorities. Free text boxes were provided under each topic, where participants were asked to list any priorities, they felt were not included. 2. Virtual workshops were held to seek comment and discussion on the survey findings and to discuss current priorities and unmet research areas priority framework. 3. Ten open access ( $n = 2559$ ) workshops were held with research teams and health workers across the globe, led by the Global Health Network COVID-19 Research Implementation and Knowledge Hub. A thematic content analysis methodology was developed to report the findings.		
Norton, A., et al., (2020), The remaining unknowns: a mixed methods study of the current and global health research priorities for COVID-19., <i>BMJ Global Health.</i> , 2020;5: e003306. Text link: <a href="https://gh.bmj.com/content/5/7/e003306">https://gh.bmj.com/content/5/7/e003306</a> Published: 29th July 2020			1. The mapping of research priorities against the established World Health Organisation COVID-19 Roadmap provides an update and extension to existing work by international agencies whilst also providing an opportunity for stakeholders internationally to provide global insight and representation to the challenges being faced in the short and longer-term that is socially and economically representative. 2. Detailed mixed methods approach specifically the survey and subsequent workshops, provide meaningful data that is captured in the decision-making process and provides 3. The new research priorities presented in Table 2, highlight the need for epidemiological investigation and the development of clinical management strategies in the post-hospitalisation phase, whilst this is important and needed the effectiveness of developed vaccines has played some part in reducing hospitalisations and mortality and the data also highlights the challenge for those living in community settings with Long-COVID complications and exacerbated symptom profiles. Therefore, mechanisms of support should consider the broad impact of COVID-19 and the individual experiences that are manifesting globally.



**Fig. 3.** A second word cloud developed following refinement of the research questions and priority areas.

#### Step 5: public engagement and panel consensus

Received submissions were reviewed by the core authorship and confirmed as appropriate for consideration if it addressed a public health need and/or had a significant impact on global health and wellbeing in response to, or if it had been exacerbated by the COVID-19 pandemic. To achieve consensus, recommendations were reviewed in an online survey of network members ( $n = 45$ ) and a series of online focus group meetings with international representation. From the online survey, 63% of participants ranked the social & environmental and clinical research priorities as being equally important (Fig. 4). Stakeholders engaged in focus group discussions ( $N = 8$ ) were encouraged to comment in a non-threatening environment on the need and scale of the challenge to society and public health in the context of COVID-19.



**Fig. 4.** Ranking of importance by HL-Pivot network members between the two theme areas of societal and environmental and clinical research priorities.

#### Previously established research priorities

Our review of existing research in this space, highlighted eight papers/published areas of interest that were reviewed, the results of which are highlighted in Table 2. Concluding our process, we were able to establish eight research priorities that address long-standing societal and environmental (cluster A) and clinical (cluster B) research priorities.

##### Established HL-PIVOT research priorities

Here we present two clusters of research priorities that can be categorised as A: Social and Environmental research themes and B: Clinical research priorities. The total submissions and engagement with stakeholders produced several research priorities that were not included following the conclusion of the consensus process. Detail of these can be found in Table 3. Whilst the authors acknowledge that these are still important and warrant investigation, there is a need to consolidate efforts in the highlighted areas to achieve broad health and wellbeing, societal and economic impact,

##### Cluster A: societal & environmental

This cluster of four questions are linked by ethical concerns related to either ensuring Exercise Science and Sports Medicine: i) treating people equally and ensuring that the most vulnerable can access services; and/or ii) the importance of the environment to human wellbeing and health. A theme evident in the first three questions is the integration of technologies to achieve fairer health care.

**A1: How can we ensure that the opportunity to meet evidence-based guidelines for Physical Activity are equitably distributed?**

**Rationale:** COVID-19 has identified many causal factors for severe health outcomes that are disproportionately affecting people of colour

**Table 3**

Research priorities that were put forward but not included in the resulting priority areas following the consensus process.

1	The importance of considering training and education within (i) healthy living concepts and self-care in health professionals, and (ii) how health professionals incorporate patient education and health promotion.
2	The use of online and digital platforms that can be used to promote and deliver physical activity and the impact upon human behaviour.
3	Investigate the impact of physical activity and exercise on Covid-19 cardiorespiratory sequelae, among other repercussions.
4	Screen time in children (and possibly adults) and the effect on physical and emotional health
5	What impact does COVID-19 infection have on cardiovascular and pulmonary function after recovery?
6	Energy Conservation Techniques to manage Symptoms (e.g., Fatigue, Dyspnoea due to Lung Fibrosis) of long term COVID-19.
7	How can we use lessons from the pandemic to emphasize prevention (i.e., lifestyle medicine)?
8	The impact of physical activity-based rehabilitation in recovery from long COVID.
9	Incorporation of exercise and physical activity into the treatment plans for all patients with chronic conditions.
10	Differentiating the health outcomes that result from progressive levels of physical activity (self-reported vs directly measured [pedometers, accelerometers] and cardiorespiratory fitness (estimated from attained speed/grade or kg/min) or directly measured or distance covered during the 6-min walk test.

and those with poor health status and comorbidities. To address this, we need to implement changes that allow us to move toward a more equitable future. There is a clear need for sustained local, national, and global surveillance of physical activity (PA) and sedentary behaviours. This surveillance should be implemented across multiple settings (e.g., schools, workplaces, communities) and domains (e.g., leisure, occupational), and provide frequent updates (e.g., periodicity of every 5 years). An intentional focus should be placed on social justice that prioritises equity with race, ethnicity, and language being part of the data points available for disaggregation and analyses.<sup>27</sup>

**Proposed methodology:** Traditional research methodologies overlook the complexities of the systems involved. For example, large cohort studies that use multivariate regression to identify broad associations between PA and health outcomes may overlook differences in physiology, behaviours, and social determinants. To address this, computer-based methodologies are needed which adopt a systems science approach to PA research. Incorporating systems approaches and methods means designing and implementing computer-based approaches in ways that account for and help characterize the complex systems involved. This requires approaches that use the power of Artificial Intelligence, Machine Learning and/or Computer-Simulated Modelling to achieve scalable intervention approaches and broad health and social impacts.

**Post-pandemic credentials:** The Pandemic highlighted: i) broad health inequalities; and ii) the importance to incorporate Machine Learning and big data. During the consensus process, the established network ranked this research priority as the highest priority (24%).

**Preparation for the next pandemic:** Surveillance systems enable the ongoing collection, analysis, and dissemination of data to prevent and control disease or injury. Surveillance systems for PA (or sedentary behaviour [SB]) could result in comprehensive data that, when analysed and interpreted using computer-assisted systems science-based methods, could inform population-level PA guidance, advance precision public health, and prevent disease. Comprehensive surveillance would capture the amount of time a person engages in PA or SB throughout the day, during work, their level of cardiorespiratory fitness, during commuting, availability and use of interventions that support PA, and the types of policies that encourage healthy levels of PA. Such data would also provide insight into subpopulations including those who have suffered more severe outcomes of COVID-19 than others, including ethnic groups and those with underlying health conditions.

**International dimension:** The disparities in health outcomes due to COVID-19 have been noted and experienced across the globe.

**Interdisciplinary dimension:** Multidisciplinary approaches are needed to address this question and specifically the bring together of Clinical, Exercise and Computing Sciences.<sup>19,20</sup>

**Justice aspect:** By using surveillance data to identify needs and gaps, people of all walks of life across all aspects of society and community can find ways to contribute to the common good.

**A2: How should virtual models of cardiac rehabilitation developed during the Pandemic be used to improve access to on-site supervised programmes for underserved vulnerable groups?**

**Rationale:** Globally cardiac rehabilitation (CR) programs should continue using the virtual models of delivery developed during COVID-19 to support patients not requiring close monitoring. Post pandemic this will reduce a long-standing burden on resources for patients who had previously been denied referrals owing to restrictive CR eligibility criteria.

**Proposed methodology:** A two-part methodology is proposed. First, survey CR program managers around the world to determine barriers and facilitators to including underserved populations with a needs assessment of the health workforce (e.g., size, composition, competencies, and skill mix to correspond to the health needs of these populations). Second, conduct a systematic review to inform the development of an international web-based resource of best practices to operationalize a mix of CR delivery models. Importantly, there is the need to also investigate the adaptability of existing programs to a variety of health contexts that incorporates co-design methods.

**Post-pandemic credentials:** With the success of virtual programming during the pandemic program managers will be more likely to support the continued use of virtual health delivery models for those that do not require close monitoring. This will free up resources to allow vulnerable patients to attend on-site programming. During the consensus process, the established network ranked this research priority as the joint fourth most important with 10% of the votes.

**Preparation for the next pandemic:** The continued use and development of virtual delivery models would significantly improve the resilience of CR programs come the next Pandemic.

**International dimension:** Globally, 49% of CR programs discontinued delivery during the pandemic.<sup>28</sup> In Canada, within two months of COVID-19, 41% of CR programs closed and ½ of the staff were redeployed. 1-to-1 models of care mostly by phone were adopted. Vulnerable populations became ineligible owing to safety concerns.<sup>29</sup> With evidence of greater disparities in access for these populations during the pandemic, there is an urgent need to redistribute resources to improve access globally.<sup>30</sup> With CR being offered in 111 of 123 countries,<sup>31</sup> there is potential to improve the lives of millions of people who would otherwise have not had access to CR services.

**Interdisciplinary dimension:** Input from patients, caregivers, cardiovascular clinicians, exercise physiologists, and cardiac rehabilitation specialists,<sup>32</sup> would be needed to take this work forward.

**Justice aspect:** People have the right to equitable access to health care services. However, research of people following stroke, peripheral artery disease, and lower-limb amputation pre-pandemic demonstrates that as mobility severity increases, eligibility to be referred to CR programs decreases.<sup>33–35</sup> This is regardless of having or not having a comorbid diagnosis of coronary artery disease. This demonstrates a treatment-risk paradox where the patients who most need CR are ineligible.

**A3: How can Exercise Science address the challenges of general wellness promotion to the vulnerable population through Nature-Based interventions (NBI)?**

**Rationale:** Arguably the greatest contribution that Exercise Science can make to public health lies in the prevention of disease and the promotion of wellness.<sup>36</sup> Post-pandemic, rather than returning to the 'old

normal' when health care services focused on the treatment of disease, there is an opportunity to create a 'new normal' focused on prevention, wellness, and resilience. As well as being better for 'patients' this 'new normal' may also be more rewarding and health-promoting for health and exercise professionals.

**Proposed methodology:** Whilst we know a lot about exercise in clinical and fitness settings, we know comparatively less about the therapeutic value of exercise and PA in natural settings. A two-part methodology is suggested. First, a feasibility interventional study using wearable technologies to measure physiological stress, wellbeing, and influence of NBI's on vulnerable populations. Second, A systematic review of the literature to identify how NBI is defined and another review of the literature to identify the effect of NBI on vulnerable populations' wellbeing.

**Post-pandemic credentials:** We did not know how fragile the current system was until it was fractured by the Pandemic. Incorporating NBI into mainstream healthcare options will also provide opportunities to build conservation elements into wellbeing practices. During the consensus process, the established network ranked this research priority as the joint fourth most important with 10% of the votes.

**Preparation for the next pandemic:** Exploring ways to increase general wellbeing in vulnerable populations (and healthcare workers) may provide a stronger and broader foundation for global resilience.

**International dimension:** As natural settings differ across geographical locations there are opportunities to conduct comparative studies.

**Interdisciplinary dimension:** A focus on NBI would enable Exercise Science to investigate in more detail the environmental determinants and outcomes of active living. This would bring together researchers from a range of disciplines from the social sciences including psychology, geography, and sociology.

**Justice aspect:** As conceived here NBI would not only provide opportunities to work with vulnerable groups but also improve global health.

#### A4: How can Exercise Science, clinical exercise physiologists and Sports Medicine help address the climate change emergency?

**Rationale:** COVID-19 negatively impacted the quality of life for millions of people worldwide. It has damaged societies, crippled economies, and ravaged the educational opportunities of a generation. This wake of destruction cannot be allowed to stand as the Pandemic's only legacy. A 'silver lining' in the very dark cloud of the Pandemic is an opportunity to do more to tackle the climate change emergency. Physical activity is negatively impacted by air pollution, extreme temperatures, and natural disasters which in broader contexts has implications for the global health and wellbeing agenda.<sup>37</sup> Accordingly, exercise science professionals as part of their roles should be advocates for climate change initiatives to improve climate change goals and health outcomes in an interconnected approach.<sup>38</sup>

**Proposed methodology:** The proposed research methodology is as follows. A systematic review of the literature to identify what other scientific disciplines professions and organisations are doing to actively reduce their carbon footprint and to become more sustainable. A survey of the world's Exercise Science professional bodies and learned societies (e.g., British Association of Sport and Exercise Science and the American College of Sports Medicine) to establish what actions are being taken. A longitudinal case study of an Exercise Science Laboratory and/or clinic to demonstrate a process of change aimed at decreasing its carbon footprint.

**Post-pandemic credentials:** This question could have been asked before the Pandemic but was not. It has taken COVID-19 to remind us of the fragility of the human condition. During the consensus process, the established network ranked this priority as the fifth most important with 6% of the votes.

**Preparation for the next pandemic:** It is a sobering thought that the Climate Change Emergency presents a bigger existential threat to humankind than COVID-19. In that sense, it is the next 'pandemic' or more accurately a 'syndemic' requiring urgent action.<sup>39</sup>

**International dimension:** Climate change is recognised as a global challenge.

**Interdisciplinary dimension:** The interdisciplinary dimension to this research question is the need to develop sustainable practice in physiology, psychology, and biomechanics. This is inclusive of but not limited to reducing laboratory consumable budgets, moving away from single-use plastics, and looking at sustainable practices for conferences/international meetings.

**Justice aspect:** Sanders (2020) writes 'From Aristotle to the American republican tradition, from Hegel to Catholic social teaching, theories of contributive justice teach us that we are most fully human when we contribute to the common good and earn the esteem of our fellow citizens for the contribution we make' (page 212,<sup>40</sup>). By acting proactively to help address the climate change emergency we will make a positive contribution to the global common good.

#### Cluster B: clinical

This cluster of questions focus on clinical issues and focus on a variety of ways of patient care either in the acute or chronic stage of infection. In this way, they are different but complementary to the questions proposed in Cluster A.

#### B1: How will we screen and identify pulmonary arterial hypertension (PH) among patients in post-COVID-19 rehabilitation?

**Rationale:** COVID-19 has a direct impact upon the cardio-respiratory systems and its sequelae have broad implications for exercise intolerance and healthy lifestyle behaviours.<sup>5,41</sup> The incidence of PH may increase post-pandemic.<sup>42</sup> Therefore, it is important to understand the factors that contribute to chronic exercise intolerance among those infected by the virus. This will affect how professionals prescribe exercise to improve functional status. Researchers across specialisations should be prepared to implement large-scale, well-conducted multi-national follow-up registries to i) monitor the incidence of PH post-pandemic; and ii) inform rehabilitation approaches.

**Proposed methodology:** Approaches to addressing this question include surveying exercise specialists to determine evaluation and prescription patterns for those with PH. In addition, observational studies focused on exercise-based evaluations (e.g., cardiopulmonary exercise testing; CPX or functional tests) in COVID-19 survivors with and without PH are vital to identify specific responses to exercise when used in isolation or combination with other investigations such as transthoracic echocardiography and pulmonary function tests. The relevance of PA cannot be understated and assessing PA (objectively and subjectively), activities of daily living and experiences (qualitatively) among COVID-19 survivors with and without PH are important areas to study. Knowing that the various exercise limitations in PH respond to exercise training,<sup>43,44</sup> it is important to assess the effects of exercise training interventions in COVID-19 survivors +PH and also study the recovery trajectories of cardiorespiratory fitness among COVID-19 survivors with and without PH.

**Post-pandemic credentials:** This question focuses on COVID-19 survivors and addresses an important pandemic legacy. During the consensus process, the established network ranked this research priority as the least important with 1% of the total votes.

**Preparation for the next pandemic:** Improving our understanding of PH would improve healthcare when the next virus reaches pandemic status.

**International dimension:** Anecdotal evidence suggests a geographical variation in the occurrence of PH among COVID-19 survivors.

**Interdisciplinary dimension:** This area of research will require the involvement of basic scientists, molecular biologists, clinicians in cardiology and pulmonology, exercise scientists and rehabilitation experts.

**Justice aspect:** In resource-limited settings, where access to CPX is limited, the use of alternate field tests could increase access.<sup>45</sup>

**B2: How can clinical exercise physiology help prevent and respond to chronic symptomatology (e.g., fatigue) related to viral infections including COVID-19?**

**Rationale:** The pandemic has spotlighted the need to learn more about how to manage long-haul symptomatology.

**Proposed methodology:** A Randomised Control Trial (RCT) on the effects of exercise on chronic fatigue and other symptoms in individuals with long-haul COVID-19.

**Post-pandemic credentials:** We can learn from analysing data from pre and during the pandemic to learn about health behaviours that are related to symptoms and outcomes. During the consensus process, the established network ranked this research priority as the third most important with 16% of the votes.

**Preparation for the next pandemic:** The next pandemic may result in some patients suffering from chronic symptoms such as fatigue. By learning from this pandemic, we can be better placed to develop bespoke support mechanisms to care for affected patients.

**International dimension:** The findings from this study will have a global impact and sit across political borders.

**Interdisciplinary dimension:** The response of clinical exercise physiologists to addressing the prevalence of symptoms due to pandemic disease is specific to the field but there are large public health implications to this research question, especially in understanding the cause and effect between healthy behaviours and symptomatology.

**Justice aspect:** The assessment of health behaviours will always be framed within these themes.

By reducing the chronic impact of COVID-19 survivors will be better placed to contribute to society and stay in employment thereby reducing the risk of them falling into poverty.

**B3: What are the long-term impacts of 24-h activity behaviours (PA, sedentary, sleep) and cardiometabolic health?**

**Rationale:** COVID-19 has markedly impacted health behaviours, including PA.<sup>11</sup> Many have had to adapt their lifestyles, of which, some adaptations are likely to persist. Currently, while it is clear that *moving more and sitting less* leads to numerous health benefits,<sup>46,47</sup> the minimum amount needed and optimal combination of activity behaviours to promote health is unknown. In addition, more research is needed to understand the determinants of these behaviours and how to effectively promote behaviour change and long-term adherence.<sup>48</sup>

**Proposed methodology:** A systematic review of the literature reporting on activity behaviours during and post-COVID. This was followed by the collection of observational cohort data to determine which cluster of 24-h activity behaviours is most associated with cardiometabolic disease risk, and the multi-level determinants of the cluster.

**Post-pandemic credentials:** The PA behaviours component has been well-researched, and sleep and sedentary behaviour research have gained momentum. The interest in these behaviours has been accelerated during COVID-19. During the consensus process, the established network ranked this research priority as joint second highest with 17% of the votes.

**Preparation for the next pandemic:** An increased understanding of how activity behaviours interact with other behaviours will help us prepare for the next health crises.

**International dimension:** Health enhancing behaviours over the 24-h cycle will likely differ across cultures, providing an opportunity for international and cross-cultural comparisons.

**Interdisciplinary dimension:** To address this question will require input from physiology, psychology, public health, systems science, and implementation science.

**Justice aspect:** Minority groups have been disproportionately affected by COVID-19 and are frequently less resourced and therefore less resilient.<sup>27</sup>

**B4: What is the impact of PA on the severity of COVID-19 infection, and which are the determinants of a poor prognosis in athletes?**

**Rationale:** Whilst several studies have shown that for the majority of people PA has helped protect individuals from the more severe effects of

COVID-19 infection: i) the mechanism by which this happens remains unclear, and ii) despite high levels of fitness some athletes have been severely impacted when infected.<sup>49–51</sup>

**Proposed methodology:** A two-part methodology is proposed. First, a questionnaire would collect data from medical care institutions to 'mine' their data on this subject. Second, patients would be interviewed by phone to collect retrospective data relating to their training history, competition status and experience of COVID-19 concerning infection and impact upon training and by extension the implication on physical and mental wellbeing.

**Post-pandemic credentials:** During the pandemic, all resources were rightly directed to respond to the immediate challenge of saving lives and preventing transmission. When the pandemic is over, studies such as the one proposed here will help us understand 'what just happened.' During the consensus process, the established network ranked this research priority as joint second highest with 17% of the votes.

**Preparation for the next pandemic:** Reflections and learning from this would enable us to know what levels and methods of physical activity are most beneficial and which is compromising during the next pandemic.

**International dimension:** This question addresses an issue that is a global challenge.

**Interdisciplinary dimension:** There is an interdisciplinary dimension to this question in that it would need input from a range of disciplines and medical specialists.

**Justice aspect:** By routinely advising appropriate levels of PA, we contribute to the public good, especially for the most vulnerable in our societies who may be unable to pay for adequate treatment.

## Discussion

Increased collaborative efforts and global initiatives have permitted the development of efficacious vaccines and acute management strategies that have and continue to be effective in reducing severe illness and mortality during these latter stages of the COVID-19 pandemic. Whilst concentrated efforts are required to ensure that vaccines and treatments are accessible and equitable for all,<sup>52</sup> there is a need to focus on the long-term impacts that will undoubtedly pose challenges to health settings and providers and have a long-standing impact upon population health and well-being. This includes the need to strengthen links between scientists, health care professionals and the community to develop targeted support and rehabilitative pathways aimed at increasing functional status and quality of life. In addition, there is a need to reflect on the lessons that have been learnt during the COVID-19 pandemic and begin planning and developing proactive mitigation strategies in preparation for the next pandemic/global health crisis. Finally, there is a need to celebrate and forge interdisciplinary collaborations and maximise the global appetite for collaborative efforts to address long-standing health challenges.<sup>9</sup> These can be impacted by the adoption of healthy lifestyle behaviours to mitigate the burden on health care services and economies globally. A previously published consensus statement entitled "Healthy lifestyle interventions to combat noncommunicable disease—a novel non-hierarchical connectivity model for key stakeholders: a policy statement from the American Heart Association, European Society of Cardiology, European Association for Cardiovascular Prevention and Rehabilitation, and American College of Preventive Medicine" called for a forward-thinking community model to address the chronic disease crisis.<sup>28,53</sup> These same principles apply in the COVID-19 era, perhaps more so.

Whilst we acknowledge at the time of writing that the COVID-19 pandemic is not yet over, there appears to be a glimmer of light at the end of a very long tunnel. The threat of sustained transmission and the threat of emerging variants remains real and serious threats to global health and wellbeing, global and domestic economies, and the multitude of ways in which society interacts. As we look forward to the endemic phase of COVID-19 in the near future, there are considerable knowledge gaps and complexities that need to be addressed and

should inform the development of research questions and hypotheses designed to generate results that will instruct clinical practices, initiate policy development, and influence international health agendas. Previous attempts to address the COVID-19 research agenda were the result of a need to develop effective treatments or understand the implications of imposed social restrictions. Whereas this was imperative to the international management of the pandemic, the evidence and longstanding impacts are only now coming to fruition. Accordingly, we consulted a multi-disciplinary international group of experts with varying backgrounds and a shared enthusiasm for promoting healthy-lifestyle behaviours to conceptualise and direct research in the endemic phase. We are conscious of a perceived bias in the publication of the resulting research priorities but feel that the methodology utilised was evidence-based and in line with best practice recommendations that was established in accepted epistemological approaches and that permitted scrutiny of a 'group think' approach.<sup>23</sup> Accordingly, the resulting research priorities are driven by a need for collaborative approaches to tackling new and longstanding issues that pose challenges to population health and wellbeing.

## Conclusion

COVID-19 has and continues to have broad implications for population health and wellbeing. Here we propose eight research priorities that have been developed by leading researchers, clinicians and health professionals that can address long-term pandemic impacts and global health challenges. The proposed research priorities can answer the 'so what?' challenge as they have a direct link to improving public health through optimising patient care and advocating healthy lifestyle behaviours.

## Research funding

None.

## Authorship contributions

AS MF and RA were responsible for conceiving the project idea and leading the project through to completion. AB, JC, SM, DP, AV, NP, and LS were responsible for the delivery and reviewing of submissions and formed the panel with AS, MF and RA to reach this consensus.

## Declaration of Competing Interest

Andy Smith is Chair of the Climate Action Change Team of the British Association of Sport and Exercise Sciences.

No other authors have conflicts to declare.

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