A multinational Delphi consensus to end the COVID-19 public health threat

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Article

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Despite notable scientific and medical advances, broader political, socioeconomic and behavioural factors continue to undercut the response to the COVID-19 pandemic[1,2]. Here we convened, as part of this Delphi study, a diverse, multidisciplinary panel of 386 academic, health, non-governmental organization, government and other experts in COVID-19 response from 112 countries and territories to recommend specific actions to end this persistent global threat to public health. The panel developed a set of 41 consensus statements and 57 recommendations to governments, health systems, industry and other key stakeholders across six domains: communication; health systems; vaccination; prevention; treatment and care; and inequities. In the wake of nearly three years of fragmented global and national responses, it is instructive to note that three of the highest-ranked recommendations call for the adoption of whole-of-society and whole-of-government approaches[1], while maintaining proven prevention measures using a vaccines-plus approach[2] that employs a range of public health and financial support measures to complement vaccination. Other recommendations with at least 99% combined agreement advise governments and other stakeholders to improve communication, rebuild public trust and engage communities[3] in the management of pandemic responses. The findings of the study, which have been further endorsed by 184 organizations globally, include points of unanimous agreement, as well as six recommendations with >5% disagreement, that provide health and social policy actions to address inadequacies in the pandemic response and help to bring this public health threat to an end.

Pandemics have disrupted societies and impacted public health throughout human history[4]. Today, almost 3 years after SARS-CoV-2 was first identified and more than 1.5 years after the first vaccines became available, pandemic fatigue[5] threatens to undercut our vigilance and the effectiveness of our responses to ongoing and new pandemic-related challenges. As of September 2022, more than 620 million cases of COVID-19 and over 6.5 million deaths have been reported[6], although mortality estimates range as high as 20 million[7,8]. The healthcare for millions more people has been delayed, often as a result of overwhelmed health systems[9–12]. Highly transmissible variants continue to spread globally, while surveillance for variants of concern remains largely inadequate[13–15]. Reinfection risks are not fully understood. Low vaccination rates[16] may compound the risk from waning immunity[17,18]. Long COVID has emerged as a serious chronic condition[19–21] that represents a considerable burden of disease and still lacks adequate understanding and appropriate preventive or curative solutions. In addition to its direct health consequences, COVID-19 has disrupted economic activity, social interactions and political processes, affected civil liberties and interrupted education at all levels[22–26]. Although many governments and individuals no longer have the same level of concern as earlier in the pandemic[27], many public health leaders, including members of this panel[28], continue to regard COVID-19 as a persistent and dangerous health threat[29–31].

Responses to the COVID-19 pandemic have been hindered by interrelated factors that include false information[32], vaccine hesitancy[33,34], inconsistent global coordination[35], and the inequitable distribution of supplies[36], vaccines[37,38] and treatments[39]. Despite increased levels of trust in science during the pandemic[23,40], there is information

A list of affiliations appears at the end of the paper.

fatigue[4] and waning compliance with those public health and social measures[41–43] that remain in place, particularly those that affect daily lives[44]. Meanwhile, during periods of high community transmission, needs for services continue to exceed the capacity of many health systems[45], which also are challenged by ongoing risks to the health of their workers[46–48]. Furthermore, long-standing social inequities have caused some populations to experience greater risk of COVID-19 infection, severe disease and death[37]. Many of these populations continue to have less access to COVID-19 vaccines[37,49] and treatment[39], as well as to resources to mitigate the mental health, social and economic consequences of the pandemic[50–52].

Beneficial knowledge about COVID-19 aetiology, pathophysiology, prevention, vaccination, treatment and care has rapidly advanced through rigorous scientific, medical and public health inquiry, debate and collaboration[53–56]. Notwithstanding these advances, the responses of individual countries have been heterogeneous and often inadequate, in part because they lack coordination and clear goals.

To develop a global consensus regarding these ongoing problems, we carried out a Delphi study with a multidisciplinary, geographically diverse panel of 386 academic, health, non-governmental organization (NGO), government and other experts in COVID-19 response from 112 countries and territories (Table 1 and Methods). We achieved response rates of 85% in the second round (R2) and 82% and 81% in the third round (R3) surveys of the 41 statements and 57 recommendations, respectively. The mean levels of combined agreement (agree + somewhat agree) increased across the three rounds of the consensus statements (R1, 89%; R2, 90%; R3, 96%) and the two rounds of recommendations (R2, 93%; R3, 98%). The resulting consensus statements and recommendations (Fig. 1) can serve as a strong basis for decision-making to end COVID-19 as a public health threat, and permit a more durable resumption of social, cultural, religious, political, healthcare, economic and educational activities, with less burden on vulnerable populations.

Table 1 | Expert panel characteristics (*n*=386)

Characteristic	*n* (%)
Gender	
Man	225 (58)
Woman	155 (40)
No response	6 (2)
Primary sector of employment[a]	
Civil society	254 (66)
Private	61 (16)
Academic	39 (10)
Public	21 (5)
Other	6 (2)
No response	5 (1)
Primary field[b]	
Public health	156 (41)
Clinical research/care	92 (24)
Health policy/advocacy	67 (17)
Basic/physical/mathematical sciences	41 (11)
Other	24 (6)
No response	6 (2)
Country income level[c]	
Low- or middle-income country	195 (51)
High-income country	186 (48)
No response	5 (1)
Global region of origin[c]	
Europe and Central Asia	117 (30)
Latin America and Caribbean	56 (15)
East Asia and Pacific	49 (13)
North America	47 (12)
Sub-Saharan Africa	44 (11)
Middle East and North Africa	33 (9)
South Asia	35 (9)
No response	5 (1)

Percentages may not sum to 100 owing to rounding.
[a]Panellists were provided with these four standard categories for public health sectors and were able to provide a different response with the 'other' option.
[b]Panellists were provided with six response options (clinical research, public health research, healthcare provider, advocacy, health department or ministry and health policy) and 'other'. The text responses under the 'other' option (*n*=76) were analysed and recategorized into the four categories reported in the table.
[c]Country income level and global region correspond to World Bank classification for 2022 (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups).

Top-ranked consensus recommendations

This multidisciplinary and multinational consensus study yielded 41 statements (Tables 2 and 3) and 57 forward-looking recommendations (Tables 4–7) on ending COVID-19 as a threat to public health grouped into six domains. Although we suggest that policymakers and other interested stakeholders review and consider the entire study findings, for expediency, we break out the top 10 recommendations ranked by the panellists in Table 8.

The top three recommendations focus on whole-of-society[1] action and maintaining, or in some cases returning, to a vaccines-plus approach[2]. First, to avoid the inefficiency and ineffectiveness of fragmented efforts, pandemic preparedness and response should adopt a whole-of-society strategy that includes multiple disciplines, sectors and actors. Second, going forward, whole-of-government approaches (such as interministry coordination) can identify, review and address resilience in health systems to make them more responsive to people's needs. Third, all countries should adopt a vaccines-plus approach, which includes a combination of COVID-19 vaccination, other prevention measures, treatment and financial incentives such as support measures. Infection rates tend to increase when governments discontinue social measures, including non-pharmaceutical interventions, regardless of the level of vaccination[57,58].

The degree of consensus achieved for statements and recommendations, along with a ranking exercise in the final round, informed our synthesis of the study's findings into six cross-cutting themes (Box 1) to which we believe decision-makers should pay particular attention: (1) SARS-CoV-2 is still present among us—despite some governments moving on—requiring continued efforts and resources to save lives; (2) vaccines are an effective tool against COVID-19 but will not alone end COVID-19 as a public health threat; (3) multisectoral collaboration that centres on communities and fosters trust is needed; (4) responsive health systems are crucial for responding to the COVID-19 pandemic and require coordinated government support; (5) adverse forces challenge efforts to end the COVID-19 public health threat; and (6) none of us is safe until everyone is safe. For ease of review, we report the tophalf ranked recommendations within each domain (Extended Data Fig. 1).

Areas of less agreement

The Delphi process involves a review and revision methodology that can result in relatively greater agreement among statements and recommendations over successive survey rounds while also identifying areas of disagreement that may require special efforts going forward. In addition to its the four-point Likert agreement–disagreement response options available in this study, panellists could select 'not qualified to

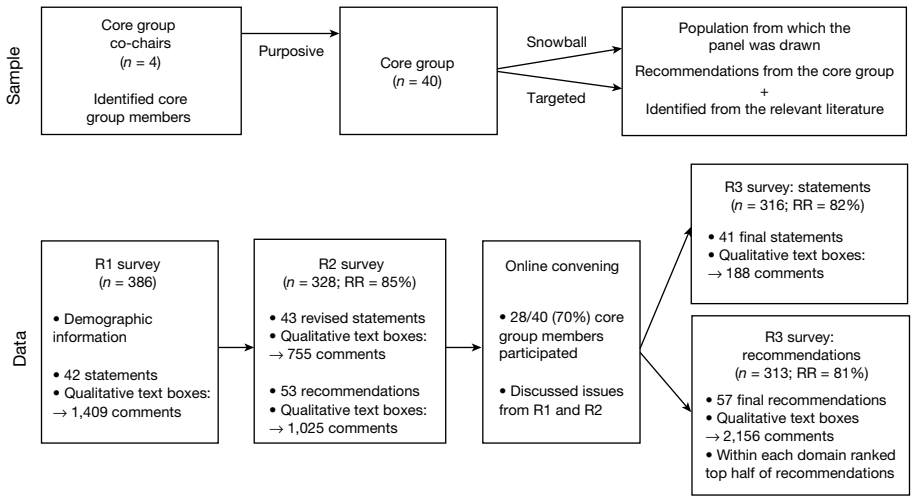

Fig. 1 | Delphi panel generation and data collection. Study methodology, including sample and data collection. Top, the iterative sampling approach used to generate a large, diverse Delphi panel (n = 386): four project co-chairs identified a core group of 40 academic, health, NGO, government and policy experts from 25 countries; the core group identified individuals with expertise in COVID-19; under-represented countries (that is, with fewer than one invitee) were identified and targeted through PubMed/Medline searches for authors of COVID-19 research studies in these countries. Bottom, the iterative digital data-collection process, including two survey rounds (R1 and R2) of draft statements; an online consensus meeting of the core group (Supplementary Discussion 3); one round of draft recommendations (R2); and a final survey round (R3) of the consensus statements and recommendations. Earlier rounds included text boxes for panellists to provide comments and suggest edits to individual statements (R1, R2) and recommendations (R2); the final statement and recommendations round (R3) allowed for overall comments at the end of each domain. For the final set of recommendations in R3, panellists ranked the top half in each of the six domains. RR, response rate.

respond' for items that they perceived as falling outside their expertise (see the 'Delphi expert panel member sample' section in the Methods). Although our study reflects relatively few areas of disagreement, we believe that highlighting the key areas of disagreement may be instructive for decision-makers in their own prioritization processes addressing the COVID-19 pandemic.

Extended Data Table 1 presents the six recommendations reflecting 5% or greater disagreement (disagree + somewhat disagree). Of those six, only two recommendations had greater than 10% disagreement: 18% of panellists disagreed with the recommendation to consider further economic incentives to potentially address vaccine hesitancy (REC3.6) and 11% disagreed with the recommendation that providers adopt a syndromic approach to COVID-19 diagnosis in settings with lower access to testing (REC2.18). The remaining four recommendations broadly relate to the use of governmental regulatory and enforcement powers in disease control efforts.

For statements and recommendations with response rates of 'agree' alone (that is, not combined with 'somewhat agree') below 67%, we conducted bivariate analyses to examine potential associations with panellist demographics; six statements (STMT1.2, STMT1.3, STMT2.1, STMT2.3, STMT3.5, STMT6.6) and one recommendation (REC4.5) demonstrated significant differences. Respondents who disagreed were significantly more likely to work in low- and middle-income countries than in high-income countries ($P < 0.05$; Supplementary Discussion 2). Few differences in agreement were identified by sector or field of employment, except for STMT1.1, for which greater disagreement was identified among those working in the health policy/advocacy field, and for STMT1.3, for which the academic and public sectors evidenced greater disagreement than other sectors.

Key statements and recommendations

The following six domains summarize the main areas of agreement, with a particular focus on the recommendations. The quantitative results on agreement and disagreement for the statements and recommendations are reflected in the tables and are further illustrated in Supplementary Discussion 1.

Communicate effectively

Substantial combined agreement among the panellists (range, 88–100%) indicates that communication issues remain a key area of risk and opportunity for ending COVID-19 as a public health threat. Policymakers and public health agencies should take special care when communicating the causation of and continuing accountability for the pandemic (Tables 2 (STMT1.7) and 4 (REC1.1)). The lowest level of agreement in this domain (agree, 57%; combined agreement, 88%) was found for a statement about government accountability receiving less attention when unvaccinated individuals are blamed for the pandemic's continuation (Table 2 (STMT1.6)).

The panel focused primarily on the role of trust in government (Table 2 (STMT1.5)), the consequences of false information (Table 2 (STMT1.2, STMT1.3, STMT1.4)) and the rapid production of large volumes of new COVID-19-related information (Table 2 (STMT1.1)). That said, governments themselves may be a source of misinformation, for example, in the context of identifying transmission mechanisms (Table 6 (REC4.3)) and when stating that the COVID-19 pandemic has ended (Table 2 (STMT1.7)).

To counteract the infodemic and false information, governments should monitor false information (Table 4 (REC1.7)), expose networks of false information (Table 4 (REC1.9)) and consider holding publishers of false information liable (Table 4 (REC1.10)). Furthermore, public health professionals and other authorities should use clear, culturally responsive messaging to combat false information (Table 4 (REC1.3)). In parallel, social media companies should implement controls that reduce the publication and dissemination of false health information (Table 4 (REC1.8)).

Institutions and individuals should advance public trust by seeking training on building trust and developing trust-oriented communication strategies (Table 4 (REC1.4)), expanding collaboration with community leaders and the scientific community (Table 4 (REC1.1)), and working with individuals and organizations that have established trust in communities (Table 4 (REC1.2)). Using the preferred means of communication for different populations was unanimously recommended to further earn trust (Table 4 (REC1.1)).

Table 2 | Consensus statements to end COVID-19 as a public health threat

Statement		Grade	A (%)	SA (%)	SD (%)	D (%)	N (%)	NQ (%)
Communication								
STMT1.1	The volume and velocity of information during the COVID-19 pandemic have made it difficult for people to assess the accuracy of information.	A	81	19	0	1	316	0
STMT1.2	Public health authorities contribute to the dissemination of false information when their communications do not reflect current scientific understanding that transmission of SARS-CoV-2 is primarily airborne.	A	68	24	6	3	313	1
STMT1.3	Governments have inconsistently counteracted false information in the context of the COVID-19 pandemic.	A	70	23	4	3	312	1
STMT1.4	Sources of false information undermine the social cohesion needed for an effective public health response.	A	91	8	1	0*	316	0
STMT1.5	During the pandemic, public health officials have ineffectively engaged populations that have low levels of trust in government.	A	69	25	4	1	312	1
STMT1.6	Blaming unvaccinated individuals for continuation of the pandemic shifts attention away from government accountability.	B	57	31	8	4	307	3
STMT1.7	A government's decision to reduce COVID-19 pandemic control measures does not mean that the threat to public health has ended.	A	94	5	1	0	315	0
Health systems								
STMT2.1	The world has not implemented an evidence-based, globally agreed-upon set of minimum COVID-19 pandemic response standards addressing monitoring, prevention, treatment and care.	A	73	18	6	3	309	1
STMT2.2	There continue to be systemic risks of COVID-19 infection for healthcare workers in many healthcare settings.	A	82	16	2	1	306	2
STMT2.3	Health systems are continuing to face abnormal staffing shortages due to the mental and physical health impacts on their workers from the COVID-19 pandemic.	A	79	16	4	0	305	3
STMT2.4	Healthcare workers continue to experience unaddressed mental health issues due to the pandemic.	A	81	17	2	0	296	5
STMT2.5	Governments have not always addressed the high out-of-pocket expenditure to consumers for some pandemic control measures (for example, testing) and personal protective equipment (for example, facemasks).	A	78	17	3	2	310	1
STMT2.6	The COVID-19 pandemic continues to reveal vulnerabilities in the global supply-chain framework for essential public health supplies.	A	91	8	1	0*	306	2
STMT2.7	The COVID-19 pandemic has catalysed opportunities for rapid innovation in digital health solutions throughout the care continuum.	A	84	14	1	1	308	1
STMT2.8	Leveraging economies of scale and scope through multicountry pooled procurement can enable health systems to increase access to essential medicines and supplies during public health crises.	A	85	14	1	1	305	2
STMT2.9	Community-based interventions and services to address the pandemic continue to be underused by health systems.	A	79	19	2	0*	302	4
Vaccination								
STMT3.1	When the risk of harm to others is sufficiently severe, governments may determine that the right of all individuals to good health overrides the autonomy of any one individual to choose not to be vaccinated.	A	68	24	5	4	309	1
STMT3.2	Individual medical autonomy acknowledges that individuals who have decision-making capacity have the right to make decisions regarding vaccination, even when their decisions contradict their healthcare providers' recommendations.	B	59	25	8	8	306	2
STMT3.3	Vaccine hesitancy, which ranges from delay to refusal despite the availability of vaccine services, remains a major challenge to ending the COVID-19 pandemic as a public health threat.	A	75	21	3	1	309	1
STMT3.4	Discussing vaccine hesitancy as primarily a function of information or worldview is inaccurate, as vaccine hesitancy is a multifactorial phenomenon comprising other factors (for example, socioeconomic).	A	82	12	3	2	308	1
STMT3.5	Continued low levels of trust in information from government sources are associated with vaccine hesitancy.	A	78	17	4	2	309	1
STMT3.6	Vaccination alone is insufficient to end the COVID-19 pandemic as a public health threat.	A	83	14	3	1	311	0

Grades are based on the percentage of combined agreement (agree+somewhat agree). U, unanimous (100%) agreement; A, 90%–99% agreement; B, 78%–89% agreement; C, 67%–77% agreement. Responses to each statement (STMT) are presented as percentages of the total responses. A, agree; SA, somewhat agree; SD, somewhat disagree; D, disagree; N, total number of responses; NQ, the number of participants that indicated that they were not qualified to respond. The asterisks indicate that rounding resulted in 0% despite the presence of ≥1 response in the disagreement category.

Multidisciplinary research should assess the impact of the COVID-19 infodemic on health behaviours and outcomes (Table 4 (REC1.5)). Research funders should commission more reviews that synthesize, evaluate and disseminate COVID-19-related evidence to inform needed interventions (Table 4 (REC1.6)).

Strengthen health systems

Health systems have experienced wide-ranging circumstances throughout the pandemic, from periods of relative calm to periods of near collapse. The broad agreement among panellists strongly

Table 3 | Consensus statements to end COVID-19 as a public health threat

Statement		Grade	A (%)	SA (%)	SD (%)	D (%)	N (%)	NQ (%)
Prevention								
STMT4.1	SARS-CoV-2 is an airborne virus that presents the highest risk of transmission in indoor areas with poor ventilation.	A	92	8	0*	0*	311	0
STMT4.2	The assumption that endemicity automatically means that variants will have lower virulence is not scientifically sound and should not be a basis for public policy decision-making.	A	81	15	2	1	297	5
STMT4.3	SARS-CoV-2 mammal-to-mammal, outdoor transmission represents a reservoir for future zoonotic variants.	A	76	20	3	1	268	14
STMT4.4	Relying on individual, voluntary compliance with transmission prevention measures is insufficient to end COVID-19 as a public health threat.	A	81	15	3	1	311	0
STMT4.5	Infection rates tend to increase when governments discontinue social measures, including non-pharmaceutical interventions, regardless of the level of vaccination.	A	75	19	4	2	306	2
STMT4.6	Wide use of high-filtration and well-fitting facemasks (for example, N95, KF94, KN95, FFP2/3) is important to reduce transmission, particularly in high-risk settings.	A	87	9	3	1	307	1
STMT4.7	Most countries have not adequately protected children throughout the pandemic, that is, preventing SARS-CoV-2 transmission while simultaneously addressing their physical, mental and social well-being.	A	77	17	5	2	309	1
Treatment and care								
STMT5.1	Prioritizing the treatment of severe COVID-19 over the prevention of SARS-CoV-2 transmission risks increasing infections, long COVID and the overall burden of disease.	A	72	20	5	2	299	4
STMT5.2	More effective COVID-19 therapeutic options, as well as care delivery models, are needed.	A	91	8	1	0	303	3
STMT5.3	In addition to the standardized long COVID case definition for adults, a standardized definition is needed for children.	A	90	10	0*	0	298	4
STMT5.4	Research is needed to determine whether infection from distinct variants of SARS-CoV-2 is associated with significant differences in long-term morbidity.	A	91	8	1	0	305	2
Pandemic inequities								
STMT6.1	The COVID-19 pandemic disproportionately impacts the most vulnerable populations within communities, countries and globally.	A	92	6	1	1	311	0
STMT6.2	The decision by most high-income countries to protect intellectual property rights for COVID-19 vaccines and treatments has contributed to limited options available to low- and middle-income countries for addressing the pandemic.	A	83	11	4	3	304	3
STMT6.3	It is in the best interests of high-income countries to fund the equitable distribution of vaccines and treatments to low- and middle-income countries.	A	88	9	2	0*	308	1
STMT6.4	There is a disproportionate consumption of health system resources by those voluntarily unvaccinated.	A	65	25	7	3	295	5
STMT6.5	When expanding use of digital communications technology (for example, online appointment systems, mobile patient communications and telehealth applications) health systems may inadvertently contribute to inequitable access to healthcare services.	A	64	30	6	1	307	1
STMT6.6	The global pandemic response has generally not taken into account the underlying role of social determinants of health.	A	77	21	2	0*	308	1
STMT6.7	Few governments have adequately engaged vulnerable populations to inform pandemic response priorities.	A	78	17	4	0*	303	3
STMT6.8	The incorporation of research paradigms from diverse disciplines has greater potential to end COVID-19 as a public health threat than reliance on a single research paradigm (for example, evidence-based medicine).	A	88	9	2	1	309	1

Grades are based on the percentage of combined agreement (agree + somewhat agree). U, unanimous (100%) agreement; A, 90%–99% agreement; B, 78%–89% agreement; C, 67%–77% agreement. Responses to each statement (STMT) are presented as percentages of the total responses. A, agree; SA, somewhat agree; SD, somewhat disagree; D, disagree; N, total number of responses; NQ, the number of participants that indicated that they were not qualified to respond. The asterisks indicate that rounding resulted in 0% despite the presence of ≥1 response in the disagreement category.

suggests that, although many health systems will remain at risk of once again being overwhelmed, those risks can be mitigated. Certain sources of risk to health systems are essentially structural, such as the lack of implementation of an evidence-based, globally agreed-upon set of minimum COVID-19 pandemic response standards (Table 2 (STMT2.1)).

As noted above, health systems recommendations with respect to whole-of-society (Table 4 (REC2.5)) and whole-of-government approaches (for example, multiministry coordination) (Table 4 (REC2.6)) were among the most highly ranked by the panel.

As community transmission of SARS-CoV-2 continues to present a risk to health systems, particularly through variants of concern, extensive virological surveillance should be used (Table 5 (REC2.8)). Public health policies should take better account of the potential long-term impact of the unchecked spread of COVID-19 given the ongoing uncertainties about the prevalence, severity and duration of post-COVID-19 morbidity (long COVID) (Table 5 (REC2.9)). Member States should authorize the World Health Organization (WHO) to lead a large, inclusive, multistakeholder, global effort to provide public health and clinical targets pertaining to SARS-CoV-2 and COVID-19, with an emphasis on cases, vaccination, morbidity and mortality (Table 5 (REC2.17)).

Economic impacts, notably costs borne by consumers (Table 2 (STMT2.5)), create risks to health systems. To address these risks, structural and economic recommendations include removing economic barriers to SARS-CoV-2 tests, personal protective equipment, treatment and care (Table 4 (REC2.1)), supporting the development of

Table 4 | Recommendations to end COVID-19 as a public health threat

Recommendation		Grade	A (%)	SA (%)	SD (%)	D (%)	N (%)	NQ (%)	Rank
Communication									
REC1.1	Community leaders, scientific experts and public health authorities should collaborate to develop public health messages that build and enhance individual and community trust and use the preferred means of access and communication for different populations.	U	96	4	0	0	312	0	1
REC1.2	Public health authorities should partner with individuals and organizations that are trusted within their communities to provide accurate, accessible information about the pandemic and inform behaviour change.	A	95	5	0*	0	312	0	2
REC1.3	Public health professionals and authorities should combat false information proactively based on clear, direct, culturally responsive messaging that is free of unnecessary scientific jargon.	A	94	5	0*	0*	311	0	3
REC1.4	Institutions and individuals that wish to advance public trust should: (1) draw on evidence about how trust is created and restored; (2) provide training and professional development emphasizing skills and competencies that convey trustworthiness; and (3) develop, implement and assess communication strategies that are highly likely to create or restore trust.	A	94	5	1	0	311	0	4
REC1.5	Multidisciplinary researchers should assess the impact of the 'infodemic' on health behaviours and outcomes in specific populations of all countries.	A	93	6	1	0*	311	0	
REC1.6	Research funders should commission more scoping, narrative and systematic reviews to synthesize, evaluate and disseminate COVID-19-related evidence.	A	83	16	1	0*	309	0	
REC1.7	Governments should determine which agencies are or should be accountable for monitoring health information and develop monitoring tools to identify false information.	A	81	17	2	1	312	1	5
REC1.8	Social media companies should engage transparently with researchers and developers, who are free of a direct conflict of interest, to implement controls for their platforms that reduce publication and dissemination of false health information.	A	87	11	2	1	311	0	
REC1.9	Governments, industry and non-governmental organizations should actively identify and expose individuals and networks that promote false health information about the COVID-19 pandemic.	A	80	17	2	1	310	1	
REC1.10	Governments should consider holding publishers of false health information liable, while balancing civil liberties.	A	76	17	6	1	308	1	
Health systems									
REC2.1	Governments should remove economic barriers to SARS-CoV-2 tests, personal protective equipment, treatments and care.	A	90	10	0*	0	313	0	6
REC2.2	Governments and global health organizations should support the development of regional hubs for the manufacturing of COVID-19 supplies, treatments and vaccines.	A	91	8	0	0*	308	2	5
REC2.3	The user experience and interface with digital health technologies should be adapted to expand access for all, with particular attention to vulnerable groups.	A	86	13	0*	0*	313	0	
REC2.4	Healthcare organizations should support their workers' physical, mental and social well-being.	A	97	2	0	1	311	0	4
REC2.5	Pandemic preparedness and response planning should adopt a whole-of-society approach that includes multiple disciplines, sectors and actors (for example, business, civil society, engineering, faith communities, mathematical modelling, military, media and psychology).	A	95	4	1	0	312	0	1
REC2.6	Preparedness and response strategies should adopt whole-of-government approaches (for example, multiministry coordination) to identify, review and address resilience in health systems.	A	93	6	1	0	309	2	2

Grades are based on the percentage of combined agreement (agree + somewhat agree). U, unanimous (100%) agreement; A, 90%–99% agreement; B, 78%–89% agreement; C, 67%–77% agreement. Responses to each recommendation (REC) are presented as percentages of the total responses. A, agree; SA, somewhat agree; SD, somewhat disagree; D, disagree; N, total number of responses; NQ, the number of participants that indicated that they were not qualified to respond. The asterisks indicate that rounding resulted in 0% despite the presence of ≥1 response in the disagreement category.

regional manufacturing hubs for COVID-19 supplies, treatments and vaccines (Table 4 (REC2.2)), and considering legislative and regulatory reforms to address market failures (Table 5 (REC2.16)). Where access to PCR or antigen tests is limited, providers should consider adopting a syndromic approach (Table 5 (REC2.18)). Notably, REC2.18 is the health systems recommendation with the highest percentages of panellists disagreeing as well as panellists indicating 'not qualified to respond'.

To reduce the burden on hospitals, the role of primary health care should be strengthened (Table 5 (REC2.10)), while health care workers' physical, mental and social well-being should be supported (Table 4 (REC2.4)).

With respect to digital health, the recommendations encourage increasing investments in digital health infrastructure (Table 5 (REC2.13)), adapting user interfaces and experience to expand access, particularly for vulnerable groups (Table 4 (REC2.3)), and leveraging implementation science to determine which digital health solutions can be quickly scaled (Table 5 (REC2.12)).

With respect to procurement practices, engaging continuous improvement disciplines for intercountry procurement, pooling and supply-chain management was urged (Table 5 (REC2.11)). To best leverage community-based interventions and services, community-based organizations and students pursuing degrees in health-related fields should be engaged in providing COVID-19 education, testing and vaccination services (Table 5 (REC2.14)).

As social, political and economic sector risks continue to have spillover effects on health systems, key multisectoral indicators for

Table 5 | Recommendations to end COVID-19 as a public health threat

Recommendation		Grade	A (%)	SA (%)	SD (%)	D (%)	N (%)	NQ (%)	Rank
Health systems									
REC2.7	As social, political and economic sector risks continue to have spillover effects on health systems, key multisector indicators for systemic risks to health systems must be identified and assessed.	A	92	7	1	0*	305	2	
REC2.8	The identification of several variants of concern necessitates substantial virological surveillance based on whole-genome sequencing of positive specimens.	A	86	13	1	0	287	8	
REC2.9	Public health policy should take better account of the potential long-term impact of the unchecked spread of COVID-19, given ongoing uncertainties about the prevalence, severity and duration of post-COVID-19 morbidity (long COVID).	A	86	13	1	0*	310	1	
REC2.10	To reduce the burden on hospitals, primary care should be strengthened to include testing, contact tracing, the monitoring of mild symptoms and vaccination.	A	92	6	1	0*	310	1	3
REC2.11	Governments and industry should engage continuous improvement disciplines for intercountry procurement, pooling and supply chain management to reduce cycle times and costs, as well as improve product quality and data to rapidly scale up the availability of medicines, protective equipment and vaccines.	A	91	7	2	0	301	4	8
REC2.12	Public health systems should prioritize the use of implementation science to determine which digital health solutions can and should be quickly scaled up globally.	A	85	13	2	0	300	4	
REC2.13	Investments in digital health infrastructure, software and training should be made to institutionalize quality telehealth and telemedicine services.	A	86	12	2	0	310	1	
REC2.14	To reduce the burden on health systems and healthcare workers, community-based organizations and students pursuing degrees in health-related fields should be engaged to educate, test and vaccinate the population.	A	77	20	3	0*	312	0	
REC2.15	Health systems should identify and, where possible, reduce diagnostic, treatment and care backlogs for non-COVID-19-related medical conditions.	A	88	9	1	3	305	3	
REC2.16	Because the global marketplace has not satisfied demand for vaccines, treatments and supplies, countries and regions should consider legislative and regulatory reforms to address these market failures (for example, nationalizing manufacturing capacity, negotiating global and regional trade agreements, adjusting intracountry intellectual property rights).	A	80	13	4	3	297	6	7
REC2.17	In the absence of a new multilateral organization focused on pandemic control, Member States should authorize the WHO to lead a large, inclusive, multistakeholder, global effort to provide public health and clinical targets pertaining to the pandemic, with an emphasis on cases, vaccination, morbidity and mortality.	A	73	19	6	2	306	3	9
REC2.18	In settings in which access to PCR or antigen tests may be limited, providers should consider adopting a syndromic approach to COVID-19 diagnosis for symptomatic individuals.	B	68	21	9	2	282	11	

Grades are based on the percentage of combined agreement (agree + somewhat agree). U, unanimous (100%) agreement; A, 90%–99% agreement; B, 78%–89% agreement; C, 67%–77% agreement. Responses to each recommendation (REC) are presented as percentages of the total responses. A, agree; SA, somewhat agree; SD, somewhat disagree; D, disagree; N, total number of responses; NQ, the number of participants that indicated that they were not qualified to respond. The asterisks indicate that rounding resulted in 0% despite the presence of ≥1 response in the disagreement category.

systemic risks to health systems should be identified and assessed (Table 5 (REC2.7)).

Finally, health systems should identify and, where possible, reduce diagnostic, treatment and care backlogs for non-COVID-19-related medical conditions (Table 5 (REC2.15)).

Emphasize vaccination, but not exclusively so

Even assuming continued innovation of vaccines and interventions that reduce vaccine hesitancy, 97% of the panel agrees that vaccination alone is insufficient to end the COVID-19 pandemic as a public health threat (Table 2 (STMT3.6)). Thus, the panel places a strong emphasis on additional prevention measures, particularly, as noted above and in the ten highest-ranked recommendations (Table 8), for countries to adopt a vaccines-plus approach, as discussed in the next domain.

Regarding the key role of vaccines, the panel made a range of recommendations. Government, philanthropic and industry funding should invest in developing vaccines that provide long-lasting protection against multiple SARS-CoV-2 variants (Table 6 (REC3.4)). As waning immunity remains a risk, calculations for immunity should consider the time after the date of vaccination and/or infection and be regularly updated with new scientific evidence (Table 6 (REC3.5)).

Vaccine hesitancy, which ranges from delay to refusal despite availability of vaccine services, remains a major challenge (Table 2 (STMT3.3)). To reduce vaccine hesitancy and increase uptake, several interventions are recommended: engaging trusted local leaders and organizations in vaccination efforts (Table 6 (REC3.2)), providing information that clearly explains the efficacy and limitations of current vaccines (Table 6 (REC3.1)) and tailoring messages to address the underlying bases of various populations' specific concerns through targeted public health communications (Table 6 (REC3.3)). Vaccine hesitancy may also be associated with false information, which is addressed in the communication domain above.

On the one hand, panellists largely agree that medical autonomy of individuals with decision-making ability extends to the right to make one's own decisions regarding vaccination (Table 2 (STMT3.2)). On the other hand, panellists also acknowledge that, when the risk of harm to others is sufficiently severe, governments may determine that the right of all individuals to good health overrides the autonomy of any one individual to choose not to be vaccinated (Table 2 (STMT3.1)). These statements

Table 6 | Recommendations to end COVID-19 as a public health threat

Recommendation		Grade	A (%)	SA (%)	SD (%)	D (%)	N (%)	NQ (%)	Rank
Vaccination									
REC3.1	Vaccination messaging should clearly explain the efficacy and limitations of current vaccines in preventing SARS-CoV-2 transmission and reducing the severity of COVID-19.	A	93	7	0*	0*	312	0	2
REC3.2	In settings where individuals have lower levels of trust in government, vaccination efforts should engage trusted local leaders and organizations.	A	93	6	1	0	311	0	
REC3.3	To combat vaccine hesitancy, tailored messages that address the underlying bases of an individual's concerns should be used in targeted public health communications.	A	93	6	1	0	310	1	3
REC3.4	Government, philanthropic and industry funding should include a focus on developing vaccines that provide long-lasting protection against multiple SARS-CoV-2 variants.	A	90	9	1	0	309	1	1
REC3.5	Calculations for immunity should take into consideration the time following the date of vaccination and/or infection and be regularly updated with new scientific evidence.	A	93	4	2	1	398	4	
REC3.6	As the causes of vaccine hesitancy are not solely a function of information or worldview, economic incentives should be considered in parallel with information and access to increase vaccination rates.	B	57	25	13	5	303	3	
Prevention									
REC4.1	Governments should regulate and incentivize the development and deployment of structural prevention measures (for example, ventilation, air filtration) to mitigate airborne transmission of SARS-CoV-2, with an early emphasis on high-risk settings.	A	86	12	1	0	307	0	
REC4.2	Measures that are no longer scientifically valid for COVID-19 prevention should be immediately removed from COVID-19 guidance and policy.	A	88	10	2	0	307	0	
REC4.3	Risk communications should clearly emphasize that transmission of SARS-CoV-2 is primarily caused by inhalation of the virus.	A	90	8	2	0	302	1	
REC4.4	National and international travel restrictions should be based on current scientific knowledge and prevailing transmission rates of all variants that take into account relevant, health-based factors (for example, traveller's vaccination status, proof of recent recuperation from COVID-19 or a negative result of an antigen or PCR test).	A	85	12	1	2	305	0	
REC4.5	All countries should adopt a vaccines-plus approach that includes a combination of COVID-19 vaccination, prevention measures, treatment and financial incentives.	A	82	14	4	0	307	0	1
REC4.6	Prevention of SARS-CoV-2 transmission in the workplace, educational institutions and centres of commerce should remain a high priority, reflected in public health guidance and supported through multiple social measures and structural interventions (for example, remote work/schooling policies, ventilation, air filtration, facemask wearing).	A	85	11	3	1	307	0	2
REC4.7	Governments should consider imposing broad restrictions on civil liberties only in the event of variants of concern presenting risk of high rates of transmission and severity, coupled with (1) waning immunity or (2) vaccine resistance.	A	71	21	5	3	305	0	3

Grades are based on the percentage of combined agreement (agree + somewhat agree). U, unanimous (100%) agreement; A, 90%–99% agreement; B, 78%–89% agreement; C, 67%–77% agreement. Responses to each recommendation (REC) are presented as percentages of the total responses. A, agree; SA, somewhat agree; SD, somewhat disagree; D, disagree; N, total number of responses; NQ, the number of participants that indicated that they were not qualified to respond. The asterisks indicate that rounding resulted in 0% despite the presence of ≥1 response in the disagreement category.

reflect among the highest levels of combined disagreement (Table 2 (STMT3.1, 9%; STMT3.2, 16%)). Civil liberties implications are further discussed in the next domain.

Promote preventive behaviours

As noted above, vaccination alone will not end COVID-19 as a public health threat (Table 2 (STMT3.6)) for all people. Infection rates tend to increase when governments discontinue social measures, including non-pharmaceutical interventions, regardless of the level of vaccination (Table 3 (STMT4.5)). Thus, all countries should adopt a vaccines-plus approach, including a combination of COVID-19 vaccination, other prevention measures, treatment and possibly financial incentives (Table 6 (REC4.5)).

Although the nature and vectors of SARS-CoV-2 transmission were not clearly understood early in the pandemic, current evidence guided the panellists to near-unanimous agreement that SARS-CoV-2 is an airborne virus that presents the highest risk of transmission in indoor areas with poor ventilation (Table 3 (STMT4.1)). Risk-related communications from all actors should clearly emphasize that transmission of SARS-CoV-2 is primarily caused by inhalation of the virus (Table 6 (REC4.3)). Considering the airborne nature of transmission, governments should regulate and incentivise structural prevention measures, such as ventilation and air filtration (Table 6 (REC4.1)), and high priority should be given to preventing SARS-CoV-2 transmission in the workplace, educational institutions and commercial centres (Table 6 (REC4.6)).

Mammal-to-mammal transmission represents a reservoir for future zoonotic variants (Table 3 (STMT4.3)). Thus, substantial virological surveillance based on whole-genome sequencing of positive samples in human and high-risk mammal populations is an essential component of the continued pandemic response and preparedness (Table 5 (REC2.8)).

National and international travel restrictions should be based on current scientific knowledge and prevailing transmission rates of all variants that consider relevant, health-based factors (Table 6 (REC4.4)). Measures that are no longer scientifically valid for COVID-19 prevention should be immediately removed from COVID-19 guidance and policy (Table 6 (REC4.2)). Going forward, governments should consider imposing broad restrictions on civil liberties only in the event of variants of concern presenting risk of high rates of transmission and severity, coupled with waning immunity or vaccine resistance (Table 6 (REC4.7)).

Table 7 | Recommendations to end COVID-19 as a public health threat

Recommendation		Grade	A (%)	SA (%)	SD (%)	D (%)	N (%)	NQ (%)	Rank
Treatment and care									
REC5.1	Global case definitions for SARS-CoV-2 and for COVID-19 morbidity and mortality should be standardized.	U	92	8	0	0	305	0	3
REC5.2	Promote multisectoral collaboration to accelerate the development of new therapies for all stages of COVID-19 (for example, outpatient, hospitalization and long COVID).	A	95	5	0	0*	309	1	1
REC5.3	Clinical trials and longitudinal cohorts should include statistically sufficient samples from all age groups, genders and vulnerable populations.	A	93	7	0*	0	306	1	
REC5.4	Expand the evidence base on the cumulative effect of COVID-19 reinfection to inform public health policy.	A	90	9	1	0*	308	1	
REC5.5	Governments should now prioritize early case detection so that health systems can facilitate earlier treatment and care.	A	80	17	1	1	304	1	
REC5.6	Prioritize research funding for long COVID to develop diagnostic tools, treatment and care, and knowledge about extrinsic factors (for example, stigma and discrimination).	A	85	12	3	0	306	0	2
Pandemic inequities									
REC6.1	Recognizing that local and regional contexts are important for equitable responses to the pandemic, governments should engage communities and multidisciplinary experts who understand the local context when developing operational plans for ending COVID-19 as a public health threat.	A	95	5	0*	0	311	0	3
REC6.2	In addition to current vaccine equity efforts, governments and global health organizations should better coordinate to make COVID-19 tests and treatments affordable for all people in all countries.	A	93	6	0*	0	310	0	4
REC6.3	Decision-making bodies (for example, governments, WHO committees) should meaningfully and transparently engage with a broad base of voices to inform their decisions.	A	93	6	0*	0	311	0	
REC6.4	Governments, regional bodies, industry and health systems should anticipate the procurement and supply management needs for supplies, treatments and vaccines in low-resource settings (for example, transportation logistics, storage, refrigeration).	A	93	6	0*	0*	306	2	
REC6.5	Pandemic preparedness, response planning and policy should be reviewed and updated to protect children, emphasizing the prevention of SARS-CoV-2 transmission while simultaneously addressing their physical, mental and social well-being.	A	90	9	0*	1	309	0	
REC6.6	Global trade and health organizations should coordinate with countries to negotiate the transfer of technologies enabling manufacturers in low- and middle-income countries to develop quality assured and affordable vaccines, tests and therapeutics.	A	95	4	1	0*	307	2	2
REC6.7	Pandemic preparedness and response should address pre-existing social and health inequities.	A	94	5	1	0*	307	1	1
REC6.8	Governments, industry and health systems should prioritize minimizing closed- and open-vial vaccine wastage, with an early emphasis on wastage resulting from unnecessarily short expiration dates, and by addressing regulatory barriers and procurement and supply management challenges for transferring or donating vaccine doses.	A	86	13	1	0	301	3	
REC6.9	Pandemic preparedness and response efforts should assess and mitigate the risks and effects of SARS-CoV-2 transmission among people within and emigrating from conflict zones.	A	86	13	2	0		1	
REC6.10	High-income countries should refocus the distribution of vaccines to countries with low rates of vaccination and inadequate access to vaccines.	A	86	12	2	0*		0	5

Grades are based on the percentage of combined agreement (agree + somewhat agree). U, unanimous (100%) agreement; A, 90%–99% agreement; B, 78%–89% agreement; C, 67%–77% agreement. Responses to each recommendation (REC) are presented as percentages of the total responses. A, agree; SA, somewhat agree; SD, somewhat disagree; D, disagree; N, total number of responses; NQ, the number of participants that indicated that they were not qualified to respond. The asterisks indicate that rounding resulted in 0% despite the presence of ≥1 response in the disagreement category.

Expand treatments

Panellists had substantially high agreement regarding all aspects of treatment and care, indicating that treatment will continue to be an area of major importance both for ending COVID-19 as a public health threat and for individual patient care. Notably, a statement addressing the risk of prioritizing treatment over prevention (Table 3 (STMT5.1)) had the highest level of combined disagreement (7%) for this domain.

With current public health policies reflecting greater tolerance for community transmission and increased rates of infection, research into COVID-19 must adapt and develop further evidence to understand the cumulative effect of COVID reinfection (Table 7 (REC5.4)). Research is needed to determine whether infection from distinct variants of SARS-CoV-2 is associated with significant differences in long-term morbidity (Table 3 (STMT5.4)). Additional research funding, particularly for long COVID, should be prioritized (Table 7 (REC5.6)), and multisectoral collaboration should accelerate new therapies across all stages of COVID-19 (Table 7 (REC5.2)). Moreover, global case definitions should be standardized (Table 7 (REC5.1)).

Echoing some statements and recommendations in the pandemic inequities domain (discussed below), clinical trials and longitudinal

Table 8 | Ten highest ranked recommendations

Rank	Domain	Recommendation	Disagreement (SD+D) (%)
1	Health systems	Pandemic preparedness and response planning should adopt a whole-of-society approach that includes multiple disciplines, sectors and actors (for example, business, civil society, engineering, faith communities, mathematical modelling, military, media and psychology).	1
2	Communication	Community leaders, scientific experts and public health authorities should collaborate to develop public health messages that build and enhance individual and community trust and use the preferred means of access and communication for different populations.	0
3	Prevention	All countries should adopt a vaccines-plus approach that includes a combination of COVID-19 vaccination, prevention measures, treatment and financial incentives.	4
4	Pandemic inequities	Pandemic preparedness and response should address pre-existing social and health inequities.	1
5	Communication	Public health authorities should partner with individuals and organizations that are trusted within their communities to provide accurate, accessible information about the pandemic and inform behaviour change.	0*
6	Vaccination	Government, philanthropic and industry funding should include a focus on developing vaccines that provide long-lasting protection against multiple SARS-CoV-2 variants.	1
7	Communication	Public health professionals and authorities should combat false information proactively based on clear, direct, culturally responsive messaging that is free of unnecessary scientific jargon.	1
8	Health systems	Preparedness and response strategies should adopt whole-of-government approaches (for example, multiministry coordination) to identify, review and address resilience in health systems.	1
9	Pandemic inequities	Global trade and health organizations should coordinate with countries to negotiate the transfer of technologies enabling manufacturers in low- and middle-income countries to develop quality assured and affordable vaccines, tests and therapeutics.	1
10	Treatment and care	Promote multisectoral collaboration to accelerate the development of new therapies for all stages of COVID-19 (for example, outpatient, hospitalization and long COVID).	0*

SD+D, the combined percentage of 'somewhat disagree' and 'disagree' responses. The asterisks indicate that rounding resulted in 0% despite the presence of ≥1 response in the disagreement category.

cohorts should be more inclusive and statistically representative regarding age, gender and vulnerable populations (Table 7 (REC5.3)).

Eliminate inequities

The substantial agreement of the panellists suggests that addressing inequities remains a global challenge. Immediate efforts should be made to reduce vaccine wastage (Table 7 (REC6.8)), addressing the need for cold storage, transport and other infrastructure-based barriers in low-resource settings (Table 7 (REC6.4)), addressing the affordability of testing and treatment for people in all countries (Table 7 (REC6.2)), as well as accelerating efforts to distribute vaccines in low- and middle-income countries (Table 7 (REC6.10)).

Transfer agreements to increase production capacities in low- and middle-income countries should be expedited (Table 7 (REC6.6)). Pre-existing social and health inequities must be considered in pandemic preparedness and response going forward (Table 7 (REC6.7)). The findings call special attention to two vulnerable populations: children (Table 7 (REC6.5)) and those living within or fleeing from conflict zones (Table 7 (REC6.9)).

The pandemic has illustrated the risk of over-reliance on experts from a small number of disciplines (Table 3 (STMT6.8)), often excluding the expertise of community members (Table 4 (REC1.2)) and vulnerable groups (Table 3 (STMT6.7)). Instead, vulnerable groups should be sought out and actively engaged (Table 7 (REC6.3)). As noted in the communication domain, community leaders should also be engaged (Table 4 (REC1.1)). Multidisciplinary experts who understand local contexts should be included in developing national operational plans for ending COVID-19 as a public health threat (Table 7 (REC6.1)). COVID-19 tests and treatments should be affordable for all people in all countries (Table 7 (REC6.2)).

Discussion

Wide-ranging pandemic control measures[59–62] have not ended COVID-19 as a public health threat[63–68]. Although this study echoes some earlier findings—for example, the Independent Panel for Pandemic Preparedness and Response[35], the European Union 2022 communication on preparedness and response[69] and WHO's 2022 plan on strategic preparedness[53]—it is distinct from previous efforts[22] given its design, which emphasized consensus building and the reporting of disagreement through the Delphi method, panellist diversity with regard to geography and disciplines, and the large sample size. The study's focus—ending COVID-19 as a public health threat—is defined as being evidenced by the resumption of pre-pandemic social, cultural, religious, political, healthcare, economic and educational activities in each country's context. Some retrospective matters (for example, pandemic root-cause analysis), theoretical questions and modelling were judged to be beyond the scope of the study.

Where possible, the study emphasizes recommendations that can be implemented in the short term (that is, in months, not years) to end COVID-19 as a public health threat. Although examples of countries implementing multiple recommendations exist (for example, free tests[70], combining widespread testing and free treatment of positive cases along with digital technologies[71], the development of vaccines providing long-lasting protection against variants[72,73]), the exceptions accentuate global challenges and provide new opportunities for action. Certain statements and recommendations resulting from this consensus process address gaps in WHO's strategic plan[31], most strikingly, the failure to directly address the airborne nature of transmission. Initially, the WHO incorrectly labelled airborne transmission of SARS-CoV-2 as 'misinformation'. Only much later, after multidisciplinary scientific efforts, did the WHO recognize airborne transmission to be a predominant mode of transmission[74–76]. By contrast, this panel recommends that 'risk communications clearly emphasize' (Table 6 (REC4.3)) the causal link between inhalation of SARS-CoV-2 and the transmission of COVID-19 as well as policy incentivizing 'structural prevention measures (for example, ventilation, air filtration) to mitigate airborne transmission' (Table 6 (REC4.1)).

The WHO's slow pace in directly addressing the airborne nature of transmission underscores why public health policy and risk communications should be based on evidence. For example, supposing that endemicity will result in lower virulence is an erroneous assumption[77–79] that may exacerbate disproportionate risks of COVID-19 among vulnerable

Box 1

Cross-cutting themes for action to end COVID-19 as a public health threat

(1) SARS-CoV-2 still moves among us—despite some governments moving on—requiring continued efforts and resources to save lives. Reservoirs exist from which variants of concern may yet emerge[104,105]; possible endemicity[45] does not necessarily mean lower disease severity[106]. Broad-based funding to develop long-lasting immunogenic vaccines must proceed concurrent with other prevention measures. The long-term impact of infection must be assessed, as long COVID has emerged as a chronic condition[107–110].

(2) Vaccines are an effective tool against COVID-19 but will not alone end COVID-19 as a public health threat. Vaccination as a sole pandemic response strategy has limitations due to immune escape[111–113], waning immunity[17,114,115], inequitable access[34,116], vaccine hesitancy[117–120] and the absence of immunization strategies[121]. A multifaceted public health vaccines-plus approach is needed, including testing, surveillance, treatment[122], community engagement and implementation of social prevention measures (such as facemasks[123,124], distancing and quarantine), structural interventions (such as ventilation and air filtration)[2] and financial incentives (for example, support measures).

(3) Multisectoral collaboration that centres on communities and fosters trust is needed. Ending COVID-19 as a public health threat requires whole-of-society and whole-of-government approaches engaging trusted community leaders and organizations, scientific experts, businesses, and other disciplines and sectors[1,125]. This expanded pool of collaborators can best address diverse needs regarding modes of access, communication, innovation and trust among different populations[126,127].

(4) Responsive health systems are crucial for responding to the COVID-19 pandemic and require coordinated government support. The persistent demand on health systems requires protecting the physical and mental wellbeing of healthcare workers; reducing economic barriers for equipment and treatment, including addressing supply-chain factors[128]; strengthening primary care; and adopting a comprehensive, intersectoral, multilevel approach to preparedness and response activities.

(5) Adverse forces challenge efforts to end the COVID-19 public health threat. Counteract sovereign state actors who are openly antagonistic toward science and public health and other entities with vested interests that disseminate false information. Public health authorities should build trust in evidence-based communications and partner with those monitoring and holding accountable disseminators of false information[129].

(6) None of us is safe until everyone is safe. Pandemic inequities must end. This includes taking into account pre-existing social determinants of health, addressing access to affordable vaccines, tests, other supplies and treatment[50,130], and paying special attention to the needs of vulnerable groups (such as older[131,132] and immunocompromized[133] individuals, children[134] and healthcare workers[48,135,136]).

groups[80]. By extension, engagement with communities through effective risk communication should remain a priority for all countries.

The WHO recognizes the infodemic as a key challenge to effective communication for general populations[53,81–83], vulnerable groups[84] and scientists[85]. Governments, health authorities and healthcare providers should especially take care in the accuracy of their communications. The panel also emphasized that institutions should proactively monitor false health information and collaborate with trusted community leaders to refute it and enhance trust[86].

Given the disproportionate impact that the pandemic has had on vulnerable groups to date[87–89], the panel voiced concern that policy decisions must aim to find ways of lowering risk within these groups after resumption of the aforementioned activities (STMT6.1). As those vulnerable to COVID-19 in many countries can no longer rely on other individuals practising basic prevention measures (such as the use of face masks and isolating after testing positive), the structural changes recommended in this study (for example, indoor ventilation and filtration) assume heightened importance. Furthermore, COVID-19 continues to prompt global discussion and vigorous debate, particularly about tensions among medical ethics, civil liberties and pandemic control measures[80]. This study is no exception, with statements STMT1.6 (blaming unvaccinated individuals) and STMT3.2 (individual decisions regarding vaccination) receiving the highest levels of disagreement, underscoring the need for equitable structural interventions. In countries with widespread availability of vaccines, it is important for health authorities to distinguish between those who have clearly refused and are unlikely ever to seek vaccination and those who remain hesitant and continue to delay vaccination[90]. In the latter case, specific factors prolonging the delay can be addressed by targeted interventions. Finally, continued uncertainty about the widespread consequences of long COVID and its implications for public health policy (REC2.9) is an ongoing concern[91,92].

Some innovations, notably vaccines[37,38], have not been equitably distributed to low- and middle-income countries, and others, such as high-quality facemasks, have not been widely adopted in high-income countries despite their availability[93]. Some recommendations addressing pandemic inequities remain underleveraged; for example, providing more vaccines[94] to countries with a low percentage of people vaccinated (REC6.10). Other recommendations may necessitate increased funding and time— for example, calls for continued vaccine and treatment innovations (REC2.12, REC5.2, REC5.6).

Importantly, the single significant difference in levels of panel agreement between those working in high-income countries and those working in low- and middle-income countries pertained to the role of economic incentives (REC3.6), probably reflective of sociocultural distinctions or perhaps disagreement over feasibility in implementation and ethics concerns[95,96]. Furthermore, 14% of the panellists considered themselves to be not qualified to respond to STMT4.3 concerning zoonotic variants, which probably indicates a lower understanding of biological vectors and the aetiology of variants among some of the disciplines included in the panel compared with the other topics covered[97].

As noted above, the panellists nearly unanimously agreed on and prioritized whole-of-society and whole-of-government approaches[98–101] (Table 8). The panellists also prioritized recommendations for communicating effectively with the public and developing technologies (for example, vaccines, therapies and services) that can reach target populations (Table 8). Failure to use these approaches risks not only prolonging COVID-19 as a public health threat, but also further diversion of resources from efforts to achieve other extant public health goals[102,103].

Strengths and limitations

One of the strengths of this study is its use of Delphi methodology. By demonstrating increased agreement with each subsequent round, this method enabled us to determine whether our incorporation of feedback was successful in refining the statements and recommendations, increasing the degree of consensus and, in some cases, reaching unanimity. The consistently increasing mean levels of agreement with the consensus statements and recommendations observed across all three survey rounds strengthens our confidence in the relevance of the iterative Delphi process in eliciting feedback to improve subsequent rounds. This is particularly noteworthy given that the effort to incorporate feedback from the expert panel may have resulted in more complex (for example, multiple item) statements and recommendations. Generally, there may be concerns as to the clarity of such statements; however, levels of agreement tended to be either maintained or increased, providing greater confidence in their resonance with the panel. The overall high response rates across three survey rounds speaks to both the rigorous implementation of the method and the commitment of the assembled panel of experts. Endorsement of the resultant consensus statements and recommendations by 184 organizations in 72 countries (Supplementary Table 2) at the time of publication further testifies to their global relevance.

Although the Delphi method is a robust approach (Methods) to assess levels of agreement on specific issues and explore whether a consensus can be reached, it is not without limitations. A main concern pertains to the construction of a truly representative expert panel. The sequential, multimethod sampling approach that we used (see the 'Delphi expert panel member sample' section in the Methods) minimized potential bias from purposive sampling of a small group and, instead, generated a large, geographically and disciplinarily diverse panel from multiple sources (that is, the core group, nominees from the core group and corresponding authors of key COVID-19 literature). While potential panellists were identified from their work related to COVID-19, infectious diseases, public health preparedness and other fields, the chairs further confirmed their appropriateness for the study by instructing them to not participate if they felt they lacked expertise concerning the pandemic. This approach appears to have been appropriate, as only 5–14% of the panellists felt they were not qualified to respond to just 5 out of the 41 statements, and 3 of the 57 recommendations. Although conducting the study in English limited the participation to English speakers, the inclusion of experts from 112 countries and territories strengthens our confidence in the potential broad applicability of these recommendations to a range of cultures and countries. With regard to the mid-study convening of the core group to discuss issues raised in the initial survey rounds, another limitation may have been that we conducted it virtually rather than in person (see the 'Delphi data collection' section in the Methods).

Conclusions

The multidisciplinary panel's emphasis on actionable, near-term recommendations guided the Delphi consensus-building process and increased the relevance of the study's findings to a broad group of stakeholders, including governments, public health authorities, NGOs, community-based organizations, industry, and social media platforms and other media. This consensus study advances a global vision of informed decision-making on how the world can end COVID-19 as a public health threat without a return to sweeping limitations on civil liberties, without risking the health and lives of vulnerable groups, and without exacerbating economic burdens.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41586-022-05398-2.

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Methods

Delphi expert panel member sample

We used an iterative sampling approach to generate a large panel for this Delphi study (Fig. 1). The four co-chairs (J.V.L., A.B., A.K. and A.E.-M.) identified a core group of 40 academic, health, NGO, government and policy experts from 25 countries and territories. Selection by the co-chairs was primarily based on publication record and engagement on COVID-19 issues as well as online biographies. Twenty-nine of these experts were well known to the chairs while seven were suggested through snowball sampling to result in geographical and gender equity among the core group of 40. Furthermore, a concerted effort was made towards multidisciplinary representation in the core group, including medical sciences (such as infectious diseases, public health and vaccinology), engineering, and social sciences (such as policy, law and ethics). The core group proposed additional experts to create a global panel of approximately 400 experts. The lead chair (J.V.L.) and methodologist (D.R.) led this core group through implementation of the project. Snowball sampling was then used as core group members identified individuals with expertise in COVID-19 from their professional networks to generate an initial list of potential Delphi panel members with the goal of broad representation. In proposing experts, co-chairs focused on identifying at least one representative from at least 100 countries. One co-chair (J.V.L.) took responsibility for reviewing the suggestions, with support from a research assistant who shared recent publications and a professional biography for every proposed co-author. Many initial suggestions were of leading experts with whom the co-chairs had previously collaborated.

The core group then reviewed the panel list for under-represented countries and PubMed/Medline searches were conducted using the search term 'COVID-19' in combination with the names of under-represented countries to identify authors of COVID-19 research studies involving primary data collection in these countries. Authors of relevant studies were invited to participate in the Delphi panel to further increase geographical diversity and include panellists beyond the core team members' networks. All of the panel participants were carefully vetted; most had published in one or more relevant fields.

To further validate the expertise of the panel, the study was described to the invitees (n = 696) with the following instructions: "If you consider your professional training and expertise applicable to the subject matter of this global consensus statement project, we encourage you to participate in the panel." Informed consent was obtained for each panellist after explaining the purpose of the study and their expected contributions, including review and approval of the submitted manuscript, by accession to the Round 1 (R1) survey. Our objective was for invited participants to explicitly consider whether they had the necessary level of expertise before joining the Delphi panel. We do not have specific information regarding the basis of invitees' non-participation but expect that these instructions enabled a substantial portion of non-respondents to self-select out of the study. We know that 84 invitees began the R1 survey but did not complete it; thus, if we assume that they did consider themselves to be eligible to participate but then decided not to do so, that would result in an estimated response rate of 82.1% (386 out of 470). The resultant expert panel is diverse in terms of demographic, disciplinary and geographical characteristics (Table 1).

Delphi statement domains

The core group reviewed the published literature available up to January 2022 to draft initial statements for the first Delphi survey round, grouped in the following domains: (1) communication; (2) health systems; (3) vaccination; (4) prevention; (5) treatment and care; and (6) pandemic inequities. No formal systematic review with stringent criteria for levels of evidence was performed owing to the sheer volume of COVID-19-related published studies and the frequency at which they were and continue to be published. However, all of the authors and panellists were invited to suggest relevant papers, which were reviewed by the core group members based on journal rankings, paper citations and other metrics. In R1, panellists considered draft consensus statements based on the literature before moving to the next step of recommendations in round two (R2), which emanated from the panellists' feedback on the statements as well as new research findings over the course of data collection from 18 February 2022 to 28 April 2022.

Delphi method data collection

The study design consisted of digital data collection: two survey rounds (R1 and R2) of draft statements; an online consensus meeting of the core group (16 March 2022) to discuss salient issues; one round of draft recommendations (in R2); and, a final, third survey round (R3) of the consensus statements and recommendations (Fig. 1). The core group decided a priori to use a supermajority (that is, ≥67% combined agreement) minimum cut-off for consensus. This more demanding cut-off (relative to a simple majority of greater than 50%) was considered to be necessary given the project goal of supporting global policy and programmatic actions to address the COVID-19 public health crisis. We used the QualtricsXM platform to develop and distribute the surveys (round duration ranged from 1.5 to 3 weeks) with four-point Likert-type categories for measuring the level of agreement with the statements and recommendations (that is, agree, somewhat agree, somewhat disagree, disagree); a fifth 'not qualified to respond' option was provided given the panel's range of COVID-19 expertise. Panellists could provide comments and suggest edits to individual statements and recommendations in text boxes, which followed each of the statements and recommendations. All rounds allowed for overall comments at the end of the survey, and the researchers reviewed 1,409, 755, and 188 comments associated with the statements in R1, R2 and R3, respectively, and 1,025 and 2,156 comments associated with the recommendations in R2 and R3, respectively. Summaries of changes based on panellist input from a previous round were available in text boxes next to each statement and recommendation in the subsequent round. Similarly, the definition for "Ending COVID-19 as a public health threat as evidenced by the resumption of social, cultural, religious, political, healthcare, economic and educational activities in each country's context" was presented during each round so that panellists could respond to statements on the basis of a shared understanding of how the phrase "ending COVID-19 as a public health threat" was defined for the purpose of this study. In R3, panellists also ranked the top half of recommendations within each of the six domains, which were automatically randomized to mitigate order-effect bias. Using Microsoft Excel (v.16), scores were calculated and normalized using the Dowdall system to compare rankings across domains by accounting for weighting bias due to differences in the total number of recommendations in each domain[137,138].

An important component of the data-collection process involves the discussion among core group members of issues that emerge from the early survey rounds and how best to incorporate such feedback in subsequent rounds. Given the geographical distribution of panel members and COVID-19-related travel and health concerns, we convened the core group virtually for in-depth, real-time deliberation. This web-based approach is different from in-person discussion of complicated or contentious issues; however, panel members had multiple opportunities to provide open-ended comments in the absence of dominant voices that can inhibit the expression of minority viewpoints during in-person convenings. Thus, the combination of real-time feedback (from core group members) and written feedback (from the entire panel) probably resulted in more comprehensive contributions overall.

Delphi data analysis

Data analysis reflected the multiple-methods nature of Delphi studies and was managed by an analytic team of core group members, the study methodologist and research assistants. Across the three rounds, we ran frequencies of all statements and recommendations (Supplementary

Discussion 2); the proportion who selected 'not qualified to respond' is reported in the data tables but removed from the denominator to calculate levels of agreement/disagreement from the relevant sample. The team then analysed the extensive qualitative data (that is, open-ended text-box comments). Specifically, comments were first reviewed individually by at least three core group members (J.V.L., co-chair; D.R., methodologist; and C.J.K.) and an additional co-author (T.M.W.). For each data collection round, comments were then discussed in online review meetings, including at least three core group members and an additional co-author. After review and discussion, comment suggestions were incorporated into statement and recommendation revisions for subsequent rounds. A supermajority of core group members (28 out of 40; 70%) participated in the online consensus meeting, which permitted in-depth breakout-group discussions on salient issues from R1 and R2 informing R3 revisions (Supplementary Discussion 3). Quantitative analysis of the final R3 results involved assigning each statement and recommendation a grade to indicate the level of combined agreement (agree + somewhat agree), using a system that has been used in other Delphi studies[139–141] in which 'U' denotes unanimous (100%) agreement; 'A' denotes 90%–99% agreement; 'B' denotes 78%–89% agreement; and 'C' denotes 67%–77% agreement. Although all statements and recommendations exceeded the standard supermajority minimum of ≥67% combined agreement for consensus, we highlighted those with <67% for 'agree' alone for further analysis. Statements and recommendations were analysed using Fisher's exact tests in Stata (v.16) to assess differences in agreement by the following panellist characteristics: income level (high income versus low- and middle-income) for country of birth and country where currently working, primary sector of employment and primary field of employment (Supplementary Discussion 2). The use of the terms combined agreement and combined disagreement are presented in the results.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

Additional data will be shared on request from the corresponding author for fair use.

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Author contributions This study was led by four co-chairs (J.V.L., A.B., A.K. and A.E.-M.) who were part of a core group of 40 co-authors (J.V.L., D.R., C.J.K., S.A.K., L.J.A.R., G.A., R.B.L., J.A.B., M.L.B., Y.B.-Y., Q.B., C.B., M.B., S.-T.C., C.d.R., G.J.D., G.G., L.O.G., M.H., J.L.J., C.K., N.L., M.M., M.M.K., S.N., M.O.B., B.P., O.P., K.R., S.R., S.R., M.R., R.S., S.S., M.T.-H., S.V., P.Y., A.B., A.K. and A.E.-M.). The co-chairs regularly updated the core group members by email and J.V.L. led an online consensus meeting hosted by Wilton Park in March 2022. D.R., the lead chair (J.V.L.) and T.M.W. led the methodology. J.V.L., D.R., T.M.W. and C.J.K. reviewed all comments submitted as part of the three survey rounds. J.V.L., C.J.K. and T.M.W. reviewed all comments sent directly by email. J.V.L., D.R., C.J.K., T.M.W. and K.R. reviewed all comments from the peer reviewers. All COVID-19 Consensus Statement Panel members had the opportunity to review the full draft of the manuscript and provide three rounds of comments through QualtricsXM. Those fulfilling authorship criteria are named (n=364).

Competing interests J.V.L. reports research grants to his institution from AbbVie, Gilead Sciences and MSD, and speaker fees from AbbVie, Gilead Sciences, Intercept, Janssen, MSD and ViiV, and an advisory board fee from AbbVie and Novavax, all unrelated to this work. R.A. is a co-chair of the Occupational Medicine Committee of the British Medical Association and a member of the Industrial Injuries Advisory Council (UK). S.A. reports honoraria for lectures and educational events from Gilead, AbbVie, MSD and Biogen, and reports grants, not related to COVID-19, from Gilead and AbbVie. The A.G.-S. laboratory has received research support from Pfizer, Senhwa Biosciences, Kenall Manufacturing, Avimex, Johnson & Johnson, Dynavax, 7Hills Pharma, Pharmamar, ImmunityBio, Accurius, Nanocomposix, Hexamer, N-fold, Model Medicines, Atea Pharma, Applied Biological Laboratories and Merck. A.G.-S. has consulting agreements for the following companies involving cash and/or stock: Vivaldi Biosciences, Contrafect, 7Hills Pharma, Avimex, Vaxalto, Pagoda, Accurius, Esperovax, Farmak, Applied Biological Laboratories, Pharmamar, Paratus, CureLab Oncology, CureLab Veterinary, Synairgen and Pfizer. A.G.-S. has been an invited speaker in meeting events organized by Seqirus, Janssen and AstraZeneca. A.G.-S. is listed as an inventor on patents and patent applications (US patent numbers: 5,820,871; 5,854,037; 6,001,634; 6,146,642; 6,451,323; 6,468,544; 6,544,785; 6,573,079; 6,635,416; 6,649,372; 6,669,943; 6,740,519; 6,852,522; 6,866,853; 6,884,414; 6,887,699; 7,060,430; 7,384,774; 7,442,379; 7,494, 808; 7,588,768; 7,833,774; 8,012,490; 8,057,803; 8,124,101; 8,137,676; 8,591,881; 8,629,283; 8,673,314; 8,709,442; 8,709,730; 8,765,139; 8,828,406; 8,999,352; 9,051,359; 9,096,585; 9,175,069; 9,217,136; 9,217,157; 9,238,851; 9,352,033; 9,371,366; 9,387,240; 9,387,242; 9,549,975; 9,701,723; 9,708,373; 9,849,172; 9,908,930; 9,968,670; 10,035,984; 10,098,945; 10,131,695; 10,137,189; 10,179,806; 10,251,922; 10,308,913; 10,543,268; 10,544,207; 10,583,188; 10,736,956; 11,254,733; and 11,266,734) on the use of antivirals and vaccines for the treatment and prevention of virus infections and cancer, owned by the Icahn School of Medicine at Mount Sinai, New York. S.G. reports being a member of Independent SAGE and member of the Pfizer Antivirals Advisory Board. P.H. reports being co-inventor of a COVID-19 recombinant protein vaccine technology owned by the Baylor College of Medicine (BCM) that was recently licenced by BCM non-exclusively and with no patent restrictions to several companies committed to advance vaccines for low- and middle-income countries. The co-inventors have no involvement in licence negotiations conducted by the BCM. Similar to other research universities, a long-standing BCM policy provides its faculty and staff, who make discoveries that result in a commercial licence, a share of any royalty income. To date, BCM has not distributed any royalty income to the co-inventors on the COVID-19 recombinant protein vaccine technology. Any such distribution will be undertaken in accordance with BCM policy. A.K. has served as a paid consultant to the Independent Panel on Pandemic Preparedness and Response in 2020–21. K.K. is Chair of the Ethnicity Subgroup of the UK Scientific Advisory Group for Emergencies (SAGE) and Member of SAGE. J.L. reports owning equity in Codiak BioSciences and Exocure Biosciences, both having developed experimental COVID-19 vaccines. G.M. reports honoraria for a presentation from Novartis and consulting fees from AstraZeneca. S.M. reports being founder and chief scientific officer of PulmoBioMed. T.S. serves as the scientific director of the O'Brien Institute for Public Health and reports funding from the Canadian Institutes of Health Research. V.S. is a member of the National Scientific Committee of Experts for COVID-19 in Greece and reports grants from Gilead and Abbvie that are not related to this work or to COVID-19 research. A.T. reports grants from the Foundation for Advancing Family Medicine Janus Research Grant; Canadian Frailty Network Research Grant, Speaking Honoraria: University of Ottawa, McMaster University, Northern Ontario School of Medicine, McGill University, University of Calgary, BC Bereavement Hotline, Early Education Teachers of Ontario-Yok Region Union, Ontario Council for Cooperation, TELUS Science World-Vancouver. R.B. has been COVID-19 adviser to UK government and acts as a senior scientific adviser for a communications company working for the UK Government on COVID-19. A.W. reports research funding from Pfizer (unrelated to COVID-19) and a consulting fee from Ocugen. K.Y. is an unpaid member of the Independent SAGE group of scientists. The other authors declare no competing interests.

Additional information
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Peer review information *Nature* thanks Jeremy Farrar, Sean Grant and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.

Extended Data Fig. 1 | Top half of the ranking of the recommendations in each domain. In the third and final round of the Delphi process, panel members were asked to rank the recommendations per domain (n = 6) based on importance. This figure shows the top half of the recommendations for each of the six domains (communication; health systems; vaccination; prevention; treatment and care; and inequities).

Extended Data Table 1 | Recommendations with 5% or greater disagreement

REC3.6 (18% SD/D)	As the causes of vaccine hesitancy are not solely a function of information or worldview, economic incentives should be considered in parallel with information and access to increase vaccination rates.
REC2.18 (11% SD/D)	In settings where access to polymerase chain reaction (PCR) or antigen tests may be limited, providers should consider adopting a syndromic approach to COVID-19 diagnosis for symptomatic individuals.
REC2.17 (8% SD/D)	In the absence of a new multilateral organisation focused on pandemic control, Member States should authorise WHO to lead a large, inclusive, multi-stakeholder, global effort to provide public health and clinical targets pertaining to the pandemic, with an emphasis on cases, vaccination, morbidity and mortality.
REC4.7 (8% SD/D)	Governments should only consider imposing broad restrictions on civil liberties in the event of variants of concern presenting risk of high rates of transmission and severity, coupled with (i) waning immunity or (ii) vaccine resistance.
REC1.10 (7% SD/D)	Governments should consider holding publishers of false health information liable, while balancing civil liberties.
REC2.16 (7% SD/D)	Because the global marketplace has not satisfied demand for vaccines, treatments and supplies, countries and regions should consider legislative and regulatory reforms to address these market failures (e.g., nationalising manufacturing capacity, negotiating global and regional trade agreements, adjusting intra-country intellectual property rights).

Across the study, only six recommendations evidenced 5% or greater disagreement (combined "somewhat disagree/disagree") among the 386 panellists. Areas of disagreement broadly included socio-political and socio-cultural considerations that vary among countries, geopolitical concerns that may impact public health guidance and distinct medical points of view.

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Software and code

Policy information about availability of computer code

Data collection	QualtricsXM® platform
Data analysis	Microsoft Excel v16 and Stata v16

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

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Human research participants

Policy information about studies involving human research participants and Sex and Gender in Research.

Reporting on sex and gender	We report proportion of participants selecting "man", "woman", "non-binary or gender diverse", and "prefer not to say". As neither sex nor gender are determinative of one's subject matter expertise (the primary inclusion criteria for the panel), we did not consider any tests to investigate differences in this expertise by gender. Sex was not collected. The panel reported near-gender parity between men and women.
Population characteristics	The panel's characteristics are reported in Table 4 and are as follows: Gender: Man (58%), Woman (40%), No response (2%) Primary sector of employment: Civil Society (66%), Private (16%), Academic (10%), Public (5%), Other (2%), No response (1%) Primary field of employment: Public Health (41%), Clinical Research/Care (24%), Health Policy/Advocacy (17%), Basic/ Physical/Mathematical Sciences (11%), Other (6%), No response (2%) Country income level: Low or middle income country (50%), High income country (48%), No response (1%) Global region of origin: Europe & Central Asia (30%), Latin America & Caribbean (15%), East Asia & Pacific (13%), North America (12%), Sub-Saharan Africa (11%), Middle East & North Africa (9%), South Asia (9%)
Recruitment	We employed an iterative sampling approach to generate a large panel for this Delphi study (Figure 1). The four co-chairs (JVL, AB, AK, AE-M) identified a core group of 40 experts from 25 countries, representing discipline, geographic and gender diversity to guide development of consensus statements and recommendations to end COVID-19 as a public health threat. The lead chair (JVL) and methodologist (DR) led this core group through implementation of the project. Snowball sampling was then used as core group members identified individuals with expertise in COVID-19 from their professional networks to generate an initial list of potential Delphi panel members with the goal of broad representation. The core group reviewed the panel list for under-represented countries and PubMed/Medline searches were conducted using the search term "COVID-19" in combination with the names of under-represented countries to identify authors of COVID-19 research studies involving primary data collection in these countries. Authors of relevant studies were invited to participate in the Delphi panel in order to further increase geographic diversity and include panellists beyond the core team members' networks. To further validate the expertise of the panel, the study was described to the invitees, who were instructed not to participate if they considered themselves lacking the necessary level of expertise. Informed consent was obtained for each panellist after explaining the purpose of the study and their expected contributions, including review and approval of the submitted manuscript, by accession to the R1 survey.
Ethics oversight	This study has been exempted from ethical review by the Research Ethics Committee of the Hospital Clinic, University of Barcelona, Spain.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

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All studies must disclose on these points even when the disclosure is negative.

Study description	This is a three-round, standard Delphi consensus statement study.
Research sample	Selection of participants was primarily based on publication record and engagement on the issues, not necessarily to be representative of any country, sector, or field. A number of these experts were well known to the chairs while others were suggested through snowball sampling to ensure broad international geographic and gender equity among the core group of 40. Further, a concerted effort was made to ensure multi-disciplinary representation in the core group, including medical sciences (e.g., infectious diseases, and public health, vaccinology), engineering, and social sciences (e.g., policy, law, ethics). It was a prerequisite that the core group would be able to suggest additional experts to create the global panel of 386 experts (58% male, 66% working primarily in civil society, 41% working primarily in public health, and 50% working in low and middle income countries).
Sampling strategy	We employed an iterative sampling approach via a core group of 40 public health experts that represented gender and geographic

Sampling strategy	parity in order to create a robust international multi-disciplinary panel that could substantively engage with the content of the study.
Data collection	We used the QualtricsXM® platform to develop and distribute the surveys (round duration ranged from 1.5 to 3 weeks) with 4-point Likert-type categories for measuring level of agreement with the statements and recommendations (i.e., Agree, Somewhat agree, Somewhat disagree, Disagree); a fifth 'not qualified to respond' option was provided given the panel's range of COVID-19 expertise. Panellists could provide comments and suggest edits to individual statements and recommendations in text boxes, which followed each of the statements and recommendations.
Timing	The study design consisted of digital data collection: two survey rounds (R1 and R2) of draft statements and recommendations (18 February-15 March 2022); an online consensus meeting of the core group (16 March 2022); and a third survey round (R3) (15 April-28 April 2022).
Data exclusions	No data were excluded.
Non-participation	All co-authors participated in the Delphi process and approved the submitted consensus statement manuscript.
Randomization	Panelists participated as a single group. However, when ranking the recommendations, the recommendation items were randomized within each domain so as to avoid question-order bias.

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☒	☐ Dual use research of concern

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
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