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Evaluation of the Clinical Response Decision Tree for Respiratory Diseases in Mountain Gorillas (Gorilla beringeii beringeii) in the Virunga Massif

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ACCRONYMS AND ABBREVIATIONS

CDC	*: Centers for Disease Control and Prevention*
CRDT	*: Clinical Response Decision Tree*
DFGI	*: Dian Fossey Gorilla Fund International*
DRC	*: Democratic Republic of Congo*
EHP	*: Employment Health Program*
GIS	*: Geographical Information System*
HVA	*: Host country wildlife Veterinary Authorities*
ICCN	*: Institut Congolais pour la Conservation de la Nature*
IGCP	*: International Gorilla Conservation Program*
IMPACT	*: Internet-Supported Management Program to Assist Conservation Technology*
IRB	*: Institutional Review Board*
MGVP	*: Mountain Gorilla Veterinary Project*
MOH	*: Ministry of Health in Rwanda*
NGOs	*: Non-Governmental Organizations*
ORTPN	*: Office Rwandais du Tourisme des Parcs Nationaux*
PAA	*: Protected Area Authorities*
PDA	*: Personal Data Assistant*
PD	*: MGVP project director*
PNV	*: Parc National de Virunga*
RDB	*: Rwanda Development Board*

ABSTRACT

Approximately 336 (70%) of the 480 mountain gorillas living in the Virunga Massif are habituated for tourism or research and are visited daily by park rangers, scientists, veterinarians, guides, and tourists, which poses a risk of cross-species transmission of diseases. Clinical respiratory outbreaks are common and usually pose the greatest risk especially to infant gorillas, and they are suspected of being caused by pathogens shared with humans and other species. The clinical-response decision tree was developed to provide a consistent framework for evidence-based health intervention. We evaluated the decision tree to see how well this surveillance system operates to detect respiratory outbreaks in mountain gorillas.

The purpose was to assess whether the clinical decision tree for respiratory diseases in mountain gorillas in Virunga Massif was meeting its set objectives and detecting respiratory outbreaks in the gorilla population. We conducted a cross sectional study using CDC guidelines to evaluate the clinical decision tree. We reviewed clinical reports and assessed some of the attributes of this clinical surveillance system including the simplicity, flexibility, data quality, acceptability, sensitivity, predictive value positive, representativeness, timeliness and stability.

The clinical-response decision tree has helped to detect respiratory outbreaks in mountain gorillas. Four respiratory diseases outbreaks were detected in 2008 and two in 2009. More than 106 respiratory cases were detected using the decision tree from 2003-2010. Those cases accounted for more than 79 % of all the health conditions reported in mountain gorillas in the Virunga Massif during that period. The clinical-response decision tree is the product of a multidisciplinary group of veterinarians, epidemiologists, and public health professionals, with input and consensus from other stakeholders.

The clinical-response decision tree is a useful tool. It has changed clinical approaches in the response to respiratory outbreaks, particularly those involving multiple infants. It can detect any health problem in mountain gorillas based on routine clinical observations. Recommendations were formulated to make the decision tree more participatory for the high densely communities surrounding the Virunga Massif, considering the One Health approach. Findings and conclusions from this evaluation exercise have been disseminated accordingly to all stakeholders.

RÉSUMÉ

Environ 336 (70%) des 480 gorilles de montagne vivant dans les massifs de Virunga sont habitués aux humains et sont visités quotidiennement par les gardes du parc, les touristes, les scientifiques, les vétérinaires, et les guides, ce qui pose un risque de transmission des maladies. Les épidémies de maladies respiratoires sont fréquentes et posent généralement le plus grand risque en particulier pour les bébés gorilles, et ces maladies sont causées par des pathogènes communs entre les humains et les gorilles. L'arbre de décision clinique a été développé pour fournir un cadre cohérent d'intervention sur les gorilles basée sur des preuves objectives. Nous avons évalué cet arbre pour voir comment fonctionne ce système de surveillance pour détecter les épidémies des maladies respiratoires chez les gorilles de montagne.

Le but était d'évaluer si l'arbre de décision clinique pour les maladies respiratoires chez les gorilles de montagne dans les massifs de Virunga atteint ses objectifs fixés et détectent les épidémies des maladies respiratoires chez les gorilles. Nous avons mené une étude transversale utilisant les lignes directrices des CDC pour évaluer ce système de surveillance. Nous avons examiné les rapports cliniques et évalué les attributs de ce système de surveillance, à savoir la simplicité, la flexibilité, la qualité des données, l'acceptabilité, la sensibilité, valeur prédictive positive, la représentativité et la stabilité.

L'arbre de décision clinique a permis de détecter des épidémies des maladies respiratoires chez des gorilles de montagne. Quatre épidémies ont été détectées en 2008 et deux en 2009. Plus de 106 cas ont été détectés de 2003 à 2010. Ces cas représentaient plus de 79% de toutes les maladies signalées chez les gorilles de montagne dans les massifs de Virunga au cours de cette période. Cet arbre est le produit d'un groupe multidisciplinaire de vétérinaires, des épidémiologistes et des professionnels de la santé publique, avec la participation et le consensus des autres partenaires.

L'arbre de décision clinique est un outil utile. Il a changé les approches cliniques dans la réponse aux épidémies respiratoires, en particulier celles affectant les enfants gorilles. Il permet de détecter tout problème de santé chez les gorilles de montagne sur la base des observations cliniques de routine. Des recommandations ont été formulées pour faire ce système de surveillance plus participatif pour les communautés environnantes des massifs de Virunga, en tenant compte de l'approche de santé unique.

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Mountain gorillas (Gorilla gorilla beringei) are highly endangered sub-species of great apes. They are at risk due to their habitat being surrounded by high densities of human populations and well-established intense gorilla-based eco-tourism.

Due to conservation purposes and the growing eco-tourism, many groups of free ranging gorillas have been habituated to humans (1,2). With increased habituation of mountain gorillas close contact between humans and mountain gorillas has led to increase in potential of disease transmission between humans and gorillas. The threat of disease looms as a recognized high risk to the viability of these small populations.

Habituation of mountain gorillas to humans is a management choice justified for conservation of these endangered animals and economic factors. Mountain gorillas represent an important revenue source for African countries and therefore their disease status is constantly monitored (2).

Individual health care for 50% of the Mountain gorilla population is possible because of habituation. Dian Fossey habituated the Virunga Mountain gorillas to the presence of humans at close distances to enhance her behavioral studies. More recently, further gorilla groups have been habituated to support a very successful tourism industry. Approximately 70% of the Virunga Massif gorillas, 30% of the Bwindi gorillas and a handful of Eastern lowland gorilla groups are habituated.

The Mountain Gorilla Veterinary Project (MGVP) monitors the health of free-ranging habituated mountain gorillas (Gorilla beringei beringei) in Rwanda, Uganda and the Democratic Republic of Congo, and Grauer's gorillas (Gorilla beringei graueri) in the Democratic Republic of Congo.

MGVP staff also strive to develop programs and technologies that have applications in a larger context, benefiting gorillas as well as other species. Figure 1 reflects the organization's one-health approach: the health of the gorillas is dependent on a wide circle of health that includes the surrounding populations with which they interact. It takes an integrated team of experts trained in many disciplines to accomplish this comprehensive approach. MGVP Inc. must also integrate its vision, mission, and goals with those of the combined government agencies and NGOs responsible for the gorilla ecosystem as well as the broader needs of the community and country. Lastly, the staff team must be flexible in order to implement these strategies within different political and cultural situations.

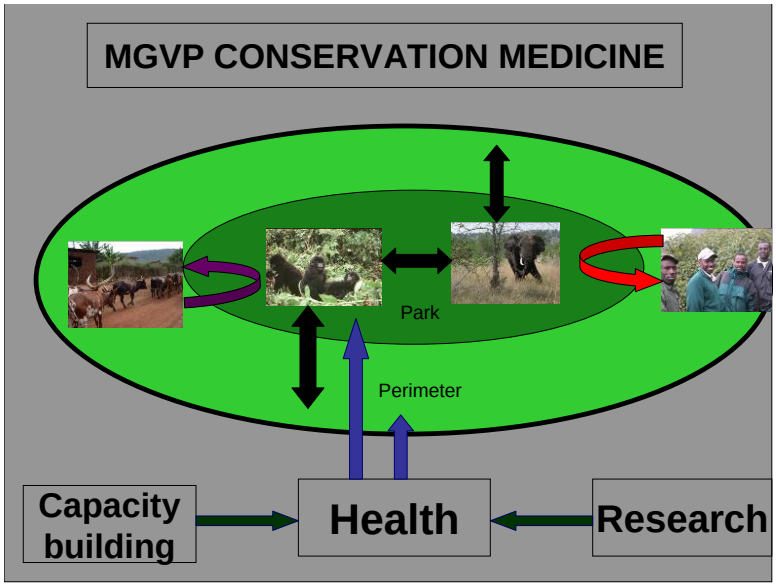


Figure 1: Concept of "one-health"

Source: MGVP Inc.

Conservation medicine has been defined as a specialty field of study that exists at the intersection of animal, human, and ecosystem health. It differs from classical public health epidemiology in that it aims to protect and improve ecosystem and animal health, in addition to human health. Conservation medicine studies diseases shared between or among species and interactions with environmental variables over long-term biological and spatial scales. Zoonotic diseases and the emergence of new diseases are therefore of primary concern, and are particularly important when threatened and endangered great ape populations are involved.

MGVP also provides emergency and routine health care for orphaned gorillas confiscated from poachers. Veterinary intervention is rare and only performed when the gorilla's illness or injury is life threatening, and usually only when the problem is human induced. Otherwise, the veterinary team monitors the health of the gorillas by non-invasive methods, including direct observation of clinical signs as well as collection of fecal samples, and occasionally urine or other bodily fluid samples for diagnostic screening (1).

Human-origin diseases are of particular concern among mountain gorillas. In Rwanda, three quarters of the mountain gorillas are habituated for tourism or research and are visited daily by park rangers, scientists, veterinarians, guides, and tourists, which poses a risk of cross-species transmission of diseases.

To better understand the basic epidemiology of diseases within the ecosystem and monitor gorilla health, a standardized method of data collection and analysis was developed and implemented. As a byproduct, this led to the design of a clinical decision tree to standardize the intervention response to health-related issues. This decision tree is helping to ensure standardized data collection so that meaningful comparisons can be made to better assess risk and risk-management options (3).

1.2. PROBLEM STATEMENT

For conservation purposes and due to increased eco-tourism, some populations of mountain gorillas have been habituated to human beings. The increase in interactions between the gorillas and man can enhance anthropozoonotic pathogens (4,5), which can lead to occurrence of disease. The popularity of tourism has brought enormous amounts of interest in the gorillas. This same eco-tourism innovation used to protect the gorillas has led to increased gorilla exposure to people and brings potential carriers of diseases within sneezing distance of the gorillas on a daily basis. Yet, so little is known about the risks this has created for these unique animals (6,7). Disease is one of the factors that could lead to a population crash (2). If disease is considered to be a major issue in the conservation of mountain gorillas, there is a need for development of conceptual mapping process to illustrate the potential sources of disease and their potential impact on gorillas. Mountain gorillas periodically suffer from illnesses and especially respiratory infections,

some of which are suspected of being caused by pathogens shared with humans and other species (8).

To better understand the basic epidemiology of diseases within the ecosystem and monitor gorilla health, a standardized method of data collection and analysis was developed and implemented. As a byproduct, this led to the design of a clinical decision tree to standardize the intervention response to health-related issues. This decision tree is helping to ensure standardized data collection so that meaningful comparisons can be made to better assess risk and risk-management options (3,9).

This study addresses the problem of respiratory diseases in mountain gorillas and how the clinical response decision tree helps to detect them in the Virunga Massif. We have evaluated the syndromic surveillance system using the CDC guidelines for surveillance systems evaluation (10).

1.3. JUSTIFICATION OF THE STUDY

The Mountain Gorilla Veterinary Project and the Rwanda Development Board / Conservation Department monitor the health of the gorilla population by observation, non-invasive biological sampling, and post mortem examination. Important baseline data is collected infrequently and on an opportunistic basis for example during interventions. Zero disease risk does not realistically exist and is the reason for the development of a contingency plan. This plan helps to maintain a science-based decision-making and ensure that MGVP activities link directly to the mission: an integrated, or one-health, approach that improves the sustainability of Mountain Gorilla populations.

The limited availability of local laboratories and validated field-based diagnostic tests for gorillas hamper the ability to obtain a definitive diagnosis in the presence of clinical signs. Therefore, identification and assessment of the severity of clinical signs become important. Due to limited availability of quantitative information, this assessment has been primarily qualitative in nature. The World Trade Organization, the Food and Agricultural Organization of United nations and the

Organization of the United Nations of International Epizootics- the international standard setting body for animal diseases have recognized qualitative risk assessment as a valid tool (9,11).
This plan must be useful in the real world of veterinary medicine and therefore must deviate from plans used in human medicine due to differences in the populations of concern. These differences/issues include: dependency on observed clinical signs rather than verbal communication for patient assessment, difficulties in performing physical examinations on gorillas, and the necessity for decisions regarding immobilization, sample collection, diagnostic test validation and treatment/vaccine efficiency.
It is with this background that the clinical response decision tree was designed. MGVP established a data collecting form including a place to record spatial data to be used by guides and trackers plus a computerized database as important elements of a health monitoring system.

Since the clinical response decision tree was established, it has helped to detect and respond to a number of respiratory cases in the mountain gorilla population.

1.4. OBJECTIVES OF THE STUDY

The overall objective was to evaluate the clinical response decision tree with focus on respiratory diseases in mountain gorillas in the virunga massif.

The study had the following specific objective: evaluate the following attributes of the clinical response decision tree for respiratory diseases: Usefulness, Simplicity, flexibility, Data quality, Acceptability, Sensitivity, Predictive value positive, representativeness, timeliness and stability.

Before evaluating the Clinical Response Decision Tree, we have described the system in the chapter here below.

CHAPTER TWO

DESCRIPTION OF THE CLINICAL RESPONSE DECISION TREE USED FOR RESPIRATORY DISEASES IN MOUNTAIN GORILLAS IN THE VIRUNGA MASSIF

To describe the Clinical Response Decision Tree (CRDT) used for respiratory diseases in mountain gorillas, we followed this approach:

- Present the public health importance of respiratory diseases in mountain gorillas
- Present the purpose and objectives of the CRDT
- Describe the population under surveillance
- Describe the case definition used for respiratory diseases in mountain gorillas
- Describe the surveillance system
- Describe the resources needed to run the system

2.1. PUBLIC HEALTH IMPORTANCE OF RESPIRATORY DISEASES IN MOUNTAIN GORILLAS

Gorillas share a > 98% genetic similarity with humans (6) and are susceptible to many human diseases, as well as zoonotic diseases associated with livestock.
Opportunistic blood samples have shown that gorillas lack antibodies and are probably naive to many diseases that are endemic to the region (i.e., measles). If such diseases are introduced, they may cause high morbidity and mortality, which makes this a high-risk population for a serious epidemic (4) (7).

In Rwanda, there is a very dense population of 350-600 people/km^2 around the virunga massif.
In addition, there is no buffer zone between the gorilla's remaining habitat and the densely populated farmland that surrounds the park. Many people in the local population suffer from poverty and limited medical care.

In the Parc National de Virunga (PNV Rwanda), each gorilla has 2000-3000 tourist visitors/year, the visitation rules are not always followed, some gorillas are over habituated, and people and livestock from local community enter park to collect water, hunt, and to cultivate.

Antibodies to a number of pathogens have been found in mountain gorilla serum including influenza A and B, parainfluenza types 1, 2 and 3, measles, human herpes simplex 1 and adenovirus (12). Mycobacterium tuberculosis, rhinovirus, respiratory syncytial virus and coronaviruses are also of concern due to their presence in surrounding human populations.

Table I shows some high risk diseases for gorillas, including respiratory diseases and figure 2 shows some humans diseases that can pose a threat to the health of gorillas.

TABLE I: High risk diseases for gorillas

Disease	Morbidity in great apes	Mortality in great apes	Impact on Humans
HIGH RISK			
Mycobacterium tuberculosis	**High**	**High**	**High**
Mycobacterium bovis	**High**	**High**	**High**
Measles	**High**	**High**	**Low**
Strep pneumonia	**High**	**High**	**Medium**

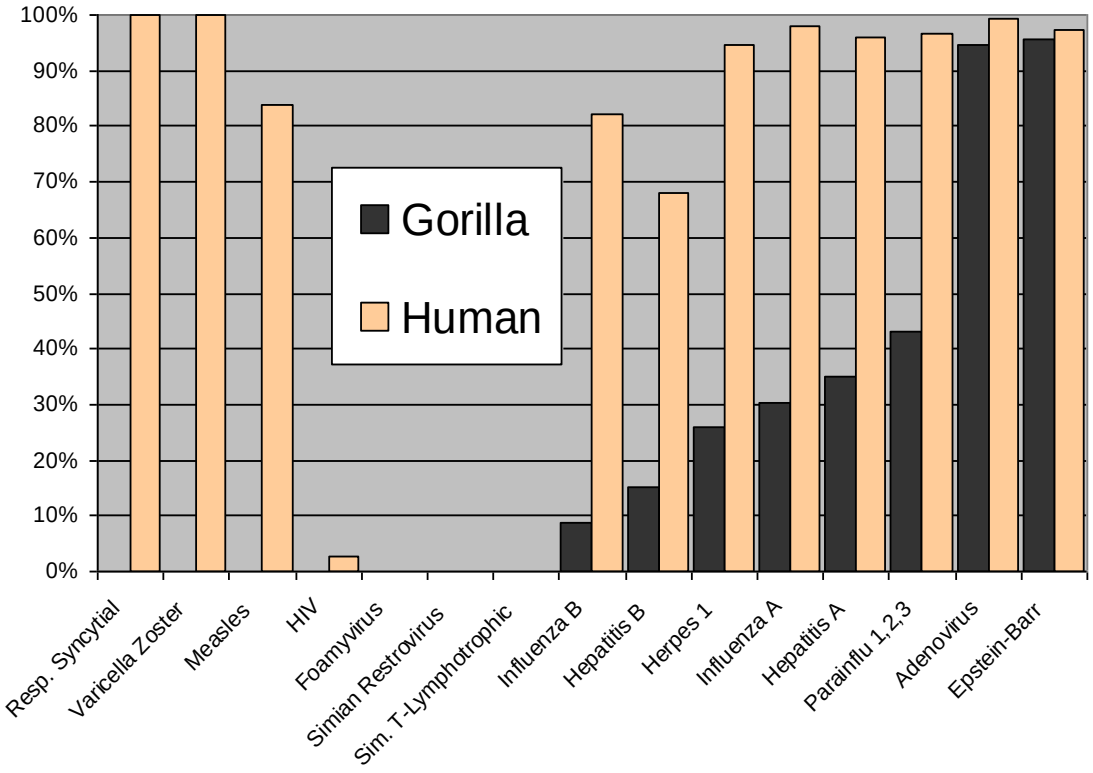


Figure 2: Diseases of Humans versus those of Gorillas

If we rule out natural trauma, respiratory diseases become the primary cause of mortality in mountain gorillas. Also many interventions conducted by MGVP in the mountain gorilla population during 2007-2009 were on respiratory diseases (MGVP reports).

Table II below shows the historic mortality data and mortality rates of important diseases in moutain gorillas in the virunga massif.

TABLE II: Historic mortality data in percentage, mid 1970's – 2005

Cause	Infant (birth to < 3 years)	Juvenile (3 to <10♀ and 13♂)	Adult (>10♀ and 13♂)	% of Total
Trauma (incl. infanticide)	15	9	16	40%
Respiratory	8	6	10	24%
Undetermined	9	1	7	17%
Multifactorial	1		4	5%
Gastrointestinal	1	1	2	4%
Metabolic	1	1	1	3%
Cardiac			3	3%
Infectious - other			1	1%
Developmental	1			1%
Neurologic	1			1%
Parasitic	1			1%
Total	38	18	44	100%

Source: Magdalena Lukasik-Braum, DVM, MGVP, Pers. Comm.

From 2007 to 2009, there has been 9 mortality cases (50%) resulting from trauma (including infanticide), 4 cases (22%) from respiratory illnesses, 2 undetermined cases (11%), 3 cases (17%) from metabolic illnesses (including cancer).

Mountain gorillas periodically suffer from illnesses and especially respiratory infections, some of which are suspected of being caused by pathogens shared with humans and other species (8). Many interventions of MGVP are on respiratory cases and this has decreased the percentage of deaths related to respiratory ailments.

Due to the importance of respiratory diseases in the Mountain Gorillas populations, this study suggests to evaluate the Clinical Response Decision Tree (CRDT) which is an integrated symptomatic surveillance system used to support decision making for clinical interventions when necessary. The CRDT encompasses many diseases including respiratory diseases.

2.2. PURPOSE AND OBJECTIVES

The MGVP's clinical-response decision tree was created for two purposes: The first was to standardize protocols for risk assessment in order to aid veterinarians and managers in making objective evidence-based intervention decisions that can be easily communicated and provide consistency in veterinary care among clinicians in the context of three different countries' management systems which are Rwanda, Uganda and the Democratic Republic of Congo.
The second was to categorize risk and thus act as a trigger to commence the actions for reducing the likelihood that a disease, once introduced, will cause a major outbreak or epidemic in the mountain gorilla population.

2.3. POPULATION UNDER SURVEILLANCE

The population of mountain gorillas living in Virunga Massif has grown by 26.3% to approximately 480 individuals in the past seven years according to the newly released results of the 2010 mountain gorilla census. The last mountain gorilla census of the Virunga region in 2003 estimated a total of 380 animals. The 447 sq km Virunga Volcanoes Massif, which encompasses Volcanoes National Park in Rwanda, Virunga National Park in DRC and Mgahinga National Park in Uganda. Some 302 additional mountain gorillas live in Uganda's Bwindi Impenetrable National Park, which was not included in this year's census (Figure 3).

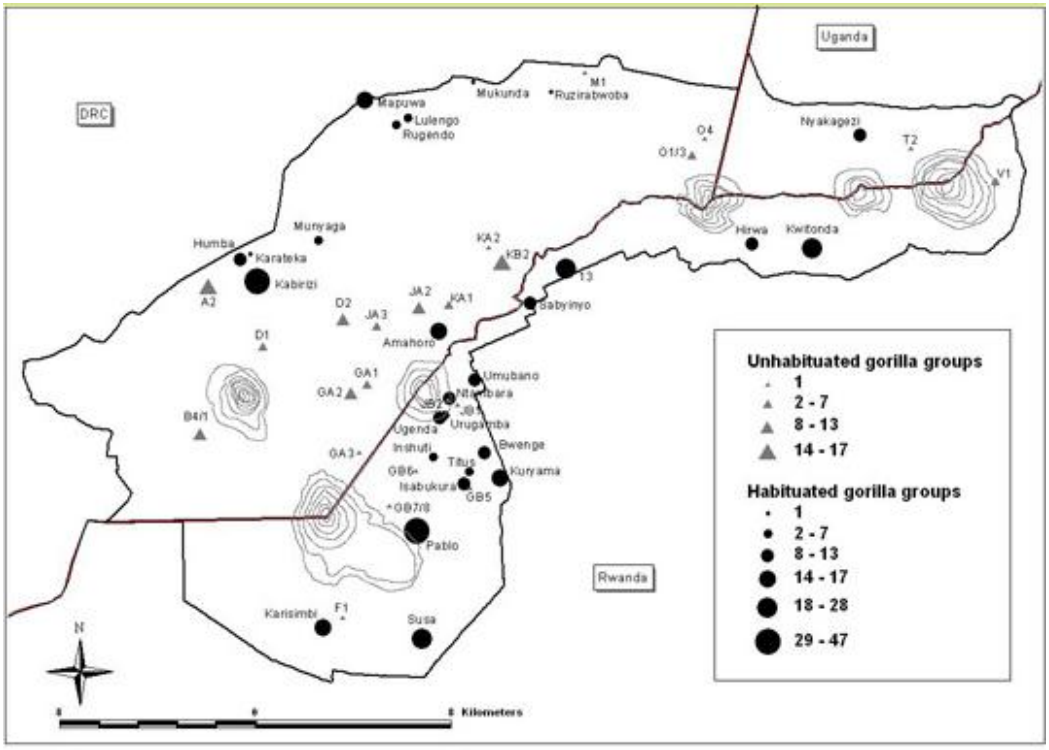


Figure 3: Map showing location and size of gorilla groups in the Virungas.
Source: MGVP Inc.

Human habituated gorilla groups that are visited and monitored every day comprise ~70% of the Virunga population and about 25% of the Bwindi population. Accounting for all potential visitors, (guides, researchers, tourists, veterinarians, guards, and sometimes porters and military personnel) gorillas in any habituated group typically average 8-12 person-hours of contact each day. That adds up to many thousands of human contact hours per year, most within 5-10 meter proximity (13).

<u>Habituated mountain gorilla groups in the Virunga Massif, Rwanda, DRC, and Uganda</u>

Tourist Groups in Rwanda (7): 1. Susa, 2. Amahoro, 3. Kwitonda, 4. Group 13, 5. Hirwa, 6. Sabinyo, and 7. Umubano.

Research Groups in Rwanda (3): 1. Pablo, 2. Shinda, 3. Beetsme

Tourist Groups in DRC (7): 1. Rushegura, 2. Rugendo, 3. Humba, 4. Kabirizi,

5. Lulengo, 6. Mapuwa, and 7. Munyaga.

Tourist Groups in Uganda: none at the present time

Habituated mountain gorilla Groups in Bwindi Impenetrable Forest, Uganda

Tourist Groups (5): 1. Habinyanja, 2. Mubale, 3. Nkuringo, 4. Rushegura, and 5. Nyakagezi

Research Groups (1): 1. Kyagurilo

2.4. CASE DEFINITION

An individual gorilla with a respiratory disease presents with respiratory clinical signs with the severity rating from mildly or moderately abnormal to highly abnormal. The clinical signs definitions are presented in the table III below.

Table III: The Data dictionary of the clinical parameters and signs with Severity ratings for the clinical decision tree of the Mountain Gorilla Veterinary Project – Respiratory check up.

		Severity rating		
Parameter	Clinical sign definition	None or normal	Mildly or moderately abnormal	Highly abnormal
Respiratory: Relating to respiration which is the talking in of oxygen and expiration of oxidation products	**Breathing rate**: Frequency of breathing, record as no. of breathes / minute	When the observer visualizes the nostrils and the chest and the animal appears comfortable and you barely visualize the movement of the chest and there are no audible sounds	Slow: Breathing observed as <15 breathes/minute and audible sounds may/may not be heard	Fast: When breathing is >25 minute /with / without audible sounds in a resting state
	Breathing difficulty: A problem in exhalation and inhalation	No breathing difficulty shown	Labored: Visible respiratory effort by an individual without respiratory noise	Extremely Labored: Visible respiratory effort by an individual with audible respiratory noise
	Coughing quality: Coughing is sudden explosive forcing of air through the glottis & larynx	No coughing	Dry: Harsh, grating, short sound with no mucus production	Productive: Moist sounding cough associated with exudates
	Coughing pattern: The sequence of coughing	Doesn't interrupt the activities of an individual	Periodic: Interemittent interruption of the individuals activities due to coughing	Continuous: Coughing >1 time in 5 minutes And interrupt the animal's activities
	Sneezing: Expelling air from the nose and mouth by involuntary spasmodic contraction of muscles of respiration	One or fewer episodes of sneezing per observation	Periodic: Episodes of sneezing that are isolated events with periods of >15 minutes between them	Continuous: >1 episodes of sneezing within <5 minutes

2.5. THE CLINICAL RESPONSE DECISION TREE

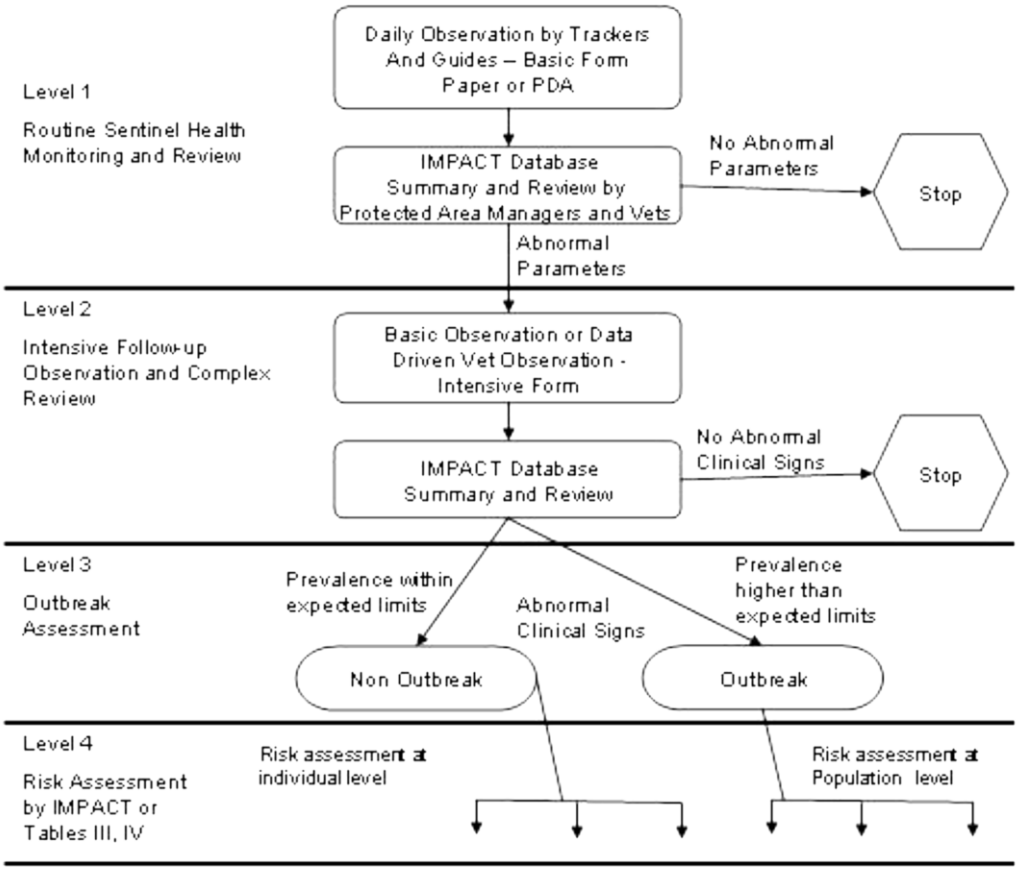
The Mountain Gorilla Veterinary Project has been making health intervention decisions since 1986. The decision to intervene has often been made subjectively due to poorly defined criteria that are often influenced by emotion. The Clinical Response Decision Tree provides a consistent framework for evidence-based health intervention decision making.

The decision tree is a five-tier process consisting of routine sentinel health observation, intensive follow-up veterinary health observation, outbreak assessment, risk assessment, and risk management.

The decision-tree process consists of five hierarchical levels (Figure 4):

Level 1: The collection and review of routine sentinel health monitoring data by trackers, guides, and/or behavioral researchers utilizing a basic standardized health observation form (paper-based or on a specially programmed personal data assistant (PDA)). Here trackers communicate problems.
Level 2: Intense follow-up observations by trained health personnel using a more complex form focused on abnormalities from the basic observation data with a more detailed level of review. Veterinarian or tech visits next day to collect data.

Level 3: Outbreak assessment that places the scenario into either an outbreak or non-outbreak category according to the prevalence of clinical signs or a definite diagnosis. We assess the risk at this level.
Level 4: Assessment and categorization into low, medium, or high risk at the individual or population level.
Level 5: Risk management through implementation of the contingency plan. Action depends on outcomes on level 3 and 4.



Level 5
Risk Management

Action	Low	Medium	High	Low	Medium	High
Immobilization	N/A	±	+	N/A	±	+
Diagnostics						
a) invasive	N/A	±	+	N/A	±	+
b) non-invasive	±	±	+	±	±	+
Treatment	N/A	±	+	±	±	+
Continued Observation	±	+	+	+	+	+
Outside Help	N/A	N/A	±	N/A	± reg	reg ± inter
Action Plan	N/A	N/A	+	±	+	+
Preventive Action	N/A	±	±	±	±	+
Reporting	PA + PD	PA + PD	PA + PD	PA + PD	S + SH + PH	S + Approp Inst.
Export Permits	N/A	N/A	N/A	N/A	±	+

Figure 4: Flow chart of the clinical - response decision tree for mountain gorillas (Gorilla beringei). N/A: not applicable; ±: decision on individual case basis; reg: regional or in-country veterinarians can handle situation; inter: international help needed; PA: protected area authority; PD: MGVP project director; PH: public health official; SH: stakeholders; S: subsequent groups; Approp Inst: appropriate institution (e.g., NIH or CDC).

2.5.1. Level One: Routine Health Monitoring and Review

Routine sentinel observational monitoring is the foundation of the health program for the mountain gorilla. Individual animals are observed for abnormalities that may indicate a health problem. Routine health observation data are gathered either by the trackers and guides or researchers on either a paper form or a PDA. Data are downloaded into an Internet-based data system (produced by the MGVP Database Team) called the Internet-Supported Management Program to Assist Conservation Technology (IMPACT™). A strict data dictionary (Table III) in conjunction with thorough training ensures the consistency and accuracy of the data. Utilizing the PDA, the observer identifies and enters the name of the group being observed, and the PDA automatically lists the names of the gorillas in the group. If the observer is utilizing the paper form, he picks the premade form that contains the names of the gorillas in the group being observed. The observer then records whether an individual animal was or was not observed (Figure 5a). If an animal is marked as observed, the program asks which of the following parameters were observed: A) body condition, B) activity, C) respiratory system, D) skin/hair, E) discharge from head orifices, F) discharge from other areas of the body, G) stool, or H) other parameters. The table III shows the different parameters considered in the case of a respiratory disease. Each parameter is then recorded as normal or abnormal, and the observer has the ability to enter a text description for each abnormality noted (Figure 5b).

Data collected on paper are entered into an Internet interface, while PDA data can be directly uploaded into IMPACT™. Once the data are uploaded, reports are automatically generated by IMPACT™ as shown in Table IV. In this example, no abnormalities were reported, so no further action would be indicated by the decision tree. The observation data are used to compile the normal prevalence rates of the parameters observed (see Figure 4, level 1). When level 1 routine observations indicate abnormal systems (Table V), the tool will direct the veterinarian or trained health personnel to complete a level 2 intensive follow-up observation for complex data collection and review (see Figure 4, level 2).

2.5.2. Level Two: Intensive Follow-Up Observation, With More-Complex Data Collection and Review

The second level of data collected for input into the decision tree requires trained field health personnel to conduct a second observation of the group to confirm the accuracy of the basic data. This evaluation utilizes a more detailed and complex paper form or PDA observation module in the IMPACT™ program.

This program is very similar in design, function, and use to the basic level program, but when a parameter with an abnormality is entered (Figure 5a), a screen appears with a list of strictly defined clinical signs to describe the abnormality in greater detail (Table III, Figure 5b). If, as in the example of Table V, a routine basic observation report indicates abnormalities, and a subsequent intensive follow-up observation shows that the abnormalities are resolved (i.e., the animal stopped coughing and the wound is healing), no further action would be taken and data are stored in the database of epidemiological information. If the intensive follow up observation shows abnormal clinical signs, as in Table VI, a decision has to be made as to whether the abnormality should be considered a non-outbreak or outbreak situation (see Figure 4, level 3).

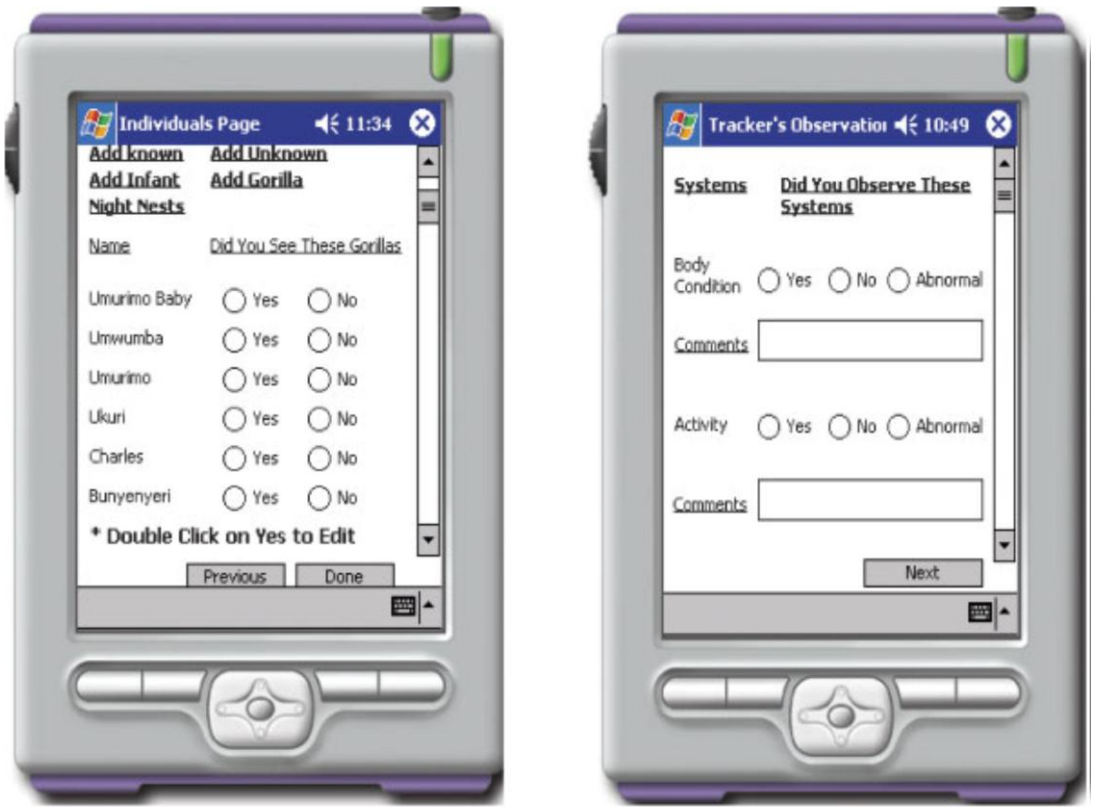


Figure 5: Screen capture of the IMPACT™ PDA data collection basic observation program showing (a- left) a list of individuals found in the observed group and (b- right) the observation of an individual gorilla, asking which parameters were seen and whether they were normal or abnormal.

2.5.3. Level Three: Outbreak Assessment

An outbreak is defined as the occurrence of a disease or other health-related event in excess of what would be expected for the specific region and period of time. Although an outbreak may be defined by a single case, the term often implies that several individuals are affected. Important considerations in the investigation of an outbreak of infectious disease includes determining that an outbreak is in fact occurring and defining the extent of the population at risk.

Given that data gaps in knowledge of the baseline prevalence of clinical signs and diseases in the mountain gorilla exist, outbreak assessment may initially prove to be the most challenging task. In the past, the identification of an outbreak was based on the collective experience and subjective judgment of the park manager and veterinarians. Currently, outbreaks are defined on the basis of past clinical observations and the new data being amassed by IMPACT™, and the veterinarians and park managers can confirm or override the program at any point. One benefit of

this system is that IMPACT™ records and updates the prevalence rates of clinical parameters and signs both spatially and temporally as it monitors for health. This was one of the faults of previous nonuniform health data collection methods, which frequently recorded data only from unhealthy animals.

Table IV. IMPACT Report from Level 1 Routine Observation with No Abnormal

Your data have been uploaded into IMPACT and analyzed	
Date of observation (s): 02/02/04	
Group Observed: Sabyinyo	
Number of individuals in the group observed	9 or 100%
Number of individuals in the group not observed	0 or 0%
Total group size	9
Number of dead gorillas observed	0
Number of non-group members observed	0
Total number of individuals observed	9
Number of abnormal parameters	0
Number of individual gorillas with abnormal parameters	0
Number of new abnormal parameters since	0
Yesterday	0
2–3 days	0
Last week	0

Tracker and guide detailed summary

	Number of abnormalities by parameters:	
Parameters	Normals	Abnormals
Body condition	9	0
Activity	9	0
Respiratory	4	0
Skin/hair	4	0
Discharge-head	2	0
Discharge-other	0	0
Stool	0	0
Other system	0	0

Individuals observed with abnormalities: 0

Name	Parameter (s) abnormal
None	None

Comments

Gorilla	Comments
None	None
Action to be taken	None

As shown in Table V, if abnormal clinical signs are equal to or less than those expected (i.e., the coughing resolved, but the cut turned out to be a snare) it is considered a non-outbreak situation

(see Figure 4, level 4) and the data are stored. Non-outbreak assessments usually deal with individual welfare issues.

If the prevalence of abnormal clinical signs is higher than expected, as we see in Table VI, the scenario would be assessed as an outbreak (see Figure 4, level 4). Outbreak risk assessment would more likely involve population welfare.

TABLE V. IMPACT Report for Level 1 Routine Observation with Abnormal Parameters

Your data have been uploaded into IMPACT and analyzed	
Date of observation (s): 02/02/04	
Group Observed: Sabyinyo	
Number of individuals in the group observed	9 or 100%
Number of individuals in the group not observed	0 or 0%
Total group size	9
Number of dead gorillas observed:	0
Number of non-group members observed	0
Total number of individuals observed	9
Number of abnormal parameters	2
Number of individual gorillas with abnormal parameters	2
Number of new abnormal parameters since	
Yesterday	2
2–3 days	
Last week	2

Tracker and guide detailed summary

	Number of abnormalities by parameters:	
Parameters	Normals	Abnormals
Body condition	9	0
Activity	9	0
Respiratory	4	1
Skin/hair	4	1
Discharge-head	2	0
Discharge-other	0	0
Stool	0	0
Other system	0	0

Individuals observed with abnormalities:

Name	Parameter (s) abnormal
Kabatwa	Respiratory
Turiho	Skin/hair

Comments:

Gorilla	Comments
Kabatwa	Coughing a lot
Turiho	Cut on left wrist
Action To Be Taken	Conduct intensified observation and more complex data collection and review

Figure 6: Screen capture of the IMPACT™ PDA data collection intensive observation program showing (a - left) the observation of an individual gorilla, asking which parameters were seen and whether they were normal or abnormal, and (b- right) the specific clinical signs for the body condition of the observed individual.

2.5.4. Level 4: Risk Assessment and Categorization As Low, Medium, or High Risk

Risk assessment is the process of estimating the implications of a disease/ hazard introduction, and results in a final estimation or characterization of the risk. Risk assessment is a logical process by which risks are evaluated based on available scientific information. This standardized format for risk assessment supports veterinarians in making evidence-based decisions in the field. It also provides organization to vital communication efforts among field personnel, the park authority, veterinarians, and other NGO stakeholders. In order for the process to work and to ensure transparency, both the assumptions made and the factors that contribute to certainty in estimates of risk must be fully elucidated and documented.

In the vast majority of cases in the field, risk assessment is based on observational/clinical signs because of the limited availability of quantitative information. Therefore, the assessment is primarily qualitative in nature.

Although qualitative risk assessment is not as desirable as quantitative assessment, it has been recognized as a valid tool by the World Trade Organization, the Food and Agricultural

Organization of the United Nations, and the Organization of International Epizootics. This decision tree must function in the stochastic world of veterinary medicine in a field situation. Therefore, it must deviate from decision mechanisms used in human medicine.

These deviations include dependency on observed clinical signs rather than verbal communication for patient assessment, the risk and difficulties of performing routine physical exams on gorillas, and the need, in the majority of cases, to anesthetize the animal for sample collection and treatment. Available human diagnostic tests may or may not be validated for gorillas, and thus have questionable diagnostic value. Although the risk-assessment decision-tree process is initiated by qualitative data, quantitative data should also be collected for confirmation or to reduce uncertainty in the characterization of risk. Over time, IMPACT^{TM} will acquire the quantitative data needed to help make the decisions objective.

TABLE VI: IMPACT Report from Intensified Observation as a Follow-Up to the Routine Observation of Sabinyo Group (Table V) Where Two Individuals Were Observed With Abnormal Parameters That Have Not Resolved, and Additional Cases Were Observed Thereby Indicating an Outbreak Situation

Your data have been uploaded into IMPACT and analyzed	
Date of observation (s): 02/02/04	
Group Observed : Sabyinyo	
Number of individuals in the group observed	9 or 100%
Number of individuals in the group not observed	0 or 0%
Total group size	9
Number of dead gorillas observed	0
Number of dead gorillas with clinical signs of infection	0
Number of dead gorillas without clinical signs of infection	0
Number of non-group members observed	0
Total number of individuals observed	9
Number of abnormal parameters	
Number of abnormal clinical signs	5
Number of individual gorillas with abnormal clinical signs	3
Number of mild or moderate abnormalities	5
Number of mild or moderate infectious abnormalities	2
Number of mild or moderate noninfectious abnormalities	1
Number of mild or moderate undetermined (+/–) abnormalities	2
Number of severe abnormalities	0
Number of severe infectious abnormalities	0
Number of severe noninfectious abnormalities	0
Number of severe undetermined (+/–) abnormalities	0
Number of new abnormal clinical signs since	
Yesterday	1
2–3 days	2
Last week	3
Number of new mild or moderate abnormalities since	
Yesterday	1
2–3 days	2
Last week	3
Number of new severe abnormalities since	
Yesterday	0
2–3 days	0
Last week	0
Estimated Transmission Rate for this group	High
Estimated Mortality Rate for this group	Low
This group is probably in an outbreak.	
If it is in an outbreak the risk level for this group is medium.	
Action to be taken: Continue observation, alert protected area manager and project director	

Veterinarian detailed summary

	Number of abnormalities by parameter		
Parameter	Normal	Mild or Moderate	Severe
Body condition	9	0	0
Activity	9	0	0
Respiratory	7	2	0
Skin/hair	8	1	0
Discharge-head	7	2	0
Discharge-other	9	0	0
Stool	2	0	0
Other system	0	0	0

Individuals observed with abnormalities

Name	Parameter abnormal
Turiho	Skin/hair
Guhonda	Respiratory, discharge-head
Kabatwa	Respiratory, discharge-head

Comments:

Gorilla	Comments
Turiho	Would healing well, using hand normally
Guhonda	Continuous productive coughing
Kabatwa	Continuous productive coughing

Level 4A. Risk assessment for an outbreak scenario

Risk assessment for an outbreak usually involves group or even population level decisions. This paper presents two methods by which outbreak risk can be assessed. The first method, disease diagnosis, is derived from clinical signs or diagnostic test results (see Table VII for examples). The categories of low, medium, and high risk are derived from data on morbidity and mortality rates from human medicine, experience with nonhuman primates in captivity, and limited disease experience in wild ape populations. Table VII updates occur as new information becomes available. The second method, which is used for cases in which a definitive diagnosis cannot be made, incorporates a combination of clinical signs, postmortem examination results, and estimated transmission and mortality rates (Table VIII). Data are analyzed by the IMPACT™ system and placed into risk categories and implementation strategies that are then confirmed by veterinarians.

The risk categories were compiled from past experiences by a team of experienced field and captive primate veterinarians, as well as veterinary and human epidemiologists. Table VIII is dynamic and will constantly be updated as IMPACT™ incorporates its own data into the decision tree.

To make risk categorization consistent and functional, parameters and clinical signs were defined and ranked by severity (Table III). The rate of transmission is defined as low (no or one new case in o3 days), medium (one new case every 2–3 days), and high (one or more new cases per day). Mortality rates are defined the same as transmission rates. If multiple observations are not available to calculate transmission and mortality rates, the field veterinarian must rely on past experience to estimate these rates.

TABLE VII: Risk Assessment for the MGVP Clinical Decision Tree by Disease Diagnosis

Disease	Morbidity in great apes	Mortality in great apes	Impact on humans
High risk			
Ebola	High	High	High
Other hemorrhagic fevers	High	High	High
Encephalomyocarditis	High	High	Medium
Rabies	Low	High	High
Polio	High	High	High
Shigella	High	High	Low
Mycobacterium tuberculosis	High	High	High
Mycobacterium bovis	High	High	High
Measles	High	High	Low
Strep pneumonia	High	High	Medium
Medium risk			
Entamoeba histolytica	Medium	Low	Medium
Rotavirus	Low	Low	Medium
Respiratory sincytial virus	High	Low	Medium
Monkeypox	High	Low	Medium
Low risk			
Parainfluenza	High	Low	Low
Coronavirus	Low	Low	Low
Salmonella	Low	Low	Low
Campylobacter	Low	Low	Low
Sarcoptes	Medium	Low	Low
Entamoeba coil	Medium	Low	Low
Microsporum	Medium	Low	Low
Mycoplasma pneumonia	High	Low	Low

Level 4B. Risk assessment for a non-outbreak scenario

The non-outbreak risk assessment usually involves decisions on the individual level rather than the population level. Clinical signs are characterized by the likelihood that they are infectious or noninfectious, as well as the likely route of introduction. If the signs are human-induced and life-threatening, and treatment is beneficial and practical, immediate intervention is warranted. If the situation is non-human-induced, whether infectious or noninfectious, then
the following decision-making criteria are utilized:

A. Low risk: Not likely life-threatening and will probably resolve without treatment.
B. Medium risk: Potentially life-threatening and may need treatment.
C. High risk: Likely life-threatening and needs treatment.

Since ‘‘natural’’ injuries and mildly abnormal clinical signs occur as part of a gorilla’s natural history, this non-outbreak intervention decision is still somewhat subjective and often relies on demographic information for decision-making. Once the risk assessment and categorization are completed, risk management protocols should be implemented (Figure 4, level 5).

TABLE VIII: Risk Assessment by Clinical Signs

Low risk category
1 dead with no clinical signs of infectious disease and no other animals with clinical signs of infectious disease
1 dead with no clinical signs of infectious disease and 1 or more individuals with mild or moderate clinical signs of infectious disease
No dead and mild or moderate clinical signs in ≤ 8 or 1/2 of the group size
1 or more individual with infectious disease with an estimated low transmission rate and low mortality rate
Medium risk category
1 dead with clinical signs of infectious disease
No dead and combination of moderate and/or severe clinical signs in 2-4 animals
No dead and combination of moderate clinical signs in ≥ 8 individual in a group or 1/2 of the group size
1 or more individuals with clinical signs of infectious disease with an estimated medium to low transmission of clinical rate but medium to high morality rate
1 or more individuals with clinical signs of infectious disease with an estimated medium to high transmission of clinical rate but medium to low morality rate
Combination of clinical signs never before observed regardless of severity
High risk category
1 dead with clinical signs of infectious disease
No dead and severe clinical signs in > animal
No dead and a combination of moderate and severe clinical signs in > 4 animals
≥ 1 dead and severe clinical signs
≥ 1 dead with a combination of mild to moderate clinical signs in ≥ 8 individuals or 1/2 the group size
≥ 1 gorilla with signs of an infectious disease and an estimated medium to high transmission rate and medium to high morality
An infant with severe clinical signs with a mother that has mild to moderate clinical signs
Suspected high zoontic potential but unlikely to cause gorilla morality

2.5.5. Level 5: Risk Management (Feedback Provided)

The goal of risk management is to reduce the implications or recurrence of an introduced hazard. Although risk-management plans must be tailored to the situation, the decision tree contains basic recommendations. Risk-management and implementation plans were developed for each risk category for both outbreak and non-outbreak situations (Figure 4, level 5).

Risk-Management Actions in Non-Outbreak Situations

Low-Risk Category Actions:

1. Continue observations.
2. Collect noninvasive samples if deemed necessary.
3. Report the problem to the protected-area authorities (PAA), the host country wildlife veterinary authorities (HVA), and the MGVP project director (PD).

Medium-Risk Category Actions:

1. Review demographic information.
2. Consider immobilization and collection of invasive sample.
3. Provide treatment or any beneficial preventive action.
4. Communicate this to the PAA, HVA, and PD.
5. Continue to monitor and report as for low risk.

High-Risk Category Actions:

1. Review demographic information.
2. Immobilize the subject for sample collection and treatment.
3. Make sure that international export permits are ready to ship samples if necessary.
4. Contact outside help if deemed desirable.
5. Formulate a written action plan.
6. Communicate this to the PAA, HVA, and PD.

Gorillas occasionally get their hands or feet accidentally caught in snares set to catch other animals. They are generally strong enough to break these snares free from their grounding, but are usually left with ropes or wires attached to their limbs. This is one example of a non-outbreak

situation because it usually only involves one animal and there is no potential for the problem to be transmitted to other gorillas. The fact that snares are human-induced and often life-threatening calls for immediate intervention.

Risk Management Actions in Outbreak Situations

Low-Risk Category Actions:

1. Continue to observe and assess for progression to moderate or high risk.
2. Collect noninvasive samples.
3. Produce reports on MGVP response and observation to the PAA, HVA and PD.

Medium-Risk Category Actions:

1. Intensify observations to watch for advancement to high risk.
2. Perform immobilizations if deemed necessary for diagnostic invasive sample collection.
3. Notify the PAA, HVA, PD, and other appropriate stakeholders and public health officials.
4. Prepare a formal report and written action plan regarding the problem and MGVP activities.

High-Risk Category Action:

1. Perform intervention(s) for diagnostics and treatment.
2. Assess new information and redefine plan if necessary.
3. Obtain additional help from regional or international resources/experts.
4. Put potentially necessary health resources on standby.
5. Obtain international export permits and distribute written protocols for immobilizations, treatments and drug dosages, vaccinations, and diagnostics to the invited health providers.
6. Communicate to all appropriate people (PAA, HVA, PD, stakeholders, and public health officials).
7. In the face of an expansive and extreme outbreak, the most extensive part of the contingency plan is implemented. When international veterinary assistance is necessary, consultation other experts, such as epidemiologists and Geographical Information System (GIS) experts, and the

Centers for Disease Control and Prevention and the World Health Organization should be utilized.

2.6. SUMMARY OF RESOURCES USED TO RUN THE CRDT

The following resources are used to operate the system:

Funding source (s): the CRDT is entirely funded and sustained by MGVP inc.

Personnel requirements:

Veterinarians, trackers, guides, researchers, and other personnel from MGVP, RDB - Rwanda Development Board/ Conservation Unit (ex : Office Rwandais du Tourisme et des Parcs Nationaux), ICCN - Institut Congolais pour la Conservation de la Nature, Karisoke Research Center (DFGI - Dian Fossey Gorilla Fund International), monitor the health of gorilla populations.

Trackers in Rwanda are permanent staff of the Karisoke Research Center. Guides, the park manager and one veterinary technician work in the Virunga National Park for RDB. One veterinary doctor is based at RDB head Quarter and he provides the overall supervision and develops policies for health monitoring of mountain gorillas.
Three (3) veterinary doctors work for MGVP in DR Congo, 4 including the regional manager are based in Rwanda, to make necessary follow up of health conditions of mountain gorillas in the virunga massifs. There is an exemplary collaboration among MGVP, RDB, DFGI in Rwanda, and ICCN in DR Congo. The Director General of MGVP is based at Maryland Zoo in US with frequent travels, at least every two months in Rwanda, DR Congo and Uganda to support the field team.

Other equipements: a basic health observation form (paper based or programmed Personal Data Assistant device) is used to collect data. A GPS is also used for georeference data. A binocular and cameras are used for remote surveillance. A car is used to transport staff from Musanze City to the park. Jeeps are more convenient for mountainous grounds. Trackers and guides live within the park.

Telephone, radios and skype are used for communication amongst stakeholders.

The IMPACT™ is the main tool that they use to analyze data. A computer with internet connection is used in this regard.

Around 70,000 USD is needed yearly to cater for the CRDT expenses. 90% is this budget is funded by conservation partners and charity organizations in the US.

The chapter below describes the methods we used to evaluate the attributes of the CRDT.

CHAPTER THREE

MATERIALS AND METHODS

We conducted a cross sectional study reviewing all clinical data and reports from 2003-2010 with focus on respiratory conditions.
We interviewed stakeholders who can provide input to ensure that the evaluation of this clinical response decision tree addresses appropriate questions and assesses pertinent attributes and that its findings will be acceptable and useful. The stakeholders included staff of the Gorilla Doctors project, Dian Fossey Gorilla Fund International, RDB, Guides, trackers and tourists. We interviewed them using an interview guide that was dully prepared to assess and measure the system attributes.

To evaluate the system attributes, we used a tool developed by CDC and that was developed based on CDC's Framework for Program Evaluation in Public Health, research and discussion of concerns related to public health surveillance systems.

In 1988, CDC published Guidelines for Evaluating Surveillance Systems to promote the best use of public health resources through the development of efficient and effective public health surveillance systems. Those Guidelines for Evaluating Surveillance Systems were updated and published in the CDC Morbidity and Mortality Weekly Report of July 2001 (10).

The following attributes were evaluated for the Clinical Response Decision Tree for respiratory diseases in Mountain Gorillas: usefulness, simplicity, flexibility, data quality, acceptability, sensitivity, predictive value positive, representativeness, timeliness and stability.

3.1. USEFULNESS

A public health surveillance system is useful if it contributes to the prevention and control of adverse health-related events, including an improved understanding of the public health

implications of such events. A public health surveillance system can also be useful if it helps to determine that an adverse health-related event previously thought to be unimportant is actually important.

An assessment of the usefulness of a public health surveillance system should begin with a review of the objectives of the system and should consider the system's effect on policy decisions and disease-control programs. Depending on the objectives of a particular surveillance system, the system might be considered useful if it satisfactorily addresses at least one of the following questions. Does the system:

- detect diseases, injuries, or adverse or protective exposures of public importance in a timely way to permit accurate diagnosis or identification, and prevention or treatment?
- provide estimates of the magnitude of morbidity and mortality related to the health-related event under surveillance, including the identification of factors associated with the event?
- detect trends that signal changes in the occurrence of disease, injury, or adverse or protective exposure, including detection of epidemics (or outbreaks)?
- permit assessment of the effect of prevention and control programs?
- lead to improved clinical, behavioral, social, policy, or environmental practices?

We conducted an interview of key stakeholders who use data from the CRDT to gather evidence regarding the usefulness of the CRDT for respiratory conditions in mountain gorillas.

3.2. SIMPLICITY

The simplicity of a public health surveillance system refers to both its structure and ease of operation. Surveillance systems should be as simple as possible while still meeting their objectives.

A chart describing the flow of data and the lines of response in a surveillance system can help assess the simplicity or complexity of a surveillance system.

The following measures might be considered in evaluating the simplicity of a system:

- amount and type of data necessary to establish that the health-related event has occurred (i.e., the case definition has been met);

- amount and type of other data on cases (e.g., demographic, behavioral, and exposure information for the health-related event);
- number of organizations involved in receiving case reports;
- method of collecting the data, including number and types of reporting sources, and time spent on collecting data;
- amount of follow-up that is necessary to update data on the case;
- method of managing the data, including time spent on transferring, entering, editing, storing, and backing up data;
- methods for analyzing and disseminating the data, including time spent on preparing the data for dissemination;
- staff training requirements; and time spent on maintaining the system.

In the case of our study, we tried to answer the above questions vis-a-vis the CRDT for respiratory conditions in mountain gorillas.

3.3. FLEXIBILITY

A flexible public health surveillance system can adapt to changing information needs or operating conditions with little additional time, personnel, or allocated funds. Flexible systems can accommodate, for example, new health-related events, changes in case definitions or technology, and variations in funding or reporting sources. In addition, systems that use standard data formats (e.g., in electronic data interchange) can be easily integrated with other systems and thus might be considered flexible.

Flexibility is probably best evaluated retrospectively by observing how a system has responded to a new demand.
The flexibility of the CRDT was assessed by seeing if this surveillance system can adapt to any other health conditions in mountain gorillas, including emerging ones.

3.4. DATA QUALITY

Data quality reflects the completeness and validity of the data recorded in the public health surveillance system.

Examining the percentage of "unknown" or "blank" responses to items on surveillance forms is a straightforward and easy measure of data quality. Data of high quality will have low percentages of such responses. However, a full assessment of the completeness and validity of the system's data might require a special study.
Our assessment of this attribute will only focus on the type of data that are collected for respiratory conditions and how the forms are completed.

3.5. ACCEPTABILITY

Acceptability reflects the willingness of persons and organizations to participate in the surveillance system.

Acceptability refers to the willingness of persons in the sponsoring agency that operates the system and persons outside the sponsoring agency (e.g., persons who are asked to report data) to use the system. To assess acceptability, the points of interaction between the system and its participants must be considered. Our assessment of the acceptability of the CRDT focused on the level of collaboration amongst stakeholders that developed and that are involved in the implementation of the CRDT.

3.6. SENSITIVITY

The sensitivity of a surveillance system can be considered on two levels.
First, at the level of case reporting, sensitivity refers to the proportion of cases of a disease (or other health-related event) detected by the surveillance system. Second, sensitivity can refer to the ability to detect outbreaks, including the ability to monitor changes in the number of cases over time.

The capacity for a public health surveillance system to detect outbreaks (or other changes in incidence and prevalence) might be enhanced substantially if detailed diagnostic tests are included in the system.

The primary emphasis in assessing sensitivity - assuming that most reported cases are correctly classified - is to estimate the proportion of the total number of cases in the population under surveillance being detected by the system.
In the case of this study, we will assess the proportion of the total number of respiratory cases in mountain gorillas being detected by the CRDT.

3.7. PREDICTIVE VALUE POSITIVE

Predictive value positive (PVP) is the proportion of reported cases that actually have the health-related event under surveillance.

The assessment of sensitivity and of PVP provides different perspectives regarding how well the system is operating. Depending on the objectives of the public health surveillance system, assessing PVP whenever sensitivity has been assessed might be necessary.
In assessing PVP, primary emphasis is placed on the confirmation of cases reported through the surveillance system.

3.8. REPRESENTATIVENESS

A public health surveillance system that is representative accurately describes the occurrence of a health-related event over time and its distribution in the population by place and person.

Representativeness is assessed by comparing the characteristics of reported events to all such actual events. Although the latter information is generally not known, some judgment of the representativeness of surveillance data is possible, based on knowledge of, among others:

- characteristics of the population such as geographic location ;

- clinical course of the disease or other health-related event (e.g., latency period, mode of transmission, and outcome);

Here, we will assess whether the CRDT encompasses all the gorilla population found in the virunga massif.

3.9. TIMELINESS

Timeliness reflects the speed between steps in a public health surveillance system.
The time interval linking any two of these steps can be examined. The interval usually considered first is the amount of time between the onset of a health-related event and the reporting of that event to the public health agency responsible for instituting control and prevention measures.
Another aspect of timeliness is the time required for the identification of trends, outbreaks, or the effect of control and prevention measures.

3.10. STABILITY

Stability refers to the reliability (i.e., the ability to collect, manage, and provide data properly without failure) and availability (the ability to be operational when it is needed) of the public health surveillance system.
Measures of the system's stability can include

- the number of unscheduled outages and down times for the system's computer;
- the percentage of time the system is operating fully;
- the desired and actual amount of time required for the system to collect or receive data;
- the desired and actual amount of time required for the system to manage the data, including transfer, entry, editing, storage, and back-up of data; and
- the desired and actual amount of time required for the system to release data.

We assess the above parameters to measure the stability of the CRDT.

In the chapter below, we present the results of the assessment of surveillance attributes of the CRDT.

CHAPTER FOUR

RESULTS

4.1.USEFULNESS

Since the CRDT was established in 1986, it has detected outbreaks and cases of respiratory illnesses in the mountain gorilla population.
Four respiratory diseases outbreaks were detected in 2008 in Hirwa Group, Susa Group, Group 13 and Kwitonda Group and 2 outbreaks were detected in 2009 in Group 13 and Hirwa Group. Data shows that there has been more than 106 respiratory cases (including deaths) that were detected in mountain gorillas using the CRDT from 2003-2010. Those cases accounted for more than 79 % of all the health conditions reported in Mountain gorillas in the Virunga massif during that period (106/135).

From 2007 to 2009, 4 mortality cases from respiratory illnesses were reported, accounting for 22 % of all the mortality cases encountered in that period (4/18).

The CRDT has helped to categorize respiratory diseases by the level of risk for mortality for mountain gorillas. We have diseases of high risk of mortality (Mycobacterium tuberculosis, Mycobactorium bovis, measles and strep-pneumonia), medium risk (Respiratory sincytial virus) and low risk (Parainfluenza and Mycoplasma pneumonia).

The CRDT has helped to establish that respiratory diseases constitute the second major cause of mortality of mountain gorillas after natural trauma.

The CRDT serves as a trigger to commence the actions as outlined in the Contingency plan that was developed by MGVP and partners in 2007 for reducing the likelihood that a disease, once introduced, will cause a major outbreak or epidemic in the mountain gorilla population.

This comprehensive contingency plan aims at producing a well communicated and coordinated response among non-governmental partners and governmental agents to a major health threat to the mountain gorilla population, and mobilizing the necessary personnel and resources to characterize and contain the threat, including national and international veterinary assistance.

As a result of analysis and interpretation of the data from the clinical response tree, targeted actions are taken to control the health condition of concern in mountain gorillas.
The CRDT served also to develop the visitation rules presented in appendix V that tourists have to abide to before entering and while in the park. Those visitation rules aim at reducing the risk of contamination between tourist and the mountain gorilla population.

In other to reduce the risk from conservation personnel, MGVP initiated in June 2001, in collaboration with the Parc National des Volcans (i.e., RDB ex ORTPN), DFGFI, and IGCP an Employee Health Program (EHP) for all park employees (including trackers, guides, researchers, and veterinarians) with support from the Rwandan Ministry of Health (MOH). Permission to undertake the health program and to periodically report summary findings was granted by the Rwandan MOH. Institutional review board (IRB) approval for periodic statistical analysis of the routine health program data comes through Mississippi State University. The program goal is to improve the health of the conservation personnel and reduce the risk of zoonotic disease transmission between them and the park's mountain gorillas.

The program offers health education, an annual health assessment including a clinical history, a clinical examination, diagnostic testing, appropriate treatment and vaccinations, and follow-up and referral, as appropriate.
This program is intended to provide a basis for identifying critical control points for preventing disease transmission between the mountain gorilla and employees, as well as developing human health recommendations and guidelines for researchers, trackers, and their families.

4.2. SIMPLICITY

The structure and the ease of operation of the CRDT in terms of communication channel are illustrated in the figure 7 below.

Trackers are in constant communication with the RDB field veterinarian and the regional MGVP office. If the suspected case of a respiratory disease is prone to an outbreak, the MGVP manager notifies the MGVP director and the chief park warden and suggests interventions to make accordingly. All of this takes less than 3 hours. This is the minimum time required for the notification of an outbreak and an action to be taken in the virunga massif. Trackers use walkie-talkies to communicate amongst themselves whilst they are in the field, but in order to communicate with the team at RDB office in Kinigi and the MGVP office in Musanze, they use cellphones. Nonetheless the cellphone network is not always available throughout the virunga massif. The higher they climb the mountains to track gorillas, the cellphone network disappears. So to be able to communicate with the team down the mountains, they have to climb down the mountain heights until network is restored.

Only two organizations, MGVP and RDB are directly involved in receiving case reports in the mountain gorilla population.

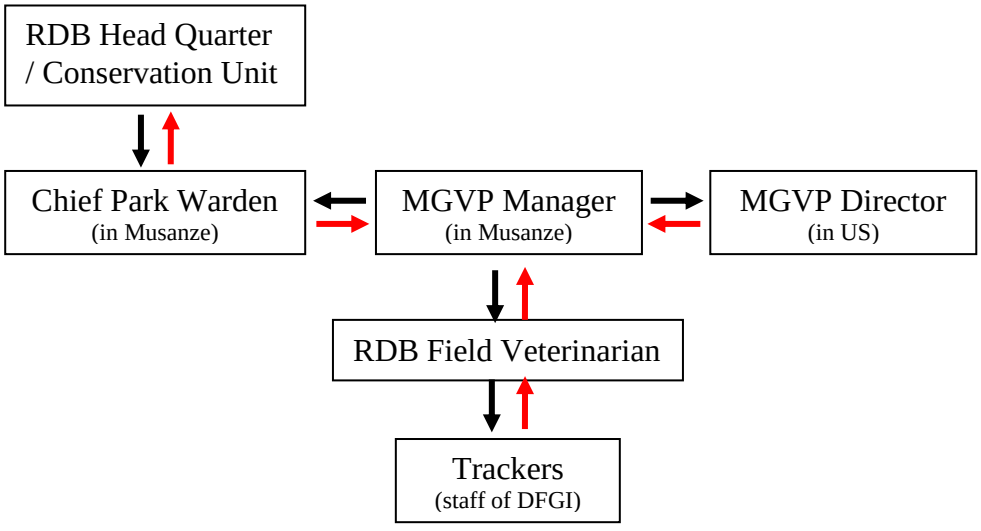


Figure 7: Flow of information for health monitoring in the mountain gorilla population – case of Rwanda

Routine health observation data are gathered either by the trackers and guides or researchers on either a paper form or a PDA. Paper forms are said not to be easy to use during rainy seasons. PDA is more practical but not all trackers can own one or are able to use one because the use of this device requires some prior training. Holistic data are collected and are all descriptive of individual gorillas presenting the health condition of interest. The following parameters are observed for respiratory diseases: breathing rate, breathing difficulty, coughing quality, coughing pattern and sneezing. Those parameters are described as normal, mildly or moderately normal, or highly abnormal using the data dictionary of the clinical parameters and signs presented in Table III. Georeference data are also collected to locate where the health condition was reported.

The forms are in English and so they are filled out only by trained trackers who understand English. The first reporting is done by oral communication before data are collected, and sometimes there are different interpretations of signs, and alarmists and inconsistent messages.
After the notification of the case, a more skilled tracker is assigned to make a close follow up of the gorilla or group of interest and to provide an update on the case. In the case of respiratory conditions, if one gorilla presents with a persistent cough along several days of the month or if more than two gorillas are coughing, there is a strong suspicion of an outbreak and an intervention is made. The intervention is always seconded by a follow up of the case of interest to check on the evolution of the condition.

Every twice a year, a meeting bringing together MGVP staff, trackers and guides is convened to share experience and knowledge on mountain gorillas health monitoring, but a more formal training with clear and specific objectives and contents is a requirement for trackers.

4.3.FLEXIBILITY

The CRDT is an integrated surveillance system that is used to detect any health condition in mountain gorillas. Any infectious diseases, trauma and others can be spotted by the CRDT. Because it is a clinically based surveillance system, it can accommodate and detect even emerging and re-emerging diseases in mountain gorillas, but based on prevailing symptoms only. However further laboratory investigations will be required to confirm the new health condition.

4.4. DATA QUALITY

The data collected in the CRDT are based on daily observations carried out by trackers and guides during sentinel health monitoring and review.
The data for respiratory conditions are very thorough and they describe the health condition over time and its distribution in the gorilla population by place and person. They serve as a basis for risk assessment in order to aid veterinarians and managers in making objective evidence-based intervention decisions.

The quality of data collected for respiratory diseases is however affected by the lack of consistency in the report of cases as some trackers do not have the optimal level of education to use the CRDT, even if the definitions of cases very clear and rigid to be of practical use. A single respiratory sign can be appraised differently by two trackers. But the forms completeness percentage is assumed high, especially when they are filled out by trained trackers.

We can note that IMPACT^{TM} is a valuable tool for epidemiologically evaluating an outbreak in a uniform and statistically valid fashion. This computerized data collection and assessment system was developed in order to standardize and streamline observations made in the field about gorilla health.

4.5.ACCEPTABILITY

The CRDT and the contingency plan for MGVP were developed by several key partners working for the conservation of mountain gorillas. Regional meetings bringing together government institutions and non-governmental organizations (NGOs), including park managers from Rwanda, Uganda and DR Congo worked together to develop, discuss and validate these documents.

In Rwanda, there is a good collaboration between RDB and DFGI, both of whom employ all the trackers and guides, and MGVP who provides the support in veterinary medicine to mountain

gorillas. All of those stakeholders participate willingly in the CRDT, especially in information sharing which is done particularly without delay.

Human epidemiologists were also involved in the process. However the district hospitals in Musanze District and other districts surrounding the Parc National de Virunga have not owned the CRDT as yet, because very little information is shared about prevailing respiratory cases or any other diseases that can pose a risk to the gorillas from those hospitals. This has a repercussion as precautionary measures to protect gorillas are delayed.

The CRDT also faces another challenge which is the non-compliance of the visitation rules (Appendix V) by tourists, especially when sneezing and coughing and the use of mask while in the park (Figure 8). Some tourists find the use of mask cumbersome and resolve not to use it. However the mask can prevent the transmission of many respiratory infections especially those originating in humans. The discussion about the use of Masks in presented in Appendix III.

Figure 8: The use of mask by tourists, trackers and guides

4.6. SENSITIVITY

The CRDT is assumed sensitive as the case definition for respiratory diseases is very sensitive. A signal of cough by a gorilla is subject to be reported and for follow up.

However, because clinical interventions are based on the presence of clinical signs alone in many cases that are often nonspecific and therefore not associated with a definitive diagnosis, the severity of the observed signs may be the best indicator of risk for a timely response.

106 respiratory cases were detected in mountain gorillas from 2003-2010, but there was no data available of the possible number of respiratory cases that could have occurred in that period and that were not detected by the CRDT. So we were not able to calculate the sensitivity of the CRDT.

4.7. PREDICTIVE VALUE POSITIVE

All reports suggest that the respiratory cases that were reported in mountain gorilla s were confirmed as so, the only difference was the severity of cases. This way, we can assume that the predictive value positive is 100%. This value is good for case management as it prompts immediate interventions to control the disease.

4.8. REPRESENTATIVENESS

The CRDT is used only for the human habituated mountain gorillas that represent around 70% (380/543) of the entire mountain gorilla population found in the virunga massif. The remaining 30% are considered as non habitutated to humans and thus dangerous, so monitoring health conditions in this group is impossible. Because the latter group is not visited by humans and also the two groups of mountain gorillas don't mingle, we can assume that the risk for contamination of respiratory diseases is very low in this group.

For the habituated group, the CRDT accurately describes the respiratory conditions over time and their distribution in the population by place and group.
The mode of transmission of respiratory diseases in the habituated group is through aerosols.

4.9. TIMELINESS

Any respiratory case is immediately reported and is subject for follow-up. Depending on the location in the park and the availability of telephone network, the timing averages 3 hours from the notification of the case to the intervention.

4.10. STABILTITY

The CRDT has not always been stable in the past year as the IMPACT^{TM} is sometimes down and the internet connectivity is also very often low at the MGVP office in Musanze where the system is managed, and so the transfer and analysis of data can take sometimes longer (up to one week). But interventions don't always wait for data to be processed as precautionary measures are always taken quickly after the notification is made.
In normal situations, the CRDT requires less than one day to process data from the field.

CHAPTER FIVE

DISCUSSION

5.1. GENERAL OBSERVATION

The present study constitutes the first report on the evaluation of the CRDT used to monitor health conditions of mountain gorillas living in the virunga massif, and using the CDC Guidelines for Evaluating Surveillance Systems.

The CDC guidelines were developed to evaluate public health surveillance systems of humans. And some of the methods used to measure the system attributes are more applicable in the context of human than animal diseases. We tried to adapt this methodology to evaluate the CRDT used for respiratory diseases in mountain gorillas. However, we acknowledge that using this methodology may have introduced some biases because this tool is not made for animal diseases. But in our knowledge, there are no guidelines available to evaluate surveillance systems and that is specific for animals, especially those living in the wild like mountain gorillas.

Because there is no other similar study conducted previously on mountain gorillas, we have used our own judgment to assess the CRDT attributes.

Our findings are still valid because we respected all throughout the evaluation guidelines and the tool that we used is a valid one.

5.2. CRDT ATTRIBUTES

The CRDT used for respiratory diseases in mountain gorillas is very useful because its meets all its objectives which are: to standardize protocols for risk assessment in order to aid veterinarians and managers in making objective evidence-based intervention decisions, and to categorize risk and thus act as a trigger to commence the actions for reducing the likelihood that a disease, once introduced, will cause a major outbreak or epidemic in the mountain gorilla population.

The CRDT has helped to detect respiratory outbreaks in the mountain gorilla population

The CRDT is also useful because most of the stakeholders involved in the mountain gorillas conservation that were interviewed acknowledged that they understand the system and its implications. Almost all tourists seemed to ignore that the systems existed and this is because they are just short-time visitors who only spend one hour with gorillas. But they are the ones who pose the greatest risk for the cross contamination of respiratory diseases with mountain gorillas. So there is a need to reinforce the policy regarding the gorilla visitation rules of tourists.

Magdalena Lukasik and Lucy Spelman(14) confirmed in their study that the visitation rules reduced considerably respiratory diseases outbreaks at Mahale and Gombe National Parks in Tanzania. In Mahale, respiratory diseases make up to 20% of mortality cases of the chimp population. This number of mortality cases declined from 101 in 1984 down to 60 in 2008 after implementation of visitation rules.
In the Gombe, there were many respiratory outbreaks since 1965 with up to 30% mortality, but there have been no deaths from respiratory disease after the implementation of visitation rules in 2002(14,15).

The CRDT used for respiratory diseases can be considered simple because of its structure and ease of operation. Only two organizations are directly involved with cases reporting. The dictionary for clinical data collected for respiratory diseases makes also the system simpler. However this attribute is affected by the fact that the forms used to collect data are all in English and they can only be filled out by a few trackers or researchers who understand English. This limitation can be addressed by either translating the forms and the dictionary of clinical data collection into Kinyarwanda language and/or improving the English level of trackers through trainings.

The CRDT is considered as flexible because it can accommodate emerging diseases in mountain gorillas just based on clinical signs. But only further laboratory investigations would give a final confirmation of the new health condition. Emerging diseases like Avian Influenza or SARS and re-emerging ones like Ebola can easily be detected by the CRDT.

The quality of data collected for respiratory diseases in mountain gorillas can be considered of good quality because they provide an overall description of respiratory diseases based on a clear

clinical data dictionary. However this quality can be improved if all trackers and researchers involved in data collection understand the contents of collection forms.

The collected data serve as a basis in making evidence-based intervention decisions. The use of the software IMPACT^{TM} also improves the quality of data. The observational data portion of IMPACT^{TM} will become more powerful as the observation database builds with ongoing utilization of the system.

The acceptability of the CRDT is still not satisfactorily because all stakeholders concerned by this surveillance system don't own it as yet. The resilience of tourists to comply with visitation rules and the lack of involvement of hospitals in Districts contiguous to the Virunga National Park makes the acceptability poor. Those hospitals are expected to participate actively in the CRDT by timely reporting any unusual increase of respiratory diseases in the communities surrounding the national park. There is a need for more sensitization of communities and local authorities including hospitals around the national park to engage actively in the CRDT.

The sensitivity and the predictive positive value are considered high, but because of lack of data we were not able to measure those attributes quantitatively. The case definition used for respiratory diseases being very sensitive, we can assume that the system sensitivity and the predictive positive value are also high.

But further studies and investigations are needed to calculate the sensitivity and the predictive positive value.

The CRDT is not representative of all the gorilla population living in the virunga massif. But it does well represent the group that is more at risk of contamination from respiratory diseases originating in humans, which is the habituated group.

The timeliness of the CRDT is good, though there are some challenges that cause the response to delay. But in general the CRDT as it is now allows a timely reporting and rapid response.

The stability of the CRDT is mainly affected a lot by the lack cellphone network in the virunga massif.

The CDC Guidelines for Evaluating Surveillance Systems (10) suggest that usefulness might be affected by all the attributes of a surveillance system. For example, increased sensitivity might afford a greater opportunity for identifying outbreaks and understanding the natural course of an adverse health-related event in the population under surveillance. Improved timeliness allows control and prevention activities to be initiated earlier. Increased predictive value positive enables public health officials to more accurately focus resources for control and prevention measures. A representative surveillance system will better characterize the epidemiologic characteristics of a health-related event in a defined population. Public health surveillance systems that are simple, flexible, acceptable, and stable will likely be more complete and useful for public health action.

So because our the CRDT meets the requirements of being a useful system for respiratory diseases surveillance in mountain gorillas, we can assume that all other system attributes are good, however we can encourage further studies and investigations on all attributes.

CHAPTER SIX

CONCLUSION

Diseases are usually considered the third most serious threat to Mountain Gorillas, and have risen in public awareness due to the highly publicized outbreaks of Ebola virus in Western Africa that resulted in high mortality in chimpanzees and gorillas (16). In protected areas (i.e., conservation areas and national parks) where deforestation and bush meat practices are a lesser threat, disease is rated as the primary threat. The Mountain Gorilla Veterinary Project (MGVP) was established to provide emergency medicine and pathology services to the mountain gorilla population of Rwanda. Interventions on Mountain Gorillas are regulated by the park authorities and veterinarians, and occur only in the presence of human-induced and life-threatening health problems. However this intervention policy can be ambiguous, often subjective and emotional. The CRDT that was developed by MGVP helps to standardize the intervention response to health-related issues. Respiratory diseases being the second most important health condition in the mountain gorilla population, the CRDT serves as a valuable tool to assess these conditions.

The benefit of the IMPACT^{TM} is that it constantly incorporates new data, including those from normal, healthy individuals, and adjusts baseline prevalence rates accordingly. This allows assessments of risk to be based on the most up-to-date information available for the population of concern.

As there are no perfect definitions of clinical signs under field conditions, due to animal behavior and vegetation, the definitions that are used for clinical signs are both practical and productive.

An example of how the development of this system has changed clinical approaches is the response to respiratory outbreaks, particularly those involving multiple infants. In one study conducted in 2005, respiratory disease was responsible for approximately 25% of the mortality in the corpse examined from 1964-2004. Clinical respiratory outbreaks are common and usually pose the greatest risk to infants (7). In the past, even if an infant died with respiratory signs and

other gorillas were showing similar signs, the dead infant would be left until the mother dropped it. This eliminated the possibility of performing a diagnostic postmortem examination. Now, if an infant dies with suspicious signs of infectious disease and/or other animals are showing signs of clinical illness, the mother is anesthetized, examined, sampled, and sometimes treated, while the dead infant is recovered for a thorough postmortem examination. Other animals are often treated as deemed appropriate based on the findings of the postmortem examination and diagnostic samples from the mother.

This CRDT has proved to be a very useful system for the surveillance of respiratory diseases in mountain gorillas because it has detected outbreaks and has triggered evidence based actions to control them. It has also improved the conservation management of mountain gorillas by inspiring conservation policies.

The CRDT helps to sustain the one health program of MGVP.

The following recommendations have been formulated to improve the CRDT:

- The CRDT should be presented to RDB and all other public institutions in charge of protected areas, to incorporate it in the disease control programs and policies for all national parks in Rwanda. CRDT is good experience that should be replicated in other national parks.
- Because CRDT is an integrated surveillance system, active participation of the district hospitals in the system is very much required or should be improved especially in the reporting of human diseases that can affect mountain gorillas.
- The CRDT should be used as a starting point to establish an Early Warning System with district hospitals surrounding national parks.
- There is need for training for all stakeholders to own the CRDT and take maximum benefit out of it.
- There is need to translate the CRDT forms and materials in Kinyarwanda for all the trackers and guides to be able to use it.

- Hotlines should be established for the populations surrounding the parks to report any cases of diseases in livestock.
- There is a need to sensitize the population surrounding national parks about zoonotic diseases that can originate from wild animals and humans, and vice versa, and how to control them.

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APPENDICES

Appendix I: Dictionary for the data collection form

Variable	Definition	Comments
Date	Date of observation in day/month/year	
Observer	Person recording the clinical signs	Use 1st names and then initials
Group	Official name of group assigned by the park authorities	The groups without names can be taken as WILD or Unknown
GPS for group	Global Positioning System. Write Northings 1st and Eastings 2nd. The GPS zone should be indicated too.	UTM and metric system are used and also set for the WGS map system. The GPS zone should be set e.g. the Virungas and Bwindi National Parks are 35.
Bearing	Number of degrees between 0-360^0 to the center of the main group being observed from where the GPS reading was taken after lining up the compass with magnetic north	This is taken only when you can't get the GPS reading near the gorillas. 0^0 is defined as magnetic North.
Distance	Number of meters estimated to within 5 meters accuracy to the center of the group being observed from where GPS reading was taken.	Taken only when you can't get a GPS.
Time start	Time you start observing the gorillas (AM/PM).	Usually one hour of observation allowed by park authorities but vary whether tourists visit a group or not.
End	Time you complete the day's observation on that group.	At the end of the observations click save immediately to avoid losing your data. You can go back to the Observation History Form and double click to edit your observation.
Altitude	Height above sea level in meters as indicated on the GPS.	Note that many GPSs will give you Eastings and Northings many seconds before the altitude
# Nests seen	Number of nests seen presumed to be from the same group and not more than 8hours old.	
GPS for the nest site	This is location of where the majority of the nests are. Write Northings 1st and Eastings last.	

For dead gorilla		
Name	Name of the gorilla found dead or given I.D.	
Time found	Time the dead gorilla was found (AM/PM)	
GPS for dead Gorilla *	Location where the gorilla was found dead.	
Description of the wound or abnormal stool	Any section on the form with an asterisk should be filled for the dead gorilla. Detailed description of the stool and wounds. Drawings of the sites of the wound if possible.	
Reviewed by park official	Indicate if yes or no. Date (dd/mm/yy) when park official has reviewed should be indicated. Signature of veterinarian who has looked through the collected data and/or done necropsy on the dead gorilla.	
Date	Date when the vet. Signs (dd/mm/yy) this form.	
Number of people present during observation	People that are part of the observation and are within 10 meters from the gorilla group under observation.	
Military	Soldiers that are given by the army to escort visitors, trackers and others to see the gorillas.	These are counted if within sight of the gorillas.
Trackers/guides	Employees of the Park helping in tracking the gorillas.	
Visitors/tourists	Those who have come to track gorillas and do so not on a regular basis (Regular basis is defined as >20 visits per year to the particular group being observed.	Some of these may have guns & still not military.
Others	Any other category of people not described above. Should be specified i.e. porter, researchers, vets etc.	The one observing and filling this form can be included in this.
Gorilla ID	Gorilla name being described by drawing what is part is affected.	

Appendix II: Response code options for respiratory signs

System	Sign	Response code options	Comments
Respiratory- Relating to respiration, which is the taking in oxygen and expiration of oxidation products.	Breathing rate- Frequency of breathing, recorded as the number of breaths per minute	N=normal: when animal appears comfortable and you can't see movement of nostrils and chest and no audible sounds. F=fast: When breathing can be observed and is faster than 20 breathes/min and with or without audible sounds. S = slow: When you can observe breathing and its <15 breathes/minute and with or without audible sounds.	Gorillas which have been chased by another group or been fighting are likely to show a fast breathing rate. Assessment of breathes per minute is difficult in the field.
	Breathing difficulty- Finding a problem in exhalation and inhalation of air.	N = none: No breathing difficulty shown at all. L = labored: Visible respiratory effort by an individual with or without respiratory noise.	
	Coughing quality-Coughing is a sudden explosive forcing of air through the glottis and the quality is characteristics of the cough.	D = dry: Harsh, grating, short sound with no mucus production. P = productive: moist cough associated with exudates and transudates and can be noisy with a hacking sound. Swallowing may be observed.	
	Coughing pattern- the sequence of coughing.	N = Normal: Doesn't interrupt the activities of the individual. C = continuous/Frequent: Coughing more than once in 5 minutes. P= periodic/Abnormal: Intermittent interruption of the activities of the individual due to coughing.	Coughing pattern should be interpreted in the context of the whole group.
	Sneezing- expelling air from the nose and mouth by involuntary spasmodic contraction of muscles of respiration due to an irritation of the mucous membranes of the nose.	N = normal: One episode of sneezing per observation. C = continuous: more than one episode of sneezing with <5minutes between them. P = periodic: Episodes of sneezing that is an isolated event with periods of >5 minutes between them.	Differences in individuals in how many times they sneeze in an episode. Any time you trigger the respiratory system you should note down something in the text box.
Discharge- That which is emitted or evacuated as an excretion or a secretion.		C = clear: Colorless secretions. B = bloody: Secretion with a tinge of blood or frank blood. O = other color: White/yellow/green /cloudy. D = dried: Free from moisture or liquid	

Appendix III: Discussion about Mask use in mountain gorillas

Pros of using a mask

- ★ Sneezing can distribute 40,000 aerosolized particles and droplets (Am Jour of Infection Control)

- ★ If the particles are more than 5 micron, they will usually drop out of the air quickly depending on humidity, size, shape, mass, air currents and other factors. Generally, the wetter they are and the heavier they are, the less likely they are to travel farther. Therefore, humid climates means they fall more quickly and do not travel as far. Dessicated particles can remain in the air for up to 48 hours depending on the air currents and can travel great distances.

- ★ Recent Chimp paper supports use of masks in disease control

- ★ Masks are recommended by the CDC for disease control

- ★ Degree of *infectivity* of a aerosolized pathogen depends on humidity, size, temperature. Humitiy decreases infectivity for measles but increases it for polio

- ★ Masks should be at least N-95 quality - filters to 1micron- to be effective against TB

- ★ Masks are more effective for controlling exhaled pathogens than inhaled ones

- ★ Some of the diseases that are transmittable by aerosol: Virus: measles, herpes zoster, small pox, influenza, RSV, adenovirus, ebola, Crimean-Congo virus; bacteria: TB, staph areus, group A strep, Q-fever; Fungi: Aspergillus, Cryptococcus, histoplasma, pnuemocystis carinii

- ★ Masks can be distributed when the visitors leave their packs with the trackers and collected immediately after seeing the gorillas. It would be incumbent upon the guides to insure that all masks are collected and disposed of properly.

Appendix IV: List of stakeholders interviewed

Number of People interviewed	**Position**	**Organisation**
1	Executive Director	MGVP Inc. - Gorilla Doctors
1	Regional Manager	MGVP Inc. - Gorilla Doctors
1	Regional Veterinarian	MGVP Inc. - Gorilla Doctors
1	Head veterinarian	MGVP Inc. - Gorilla Doctors
1	Laboratory Manager	MGVP Inc. - Gorilla Doctors
1	National Coordinator	Predict Project/ MGVP
1	Head of unit	RDB/ Conservation Unit
3	Vets	RDB/ Conservation Unit
1	Gorilla Vet Technician	Virunga National Park / RDB
1	Past Director	Karisoke Research Center
1	Current Director	Karisoke Research Center
1	Coordinator of the gorilla research program	Karisoke Research Center
10	Guides	RDB
10	Trackers	RDB/ Karisoke Research Center
20	Anonymous tourists	-

Appendix V: Visitation rules

Current Visitation Rules- Before you start your trek

- Maximum of 8 visitors in each group FOR TOURIST VISITS
- Minimum age: 15
- Wash your hands before setting out
- Use clean tracking clothes for EACH gorilla visit; please clean your shoes carefully BEFORE and after each trekking visit.
- If you feel sick (with diarrhea, sore throat, fever, and recurrent cough) you should not go visit gorillas. For tourists, please notify the headquarters office. Depending on the country, you may be eligible for a rain check/refund so you may visit when you are well.
- If you have a chronic illness such as heart disease, emphysema, or arthritis, please reconsider your decision to trek.
- You must be able to approach the gorillas on foot. If not, you need to purchase extra permits for those who need to assist you, up to a maximum of 8 visitors.
- Please use the restroom before you leave park headquarters.

Current Visitation Rules - while you are in the park.

- Do not enter the park without a guide.
- "Leave No Trace". Take only Photos. Leave only Footprints. Avoid unnecessarily damaging any plants. Do not remove any plants or wildlife from the park.
- If you must relieve yourself (number two, long call) bury solid waste (take toilet tissue with you) at least 30 cm (one foot.) If you are with a guide/tracker, ask them to dig the hole at least 100 m away from the gorillas. WASH YOUR HANDS, when finished.
- Leave all backpacks, walking sticks, food and drink, at least 100 meters from gorillas (the length of a football/soccer field) or even outside the park. The porters and extra trackers will stay here.
- No smoking or spitting.
- Please speak softly.

Appendix VI: Interview Questionnaires

Interview with stakeholders (Some questions apply only to staff working in the mountain gorilla conservation and others apply only to tourists)

1. Position……..……..
2. Organization……
3. Do work for: 1) DFGI…….RDB/ Park…….MGVP……
4. For how long?.....
5. Do you know the Clinical Respiratory Decision Tree (CRDT):
   Yes……. No……..
6. Has your institution contributed to the development of the CRDT:
   Yes……. No……..
7. Have you been in contact with a mountain gorilla?
   Yes……. No……..
8. Has someone presented to you the CRDT?
   Yes……. No……..
9. Do you know whether mountain gorillas can contract diseases from humans?
   Yes……. No……..
10. Has the CRDT detected respiratory outbreaks / cases in mountain gorillas?
    Yes……. No…….. It yes, how many?
11. Do you know about gorilla visitation rules?

    Yes……. No……..

12. Do you respect them when you are in the part?

    Yes……. No……..

13. If your answer is No in question 13, could you tell me why?

    .....

    .....

    .....

    .....

    .....

14. Any policy that was developed because of the CRDT, especially for respiratory diseases?

    .....

    .....

    .....

    .....

    .....

    .....

15. How do you report respiratory cases in mountain gorillas?

    .....

    .....

    .....

16. How long does it take for a response to take place?.....

17. Do you fill-out the paper form or PDA of the CRDT?

    Yes……. No……..

18. Do you understand the clinical data to collect for respiratory diseases?

    Yes……. No……..

19. Do you fill-out the form yourself or you are assisted?

    Yes……. No……..

20. Any challenges in using the paper form or PDA of the CRDT?

    ……

    ……

    ……..

21. What do you think are the limitations of the CRDT?

……

……

……

……..