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REVIEW PAPER

Responding to a Public Health Objection to Vaccinating the Great Apes

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Abstract Capps and Lederman, in a paper published in this journal in 2015, argued that, at the time, the dismal circumstances of the Ebola outbreak in West Africa was an opportunity to revisit public health responses to emergent infectious diseases. Using a One Health lens, they argued for an ecological perspective—one that looked to respond to zoonoses as an environmental as well as public health concern. Using Ebola virus disease as an example, they suggested shared immunity as a strategy to vaccinate both humans and great apes. Since then, vaccination as a conservation strategy *in this case* has been debated and at least one great ape vaccination trial has been proposed: some, however, are less convinced of the ethical arguments to pursue vaccinating wild animals. Using this opportunity, we review Capps and Lederman's arguments and directly respond to the plausible objections to them.

Keywords Great apes · One Health · Vaccination · Ebola

Introduction

In a paper that appeared in this Journal, we argued that, in respect to Emerging Infectious Diseases (EIDs) emanating from animals—or zoonoses (zEIDs)—the ethical debate was being dominated by their threat to *humans*, while other considerations about the environment from which they come were being overlooked

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(Capps and Lederman 2015). At the time, it was the height of the Ebola virus disease (EVD) outbreak in West Africa; and our point was that too little was being done to understand the ecological determinants that led to the pathogen spillover, and therefore opportunities were being lost. In particular, there was scope for creative, if not immediate, solutions to the epidemic. Our idea was to propose an endemic *response* rather than talking about epidemic—and potentially pandemic—preparedness. Using EVD as an example, we argued for the possibility of *shared immunity* to propose a novel approach to vaccination that might protect both human communities and the fauna they interact with and often depend upon. In particular, we recommended the vaccination of wild non-human primates, which also have been impacted greatly by EVD (Marzi et al. 2016). However, we did not conclude that the technical issues as to how to achieve this were resolved.

A comprehensive Report attests to the threat of zoonoses to the great apes. The survey found that over the past 20 years various factors have massively impacted all wild gorilla populations (Plumptre et al. 2015). However, with the West African Ebolavirus outbreak in human communities largely under control, the debate has once again shifted back to the public health implications of the virus now residing in individuals with 'Post-Ebola syndrome' (Scott et al. 2016). Our argument can therefore be restated: an ecological perspective is still absent, and, if the virus is still and more than ever at large, circulating in unknown hosts, it presents a magnified risk to both humans and non-human animals equally affected by it. This potentially endemic risk is a particular concern for the conservation of great apes.

Coincidently, Peter Walsh has proposed protecting great apes against viruses using oral vaccines (Ryan and Walsh 2011). Walsh has referred to this animal-focussed approach as the 'breaking down barriers to vaccination' that should be considered in respect to viruses like Ebolavirus and measles.[1] Imminently, his research group will be conducting a trial on an Ebola vaccine on wild great apes using a bait system and an attenuated (live) virus.[2] There have been at least two population-wide vaccination campaigns in great apes to date: during a presumed polio outbreak at Gombe, Tanzania (Woodford et al. 2002), and vaccination of gorillas during a measles outbreak in the Virungas (Hastings et al. 1991). Ryan and Walsh (2011) make the technical case for vaccination of great apes. The ethical case for infectious disease eradication in humans has a long-standing rationale (Dowdle and Birmingham 1997); we agree that this public health model should be adapted to animal populations—to do so, a One Health framework should be used (Capps et al. 2015).

Another paper found that three species of anopheles mosquitoes that were believed to be ape species-specific could potentially transmit disease to all other ape species. This finding strengthens an argument for consideration of the shared risks of zoonoses, suggesting extensive vector bridges between primate species, and potentially between humans and primates (Makanga et al. 2016). Furthermore, it is possible that some animals can match in some respects humans' ability for trans-continent contagion (Breed et al. 2010). Thus, the problem is not one of isolating

[1] From Walsh's academic website: http://www.bioanth.cam.ac.uk/s_pwalsh.html.

[2] Personal Communication. Also see (Kelly et al. 2014).

ourselves from environmental risks, but addressing the challenges within these systems directly.

We are not aware of any formal response to the our article. Commenters on online media, however, have criticised vaccination proposals in general; although they only make vague allusions to Walsh's proposed trials. It is those comments we focus on here, as they are likely to be a way into challenging our original arguments.

Critique

The Program for Monitoring Emerging Diseases (ProMED Mail) is an 'Internet-based reporting system dedicated to rapid global dissemination of information on outbreaks of infectious diseases and acute exposures to toxins that affect human health, including those in animals and in plants grown for food or animal feed.'[3] It provides for up-to-date electronic communications. Although the comments are open, and thus require cautious interpretation, they provide a legitimate way to gain insight into the expert debate. Here, one can find responses to an op-ed, 'Can great apes be vaccinated against Ebola and other diseases?', and which included comments by Walsh (Lewis 2016).

The response by Osofsky and colleagues (Hereafter, Osofsky et al. 2016 refering to note 4),[4] and second commentary made by the same group elsewhere (Osofsky et al. 2016), argue that despite the serious problem that infectious diseases are for African great apes, requiring a conservation response, they advise that the use of vaccines in apes should be approached with caution. Although their justification is brief, it is a useful jumping off point for further debate, and therefore, we have taken liberties to present them as stand-alone ethical arguments and to position them in respect to our 2015 paper. In so doing, we do not intend to speak for Osofsky and his colleagues.

Legal and Political Realities

Osofsky et al. (2016) write 'If something goes wrong (including if the wild animal subjects in question subsequently and coincidently die for totally unrelated reasons post-vaccination), the impacts on government's willingness to allow conservationist to manage when needed can be long lasting'. The concerns are clear: great apes are critically endangered and a focal point of conservation – often energising or galvanising efforts by making our closest cousins' continued survival a visible international concern. Guarding these animals and their critical habitats may be a national interest, not least because of their importance for tourism. To this end, governments, in cooperation with local and international groups, have invested a great deal in preserving remaining ape communities. Somewhat less cynically, government officials may perceive apes as the closest relatives to our own kind (see

[3] See: http://www.promedmail.org/aboutus/.

[4] At: Published Date: 2016-04-18 16:54:06; Subject: PRO/AH/EDR> Ebola update (35): vaccine, comment; Archive Number: 20160418.4167038; http://www.promedmail.org/post/4167038; see: Comment by Steven A. Osofsky, Sarah H. Olson and Kenneth Cameron.

below), thus creating a moral duty to protect them that befalls on state actors. With these in mind, governments may be rightly sensitive to any adverse effects stemming from conservation interventions, especially initiated by international actors. Conservation groups would indeed need to observe carefully the conditions set by the government they are working with since failure of any measure could be judged critically.

That said, the political sensitivity of the use of vaccines in *human* populations has been well documented. Resistance stems from perceptions about the necessity and effectiveness of vaccines, the possibilities of emergent side effects and other unforeseen incidents, and the distrust of trials originating from foreign organisations.[5] Despite this often visible and organised opposition, vaccination programmes in human communities have been successful, and notably resulted in the eradication of some extremely damaging diseases. We see no reason why the politics of vaccine trials and clinical use in apes could not be similarly negotiated with the state and local actors, as have the recent high-risk Ebola vaccine human trials (Mohammadi 2015). It is better that a sound evidence base, rather than fears of reprisal and reparations, drive responses.

Since local stakeholders may be affected as a result of an adverse event, we propose that they be consulted prior to the initiation of vaccine trials in apes. To do so:

> 'Building shared understandings of the epidemic and research strategies to help affected people and communities are critical to the success of research and access programs, making the involvement of civil society in [Ebola virus disease] research planning and implementation crucial' (Folayan and Haire 2015).

Moreover, obstacles to research need to be 'addressed with thoughtful coordination of research and clinical care plans as emergency response strategies are developed' (Thielman 2016). This may be a challenge for a number of reasons. Although we could find no evidence as such, we suspect that *non-clinical* research during natural disasters—for instance, research that focuses on ecological ramifications such as the welfare of animals—might be divisive because of the concurrent need to actively pursue an emergency humanitarian responses; the kinds of OH research we talk about might be seen to get in the way—a distraction, even an inappropriate activity—and it might be perceived as diverting attention and funding.

Osofsky et al. (2016) are then right in being concerned about the potential political ramifications of a vaccine's adverse effects in apes, but these are inherent in every intervention, human or animal, local or overseas, novel or old. Moreover, there have also been stark examples of resistance to, or failures of conservation because of political and socioeconomic instability, corruption, lack of funding and capacity, inadequate environmental protection policies, or lack of will to enforce and to follow law policies (Smith et al. 2003). In contrast, if the intervention is well negotiated and successful, the relevant local governments will be clear beneficiaries.

[5] Ghana Academy of Arts and Sciences Communique; 12 June 2015; Full narration of events leading up to the announcement of the Ebola vaccine trial in Ghana, see: Adebamowo et al. (2014).

Safety of Non-Target Species

Osofsky et al. (2016) refer to the intentional release of Genetically Modified Organisms (GMOs) under international treaties. The terms of these treaties reflect the trepidation of releasing foreign agents into complex ecosystems, and the implications of biosafety of the existing fauna and flora. These documented (horizontal and vertical gene transfer, persistence, and hybridisation) and unknown risks bring into sharp focus the tenets of the precautionary principle.

The precautionary principle has a long history in environmental policy—at least as far back as the United Nations 1992 Rio Declaration, which requires a positive obligation on states to invest in protecting the environment in spite of 'lack of full scientific certainty' as to whether degradation can be prevented (Principle 15) (Brownsword 2011). The principle has since tended to be used in a negative sense to forego scientific advances where there are uncertain or unknown consequences: threat of serious or irreversible damage ought to weigh heavily on any planned intervention in the environment. This is plausibly what Osofsky et al. mean—using a vaccine on endangered apes could add to their predicament in respect to side effects (which vaccines do come with) and other unknown consequences on a complex biome system. Yet, while the use of the precautionary principle is justified in many cases, its overuse may stall good science. The precautionary principle tends to create formidable reasons for doing one thing, despite evidence of good reasons for doing the contrary (Holm and Harris 1999). GMOs in particular have been caught in meeting the high demands of this impossibly evidence-weighted and scepticism driven debate.

Osofsky et al. then are right as far as the precautionary principle should be part of a reasonable deliberative process, but it should not substitute a careful consideration of the pros and cons associated with a specific intervention, such as medicine where lives might be saved if *something is done*. The principle should be reserved for cases whereby the potential risks are grave, and/or their likelihood is potentially high. Again, based on current data, vaccination of apes does not seem to fulfill either of the two (Capps and Lederman 2015).

'First Do No Harm' is a Foundation of Both Human and Veterinary Medicine

The principle of nonmaleficence has been a bedrock of clinical medicine since Beauchamp and Childress first iterated the Four Principles. The principle may extend to wild animals; in fact, anthroponoses (diseases transmitted from humans to animals) may be reason to have zero human-primate interactions. This would force suspension of many controllable points of contact (such as tourism), but also would face challenges from economic investments in mining and foresting where contact can occur. There are also the practices of locals, such as farming that clashes with protected areas, husbandry that potentially risks the health of wild animals, and of course hunting, which would have to be barred.

'First do no harm' is not to be found in statements of the veterinarian profession; if it is to be assumed to have relevance, then, as one example shows, it comes

second to the 'benefits of society'. As an author opined, animal welfare indicates that the welfare of animals is promoted only insofar as it conforms to the benefit of *human* society (Ani 2009). 'First do no harm' can only be stated in absolute terms, so, if we were strictly to abide by this maxim, no human medical testing or treatment would be possible either. Both medical and veterinary practitioners realise that any medical intervention carries risks, and the rational cannot possibly be that we should *above all* do no harm. Rather, the rational for interventions should be that the potential benefits can be balanced against the risks. Take human seasonal influenza vaccination for example—we know it comes with (minimal) risks, but still commonly see these as acceptable burdens in light of its great potential benefits (Salmon et al. 2013). Thus, since safety tests in captive apes have been promising, we posit that the risk of vaccinating wild apes against Ebolavirus is minimal, and in any case, it is likely outweighed by the potential benefits of resistance to a deadly virus.

So, even if the idea of 'do no harm' can be transposed to animals, one would have to show that doing nothing—a position clearly rejected by the medical profession's duty to treat patients—would bring about a better state of affairs not just for wild animals within conservation strategies that advocate non-contact, but also animal patients who might be effectively treated. In the next section we argue that a duty of non-interference is likewise implausible.

Should We be Vaccinating Wild Great Apes at All?

This question suggests two inferences:

a. Great Apes have evolved with Ebola and other diseases for millennia; therefore:
b. We should avoid intervening in (Great Ape) natural systems.

These may be perceived to follow logically. However, apes no longer reside in remote strongholds away from human interaction; even if some are inaccessible to tourists, they are likely to experience the impact of climate change and other remote anthropogenic effects. The evolution of pathogens in number and pathogenicity (which likely has a lot to do with the possibilities for contact and then spreading disease) are beyond previous epochs. Such is the pervasiveness of human action, it is claimed that we are entering the Anthropocene in which nature *is* a human project – our relationship to it has shifted to the ways in which the biosphere is controlled rather than just lived with (Purdy 2016). Conservation is an entirely valid response to overuse, degradation and irresponsibility towards ecosystems, but in many contexts if not all, it is unlikely that there is any longer an option to sit back and do nothing (as a conservation principle) in light of the damage we have already caused. It is unavoidable that we will have to confront these problems—the ever-more common emergence of zEIDs is but one example; these spillover events are likely driven by a complex interplay of interrelated factors of human migration, population growth, and increased demand for food, which push up against the wilderness (Wilcox et al. 2007). Ebolavirus and other pathogens are unlikely to be rare events, and potentially unremittent ones that great apes can no longer withstand (an 80 %

decline in their population suggest that this point has already been reached) because there are evermore opportunities for exposure to them. Simply put, the notion of 'pristine Nature' is no longer viable (Kaebnick 2014).

One of ProMED Mail's moderators appears to agree with Osofaky et al. A that vaccines for wild great apes are unethical; Pablo Beldomenico (Mod.PMB) writes:

> 'From the public health point of view, vaccinating great apes to reduce their role as an amplifying host (which is so far unknown) would be extremely costly and impracticable, because a large proportion of the population would need to be vaccinated. Besides, vaccinating the apes would prevent them from acting as sentinels of the disease.'[6]

What exactly, then, is Beldomenico's argument? Treating the short statement with due charity, we expand on the two claims.

That Vaccinating Great Apes Would be Too Difficult

Ryan and Walsh (2011) have already made the scientific case for vaccinating great apes—and argue that the logistics are not insurmountable. They do admit that administration would be a challenge, and offer some possibilities for a vaccination programme—including meeting the risks (which might be surmounted through pilot studies). Ryan and Walsh write that at least twenty-two vaccines used in humans are available for pathogens that are known to, or could potentially threaten wild apes. Many of these vaccine come with a great deal of pre-clinical evidence and clinical use (see below). Other programmes have been successful and cost effective, such as oral rabies vaccination in Europe and the USA. However, most of the recent population estimates of wild gorilla troops were made from using signs left behind such as sleeping platforms, scat, and eating spots, and not direct observations. This implies that physically getting access to a significant proportion of the populations, and enabling immunisation within idiosyncrasies of natural habitats, is going to be non-trivial. However, another paper talks about 'Self-disseminating' vaccines—using virus-based replicating vectors when EIDs are less well adapted to human infection. The authors bill this as 'high risk, high reward' science, using a 'window of opportunity' (when EIDs are potentially less well adapted to human infection) to immunologically target non-human species via 'founder' animals (Aisling et al. 2016). They talk of these opportunity ratios in respect to the public health benefits; that is benefits to humans and not necessarily to the animals vaccinated.

In any case, the habituated great apes would be the primary targets—those most likely to be in contact with contagious humans. Vaccination of more remote groups would be necessary, if, as is often the case of sudden emergent pathogens, its reservoir is a wild vector like the widespread bat species in the region. Viral transfer between habituated to non-habituated troops is plausible as well. However, many of the problems Beldomenico alludes to may be dissipated through technology and experiments. Importantly, if one was to be too precautionary, then these

[6] Published Date: 2016-04-18 16:54:06; Subject: PRO/AH/EDR> Ebola update (35): vaccine, comment Archive Number: 20160418.4167038; EBOLA UPDATE (35): VACCINE, COMMENT.

experiments (and trials) would never be done. At any rate, the challenge if one presses ahead with vaccination programmes—a plausible strategy given that vaccines are available and work in various primates (humans as well as non-human models)—would be adapting these strategies for different groupings such as habituated and more remote troops, and to different species (in different environments), such as orangutans (PLOS ONE Editors 2013).

Animals Serve Human Communities as Sentinels for Disease

Surveillance for pathogens has become an important factor in pandemic planning. Various global surveillance programmes have been more or less successful in detecting EID outbreaks. Specifically, the use of animals as sentinels for outbreak detection indeed has been useful in the past: but as a feasible strategy, it resonates somewhat like the antiquated 'canary in the mine' approach to responding to risks. More advanced surveillance implements targeting 'high-value' target wildlife species in 'hotspot' areas prone to EIDs using observation and sampling methods (Leendertza et al. 2006).[7] Perhaps the most pertinent example of a sentinel is the use of macaque monkeys for Yellow Fever detection that allowed the discovery of the Zika virus in the 50s (Dick et al. 1952). However, whether these efforts are effective is questionable. Despite many animals being part of current surveillance systems, Ebola, and before that, 'Swine' flu, were not spotted in time before spillover to human populations. In fact, EIDs tend *only* to be picked up once the disease has jumped into human populations.

Indeed, One Health suggests that a 'shared risk' approach to surveillance would entail looking at animal populations with an eye to their wellbeing, and creating conditions less likely for EIDs to spillover by addressing the health of animals as a *primary* function of pandemic planning (Rabinowitz et al. 2008). Thus, the idea that we should actively deny potential benefits to animals just to optimize surveillance is highly questionable. The analogy would be to deny rabies vaccination of stray dogs so they could be used as sentinels for disease outbreaks in human communities (and pick up the costs of such an approach in the public health systems). A 'shared risk' approach is supported by the understanding that humans and non-human animals may be susceptible to the same environmental risks, and that one may serve as a sentinel *for the other*. But one should remember that the ultimate goal of pandemic planning is not surveillance per se; rather, it is the prevention of zoonotic diseases. A 'shared benefits' approach then (which we proposed in our 2015 paper), with this in mind, relies on the idea that treating or preventing disease in animals may benefit humans and vice versa. If there is an option to prevent or cure disease, surveillance necessarily moves to the back seat.

Such a 'shared benefit' approach is not without precedent philosophical grounding, particularly in apes. The Great Ape Project has forcefully advocated for the inclusion of apes as members of a community of equals, together with humans (Cavalieri and Singer 1993). Several members of the Project argue for a

[7] Value here means visible species that respond early to emerging pathogens that risk human health. Great apes might be thought of as high value in a different—moral–sense.

duty of *equal consideration* towards apes. According to this duty, individuals should be treated similarly unless there are morally significant differences between them.[8] Other members demonstrated in their research that apes share most of humans' social and cognitive characteristics, specifically those commonly perceived to define us as humans.[9] Combining the ethical duty with these empirical data, the members of the Ape Project conclude that apes should be treated similarly to humans. Applying this conclusion to vaccination strategies, apes may permissibly be exposed to increased risk in research as long as it may benefit other humans and apes. This is not a utilitarian calculation, but an argument from parity: just as humans are commonly exposed to increased risk in research with the goal of benefiting other humans, so can apes be exposed to risk with the goal of benefiting other apes and humans. Importantly, and most controversially, the argument also entails that humans may be exposed to risk with the purpose of benefiting apes as well. If apes matter morally as 'persons', then human trials may be used to benefit their health as well.

A Viable Strategy

A OH strategy to Ebolavirus would look to finding shared benefits for humans and great apes. This in principle derives from the evidence base we already have, and applying that consistently across species. Existing Ebola vaccines were developed in part in primate models; these models were then used to justify trials in human populations. We argued that these human and captive primate trials should inform vaccination of great apes. Importantly, the animal trials could be done to benefit their relatives in the wild (and human trials would contribute to this). The source of apes for these captive trials would be contentious. With evermore chimpanzees being retired, one might have to turn to the sanctuaries where invasive research is no longer possible.

Our discussion here contributes to our original 2015 paper in the following:

1. Chimpanzee experiments are being phased out. Without these prior trials in captive populations the evidential bar would likely be insurmountable. However, we already accumulated a great deal of safety and effectiveness evidence from human population wide vaccinations to build a case for further primate vaccination programmes with established vaccines.
   Depending on their novelty, a great deal of human (and prior animal) data will be available on these vaccines. Although transposing that to animal patients would represent a potential leap, we often do not find reason to reject that same evidential chasm for our own species to benefit from the use of animal research.

[8] Hayry, H. & Hayry, M.: Who's Like Us? The Great Ape Project; Persson, I. (1993). A Basis for (Interspecies) Equality; Rachels, J.: Why Darwinians Should Support Equal Treatment for Other Great Apes; Rollin, B.: The Ascent of Apes- Broadening the Moral Community. All in: Cavalieri and Singer (1993).

[9] Fouts, R. S. & D. H. Fouts (1993). Chimpanzees' Use of Sign Language; Goodall, J. (1993). Chimpanzees- Bridging the Gap; Nishida, T. (1993). Chimpanzees Are Always New to Me. All in: Cavalieri and Singer (1993).

In current biomedical research, we already infer evidence from pre-clinical animal experiments to justify human clinical trials. We propose to reverse that inference. For that purpose, we would need to conceive of these 'animal experiments' as 'clinical trials' because of the different endpoints used in the former.

Walsh argues that survival of the species is more important to justify continued trials, which requires conceding that individual lives matter less. He proposes that 10–30 individual apes may be kept for the reason of providing an experimental base for interventions in their wild relatives.[10] The vaccine trials proposed would involve minimal risk and discomfort to the captive apes relative to the benefits of the entire species. This is the same logic that justifies the early phases of human trials—except there is no consent given by apes. However, while utilitarian type arguments might justify this, it is difficult to place the sacrifice of others when all lives matter equally. One might differently conceive of minimal risk as a justification to bring about distributive benefits for apes and humans. In this case, people and apes take on burdens for their genealogically related fellows. Importantly, the shared benefits approach creates concurrent benefits and risks for both humans and apes that justifies these burdens.

2. Concomitantly, one might require vaccination of tourists who come into contact with habituated great apes, but this may be limited given the general resistance to vaccinations in human programmes. The problem is one of distal concern: tourists and others are unlikely to recognise the risk they pose to the animals, and thus would be less willing to take on risks themselves for the animals' benefits. It would be a far easier task to make this a condition of such trips (bearing in mind that aggressive vaccination programmes have been talked about in other situations) rather than relying on convincing tourists to the benefits of vaccination (Adams et al. 2001) or relying on other coercive strategies (Palacios et al. 2011).[11] Vaccination would have to be expanded to other human groups—from indigenous communities to industries using the land (i.e. miners) who are likely to be found sharing space with non-habituated troops. Vaccination programmes for human communicable diseases are

[10] It is possible that these trials could be conducted 'humanely'—that is, vaccines trials in 'lower' animals could show safety and effectiveness (this raises another animal ethics question of course), and subsequently human *and* great ape trials conducted concurrently. These trials would likely be on prospectively non-consenting chimpanzees as the closest relative to ourselves currently used in research. Interestingly, there are cases of chimpanzees willingly taking part in minimally invasive research that may have minimal impact on their welfare—a vaccine injection might meet this criteria. But these animals are being increasingly retired, and the sanctuaries they go to may not provide the appropriate clinical trial facilities; therefore, it is argued that some may need to be kept captive in research institutions. Capps & Lederman maintained that there was an ethical case for these trials to be done—with conditions—so that there is a shared benefit across species (2015). For an illuminating discussion of these points involving Walsh and Jane Goodall, listen to the debate at around 15.40 min; RTE Radio 1, Mooney (episode 04/07/2014): 'Ebola in Africa Wiping out Chimps'. http://www.rte.ie/radio/utils/radioplayer/rteradioweb.html#!rii=b9_20610962_82_04-07-2014.

[11] Current measures include requirements to wear masks primarily to minimise respiratory infection transmission—with varying results.

sometimes required for employment; however, the moral case to vaccinate oneself to protect others may form the basis of a more effective strategy.

3. Vaccinating great apes would be strengthened with land management to minimise non-overseen contact with ape troops (i.e. outside of controlled tourist schemes), and to discourage high risk practices, e.g. activities that disrupt bat roosts or attract them to human communities. Consideration of ecology aspects would include adapting activities to the seasonal and environmental factors that seem to contribute or manifest Ebola spillovers. (Bausch and Schwarz 2014; Ng et al. 2014).
4. Importantly, expertise is already available in regions of high risk, including anthropologists, biologists, conservationists and ecologists who are not working within public health frameworks. They will have the local leverage with communities and knowledge to deliver such a programme.

The main challenges to this kind of a shared benefits approach is one of cost and logistics. These same limitations are present in public health responses, and the enlightened policy makers are addressing these head on through pandemic planning. Yet even here, there is only so much that can be done: zEID lurk as unknown threats for which preparation and resources for action are precarious. It is also well known that therapeutics are rarely brought to market effectively thus hampering expedient and fair access to human populations. The reasons for this, e.g. market disinterest leading to a lack of investment, raise particular challenges for an ape vaccine. In human vaccines, design and production are driven by commitment and mobilisation, but alone they do not get far unless, as has been known for some time, there are also communities willing to be vaccinated (Rifkin 1996). Vaccines also need materials and a manufacturer. All of these are in various ways deficient in EID responses, especially those that are focussed on neglected diseases (Graham 2016), and will likely also transpire as obstacles for many animal diseases too. Add to these, the limitations of a discredited patent strategy, and there is likely to be little investment for standalone animal programmes unless they piggyback on concurrent human therapies. Support in any case for such a programme is likely to only come from those knowledgeable of the struggles and the strategies to protect great apes, since the external politics are unsettled and public health priorities are too stretched. Investment must come from non-public health budgets as well. Therefore, this novel strategy requires conservationists to be onboard.

All of the aforementioned compounds an already existing trepidation on the part of conservationists. In many ways, this determines how much of a challenge we perceive interventions such as vaccination to be in general. Outbreaks of Rabies and Hendra viruses in humans and animals have been successfully controlled through the vaccination of animals, so the idea of vaccinating apes against Ebola in order to protect both apes and humans should at least be given serious consideration. We would therefore suggest that these challenges are to be met, not used to limit the vision of potential responses. In fact, our effectiveness to responding to zEIDs with pandemic potential is poor, and imaginative solutions are needed. Evaluating these proposals should include proper investigation of the possibilities without falling back on scepticism or trepidation. Even though caution is required, the objections

presented above do not withstand even a minimal ethical scrutiny and simply ignore previous successful vaccinations campaigns in apes and other animals.

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References

Adams, H., et al. (2001). Self-reported medical history survey of humans as a measure of health risk to the chimpanzees (Pan troglodytes schweinfurthii) of Kibale National Park, Uganda. *Oryx, 35*, 308–312.

Adebamowo, C., et al. (2014). Randomised controlled trials for ebola: Practical and ethical issues. *Lancet, 384*, 1423–1424.

Aisling, A., et al. (2016). Self-disseminating vaccines for emerging infectious diseases. *Expert Review of Vaccines, 15*, 31–39.

Ani, S. (2009). Animals as vulnerable subjects: beyond interest-convergence, hierarchy, and property. *Animal Law Review, 16*, 65–122.

Bausch, D., & Schwarz, L. (2014). Outbreak of ebola virus disease in Guinea: Where ecology meets economy. *PLoS Neglected Tropical Disease, 8*, e3056.

Breed, A., et al. (2010). Bats without borders: Long-distance movements and implications for disease risk management. *EcoHealth, 7*, 204–212.

Brownsword, R. (2011). Responsible regulation: Prudence, precaution and Stewardship. *Northern Ireland Legal Quarterly, 62*, 573–597.

Capps, B., & Lederman, Z. (2015). One Health, vaccines and ebola: The opportunities for shared benefits. *Journal of Agriculture and Environmental Ethics, 28*, 1011–1032.

Capps, B., et al. (2015). Introducing one health to the ethical debate about zoonotic diseases in South East Asia. *Bioethics, 29*, 588–596.

Cavalieri, P., & Singer, P. (Eds.) (1993). The Great Ape Project. New York: St. Martin's Griffin.

Dick, G., Kitchen, S., & Haddow, A. (1952). Zika virus (I) isolations and serological specificity. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 46*, 509–520.

Dowdle, W., & Birmingham, M. (1997). The biologic principles of poliovirus eradication. *Journal of Infectious Diseases, 175*(Suppl 1), S286–S292.

Folayan, M. & Haire, B. (2015). Ethical considerations in the conduct of research on therapies for the prevention and treatment of ebola virus disease in developing countries. *Pan African Medical Journal*, *22*(Suppl 1), 8

Graham, J. (2016). Ambiguous capture: Collaborative capitalism and the meningitis vaccine project. Medical anthropology: Cross-cultural studies in health and illness. http://dx.doi.org/10.1080/01459740.2016.1167055

Hastings, B., Kenny, D., Lowenstine, L., & Foster J. (1991). Mountain gorillas and measles: Ontogeny of a wildlife vaccination program. *Proceedings of the American Association of Zoo Veterinarians Annual Conference* (pp. 198–205).

Holm, S., & Harris, J. (1999). Precautionary principle stifles discovery. *Nature, 400*, 398.

Kaebnick, G. (2014). *Humans in nature. The world as we find it and the world as we create it*. Oxford: Oxford University Press.

Kelly, L., et al. (2014). Vaccinating captive chimpanzees to save wild chimpanzees. *PNAS, 111*, 8873–8876.

Leendertza, F., et al. (2006). Pathogens as drivers of population declines: The importance of systematic monitoring in great apes and other threatened mammals. *Infectious Disease and Mammalian Conservation, 131*, 325–337.

Lewis, D. (2016). Can great apes be vaccinated against ebola and other diseases? Smithsonian.com, April 12. http://www.smithsonianmag.com/smart-news/scientists-are-trying-vaccinate-great-apes-against-ebola-and-other-diseases-180958725/?no-ist.

Makanga, B., et al. (2016). Ape malaria transmission and potential for ape-to-human transfers in Africa. *PNAS*. doi:10.1073/pnas.1603008113.

Marzi, A., et al. (2016). Cytomegalovirus-based vaccine expressing ebola virus glycoprotein protects nonhuman primates from ebola virus infection. *Scientific Reports*. doi:10.1038/srep21674.
Mohammadi, D. (2015). Ebola vaccine trials back on track. *World Report, 385*, 214–215.
Ng, S., Basta, N. & Cowling, B. (2014). Association between temperature, humidity and ebolavirus disease outbreaks in Africa, 1976 to 2014. *Eurosurveillance*. doi:10.2807/1560-7917.ES2014.19.35.20892.
Osofsky, et al. (2016). Plan it for the apes: Sound Science must inform any plans to vaccinate gorillas or chimps against Ebola. LinkedIn: Pulse. https://www.linkedin.com/pulse/plan-apes-sound-science-must-inform-any-plans-gorillas-steve-osofsky.
Palacios, G., et al. (2011). Human metapneumovirus infection in wild mountain gorillas, Rwanda. *Emerging Infectious Diseases, 17*, 711–713.
PLOS ONE Editors. (2013). Expression of concern: Serological evidence of ebola virus infection in indonesian orangutans. *PLoS One, 8*, e60289.
Plumptre, A., et al. (2015). Status of grauer's gorilla and chimpanzees in eastern democratic republic of Congo: Historical and current distribution and abundance. Unpublished report to Arcus Foundation, USAID and US fish and wildlife service
Purdy, J. (2016). The new nature. Boston Review, January 11.
Rabinowitz, P., Odofin, L., & Dein, J. (2008). From "us vs. them" to "shared risk": can animals help link environmental factors to human health? *EcoHealth, 5*, 224–229.
Rifkin, S. (1996). Paradigms lost: Toward a new understanding of community participation in health programmes. *Acta Tropica, 61*, 79–92.
Ryan, S., & Walsh, P. (2011). Consequences of non-intervention for infectious disease in African great apes. *PLoS One, 6*, e290030.
Salmon, D., et al. (2013). Association between Guillain-Barre syndrome and influenza A (H1N1) 2009 monovalent inactivated vaccines in the USA: a meta-analysis. *Lancet, 381*, 1461–1468.
Scott, J., et al. (2016). Post-ebola syndrome, Sierra Leone. *Emerging Infectious Diseases, 22*, 641. doi:10.3201/eid2204.151302.
Smith, R., et al. (2003). Governance and loss of biodiversity. *Nature, 426*, 67–70.
Thielman, N. (2016). Ebola clinical trials: Five lessons learned and a way forward. *Clinical Trials, 13*, 83–86.
Wilcox, B., Gubler, D., & Pizer, H. (2007). Urbanization and the social ecology of emerging infectious diseases. In K. Mayer & H. Pizer (Eds.), *Social ecology of infectious diseases* (pp. 113–137). London: Academic Press.
Woodford, M., Butynski, T., & Karesh, W. (2002). Habituating the great apes: The disease risks. *Oryx, 36*, 153–160.