Knowledge and experience of physicians during the COVID-19 Pandemic: A global cross-sectional study

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Abstract

Physicians are on the frontline of the COVID-19 pandemic with responsibility to manage the disease. The aim of this study is to investigate physicians’ knowledge, attitudes, perceptions and experiences, as well as preventative practices regarding the COVID-19 pandemic and COVID-19 vaccinations. Further, we explore physicians’ recommendations for future pandemics. A mixed-methods online survey was disseminated to physicians globally. The survey was distributed via social media from August 9–30, 2021. Data collected included sociodemographic characteristics, knowledge, attitudes, and practices towards COVID-19, concerns regarding vaccinations, and perspectives on policies implemented. Descriptive statistics were reported, and qualitative data were analysed using inductive thematic analysis. A total of 399 physicians from 62 countries completed the survey, with similar participation from High Income Countries and Low- or Middle-Income Countries. Most physicians (87%) revealed a good level of knowledge while only half (54%) reported adhering to adequate preventative measures. More than half of participants (56%) indicated that the policies implemented to handle COVID-19 by their public health agencies were insufficient or disorganised. While most physicians reported increased mental stress (61%) and described their experience with COVID-19 using negative terminology (63%), most physicians (87%) indicated they are willing to continue working in healthcare. Physicians globally possessed good knowledge of COVID-19 and COVID-19 vaccinations; yet improvements in ensuring compliance with preventative measures is warranted. Findings from this study have important implications. As recommended by physicians, efforts to manage pandemics should involve (1) strengthening health systems, (2) minimising adverse effects of infodemics, (3) delegating decision-making roles appropriately, and (4) acknowledging global responsibility.
Introduction

Coronavirus disease (COVID-19), caused by SARS-CoV-2 virus, has so far claimed the lives of more than 6.2 million people as of 10 May 2022 including healthcare professionals (HCPs) [1–3]. According to reports from Amnesty International and the World Health Organization (WHO) more than 115,000 HCPs have died from COVID-19, leaving an irreplaceable gap in pandemic response worldwide [4–6]. The impact of COVID-19 on HCPs has been summarized by the WHO and consists of four concerns: (1) availability and distribution of healthcare personnel and equipment, (2) health of physicians, including the risk of burnout and mental disorders, (3) social wellbeing, such as discrimination and concern for family, and (4) working conditions, such as lack of incentives, psychological support, or vaccinations [6]. Nevertheless, HCPs continue to serve on the frontline against COVID-19, often following local, national, and international preventative and treatment guidelines on the prevention and treatment of COVID-19. Further, the response and mitigation measures to control the pandemic have been updated regularly around the world and COVID-19 vaccines have been manufactured and deployed at a rapid pace. It is therefore essential that HCPs have access to relevant updated information to protect themselves against COVID-19 and to ensure appropriate patient management.

To our knowledge, previous cross-sectional studies exploring the knowledge and experiences of HCPs towards COVID-19 were primarily conducted within the first six months of the pandemic. Given the numerous changes to the guidelines since the beginning of the pandemic, these studies may not represent the current knowledge and experience of physicians. Furthermore, the majority of these studies were conducted within one country [7–22]. Results from a systematic review in November 2020 exploring these national studies revealed that HCPs possessed adequate knowledge of the disease and generally had positive attitudes towards the pandemic [13]. However, an updated systematic review in May 2021 demonstrated that HCPs had poor compliance to particular safety practices [23]. One global study conducted in March 2020, revealed that HCPs had poor knowledge regarding the virus’s mode of transmission and symptom onset [24]. Additionally, very few studies have been conducted on HCP’s perceptions of COVID-19 vaccines. These studies were also conducted on a national level and have shown that increased knowledge is an important predictor of vaccine hesitancy among HCPs [25, 26].

This global cross-sectional mixed-methods study investigates the knowledge, attitudes, perceptions, and practices (KAPP) of physicians towards COVID-19 disease and COVID-19 vaccines. Understanding the experiences of physicians globally can highlight gaps in policies and educational interventions that have been aimed at physicians and the public. Physicians’ reflections and their recommendations for future health emergencies are also explored. Future pandemics are considered inevitable due to the presence of high-risk factors such as overpopulation, poverty, and global warming [27–30]. The findings of this study and the recommendations of physicians from 62 countries will likely inform the development of future policies within health systems to support frontline health care providers during health emergencies.

Methods

Study design and data collection

A mixed-methods cross-sectional study using an online survey was conducted to obtain responses from physicians globally between the 9th and 30th of August 2021. The online survey was distributed via social media, particularly E-mail and WhatsApp, using a snowballing technique [31]. The invitation letter included a brief description of the study and a URL link to the survey. Physicians were identified via professional groups and academic institutions. In this study, a physician is defined as a medical doctor who practices medicine and includes surgical,
non-surgical, and public health specialties. Informed consent was obtained by participants on the first page of the online questionnaire along with clear statements that participation was voluntary and uncompensated. To ensure quality control and to maximise completeness of the data, incomplete surveys and responses from non-physicians were removed from the analysis.

Sample size calculation
The sample size was calculated using the online RAOSOFT sample size calculator [32]. The required sample size would be at least 377 participants for a global survey with an estimated population of more than 20,000 physicians (the largest estimate possible), in addition to an anticipated response of 50%, confidence level of 95%, and 5% margin of error.

Survey instrument and scoring system
A structured questionnaire was designed on Microsoft Forms by the authors to cover important aspects of KAPP of physicians. The survey instrument was initially developed based on previous surveys [9, 11, 24]. The final questionnaire (S1 File) was modified for relevance based on the most recent information from the WHO Online Resources for COVID-19, as of July 07, 2021.

The final questionnaire was divided into eight sections: (1) Sociodemographic characteristics; (2) Sources of information; (3) Knowledge section: a total of 16 items were designed to measure physicians' knowledge about the COVID-19 disease and vaccines. All items were single best answer questions. Correct options were assigned 1 point and incorrect options 0 points. The total knowledge score was a sum of scores. Based on Bloom’s cut-off point [11], overall knowledge was categorised as good if above 60% and poor if below 60%. Cronbach’s alpha coefficient for the knowledge questions was 0.936. (4) Practice section: five questions were used to evaluate utilisation of various preventative measures. The three answer options included “always”, “occasional”, or “never”. The latter two were assigned 0 points, and the former was assigned 1 point. The total practice score was a sum of scores. Physician’s overall practice was categorised based on Bloom’s cut-off point [11] as good if above 80%, and poor if below 80%. Cronbach’s alpha coefficient for the practice questions was 0.638. (5) Physicians’ perspective on vaccinations; (6) Physicians’ perspective on policies implemented; (7) Physicians’ subjective attitudes towards the pandemic; (8) Physicians’ personal reflections (Describe your COVID-19 experience in one word; What are your recommendations for future pandemics?).

Content validity of the final version was assessed by three experts who specialise in the field of infection control and emergency preparedness. The survey was then pilot tested in a sample of 10 physicians to check the acceptability, clarity, readability, and relevance of all items. Physicians did not report any problems in understanding the questionnaire. On average, the survey was completed within 10 minutes. The data of the pilot study was removed from the final analysis.

Statistical analysis
Statistical analysis was carried out using the statistical software SPSS (Statistical Package for Social Sciences), version 22.0. Descriptive statistics were reported using means and standard deviations (SD) for continuous variables and frequency with percentages for categorical variables.

Thematic analysis
Data from the two open-ended questions was summarised using an inductive thematic analysis approach [33]. Three team members independently coded a sample of the data until a
consensus was reached and a coding framework was formulated. Two members independently coded the remaining data and negotiated agreements on discrepant codes. Three members reviewed the codes, sorted codes into descriptive categories based on patterns, and subsequently grouped descriptive categories to generate major themes.

The study was approved and given favourable ethics opinion by the St George’s, University of London Research Ethics Committee (SGREC) under study title “Knowledge and Perspectives of Health Care Providers on COVID-19: A Global Cross-Sectional Study” with REC Reference: 2021.0127. The overall study was guided by the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) Statement for cross-sectional studies [34].

Results

Baseline characteristics of study participants

Table 1 summarises participant characteristics. A total of 411 HCPs participated in our survey, 399 of whom were physicians, including 224 (56%) male, and 174 (44%) female. The majority were between 46–55 years old (n = 108, 27%), and practising in internal medicine (n = 80, 20%), surgery (n = 80, 20%), or general practice (n = 72, 18%). Most physicians had been practising medicine for 10 years or longer (n = 292, 73%) and most respondents identified as frontline workers (n = 268, 67%). Physicians from 62 unique countries responded to the survey, with similar participation from High Income Countries (n = 214, 54%) and Low- or Middle-Income Countries (n = 185, 46%), as identified by the World Bank [35]. Fig 1 provides a visual representation of respondents per country.

Sources of knowledge

Primary sources of knowledge amongst respondents were News Media and Official Government Websites (Table 2). Most physicians (51%) indicated Official Government Websites as their most-used source. The majority of respondents (43%) indicated social media as their least-used source.

Physicians’ knowledge towards COVID-19 virus and vaccines

Of all physician respondents, 349 (87.5%) participants had good knowledge about COVID-19 disease and COVID-19 vaccines (Table 3). Poor knowledge was observed for questions concerning the nature of disease (52%) and treatment of disease (59.9%). Conversely, good knowledge was observed in responses regarding transmission of disease (71.5%), actions dealing with cases (72.5%), and nature of vaccines (89.5%). The mean total knowledge score was 11.07 (SD = 1.49). No differences between various physician specialties, frontline worker status, or residency in LMIC versus HIC were observed.

Physicians’ practice towards COVID-19

Table 4 summarises preventative practices against COVID-19. Of the 399 respondents, 214 (54.1%) reported adequately adhering to preventative measures while working. The most prevalent practise among physicians was Item 3: I wash my hands with soap or rub my hands with hydro-alcoholic gel during my work shift (94.2%). Conversely, less than half of all respondents reported wearing gloves (Item 2) while working (39.6%). The mean score for overall preventative practices towards COVID-19 is 3.47 (SD = 1.18). No differences between residency in LMIC versus HIC were observed.
Physicians’ experience towards COVID-19 vaccinations and policies

Most physicians (63%) indicated being worried about distribution of vaccines to the general population and half (50%) were concerned with the long-term side effects of vaccinations (Fig 2). Table 5 summarises physicians’ perceptions towards the COVID-19 vaccines. The majority of physicians (n = 283, 71%) indicated Pfizer-BioNTech as most effective; while 195 (49%) physicians indicated that the AstraZeneca (Covishield and Vaxzevria) vaccine has the highest risk for complications, followed by the Janssen (n = 39, 9.8%) and Sputnik V (n = 38, 9.5%)
vaccines. Most physicians (96%) indicated having received the COVID-19 vaccine; only 10% of physicians were/are hesitant to receive a vaccine.

With regards to physicians’ experience with COVID-19 policies, most physicians (60%) indicated that policies implemented by their healthcare facility were adequate in handling COVID-19, only 42% specified that the policies implemented by their public health agencies were adequate (Fig 2).

Physicians’ attitudes towards COVID-19

With regards to attitudes (Table 6), high ratings of agreement (i.e., ≥ 50% agreement) were reached regarding questions of increased workload (Item 3), subjective mental stress (Item 4), worrying about the future (Item 8), and fear of contracting the virus and passing it on to family or friends (Item 9). Importantly, most physicians (n = 247, 87%) indicated that they are willing to continue working in the health system after the pandemic (Item 10).

Physicians’ experiences of COVID-19

A total of 389 participants responded to the question: Describe your experience with COVID-19 in one word. A total of 168 unique words were organised under 20 descriptive

Table 2. Sources of information (N = 399).

| Response   | News Media | Social Media | Official Govt. Website | Family member or colleague |
|------------|------------|--------------|------------------------|----------------------------|
| Least Used | 70 (17.5)  | 172 (43.1)   | 14 (3.5)               | 126 (31.6)                 |
| Sometimes  | 147 (36.8) | 116 (29.1)   | 58 (14.5)              | 165 (41.4)                 |
| More Used  | 117 (29.3) | 63 (15.8)    | 120 (30.1)             | 87 (21.8)                  |
| Most Used  | 65 (16.3)  | 48 (12.0)    | 207 (51.9)             | 21 (5.3)                   |
subthemes and subsequently grouped into three major themes, namely (1) Negative experience (n = 253, 65%), (2) Positive experience (n = 23, 6%), and (3) Neutral experience (n = 113, 29%). Fig 3 presents a visual representation of physicians' experiences of COVID-19 (n = 389) one-word descriptions. Table 7 summarises the thematic analysis of physician experiences. No significant differences between demographic variables (including physician specialties, frontline worker status, or residency in LMIC versus HIC) were observed in association with a...
negative, positive, or neutral experience. However, participants who indicated the policies implemented by their healthcare facilities were inadequate (i.e., disorganized or inefficient)

Table 5. Summary of physicians’ perceptions towards the COVID-19 vaccines (N = 399).

| Item                                             | N (%)     |
|--------------------------------------------------|-----------|
| **Vaccine with Highest Efficacy**                |           |
| Pfizer-BioNTech                                  | 283 (70.9)|
| Moderna                                          | 47 (11.8) |
| AstraZeneca (Covishield and Vaxzevria)           | 29 (7.3)  |
| Janssen (Johnson and Johnson)                    | 8 (2.0)   |
| Sputnik V                                        | 7 (1.8)   |
| Other                                            | 25 (6.3)  |
| **Vaccine with Highest Potential for Complications** |         |
| AstraZeneca (Covishield and Vaxzevria)           | 196 (49.1)|
| Janssen (Johnson and Johnson)                    | 39 (9.8)  |
| Sputnik V                                        | 38 (9.5)  |
| Sinopharm                                        | 23 (5.8)  |
| Sinovac Biotech                                  | 23 (5.8)  |
| Pfizer                                           | 20 (5.0)  |
| Moderna                                          | 9 (2.3)   |
| Other                                            | 51 (12.8) |
| **Vaccination Status**                           |           |
| Yes                                              | 381 (95.5)|
| No                                               | 13 (3.3)  |
| Do not want to answer                            | 5 (1.3)   |
| **Vaccine Hesitancy**                            |           |
| No                                               | 259 (90.0)|
| Yes                                              | 40 (10.0) |
| **Health System Efficacy in Procuring/Distributing Vaccines** |           |
| Yes                                              | 250 (62.7)|
| No                                               | 149 (37.3)|

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were more likely to also describe their experience with COVID-19 using negative terminology ($X^2(6) = 29, p < 0.0001$). There were no differences in one-word responses based on participants’ perspectives on policies implemented by public health agencies.

**Physicians' recommendations for future pandemics**

A total of 387 participants responded to the question: What recommendations do you have for future pandemics? Inductive thematic analysis of responses revealed twenty-seven distinct subthemes organised into seven major themes, described below. Table 8 summarises...
Table 7. Summary of thematic analysis of physicians’ experiences with COVID-19 (N = 389).

| Theme | Sub-theme (N) | Words |
|-------|--------------|-------|
| **Negative Experience** | | |
| All-Consuming (91) | Anxiety (3), Worrying (3), Draining (6), Exhausting (30), Fatigue, Overwhelming (5), Strenuous (3), Stressful (22), Taxing (2), Tiring (9), Tough, Trying, Fight for life, Long (2), Never-ending (2) |
| Appalling/Agony (37) | Suffering, Awful (3), Bad (10), Burden (2), Detrimental, F’*’*’D, Hell (2), Horrible (8), Miserable, Painful, Shattering, Terrible (5), Worse |
| Resentment (23) | Anger, Annoying (3), Boring (4), Disappointing (5), Disturbing, Frustrating (7), Irritated, Inconvenient |
| Depressive (20) | Death, Depressive (2), Disheartening, Distressing, Gloomy future, Grieve, Helpless, Hopeless, Joyless, Mental breakdown, Regrettable, Sad (6), Unpleasant, Resignation |
| Frantic (20) | Chaotic (9), Claustrophobic, Clusterfuck, Disruptive (3), Hectic, Panic (2), Pressure-filled, Risky, Impatience |
| Fear (18) | Afraid, Fear (9), Frightening (4), Horrifying, Scared, Terrified (2) |
| Uncertainty (14) | Concerning (4), Confusing (5), Doubt, Turbulent, Uncertain (3) |
| Catastrophic (11) | Devastating, Apocalyptic, Tsunami, Unimaginable, Unrelenting, War, Disaster (5) |
| Inadequate (11) | Behind, Discrimination, Disproportionate, Ignorance, Insufficient (2), Uncoordinated, Unprepared, Carelessness, Disorganized (2) |
| Seclusion (8) | Disconnected, Isolated, Lonely (2), No contact, Removed, In silos, Sheltered |
| **Positive Experience** | | |
| Worthwhile (11) | Excellent, Good (6), Love frontline work, Perfect, Positive |
| Illuminating/Revealing (10) | Amazing, Hopeful, Awakening, Enlightening (3), Extraordinary, Fascinating (2), Insightful |
| Beneficial (2) | Helpful, Useful |
| **Neutral Experience** | | |
| Demanding (35) | Difficult (6), Hard (2), Challenging (27) |
| Unparalleled (23) | Spiritual, Interesting (4), Life-changing (2), Revolutionary, Strange, Surreal (2), Unique, Unknown, Unprecedented, Vicarious, World-changing, Wow, Humbling, Surprise, Unexpected, Shocking, Touching, Mystical |
| Adequate (14) | Fair (2), Fine, Not bad, Okay, Satisfactory (3), Mixed, Neutral (2), Expected (2), Life |
| Significant/Substantial (13) | Rich, Serious (2), Extensive, Intense (4), Strong, Cautious (2), Only the beginning, Worldwide |
| Physicians’ Duty (11) | Commitment, Opportunity, Primary care experience, Responsibility (2), Telehealth, Work Load, Frontline, Experience, PPE, Politics |
| Adjustment (10) | Adaptation, Change (2), Getting used to it, Lessons, Resilience, Coping well, New (3) |
| Immersive (7) | Active, Busy (2), Dynamic, Hustle, Rollercoaster, Rapid |

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Table 8. Summary of thematic analysis of physicians’ recommendations (N = 387).

| Theme | Summary |
|-------|---------|
| **Holistic Preparation** | Physicians acknowledged the importance of preparing for future pandemics through education, prevention, proactive planning, and pre-emptive policy development and implementation. |
| **Execution of Response Measures** | Physicians expressed the need of recognizing pandemics, implementing better guidelines, minimizing response time, adequately implementing response measures, in addition to improvements in surveillance and vaccination. |
| **Health System Strengthening** | Physicians recognized the cracks in our current healthcare system and recommended strengthening the infrastructure, promoting transparency, and one that does not operate for profit. |
| **Appropriate Delegation of Roles** | Physicians observed a need to allow individuals to perform within their designated roles when managing pandemics. |
| **Minimize Infodemics** | Physicians indicated the importance of minimizing the spread of misinformation during pandemics by improving communication in addition to ensuring the distribution of credible information. |
| **Global Responsibility** | Physicians acknowledged the importance for global unity when managing global outbreaks and establishing pandemic-resistant global health systems. |
| **Uncertainty** | A few physicians were uncertain about providing recommendations or expressed limitations of their role as a physician in being able to provide recommendations. |

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physicians’ recommendations, and S1 Table provides detailed codes and exemplar quotes from the thematic analysis.

**Theme 1: Holistic preparation.** This theme represents preparing for future pandemics through education, prevention, and pre-emptive policy development and implementation. Physicians called for “more research” on pandemics and ensuring that the public, politicians, and interdisciplinary medical teams were continuously educated on the risks of a pandemic. One physician recommended to “build specific structures against pandemics”, while another suggested to “learn from mistakes” and “ensure that any knowledge gained from the past is applied proactively for future pandemics”. One physician voiced the need to “have a better pandemic preparedness strategy, don’t wait for the 2nd/3rd wave” and another revealed “now is the time to prepare”.

**Theme 2: Execution of response measures.** This theme included actionable items relating to pandemic response and highlighted the importance of attending to the emotional well-being of people. On the threat of the pandemic, physicians pointed out the need for “less denial” and to “take it seriously earlier”. Others revealed the need for accountability: “the country responsible for the outbreak must take responsibility and admit”. Some physicians (n = 9, 2%) called for clear and standardised guidelines, “have a manual of operation and follow it”. However, a need for flexibility was also voiced, “allow MDs to treat patients according to their judgement and do not limit them to strict guidelines”. Additionally, physicians proclaimed a need to “act quickly and definitively” and “be rapid and safe in your response”. Some physicians noted the need for “early diagnosing, tracing, and isolating cases”. Others recommended implementing stricter protective measures stating: “quarantines should be stronger”, “earlier ban in travel”, and “mask mandates”. Physicians expressed the need for local decision making, “decision-making at the local and state levels according to the degree of incidence”. A portion of physicians agreed on the significance of vaccinations, recommending better accessibility, compliance, and distribution of vaccinations. They noted a need for the world to “achieve herd immunity through vaccination” and some called for “mandatory vaccination”. Physicians also recommended addressing the morale of the public: “don’t panic”, “be realistic”.

**Theme 3: Health system strengthening.** Physicians recommended for health systems with stronger infrastructure and comprehensive resources for its physicians. Physicians also called for a health system that prioritises “physician health and safety” and promotes transparency among its constituents. Some physicians voiced a need for the health system to employ an interdisciplinary approach: “We should have programs that cover the entire spectrum from physical, psychological, social, and spiritual health as a continuum”. Another physician highlighted the “need to develop medical infrastructure in low-income countries”. Physicians suggested having a system that allows for “decentralized participatory planning on part of government agencies”. Physicians also communicated the need for a health system that is “not business oriented” and “invests more in mental health and financial support of entire population”. To strengthen the health system, physicians expressed a demand for adequate material resources (e.g., “have adequate stock of PPE”), additional human resources (e.g., “provide more trained manpower”), “improve epidemic control centres”, and an “established task force all year round”.

**Theme 4: Appropriate delegation of roles.** Physicians specifically highlighted the role of politicians and their responsibility to form a more “empathetic political system” that can respond to the pandemic. Physicians (n = 34, 7%) stated a need to differentiate the role of science and healthcare professionals from the role of politicians. This was recommended particularly during policy-development, “strengthen the position of the clinicians in the decision-
making”. On several occasions, physicians recommended the need for “less politics, more science”, that “policymakers should listen more to health professionals”, and that “politicians should stop managing what they can barely comprehend”. Additionally, physicians recommended, “put public health physicians and epidemiologists at the front”. Other physicians focused on the role of the WHO and the need to “re-organize it”.

**Theme 5: Minimise adverse effects of infodemics.** This theme captures physicians’ input towards minimising the spread of misinformation. Physicians particularly called for “much better and more timely public health communications needed” and to “improve social communication to avoid fake news”. Physicians stated a need to ensure that the content of information distributed is relevant and credible, “Prevent fake news from spreading, if possible. People believe it.” With regards to inter-departmental communication, physicians recommended standardising and/or centralising the distribution of pandemic-related communications, “One central body and not 50 different emails about the same advice from different departments”. On the role of communication with the public, “Don’t let social media give information to the public without peer review. The information system must be more open (data access) but it is necessary to identify the right communicator.”

**Theme 6: Global responsibility.** This theme encompasses physicians’ views on the significance of global unity during pandemics. Physicians recommended global action through “better planning with pandemic resistant health systems”. Physicians also indicated the necessity for global transparency, one wrote: “China did respond too slowly and did not communicate about the severity of the situation and did not react to control outbreak”. Physicians also emphasised a need for “global coordination, solidarity, and equity”, and stated that “the world needs to learn to work together”. Additionally, physicians specified demands for a “global initiative to reduce social inequality” and “equitable vaccine distribution all over the world”.

**Uncertainty.** Few physicians expressed uncertainty towards providing recommendations, stating they were “unsure”. Other participants acknowledged the limitations of their role in being able to provide recommendations, one respondent explicitly noted “I’m not a public health expert!”.

**Discussion**

**Main findings in light of other evidence**

The results of this global survey revealed international agreement on the burden of care experienced by physicians during the COVID-19 pandemic and particularly when working in under-prepared communities or institutions. Most physicians in this study possessed good overall knowledge of COVID-19; this is in line with previous studies [36–38]. Additionally, physicians relied on official government websites as their primary source of information, as supported by an earlier study among HCPs [24]. This suggests that physicians have been consistently utilising reliable sources to acquire information regarding COVID-19 and correlates with the good knowledge observed. However, respondents in this study exhibited poor knowledge on domains relating to the nature and treatment of disease. Previous studies on this are inconsistent, with some physicians displaying good knowledge of the disease [39] and others showing poor knowledge [40]. The discrepancy between studies could be due to differences in programmes delivered by health facilities in supporting and educating physicians, reduced accessibility to evidence-based information in some settings, as well as differences in national-level protocols for the management and treatment of disease. With regards to preventative practices towards COVID-19, many physicians reported occasionally wearing masks and/or gloves. Although this may reflect poor adherence to safety measures by physicians, it could also be due lack of available or accessible Personal Protective Equipment (PPE) such as masks and/or
gloves. Access to PPE was particularly limited in both HICs and LMICs during the initial stages of the pandemic due to lack of preparedness of health systems, disruption of global supply chains and mismanagement [41, 42].

Almost all physicians in our study indicated that they have received the COVID-19 vaccine, and only a small percentage were/are hesitant to receive the vaccine. The degree of vaccine hesitancy among this population of physicians is echoed in other studies [43]. Additionally, about half of physicians in this study were concerned about the rapid development of vaccines. Data from HICs suggests the rapid pace of vaccine development as one of the primary reasons for vaccine hesitancy [44].

COVID-19 revealed a lack of adequate policies, preparedness, and education necessary to combat a pandemic and control further outbreaks [45–47]. Further, the implementation of rapid pandemic control measures was at times delayed [48]. Our survey results indicate that many physicians perceived the policies and actions implemented by their healthcare facilities and public health agencies as being insufficient, which correlated with physicians’ overall experience with the COVID-19 Pandemic, where those who perceived their facilities as having inadequate policies were more likely to also describe their experience using negative terminology. Additionally, many physicians recommended a need to strengthen healthcare and political systems to better respond to pandemics. These findings are in line with physicians’ demands for better resources for future pandemics, since a better equipped health and political system is more likely to provide the necessary resources to tackle the pandemic. Previous studies support such recommendations, especially for evidence-based policy-making as a means to bridge the gap between clinical science and policy during the pandemic [49–52]. It is also recognised that policies to combat infectious disease outbreaks must be implemented rapidly while also meeting the needs of multiple sectors including public health, economy, and social welfare [53]. Implementing a One Health approach, recommended in this study, is crucial as the efforts of one sector, or many sectors working in silos, cannot eliminate the threat of a pandemic. As suggested by physicians in this study, the WHO has a unique responsibility in helping countries, especially LMICs, prepare for pandemics, as well as supporting efforts to initiate and mount an effective response. These recommendations highlighted the significance of early detection, risk communication with vulnerable groups, strategies for containment, and international collaboration [54].

The spread of misinformation during previous pandemics led to confusion, risk-taking behaviours, and mistrust between the public and healthcare professionals [55–57]. Furthermore, within a highly digital society, the risks of ‘infodemics’ could be dependent on effective communication strategies that counter unreliable news [58]. Hence, the recommendations in this study for better communication strategies are much warranted.

The call for global unity during pandemics, echoed by physicians in this study, is also essential. According to the Global Dashboard for Vaccine Equity, as of May 18, 2022 only 17.61% of individuals in low-income countries have been vaccinated with at least one dose, in comparison to 72.23% in high-income countries [59]. The continued inequitable vaccine distribution leaves millions of individuals vulnerable to being infected by COVID-19 and promotes the emergence and subsequent spread of deadly variants across the globe.

**Recommendations for future policy development**

In our study, physicians provided recommendations regarding future interventions and/or policies that may help mitigate the impact of future pandemics on civilians and healthcare professionals. Physicians recommended a strong need to:

1. Strengthen health systems by preparing the healthcare sector for future pandemics; suggestions included to (a) invest in virology research, (b) train HCPs, (c) develop guidelines pre-
emptively, and (d) arrange an emergency stockpile of material resources for clinicians including PPEs.

2. Prevent infodemics by having healthcare professionals collaborate with politicians and social media outlets to guarantee that credible information is being sourced to the public.

3. Delegate decision-making roles appropriately, by promoting an empathetic political system that understands the need for input from scientists and HCPs in dictating best-practices for pandemic management.

4. Acknowledge global responsibility and the necessity for international collaboration and equity. This must be done by collaborative preparation and prevention as well as through the equitable distribution of resources.

**Strengths and limitations**

This is the first up to date mixed-method global study, to our knowledge, with a large sample size (399 physicians) in 62 unique countries including high and low- and middle-income settings. The survey questionnaire was also developed based on the most recent information from the WHO and was subsequently validated and piloted prior to distribution. Additionally, this study included both quantitative and qualitative findings, ensuring that the results obtained are grounded in participants’ experiences and allowing for better translation and implementation of population and behavioural research [60, 61].

We acknowledge the following limitations. Online surveys pose specific challenges including the inability to calculate response rate, the potential for the data to not be representative, and the possibility of recall bias. A further limitation of social media research is inability to ensure respondents are truly physicians. To mitigate this limitation, our team (a) contacted known physicians directly, (b) included a screening question in the survey asking about physician status, and (c) collected data from more than the minimum sample size required for reliability. Snowballing may have also introduced bias, as participants identified in that way may share similar opinions [31]. Moreover, the survey does not account for local differences in pandemic response and management. Additionally, the results may not reflect the new knowledge acquired after the study, in particular the emergence of new variants and the introduction of new guidelines and practices. However, as new variants continue to emerge, the recommendations that physicians have expressed, in particular strengthening health systems and global collaboration, should be taken into consideration when developing guidelines. Lastly, the survey was designed and written in English, potentially introducing response bias.

**Conclusion**

Findings from this global survey indicated that most physicians possessed good knowledge of COVID-19 disease yet limited adherence to safety measures. Physicians were particularly concerned about the distribution of vaccines to the general population, and approximately one third indicated that the policies implemented by their healthcare facilities and public health agencies were insufficient in handling the pandemic. Although most physicians described their experience with COVID-19 in negative emotive language and agreed that the pandemic had led to increased mental stress, most were willing to continue working in the healthcare sector post-pandemic. Collectively, this study suggests that physicians may need to have a more dominant role in policymaking in addition to their role as clinical experts. Given that future pandemics are inevitable [62], exploring how and in what capacity clinicians will contribute to policy-making processes during health emergencies could be crucial.
Supporting information

S1 Table. List of categories, themes, codes, based on thematic analysis of physicians’ recommendations for future pandemics.

(DOCX)

S1 File. Study questionnaire.

(DOCX)

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References

1. World Health Organization. Timeline of WHO’s response to COVID-19. 2021 [cited 6 Oct 2021]. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline?gclid=Cj0KCQjwXqJhIbhC4AIRsAChq4avP4ybyhep8yx7gyCxS7h9cncZvza5zMFyfeDcx-RsUXug5PLZNsOMaAllJPEALw_wcB#event-115

2. World Health Organization. WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data. 2021 [cited 10 May 2022]. Available: https://covid19.who.int/
3. World Health Organization. Coronavirus disease (COVID-19). 2021 [cited 6 Oct 2021]. Available: https://www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19

4. Amnesty International. COVID-19: Health worker death toll rises to at least 17000 as organizations call for rapid vaccine rollout—Amnesty International. 5 Mar 2021 [cited 6 Oct 2021]. Available: https://www.amnesty.org/en/latest/press-release/2021/03/covid19-health-worker-death-toll-rises-to-at-least-17000-as-organizations-call-for-rapid-vaccine-rollout/

5. World Health Organization. The impact of COVID-19 on health and care workers: a closer look at deaths. 2021. Available: https://apps.who.int/iris/handle/10665/345300

6. World Health Organization. The impact of COVID-19 on health and care workers: a closer look at deaths. Health Workforce Department—Working Paper 1. Geneva; 2021.

7. Mbachu CNP, Azubuike CM-C, Mbachu II, Ndukuw CI, Ezeuko AY-A, Udigwe IB, et al. COVID-19 infection: Knowledge, attitude, practices, and impact among healthcare workers in a South-Eastern Nigerian state. The Journal of Infection in Developing Countries. 2020; 14: 943–952. https://doi.org/10.3855/jidc.13248 PMID: 33031078

8. Gokdemir O, Pak H, Bakola M, Bhattacharya S, Hodebecke K, Jelastopulu E. Family Physicians’ Knowledge about and Attitudes towards COVID-19—A Cross-sectional Multicentric Study. Infection & Chemotherapy. 2020; 52: 539. https://doi.org/10.3947/ic.2020.52.4.539 PMID: 33124215

9. Kramer V, Papazova I, Thoma A, Kunz M, Peter Falkai, Schneider-Axmann T, et al. Subjective burden and perspectives of German healthcare workers during the COVID-19 pandemic. European Archives of Psychiatry and Clinical Neuroscience. 2021; 271: 271–281. https://doi.org/10.1007/s00406-020-01183-2 PMID: 32815019

10. Wahed WYA, Hefzy EM, Ahmed MI, Hamed NS. Assessment of Knowledge, Attitudes, and Perception of Health Workers Regarding COVID-19: A Cross-Sectional Study from Egypt. Journal of Community Health. 2020; 45: 1. https://doi.org/10.1007/S10900-020-00882-0

11. Abou-Abbas L, Nasser Z, Fares Y, Chahrour M, el Haidari R, Atoui R. Knowledge and practice of physicans during COVID-19 pandemic: a cross-sectional study in Lebanon. BMC Public Health. 2020;20. https://doi.org/10.1186/s12888-020-09585-6

12. Amin F, Sharif S, Saeed R, Durrani N, Jilani D. COVID-19 pandemic- knowledge, perception, anxiety and depression among frontline doctors of Pakistan. BMC Psychiatry. 2020;20. Available: https://bmcpsychiatry.biomedcentral.com/pdf/10.1186/s12888-020-02864-x.pdf

13. Hesaraki M, Akbarizadeh M, Ahmadidarrehsmia S, Moghadam M, Izadpanah F. Knowledge, attitude, practice and clinical recommendations of health care workers towards COVID-19: a systematic review. Reviews on Environmental Health. 2020; 36: 345–357. https://doi.org/10.1515/reveh-2020-0099 PMID: 34469639

14. Limbu DK, Piryani RM, Id AKS. Healthcare workers’ knowledge, attitude and practices during the COVID-19 pandemic response in a tertiary care hospital of Nepal. 2020 [cited 6 Oct 2021]. https://doi.org/10.1371/journal.pone.0242126

15. Qadah T. Knowledge and attitude among healthcare workers towards COVID-19: A cross sectional study from Jeddah city, Saudi Arabia. Journal of Infection in Developing Countries. 2020; 14: 1090–1097. https://doi.org/10.3855/jidc.13083 PMID: 33175701

16. Roupa Z, Polychronis G, Latzourakis E, Nikitara M, Gholbriel S, Chrysafti A, et al. Assessment of Knowledge and Perceptions of Health Workers Regarding COVID-19: A Cross-Sectional Study from Cyprus. Journal of Community Health. 2021; 46: 1. https://doi.org/10.1007/S10900-020-00949-Y

17. Vatan A, Güçlü E, Öğütü M, Kibar FA, Karabay O. Knowledge and attitudes towards COVID-19 among emergency medical service workers. Revista da Associação Médica Brasileira. 2020; 66: 1553–1559. https://doi.org/10.1590/1806-9282.66.11.1553 PMID: 33295409

18. Zhang M, Zhou M, Tang F, Wang Y, Nie H, Zhang L, et al. Knowledge, attitude, and practice regarding COVID-19 among healthcare workers in Henan, China. The Journal of Hospital Infection. 2020; 105: 183. https://doi.org/10.1016/j.jhin.2020.04.012 PMID: 32278701

19. Assela N, Souara A, Hemler EC, Korte ML, Wang D, Abdullahi YY, et al. COVID-19 Knowledge, Perception, Preventive Measures, Stigma, and Mental Health Among Healthcare Workers in Three Sub-Saharan African Countries: A Phone Survey. The American Journal of Tropical Medicine and Hygiene. 2021; 106: 342. https://doi.org/10.4269/ajtmh.20-162 PMID: 34161297

20. Gebreaselassie AF, Bekele A, Tatere HY, Wong R. Assessing the knowledge, attitude and perception on workplace readiness regarding COVID-19 among health care providers in Ethiopia—An internet-based survey. PLoS ONE. Public Library of Science; 2021. https://doi.org/10.1371/journal.pone.0247848 PMID: 33611899

21. Unnikrishnan B, Rathi P, Shenoy SM, Nandan G, Sanil M, Saxena S, et al. Knowledge, Awareness and Perception of COVID-19 Pandemic Among Health Care Workers in a Tertiary Care Teaching Hospital.
in Coastal South India. The Open Public Health Journal. 2021; 14: 135–139. https://doi.org/10.2174/187494502114010135

22. Arslanca T, Fidan C, Daggez M, Dursun P. Knowledge, preventive behaviors and risk perception of the COVID-19 pandemic: A cross-sectional study in Turkish health care workers. PLoS ONE. 2021;16. https://doi.org/10.1371/journal.pone.0250017 PMID: 33836013

23. Fadilah SZ, Kurniawati ND, Dyjan P. A Systematic Review of Knowledge, Attitudes and Practices among Healthcare Workers on Personal Protective Equipment against Covid-19. STRADA Jurnal Ilmiah Kesehatan. 2021; 10: 1213–1224. https://doi.org/10.30994/SJK.V10I1.747

24. Srikanth A, Aldhaleei WA, Rahmani J, Mahabadi MA, Bandari DK. Knowledge and Perceptions of COVID-19 Among Health Care Workers: Cross-Sectional Study. JMI Public Health Surveill 2020; 6 (2): e19160 https://publichealth.jmir.org/2020/2/e19160. 2020;6: e19160. https://doi.org/10.2196/19160 PMID: 32320381

25. Ciardi F, Menon V, Jensen JL, Shariff MA, Pillai A, Venugopal U, et al. Knowledge, attitudes and perceptions of covid-19 vaccination among healthcare workers of an inner-city hospital in New York. Vaccines (Basel). 2021;9. https://doi.org/10.3390/vaccines9050516 PMID: 34067743

26. Guangul Bereket A, Georgescu Georgiana, Osman Mensur, Reece Rebecca, Derso Zinabu, Bahiru Aliyu, et al. Healthcare workers attitude towards SARS-COVID-2 Vaccine, Ethiopia. Global Journal of Infectious Diseases and Clinical Research. 2021; 7: 043–048. https://doi.org/10.17352/2455-5363.000045

27. Ross AGP, Crowe SM, Tyndall MW. Planning for the Next Global Pandemic. International Journal of Infectious Diseases. 2015; 38: 89. https://doi.org/10.1016/j.ijid.2015.07.016 PMID: 26253461

28. Dodds W. Chapter 4 Disease Now and Potential Future Pandemics. The World’s Worst Problems. 2019. pp. 31–44. https://doi.org/10.1007/978-3-030-30410-2_4

29. Franchini M, Mannucci PM. Impact on human health of climate changes. European Journal of Internal Medicine. 2015; 26; 1–5. https://doi.org/10.1016/j.ejim.2014.12.008 PMID: 25582074

30. Khasnis AA, Nettleman MD. Global Warming and Infectious Disease. Archives of Medical Research. 2005; 36: 689–696. https://doi.org/10.1016/j.arcmed.2005.03.041 PMID: 16216650

31. Onwuegbuzie AJ, Collins KMT. The Role of Sampling in Mixed Methods-Research. KZfSS Kölnische Zeitschrift für Soziologie und Sozialpsychologie 2017 69:2. 2017;69: 133–156. https://doi.org/10.1007/S11577-017-0455-0

32. Raosoft Inc. Sample Size Calculator by Raosoft, Inc. [cited 6 Oct 2021]. Available: http://www.raosoft.com/samplesize.html

33. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006; 3: 77–101. https://doi.org/10.1191/1478088706QP0630A

34. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg. 2014; 12: 1495–1499. https://doi.org/10.1016/j.ijssu.2014.07.013 PMID: 25046131

35. The World Bank. World Bank Country and Lending Groups–World Bank Data Help Desk. 2021 [cited 6 Oct 2021]. Available: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

36. Enenche Ejeh F, Saleh Saidu A, Owoicho S, Maurice NA, Jauro S, Marduaji L, et al. Knowledge, attitude, and practice among healthcare workers towards COVID-19 outbreak in Nigeria. 2017 [cited 6 Oct 2021]. https://doi.org/10.1016/j.heliyon.2020.e05557 PMID: 33230488

37. Kassie BA, Adane A, Kassahun EA, Ayele AS, Belew AK. Poor COVID-19 Preventive Practice among Healthcare Workers in Northwest Ethiopia, 2020. Advances in Public Health. 2020; 2020. https://doi.org/10.1155/2020/7526037

38. Saqlain M, Munir MM, Rehman SU, Gulzar A, Naz S, Ahmed Z, et al. Knowledge, attitude, practice and perceived barriers among healthcare workers regarding COVID-19: a cross-sectional survey from Pakistan. Journal of Hospital Infection. 2020; 105: 419–423. https://doi.org/10.1016/j.jhin.2020.05.007 PMID: 32437822

39. Goddard AF, Patel M. The changing face of medical professionalism and the impact of COVID-19. The Lancet. 2021; 397: 950–952. https://doi.org/10.1016/S0140-6736(21)00436-0 PMID: 33636125

40. Fouque JT, Noubom M, Kenfack B, Dongmo NT, Tabeu M, Megozeu L, et al. Poor knowledge of COVID-19 and unfavourable perception of the response to the pandemic by healthcare workers at the Bafoussam Regional Hospital (West Region-Cameroon). The Pan African Medical Journal. 2020;37. https://doi.org/10.11604/PAMJ.SUPP.2020.37.1.25688 PMID: 33343798
41. Cohen J, Rodgers Y van der M. Contributing factors to personal protective equipment shortages during the COVID-19 pandemic. Preventive Medicine. 2020; 141: 106263. https://doi.org/10.1016/j.ypmed.2020.106263 PMID: 33017601

42. World Health Organization. Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19)—Interim guidance. 2020. Available: https://www.who.int/csr/resources/publications/putontakeoff

43. Dror AA, Eisenbach N, Taiber S, Morozov NG, Mizrahi M, Zigron A, et al. Vaccine hesitancy: the next challenge in the fight against COVID-19. European Journal of Epidemiology 2020 35:8. 2020;35: 775–779. https://doi.org/10.1007/s10654-020-00671-y PMID: 33587887

44. Wouters OJ, Shadlen KC, Salcher-Konrad M, Pollard AJ, Larson HJ, Teerawattananon Y, et al. Challenges in ensuring global access to COVID-19 vaccines: production, affordability, allocation, and deployment. Lancet. 2021; 397: 1023–1034. https://doi.org/10.1016/S0140-6736(21)00306-8 PMID: 33995857

45. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia. https://doi.org/101056/NEJMoa2001316. 2020; 382: 1199–1207. PMID: 31999587

46. Mayer JD, Lewis ND. An inevitable pandemic: geographic insights into the COVID-19 global health emergency. https://doi.org/10.1080/1538721620201786425. 2020; 61: 404–422.

47. Khosrawipour V, Lau H, Khosrawipour T, Kocbach P, Ichii H, Bania J, et al. Failure in initial stage containment of global COVID-19 epicenters. J Med Virol. 2020; 92: 863–867. https://doi.org/10.1002/jmv.25883 PMID: 32297980

48. Cabral S, Ito N, Pongeluppe L. The Disastrous Effects of Leaders in Denial: Evidence from the COVID-19 Crisis in Brazil. SSRN Electronic Journal. 2021 [cited 7 Oct 2021]. https://doi.org/10.2139/SSRN.3836147

49. Yang K. What Can COVID-19 Tell Us About Evidence-Based Management?: https://doi.org/10.1177/0275074020942406. 2020; 50: 706–712.

50. Raboisson D, Lhermie G. Living With COVID-19: A Systemic and Multi-Criteria Approach to Enact Evidence-Based Health Policy. Frontiers in Public Health. 2020;8. https://doi.org/10.3389/fpubh.2020.00294

51. Lancaster K, Rhodes T, Rosengarten M. Making evidence and policy in public health emergencies: Lessons from COVID-19 for adaptive evidence-making and intervention. Evidence and Policy. 2020; 16: 477–490. https://doi.org/10.1332/174426420X15913559981103

52. Liu P, Zhong X, Yu S. Striking a balance between science and politics: understanding the risk-based policy-making process during the outbreak of COVID-19 epidemic in China. https://doi.org/10.1080/23812346201745412. 2020; 5: 198–212.

53. Belcher P, Busse R, Figureas J, le Grand J, Palm W, Lessof S, et al. Quarterly of the European Observatory on Health Systems and Policies EUROHEALTH. Brussels; 2020. Available: http://www.healthobservatory.eu/https://www.lse.ac.uk/lse-health

54. Knobler S, Mahmoud A, Lemon S, Mack A, Sivitz L, Oberholtzer K. Learning from SARS: Preparing for the Next Disease Outbreak. Washington, DX: National Academies Press; 2004. https://doi.org/10.17226/10915

55. Jaiswal J, LoSchiavo C, Perlman DC. Disinformation, Misinformation and Inequality-Driven Mistrust in the Time of COVID-19: Lessons Unlearned from AIDS Denialism. AIDS and Behavior. 2020; 24: 1. https://doi.org/10.1007/S10461-020-02925-Y

56. Baker DW. Trust in Health Care in the Time of COVID-19. JAMA. 2020; 324: 2373–2375. https://doi.org/10.1001/jama.2020.23343 PMID: 33320208

57. Dharawat A, Lourentzou I, Morales A, Zhai C. Drink bleach or do what now? Covid-HeRA: A dataset for risk-informed health decision making in the presence of COVID19 misinformation. 2020 [cited 7 Oct 2021]. Available: https://arxiv.org/abs/2010.08743v1

58. Gallotti R, Valle F, Castaldo N, Sacco P, de Domenico M. Assessing the risks of “infodemics” in response to COVID-19 epidemics. Nat Hum Behav. 2020; 4: 1285–1293. https://doi.org/10.1038/s41562-020-00994-6 PMID: 33122812

59. UNDP. Global Dashboard for Vaccine Equity—UNDP Covid-19 Data Futures Platform. 2021 [cited 18 May 2022]. Available: https://data.undp.org/vaccine-equity/

60. Glasgow RE, Vinson C, Chambers D, Khoury MJ, Kaplan RM, Hunter C. National Institutes of Health Approaches to Dissemination and Implementation Science: Current and Future Directions. American Journal of Public Health. 2012; 102: 1274–1281. https://doi.org/10.2105/AJPH.2012.300755 PMID: 22594758

61. Glasgow RE, Emmons KM. How can we increase translation of research into practice? Types of evidence needed. Annu Rev Public Health. 2007; 28: 413–433. https://doi.org/10.1146/annurev.pubhealth.28.021406.144145 PMID: 17150029

62. Norman J, Bar-Yam Y, Taleb N. Systemic Risk of Pandemic via Novel Pathogens-Coronavirus: A Note. New York; 2020 Jan.