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Opinion

The COVID misinfodemic: not new, never more lethal

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'Infodemia' is a portmanteau between 'information' and 'epidemics', referring to wide and rapid accumulation and dissemination of information, misinformation, and disinformation about a given subject, such as a disease. As facts, rumors and fears mix and disperse, the misinfodemic creates loud background noise, preventing the general public from discerning between accurate and false information. We compared and contrasted key elements of the AIDS and COVID-19 misinfodemics, to identify common features, and, based on experience with the AIDS pandemic, recommend actions to control and reverse the SARS-CoV-2 misinfodemic that contributed to erode the trust between the public and scientists and governments and has created barriers to control of COVID-19. As pandemics emerge and evolve, providing robust responses to future misinfodemics must be a priority for society and public health.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic triggered unprecedented global responses leading to rapid development of diagnostic, therapeutic, and preventive countermeasures, and a global effort for their swift implementation. For example, sequencing of >10 million full-length genomes worldwide enabled characterization of the viral spread and evolution¹. For comparison, the first million genomes from the HIV pandemic were sequenced over more than 30 years [1]. A COVID-19-related literature of over 250 000 peer-reviewed scientific papers was made available free of charge from publishers and, through a global effort, new manuscripts were uploaded to public servers prior to peer review. As such, new scientific and clinical progress led to rapid advances in diagnostics, therapeutics, and preventive vaccines in less than 1 year [2,3].

Yet, the sudden availability of enormous volumes of information also triggered a COVID-19 misinfodemic, mainly on social networks, which spread incomplete information, incorrect and deliberately false information (collectively misinformation), accelerating the spread of conspiracy theories and promoting the antivaccine movement to new levels of public harm. A self-centered 'desire for freedom' movement led to judicial challenges attempting to interfere with, and block, medical advances, resulting in the absurdity of judges being asked to rule on scientific results, such as sensitivity of diagnostic assaysⁱⁱ. Multiple phantasmagoric but unproven and potentially harmful remedies were widely promoted, eroding public trust in therapies with proven benefit. Antivaccine theories undoubtedly had the greatest negative impact, thwarting vaccination campaigns, with devastating loss of life that was preventable [4,5]. Such tragic outcomes from misinformation are not new, spread of misinformation being a common feature of every pandemic. Yet, the sheer scale of the 'misinfodemic' that has accompanied the COVID-19 pandemic is unprecedented, touching virtually every person on the planet, and calling for firm and effective countermeasures. Misinformation also plagued the early days of the AIDS pandemic, and thus comparison between the AIDS and COVID-19 misinfodemics identifies common features that can be anticipated and targeted to reduce the toll on human health during future pandemics.

Highlights

Misinfodemics constantly thwart the impact of efficacious responses to emerging pandemics.

Infodemics foster serious distrust between the people and medical professionals and the legitimate acts of governments requiring public cooperation for controlling pandemics.

Prevention of the misinfodemics by the scientific community is critical for the successful control of emerging pandemics and should be undertaken immediately.

Comparison of the HIV and SARS-CoV-2 pandemics is informative for understanding misinfodemics throughout modern history. These comparisons strongly suggest that misinfodemics will certainly be a reoccurring phenomenon with disastrous consequences without decisive actions.

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Definition, magnitude, global impact

Infodemic is a portmanteau derived from 'information' and 'epidemic', typically referring to a rapid and far-reaching spread of information about an epidemic: accurate, inaccurate (misinformation), or deliberately misleading (disinformation). As facts, rumors, and fears mix and disperse, discerning between the real and inaccurate information becomes very difficultⁱⁱⁱ. The term was coined by David Rothkop during the severe acute respiratory syndrome (SARS) outbreak (2003), as the situation in which 'a few facts, mixed with fear, speculation and rumor, are amplified and relayed swiftly worldwide by modern information technologies'^{iv}. Infodemics parallel major epidemic outbreaks, which have a high propensity to trigger a wide array of conspiracies and false information. They may impact economies, politics, national security, and public health [6]. 'Infodemiology' studies 'the determinants and distribution of health information and misinformation' [7].

The COVID-19 pandemic generated an unprecedented misinfodemic, with clear potential to derail the strategies for pandemic control, prompting a joint report of the Royal Society and British Academy^v stating that: 'COVID-19 vaccine deployment faces an infodemic with misinformation often filling the knowledge void, characterized by: (i) distrust of science and selective use of expert authority, (ii) distrust in governments and pharmaceutical companies, (iii) inaccurate explanations, (iv) use of emotion, and (v) echo chambers'^v. The panel endorsed a 2019 Singaporean legislation, which criminalizes misinformation.

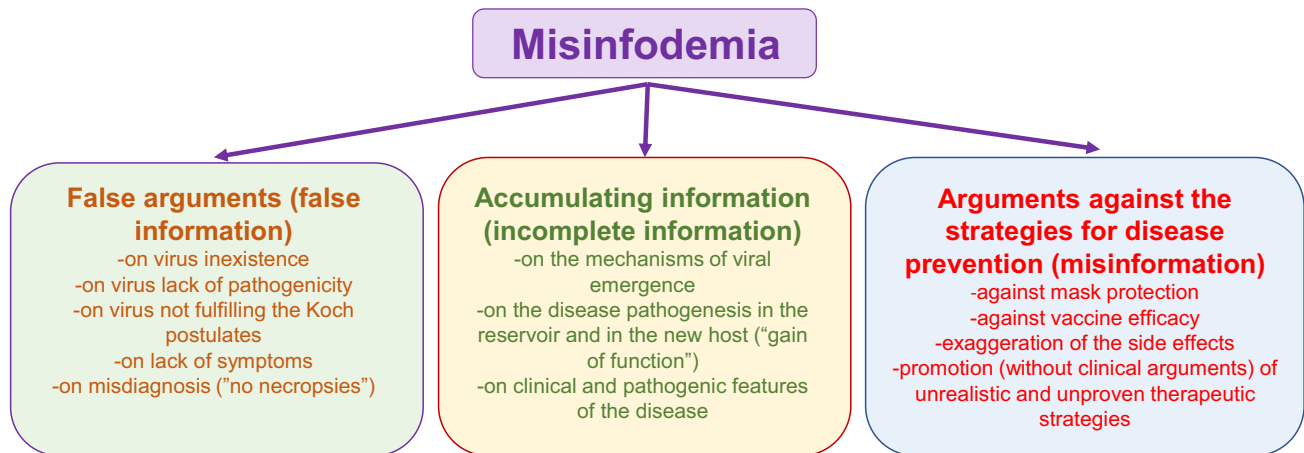
Since legislative processes are tedious and slow, and similar laws are unlikely to be adopted in most Western countries, misinfodemic control must be achieved through alternative pathways. Towards this goal, the scientific community must develop effective response strategies to misinfodemics. As AIDS scientists, we posit that the experience gained during the AIDS misinfodemic might help to counter the COVID-19 misinfodemic and those potentially arising with future pandemics.

Since the vast majority of the information conveyed – especially through the social media – is either misinformation or disinformation, we felt that 'misinfodemic' is a more appropriate term to define the reality of COVID-19 pandemic, and we will use it here.

Major common features of AIDS and COVID-19 misinfodemics

The shared features of the HIV and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) misinfodemics can be grouped as follows (Figure 1):

- Unsupported arguments that create a loud noise, distracting from the important facts established by scientific methods. As it takes longer to respond to an incorrect assertion or false allegation than to make them, vast volumes of time resources and energy are wasted to counter them. Examples from the AIDS pandemic recurring during the COVID-19 pandemic are: (i) the idea that the virus does not cause disease, being harmless to humans; (ii) the idea that the virus was created in a laboratory, or engineered (accidentally or deliberately) to have increased transmission and pathogenicity, and thus someone is to blame for the pandemic and should be held accountable. The hunt for the 'responsible party' detracts from focusing on preventing epidemic spread.
- Rapid and repeated changes in paradigms, inherent to any learning process of a completely new disease, are interpreted negatively. The gradual growth and evolution of knowledge and understanding are perceived as hesitations and, fueled by misinformation, as deliberate and biased misuse of diagnostics, therapies, and vaccines, eroding public trust in the medical profession and opening large avenues for conspiracy theories or wrongful approaches to the disease. Common features between AIDS and COVID-19 are: (i) the differences between the



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Figure 1. The shared features of the AIDS and SARS-CoV-2 misinfodemics can be grouped as (i) false arguments; (ii) accumulating information resulting in shifts in paradigms of pathogenesis, therapy, and public health measures, inherent to scientific discovery, but leading to which erode public trust; and (iii) arguments against the strategies for disease prevention. These are not mutually exclusive, they impact each other and, altogether, contribute to public confusion, eroding trust between the different components of society.

pathogenic features of the infection in the natural host, namely, nonpathogenic versus pathogenic in humans, become an incubator for conspiracies related to gain-of-function experiments; (ii) oversight of certain clinical and pathogenic features relevant to the disease outcome.

- The antivaccine movement undermines proven prevention strategies that save lives. While we do not have an AIDS vaccine yet, there were many years of reluctance to embrace the use of antiretroviral drugs as pre-exposure prophylaxis (PrEP) for HIV-1, which is a proven, safe, and effective public health measure. During the SARS-CoV-2 pandemic, the antivaccine movement gained dangerous new ground across the USA and European countries. The movement needs to be continuously targeted as counterfactual and harmful in order to avoid further spillover that might derail vaccine campaigns for other diseases.

Arguments against the viruses and their role in producing the diseases/pandemics

The discussion of HIV as the cause of AIDS thwarted AIDS research and efforts to control the pandemic for decades. AIDS was described in 1981 [8,9] as an immunodeficiency associated with depletion of CD4⁺ T cells and chronic immune activation [10]. It was rapidly acknowledged that some patients might be asymptotically infected and can still transmit the disease [10]. HIV was identified in 1983 [11] and fully sequenced in 1984 [12–14]. The AIDS pandemic was declared after showing HIV to be widespread in sub-Saharan Africa, Europe, and the Americas [15]. A simian immunodeficiency virus (SIV) that causes AIDS in macaques was shown to fulfill Koch's postulates [16,17]. Altogether, these studies firmly established that HIV/SIV is the cause of AIDS in humans and macaques and started a phenomenal race to develop prevention and therapeutic tools for HIV.

Despite this definitive evidence, the retrovirologist Peter Duesberg questioned the pathogenicity of HIV [18] and postulated that AIDS is induced by recreational drugs (poppers) and HIV therapies in use at that time (zidovudine) [19,20]. While multiple conspiracy theories questioned the role of HIV in AIDS, none of these perpetrators had Duesberg's scientific stature [21]; therefore, the scientific community responded strongly to his allegations [22,23]. The issue was considered closed until 1999, when Duesberg presented his theory to Thabo Mbeki, the president of the

Republic of South Africa (RSA), who, in response, banned the use of antiretrovirals in the public hospitals [24,25] despite an HIV prevalence of up to 30% [24] in RSA, and half of the African teenage population at risk of dying of AIDS [26]. Mbeki's decision sparked worldwide outrage, and more than 5000 scientists (including 11 Nobel laureates) signed the Durban Declaration, clearly stating that HIV causes AIDS and that curbing HIV spread will curb the pandemic [27]. Over the next 20 years, antiretrovirals demonstrated their efficacy in reducing HIV infection and disease progression in Africa. Mbeki's irrational denial led to 300 000 preventable deaths [28], providing a compelling example of the devastating impact of misinformation on epidemic control and human health [28].

Denialists of the impact of the SARS-CoV-2 infection are also numerous. In addition to those very active on social media forums, several scientists launched various theories minimizing the consequences of the pandemic [29]. In time, their predictions and statements have been clearly disproven by data, yet their pernicious ideas are still spreading, with a non-negligible fraction of the public still debating whether or not SARS-CoV-2 exists, whether it fulfills Koch's postulates, or if it is pathogenic [29].

Different from the AIDS pandemics, when denialism encountered a forceful rebuke from the scientific community, COVID denialists were responded to with fragmented, cautious arguments, or worse, ignored or minimized [30, retracted]. Meanwhile, negationism thrived on social media and mainstream TV, as conspiracies yield better ratings than scientific concepts and data.

Conspiracy theories relative to the virus origin and its accidental/deliberate release from a research laboratory

This is a cornerstone of the SARS-CoV-2 misinfodemic. Yet, it was not a common occurrence in the case of HIV until a Rolling Stone magazine theory that AIDS originated following the experiments carried in the Stanleyville (now Kisangani) laboratory in Zaire (now the Democratic Republic of Congo) for the development of a polio vaccine [31] got traction and exploded in the media following the publishing of Edward Hooper's 'The River' [32]. These inflammatory statements led the British Broadcasting Corporation (BBC) to issue a press release entitled 'Scientists started the AIDS pandemic' [33].

With the debate intensifying, the Royal Society organized a meeting to investigate the sources of the HIV and the mechanisms of its emergence into humans [34], which triggered a worldwide effort to establish a formal origin of AIDS. The polio vaccine batches claimed to be contaminated with the chimpanzee SIV (SIVcpz) were tested, and proven to be free of SIV/HIV and any other chimpanzee cell contamination [35]. Thorough characterization of SIVcpz [36,37] demonstrated that only the Central African and the East African chimpanzees naturally carry SIVcpz [36,37]. The SIVcpz infecting East African chimpanzees in the Kisangani area is phylogenetically distinct from HIV-1, providing evidence that these chimpanzees were not the source of the AIDS pandemic [38,39]. Only SIVcpz of the Central African chimpanzee was at the origin of the HIV-1 [36,40]. Similarly, in West Africa, the sooty mangabeys were at the origin of HIV-2 [41], and only the SIVsmm-infected sooty mangabeys from Ivory Coast were at the origin of the epidemic HIV-2 groups A and B [42].

This research also established the criteria of a successful cross-species pathogen transmission from a natural host to humans: (i) genetic, antigenic, and phylogenetic similarities between the viruses in the reservoir and the ones isolated from the human host; (ii) colocalization between the species habitat and the epicenters of virus transmission; and (iii) factors favoring cross-species transmission [41]. These criteria were extensively used to establish the circumstances of the SARS-CoV-2 virus cross-species transmission and emergence in the Wuhan seafood market [43,44].

The study of HIV origin also showed that, in the absence of a smoking gun, the extensive genetic diversity in the natural host makes it virtually impossible to find a source virus that is identical to the cross-species transmitted strain [36,45,46]. This might have implications for the debate on the origin of SARS-CoV-2: given the very high divergence of the SARS-CoV-2 and its *Sarbecovirus* relatives in diverse bat populations, an immediate animal source of SARS-CoV-2 has yet to be found [43,47].

Similar to the debates on the circumstances of HIV origin, the two competing hypotheses on SARS-CoV-2 origin involved the 'laboratory leak' or zoonotic emergence. Realistic pathways were identified for SARS-CoV-2 crossover from the bats in Yunnan and the princeps human cases in Wuhan [44]. Yunnan residents living close to the bat caves have ~3% positivity rates for SARS-related coronaviruses (SARSr-CoV) [48]. While a considerable geographic gap exists between Yunnan and the locations of the princeps SARS-CoV-2 human cases, pointing to the difficulty in tracking the exact pathway of virus emergence, all current evidence supports SARS-CoV-2 emergence following zoonotic transmission [43].

Other aspects of the debates on SARS-CoV-2 origin fueled the spread of false information. (i) A 2020 *bioRxiv* preprint (withdrawn since) reported HIV-1 gp120 and gag inserts in the 2019-nCoV spike protein and suggested that they resulted from genetic engineering to increase SARS-CoV-2 tropism on human cells [49]. However, SARS-CoV-2 is not specifically adapted to humans [50], being capable of efficient transmission to a wide variety of mammalian species [50]. (ii) The furin cleavage site, present on the spike protein of SARS-CoV-2, but absent in its closest known relatives, led to intense speculations of genetic manipulation. However, furin cleavage sites are relatively common on multiple divergent coronaviruses and were probably carried by this family of viruses for the past 10 000 years [43]. Furthermore, close bat relatives of SARS-CoV-2 missing the furin cleavage site can readily infect human cells [47].

Unfortunately, these speculations found a strong supporter in the Nobel laureate virologist Luc Montagnier, who backed and spread these claims, giving them weight. However, Montagnier's backing of SARS-CoV-2 emergence conspiracies did not carry much weight as, during the past decade, his scientific credibility was severely eroded by multiple claims that perplexed the scientific community, postulating that: (i) antibiotics could be used to cure autism; (ii) vaccines can be related to cases of sudden death in the newborns; and (iii) transduction of DNA information can be made through water and electromagnetic waves [51–54]. Unfortunately, as for the claims of SARS-CoV-2 inexistence, the speculations on SARS-CoV-2 origin were not addressed systematically by the scientific community, and they persisted, gained traction, and contributed to the misinfodemic.

Arguments prompted by the different pathogenicity of the viruses in the natural host and in the new human host; the potential role of gain-of-function experiments

HIV and SARS-CoV-2 ancestors are nonpathogenic in their natural hosts. Over 40 different SIVs naturally infect different species of monkeys and apes [55]. Yet, while these infections generally do not progress to AIDS, the HIV ancestors appear to be better equipped for cross-species transmission and increased pathogenicity than other SIVs. The HIV-1 ancestors, SIVcpz and SIVgor, are recombinant viruses [56] with pathogenic potential in their hosts [41,57]. The HIV-2 ancestor, SIVsmm, is pathogenic in rhesus macaques upon direct cross-species transmission [16,17,58].

The lack of SIV pathogenicity in their monkey hosts is not due to improved virus control, as they replicate at higher levels than HIV-1 in humans, lack of virulence, as they induce massive acute CD4⁺ T cell depletion [59,60], or differences in the SIV-specific immune responses [61,62]. Instead, long-term virus–host adaptation led to a certain tolerance and control of chronic

inflammation and immune activation [59,60,63,64]. A handful of cases of AIDS reported in natural host individuals whose survival largely exceeded the life span of their species show that these viruses retained pathogenic potential [65].

Similarly, betacoronaviruses, including SARS-CoV-2, are nonpathogenic in their bat hosts, due to various tolerance mechanisms that limit the inflammatory responses to the virus [66–74], which are so deleterious to humans.

Every gain of function that occurred in the evolutionary history of SIVs (*vpr* duplication resulting in a new accessory gene *vpx* in mangabeys [75] or recombination of SIVs from different monkey hosts in chimpanzees [56]) was countered by host restriction factors that limited the host range of the new virus [76]. Similarly, gain-of-function experiments aimed at adapting HIV-1 to the macaques had relatively limited success [77], these viruses being able to induce AIDS in macaques only after major alterations of the immune responses [78].

The arguments against the ‘gain-of-function’ theories for SARS-CoV-2 emergence are: (i) the generalist nature of the SARS-CoV-2, that can readily infect multiple mammalian species in the absence of any viral adaptation or manipulation, makes the gain-of-function experiments superfluous [43,50]; (ii) there is no precedent in science in which a completely new virus (such as SARS-CoV-2) served as a backbone for genetic engineering studies [43]; (iii) numerous coronaviruses isolated from different mammalian species have better human ACE-2-binding characteristics than SARS-CoV-2 [43]; (iv) the furin cleavage site is present in multiple coronaviruses, and is not specifically engineered into SARS-CoV-2; furthermore, SARS-CoV-2 cleavage site optimization evolved during its global spread [43,79].

Loss of public trust due to the clinical paradigm shifting and unsupported promotion of unproven treatments

Early in the course of a new pandemic, it is inherent in the nature of the threat to have incomplete definitions, insufficient diagnostic tools, and ineffective therapeutic strategies. Yet, the way these shortcomings were weaponized throughout the COVID-19 pandemic is unprecedented, daunting, and, unfortunately, very effective. While some of these misinfodemic features were not necessarily driven by disinformation, these aspects proved to be the most divisive and had one of the most destructive contributions to the trust of the general public.

The effective tools to counter the AIDS pandemic were optimized gradually over more than a decade, and with multiple missteps, which generated public mistrust. In the absence of proper tools for viral and treatment monitoring, the public became gradually radicalized.

When the etiology of AIDS was established to be a lentivirus, the continuous progression of the HIV-infected individuals towards overt immunodeficiency was perplexing, as the virus was not detectable in patients with the diagnostic tools available at that time. It was only after the development of the plasma HIV-1 RNA assays that a very active viral production throughout the HIV infection could be documented [80,81], with the levels of the viremia predicting the time course for disease progression [82,83], and laying the ground for effective therapy [82–84]. Use of plasma HIV-1 RNA as a surrogate for treatment efficacy accelerated the development of effective HIV treatment and AIDS prevention.

Detection and quantification of viral nucleic acids (viral load) as a predictor of the severity of viral infections was likely the most important biomarker established in the second half of the 20th century, revolutionizing diagnostic, clinical, and therapeutic management of the

chronic persistent or latent viral diseases. Viral load use as a marker of treatment success transformed the deadly HIV infection into a chronic condition with a life expectancy close to that of uninfected subjects [85].

This is why the scientists worldwide observed with perplexity and skepticism the rejection of COVID-19 diagnostics. President John Magufuli of Tanzania was the first to dismiss coronavirus test kits in 2020, because of allegedly positive results on samples taken from a goat and a pawpaw. Later on, national courts were called to decide on the efficacy of PCR, and, in fact, the Lisbon Court of Appeal judged that the PCR test 'is unable to determine, beyond reasonable doubt, that a positive result corresponds, in fact, to the infection of a person by the SARS-CoV-2 virus'ⁱⁱ, clearly a stunning and contrary statement to the field of diagnostic virology worldwide.

With regard to clinical paradigms, after the initial focus nearly exclusively on lung and gut pathology, a paradigm of an altered coagulation emerged, similar to the one described for HIV/SIV [86,87], and therapeutic approaches to address this critical issue were designed relatively early during the pandemic [88,89]. Similar to HIV/SIV infection [90], a significant role of the neutrophil extracellular traps was established for the pathogenesis of severe SARS-CoV-2 infection [91].

More than 30 antiretrovirals are available, and HIV therapy is one of the most prominent successes of the 20th century. Yet, this process was gradual: zidovudine was approved for the treatment of AIDS in 1987; dual therapy was implemented in 1992–1995, and triple combination therapy became widely available only in 1996 [92]. Therapeutic prevention of maternal-to-infant transmission with zidovudine was first reported in 1994, and pre- and post-exposure (PrEP and PEP) prevention therapies became widely used only during the past decade [92]. In the initial stages of AIDS therapeutics, there were multiple failures (important small molecules, hydroxychloroquine, interferons, IL-2, IL-7), which generated discontent among community organizations [93].

Similarly, over the past 2 years, much distrust was instilled in the general population by much touted 'therapeutics' that were claimed to be miraculously effective in treating COVID-19: hydroxychloroquine, azithromycin, ivermectin, umifenovir, favipiravir. When these results were based on trials, those clinical experiments were weak and data were unconvincing [94]. Yet, through their extensive promotion as part of the misinfodemic, these 'miracle therapies' triggered heated political debate, and a useless spread of money, time, and energy in multiple clinical trials that all disproved their utility [95,96]. None of these drugs was included in any guidelines, yet there are so many users that the producer of ivermectin, Merck, issued a statement urging the public to not use its drug for COVID treatment. In the end, these miracle solutions proved to be great distractions to effective treatments, costing many lives too.

Similar to the major organizations that conducted with great efficacy the major AIDS clinical trials [AIDS Clinical Trials Group (ACTG), Agence Nationale de Recherches sur les SIDA (ANRS)], the establishment and funding of consortia able to conduct rigorous clinical trials for COVID (Recovery, REMAP-CAP) decisively contributed to the rapid development of effective therapeutic strategies [97].

Arguments against the prevention measures in general and against the vaccination strategies in particular

While the antivaccine arguments have not been made for HIV infection, mainly because an anti-HIV vaccine is not within our grasp, this is nonetheless a critical aspect of the SARS-CoV-2 misinfodemia, and undoubtedly, the most damaging and daunting of all. Vaccine campaign failures in countries in

which the vaccine was widely available are an absolute expression of a major communication and education failure. Multiple factors (social and conventional media, political factors, and an overall misunderstanding of the vaccine expectations) contributed to this failure.

The fear of vaccine has deep roots in the Western culture that is intrinsically resistant to new ideas. Many occurrences of innovative changes for the society were countered by arguments postulating fake beliefs or information. Upon its introduction to the Western world, coffee was feared to induce sterility; steam engine-powered trains were predicted to slip off the rails; electric bulbs were predicted to spark fires and fatal electrocution [98]; use of genetically modified foods is contested widely for fears that they may interfere with people's health, while they reduce the use of pesticides, which are a well-established cause of cancers [99].

Probably the most unfortunate aspect of vaccine distrust is the nature of the SARS-CoV-2 vaccines. The general public expected that the vaccines will induce sterilizing immunity, preventing further transmission of SARS-CoV-2, such as the one induced by the measles vaccine. Yet, SARS-CoV-2 vaccines induced protection against only severe disease and death. Similarly, a major desideration of an anti-HIV vaccine is to drastically reduce the viral load below the threshold needed to prevent disease progression and transmission.

As such, the public resistance to the vaccination should be continually targeted and the public should be helped to realize the magnitude of the impact that vaccines have had on our society. In the USA alone, the vaccination campaigns contributed, since 1889, to the prevention of at least 76–120 million deaths [100].

Counteracting misinfodemic: 11 arguments

The common features of the AIDS and COVID-19 misinfodemics presented above clearly call for a concerted action to counter them. Throughout the pandemic, the scientific community has engaged in efforts to combat both SARS-CoV-2 and the misinformation: in scientific media, in mass media and in social media, through various posts, threads, or interviews, or through panel discussions. Yet, the evolution of the misinfodemic during the past 2 years calls for a more systematic and targeted action to clearly and unequivocally state the following key facts to counteract the COVID-19 misinfodemic: (i) SARS-CoV-2 is the cause of COVID-19; (ii) SARS-CoV-2 emerged through cross-species transmission (either direct or through an intermediate host) from the horseshoe bat (*Rhinolophus* spp.); (iii) SARS-CoV-2 cross-species transmission to humans most likely occurred in the Huanan seafood market in Wuhan, China, at the end of 2019; (iv) SARS-CoV-2 was isolated, characterized, and passaged in multiple animal models, therefore fulfilling the Koch's/Rivers postulates for the causality of an infectious disease; (v) there is no evidence that SARS-CoV-2 pathogenicity in humans is the result of gain-of-function experiments; (vi) the furin binding site, although not present in the immediate known relatives of SARS-CoV-2, is widely present in coronaviruses infecting multiple mammal hosts; (vii) bat coronaviruses can efficiently replicate in human cells and tissues without any preadaptation; (viii) the diagnostic methods for SARS-CoV-2 are well established, have excellent sensitivity and specificity, and can be widely used to identify SARS-CoV-2-infected individuals; (ix) broad organ involvement from SARS-CoV-2 infection was thoroughly characterized from numerous necropsies performed throughout the pandemic; (x) SARS-CoV-2 vaccines are not experimental, have been extensively tested, and are highly effective in preventing severe forms of disease and death from SARS-CoV-2 infections and COVID-19; (xi) the side effects of SARS-CoV-2 vaccines are many times less frequent than the complications from SARS-CoV-2 infection, including severe disease, death, and long-COVID; therefore, the vaccine is preferable to natural infection.

Concluding remarks

We have reviewed common elements between two misinfodemics that paralleled two recent major pandemics – AIDS and COVID-19. Since pandemic threats from multiple sources are possible [101], it is important that the strategies for controlling any new or ongoing pandemics seriously address their misinfodemic aspects along with the biomedical challenges posed. Otherwise, the burden of the misinfodemics may significantly derail any strategy for pandemic control. ‘A lie is more comfortable than doubt, more useful than love, more lasting than truth...’ [102]. SARS-CoV-2 pandemic was significantly impacted by the ongoing misinfodemic. A cause of this successful misinfodemic is that the scientific community opted, as expected, to focus on solving urgent scientific needs and developing strategies for diagnostics, treatment, and control, rather than rapidly addressing misinformation. The time has come that scientists address misinfodemic as a corpus, by documenting the obvious and refuting falsehoods with scientific facts to the public through multiple means of communication.

In the case of the AIDS infodemic, the Durban Declaration worked wonders to refute harmful misinformation. It is time that we act again to ensure the success of the pandemic-control measures for SARS-CoV-2 and future pandemics (see [Outstanding questions](#)).

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Declaration of interests

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Resources

ⁱwww.gisaid.org/

ⁱⁱwww.theportugalnews.com/news/2020-11-27/covid-pcr-test-reliability-doubtful-portugal-judges/56962

ⁱⁱⁱwww.who.int/health-topics/infodemic#tab=tab_1

^{iv}www.proquest.com/docview/279705520

^v<https://royalsociety.org/-/media/policy/projects/set-c/set-c-vaccine-deployment.pdf?la=en-GB&hash=43073E5429C87FD2674201CA19280A8E>

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Outstanding questions

Is the magnitude of misinfodemic impact on pandemics dependent on the severity of the disease (i.e., would disinformation be equally successful during an outbreak of a disease with high transmissibility and high mortality)?

Can misinfodemics be prevented? Or, will there always be a fraction of the population that cannot be convinced with rational arguments, and thus prone to being misguided?

Should misinfodemic-preventing strategies be included in the overall strategies for pandemic control?

Would an early initiation of the countermeasures for the misinfodemic control improve the outcome of the pandemic responses?

What is the effective strategy to prevent the political weaponization of the misinfodemic that, in the case of SARS-CoV-2, contributed to the failures of the prevention strategies (including the vaccination campaigns)?

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