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Preventing zoonotic and zoonanthroponotic disease transmission at wild great ape sites: Recommendations from qualitative research at Bwindi Impenetrable National Park

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1 Preventing zoonotic and zoonanthroponotic disease transmission at wild great ape  
2 sites: Recommendations from qualitative research at Bwindi Impenetrable National  
3 Park

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## 28 **Abstract**

29 Employees at wild great ape sites are at high risk of transmitting infectious diseases to  
30 endangered great apes. Because of the significant amount of time employees spend near great  
31 apes, they are a priority population for the prevention and treatment of zoonotic and  
32 zoonoanthroponotic spillover and need adequate preventive and curative healthcare. Qualitative,  
33 semi-structured interviews with 46 staff (rangers and porters) at Bwindi Impenetrable National  
34 Park, Uganda (BINP) and key informants from five other wild great ape sites around the world  
35 were performed. The objectives of the study were to 1) evaluate health-seeking behavior and  
36 health resources used by staff in contact with great apes at Bwindi Impenetrable National Park; 2)  
37 evaluate existing occupational health programs for employees working with great apes in other  
38 parts of the world; and 3) make recommendations for improvement of occupational health at  
39 BINP. Results show that BINP employees do not frequently access preventive healthcare  
40 measures, nor do they have easy access to diagnostic testing for infectious diseases of spillover  
41 concern. Recommendations include assigning a dedicated healthcare provider for great ape site  
42 staff, providing free annual physical exams, and stocking rapid malaria tests and deworming  
43 medication in first aid kits at each site.

44

45 **Keywords:** zoonoses; zoonoanthroponoses; great apes; occupational health; qualitative research;

46 One Health

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## 52 **Introduction**

53 Transmission of infectious pathogens among nonhuman primates, humans and domestic  
54 livestock poses a significant threat to human and domestic animal health and the sustainability of  
55 wildlife (1). This potential transmission is a key element of the One Health approach, which  
56 recognizes and emphasizes the interdependence of human, animal and environmental health, and  
57 postulates that the health of all must be addressed to achieve full ecosystem health (2). The risk  
58 of human infectious disease crossing over to animals (zooanthroponotic transmission), and  
59 animal infectious disease being transmitted to humans (zoonotic transmission) is particularly  
60 high for great apes, because of the genetic similarity between humans and great apes (3).

61

62 Gorillas and other great ape species are susceptible to human pathogens, including respiratory  
63 infections such as measles, human respiratory syncytial virus and human metapneumovirus,  
64 which often cause high morbidity and mortality (4–6). Parasitic infections can also be shared  
65 between humans and nonhuman primates including *Plasmodium* spp., *Mycobacterium*  
66 *tuberculosis*, *Giardia duodenalis* and *Cryptosporidium* spp. (7). Human-origin scabies has been  
67 documented in mountain gorillas (8).

68

69 Disease outbreaks can be devastating to endangered species. One study that used data from  
70 sixteen previous studies on outbreaks among great apes in East and West Africa predicted that

71 recovery time for a gorilla population (time taken for a population to reach initial size again) for  
72 a low-mortality (4%) infectious disease outbreak was 5 years. That of a high-mortality infectious  
73 disease outbreak, such as Ebola (96% mortality), would be 131 years (9). The risk of infectious  
74 disease to gorilla populations is increasing as habituation to tourism and increasing human  
75 populations around their habitats rise. The risk of great apes transmitting pathogens to human  
76 populations is also present. The most pertinent example is human immunodeficiency virus,  
77 which is thought to have originated from an interaction between a human and a wild chimpanzee  
78 in Cameroon during the early 20<sup>th</sup> century (10).

79

80 Mountain gorillas (*Gorilla beringei beringei*), an endangered nonhuman primate species, are  
81 threatened by habitat loss, military and rebel activity, and human pathogens. The last remaining  
82 populations survive in Virunga National Park in the Democratic Republic of the Congo,  
83 Volcanoes National Park in Rwanda, and Mgahinga Gorilla National Park and Bwindi  
84 Impenetrable National Park (BINP) in Uganda (11). BINP is a popular tourist destination for  
85 mountain gorilla viewing and tracking. The park attracted 36,341 tourists in 2019 (12) and it  
86 currently employs ~600 staff including rangers, porters and security personnel. ‘Rangers’ in this  
87 paper will be used to refer to full-time staff employed by the Uganda Wildlife Authority (UWA)  
88 who work in the forest. UWA is the branch of government responsible for the management of  
89 national parks. The term encompasses staff who specialize as guides, security personnel and  
90 trackers, as well as those who do not. It does not include porters, as they are not formally  
91 employed by UWA. The areas around BINP are some of the most densely populated in rural  
92 Africa, with over 350 people per square kilometer (13). Park rangers and porters frequently  
93 interact with gorillas through guiding, tracking, and monitoring activities. They also interact

94 daily with each other, tourists, and local communities. These contacts pose a risk of disease  
95 transmission between humans and gorillas. A 2003 survey of communities around the park found  
96 a high prevalence of infectious disease symptoms, including 72% of people with coughs and  
97 56% with fevers (14). Early diagnosis and treatment of infectious diseases in humans can lower  
98 the risk of zoonanthroponotic transmission, and preventative healthcare can maintain good health  
99 and prevent zoonanthroponotic diseases.

100

101 To date, there have been few studies of employee health programs or employee access to  
102 healthcare in wild great ape settings. A 2004 study describes a health program in Rwanda for  
103 employees working with mountain gorillas, including screenings for tuberculosis (TB), human  
104 immunodeficiency virus (HIV) and screening of blood, urine and stool (15). The program offered  
105 yearly retesting and screenings as well as interventions including deworming. The International  
106 Union for the Conservation of Nature (IUCN) has published guidelines on great ape health (16)  
107 that detail that a standard employee health program should include an annual physical exam  
108 administered by a physician, access to health tests including temperature, diagnostic testing,  
109 access to vaccines and vaccine verification, deworming medication administered quarterly,  
110 referrals if employees have emergency or complicated conditions, and lastly to be provided with  
111 relevant health education. The IUCN employee health guidelines are not context-specific, and  
112 they are the ideal, assuming that every site has the necessary resources. However most wild great  
113 ape sites are located in resource-poor, remote settings, and it is simply not possible to implement  
114 employee health programs that reach the standards in the guidelines (17).

115

116 This aims of this study were to 1) evaluate health-seeking behavior and health resources used by  
117 national park rangers in contact with great apes at Bwindi Impenetrable National Park through  
118 qualitative semi-structured interviews; 2) evaluate existing occupational health programs for  
119 employees working with great apes in other parts of the world against IUCN employee health  
120 guidelines using key informant (KI) interviews; and 3) make recommendations for improvement  
121 of occupational health at BINP.

## 122 **Methods**

### 123 **Study Design**

124 The study used a cross-sectional qualitative design, as the objective was to gain an understanding  
125 of the status of employee health programs at BINP and five other great ape sites. A qualitative  
126 design enables a richer description of complex issues, such as individual health-seeking  
127 behavior, and allows participants to speak freely on their experiences and recommendations for  
128 the healthcare available to them. The study had two parts, detailed below: healthcare access and  
129 use for Bwindi Impenetrable National Park staff, and key informant interviews regarding  
130 employee health programs at other great ape sites.

### 131 **Ethics statement**

132 Institutional Review Board approval was obtained from The AIDS Support Organization  
133 (TASO) in Uganda (Ref # TASOREC/105/2022-UG-REC-009), from University of California  
134 Berkeley's Office for the Protection of Human Subjects (Protocol #2022-02-15057) and from the  
135 Uganda National Council for Science and Technology (Ref #HS2136ES). Additional approval  
136 was obtained from Bwindi Community Hospital (no reference number), and from the Uganda

137 Wildlife Authority (no reference number) to interview their staff. Written informed consent was  
138 obtained from all participants. Participants at BINP were given one hard copy of the informed  
139 consent form, and the investigators kept a second copy, while KIs signed the informed consent  
140 via email.

## 141 **Data Collection**

142 Gorilla Doctors, a partnership between the UC Davis Wildlife Health Center and the Mountain  
143 Gorilla Veterinary Project (MGVP, Inc.), provides veterinary care for the gorillas at BINP and in  
144 other mountain gorilla parks, and has been at BINP since 2009. Recruitment of subjects at BINP  
145 took place from the June 17 to July 2, 2022. Based on the researcher's request to interview a  
146 certain number of individuals who performed a variety of jobs, Gorilla Doctors conducted  
147 purposive sampling and suggested individual rangers at the Buhoma, Ruhija and Nkuringo  
148 ranger stations to be interviewed and to recruit other participants for interviews. The rangers at  
149 each sector identified by Gorilla Doctors then explained the purpose of the research to their staff  
150 and suggested off-duty staff to participate in interviews. A condition of conducting research with  
151 UWA staff was that they would recommend potential participants and thus make sure those  
152 participating were not on duty or on leave. Rushaga, the fourth sector, was not included due to  
153 time and budget constraints. The omission of this sector may have left out important findings in  
154 terms of healthcare accessibility and health seeking behavior. On the other hand, Rushaga is not  
155 far from Nkuringo, meaning it is unlikely that staff would have had drastically different  
156 healthcare facilities accessible to them.

157 The sampling aimed to recruit an equal distribution of participants across occupational  
158 categories, gender, and stationed sector of the park. The sample size was limited by budget and

159 time constraints and was capped at 50 participants. Buhoma is the sector of the park where the  
160 Uganda Wildlife Authority (UWA) headquarters and Bwindi Community Hospital (BCH) are  
161 located. Ruhija and Nkuringo sectors are more remote from commercial centers and large human  
162 settlements, and only have access to small trading centers (Figure 1). Key informants were  
163 purposively sampled by the study team and had to be working at a wild great ape site and have  
164 knowledge of the employee health program at the site. There was no overlap between KIs and  
165 participants from BINP. KIs were contacted via email to inquire whether they would be willing  
166 to participate between October 31<sup>st</sup>, 2022, and December 28<sup>th</sup>, 2022. Nine KIs were contacted,  
167 and four dropped out or declined to participate in KI interviews, while no participants out of the  
168 46 identified by rangers declined to participate at BINP. KIs who did not participate either did  
169 not reply to emails or felt they did not have the required knowledge to participate.

170

171 **Phase I: Healthcare access and use for Bwindi Impenetrable National Park**  
172 **staff.**

173

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177 © OpenStreetMap contributors

178 **Fig 1. Data collection sites at BINP.** Red dots indicate sectors of the park where ranger stations are located, which  
179 is where data collection took place. Not pictured is Rushaga station, south of Nkuringo, as data collection did not  
180 take place there.

181 Data were collected using a short qualitative individual interview guide (S1 appendix). Pilot  
182 interviews with one Bwindi Community Hospital staff member and two park rangers were  
183 carried out before data collection began. Three different groups were included: 1) park wardens,  
184 rangers, porters, and security personnel were asked about health facilities available to them,  
185 health seeking behavior, and instances when one would take time off work because of illness 2)  
186 two senior Bwindi Community Hospital staff members (head doctor or nurse) were interviewed  
187 about services provided by BCH, including immunizations, preventative healthcare, and other  
188 treatments for conditions prevalent in the area, and 3) a senior member of BINP management  
189 was asked about what policies are in place for staff sick leave, how prevention and care services  
190 are provided to staff, and what policies are implemented to minimize disease exposure and  
191 transmission between staff and gorillas, and what procedures are followed if staff accidentally  
192 expose gorillas to infections. Interviews were de-identified by giving participants a number at the  
193 time of the interview, and recording their job title, age and gender.

194 Semi-structured qualitative interviews were conducted among 46 participants in English.  
195 Interviews were carried out by the student investigator Maya Homsy King and a research  
196 assistant from the Bwindi area. Maya is a White female Master of Public Health Student at the  
197 University of California Berkeley, who grew up in Uganda. She has prior experience conducting  
198 qualitative interviews in Uganda and has formal training in qualitative analysis. Informed  
199 consent and purpose of the study was explained prior to beginning the interview. Interviews were  
200 comprised of nine questions and lasted 30 minutes on average. Data were recorded via  
201 handwritten notes, and short field notes were made after the interviews each day. No interviews  
202 were audio-recorded due to IRB constraints. All interviews took place at participants' places of

203 work, e.g., ranger stations and visitor centers. Each sector at BINP has a building where rangers  
204 report to work, and researchers were given an empty room or secluded outdoor space to conduct  
205 interviews with rangers who were not in the field. No people other than the interviewer and  
206 participant were present during the interview, no repeat interviews were carried out, and  
207 transcripts were not returned to participants. Thirteen participants were interviewed at Buhoma,  
208 15 at Ruhija, 15 at Nkuringo, two senior staff at BCH, and one senior member of BINP  
209 management. Participants at BINP were given a new umbrella for as a token of appreciation for  
210 their time while participating in the study.

211 **Phase II: Key informant interviews regarding employee health programs at**  
212 **other wild great ape sites**

213 Key informant (KI) interviews were conducted with individuals who are knowledgeable about  
214 the employee health programs at their great ape site. Individuals were contacted if: 1) they  
215 worked at a wild great ape site; and 2) had knowledge of employee health protocols at their place  
216 of work. KI's sites included national parks, a research reserve and a rehabilitation center (Table  
217 3). Key informants were given a list of questions (S2 appendix) and the informed consent  
218 document for participants to read and sign. Five interviews were conducted, and transcription  
219 software was used to transcribe the interview. No repeat interviews were carried out and  
220 transcripts were not returned to participants. Interviews lasted 30 to 40 minutes. Questions were  
221 centered around employee health practices at participants' places of work and included  
222 information on preventive healthcare practices at wild great ape sites, PPE regulations, and what  
223 healthcare is available to employees.

224

225 After analysis of the data, a summary of recommendations and findings was submitted to the  
226 Chief Warden at BINP, the Research and Monitoring ranger, and head rangers at each  
227 participating sector. Unfortunately, it is impossible to ensure that individual participants receive  
228 results as we did not retain identifying information for them, but the study team received a  
229 detailed response from the Chief Warden acknowledging the results, detailing progress already  
230 made on healthcare at BINP, and using the results to find ways forward for all recommendations.  
231 The full draft version of this paper has been also shared with the Chief Warden, staff at BCH and  
232 all KIs.

233

## 234 **Data Analysis**

235

236 Data were analyzed using qualitative research software Atlas.ti 9.1.3. Thematic analysis was  
237 conducted for both BINP and KI components, which is suitable for semi-structured interviews as  
238 it enables researchers to structure interview data according to themes and categories, and is  
239 useful for understanding the meanings that people give to their experiences and what led them to  
240 certain behaviors (18). Data was first coded according to the question being asked (open coding),  
241 then axial coding was used to identify patterns in the data and make connections among codes.  
242 Themes were constructed based on participants responses and the employee health guidelines  
243 from the IUCN. The results and paper are structured according to the Consolidated Criteria for  
244 Reporting Qualitative Research (S3 appendix) (19).

245

246 Results from interviews at BINP specifically were analyzed thematically based on elements of  
 247 internationally established employee health guidelines (16). Themes focus broadly on preventive  
 248 care (annual physical examinations, infectious disease screenings and deworming), whether and  
 249 where diagnostic testing is available, the types of facilities used for different conditions, and  
 250 when staff take time off for sick leave.

## 251 **Results**

252 Most respondents were rangers (61%; 28/46) (Table 1). Rangers are employed by the Uganda  
 253 Wildlife Authority to protect the park, guide tourists into the park and monitor mountain gorillas.  
 254 Trackers, guides, and security personnel are all rangers, but have slightly different  
 255 responsibilities and expertise. Most respondents were male (74%; 34/46); the ranger population  
 256 in Uganda is 80% male. Fourteen porters, who are not directly employed by UWA, were also  
 257 interviewed. Porters are community members who work part-time carrying bags for tourists who  
 258 hike into the park.

259

260

261

262

Occupational category	Participants (n =46)	Male	Female
Rangers	9	6	3
Trackers	8	6	2
Guides	5	4	1
Security personnel	6	5	1
Porters	14	9	5
Soldier	1	1	0
BINP management	1	1	0
BCH Staff	2	2	0
Total		34	12

263 Table 1: Participant demographics from Bwindi Impenetrable National Park. ‘Rangers’ refers to staff who simply  
 264 described themselves as rangers, and did not mention a specialized role such as tracker, guide, or security personnel.

265

266 **Interviews with Park Staff from BINP**

267 Thematic analysis revealed that employees do not obtain regular physical examinations by a  
 268 physician, nor do they receive regular deworming. Diagnostics are mostly available at hospitals,  
 269 not clinics or government health centers and medication is frequently unavailable at health  
 270 centers. In addition, treatment of chronic or severe illness happens most frequently at hospitals,  
 271 whereas acute conditions are treated at clinics. Rangers take time off depending on personal  
 272 opinions of risk to themselves and to gorillas, and assessment of what duties can be performed  
 273 while ill (Table 2). Each theme is discussed in detail below.

274

Theme	Summary finding	Detailed findings
Preventative care	Employees do not obtain regular physical examinations by a physician, nor do they receive regular deworming.	<ul style="list-style-type: none"> <li>- Rangers have insurance that covers services for symptomatic illnesses at selected hospitals, but insurance does not cover physical exams or screenings.</li> <li>- Whether employees go to physical exams depends on personal attitudes towards health.</li> <li>- Deworming medication is taken only if the individual is experiencing symptoms.</li> </ul>
Diagnostics	Diagnostics are mostly available at hospitals, not clinics or government health centers, medication is frequently unavailable at health centers.	<ul style="list-style-type: none"> <li>- Hospitals were most frequently mentioned as providing any kind of diagnostic testing (e.g., for blood, stool, or urine samples).</li> <li>- Clinics and health centers were sometimes said to have access to tests for malaria and unspecified sexually transmitted infections.</li> <li>- Medication is available at clinics and hospitals, but rarely at government health centers.</li> </ul>

Treatment options	Treatment of chronic or severe illness happens at hospitals, whereas acute conditions are treated at clinics.	<ul style="list-style-type: none"> <li>- Clinics are located closer to participants' workplaces than hospitals and provide faster services than hospitals or government health centers, making them more convenient for acute conditions.</li> <li>- Hospitals have more capacity for treatment of severe, chronic conditions and better qualified staff than clinics or health centers.</li> <li>- Local herbalists were mentioned as an occasional solution to problems such as cough, flu, malaria.</li> <li>- First Aid kits provide free supplies including cough and cold medication for rangers but are frequently understocked.</li> </ul>
Sick leave	Rangers take time off depending on personal opinions of risk to themselves and to gorillas, and assessment of what duties can be performed while ill.	<ul style="list-style-type: none"> <li>- Some rangers referred to doctor's notes and prescriptions as guideline for how much time to take off.</li> <li>- Many expressed that it was their own opinion of their condition that guided how much time to take off.</li> <li>- Some participants said that if they had mild symptoms, they would do less strenuous work (gate duty, administrative) and rarely said they would go to the forest and interact with gorillas.</li> </ul>

275 Table 2: Themes from interviews with staff at Bwindi Impenetrable National Park

276

277

278 **Employees do not obtain regular physical examinations, nor do they receive**

279 **regular deworming.**

280

281 All employees of UWA were insured by AAR, an East African health insurance company.

282 Rangers have a comprehensive plan, which most of them say covers all common ailments and

283 treatment for them and their families (up to 4 people), although it did not cover preventive

284 physical exams. Porters, who were classified as 'support staff,' were not insured and had to pay

285 out of pocket for services at any private facility. Only select hospitals were enrolled in UWA's

286 insurance scheme; private clinics were not covered by the insurance scheme. For all rangers

287 other than those stationed at Buhoma (who could walk to Bwindi Community Hospital), private

288 clinics were more convenient; hospitals were over an hour's drive away. Many participants said  
289 they were satisfied with the insurance, and glad that it was available to them, however all  
290 participants had to pay out of pocket for any preventive service they requested.

291

292 *“They do all the tests for whatever you're suffering from. If you're not suffering from*  
293 *anything, and you want to check your condition, insurance doesn't cover it.”* Ranger-  
294 guide, Ruhija, 39 y/o, F

295

296 Therefore, many participants said they only went to a health facility if they had symptoms, and  
297 there was no regulation in place mandating physical examinations for any employees. Fewer  
298 porters than rangers described going to a health facility for a physical exam. Those who went for  
299 physical exams gave reasons such as sexually transmitted infection (STI) testing, especially HIV,  
300 and antenatal visits for women.

301

302 *“I go there to check myself and some special treatment that are not at the clinics near here. I*  
303 *also go to test blood for general issues - if you're sick and don't know the cause. After 6 or 3*  
304 *months I would go just to check even if not sick.”* Private ranger, Nkuringo, 32 y/o, M

305

306 In addition to the cost, whether participants went for regular physical exams depended on  
307 personal attitudes towards their own health or having a chronic condition, such as allergies, that  
308 necessitated regular visits to a health facility. Many participants said they only went to a health  
309 facility if they were experiencing symptoms, and while a few said they went regularly for  
310 physical exams without symptoms.

311

312 Finally, porters and rangers said that they rarely, if ever, took deworming medication.

313 Participants said only children took deworming medication at regular intervals. A few said that

314 they took the medication every few months of their own volition, because the health facility

315 reminded them, or when they felt abdominal discomfort. One participant said they used herbs

316 from the forest for deworming purposes.

317

318 **Diagnostics are mostly available at hospitals, not clinics or government health**

319 **centers, and medications are frequently unavailable at health centers.**

320

321 Interviewees stated that the hospitals they access to consistently had the laboratory facilities and

322 equipment to diagnose a range of conditions, but clinics were more limited. Participants

323 mentioned availability of blood, urine, and stool sample diagnostic testing at hospitals, as well as

324 ultrasound scans, X-rays and a larger number of staff qualified to operate this equipment. Bwindi

325 Community Hospital provided screenings including tuberculosis, blood pressure, and Hepatitis B

326 and STIs for pregnant women, which were covered under the consultation fee. These services

327 were not present at clinics or health centers. At BCH, screening for helminthic infections is done

328 on a symptomatic basis, and triage for respiratory symptoms and temperature happens as soon as

329 patients enter the gate of the facility.

330

331           *“If you are pregnant, a Hepatitis B screening is required, as well as other STIs. Some*  
332           *screenings are included in general care- for example, TB screening starts at triage (with*  
333           *a questionnaire), blood pressure is taken.”* Senior BCH staff, 35 y/o, M

334

335 Some clinics had malaria, pregnancy, and STI testing, but some were said to have no testing  
336 capacity at all. Clinics were rarely said to have any scanning capabilities. Several participants  
337 expressed their wish for better-equipped facilities nearer to their workplaces, especially relating  
338 to diagnostic capabilities.

339

340           *“If the clinic could test people, they would be doing well. We need scanning, x-rays,*  
341           *fridges for keeping some medicines.”* Ranger-tracker, Nkuringo, 26 y/o, F

342

343 Another important factor in the choice of healthcare facility was the availability of medications.  
344 Many people cited lack of available medication at government health centers near them, which is  
345 why private clinics or hospitals were the facility of choice for most people. Availability of  
346 treatment at clinics was variable; participants at Ruhija frequently described clinics consistently  
347 stocking medication, while participants at Nkuringo were more likely to mention that even  
348 clinics sometimes had no medication, or only had over-the-counter pain relievers.

349

350           *Mostly in clinics you find only one person, or the clinic is closed. We need more clinics;*  
351           *the government could provide more health centers. In most cases, in clinics you can*  
352           *request for tablets, and they don’t have. Mostly they deal with minor illnesses and tablets.*

353 Ranger, Nkuringo, 37 y/o, F.

354

355 **Treatment of chronic or severe illness happens at hospitals, whereas acute**  
356 **conditions are treated at clinics.**

357

358 One frequently mentioned recommendation by staff was to have a health provider within the park  
359 for BINP staff. Reasons for this included the slow nature of services at many hospitals and the  
360 distance staff must travel to reach better equipped facilities, which is especially important when  
361 staff need urgent care. The clinic is much faster, and in most cases closer to where the  
362 participants reside (Fig 2). The wait time reported at hospitals varied from 30 minutes to a whole  
363 day, but participants said that it depended on the time of day, and on how many patients were  
364 waiting to receive care.

365

366 *“To me, what would be important is that the organization should have clinics within*  
367 *working places. If you fall seriously sick, you have to be rushed to far places. Pregnant*  
368 *staff who are rushed to nearest places sometimes lost the baby. It is hard to find a good*  
369 *facility near the ranger post.”* Ranger-guide, Ruhija, 39 y/o, F

370

371

372 **Fig 2. Types of health facilities used by park staff at BINP and their pros and cons according to the majority**  
373 **of participants.**

374

375 Participants reported going to the hospital rather than the clinic for issues they perceived to be  
376 more serious, except when a condition needed to be treated immediately, in which case they

377 went to the closest clinic (Figure 2). In many cases, despite the fact that it cost money,  
378 participants would go to a nearby clinic first, and if a condition was not resolved, they would  
379 make the trip to the hospital. Serious conditions were more likely to warrant testing to determine  
380 the cause of the illness, and thus was more likely to require a trip to a hospital. The factors of  
381 transport availability and cost were mentioned multiple times as limiting factors in accessing  
382 better-equipped facilities where insurance is accepted.

383

384 *“At clinics, you can go for consultation, history taking, some tests and treatment. At*  
385 *BCH, you can go for tests for different illnesses, HIV, some treatments and medicines.*  
386 *BCH is the most used- you can also access screening for diabetes, hepatitis B, malaria*  
387 *and hypertension.”* Porter, Buhoma ,43 y/o, F

388

389 Participants differed in how they reported reacting to symptoms of malaria; some reported going  
390 to the clinic to buy medication, while others would go to the hospital to be tested and treated. All  
391 participants perceived ‘general body weakness’, meaning a feeling of fatigue and muscle  
392 weakness as serious. Unless it was only ‘mild weakness’, respondents said that body weakness  
393 and fatigue warranted staying home from work and seeking diagnosis and treatment.

394

395 *“[I go to the hospital for] mostly malaria and fever. For cough and flu, I visit the clinic.*  
396 *Sometimes, for small wounds, like a cut, I go without [going to either the clinic or*  
397 *hospital]. When I’m suffering from malaria, they get blood, take it to the lab and give me*  
398 *drugs.”* Porter, Ruhija, 36 y/o, M

399

400 Participants said they usually go to the clinic for severe stomach problems and resolve less  
401 severe stomach issues by themselves. Some participants mentioned that they suffered from  
402 stomach ulcers, and these sometimes warranted a visit to the hospital. Local herbs were also  
403 mentioned as treatments for ulcers in Nkuringo and Ruhija.

404

405 *“For ulcers, we visit an old woman who can give you a medicine, called ebiculinganyi. She*  
406 *dries it inside the house and makes it a paste and you drink. At the hospital, they give you*  
407 *magnesium and if you don’t feel okay after that, you can try the herbs.”* Porter, Ruhija, 31 y/  
408 o, M

409

410 Participants also stated that they sometimes use traditional medicines for the treatment of other  
411 ailments, such as cough, flu, malaria, and stomach problems. However, when asked about  
412 visiting traditional healers, all participants denied using their services, and mention of traditional  
413 healers at times provoked laughter or emphatic denial of the use of their services.

414

415 Common ailments including cough, flu, and malaria could be treated using the first-aid kits that  
416 UWA keeps at each office in the four sectors of the park. The kit is stocked with medication for  
417 common ailments and with bandages. These supplies are free for rangers to use, and many of  
418 them mentioned that they would look there first before going to buy medication from the clinic.  
419 However, respondents frequently said the kits were not restocked as often as necessary and could  
420 be understocked for months on end.

421

422 Finally, respondent's perception of staff and their qualifications, as well as the way they treat  
423 patients, was of importance in making decisions for healthcare. Participants said that staff at  
424 hospitals were more qualified than those at clinics, which is one reason why more serious  
425 illnesses warranted a visit to the hospital (Figure 2). Some participants however mentioned harsh  
426 treatment by providers at hospitals because of understaffing.

427

428 **Rangers take time off depending on personal opinions of risk to themselves**  
429 **and to gorillas and assessment of what duties can be performed while ill.**

430

431 Decisions on whether to come to work depended on individual opinions of risk to themselves  
432 and to the gorillas, and assessment of what duties could be performed while ill. Some  
433 participants mentioned doctor's opinions or prescriptions determining how long they would stay  
434 away from work, and park management described that the length of necessary sick leave was  
435 determined by a doctor's recommendation. Rangers had allowance for up to 6 months of paid  
436 sick leave, if necessary, but this must be proven with a doctor's note. They also have eight days  
437 off per month including weekends (regardless of whether they are sick), which are sometimes  
438 used to take time off for less severe issues like cough, headache, and gastrointestinal issues.  
439 Porters are paid every day they work and not otherwise.

440

441 Many rangers said that they would do 'simple work' if they had mild symptoms such as  
442 headaches or mild cough or flu. Reasons given frequently included the risk of transmission to  
443 gorillas, as well as not being able to hike for long periods of time when sick. 'Simple work'

444 encompassed office work or gatekeeping, but not going into the forest. Some people said that  
445 they would skip work for ‘running stomach’ (diarrhea), as this would make hiking or dealing  
446 with clients challenging.

447

448 *“Mostly when we are sick, we may even transmit diseases to gorillas, and you may have*  
449 *no energy. When I’m sick, I report to supervisors. Sometimes, they advices me to go to*  
450 *the nearest clinic or hospital. Sometimes they assist with transport if I am in the field.”*

451 Ranger-tracker, Buhoma, 35 y/o, M

452

453 There were some exceptions when people would come to work. A few rangers said that they  
454 would go into the forest with respiratory symptoms, including mild cough or cold, but that they  
455 would wear a mask.

456

457 *“Sometimes I may have headache and still go to work. Sometimes I may have cough and flu*  
458 *and still go when it is not strong [severe]. If it’s strong, I can’t go for hiking.”* Ranger,

459 Nkuringo, 37 y/o, F

460

461 Rangers knew that respiratory infections were dangerous for gorillas but mentioned that  
462 understaffing put pressure on them to come back to work before they felt fully recovered. It was  
463 unclear whether supervisors, a personal sense of obligation, or co-workers were the source of this  
464 pressure.

465

466 *“It depends on how you feel to come back [to work]. Maybe the pressure at work and the*  
 467 *high season can force you to come back.”* Ranger-guide, Ruhija, 39 y/o, F

468 **Key Informant Interviews: Status of Employee Health at Wild**  
 469 **Great Ape Sites in Africa and Asia**

470 KIs were conducted with four sites were in Africa, where gorillas, chimpanzees, and bonobos are  
 471 endemic, and one site was in Asia, where orangutans are endemic (Table 3). Three out of the five  
 472 sites included were national parks and overseen by the government. Site 1 had a non-  
 473 governmental organization (NGO) affiliated with the park that employed their own staff, so  
 474 employees of the NGO benefitted from NGO healthcare as well as national healthcare. Site 2 was  
 475 a forest reserve and primarily managed by the research group that started it; it does not have a  
 476 tourist program, and the only human- primate interaction is for research purposes. Site 3 is a  
 477 primate rehabilitation center that serves to rehabilitate and reintroduce orangutans to the wild and  
 478 does not involve tourism.

479

480

Site	Type of site	Region	Governance and funding	Approximate number of field staff	Key informant occupation
00	National Park (Bwindi Impenetrable National Park)	East Africa	Government	600	Rangers, porters, park management
01	National Park and affiliated NGO	East Africa	NGO and government	30	NGO-affiliated field veterinarian
02	Forest	East Africa	Government and	15	Director of

	reserve; research site		external funding		research site
03	Rehabilitation center	Southeast Asia	NGO	100	Veterinarian, consultant, and advisor for NGOs
04	National Park	Central Africa	Government; external funding for employee health	52	Veterinarian and responsible for health program
05	National Park	West Africa	Government; external funding for employee health	7	Researcher in conservation science

481 Table 3: Type of site, region, governance of the site, and occupation of each KI is detailed in this table. Site 00  
482 refers to BINP, which was discussed in the previous section of the results.

483  
484 Thematic analysis of occupational health provided at other great ape sites identified four main  
485 themes: 1) most sites do not provide for preventive healthcare; 2) staff must travel outside the  
486 site to access healthcare; 3) access to diagnostics varies across sites; and 4) all sites have PPE,  
487 and clothing requirements for staff, while some have quarantine requirements. Employee  
488 healthcare varied greatly per site, depending on funding, location, and type of site (Table 4).

489  
490

<b>IUCN Guideline</b>	<b>Site 0 East Africa [Bwindi NP]</b>	<b>Site 1 East Africa [National Park]</b>	<b>Site 2 East Africa [Research Site]</b>	<b>Site 3 Southeast Asia [NGO]</b>	<b>Site 4 Central Africa [National Park]</b>	<b>Site 5 West Africa [National Park]</b>
A periodic, at least annual, physical examination administered by a physician.	Not present	Not present	Not present	Present	Present	Not present
Basic health tests to reveal underlying or chronic conditions that could affect quality of life or life expectancy.	Sometimes present in clinics, present in hospitals farther away	Present at referral hospital 15-30 mins away	Mostly not present. Employees go to clinics on time off, rarely hospitals	Present for HIV and TB yearly	Present with annual physical examination .	Not present
Diagnostic testing	Present at	COVID tests	Unclear. Site	Present for	Present for	Not

(including imaging tests, like chest radiographs) for select infectious diseases, such as malaria, TB, hepatitis and HIV and others of particular concern in the region.	Buhoma, staff must travel far to hospitals from other sectors	available, first aid kits available. Lab tests for respiratory syncytial virus (RSV), human metapneumovirus and <i>S. pneumoniae</i>	is remote and far from healthcare facilities	malaria, TB, HIV	COVID-19, malaria, hMPV, Ebola, RSV, Mpox and Anthrax	present
Verification and/or boosting of immunizations for select communicable diseases of concern for great apes	Not present	Present for meningitis, Hepatitis B, COVID-19	Not present	Not present. Verification and provision only of Hepatitis B vaccine.	Present for Hepatitis B, tetanus, typhoid, and COVID-19.	Not present
Deworming medications administered to personnel and to their immediate families on a quarterly basis, alternating the medication quarterly to reduce the potential for anthelmintic resistance.	Taken as needed from clinics or pharmacies [alternation of medication unclear]	Taken as needed from first aid kit on site [alternation of medication unclear]	Not present	Present [alternation of medication unclear]	Taken as needed [alternation of medication unclear]	Not present
Referral of employees found to have emergency, complicated or chronic conditions to a health care facility or programme for treatment; the minimum Employee health program responsibility should be to ensure that referrals occur and are effective.	Unclear^ All staff have health insurance at select hospitals, but cost of transport is not always covered	Present. Cost of referral to regional hospital is covered	Unclear. All transport for staff is paid for	Present. All staff have health insurance which covers referrals	Unclear. Staff are covered under national health insurance and can access care at the public hospital	Unclear. Treatment is paid for by research group
Health and hygiene education relevant to the location and situation.	Sometimes present. NGOs have provided trainings on prevention of zoonotic	Sometimes present. Deworming information given to staff, and training on	Not present	Present. Information sessions on health and healthcare are given to staff.	Sometimes present	Sometimes present. Guides were trained with

	disease transmission for some rangers	diagnostics for respiratory disease in chimps.		Normally the topic is on common zoonotic pathogens found in the primate species		material on how to protect great apes from disease
<b>*PPE and quarantine regulations per site compared to IUCN best practice for disease prevention guidelines</b>						
Seven days of quarantine after having been sick or traveling internationally	Not present	Not present.	Somewhat present. Quarantine period of 3 days for individuals who leave the site and come back	Not present.	Present. Quarantine period of one week for staff who leave the site and come back	Not present
Change clothes and footwear every time a great ape group is visited, and between great ape groups.	Not present. Staff have a uniform, but it is also used for administrative duties	Present. Unclear about changing between great ape groups	Present. Unclear about changing between great ape groups	Present. Unclear about changing between great ape groups.	Not present. Shoes are cleaned with bleach before and after the forest	Not present
Wear a facemask when coming within 10 meters of great apes.	Present	Present	Present	Present	Present	Present

491 Table 4: IUCN employee health guidelines compared to employee health programs at various wild great ape sites.

492 ^ Unclear = information was incomplete

493 \* This section details measures that are not part of the guidelines specific to employee health, but are part of the IUCN best  
494 practices for disease prevention for all those interacting with great apes (16).

495

496 **Most sites do not provide for preventive healthcare.**

497 Sites 3 and 4 were the only ones that provided staff with an annual health check with a physician.

498 Site 3 described screening for TB and HIV yearly. Site 3 dewormed humans as often as the apes

499 are dewormed, every 3 or 6 months. At Site 4, deworming medication was only given if

500 symptoms were present, similar to all the other sites. Site 4 contracted a doctor from the national

501 health service to provide free annual health checks to park staff including screening for malaria

502 and other infectious diseases such as, TB, COVID-19, respiratory syncytial virus, and human  
503 metapneumovirus. The country they are based in also has a national health insurance scheme.

504

505 *“Then we collaborate with the doctor, the national doctor from the public hospital. So,*  
506 *we send our trackers and all the people who are working in the park to go in the hospital*  
507 *and the doctor is going to consult them, and to treat them against the disease.” – Site 04*

508

509 Site 4 received funding from a European organization for staff healthcare. Although Site 2 also  
510 received external funding, they did not have an annual health check and staff seek services as  
511 needed. Site 4 requires park staff, who usually spend two weeks in the field, to take a rapid test  
512 for COVID-19 every time they go to the field from camp and one week later.

513

514 Three of the six sites (sites 1,3 and 4) mentioned providing vaccinations against Hepatitis B, and  
515 COVID-19. Hepatitis B is not currently a concern for zoonanthroponotic transmission. KIs from  
516 sites 1 and 4 mentioned that provision of the Hepatitis B vaccination was a governmental  
517 initiative and happened once people were recruited into the park service. Sites 0, 2 and 5 did not  
518 require any vaccinations.

519

## 520 **Staff must travel outside the site to access healthcare**

521 Staff normally had to travel outside their place of work to access healthcare, except for site 1.

522 Site 1 has a dispensary within the park with employee health workers present. The KI described

523 that this was normally the first point of care for sick employees, and from there they were  
524 normally referred to hospitals outside the park.

525

526 Site 4 brings in a doctor from the national health system once per year to provide an annual  
527 physical exam to employees, but otherwise employees go to the government hospital for their  
528 healthcare. Sites 2 and 5 described being especially far from healthcare facilities. Site 2  
529 described being 70 km away from the nearest village or town, meaning employees normally  
530 sought healthcare on their time off, as they get two weeks off every six weeks. Site 3 described  
531 providing most healthcare through the NGO, although it was not clear where Site 3 was in  
532 comparison to the nearest health facility.

533

#### 534 **Access to diagnostics varies across sites**

535 Sites 1 and 4 had access to a laboratory onsite with capacity to test for infectious diseases of  
536 concern to great apes, including hMPV and RSV. Other sites relied on access to healthcare  
537 facilities outside the park for diagnostic testing. At Site 3 new employees were screened for TB,  
538 herpesvirus, HIV, Hepatitis A, B and C, and COVID, and are tested for TB and HIV yearly.

539

540 The feasibility of referrals and access to facilities where diagnostic testing and screenings happen  
541 depends on the site itself. Some sites, such as Site 1, are closer to urban centers where hospitals  
542 and clinics are accessible, whereas others, like Sites 2 and 5 are remote and difficult to access.

543

544 **All sites have PPE, and clothing requirements for staff, some have quarantine**  
545 **requirements**

546 All sites have PPE requirements for staff, with a minimum of a facemask worn when near  
547 primates, and with the most conservative requiring that staff change clothes and shoes before and  
548 after going to the forest. Site 0 has uniforms for staff, but staff wear these uniforms at the  
549 administrative building as well as in the forest. Site 2 has a structure to change clothes on the  
550 boundary of the forest, where staff put on forest clothes, and then change into camp clothes after  
551 returning from the forest. Sites 1 and 3 also require changing clothes and shoes before going to  
552 the forest, or interacting with primates, while Site 4 only implements cleaning shoes with bleach  
553 before and after going to the field. Site 5 only requires a face mask, but the primates at this site  
554 are not habituated to humans and therefore typically stay far from people.

555

556 Site 2 has a quarantine period of three days for individuals who leave the site and come back.  
557 During this quarantine period they stay in camp but are not allowed to interact with the chimps.  
558 The key informant from Site 2 described that the quarantine used to be five days, but because of  
559 loss of staff during the COVID-19 pandemic, they had to reduce it to three days. Site 4 also has a  
560 quarantine period of about one week for staff that come back to camp; they admitted it was  
561 difficult to implement by did not specify why.

562 **Discussion**

563 This study aimed to explore the status of healthcare and health-seeking behavior at BINP for  
564 park staff working in close proximity to mountain gorillas and learn what employee health

565 programs exist at other great ape sites to provide recommendations for improving healthcare for  
566 employees at BINP. Results show that rangers and porters at Bwindi Impenetrable National Park,  
567 whose jobs involve daily tracking and visiting of the remaining population of mountain gorillas,  
568 are not accessing or achieving the standard of health care that is necessary to minimize the risk  
569 of transmission of infectious disease from humans to mountain gorillas and vice versa (16).  
570 Rangers' health insurance does not cover preventive physical exams, and porters do not have  
571 health insurance through UWA. Hospitals that provide diagnostic testing and screenings for risky  
572 infectious diseases are far from participants' places of work, and BINP had no mandatory  
573 guidelines on staying home from work for symptomatic staff members.

574

575 The primary gaps that could be addressed by BINP are provision of preventive healthcare and  
576 health screenings for park staff, and increased access to diagnostic testing. Results from key  
577 informant interviews at great ape sites around the world paralleled this finding, revealing that  
578 most sites did not expressly provide preventive healthcare to their staff, and only two sites out of  
579 six provided an annual health check. Key informant interviews also showed that while employee  
580 health programs differ across sites, all sites require use of PPE. The authors' main  
581 recommendations for BINP are to improve preventive healthcare by implementing annual health  
582 checks, regular deworming, and access to diagnostic tests for malaria, COVID-19, and other  
583 human infectious diseases of potential threat to great apes.

584

585 Participants from BINP most often accessed care for acute or less serious conditions at private  
586 clinics or government health centers near their workplaces and would make the trip to a hospital  
587 for severe or unknown, chronic conditions. This was especially pronounced in Ruhija and

588 Nkuringo, where the two closest hospitals were over an hour's drive away from rangers' and  
589 porters' places of work. While insurance covered many of the procedures at these hospitals, staff  
590 had to invest considerable time and money to reach the facilities. This was mirrored at many  
591 sites in KI interviews. Some sites are very remote and to access a hospital could take hours,  
592 meaning that staff normally only go during their time off. Time availability has been found to be  
593 a barrier to utilization of appropriate healthcare access in other studies in Sub-Saharan Africa, as  
594 it interferes with employment (20,21). As a result of this limited access, participants in distant  
595 sectors of BINP reported that they seek healthcare for serious conditions primarily at private  
596 clinics as a first step, before going to hospitals. Similar findings were seen in Konde-Lule et al.'s  
597 2010 study on healthcare provider choice in rural Uganda (22). Implications of these include  
598 reduced access to diagnostic and testing and preventive care and screening, as these are most  
599 often available at hospitals.

600

601 Although, screening for health conditions based on demographics and risk profile can reduce the  
602 risk of severe disease (23), there was the lack of preventive health services accessible to and  
603 sought by rangers and porters, who have strenuous, hazardous occupations that involve frequent  
604 interactions with non-human primates in an area of the globe highly susceptible to emerging  
605 infectious diseases. Prevention is critical to preventing zoonothroponotic transmission and  
606 identifying zoonotic disease before an outbreak occurs. Yet, rangers reported their insurance  
607 does not cover preventive screenings and porters have no insurance through UWA. When  
608 patients visit a large hospital, like BCH, they are offered free general screenings including TB,  
609 blood pressure, and Hepatitis B for pregnant women. However, these exams were not performed  
610 in small clinics. Thus, for those who visit hospitals less than annually, it could be years between

611 health screenings. Most sites from KI interviews mirrored this finding. Apart from Sites 4 and 5  
612 that required an annual health check, KIs indicated that staff seek care only when something is  
613 wrong. Possible explanations could involve cost, as screenings and physical exams are not  
614 always covered by insurance and distance necessary to travel as diagnostic labs and equipment  
615 are often available at larger hospitals (24). Inadequate knowledge or incorrect beliefs about  
616 causes and consequences of tuberculosis has also contributed to hesitation to seek diagnosis and  
617 treatment in East Africa (24). Providing regular health education and providing all staff with a  
618 free annual physical exam would ameliorate these conditions and improve chances of identifying  
619 symptoms and treating them earlier to avoid a zoonotic outbreak among staff or among gorillas.  
620

621 An important component of preventive care in Sub-Saharan Africa is regular deworming. Most  
622 staff at BINP reported only taking deworming medication when they had symptoms of  
623 helminthic infection, rather than taking it quarterly, as is recommended by the IUCN (16).  
624 Helminthic infections are of increasing concern in mountain gorillas (25). Habituated gorilla  
625 groups in BINP have been found to have higher helminth egg counts than non-habituated groups,  
626 indicating that human interaction may be at fault (26). Fecal samples collected from the Republic  
627 of Congo also showed similar prevalence of multiple helminths including *Necator americanus*  
628 and *Enterobius vermicularis* in humans and gorillas inhabiting the same forest (27). Other recent  
629 results show increased helminth egg counts being associated with smaller gorilla group size in  
630 Rwanda and the Mgahinga region of Uganda (25). These findings underscore the importance of  
631 providing deworming medication to staff at regular intervals to reduce the prevalence of  
632 helminths in the area, thus interrupting potential transmission, and to stop infections in humans at  
633 early stages (28).

634

635 The situation at BINP supports the finding that unequal access to health insurance and benefits  
636 exacerbates the disparity in health outcomes between higher and lower income and educated  
637 versus uneducated people in East Africa (29). At BINP, rangers are salaried and educated  
638 compared to porters, who are often subsistence farmers when not serving as porters. Porters were  
639 employed only as daily wagers by the park and did not have the same benefits as rangers, even  
640 though they were exposed to the same occupational hazards as rangers. Porters in Ruhija and  
641 Nkuringo were more likely than rangers to report using clinics for their healthcare than hospitals  
642 meaning they are less likely to receive diagnostic testing or screening, as well as be seen by a  
643 doctor. On the other hand, porters and rangers stationed in Buhoma had access to the BCH  
644 community health insurance scheme that covers several preventive and curative services that  
645 other clinics do not. Porters in Ruhija and Nkuringo tended to use other hospitals as they were  
646 easier to access than BCH. Health insurance has been shown to improve health outcomes relative  
647 to having no health insurance (30), and participants mentioned cost as a barrier to accessing  
648 medication and healthcare. KI interviews did not go into detail about whether people with  
649 different occupations had differential access to healthcare, except at Site 5, where trackers who  
650 were part of a particular indigenous group had free public healthcare while field assistants, who  
651 were not part of the group, had to pay for healthcare. However, all staff at Site 5 were provided  
652 with a free annual physical exam. At BINP, providing porters and rangers with equal access to  
653 insurance would reduce the financial burden on porters and decrease inequalities within the  
654 workforce.

655

656 Diagnostic testing was not uniformly available across sites, or across sectors at BINP. At BINP,  
657 diagnostic testing was said to be more frequently available at hospitals than at private clinics or  
658 government health centers. Many participants mentioned clinics lacked malaria or TB tests and  
659 have medication for sale without needing diagnostic test results or a prescription. Participants  
660 also mentioned that first aid kits at each sector of the park provide injury management materials  
661 as well as medication for malaria and coughs free of charge, although they were said to be  
662 frequently understocked. This is problematic for several reasons. Symptoms of malaria include  
663 high fever, muscle aches, fatigue and flu-like illness (31). These are relatively non-specific  
664 symptoms that could be indicative of any common febrile illness (32). As such, it is easy to mis-  
665 diagnose malaria. While malaria caused by *Plasmodium falciparum* is a major cause of  
666 morbidity and mortality in many parts of Uganda (33, (34), prescribing antimalarial drugs  
667 without a definitive diagnosis of malaria may result in inappropriate care and poor patient  
668 outcomes, as well as increasing antimalarial drug resistance (32,35). Assuming that all  
669 nonspecific febrile illness is malaria also increases the likelihood that emerging zoonotic diseases  
670 will be able to spread in human populations before they are identified. Sites 2 and 5 had  
671 diagnostic testing capacity available in the park. Although reagents were limited, they had  
672 capacity to test for most common and zoonotically important infections including human  
673 metapneumovirus and respiratory syncytial virus. It is critical that employees at wild great ape  
674 sites have access to diagnostic testing for symptoms of infectious disease such as febrile illness  
675 and respiratory symptoms to improve the accuracy of treatment, minimize inappropriate use of  
676 antibiotics, allow for facility-based surveillance, and identify emerging zoonotic disease (36). A  
677 feasible suggestion would be to provide rapid malaria and COVID-19 tests in first aid kits free of  
678 charge since these are often the first point of care for staff at BINP.

679

680 Finally, although there is ample allowance for sick leave at BINP, many staff reported coming  
681 back to work according to their own assessment of what kind of work they could do and how  
682 they were feeling rather than using their sick leave to take time off until they had fully recovered.  
683 Park management indicated that number of days off should be determined by a doctor's note or  
684 prescription; however, some staff did not mention this when asked how they decided when to  
685 start working again. Staff were aware that interacting with gorillas while experiencing a cough or  
686 flu could result in zoonothroponotic transmission, but a few staff reported still entering the forest  
687 with mild symptoms. Progress has been made by the by the non-governmental organization  
688 Conservation Through Public Health (CTPH), who trained 400 staff at BINP in 2020-2021 on  
689 measures to prevent disease transmission through masking, hand hygiene and enforcing a 7  
690 meter viewing distance for gorillas (37). Understaffing was also mentioned as a pressure to come  
691 back to work, which may have been one reason for this behavior, however, this may also indicate  
692 insufficient education of staff members. To combat this, annual education of staff members, such  
693 as the one provided by CTPH, emphasizing the risk of zoonotic and zoonothroponotic  
694 transmission should be undertaken.

695

696 Limitations of this study include the way in which interviews were carried out at BINP. UWA  
697 rangers organized participants based on ranger timetables so as not to disrupt the flow of work.  
698 This may have led to selection bias, as head rangers could have recommended participants more  
699 likely to give positive feedback about their employer. However, upon review of transcripts,  
700 participants provided substantial critical feedback of their employer, including complaints about  
701 transport, insurance, and understaffing. This provides evidence that employees were not wary of

702 negative consequences should they criticize their employers. With regard to KI interviews,  
703 participants provided information on regulations and facilities at each site, but enforcement of  
704 the regulations and use of facilities was not assessed. Additionally, all interviews were carried  
705 out in English. Although all participants and KIs were fluent in English, English was not all of  
706 their mother tongues, and results may have lost nuance or complexity. Since participants' work  
707 involves daily interaction with English-speaking tourists, they speak English quite well and  
708 language did not appear to be a barrier during the interviews. While it is possible that  
709 participants would have shared more information had the interview been conducted in their  
710 mother tongue, limited study funding precluded interviews in languages other than English.  
711 Should participants have needed clarification on words or phrases, a research assistant who spoke  
712 Lukiga and Lufumbira was available.

## 713 **Recommendations for the employee health program at Bwindi**

### 714 **Impenetrable National Park**

715 The results of this study suggest that employees need easier access to preventive care,  
716 screenings, and diagnostic testing to ensure timely identification, response and containment of  
717 zoonotic and zoonoanthroponotic disease transmission in humans and gorillas.

718

719 Many of the issues raised by staff could be addressed by opening a small clinic or nurse's station  
720 within the park stocked with supplies including injury management and medications and rapid  
721 tests for common conditions, such as the practice at Site 1. Several participants mentioned that  
722 they would like a health provider to be employed specifically for staff of BINP. If a doctor or

723 nurse were present at each sector, this would improve emergency services, first aid services, and  
724 enable staff to receive expert advice and referrals should they be necessary. This clinic should  
725 serve porters as well as rangers, so that they can seek care when needed and participate in regular  
726 check-ups, reducing the risk for zoonotic and zooanthroponotic disease transmission.

727

728 Additionally, all staff, including porters, should be provided with deworming medication at  
729 quarterly intervals, and to alternate the type of medication quarterly to mitigate potential  
730 resistance in keeping with the guidelines on great ape health (16). Deworming pills are widely  
731 available and cheap in Uganda. Deworming medication should be kept in the first aid kits at each  
732 site, and a designated individual, such as a head ranger or healthcare provider, should be  
733 responsible for reminding employees at the appropriate intervals.

734

735 First aid kits should also be stocked with rapid malaria tests and COVID-19 tests, and if possible  
736 a joint COVID-19, flu and RSV assay (39). This would improve accessibility of diagnostic  
737 testing for the common symptoms of malaria and rule out COVID-19 for respiratory illness  
738 symptoms. Providing these tests would also reduce overuse of antimalarials and provide more  
739 information to staff for how to manage their illness. Both tests are easy to administer to oneself.  
740 Malaria tests are widely available, and Uganda recently came out with a COVID-19 rapid test  
741 (40); international tests are also available.

742

743 In addition to stocking first aid kits at BINP with deworming medication and rapid tests, training  
744 staff on first aid could empower them on how to manage early signs of infectious disease using  
745 the materials in the first aid kits, and when to seek further diagnostic testing and treatment.

746 UWA, or equivalent agencies in other countries could contract Bwindi Community Hospital, or  
747 nearest large hospitals to provide first aid trainings once a year at each sector in the park for  
748 rangers and porters. Finally, health camps, or outreach programs for regular screening of risky  
749 infectious diseases, as well as other pertinent conditions would be a feasible way to provide  
750 preventive care that does not necessitate long travel, high costs and taking time off work. These  
751 outreach programs could also include refresher trainings on zoonotic and zooanthroponotic  
752 diseases and safe practices for working in the forest.

753

754 To identify the emergence of new zoonotic diseases or zoonotic outbreaks, hospitals and clinics  
755 utilized by park staff could keep records of symptoms or conditions of staff and compare them to  
756 symptoms and conditions of surrounding community members. This would be useful data in  
757 terms of emerging infectious diseases, and common occupational hazards. It was made clear by  
758 the BCH staff interviewed that no effort had been made to formally record conditions presented  
759 by park staff versus community members, but one member of staff indicated that BINP staff  
760 more commonly presented with animal injuries than community members, while the other BCH  
761 staff member interviewed had observed no differences. To better tailor occupational health  
762 services, larger scale data on what park staff most commonly suffer from would be invaluable.

763

764 This study provided an illustration of the One Health factors and linkages at work affecting the  
765 health of BINP staff, and employees at wild great ape sites around the world, which in turn has  
766 implications for the health of the apes they are aiming to protect. Key recommendations for  
767 preventing zoonotic and zooanthroponotic diseases include opening a small clinic or nurse's

768 station within the park, providing deworming medication and rapid tests in first aid kits and  
769 keeping records of park staff's reported conditions at hospitals.

770

## 771 **Acknowledgments**

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## 775 **References**

- 776 1. Goldberg TL, Gillespie TR, Rwego IB, Estoff EL, Chapman CA. Forest Fragmentation as  
777 Cause of Bacterial Transmission among Nonhuman Primates, Humans, and Livestock,  
778 Uganda - Volume 14, Number 9—September 2008 - Emerging Infectious Diseases journal -  
779 CDC. 2008 [cited 2022 Mar 10]; Available from: [https://wwwnc.cdc.gov/eid/article/14/9/07-1196\\_article](https://wwwnc.cdc.gov/eid/article/14/9/07-1196_article)  
780
- 781 2. Lerner H, Berg C. A Comparison of Three Holistic Approaches to Health: One Health,  
782 EcoHealth, and Planetary Health. *Front Vet Sci.* 2017 Sep 29;4:163.
- 783 3. Devaux CA, Mediannikov O, Medkour H, Raoult D. Infectious Disease Risk Across the  
784 Growing Human-Non Human Primate Interface: A Review of the Evidence. *Front Public*  
785 *Health.* 2019 Nov 5;7:305.
- 786 4. Grützmacher K, Keil V, Leinert V, Leguillon F, Henlin A, Couacy-Hymann E, et al. Human  
787 quarantine: Toward reducing infectious pressure on chimpanzees at the Taï Chimpanzee  
788 Project, Côte d'Ivoire. *Am J Primatol.* 2018;80(1):22619.
- 789 5. Mazet JAK, Genovese BN, Harris LA, Cranfield M, Noheri JB, Kinani JF, et al. Human  
790 Respiratory Syncytial Virus Detected in Mountain Gorilla Respiratory Outbreaks.  
791 *EcoHealth.* 2020 Dec 1;17(4):449–60.
- 792 6. Palacios G, Lowenstine LJ, Cranfield MR, Gilardi KVK, Spelman L, Lukasik-Braum M, et  
793 al. Human Metapneumovirus Infection in Wild Mountain Gorillas, Rwanda. *Emerg Infect*  
794 *Dis.* 2011 Apr;17(4):711–3.

- 795 7. Chapman CA, Gillespie TR, Goldberg TL. Primates and the Ecology of their Infectious  
796 Diseases: How will Anthropogenic Change Affect Host-Parasite Interactions? *Evol*  
797 *Anthropol Issues News Rev.* 2005 Aug 25;14(4):134–44.
- 798 8. Kalema-Zikusoka G, Kock RA, Macfie EJ. Scabies in free-ranging mountain gorillas  
799 (*Gorilla beringei beringei*) in Bwindi Impenetrable National Park, Uganda. *Vet Rec.* 2002  
800 Jan 5;150(1):12–5.
- 801 9. Ryan SJ, Walsh PD. Consequences of Non-Intervention for Infectious Disease in African  
802 Great Apes. *PLOS ONE.* 2011 Dec 22;6(12):e29030.
- 803 10. Rupp S, Ambata P, Narat V, Giles-Vernick T. Beyond the Cut Hunter: A Historical  
804 Epidemiology of HIV Beginnings in Central Africa. *EcoHealth.* 2016 Dec 1;13(4):661–71.
- 805 11. Gray M, Kalpers J. Ranger Based Monitoring in the Virunga–Bwindi Region of East-Central  
806 Africa: A Simple Data Collection Tool for Park Management. *Biodivers Conserv.* 2005 Oct  
807 1;14(11):2723–41.
- 808 12. Bwindi Impenetrable National Park-2020 Conservation Impact Assessment. IUCN; 2020  
809 Dec p. 1–18.
- 810 13. UNESCO World Heritage Convention [Internet]. 2011 [cited 2022 Aug 13]. Bwindi  
811 Impenetrable National Park. Available from: <https://whc.unesco.org/en/list/682/>
- 812 14. Guerrero W, Sleeman JM, Jasper SB, Pace LB, Ichinose TY, Reif JS. Medical Survey of the  
813 Local Human Population to Determine Possible Health Risks to the Mountain Gorillas of  
814 Bwindi Impenetrable Forest National Park, Uganda. *Int J Primatol.* 2003 Feb 1;24(1):197–  
815 207.
- 816 15. Ali R, Cranfield M, Gaffikin L, Mudakikwa T, Ngeruka L, Whittier C. Occupational health  
817 and gorilla conservation in Rwanda. *Int J Occup Environ Health.* 2004 Sep;10(3):319–25.
- 818 16. Gilardi KV, Gillespie TR, Leendertz FH, Macfie EJ, Travis DA, Whittier CA, et al. Best  
819 Practice Guidelines for Health Monitoring and Disease Control in Great Ape Populations.  
820 IUCN; 2015.
- 821 17. Sandbrook C, Roe D. *Linking Conservation and Poverty Alleviation: the case of Great Apes.*  
822 Arcus Found. 2010;
- 823 18. Jason L, Glenwick D. *Handbook of Methodological Approaches to Community-based*  
824 *Research: Qualitative, Quantitative, and Mixed Methods.* Oxford University Press; 2016. 409  
825 p.
- 826 19. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research  
827 (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*  
828 [Internet]. 2007 [cited 2023 Mar 6]; Available from:  
829 <https://www.equator-network.org/reporting-guidelines/coreq/>

- 830 20. Adugna M, Nabbouh F, Shehata S, Ghahari S. Barriers and facilitators to healthcare access  
831 for children with disabilities in low and middle income sub-Saharan African countries: a  
832 scoping review | SpringerLink. BMC Health Serv Res [Internet]. 2020 [cited 2022 Aug  
833 18];20. Available from: <https://link.springer.com/article/10.1186/s12913-019-4822-6>
- 834 21. Rutherford ME, Mulholland K, Hill PC. How access to health care relates to under-five  
835 mortality in sub-Saharan Africa: systematic review. Trop Med Int Health. 2010;15(5):508–  
836 19.
- 837 22. Konde-Lule J, Gitta SN, Lindfors A, Okuonzi S, Onama VO, Forsberg BC. Private and  
838 public health care in rural areas of Uganda. BMC Int Health Hum Rights. 2010 Nov  
839 24;10(1):29.
- 840 23. Johns Hopkins Medicine [Internet]. 2019 [cited 2022 Aug 19]. Screening Tests for Common  
841 Diseases. Available from: <https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/screening-tests-for-common-diseases>
- 843 24. Msoka EF, Orina F, Sanga ES, Miheso B, Mwanyonga S, Meme H, et al. Qualitative  
844 assessment of the impact of socioeconomic and cultural barriers on uptake and utilisation of  
845 tuberculosis diagnostic and treatment tools in East Africa: a cross-sectional study. BMJ  
846 Open. 2021 Jul 1;11(7):e050911.
- 847 25. Petrželková KJ, Uwamahoro C, Pafčo B, Červená B, Samaš P, Mudakikwa A, et al.  
848 Heterogeneity in patterns of helminth infections across populations of mountain gorillas  
849 (*Gorilla beringei beringei*). Sci Rep. 2021 May 25;11(1):10869.
- 850 26. Kalema-Zikusoka G, Rothman JM, Fox MT. Intestinal parasites and bacteria of mountain  
851 gorillas (*Gorilla beringei beringei*) in Bwindi Impenetrable National Park, Uganda. Primates.  
852 2005 Jan;46(1):59–63.
- 853 27. Medkour H, Amona I, Laidoudi Y, Davoust B, Bitam I, Levasseur A, et al. Parasitic  
854 Infections in African Humans and Non-Human Primates. Pathogens. 2020 Jul;9(7):561.
- 855 28. Werkman M, Wright JE, Truscott JE, Oswald WE, Halliday KE, Papaiakovou M, et al. The  
856 impact of community-wide, mass drug administration on aggregation of soil-transmitted  
857 helminth infection in human host populations. Parasit Vectors. 2020 Jun 8;13(1):290.
- 858 29. Weldesenbet AB, Kebede SA, Ayele BH, Tusa BS. Health Insurance Coverage and Its  
859 Associated Factors Among Reproductive-Age Women in East Africa: A Multilevel Mixed-  
860 Effects Generalized Linear Model. Clin Outcomes Res. 2021 Dec 31;13:693–701.
- 861 30. Barker AR, Li L. The cumulative impact of health insurance on health status. Health Serv  
862 Res. 2020;55(S2):815–22.
- 863 31. CDC - Malaria [Internet]. 2022 [cited 2022 Aug 18]. Available from:  
864 <https://www.cdc.gov/malaria/about/faqs.html>

- 865 32. Allen LK, Hatfield JM, DeVetten G, Ho JC, Manyama M. Reducing malaria misdiagnosis:  
866 the importance of correctly interpreting Paracheck Pf® "faint test bands" in a low  
867 transmission area of Tanzania. *BMC Infect Dis.* 2011 Nov 3;11(1):308.
- 868 33. Cote CM, Goel V, Muhindo R, Baguma E, Ntaro M, Shook-Sa BE, et al. Malaria prevalence  
869 and long-lasting insecticidal net use in rural western Uganda: results of a cross-sectional  
870 survey conducted in an area of highly variable malaria transmission intensity. *Malar J.* 2021  
871 Jul 5;20(1):304.
- 872 34. Yeka A, Gasasira A, Mpimbaza A, Achan J, Nankabirwa J, Nsobya S, et al. Malaria in  
873 Uganda: challenges to control on the long road to elimination. I. Epidemiology and current  
874 control efforts. *Acta Trop.* 2012 Mar;121(3):184–95.
- 875 35. Reyburn H, Mbatia R, Drakeley C, Carneiro I, Mwakasungula E, Mwerinde O, et al.  
876 Overdiagnosis of malaria in patients with severe febrile illness in Tanzania: a prospective  
877 study. *BMJ.* 2004 Nov 18;329(7476):1212.
- 878 36. Allen KE, Beekmann SE, Polgreen P, Poser S, St. Pierre J, Santibañez S, et al. Survey of  
879 diagnostic testing for respiratory syncytial virus (RSV) in adults: Infectious disease  
880 physician practices and implications for burden estimates. *Diagn Microbiol Infect Dis.* 2018  
881 Nov 1;92(3):206–9.
- 882 37. Kalema-Zikusoka G, Rubanga S, Ngabirano A, Zikusoka L. Mitigating Impacts of the  
883 COVID-19 Pandemic on Gorilla Conservation: Lessons From Bwindi Impenetrable Forest,  
884 Uganda. *Front Public Health* [Internet]. 2021 [cited 2022 Nov 24];9. Available from: [https://](https://www.frontiersin.org/articles/10.3389/fpubh.2021.655175)  
885 [www.frontiersin.org/articles/10.3389/fpubh.2021.655175](https://www.frontiersin.org/articles/10.3389/fpubh.2021.655175)
- 886 39. COVID 19, Flu, RSV | Respiratory Multiplex qRT-PCR [Internet]. Nonacus. [cited 2023 Jul  
887 14]. Available from: <https://nonacus.com/covid-19-flu-rsv-multiplex/>
- 888 40. Wamai M. Makerere University. 2021 [cited 2023 Apr 27]. Mak Launches Homegrown  
889 COVID-19 Rapid Antibody Test Kits | Makerere University College Of Health Sciences |  
890 MakCHS. Available from: [https://chs.mak.ac.ug/news/mak-launches-homegrown-covid-19-](https://chs.mak.ac.ug/news/mak-launches-homegrown-covid-19-rapid-antibody-test-kits)  
891 [rapid-antibody-test-kits](https://chs.mak.ac.ug/news/mak-launches-homegrown-covid-19-rapid-antibody-test-kits)

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