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| **Title:** | Proposal: First medical decision‐support tool for snake identification based on artificial intelligence and remote collaborative expertise |
| **Purpose:** | Discussion |
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| **Abstract:** | This document contains a use-case proposal for a first medical decision‐support tool for snake identification based on artificial intelligence and remote collaborative expertise. R1 of this document includes answered to the proposal submission questionnaire. |

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**Project Title:** First medical decision‐support tool for snake identification based on Artificial Intelligence and remote collaborative expertise

**Overview**

*Please give a general overview of the project, and describe what health problem it is attempting to contribute to solve.*

Snakebite is the first most deadly neglected tropical disease (NTD), being responsible for a dramatic humanitarian crisis in global health (Waldmann, 2017). Snakebite causes over 100,000 human deaths and 400,000 victims of disability and disfigurement globally every year, affecting poor and rural communities in developing countries, which host the highest venomous snake diversity and the highest burden of snakebite due to limited medical expertise and access to antivenoms (Gutierrez et al., 2017; Longbottom et al., 2018). Antivenoms can be life‐saving when correctly administered but this depends first on the correct taxonomic identification (i.e. family, genus, species) of the biting snake. Snake identification is challenging due to snake diversity and incomplete or misleading information provided by snakebite victims or bystanders to healthcare professionals, who generally lack the necessary knowledge or resources in herpetology. To reduce potentially erroneous and/or delayed healthcare actions, and taking advantage of the expansion of mobile technologies in developing and emerging countries, we propose the first medical decision‐support mobile app for snake identification based on Artificial Intelligence (AI) and remote collaborative expertise in herpetology. With a highly transdisciplinary approach and involving end-users in snakebite hyper-endemic countries, our app will combine computer vision with the expertise from a network of professional and non-professional herpetologists to identify photos of snakes, particularly supporting victims and healthcare professionals when urgent and reliable snake identification is needed. This app will serve as an educational and capacity-building platform for both citizens and healthcare professionals around the world and the data collected through it (e.g. snake distribution, snakebite epidemiology, clinical management and outcomes etc.) will improve our understanding of snakebite and reinforce health systems in snakebite endemic countries (e.g. distribution of antivenoms where more are needed).

**Impact**

*Please explain the significance of the problem and describe the potential impact of the project. Please also provide a brief overview of existing work in the area of the project, and describe the current state of the art how the problem is currently addressed.*

In June 2017, after years of sustained efforts by groups such as Global Snakebite Initiative, Doctors Without Borders (MSF), Kofi Annan Foundation as well as the support by key member states, the WHO included snakebite in the NTD list. In May 2018, the 71st World Health Assembly adopted a resolution formally providing the WHO with a strong mandate to tackle the snakebite crisis, generating an unprecedented momentum and urging for political action and scientific acceleration (WHO 2018). Besides the critical importance of safe, accessible and effective polyvalent antivenoms, innovative expertise, approaches and tools are urgently needed to tackle snakebite, particularly those leveraging digital technologies.

Taxonomic identification of the biting snake is crucial to anticipate patient clinical signs and to ensure adequate management, including the precise administration of antivenom, which is often expensive, taxon-specific, and very limited in number. The general distinction between a venomous and non-venomous snake has already major implications but snake identification can be very challenging and healthcare professionals are not herpetologists. For instance, in certain countries such as Myanmar, communities tend to kill the biting snake and carry it to the health facility for identification (Schioldann et al., 2018) but, besides the conservation implications, this practice is not recommended, both because it entails additional risks of repeated snakebite and because the capacity of clinicians to finally identify the snake is limited. Appropriate snake identification tools are lacking and, although molecular techniques to identify snake DNA from the bite site have been explored (Sharma et al, 2016), the limited number of cases and low sensitivity of the test has prevented the evaluation of its true diagnostic performance. In this context, the ultimate objective of our project is to improve clinical management of snakebite by supporting clinicians and other healthcare professionals (e.g. local practitioners, University Hospitals of Geneva and MSF in the field), as well as snakebite victims, in the identification of biting snakes (Figure 1).

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**Figure 1:** Different scenarios in which the app could be used for snake identification in context of snake encounters involving or not snakebite (in red and blue semicircles, respectively). Diagram by V. Macalupu, F. Amrouche, X.L. Zhang, C. Zhou (SDG Summer School & Geneva-Tsinghua Initiative).

First, we aim to build a massive and global photo repository of venomous and non-venomous snakes.We have already gathered about 200,000 existing images from museums, personal collections, and open online biodiversity platforms based on citizen science and crowdsourcing (e.g. [iNaturalist](https://www.inaturalist.org/), [VertNet](http://vertnet.org/), [GBIF](https://www.gbif.org/), [HerpMapper](https://www.herpmapper.org/)) and we plan to use additional sources (e.g. [The Reptile Database](http://www.reptile-database.org/), Facebook groups on herpetology) to gradually expand the database. We have experience with these large biodiversity platforms and in 2016 we launched a project on [Medically Important Venomous Snakes](https://www.inaturalist.org/projects/medically-important-venomous-snakes) on iNaturalist, which served as a central source of data (over 10,000 snake observations) for an article by our team recently published in *PloS NTDs* (Genevieve et al., 2018). Prof. F. Grey and R. Mondardini from Citizen Cyberlab and Citizen Science Centre at the University of Geneva (UNIGE) and ETH-Zurich respectively, strongly support this project, bringing top expertise in citizen science and crowdsourcing. We also collaborate with J. Louies, founder of [indiansnakes.org](http://indiansnakes.org/) and [snakebiteinitiative.in](http://snakebiteinitiative.in/). With his Indian [BIG 4 Mapping Project](http://snakebiteinitiative.in/snake/), involving a national network of snake-catchers, he agreed to share over 10,000 photos of snakes with high public health relevance. Dr. A. Durso, who holds a PhD in herpetology and co-leads the [Snake Identification Facebook group](https://www.facebook.com/groups/22137638452/), with over 100,000 members, joined our team at UNIGE’s Institute of Global Health to work on this project. His expertise in snake identification and his global network open unique opportunities for snake photo gathering and identification. Clinicians and herpetologists from the University Hospitals of Geneva (HUG) and MSF (F. Chappuis, G. Alcoba), University of Frankfurt (Dr. U. Kuch), and University of Melbourne/WHO (Prof. D. Williams) managing snakebite in endemic areas could provide additional photos and expertise. This repository will be dynamic and actively nourished with new images throughout the project, also providing unique opportunities for research in snake ecology (e.g. geographical distribution) and snakebite epidemiology (e.g. potential snakebite hotspots).

Using this large and dynamic snake image dataset and in close collaboration with the EPFL’s Digital Epidemiology Lab (Prof. M. Salathé), we plan to develop a computer vision algorithm to taxonomically identify snakes from around the world, particularly from those areas most affected by snakebite (e.g. India). We plan to use [CrowdAI](https://www.crowdai.org/) and its innovative collaborative approach in the development of algorithms. In addition, we will establish an international group of professional and non-professional herpetologists for a collaborative service of remote identification of snakes. This will complement and help to improve the AI-based identification process, while at the same time facilitating exchanges between herpetologists, reinforcing their links and encouraging them to undertake more applied herpetological research and action in Global Health.

Besides its ultimate expected impact on health and healthcare quality in snakebite endemic areas of the world, additional expected impacts of this project include:

* A global and dynamic photo repository of snakes, which provides unique opportunities for research in snake ecology (e.g. geographical distribution) and snakebite epidemiology (e.g. potential snakebite hotspots).
* Development of a computer vision system for taxonomic identification of snakes. This could be extended to new applications of computer vision and artificial intelligence for tackling other neglected tropical diseases (e.g. mosquitos and vector-borne diseases).
* An online geospatial platform enabling the visualisation of geolocalized snake photos and potential snakebite incidents, together with other contextual data (e.g. snake species range, snake habitat range, etc.).
* An increased level of awareness, capacity, and acceptance by clinicians and other health professionals to use and integrate our future app for an improved management of snakebite in endemic countries (e.g. Nepal and India).
* An increased level of awareness and education about snakes and snakebite prevention and management (e.g. first aid actions) at the community level and in healthcare settings in endemic countries.

**Data Availability**

*Please describe what data sets would be available for the project. In particular, please describe if there are high quality open data sets for training purposes that are available, and / or if you would be able to contribute to an open data set for training purposes. Please also describe what (undisclosed) test data would be available for an evaluation. For any data set, please describe briefly if and how the data have been annotated.*

*[NOTE: This is where a link to the data submission document could be made, but it is suggested that very detailed information about the data is only solicited after the preliminary acceptance of the proposal for further consideration.]*

High-quality open data sets that are available for training purposes include images annotated with species ID, geolocation, timestamp, and anonymous contributor ID from citizen science platforms such as HerpMapper (80,000) and iNaturalist (85,000). Both platforms include crowd-based quality-controls. We will contribute to an open data set for training purposes by collecting and annotating images from web sources (e.g. Flickr, Twitter), experts, and unique open images collections such as IndianSnakes.org (5,000 images). Annotation status of these images varies, with some georeferenced with a timestamp but with the species ID within a string of text such as a photo caption rather than its own unique field. Undisclosed test data that are available for an evaluation but which will not be made accessible to the AI developers include all-rights-reserved images annotated with species identification, geolocation, timestamp, and anonymous contributor ID from citizen science platform iNaturalist (40,000), as well as all-rights-reserved untagged images from Flickr and images we are collecting from books and from experts who prefer their images to be used privately. At present, our open data set includes 200,000 images, and we anticipate collecting and annotating close to 500,000 images from web sources and experts within the next 6 months. Our eventual target is 1.5 million images within 2 years, with no fewer than 10 images per species (3,700 snake species = minimum 370,000 images, but many species are already represented by far more).

**Benchmarking**

*Please describe what you expect participants in the benchmarking process to submit. Please also describe how the submissions should be evaluated, and why.*

Using a training dataset and working in close collaboration with herpetologists and experts in clinical management of snakebite from our team (e.g. A. Durso, G. Alcoba, D. Williams) to define the right experiments, computer vision algorithms will be developed by the Digital Epidemiology Lab at EPFL (Prof. Marcel Salathé, S.P. Mohanty, C.M. Montalcini) and CrowdAI. Accordingly, algorithms will be crowdsourced globally and submitted for validation. This process of validation will be done using an undisclosed test dataset. We will evaluate the identification accuracy at different taxonomic levels (e.g. family, genus, species) considering the following questions: Is the prediction affected by the number of images per class? Is there a genus/species-specific threshold and what is it? Does the accuracy improve when taking into account the geographic distribution of the snake? Can computer vision accurately distinguish between very similar non-venomous mimics and venomous models (e.g. Lampropeltis king snakes and Micrurus coral snakes)?

**Organizer Details**

*Please describe why your organization is interested in this project, and if you have run similar projects / benchmarks / challenges before.*

Snakebite and this project in particular is highly interdisciplinary and brings together experts in tropical and humanitarian medicine, public and global health, epidemiology, one health, zoology (herpetology) and animal ecology, environmental sciences and geospatial analysis, machine learning and AI, and citizen science, from a large diversity of institutions based Switzerland and internationally, including snakebite hyper-endemic countries such as India, Nepal and Cameroon. The project is led by experts at the Institute of Global Health at the Faculty of Medicine of the UNIGE (R. Ruiz de Castañeda, I. Bolon, A. Durso, N. Ray) in very close collaboration with experts from the Service of Tropical and Humanitarian Medicine of the HUG (F. Chappuis, G. Alcoba) and from MSF (G. Alcoba). Both the HUG and MSF have a very strong international reputation with more than 10 years of experience in research (e.g. diagnostic and treatment, epidemiology, public health) and clinical management of snakebite in some of the most affected areas of the world (e.g. Nepal, Cameroun, Soudan) (Alirol et al., 2010, 2015, 2017; Sharma et al., 2004, 2013, 2016). Snakebite has become a central area of research, education and humanitarian action at the UNIGE and at its HUG. In addition, the UNIGE’s Institute of Global Health and Institute of Environmental Sciences (second affiliation of N. Ray), have recently brought a whole new perspective to tackling snakebite, particularly leaning on digital innovation, for example geo-spatial analysis and modelling. Accordingly, this team is leading a second project on snakebite entitled Snake-Byte (started in March 2018 and funded by Swiss National Science Foundation), which focuses on snakebite epidemiology in Nepal and Cameroon using advanced digital techniques for predicting snakebite hotspots and modelling accessibility to healthcare. Snake-Byte and this project on snake identification currently run in parallel and actively cross-fertilise each other in terms of common study sites, opportunities for data collection and field testing, digital methods (e.g. geospatial analysis) etc. Recent articles in this area have been published by the team in *Plos NTDs* (Genevieve et al., 2018) and *The Lancet* (Longbottom et al., 2018). Genevieve et al. (2018) was based on citizen science and involved a close collaboration with experts from the Citizen Cyberlab at the UNIGE and the Citizen Science Centre at the ETH-Zurich (R. Mondardini, F. Grey, J.L. Fernandez). These two institutions are now part of the project core team and their expertise is key to crowdsource a large number of snake images and their identification, while serving as major platforms for raising awareness on snakebite at the global scale. For instance, [HerpMapper](https://www.herpmapper.org/), the largest global citizen science initiative around snake diversity, recently joined as a collaborator in this project. The Digital Epidemiology Lab at EPFL (M. Salathé, S.P. Mohanty, C.M. Montalcini) is also part of the project core team and provides top AI expertise. A specific challenge to identify snake images will be launched on Crowd AI in the coming weeks. These collaborations illustrate the need to combine life, social and data sciences, as well as citizen participation, to tackle complex global health issues such as snakebite.

This project has reinforced existing collaborations and generated new ones between the UNIGE and players from the International Geneva. The project counts with the support from MSF, one of the strongest advocates and field actors in snakebite. Besides the role of G. Alcoba (see above), A. Tamrat, Medical Technologies Analyst at MSF, is part of the expert advisory board of the project. Also part of this board, D. Williams from the University of Melbourne, is currently in charge of the coordination and development of the WHO roadmap on snakebite. He is also the President of the Global Snakebite Initiative and he made possible the partnership with the Indian Snakebite Initiative, which has already shared with us more than 4,000 snake images from highly venomous snakes in India. This project was presented at ITU in Geneva during the AI for Good Global Summit 2018, which has reinforced existing collaborations between UNIGE and ITU in the areas of Global Health and Medicine (e.g. A. Geissbuhler).

This project gathers a unique set of players around snakebite and offers an excellent opportunity to tackle this ongoing global health crisis through scientific evidence, social and digital innovations. Our innovative approach is timely and responds to the urgent need for cutting‐edge research and scientific leadership following the recent acceptance of snakebite in the WHO‐NTD list.

**Detailed list of partners:**

Dr. Rafael Ruiz de Castañeda, Institute of Global Health, UNIGE

Dr. Isabelle Bolon, Institute of Global Health, UNIGE

Dr. Andrew Durso, Institute of Global Health, UNIGE

Prof. François Chappuis, Division of humanitarian and tropical medicine, HUG/UNIGE

Dr. Gabriel Alcoba, MSF and Division of humanitarian and tropical medicine, HUG/UNIGE

Dr. Nicolas Ray, Institute of environmental sciences & Institute of Global Health, UNIGE

Prof. Marcel Salathe, Digital Epidemiology Lab, EPFL

Sharada Prasanna Mohanty, Digital Epidemiology Lab, EPFL

Camille Montalcini, Digital Epidemiology Lab, EPFL

Prof. François Grey, Citizen Cyberlab, UNIGE

Dr. Jose Luis Fernandez, Citizen Cyberlab, UNIGE

Rosy Mondardini, Citizen Science Center Zurich, ETH / UNIZH

Prof. David Williams, Global Snakebite Initiative, University of Melbourne

Dr. Abiy Tamrat, Médecins Sans Frontières, Geneva

Hanne Epstein, Médecins Sans Frontières, Copenhagen

Donald Becker, Christopher Smith, Michael Pingleton, HerpMapper

M. Jose Louies, IUCN Viper Specialist Group, indiansnakes.org & snakebiteinitiative.in

Dr. Brian Lohse, AntiVenom Venture & University of Copenhagen

Dr. Ulrich Kuch, University of Frankfurt, Germany

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Annex:
Answers to the questionnaire

1. **Relevance - How relevant is the health problem to be addressed?**

Snakebite is among the most deadly neglected tropical disease (NTD), being responsible for a dramatic humanitarian crisis in global health (Waldmann, 2017). Snakebite causes over 100,000 human deaths and 400,000 victims of disability and disfigurement globally every year, affecting poor and rural communities in developing countries, which host the highest venomous snake diversity and the highest burden of snakebite due to limited medical expertise and access to antivenoms (Gutierrez et al., 2017; Longbottom et al., 2018). Antivenoms can be life‐saving when correctly administered but this depends first on the correct taxonomic identification (i.e. family, genus, species) of the biting snake. Snake identification is challenging due to snake diversity and incomplete or misleading information provided by snakebite victims or bystanders to healthcare professionals, who generally lack the necessary knowledge or resources in herpetology.

In June 2017, after years of sustained efforts by groups such as Global Snakebite Initiative, Doctors Without Borders (MSF), and the Kofi Annan Foundation as well as the support of key member states, the WHO included snakebite in the NTD list. In May 2018, the 71st World Health Assembly adopted a resolution formally providing the WHO with a strong mandate to tackle the snakebite crisis, generating an unprecedented momentum and urging for political action and scientific acceleration (WHO 2018). Besides the critical importance of safe, accessible and effective polyvalent antivenoms, innovative expertise, approaches and tools are urgently needed to tackle snakebite and support health professionals, particularly leveraging digital technologies (e.g. AI).

1. **Impact - What level of impact will a benchmark in the context of the proposed project have?**

Taxonomic identification of the biting snake is crucial to anticipate patient clinical signs and to ensure adequate management, including the precise administration of antivenom, which is often expensive, taxon-specific, and very limited in availability. The distinction between venomous and non-venomous snakes has major implications, but snake identification can be very challenging and healthcare professionals are not herpetologists. For instance, in certain countries such as Myanmar, community members tend to kill the biting snake and carry it to the health facility for identification (Schioldann et al., 2018) but, besides the conservation implications, this practice is not recommended, both because it entails additional risks of repeated snakebite and because the capacity of clinicians to identify the snake is limited. Appropriate snake identification tools are lacking and, although molecular techniques to identify snake DNA from the bite site have been explored (Sharma et al, 2016), the limited number of cases and low sensitivity of the test has prevented the evaluation of its true diagnostic performance. In this context, the ultimate objective of our project is to improve clinical management of snakebite by supporting clinicians and other healthcare professionals (e.g. local practitioners, University Hospitals of Geneva and MSF in the field), as well as snakebite victims, in the identification of biting snakes.

We propose the first medical decision‐support mobile app for snake identification based on AI and remote collaborative expertise in herpetology. With a highly transdisciplinary approach and involving end-users in snakebite hyper-endemic countries, our app will combine computer vision with the expertise from a network of professional and non-professional herpetologists to identify photos of snakes, particularly supporting victims and healthcare professionals when urgent and reliable snake identification is needed. This app will serve as an educational and capacity-building platform for both citizens and healthcare professionals around the world and the data collected through it (e.g. snake distribution, snakebite epidemiology, clinical management and outcomes etc.) will improve our understanding of snakebite and reinforce health systems in snakebite endemic countries (e.g. distribution of antivenoms where more are needed).

1. **Existing work - Does the project start from scratch, or are there preliminary experiences?**

We have brought together a highly interdisciplinary and international team involving experts in snakebite clinical management, epidemiology, herpetology, AI, citizen science and crowdsourcing etc. (see details of the team at the end of the document). This project idea has emerged and been developed over the last 1-2 years from key discussions with health professionals confronted with snakebite in the field (e.g. MSF). We have solid experience with these large biodiversity platforms and in 2016 we launched a project on [Medically Important Venomous Snakes](https://www.inaturalist.org/projects/medically-important-venomous-snakes) on iNaturalist, which served as a central source of data (over 10,000 snake observations) for an article by our team recently published in *PloS NTDs* (Genevieve et al., 2018). In addition, Dr. A. Durso, who holds a PhD in herpetology and co-leads the [Snake Identification Facebook group](https://www.facebook.com/groups/22137638452/), with over 100,000 members, joined our team at UNIGE’s Institute of Global Health to work on this project. His expertise in snake identification and his global network open unique opportunities for snake photo gathering and identification. The Fondation privees des HUG (<http://www.fondationhug.org/>) currently funds this project, which officially started in September 2018 and runs for the next two years.

1. **Feasibility - Is the project feasible, based on the current state of the art?**

The AI-based identification of images of animals and plants and some of their features (e.g. birds, leaves, diseases) is already well developed and we can build from lessons learnt from other research groups and other taxa, for example birds (<http://merlin.allaboutbirds.org/>). In addition, we plan to use a collaborative approach in the development of the algorithm using CrowdAI platform (<https://www.crowdai.org/>). Snake identification already happens informally through platforms such as WhatsApp & Facebook snake ID groups with which we are collaborating to capture data on the speed and accuracy of the process.

**5. Data Availability - Is there sufficient data available? How much of it can be openly available? How much of it as part of the non-disclosed data set?**

Today, we have over 200,000 images of snakes and our goal is to reach 1.5 million images from across the world in a period of two years. The great majority of the images will be openly shared (e.g. public domain, CC-BY-NC). A fraction of the images, for example coming from some expert private collections, will be kept as part of the non-disclosed data set. Further details on this and other points are provided in our response to question 8.

**6. Data Quality - Is the available data of high quality?**

We count on high-quality open and private data sets (e.g. validated by experts, well organised citizen science initiatives) as further described in our response to question 8. We are implementing processes to improve the quality of metadata associated with images taken from informal social media snake identification communities, for example when the species ID or location is located within a string of text such as a photo caption rather than its own unique field.

**7. Annotation / Label Quality - Are the annotations / labels of the data of high quality?**

Snake images are identified to the species level and include geographic information (e.g. GPS location or at least country) in most cases. For non-annotated images, we plan to involve professional and non-professional herpetologists and snake enthusiasts to help tag images. We are currently working on a study to scientifically assess the accuracy and speed of non-professional herpetologists and snake enthusiasts in the identification of snake images. The online community of snake enthusiasts with which we have intimate contact has indicated an eagerness to aid in this process. Further details on this and other points are provides in our response to question 8.

**8. Data Provenance - Has the data been obtained in a professional and ethically correct way?**

High-quality open data sets that are available for training purposes include images annotated with species ID, geolocation, timestamp, and anonymous contributor ID from citizen science platforms such as HerpMapper (80,000) and iNaturalist (85,000). Both platforms include crowd-based quality-controls. We will contribute to an open data set for training purposes by collecting and annotating images from web sources (e.g. Flickr, Twitter, Facebook), experts, and unique open images collections such as IndianSnakes.org (5,000 images). Annotation status of these images varies, with some georeferenced with a timestamp but with the species ID within a string of text such as a photo caption rather than its own unique field. Undisclosed test data that are available for an evaluation but which will not be made accessible to the AI developers. This mainly includes images from experts who prefer their images to be used privately. We could also consider all-rights-reserved images annotated with species identification, geolocation, timestamp, and anonymous contributor ID from citizen science platform iNaturalist (40,000), as well as all-rights-reserved untagged images from Flickr and images we are collecting from books. At present, our open data set includes 200,000 images, and we anticipate collecting and annotating close to 500,000 images from web sources and experts within the next 6 months. Our eventual target is 1.5 million images within 2 years, with no fewer than 100 images per species (3,700 snake species = minimum 370,000 images, but many species are already represented by far more).

 **9. Benchmarking - Do the applicants have a clear proposal about what exactly should be evaluated / measured?**

Yes. We aim to measure the accuracy and speed of snake image identification at different taxonomic levels (i.e. genus and species). We will consider images of different levels of quality in order to cover the diversity of real field scenarios and possible photographic devices (i.e. from high resolution image including the full body of the snake to images only including part of the snake and at low resolution). In addition, snake images will also include geographic information (e.g. exact GPS location of the snake, country).

**10. Organizers - Can the Focus Group work with the applicants, and do they have the time / resources to work with the Focus Group on the problem?**

Yes. The core team (Institute of Global Health, University of Geneva and University Hospitals of Geneva; Citizen Cyberlab, University of Geneva; Citizen Science Centre, ETH-Zurich/University of Zurich; Digital Epidemiology Lab, EPFL) in collaboration with our partners (i.e. other academic institutions and NGOs such as MSF, Global Snakebite Initiative) are committed to this project and to work with the Focus Group. Besides active contributions from the different experts, the Institute of Global Health at the University of Geneva has specifically hired a postdoc researcher (Dr. Andrew Durso, PhD in snake biology) to work 100% on this project over the next two years.

**Detailed list of partners:**

Dr. Rafael Ruiz de Castañeda, Institute of Global Health, UNIGE

Dr. Isabelle Bolon, Institute of Global Health, UNIGE

Dr. Andrew Durso, Institute of Global Health, UNIGE

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Dr. Gabriel Alcoba, MSF and Division of humanitarian and tropical medicine, HUG/UNIGE

Dr. Nicolas Ray, Institute of environmental sciences & Institute of Global Health, UNIGE

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