# What Should We Do to Prevent Zoonoses with Pandemic Potential?

This is the author's version of the article accepted on 24 October 2023 for publication in: *Journal of Applied Animal Ethics Research*, https://doi.org/10.1163/25889567-bja10043

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**Abstract**

The majority of new infectious diseases that affect human beings are zoonoses. Zoonotic pressure is increasing for various reasons. These include: 1. the growth of the human population; 2. the growing concentration of human beings; 3. the growing mobility of the human population; 4. the rapid growth in the human usage of nonhuman animals; 5. the increasing intensification of the farm animal sector; 6. increasing ecological degradation, and 7. the lack of political will to address the previous six factors. These factors and the interplay between them create perfect storm conditions for the emergence of zoonoses with pandemic potential. What compounds the problem is a lack of moral theory on how to prevent zoonoses and associated pandemics. This article aims to address this gap by drawing on interdisciplinary work on zoonotic and pandemic prevention.

**Keywords**

animals, Covid-19, ethics, pandemic, philosophy, SARS-CoV2, zoonosis

## 1. Introduction

Around two thirds of circa 400 infectious diseases that have emerged since the 1940s are zoonotic (Jones et al. 2008; Morse et al. 2012; Franjić 2022). Even if the concept of zoonosis (plural: zoonoses) is sometimes reserved for diseases that can be spread from vertebrate animals (McNamara et al., 2020) or for diseases that can spread to human beings more than once due to the presence of a nonhuman “animal reservoir host” (Tajudeen et al. 2022,  3), the concept is used here to refer to a disease that can be transmitted horizontally from a nonhuman to a human animal. The word ‘horizontally’ is important here as, ultimately, all human diseases emerge from nonhuman animals, given that human beings descend vertically (evolutionarily) from nonhuman animals. Of all the pathogens that affect people, around 95% of helminths, around 80% of viruses, around 70% of protozoa, around 50% of bacteria, and around 40% of fungi are zoonotic. Whilst many diseases can spread from nonhuman to human animals, the reverse is also the case. More viruses pass from humans to pigs, for example, than the other way round (Holmes 2022). Speciesism is the reason the study of zoonoses is more of a hot topic than the study of diseases that spread from humans to nonhumans.

The frequency with which new diseases are emerging is increasing. Around half of all the pathogens that are known to affect farmed and companion animals can infect human beings, and around half of those that affect companion animals can infect other vertebrates (Morse et al. 2012). Transmission is particularly high between nonhuman mammals and human beings. Viruses are of particular concern as they appear to be relatively better-equipped to spread widely. Some of these new diseases can undermine human health severely and cause death, and some can affect very large numbers of people. When an epidemic is marked by “widespread geographic extension” (Morens et al. 2009,  1020), it may be appropriate to speak of a pandemic. In spite of the fact that the coronavirus SARS-CoV2 (COVID-19) is one of the most serious pandemics that has plagued humanity in recent times, having caused disease or death to many millions of people, we lack an adequate moral theory on what we should do to prevent zoonoses with pandemic potential. I can identify at least three reasons this might be so.

Firstly, we must recognise that we live in a culture that is marked and marred by significant moral phobia. This recognition would be the first step towards tackling it. Let me explain what I mean by means of a personal story. In 2011 I published my first article on the ethics of zoonoses, in the Journal of Medical Ethics, one of the leading journals in health care ethics. It aimed “to promote debate on the question as to whether a range of systems used by the farm animal sector survive moral scrutiny” in light of the sector’s contributions to the emergence of H1N1 flu and the burden of disease in general (Deckers 2011). Whilst the article might have promoted debate, it has so far not been cited by any other scholar. By comparison, I also published a co-authored article on the ethics of artificial intelligence (Lara and Deckers 2020). In spite of its recent publication date, it has already been cited by more than 50 authors. The former paper was written just after the swine flu pandemic of 2009, and suggests that zoonoses may not just be sad, but also (morally) bad. The latter paper wonders whether we should develop an AI system to help us to make moral decisions, and argues that such a system would need to possess specific properties. I am puzzled as to why the latter article seems to attract so much attention where the former does not. I think we need to reflect on this in order to understand better why we are where we are now on the ethics of zoonoses, and what we might need to do to overcome zoonotic ethics apathy.

I think this difference in attraction is at least partly related to moral phobia, a tendency to eschew moral questions due to the fact that answering moral questions can make one feel guilty. I think this phenomenon exists also amongst ethicists. Compare the guilt of causing a pandemic with the guilt of not using a computer to help one to resolve ethical questions. The guilt associated with the former might be much greater as one can hardly blame a person for not using a computer to answer ethical questions. I wonder whether this preference for rather abstract issues in ethics that are more distantly related to everyday matters, such as the health impacts associated with zoonoses, might stem from a culture that more generally values the abstract over the concrete. The Platonic world of mathematics that is loved so much by computer scientists is also a world in which the world in which we live is but a façade of the real world of abstract ideas. This preference for the abstract may not just be shared by some computer scientists, but also by some ethicists. It is good to remind ourselves that the discipline of ethics is also known as moral philosophy. Contemporary preference for the former word, at least in academic circles, may itself signal this preference for the abstract over the concrete. Lay people who do not study ethics and who may dwell less in a world of abstractions may be much more likely to refer to their value systems by the word 'morality' rather than by the word 'ethics'.

Secondly, bioethicists not only share in this culture of moral phobia, but also in a different kind of phobia that pervades the culture of academic scholarship in bioethics. This phobia is a mutual fear that exists between those bioethicists who preoccupy themselves with human health care ethics and those who entertain themselves with nonhuman animal ethics. One can even speak of a rift between scholars who focus on human health care ethics and those who focus on (nonhuman) animal ethics. The former focus exclusively on narrow human interests, ignoring the interests of nonhuman animals. The latter, scholars who identify as working within the field of 'animal ethics', focus almost exclusively on the interests of nonhuman animals, ignoring significant human interests, for example the interest in consuming animal products. The former tend to publish in journals with names that include the words 'medical', 'health care', or 'bioethics', and the latter tend to publish in journals that avoid these labels either in the journal's name or in its mission. The general, but unspoken rule, is that never the twain shall meet, in spite of the fact that there is no reason why the words 'health care' and 'bioethics' should be reserved for humanity.

A good example of this rift is the fact that the journal 'Bioethics', which was co-founded by Peter Singer, who is renowned for his work on animal ethics, hardly contains any articles that focus primarily on how we should treat nonhuman biological organisms. Indeed, a paper that I submitted to the journal a while ago – subsequently published elsewhere (Deckers 2018) – was rejected by the editors as they decided that the topic did not fit the remit of the journal. Whilst approaches such as the 'one health' and 'planetary health' movements go some way to addressing this rift, many scholars continue to focus predominantly on relatively narrow human health interests to the exclusion of the interests of the nonhuman world. In order to tackle zoonoses, this rift must be overcome.

Thirdly, whilst this moral phobia and the bioethical rift may account to some extent for why few bioethicists have spent time on animal ethics, and a fortiori on developing theories on how to prevent zoonoses and pandemics, some moral scholars have entertained themselves with this aspect of health care (Huth 2018; Lakan et al. 2022). However, few concrete proposals have been made as to what should (not) be done, perhaps partly because of moral philosophy prioritising the abstract over the concrete. Van Herten and Bovenkerk (2021), for example, argue rightly that we should focus more on the prevention of zoonoses, but they do not provide much detail as to what we should do to achieve this goal. I agree with these authors that we should consult a wide range of stakeholders in order to develop this detail, a point made also by De Paula Vieira and Anthony (2021, 225), who add that "animal health and welfare perspectives … should be strengthened in disaster risk reduction and management strategies".

However, it is also incumbent on moral philosophers to argue for their theories of what a good zoonotic prevention strategy might look like. This is not easy. To develop such a theory, moral scholars must not only identify the sociological and psychological factors that drive zoonoses (see e.g. Stel et al. 2022), but also possess good scientific knowledge of their causes. Many bioethicists, myself included, have relatively little training in science. Due to our lack of expertise in the science of zoonoses, we are hampered in the ability to develop specific proposals on what we ought to do to prevent (specific kinds of) zoonoses. Scientists might be in a better position here, but they may be hampered by not being trained in moral philosophy. Whilst they may know a lot about the science of zoonoses, they may lack the ability to relate their ideas to ethical theory and public policy.

In spite of these problems, this article aims to draw on interdisciplinary work to develop a better understanding of the complexities of human interests and of how these can both promote and undermine the emergence of zoonoses, in order to develop a new moral theory on the prevention of zoonoses and, particularly, on pandemics caused by zoonoses. Elsewhere, I have argued that an appropriate ethical theory can only emerge when all human interests are balanced appropriately (Deckers 2016). The main interests that are relevant here and that will be discussed in the ensuing section are the human interests in reproduction, in living together in cities, in mobility, in engaging with other animals, in (not) confining animals in intensive production systems, in (not) altering ecosystems, and in (not) ignoring strategies that can prevent zoonoses and pandemics.

**2. What are the main drivers of zoonoses with pandemic potential?**

Whilst zoonoses have been around as long as humanity has existed, zoonoses have become more of a threat for several reasons. Firstly, the human population has never been greater in number. The global human population is estimated at almost 8 billion people (https://www.worldometers.info/world-population/) and is projected to increase (Fig. 1).

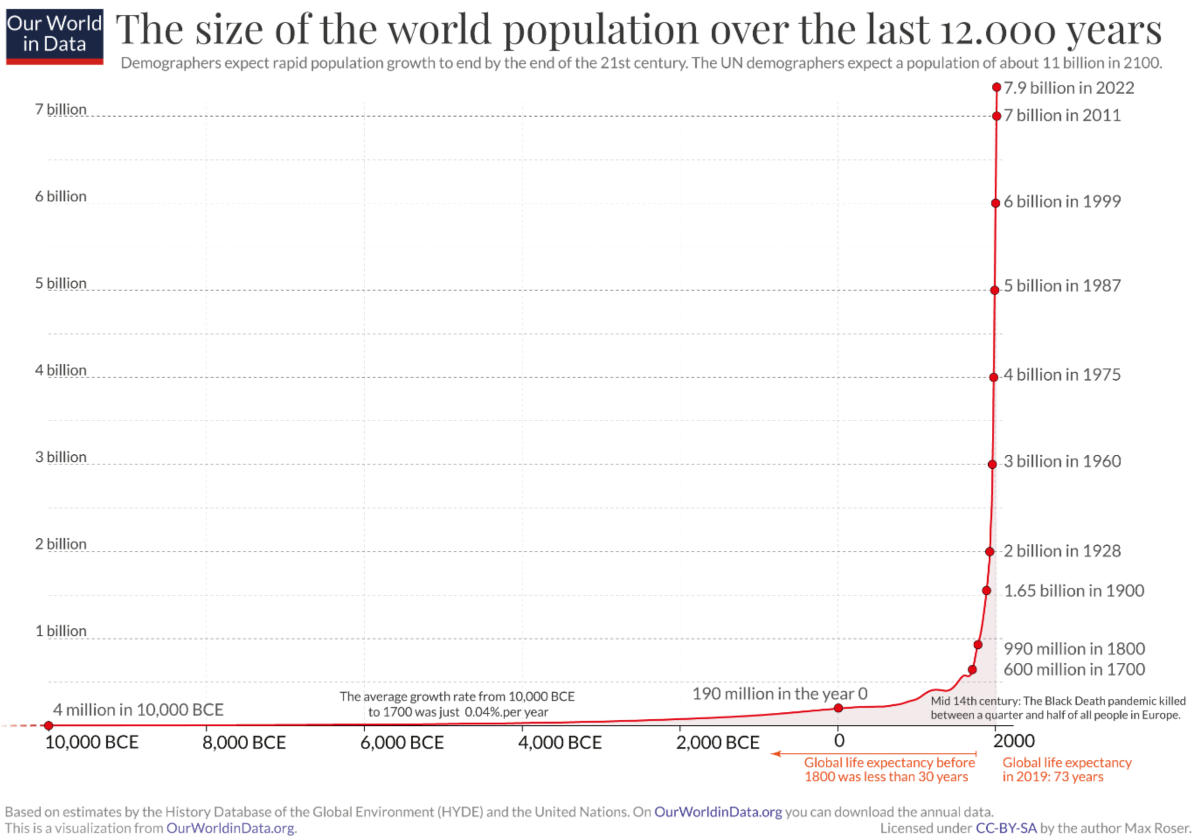


**Figure 1: A graphic illustration of how the human population has grown over the last 12,000 years**

**SOURCE: https://ourworldindata.org/world-population-growth**

Whilst many zoonoses only affect a few individuals or local populations for a short amount of time, due to this number being so high, many people live in close contact with other people, facilitating the spread of disease beyond small geographical sites. The rise in the human population in West Africa, for example, is likely to have contributed to the unprecedented scale of the 2014 Ebola outbreaks (Rulli et al. 2017).

Secondly, whilst the total population has increased in density, human population density varies greatly between different locations. Whilst some areas have become relatively less dense, many more areas have become denser. Whilst an increase in density need not necessarily imply a greater risk of the spread of infections, an increase in population density is generally associated with a greater risk of infections spreading as people live in closer proximity to one another. The organisation 'Our World in Data' provides an interactive map which provides a very good illustration of how human population density has developed since 10,000 BCE and how it is expected to develop up to the year 2100 (https://ourworldindata.org/grapher/population-density?time=latest). Whilst human population is rising in rural areas, the following graphic shows clearly that the urban population has been growing more rapidly (Fig. 2).

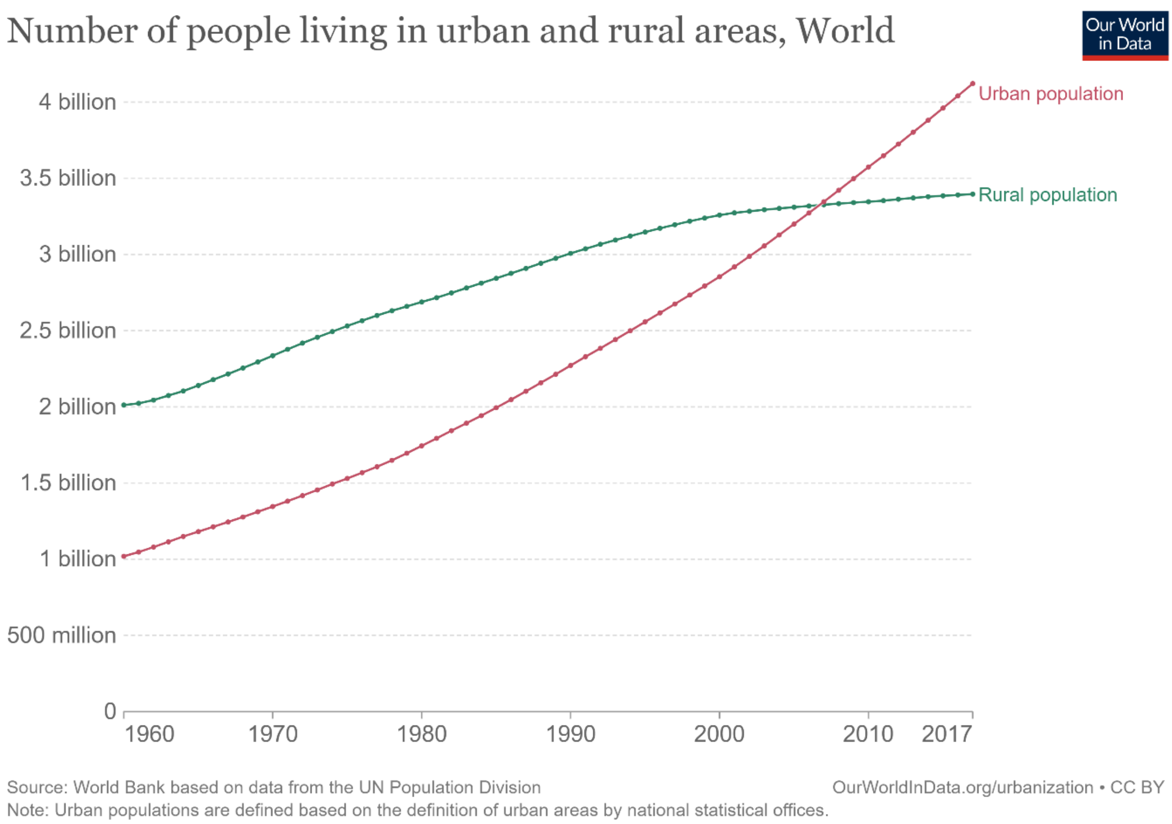


Figure 2: How the human population has grown more in urban areas

SOURCE: https://ourworldindata.org/urbanization

Thirdly, human beings have become much more mobile. With greater mobility comes a greater capacity to spread diseases from one area to another. An example is the recent spread of the coronavirus. Whilst significant efforts were made to control the coronavirus epidemic so that it would remain restricted to a few geographical areas, it spread around the world like wildfire from the Huanan Seafood Wholesale Market in Wuhan (China), where it emerged. Air travel in particular, which accounted for around 3.5% of total anthropogenic radiative forcing in 2018, has been identified to carry great zoonotic potential (Murphy et al. 2020). The following graphic shows that air transport has grown more than fivefold since 1990 in terms of the number of people who have been carried, and that it has grown much more in relatively affluent countries (Fig. 3).

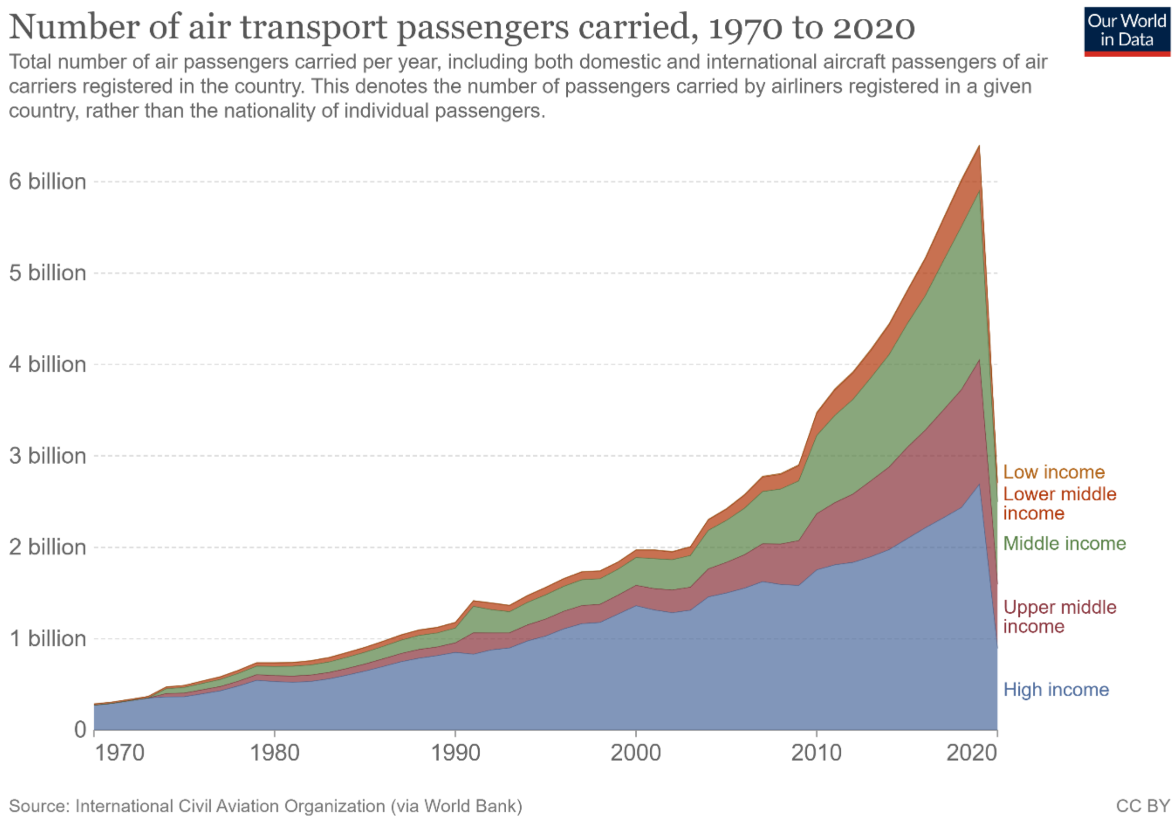


**Figure 3: Growth in air transport**

**SOURCE: https://ourworldindata.org/grapher/number-of-air-transport-passengers-carried?tab=chart**

Note that the red line showing the share for low income countries in figure 3 is hardly visible, and situated above the orange area for lower middle income countries. This global inequality is also apparent from the next chart, which shows that high-income countries account for the greatest amount of $CO_2$ emissions. It also shows that total emissions reached almost a billion tonnes in 2018 (Fig. 4).

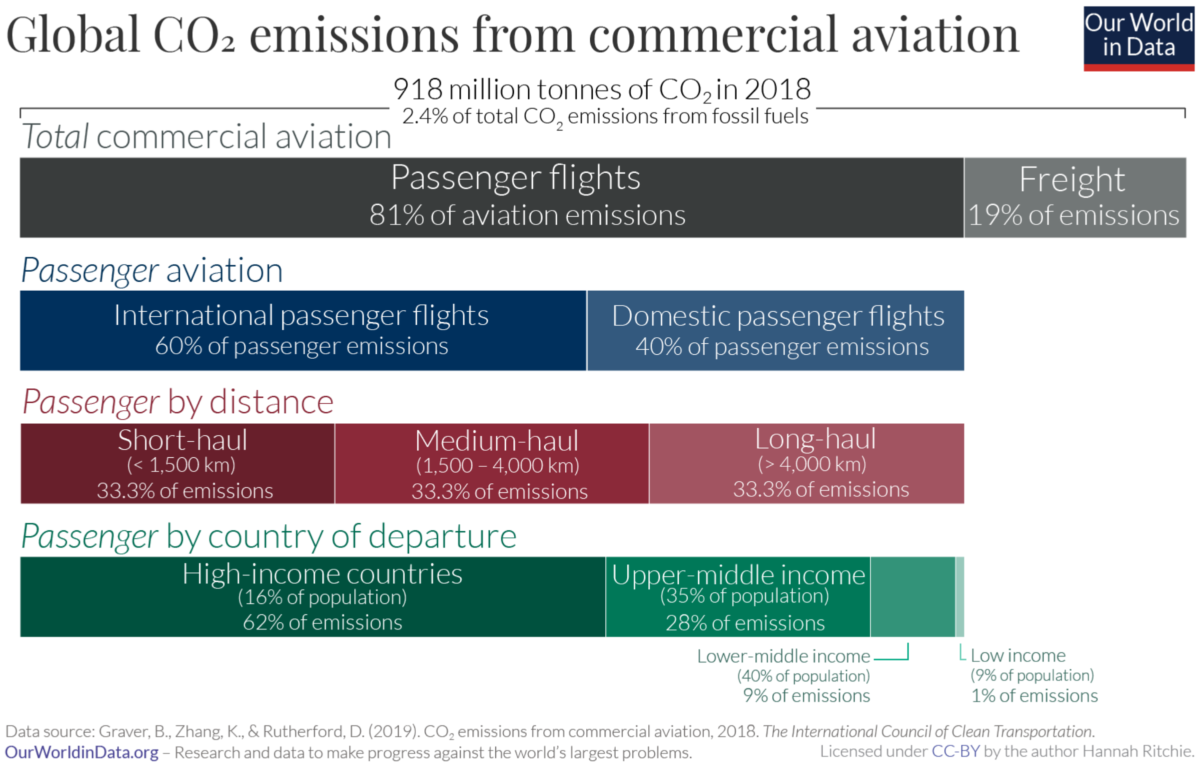


**Figure 4: $CO_2$ emissions in 2018, with relevant details**

**SOURCE: https://ourworldindata.org/transport**

Fourthly, the human usage of nonhuman animals is growing rapidly. More people keep nonhuman animals and more consume animal products, particularly from domesticated animals. In relation to the human usage of nonhuman animals for companionship, animals are either captured in the wild or bred, and frequently kept in close proximity with other animals during transportation. Sometimes, they are transported in close proximity with individuals from different species, where these “unnatural associations” create opportunities for inter-species transmission of pathogens (Bernstein et al. 2022,  6). They may also be kept as companion or working animals by people who may house them in close proximity to themselves and to animals from other species. An example of a zoonosis that spread through the trade in companion animals is a variant of monkeypox, which spread from

Ghana to Texas through the trade in Gambian pouched rats (Centers for Disease Control and Prevention 2003).

In relation to the consumption of animal products, more animals are being hunted or reared for human consumption than ever before, increasing zoonotic potential. Whilst hunting does not provide much food in industrialised nations, it nourishes more people who live in many less industrialised and less affluent areas (Nielsen et al. 2018). Whilst wild mammal zoomass (the weight of animals) was greater than that of domesticated species in 1800, domesticated bovine zoomass was more than 20 times that of wild mammals in 2000, and continues to rise (Smil 2021). More generally, people now slaughter more than 80 billion animals each year for human consumption. Around 340 million tonnes of flesh from animals was produced in 2018, a greater than threefold increase over a period of 50 years (https://ourworldindata.org/meat-production).

Practices associated with the consumption of animal products are significant sources of zoonotic disease. One example is Crimean-Congo hemorrhagic fever, which does not spread from person to person, but increases where people are more exposed to ticks, for example through hunting and farming (Bente et al. 2013). Dabie bandavirus, also called SFTS virus, is another example of a tick-borne virus that can spread through close human contact with many nonhuman animals. It causes severe fever with thrombocytopenia syndrome. Whilst it emerged in China in 2009, it subsequently spread to South Korea, Japan, Vietnam and Taiwan. China has also witnessed several H7N9 influenza outbreaks since 2013, with influenzas emerging from the farming of ducks and chickens (Zhu et al. 2016).

The consumption of bats is associated with the emergence of the SARS-CoV2 coronavirus, with the pangolin possibly as intermediate host (do Vale et al. 2021). As bats are known to carry many viruses without being affected much by many of them, they are implicated in many other human viral diseases. One example is the SARS coronavirus, which spreads much more readily between people. It emerged in 2003 in China from the hunting of bats for food, where bats infected civets in markets in Southern China, who then transmitted the virus to people (Wang and Eaton 2007). Bats are also implicated in the emergence of the Middle East respiratory syndrome coronavirus (MERS-CoV), with the camel as intermediate host (Zaki et al. 2012; Zumla et al. 2015), and the consumption of bats may also have contributed to the emergence of Ebola virus epidemics in Africa (Olivero et al. 2020).

Fifthly, many animals who are consumed by human beings, particularly pigs and chickens, are bred in intensive systems, which frequently increase zoonotic potential over extensive systems (Hayek 2022). Most animals kept in intensive systems are characterised by great genetic uniformity, providing great opportunities for pathogen mutation and spread. Examples that have been associated with agricultural intensification include recent revivals of anthrax, brucellosis, and salmonellosis (Stephens et al. 2021). Pigs are intermediate and amplifying hosts for multiple viruses, including various influenzas, Japanese encephalitis and Nipah viruses. The Nipah virus outbreak in Malaysia in 1997, for example, emerged after intensive pig farms and fruit orchards had been established on the edge of a forest. Fruit bats then started eating the cultivated mangoes and transmissed a virus to pigs who, eventually, passed on a modified virus to human beings. Multiple influenza strains, including H5N1, have also originated from industrialised poultry farms (Graham et al. 2008).

Sixthly, zoonotic potential is also increased when ecosystems are altered significantly by human activities. The most significant cause of ecosystem alteration lies in the expansion of the farm animal sector, which now occupies about 78 percent of all agricultural land (Benton et al. 2021). The sector has expanded into territories that used to be rich in wildlife and that are adjacent to such areas, facilitating the spread of pathogens between wild and domesticated animals, as well as human beings. Almost three quarters of all zoonoses originating between 1940 and 2004 emerged from wild animals (Jones et al. 2008). Zoonotic hotspots are places where significant human activity takes place in ecological settings marked by high biodiversity (Morse et al. 2012).

Reducing this biodiversity in particular has been associated with a rising risk of zoonose. This is probably at least in part due to the dilution effects of areas that are rich in biodiversity: pathogens that spread over a larger number of species are thought to be less competent compared to pathogens that spread over a smaller number of species. In areas rich in biodiversity, pathogens may thus be more dilute, lowering risks of spreading to human beings (Ostfeld 2009; Civitello et al. 2015). Low bird diversity, for example, has been associated with an increased risk of West Nile encephalitis infections in human beings (Ostfeld 2009). Another example is the Hantavirus infection in Panama, which has been associated with a decline in small mammal diversity (Suzan et al. 2009). The destruction of tropical rainforests in particular is an area of great concern as people who encroach in forested areas enter into contact with animals who carry pathogens that people are not adapted to. Whilst less visible than deforestation, trophic downgrading – the extirpation of apex species, may also increase zoonotic risks. The eradication of lions and leopards from some parts of Ghana, for example, caused an increase in the number of baboons, leading to a greater number of transmissions of intestinal parasites to people (Ryan et al. 2012; Taylor et al. 2016).

Not only the expansion of the farm animal sector, but also climate change is a major contributor to ecological degradation as it causes significant alterations in the distribution and interactions of hosts, vectors, and pathogens due to changes in temperatures and levels of precipitation, amongst other things. As the ranges of Aedes species mosquitoes have expanded, for example, dengue has increased (Lambrechts et al. 2010). Climate change has also increased the ranges of many other arthropod vectors, for example flies, ticks, midges, and fleas. Extreme weather events can also favour particular pathogens, for example Vibrio cholerae, the bacterium that causes cholera. Positive correlations have also been established between El Niño–Southern Oscillation (ENSO)—an extreme weather event—and outbreaks of plague, Hantavirus, and Rift valley fever (Anyamba et al. 2009; Anyamba et al. 2019).

Finally, there is a lack of political will to address the previous six drivers. Many policy-makers focus exclusively or mainly on identifying and containing zoonoses, rather than on trying to prevent them (McCloskey et al. 2014; Elias et al. 2021), resulting in science being skewed similarly. There is 'good' reason for this, as perceived rightly by Shanks et al. (2022, 4): "prevention protects the most deprived and vulnerable, whereas, detection and response measures tend to protect those in more privileged positions who are least likely to be harmed by future disease emergence crises". However, preventing zoonoses is not only necessary to save lives and to tackle these health inequalities, but also to reduce the economic costs associated with tackling them. Whilst the economic costs of zoonoses are hard to quantify, they may cost around $ 200 billion per year (Bernstein et al. 2022). By contrast, Bernstein et al. (2022, 10) have calculated that the implementation of a number of primary prevention measures would only cost around 10% of this amount and may "create a significant number of jobs across a range of skills".

**3. How to address the emergence of zoonoses with pandemic potential**

In order to tackle these causes of zoonoses with pandemic potential, we must take drastic action. Before setting out what kind of action we must commit to, it is important to recognise that the factors that drive the emergence of zoonoses do not exist in isolation. As an increase in one factor may trigger another factor or make it more likely, thus increasing vulnerability, they should be considered jointly. An example of such an entanglement are the arrivals of different strains of HIV in West and Central Africa, which are caused by the interplay between various factors, including rapid population growth, deforestation, and the consumption of flesh from wild animals (Bernstein et al. 2022, 8-9). To tackle the causes of zoonoses successfully, we must also work on multiple factors simultaneously. For analytical purposes, however, I will treat each factor separately when setting out what kind of action we must take.

Firstly, we must curtail the growth of the human population. Whilst a significant reduction in the reproductive rate of some population groups may lead to an ageing population in some locations, the fact that a particular population may be ageing does not, ipso facto, provide an argument for encouraging a greater reproductive rate. Migration is another option. Whilst massive migration is not free from concerns related to how people integrate when they live in the presence of those who adopt very different cultural and social practices, lessons could be drawn from present mass migrations, for example from Ukraine, to explore how people from different cultures can live together harmoniously. Reducing the human population globally is not an easy task as people might invoke the principle of procreative liberty, which has been defined as “the freedom to control one’s reproductive capacity” (Bognar 2019,  321), but might be better defined as the idea that one should be free to procreate, without external constraints, at least as long as two people consent to collaborating on a procreative project. Whilst I do not deny that it is a significant human interest for people to decide jointly whether or not to have children, I also think that more constraints should operate in this area. Constraining procreative liberty is associated with some significant concerns, for example the possibility that some people might simply not comply or resort to abortion and infanticide because of social pressures that may exist to limit the size of one’s family. Whilst these concerns must be taken seriously, we cannot deny that there are significant concerns related to allowing people to reproduce at the rates that they are currently doing. These concerns extend far beyond zoonotic risk, for example risks associated with the climate crisis.

A renowned scholar who has argued about the population problem for a long time is Paul Ehrlich. He has co-authored a piece in which it is argued that 1.5 to 2 billion people would be likely to “permit … Homo sapiens to live a good life over the long run” (Daily et al. 1994, p. 474). Whilst the authors appreciate that a world with 4 billion people might be sustainable, provided that radically new technologies are developed and implemented quickly, a world in which 2 billion people existed would be a world in which the human population would roughly equal that of 1930. A different estimate is provided by Lowe (2016), who thinks that a human population size that ranges between 1.5 and 5 billion people might be sustainable, depending on consumption levels and available technologies to limit negative health impacts. Whilst I do not aim to settle the debate here as to how big the human population should be in order to reduce the risks of zoonoses to acceptable levels, it is very clear that there are very good zoonotic and ecological grounds to reduce the human population. In spite of this clarity, the questions as to how big the human population should be and what we should do to curtail the human population have received little debate. However, I am at one with Ganivet (2019, 4979) who argues that, "although limiting population growth may not be the only solution required to fix current environmental problems, ignoring it is likely to hinder any ecologically sustainable future". The same applies to fixing current neglect about trying to prevent zoonoses and pandemics.

When it comes to deciding how to do this, Bognar (2019) has recently revived a proposal originally made by Ehrlich, Holdren, and Ehrlich (1977). It rests on two pillars. The first is the idea that, should the technology be available, it might be worth introducing a scheme whereby young men and women are given a mandatory long-term contraceptive before they reach the age at which they can reproduce biologically. Whilst Bognar mentions that this should only be done once, the reality is that it may need to be applied mandatorily more than once. Bognar is right that such a scheme would not breach procreative liberty as everyone would be free to decide when they wish to switch off or remove the contraceptive (implant) in order to start a procreative project, even if it would undermine liberty by not allowing people to opt out of mandatory contraception at times that they are not thinking about reproducing. In the absence of such a scheme or if such a scheme would not be sufficient to reduce the world population, a second pillar should be considered: the introduction of a scheme where a fixed number of tradeable permits should be obtained by those who wish to have more than one child. Every person could, for example, be entitled to have 0.75 children without needing to pay. If a couple, for example, wanted to have a second child, they would need to buy a 0.5 entitlement. If they wanted to have a third child, they would need to buy a permit for 1 entitlement. Whilst Bognar recognises that such a scheme may favour the rich over the poor, governments might be able to provide vouchers to the poor so that they are not disadvantaged in the market or allocate entitlements to those who want to have more than 1 child by means of a lottery. Whilst both pillars raise questions regarding the protection of autonomy, the time to consider this proposal seriously is overdue.

Secondly, we must curtail the expansion of some cities in order to reduce population density in places where high densities are likely to increase zoonotic risks significantly. Whilst living in cities is associated with many benefits for people, for example increasing opportunities for socialising and complex artistic expressions, as well as allowing more land to be set aside for purposes other than human habitation, it is an undeniable fact that, all else being equal, many zoonoses can be transmitted more easily where people live in close contact to one another. Other problems have been associated with living in highly dense areas, for example a restriction of personal freedom (Daily et al., 1994), a greater exposure to some pollutants, a decline in physical activity and nature exposure, and increases in some non-communicable health concerns, such as obesity, stress, and mental health issues (Dye 2008; Cox et al. 2018). Whilst rural life is not free from problems and not all places where people live in close contact with other people should be avoided, city and town planning agencies should give due consideration to how the increasing expansion of many cities and towns across the globe might enhance zoonotic potential, and take appropriate mitigating measures.

Thirdly, we must curtail human mobility. Again, this is not free from concerns, given that many people love to travel. Travel is undeniably a social good that is and must be valued highly (Árnadóttir et al. 2021), in spite of its significant personal, social, and ecological costs (Kamb et al. 2021). However, present mobility not only presents significant zoonotic, but also many other concerns, including ecological degradation and climate change. Aviation, for example, contributes to radiative forcing because of its $CO_2$ impacts and its emissions of other gases (including water vapour, nitrogen oxides, sulphur, and soot) that account for roughly 50% of its impacts (Lee et al. 2021). Whilst some mobility concerns can be tackled by addressing the mindless transportation of some goods, for example the transportation of biscuits over thousand of miles to areas where similar biscuits are produced, the transportation of people must also be scrutinised. As the world population has become much more mobile in the last few decades, many people's families are spread out over vast areas. Whilst I believe that we should allow people to visit their family members now and again, even if they live a long distance away, this is different from allowing people to travel long distances for a range of other goals, for example tourist or academic purposes, where many journeys "lack importance" (Gössling et al. 2019). Some universities, for example, are already adopting policies to reduce air travel for academics who may be able to use video conferencing instead (Glover et al. 2018; Jack & Glover 2021). Such moves must be embraced, even if political support is needed to ensure that this does not disadvantage some academics over others (Tseng et al. 2022). More generally, careful decisions will need to be made to prohibit transportation for the wrong reasons and to allow or even to encourage it for the right reasons.

Whilst it may not be easy to decide what is a right and what is a wrong reason, I agree with Higham et al. (2016,  336) that "voluntary approaches will be insufficient alone". Apart from curtailing air travel, various things should be done to reduce the zoonotic risks of air travel, for example the development of better on board ventilation systems. Allowing people more space on aircrafts might decrease zoonotic risk, but prohibiting business class travel might be necessary to reduce the contribution of aviation to radiative forcing. Various options exist to curtail air travel. One option is to restrict airport expansion or to shrink existing airports. Another option is to ban “the marketing communications of airlines”, which “systematically promote moral disengagement and drive unrestrained and excessive consumption” (Higham et al. 2022). Rather than to provide tax exemptions and subsidies to aircraft companies, as is currently the case (Higham et al. 2022), another option is to tax aviation in such a way that demand will diminish and/or the eco-social costs are compensated for. Research has shown that such a form of taxation may be much less problematic compared to other carbon taxes (Büchs and Mattioli 2022). One concern with taxation is that it may affect poor people more, but it is possible to devise schemes that ensure that some contribute more to paying for an aviation fuel tax compared to others, for example an air miles levy which escalates with the number of air miles that are travelled within a particular period of time (Carmichael 2019). An alternative option is to allow air travel only for specific purposes. Many people are already used to applying for visas in order to be able to travel to particular countries. A similar application system could be developed to ensure that people only travel for legitimate purposes. An international agency could be set up that people should apply to in order to be granted permission to travel, or the International Civil Aviation Organization could adopt such a role.

Regardless of which option or combination of options might be pursued, the bottom line is that we must agree to a fixed quota of how many kilometres the total human population should be allowed to travel by plane annually. This quota should be allocated fairly between those who wish to travel by plane. This raises the question of what this quota should be. Klöwer et al. (2021, 1) have argued that “aviation’s contribution to further warming would be immediately halted by either a sustained annual 2.5% decrease in air traffic under the existing fuel mix, or a transition to a 90% carbon-neutral fuel mix by 2050”. Klöwer et al. (2021, 4) proceed that “the impacts of the continued rise in accumulated $CO_2$ emissions and the fall of non-$CO_2$ climate forcers would balance each other” by adopting either approach, whereas a business as usual scenario would set us on course to exceeding the 2015 Paris Agreement's goal to limit warming to 1.5˚C by 2050 relative to the pre-industrial level (United Nations, 2015). Given that the adoption of other fuels is associated with significant challenges due to land pressures and that we should not embrace a world with warming that exceeds 1.5˚C, I argue that we must adopt a minimum of a 2.5% annual reduction, which would see air traffic in 2050 being "reduced to about 50% compared to pre-COVID levels" (Klöwer et al. 2021, 7). Whilst we should also address other modes of transportation and refrain from treating aviation in isolation from other transportation methods, by tackling air transportation in this manner, a significant method by means of which zoonoses may spread rapidly to give rise to pandemics would be curtailed.

Fourthly, the trade in nonhuman animals and the rapid growth in the consumption of animal products must be curtailed. In relation to the former, we should abandon all trade in nonhuman animals in situations where trading animals produces more eco-social harms compared to not trading them. Where trade is justified, it should be done in such ways as to minimise zoonotic risk, for example through trying to ensure that animals experience a minimum amount of stress and are kept in environments that minimise the risk of spreading infection. In relation to the latter, various mechanisms could be used to promote the consumption of vegan foods, including the use of educational tools, financial incentives, financial and other penalties, and legal prohibitions to ban the consumption of (particular) animal products. I have discussed these policy options elsewhere and argued that veganism should be the norm for people who are able to obtain adequate food in all situations where the consumption of vegan food is associated with lower personal, social, or ecological costs (Deckers 2016). The increasing intensification of the farm animal sector emerged partially in response to greater demand for animal products. Whilst this intensification is associated with an increase in zoonotic risk, it is also associated with many other concerns, for example its contribution to increasing antibiotic resistance and to land, water, and atmospheric pollution (Cohen 2022). In situations where the consumption of animal products survives critical scrutiny, incentives should be provided to promote the rearing of animals in extensive systems wherever such systems decrease harm compared to intensive systems.

Sixthly, we must halt and reverse ecological degradation. In order for human beings to live, they cannot let all other organisms live. We destroy other lives by travelling, eating, building, etc. Whilst ecological destruction is part and parcel of human culture, the slogan 'live and let live' may nevertheless do some useful work for zoonotic ethics. Elsewhere, I have argued that we should adopt a prima facie duty to safeguard the integrity of nature (Deckers 2016). Our duty to transform nature in order to enable human life should be held in tension with a duty to leave nature alone. It might be objected that there is no such thing as pristine nature anyway and that it is therefore unclear what it might mean to leave nature alone. The problem with this objection is that the fact that there is hardly or no pristine nature left on earth that has not been transformed by humanity does not imply that there is no spectrum of (un)naturalness (Deckers 2021). The slogan 'leave nature alone' can be usefully applied to this spectrum in the sense that one could adopt a prima facie duty to leave things as close as possible to the more natural end of the spectrum. In this light, safeguarding the integrity of nature is about keeping things as natural as possible, or leaving them as untouched by human culture as possible. Whilst this is only a prima facie duty, it is nevertheless a duty that we should embrace. This duty is both a duty that we owe to the nonhuman entities that make up the (nonhuman) natural world as well as a duty that we owe to ourselves, both for the narrow reason of protecting our physical health from the emergence of new zoonoses as well as for the deeper reason of protecting our mental health, which depends on the capacity to experience places that are relatively untouched by humanity. Our mental health can only be protected if we balance all moral duties, which includes a duty to respect or safeguard nature. It is important to recognise that a 'leave nature alone' approach is not necessarily a call for existing areas of cultivation to be intensified in order to spare other areas. One can also adopt such an approach by expanding agricultural area to allow intensively farmed areas to become less intensive. 'Land sparing' and 'land sharing' approaches must be compared critically to see which works best in any particular settings. An exclusive focus on the former would cause serious issues, including the expansion of vast monocultures and their associated and increasing problems, including soil degradation, a loss of pollinators, and the growing use of pesticides due to the loss of natural pest controlling agents (Baudron and Liègeois 2020).

Finally, policy-makers must recognise the six factors that drive the emergence of zoonoses, and focus more on prevention. They must invest more in science and scientists, both to predict where zoonoses might emerge and to reduce the risks of their emergence and spread. In relation to the former, genetic and molecular techniques could be used to try to identify pathogens with zoonotic or pandemic potential. In relation to the latter, we should try to ensure that those who are at an increased risk of contracting and spreading zoonoses take adequate personal measures to protect themselves, for example the wearing of protective clothing and the use of clean needles and safe practices for infections that are blood-borne. The role of veterinarians should be emphasised in this endeavour as zoonoses are more likely to emerge and to spread in areas with relatively few veterinarians as they may be able to survey the spillover of pathogens from one species to another, thus facilitating rapid action to isolate pathogens of concern (Bernstein et al. 2022). Global databases of virus genomics and serology could also be established to facilitate better understanding.

Whilst science is needed to prevent the spread of zoonoses, this article has argued that much greater emphasis must be placed on how science can help us to prevent zoonoses from emerging in the first place. To develop better agricultural practices, policy-makers must urgently devote resources to understanding better how agriculture can work together with nature. For example, agricultural systems that already work well with nature must be studied much more deeply in order to see how they might inspire agricultural reform elsewhere, for example by studying the farm run by Iain Tolhurst in the UK or the farms in Southern Ethiopia that manage to combine great productivity with great biodiversity (Baudron and Liègeois 2020).

## 4. Conclusion

The emergence and spread of zoonoses is caused by a number of factors. These include the growth of the human population, the growing concentration and mobility of human populations, the rapid growth in the human usage of nonhuman animals, the increasing industrialisation of the farm animal sector, and increasing ecological degradation. Zoonoses and the factors that drive them have received relatively little attention from moral philosophers. I have set out three reasons why this might be so. As zoonoses can unleash vast eco-social problems, seen for example by the COVID-19 pandemic, we must urgently work towards addressing these causes. I have argued that appropriate policies must be developed and implemented to reduce the size of the human population, to reduce local human population densities in some areas, to reduce the trade of animals and animal products, to make vegan diets the norm in situations where adopting such diets produces less harm, to counter the intensification of the farm animal sector, to address ecological degradation, and to promote science to prevent zoonoses, and particularly those with pandemic potential.

**Acknowledgments**

I am grateful to the organisers of the November 2022 retreat week on 'Zoonoses of companion animals as case study for animal ethics' at the Stiftung Tierärztliche Hochschule Hannover for inviting me and to all the participants in this event for the discussions that helped in the writing of this paper.

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