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

Mark A. Faghy, Ross Arena, Abraham Samuel Babu, Jeffrey W. Christle, Susan Marzolini, Dejana Popovic, Amber Vermeesch, Nicolaas P. Pronk, Lee Stoner, Andy Smith, on behalf of the HL-PIVOT Network

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. This methodology was deployed by an international and interdisciplinary team from the Healthy Living for Pandemic Event Protection (HL-PIVOT) network. 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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Keywords: COVID-19 Research Priorities Health and wellbeing Collaboration exercise medicine Pandemic legacy Prevention

Methods

Step 1: call for submissions

The people

Step 3: review of submissions

Step 4: context against published research priorities

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.

* Corresponding author at: Human Sciences Research Centre, University of Derby, England, UK.

E-mail address: M.Faghy@Derby.ac.uk (M.A. Faghy).

Denotes equal contribution.
Longstanding health crises have affected global health for decades and have troublingly synergized with the coronavirus disease 2019 (COVID-19) pandemic.\(^2\) Numerous studies have highlighted the impacts of living an unhealthy lifestyle,\(^3\) 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,\(^6,10\) 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 accelerated 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\(^12\) and to address factors associated with living in forced isolation.\(^15\) 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.\(^19\) 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\(^11\) and to mitigate against the longstanding impacts of COVID-19. Acknowledging the need and importance of rigour in achieving consensus, 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.\(^24\) 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.\(^23\) 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.\(^25\) These demographics capture the much-needed interdisciplinary 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.](image-url)

| Step | Public Engagement and Panel Meetings to achieve consensus |
|------|----------------------------------------------------------|
| 1    | Initial Call sent to HL-Pivot Network Members             |
| 2    | Submissions received using an established template shown in Table 1 |
| 3    | Review of submissions by core research group             |
| 4    | Mapping of submissions against peer-reviewed and published research priorities in context of COVID-19 |
| 5    | Public Engagement and Panel Meetings to achieve consensus |
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.

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 specialties 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 interdisciplinary 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. The need for interdisciplinary research has been recognised. |
| Is there a social or contributive justice aspect to your research question?          | 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.                                               |
| Is there an interdisciplinary dimension to your research question or proposed methodology? If so, can you explain it? | This item helped locate the proposed research priorities within the existing literature.                                                                                                                                 |
| Is there an interdisciplinary dimension to your research question or proposed methodology? If so, please reflect upon it here. | This open question was designed to ensure that responders had every opportunity to unpack their thinking.                                                                                                    |
| 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.                                                                                                    |

‘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...’
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 AstraZeneca 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,23 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.

Records excluded based on their title (n= 968)

Screened Excluded on abstract (e.g., age group, measurement tool(s), dynamic balance rather than static balance) (n=89)

Full text articles excluded with reasons (n=22, e.g., no single leg balance, only FMS no PA data)

Studies included in synthesis (n=28)
Summary of published post-pandemic and COVID-19 related research priorities.

| Research priorities |
|---------------------|
| Summary of published post-pandemic and COVID-19 related research priorities. |
| Methodology |
| POST sought to establish a Global patient voice and the implications for mid- and long-term planning. |
| Public forum to increase understanding of Long-COVID and define research priorities for funders and researchers to take forward. |
| Long-COVID and define research priorities for funders and researchers to take forward. |
| POST sent an online survey to members of its COVID-19 Areas of Research Interest Link: https://post.parliament.uk/areas-of-research-interest/ |
| The research priorities highlight the broad and international collaboration between patients, clinical, economic, and social scientists, and policy-makers that are needed to understand the aetiology, identify potential treatments, and develop holistic care pathways for rehabilitation, interventions, and social support systems. |
| The research priorities set out a broad and international collaborative approach by cross-referencing with the R&D Blueprint and ensuring the research priorities are informed by the rapid, effective, and ethical development of vaccines, medicines, and tests. |
| The World Health Organization and the R&D Blueprint are global strategies that allow the rapid activation of research and development activities to ensure the availability of effective vaccines, medicines, and tests. Vaccines, medicines, and tests can be used to save lives and avert large-scale suffering. |

| Evaluation |
| 1. The priorities set out a broad and international collaborative approach by cross-referencing with the R&D Blueprint and ensuring the research priorities are informed by the rapid, effective, and ethical development of vaccines, medicines, and tests. Vaccines, medicines, and tests can be used to save lives and avert large-scale suffering. |
| 2. The blueprint sets out a plan of action that can be broadly interpreted and tailored to suit the needs of countries and regions. It is important that COVID-19 research and the rapid development of vaccines, medicines, and tests are not about the mythological or political will of any one nation but about the need to provide effective health outcomes for all. |
| 3. The areas of activity are covered by many established international working groups and there is little detail in the report about the development of new international collaborations or the relationship between the R&D Blueprint and other global health strategies. |
| 4. Development approaches that are broad in scope and maintain longitudinal focus. |

References:
1. Carson, G., Long-COVID Forum Group., (2021),. 
2. Post-COVID: priorities for future research and policy following the COVID-19 pandemic. 
3. Global and country-specific responses. 
4. Biondi-Zoccai, G.G., Carinci, F., Corrigan, J.C., et al. (2020). 
5. Psychological health. 
6. Public forum to increase understanding of Long-COVID and develop holistic care pathways for rehabilitation, interventions, and social support systems. 
7. Sustainability. 
8. Economic recovery and growth. 
9. Social, economic, and health inequalities. 
10. Resilience of the economy to future shocks. 
11. Resilience of society to future shocks. 
12. Changes to the availability of work, working conditions and types of work. 
13. Surveillance, data collection and data privacy. 
14. Democratic participation and data privacy. 
15. Change to democratic participation and data privacy. 
16. Change to democratic participation and data privacy. 
17. Change to democratic participation and data privacy. 
18. Strategy for vaccine development, production, and distribution. 
19. Future sustainability of the NHS and social care system. 
20. Change to clinical, population, and health justice systems. 

Methodology:
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3. The areas of activity are covered by many established international working groups and there is little detail in the report about the development of new international collaborations or the relationship between the R&D Blueprint and other global health strategies. 
4. Development approaches that are broad in scope and maintain longitudinal focus.
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.

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 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?
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 psychobiological 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?

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. 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)
The research priorities highlighted are categorised as either immediate or longer-term strategic priorities.

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:
     - Determine ways of signposting and delivering mental health services for vulnerable groups.
     - Ascertain evidence-based interventions that can be repurposed for mental health issues being felt globally during the COVID-19 pandemic.
     - Identify gaps requiring bespoke interventions to boost wellbeing and reduce mental health issues.
     - Provide interventions to promote mental wellbeing in frontline healthcare workers exposed to stress and trauma that can be delivered now and at scale.

   - Longer-term strategic priorities:
     - Design bespoke approaches for population-level interventions targeted at the prevention and treatment of mental health symptoms and boosting coping and resilience.
     - Develop interventions from experimental and social sciences to help mental health.
     - Assess the effectiveness of arts-based and life-skills based interventions and other generative activities including exercise outdoors.

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:
     - Understand the role of repeated media consumption in amplifying distress and anxiety, and optimal patterns of consumption for wellbeing.
     - Develop strategies and mitigate over-exposure to media, including encouraging diverse populations to stay informed by authoritative sources.

   - Longer-term strategic priorities:
     - Inform media policy on pandemic reporting.
     - Mitigate individuals’ risk of misinformation.
     - Understand and harness the uses of traditional media, online gaming, and social media platforms.

3. Promoting successful adherence to behavioural advice about COVID-19 and enabling mental wellbeing and minimizing distress?

   - Immediate actions:
     - 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.

   - Longer-term strategic priorities:
4. Neuroscience: effects of the virus on brain health and mental health

Immediate actions:

• Build a neuropsychological database of UK coronavirus disease 2019 (COVID-19) cases that is inclusive.

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 correlates with the long-term relationship between SARS-CoV-2 infection and post-infective fatigue or depressive syndromes.

• Investigate the long-term relationship between SARS-CoV-2 infection and mental health and neurological symptoms.

• 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.

Tong, A., et al. (2021). Research priorities for COVID-19 sensor technology. Nature Biotechnology, 39, pages 144–147 (2021). Text link: https://www.nature.com/articles/s41587-021-00816-8

Published: 18th January 2021

Forty-three participants completed an online survey. Participants included patients with COVID-19, family members, members of the public, scientists, engineers, healthcare professionals, policymakers, 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).

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. In this paper, research priorities are summarized in four themes:

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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. In this paper, research priorities are summarized in four themes:
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.

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

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.

1. Norton., A., et al., (2020)., The remaining unknowns: a mixed methods study of the current and global health research priorities for COVID-19., BMJ Global Health., 2020;5: e003306.

Text link: https://gh.bmj.com/content/5/7/e003306
Published: 29th July 2020
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.

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...
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 (i.e., 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.27

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 physiological, 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.19,20

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.28 In Canada, within two months of COVID-19, 41% of CR programs closed and 1/3 of the staff were redeployed. 1-to-1 models of care mostly by phone were adopted. Vulnerable populations became ineligible owing to safety concerns.29 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.30 With CR being offered in 111 of 123 countries,31 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 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.32–34 This is regardless of having or not having a co-morbid 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.35 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.32 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.33

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.34

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). 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.5,41 The incidence of PH may increase post-pandemic.42 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 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 vital to identify specific responses to exercise when used in isolation or combination with other investigations such as transthoracic echocardiography and pulmonary function tests.

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.45
Rationale: The pandemic has highlighted the need to learn more about how to manage long-haul symptomology.

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 symptomology.

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.

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, 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. 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. 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 long-standing 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.22 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.

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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 Change Action Team of the British Association of Sport and Exercise Sciences. No other authors have conflicts to declare.

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