

Assessment of Health Risks Posed by Tourists Visiting Mountain Gorillas in Bwindi Impenetrable National Park, Uganda

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Abstract: The mountain gorilla, *Gorilla beringei beringei*, is listed by the International Union for Conservation of Nature (IUCN) as Endangered. About 1000 individuals remain in the wild, and the loss of even a single animal has implications for the viability of their two populations. Poaching, political instability and risk of anthrozoonotic disease transmission are potential threats to this species' recovery. Consequently, reducing the risk of infectious disease transmission by humans to the approximately 400 mountain gorillas of Bwindi Impenetrable National Park, Uganda, must be a priority for conservationists, tourists and the Uganda Wildlife Authority (UWA). Tourist revenue from gorilla trekking is significant and vital to the local communities and the UWA, and for the total gross revenue of Uganda. Data collected through a questionnaire survey (N = 136) and semi-structured interviews (N = 25) were used to (i) document tourists' self-reported health status, (ii) explore risk of disease transmission to gorillas, and (iii) assess tourists' reported willingness to wear disposable face masks during gorilla trekking. Results show that tourists pose a health risk to gorillas—contact and proximity to gorillas while trekking has increased compared to previous studies, and most respondents reported an average viewing distance of 5 m or less. Twenty-five percent of respondents indicated they might trek if sick, especially when symptoms were not severe and even when aware of regulations forbidding they do so. However, tourists are willing to adapt to new protocols, especially the use of face masks (51%). The introduction of face masks for tourists and guides during gorilla trekking is unlikely to reduce tourism revenue by reducing tourist numbers or reducing their willingness to pay. There is a need for improved access to information regarding potential risks of tourist-gorilla disease transmission in order to encourage responsible health-related behavior in tourists.

Key Words: Conservation, disease transmission, great apes, health, primates, veterinary medicine

Introduction

Bwindi Impenetrable National Park (BINP), Uganda, has approximately 400 of the world's 1,004 mountain gorillas (*Gorilla beringei beringei*), recently down-listed to Endangered on the International Union for Conservation of Nature (IUCN) Red List (Hickey *et al.* 2018a, 2018b). This extremely small population is susceptible to various anthropogenic threats, including disease, small-scale encroachment and deforestation, conflict from humans when ranging in community land, and civil unrest (Woodford *et al.* 2002; McNeilage *et al.* 2006; Plumptre *et al.* 2016). Disease, particularly respiratory illnesses, is a common cause of mortality in mountain gorillas, second only to trauma (Gilardi *et al.* 2015). Outbreaks of respiratory diseases are prevalent among gorilla families as well as the conservation personnel during the rainy season (Cranfield 2008).

Humans share more than 98% of genes with great apes, allowing for the transmission of many pathogens between them (Wallis and Lee 1999; Daszak *et al.* 2000; Hacia 2001; Gilardi *et al.* 2015). Disease transmission from habituated primates to humans (zoonotic) and from humans to primates (anthrozoonotic) has been documented since the 1960s. In 1966, a polio-like virus was recorded in a population of chimpanzees habituated for research at Gombe National Park (Goodall 1986; Kormos *et al.* 2003). Since then other chimpanzee and gorilla research and tourism sites have experienced the devastating impact that infectious diseases can have on small populations. Köndgen *et al.* (2008) found habituated chimpanzees in Taï National Park (Ivory Coast) dying after being infected by two common human paramyxoviruses, and Hanamura *et al.* (2008) reported that chimpanzees in the Mahale Mountains National Park (Tanzania) were dying from an influenza-like disease. Scabies (*Sarcoptes scabiei*),

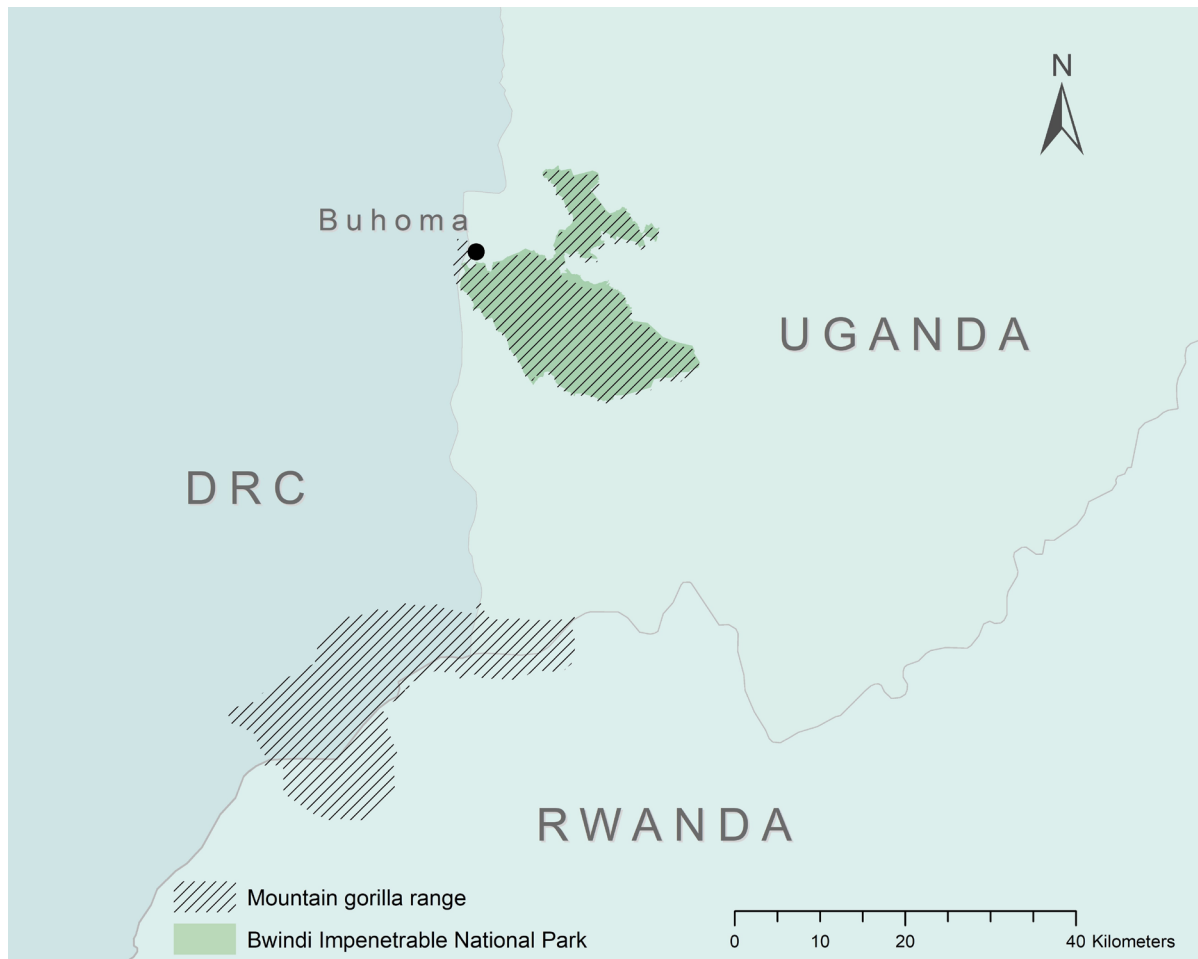


Figure 1. Location of the Bwindi Impenetrable National Park, Uganda, and the distribution of the mountain gorilla (*Gorilla gorilla beringei*). Map created using IUCN shape files (Plumptre *et al.* 2016).

intestinal parasites, yaws, various respiratory infections, and measles (suspected) are examples of infections recorded in great apes, all believed to be of human origin (Hastings *et al.* 1991; Kalema *et al.* 1998; Mudakikwa *et al.* 1998; Pusey 1998; Adams *et al.* 2001).

Over time, human and animal populations build immunities when exposed to pathogens and viruses, but there can be considerable morbidity and mortality when confronting new diseases or strains (Cranfield 2008). Between August and December 1996, scabies affected all members of a BINP gorilla group habituated for tourism. An infant was the most severely affected, dying before it could be treated (Kalema-Zikusoka *et al.* 2002). The source of the outbreak was traced to a local human community (Graczyk *et al.* 2001; G. Kalema-Zikusoka, pers. obs.). Two wild Rwandan mountain gorillas died of human metapneumovirus (HMPV) during a series of respiratory outbreaks in 2009 (Palacios *et al.* 2011). Post-mortem analysis of HMPV samples from the female and her infant exhibited a close relationship to South African human isolates, leading many experts to believe the outbreak source was a tourist (Palacios *et al.* 2011; G. Kalema-Zikusoka, pers. obs.).

Bwindi Impenetrable National Park is regarded as one of the most biologically diverse parks in Africa. It was gazetted

as a national park in 1991 with the Ugandan Parks Act of 1952, allowing for higher protection status against threats that would compromise the integrity of its forest (Castro and Nielsen 2003; Nolan *et al.* 2017). The park, of 32,092 ha, is located on the eastern edge of the Albertine Rift Valley sharing a border with the Democratic Republic of Congo (DRC). It has a wet and mild climate with a mean temperature range of 11–23°C with no dry season, and provides habitats ranging from 1160 to 2706 m above sea level (Nolan *et al.* 2017). Renowned as a biodiversity hotspot, the park contains more than 163 species of tree, 104 species of fern, 202 butterfly species, 350 species of bird and 120 mammal, including 11 primates (Butynski and Kalina 1993; Nolan *et al.* 2017; UNESCO 2017). It is home to many endangered and threatened species including the African green broadbill (*Pseudocalyptomena graueri*), Grauer's rush warbler (*Bradypterus graueri*), cream-banded swallowtail (*Papilio leuco-taenia*), African elephant (*Loxodonta Africana*), chimpanzee (*Pan troglodytes*), l'Hoest's monkey (*Allochrocebus lhoesti*), and the mountain gorilla (UNESCO 2017). Afromontane endemic species of the Rift Valley and almost half the world's population of mountain gorillas increase the conservation significance of the area (Butynski and Kalina 1993) and have resulted in BINP becoming a UNESCO World Heritage Site.

The park is surrounded by some of the highest and most steadily increasing human population densities in Africa, with 200–700 people/km², increasing the likelihood of contact between humans and gorillas (Plumptre *et al.* 2016; Nolan *et al.* 2017). The growing need for land fosters aggressive human encroachment, threatening the gorilla population and compromising conservation goals (Guerrera, *et al.* 2003; Plumptre *et al.* 2016; Nolan *et al.* 2017). Despite extensive and sustained management, and support from local and international non-governmental organizations (NGOs), gorillas remain vulnerable in this volatile region, and especially to disease transmission (Gilardi *et al.* 2015). Appropriate research and rigorous preventive measures need, therefore, to be implemented in Uganda to protect the existing population from disease transmission risks that exposure to increasing numbers of travelers might impose (Wallis and Lee 1999; Cranfield 2008; Macfie and Williamson 2010; Russon and Wallis 2014).

This study of the potential risk of anthrozoönotic disease transmission from humans to gorillas focuses on tourists visiting three groups of gorillas habituated for tourist-viewing (Habinyanja, Mubare, and Rushegura) in the northwestern region of BINP, Uganda. We investigated health risks that tourists potentially pose to the gorillas, the tourists' knowledge and their perceptions of disease risk to gorillas, and the tourists' responses to the proposal to implement enhanced disease-transmission prevention protocols (i.e. the use of face masks) at BINP.

Methods

Data were collected during a six-week period (May–June 2011) using a combination of questionnaires and semi-structured interviews. Our study took place near Buhoma village in BINP, Uganda (331 km²) (Fig. 1). Buhoma is located in Kanungu District, Kayonza Subcounty, Mukono Parish (0°58'0"S, 29°36'0"E). A questionnaire was used to gather demographic information that included nationality, mother tongue, residence, education level, income, and occupation. Additional questions included length of vacation, type of holiday accommodation, vaccination history, recent travel history, exposure to animals or wildlife prior to and following the visit, current illness symptoms, willingness to wear extra protective attire, and access to pre-departure education. The questionnaire was piloted prior to beginning data collection to identify potential biases or ambiguity within questions. Tourists were invited to participate in the study while they waited at the UWA briefing point for their gorilla trekking certificates. Only adults over the age of 18 were included. A total of 136 completed questionnaires were returned. Sample size was $N = 136$ unless otherwise indicated.

We used semi-structured interviews (SSIs) to explore tourist knowledge of potential disease transmission risks between humans and apes, reflections on gorilla trekking experience, and the interviewees' potential willingness to adopt further measures to reduce risk of disease transmission

during trekking. Interviews were piloted at the start of the study with eight participants and were subsequently refined. We completed a maximum of two interviews for each tourist, either at the briefing point following a trek, or scheduled for a later time at the tourist's lodge. The interviews were recorded using a tape recorder and/or video recorder with the permission of the interviewee. Twenty-five SSIs were completed, conducted by AH. Because questionnaires were completed anonymously, it was not possible to link an individual's questionnaire responses to their interview responses (not all participants completed both).

Quantitative data were coded and analyzed using SPSS (version 25.0). Kolmogorov-Smirnov tests revealed data were not normally distributed and so non-parametric tests were applied. Descriptive statistics were run on all questionnaire data, including the mean and median ages of participants. Pearson's chi-square and Fisher exact tests were used to compare categorical data (Kranzler 2007). Statistical *p*-values were considered significant at $p < 0.05$. For length of stay of tourists, we used the median instead of the mean because one tourist stated that their vacation was one year, skewing the mean from 18 days to 25.9 days. Interview data stood alone from questionnaire data, but complimented questionnaire material.

Ethics clearance was granted by Oxford Brookes University Research Ethics Committee prior to commencing data collection. Permission to conduct this research was granted by UWA, the Uganda National Council for Science and Technology, and the President's office of Uganda.

Results

Tourist profiles – who goes gorilla trekking?

One hundred and thirty-six tourists completed questionnaires; 27% completed them before embarking on a gorilla trek and 73% upon returning from their trekking experience. Forty-five percent of respondents were male and 55% female, with ages ranging from 18–83 years (median = 41). The majority of people sampled were nationals of developed countries, residing in North America and Europe: approximately 59% were from North America and the United Kingdom. Just over 4% were African (South African) ($n = 6$), and 1.5% were from developing countries outside of Africa ($n = 2$). Only 2.2% ($n = 3$) resided in Uganda.

All tourists stated that they had completed secondary education, with 87.5% having completed some form of tertiary education. More than 56 different occupations were recorded across the sample; 24.3% health-related and 66.9% non-health related; 11.8% of respondents were retired, some of the retired respondents stated their previous occupation.

To understand the risk tourists might pose to gorillas during trekking, we examined (i) visitor self-declared vaccination and health status, (ii) travel behavior and degree of contact with animals prior to arrival at BINP, (iii) tourist knowledge of trekking regulations and risks of disease transmission, and (iv) the tourists' likely willingness to accept measures to

Table 1. Self-reported vaccination status of tourists at BINP, Uganda. Informants were asked to give the most recent date they had received each vaccination. Values shown in percentages (N=136).

Vaccine	Vaccination status – vaccinated	Vaccination status – not vaccinated	Unsure of vaccination status	Vaccination date provided
Yellow fever ^{1a}	96.3	2.2	0.7	38.2
Influenza ^{ab}	54.4	35.3	5.9	44.6
Tetanus ^a	92.6	5.1	0.7	35.7
Measles, mumps, rubella ^a	81.6	11.8	5.1	27.0
Polio ^a	87.5	6.6	3.7	32.8
Chickenpox ^{2ab}	68.4	18.4	6.6	28.0
Meningitis C ^a	52.9	28.7	10.3	25.0
Hepatitis A ^a	90.4	3.7	4.4	35.0
Hepatitis B ^{ab}	90.4	3.7	2.9	33.3
Typhoid	77.9	11.8	5.9	32.1
Tuberculosis ^b	62.5	25.7	6.6	30.6
Rabies	28.7	59.6	6.6	12.5

¹ Only mandatory vaccine required to enter Uganda.

² Includes chickenpox vaccine and participant having had illness.

^a Recommended adult immunizations by the Centers for Disease Control and Prevention (CDC 2017).

^b Vaccinations available to adults in certain 'at risk' groups by the National Health Service (NHS), United Kingdom. There are no vaccinations routinely offered to adults (NHS 2017).

Table 2. Percentage of tourists who report experiencing symptoms of infectious disease during the month prior to, or at the time of, gorilla trekking at BINP, Uganda. (N=136).

Reported symptoms	Within month prior to going trekking (%)	Current at time of trek (%)
Cough	16.9	1.5
Sore throat	11.0	0.7
Congestion	9.6	2.2
Fever	2.9	0.7
Vomiting	3.7	0.7
Diarrhoea	19.1	5.9
Other	2.2	2.9

reduce risks of disease transmission to gorillas during trekking. Infectious diseases of particular interest to this study included influenza A and B, because of their known capacity to infect great apes (Buitendijk *et al.* 2014). The standard health recommendations for travelling to Uganda are yellow fever vaccination and malaria prophylaxis (FCO 2017).

Self-declared tourist health status

Just over half the sample (54.4%) reported they were covered by an up-to-date influenza vaccination (N = 136); however, less than 50% of those people were able to recall the date they received the vaccine (Table 1). Similarly, although the majority of visitors reported up-to-date vaccination status for key infectious diseases (Measles, Mumps and Rubella – MMR; Polio; Chickenpox and Tuberculosis), relatively few of them could give further information about when they had been vaccinated. Contrary to what might be expected, tourists with health-related occupations were no more likely to report having been vaccinated against influenza ($\chi^2 = 6.410$, $df = 4$, $p = 0.171$), or any other infectious diseases, than were those in non-health related occupations.

There were no significant differences associated with tourist vaccination status and their income ($\chi^2 = 25.590$, $df = 24$, $p = 0.374$). When looking at place of residence, however, North American nationals were more likely to report having an up-to-date influenza vaccination than were UK nationals (Fisher exact test, $p = 0.025$, $N = 58$).

A higher number of tourists reported having experienced symptoms indicative of possible respiratory or gastrointestinal infections in the month prior to trekking ($n = 49$) than at the time of trekking ($n = 8$); diarrhoea was the symptom most frequently cited amongst both groups (Table 2).

Tourist travel behavior prior to arrival at BINP and after visiting BINP

The median number of different countries visited by tourists within the previous 12 months was five (range 0–53, $N = 136$). Seventy-two percent of these countries are categorized as developing countries (World Bank 2017). The length of stay in Uganda reported by respondents ranged from 3–365 days with a median of 18 days of travel for their vacation ($N = 136$).

The majority (91.2%) of respondents claimed to have been within 10 m of domestic or wild animals during the month prior to their gorilla trek ($N = 136$). More than 55 different types of animals were listed, and nearly 40% of respondents specifically mentioned they were within 10 m of nonhuman primates (great apes, monkeys and prosimians) at other sites within the previous month; 30 people (22.1%) reportedly had been within 10 m of gorillas within the past month. Just over 20% of tourists stated they were intending to view other nonhuman primates after their visit to BINP ($n = 29$), with nearly 12% of those indicating they would be visiting sites where there were opportunities to view gorillas

or chimpanzees ($n = 16$). There was a significant association between having already been in proximity to primates during the month prior to gorilla trekking and experiencing diarrhoea ($\chi^2 = 10.816$, $df = 1$, $p = 0.001$), symptoms of gastrointestinal infection ($\chi^2 = 8.817$, $df = 1$, $p = 0.01$), symptoms of upper respiratory infection ($\chi^2 = 5.402$, $df = 1$, $p < 0.05$) or multiple symptoms consistent with minor infections ($\chi^2 = 3.950$, $df = 1$, $p < 0.05$) during this same period. However, there was no evidence that such people were more likely to report experiencing disease symptoms at the time of their gorilla trek at BINP as compared with the rest of the sample ($\chi^2 = 2.687$, $df = 1$, $p = 0.101$). There was no significant relationship between whether people who had already trekked gorillas within the month prior to visiting BINP were as likely to trek when sick as those who had not previously visited the gorillas (Fisher exact test: ns, $N = 128$).

Tourist knowledge of trekking regulations and disease transmission risks

The majority of tourists completing the questionnaire (87.5%) indicated they knew about the UWA regulation that people should not trek gorillas if unwell ($N = 136$), with nearly 64% indicating they would be willing to observe this regulation. Approximately 25% ($n = 32$) of respondents indicated they might, or definitely would, trek if sick, even though they were aware of the regulation forbidding this action (Fig. 2). More detailed/nuanced information from SSIs highlights the fact that not all individuals necessarily understand why such regulations are in place, as illustrated by the following comment recorded during an interview: “I think if I was just told gorillas have died from human disease transmission, I would not think twice about going sick. I would never want to hurt the gorillas, but I did not know about this.”

Several informants stated they would like to think they would not trek gorillas if unwell, but qualified this by saying they would probably still trek if their symptoms were not

severe. Eleven out of 25 interviewees indicated they either would, or might, still trek when unwell. For example, one interviewee reported they and their partner had just returned from trekking while experiencing symptoms of congestion they thought were due to either an ‘allergy or sinus infection’. Another interviewee said they would trek while sick and “would try and hide it as much as possible”. A third stated “I would trek sick, but only if I was a bit sick, and I would make sure not to come too close to the gorillas or let them touch me”, suggesting they had at least some degree of awareness of the potential risks to the gorillas of such actions.

Interviewees indicated the lack of a full refund (currently people get a 50% refund if they are unable to trek because of illness), and the money spent on transportation and accommodation to get to BINP, would very likely influence their decision whether or not to go gorilla trekking when experiencing signs of infection. In reference to trekking while ill, a tourist wrote “I would like to think I would not go, but I had been looking forward to seeing gorillas for two to three months and if I was going to lose out on 500 USD, well maybe.”

How and when are tourists exposed to information about disease risks to gorillas?

Sixty-four percent of questionnaire respondents reported they had received some information about gorillas and trekking protocols before their trek ($n = 87$). Approximately 65% of these respondents ($n = 57$) provided no details of the information they received; of the remaining 49 respondents, 63% reported they were told not to trek gorillas if they were unwell ($n = 31$), and 67% were given information about how to behave with the gorillas ($n = 33$). Tourists appeared to obtain any information they receive mainly from the park headquarters ($n = 35$) or their travel agents/tour operators ($n = 14$). Sample size was too small to determine whether there is a relationship between the type of information people received and the source of that information. However, these

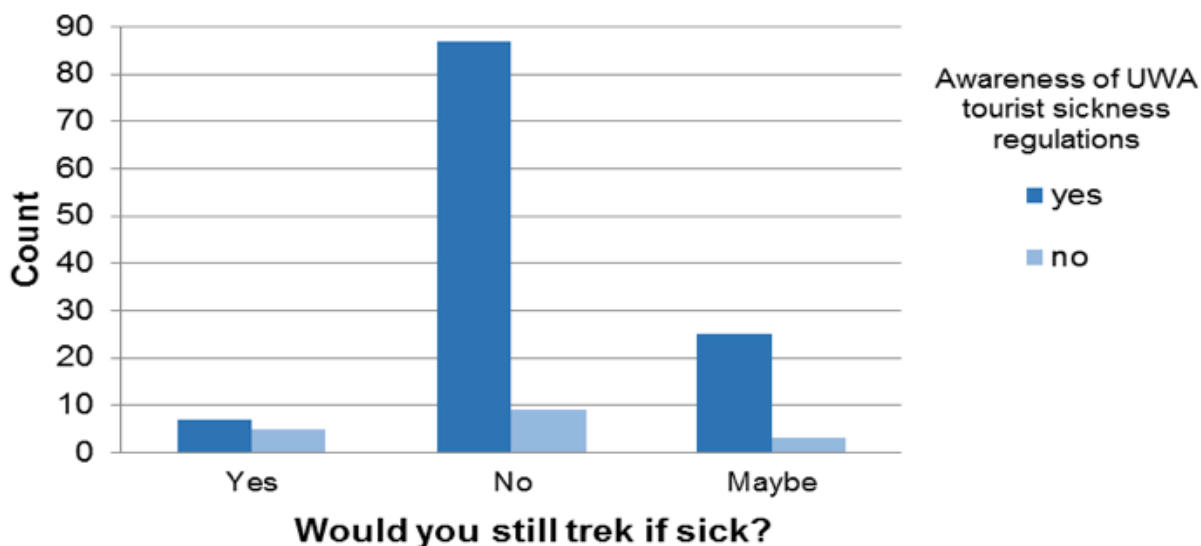


Figure 2. Tourists’ awareness of UWA regulations about not trekking gorillas when experiencing symptoms of ill health and whether they would trek when unwell ($\chi^2=10.272$, $df=2$, $p=0.006$, $N=136$).

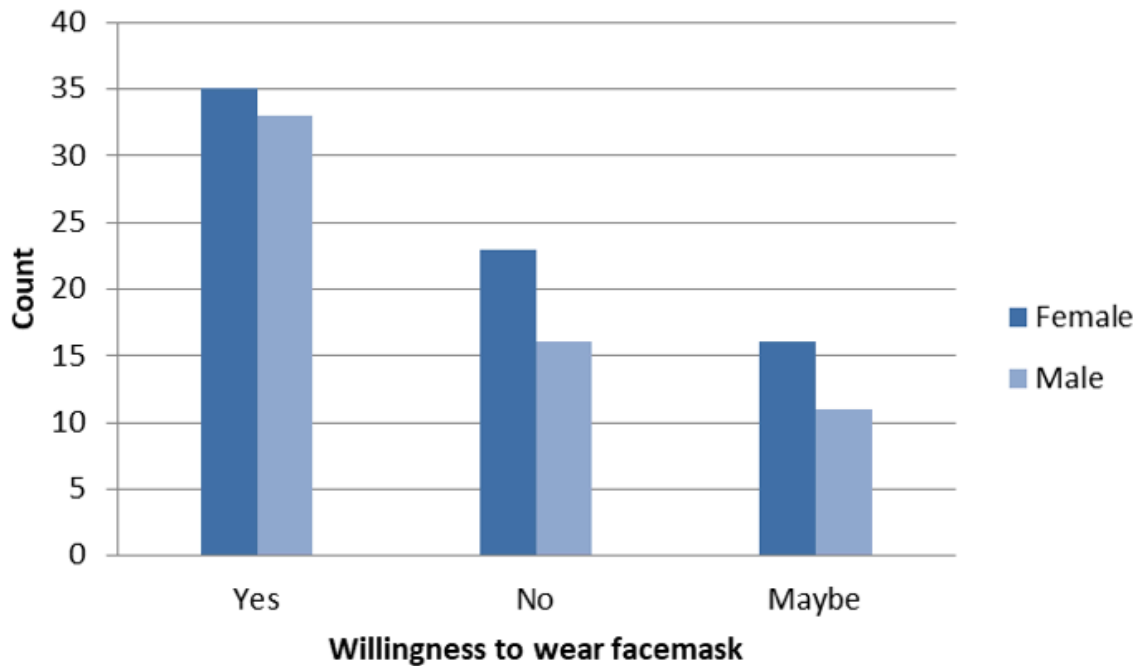


Figure 2. Tourists' awareness of UWA regulations about not trekking gorillas when experiencing symptoms of ill health and whether they would trek when unwell ($\chi^2=10.272$, $df=2$, $p=0.006$, $N=136$).

results highlight some possible concerns: many visitors did not arrive early enough to watch the pre-trekking educational video (A. Hanes, pers. obs.), and not all visitors received adequate information prior to trekking.

Visitor and gorilla proximity during trekking

During the SSIs, people were asked how close they came to gorillas during their viewing. Only 2 of 25 interviewees stated that the regulatory 7-m distance was maintained. Most people estimated they would approach to a viewing point of about 5 m from the animals, and as the viewing continued sometimes the gap would lessen. Five people reported that they had had physical contact with a gorilla, including incidents when subadult and juvenile gorillas held onto or chewed their trousers for 10 seconds or more. According to interviewees, the average closest distance the gorillas came to a visitor was just over 2 m. There was no evidence that either men or women were more likely to be touched by the animals.

Tourists' willingness to wearing protective attire when gorilla trekking

The majority of tourists stated that they were willing to wear protective attire, specifically, face masks, during a trek, in order to reduce potential disease transmission risks to gorillas (Fig. 3). Men and women were equally likely to indicate a general willingness to wear face masks ($\chi^2 = 0.869$, $df = 2$, $p > 0.05$, $N = 135$). There was no significant difference in willingness to wear protective attire during trekking between tourists who indicated they would trek if sick and those who would not (Fisher exact test, $p > 0.05$, $N = 135$), confirming that those exhibiting possible symptoms of an infectious disease are no more willing than anyone else to adopt protective attire to reduce risks to the gorillas. However, during the SSIs,

those who indicated they did not want to wear face masks said it would not stop them from coming to view the gorillas if it became mandatory.

Discussion

Tourists' underlying health status and travel behavior as predictors of disease risk

As a consequence of their travel patterns and behavior, tourists pose health risks to mountain gorillas (Muehlenbein *et al.* 2010). The average duration of tourist visits was short, visiting Uganda for only 2–3 days. Brief visits are particularly problematic because (i) this is too short a period for incubating infections to become symptomatic, yet the host could still be shedding the pathogen (Muehlenbein and Ancrenaz 2009; Gilardi *et al.* 2015); (ii) many symptoms of illness can be confused with jetlag (Waterhouse *et al.* 1997); (iii) the stress of travel and higher exposure to novel pathogens makes tourists more susceptible to infectious disease compared with other groups of people, providing yet more opportunities for the spread of infections (Adams *et al.* 2001).

Tourists exhibited poor vaccination recall, as has been reported by a similar study in Asia (Muehlenbein *et al.* 2008). Poor responses to questions about vaccination may be because respondents have poor personal health knowledge, do not care, or are careless in their completion of the questionnaire. While it is reasonable to assume tourists generally have a good standard of health, the majority reside in temperate regions that harbor various strains of influenza, and they travel frequently into disease-rife regions of the world (Muehlenbein *et al.* 2008). This, combined with the fact that many also had contact with other non-human primates a month or less prior to trekking and the degree of phylogenetic relatedness

between humans and gorillas, further increases the potential risk for disease transmission from tourists to gorillas (Woodford *et al.* 2002). An organism that is mildly virulent in its host can be life threatening in another species (Wallis and Lee 1999). Furthermore, the limited genetic pool of gorillas may also impact gorilla immune systems, making them even more susceptible to diseases (Luquet *et al.* 2012). Consequently, a mild influenza strain from North America could jeopardize the gorilla population in BINP (*ibid.*), making influenza a particular concern to staff and veterinarians in gorilla range countries (CTPH 2017). It is, therefore, advisable that all people visiting gorillas have up to date influenza cover.

Tourist and gorilla behavior during trekking as predictors of disease risk

Interview results indicate that at least two tourists trekked gorillas while exhibiting symptoms consistent with either a respiratory infection or an allergic response. Worryingly, approximately a quarter of visitors completing questionnaires stated they would, or might, trek when unwell. However, official annual tourist reports of illness were, and continue to be, low. Between September 2008 and February 2011, UWA documented cases of self-reported diarrhoea (12), vomiting (4), cough (1), and symptoms consistent with influenza (2) (G. Balyesiima, pers. comm.). Most of the symptoms reported were diarrhoea and vomiting, obvious symptoms that might be difficult to conceal. While these may appear more severe/unpleasant to the person experiencing them than a cough or cold, airborne respiratory infections are more readily transmissible than are direct contact pathogens in feces or vomit (Roy and Milton 2004). Some pathogens, like Respiratory Syncytial Virus Infection (RSV), can remain infectious via droplets and fomites for up to 12 hours. RSV is the leading cause of serious upper and lower respiratory tract infection in human children in the United States (Black 2003). During a tourist trek, close interactions between tourists and younger, more curious, gorillas occurred. Gorilla juveniles would touch shoes, boots and bottoms of trousers where viruses can temporarily survive. Our results suggest that previous exposure to gorillas at other sites does not necessarily instill a more responsible attitude towards gorilla health and wellbeing among tourists, as people who had already trekked gorillas within the month prior to visiting BINP were as likely to trek when sick as those who had not previously visited the gorillas.

Our results suggest that tourists and gorillas are frequently less than the recommended 7 m apart during trekking events, as has been reported previously from this site (Sandbrook and Semple 2006; Hanes 2012). This is disappointing given the number of studies/publications making strong recommendations that maintaining a distance of 7 m between visitors and gorillas is important to minimize risk of disease transmission (*ibid.*). What is yet more concerning is the fact that participants in this study reported at least five occasions when tourists and gorillas were in direct physical contact.

It is hard to predict gorilla behavior, especially that of young animals. Additionally, some groups have more than 20 animals for guides to monitor, making it imperative that a distance of at least 7 m between tourists and animals be maintained at all times. The 7-m distance provides guides and tourists time to react and move away slowly when gorillas are approaching. It also reduces overhabituation (Macfie and Williamson 2010; Strier 2010), which is important given the proximity of these animals to local villages and farming areas (Hockings and Humle 2009).

Tourist knowledge of regulations, risks of disease transmission and willingness to wear protective attire

Tourists had basic knowledge of disease transmission risks. Most people indicated they were willing to adopt protocols to help protect gorillas against the risks of disease transmission, including the use of face masks. However, tourists who participated in the questionnaire survey appeared less willing to wear protective attire than those who participated in SSIs. This apparent difference may be more a reflection of the fact that some people, during face-to-face interviews, felt inhibited expressing discontent about, or unwillingness to, adopt protective attire as compared with those completing the questionnaire anonymously. Alternatively, perhaps because interview participants had the opportunity to handle and try on face masks, they were able to give a better-informed answer to this particular question. However, most tourists are, reportedly, willing to take extra precautions to prevent disease transmission.

Face masks have been compulsory for tourists trekking gorillas in the DRC since May 2009, and, according to the field veterinarian of the Congolese Wildlife Authority – Institute Congolais de Conservation de la Nature (ICCN), they are accepted without problems by tourists (A. Kalonji, pers. comm.). The *IUCN Best Practice Guidelines for Health Monitoring and Disease Control in Great Ape Populations* recommends surgical face masks because they decrease aerosolized diffusion of potential pathogens from the wearer—droplets, for example, exhaled by the wearer when sneezing (Gilardi *et al.* 2015). Face masks worn by veterinarians, trackers, and researchers in Uganda and Rwanda, as well as, tourists in the DRC, have not disturbed gorillas behaviorally (Gilardi *et al.* 2015; A. Kalonji, pers. comm.; J. Ramer, pers. comm.). Our results support the idea that tourists would willingly adopt new protocols in BINP if they were properly informed of the benefits of doing so. Consequently, given the successful introduction of compulsory face masks when trekking gorillas in the DRC, we anticipate that compulsory use of face masks is unlikely to have a significant negative effect on tourist numbers, or tourist experience, in Uganda if/when it is implemented.

In addition, thorough hand-washing before a trek is an effective and practical precaution to disease transmission (Doebbeling 1988), and should be encouraged/required immediately prior to departure on the trek.

The need for better information for tourists prior to trekking gorillas

The information tourists received at BINP at the time of this study was inadequate and has still not been revised or updated (G. Kalema-Zikusoka, pers. obs.). Not all tourists were aware of the potential risks to gorilla health and/or why it is required to maintain a minimum distance of 7 m between tourists and gorillas. Some tourists assumed this requirement was solely to ensure their safety rather than to reduce the risk of disease transmission.

Tourists are provided with a briefing talk before beginning their trek. This occurs at the entrance of the park/UWA briefing point and comprises a talk and/or opportunity to watch an informational film. Unfortunately, the information provided about gorilla biology and behavior, or the risks of disease transmission, appears to be inadequate, and the film includes footage of visitors closer than 7 m from the gorillas. Additionally, not all tourists observed in this study had the opportunity to watch the film prior to embarking on their trek, and those that did, were highly critical of its content.

This could be addressed in several ways, including (i) improving the quality of the information provided at the embarkation point, immediately prior to setting out on a trek; (ii) ensuring that all tourists arrive at the departure point in plenty of time to view the film and ask the guides any additional questions about the film content prior to departure; (iii) ensuring detailed information about disease transmission risks to gorillas is available through all booking opportunities for gorilla trekking (UWA, tour operators and booking agents) in and outside of Uganda, including all official travel health sites. Additionally, all gorilla trekking information should strongly recommend tourists are covered by an up to date influenza vaccination. This information should be posted on the Uganda High Commission and UWA websites and all relevant sites, including tourist origin country health sites such as the Centers for Disease Control and Prevention (CDC – US) and the National Health Service (NHS – UK) to ensure that healthcare employees (for example, doctors, travel nurses) and the general public are fully informed of the importance of minimizing risk of cross-species disease transmission in wildlife tourism (Muehlenbein *et al.* 2008).

Conclusions/Recommendations

To reduce the risk of human-gorilla disease transmission requires a two-pronged approach to (i) reduce the immediate opportunities for disease transmission by introducing certain biosecurity protocols, and (ii) improving visitor compliance with existing regulations and recommendations through improved education, making the linkages between visitor behavior, risk of disease transmission, and potential implications for gorilla population health and conservation. To achieve the first, we suggest the following:

- For international visitors an up-to-date influenza vaccination should be mandatory; supporting documentation confirming vaccination status from a recognized source

should be requested at the UWA park entrance during tourist registration.

- Disinfectant footbaths (i.e., chlorhexidine disinfectant or bleach) are provided at the point of embarkation for the trek, and all tourists and guides required to use them, to reduce pathogen transmission risks, particularly where tourists have previously trekked wildlife at another site.

- Adequate hand-washing facilities are provided at the point of embarkation for the trek, including clean running water and antibacterial soap to avoid spreading pathogens (CDC 2017). All tourists, guides and porters should be required to wash their hands prior to setting out, and guides should demonstrate proper hand washing techniques, including the application of hand sanitizer.

- All people involved in gorilla trekking (tourists, guides and porters) be required to complete a health declaration form just prior to trekking. Having to oversee the completion of these forms at this point will remind staff to ask tourists about their health.

- All tourists and guides should be required to wear a properly fitted surgical mask during the one-hour viewing with the gorillas. The masks should be given to tourists by the guides at the moment when the tourists separate from the porters, close to the gorillas. All masks must be collected by the guide immediately after the gorilla viewing, to be counted and to ensure none remain in the forest where gorillas might find them, and returned to the UWA headquarters briefing point for appropriate disposal.

- The current policy of refunding 50% of the trekking fee on cancellation due to ill health should be revised to offer tourists larger refunds in such cases, as well as an opportunity to reschedule, providing greater incentive for tourists to comply with this regulation.

Secondly, current trekking regulations need to be enforced more effectively, ensuring that tourists and guides do not trek when experiencing any signs of ill health, and that tourists and guides maintain a minimum distance of 7 m from the animals. To facilitate this, we recommend the following.

- A priority would be the development of a new film to provide tourists with clear, concise information on (i) trekking regulations and why it is important they comply with them to safeguard both the health of the gorillas and tourists, (ii) about how they should behave during the trek to ensure their own safety and the wellbeing of the gorillas, and (iii) to provide up-to-date basic information about gorilla behavior, biology and conservation status and threats, including the risk of disease transmission to the gorilla population.

- Lodge owners/tour operators should be required to deliver tourists to the briefing point at least one hour prior to the trek departure to ensure there is adequate time available for everyone to watch the mandatory film before trekking.

- Further, clear guidance should be made readily available to lodge and UWA staff and tourists about what constitutes being ‘sick’, distinguishing the difference between an allergy and contagious viral symptoms.

- Information from the *IUCN Best Practice Guidelines to Great Ape Tourism* and the document itself should be available for consultation at the briefing point and lodges for tourists to read. This information and the new film should also be provided on UWA websites with links to the PDFs and included in tour guide packets which would be made available to tourists at the point of booking a gorilla trek, whether the booking is made in Uganda or outside.

- Guides and trackers should be provided with regular opportunities to update their knowledge of gorilla behavior, biology, and trekking protocols. This will enable them to provide an excellent and up-to-date gorilla viewing experience for tourists.

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