frontiers | Frontiers in Conservation Science

TYPE Perspective
PUBLISHED 18 October 2024
DOI 10.3389/fcosc.2024.1470645

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OPEN ACCESS

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RECEIVED 25 July 2024
ACCEPTED 30 September 2024
PUBLISHED 18 October 2024

CITATION
Smith LJ, Gelman N, O'Mara MT, Frick WF, Ronis EM, Cameron KN, Gonzales A, Coleman JTH, Reichard JD and de Wit LA (2024) Application of the MENTOR model to advance One Health by promoting bat conservation and reducing zoonotic spillover risk. *Front. Conserv. Sci.* 5:1470645. doi: 10.3389/fcosc.2024.1470645

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Application of the MENTOR model to advance One Health by promoting bat conservation and reducing zoonotic spillover risk

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For few taxonomic groups do conservation efforts have such a disproportionate impact on biodiversity and human well-being as they do with bats. Bats face significant conservation challenges that affect their long-term viability, inhibit their ecosystem functions and services, and increase zoonotic spillover risks. Protecting bat populations and their habitats ultimately reduces these conservation threats, helps prevent pandemics, and supports essential ecosystem services. MENTOR-Bat is a fellowship program focused on strengthening technical research, and leadership capacity in the Global South to promote healthy environments where bats and humans can coexist with reduced risks of pathogen transmission. Co-designed by the United States Fish and Wildlife Service (USFWS) and Bat Conservation International (BCI), MENTOR-Bat mirrors the One Health framework by featuring a transdisciplinary team of three mentors and nine fellows from Cameroon, Colombia, and Indonesia. Fellows and mentors receive academic and field-based training on bat ecology and conservation, One Health, human dimensions of conservation, behavior change, strategic communications, international policy, adaptive management, project planning, conservation leadership, and public health. Fellows will then design and implement team pilot projects to advance One Health and bat conservation in their respective countries. Program evaluation of MENTOR-Bat is based on Kirkpatrick's Hierarchy and focuses on measuring the development of established One Health core competences. By incorporating One Health and conservation within its activities, MENTOR-Bat can become a valuable programmatic template for transdisciplinary programming advancing evidence-based strategies for improving the well-being of bats, humans, and the environment.

KEYWORDS

capacity development, spillover, nature-based solutions, conservation leadership, curriculum

Introduction

Bats are a highly diverse order of mammals found across the world and are facing major conservation threats including land-use change, disturbance, disease, hunting, and climate change (Frick et al., 2020). Some bat species can be reservoir hosts to zoonotic pathogens, meaning that they naturally harbor these pathogens and serve as a source of them (Luis et al., 2013; Brook and Dobson, 2015; Johnson et al., 2020). Following sporadic outbreaks of Nipah Virus in South Asia, the 2002 SARS epidemic, Marburg virus in Central Africa, and the COVID-19 pandemic, fear of bats increased due to expanding awareness of zoonotic spillover risks (Lu et al., 2021; Ejotre et al., 2022; Nanni et al., 2022; Straka and Voigt, 2022; Osofsky et al., 2023). Pressures like habitat disturbance and climate change further increase the risk for zoonotic spillover: as bats become stressed, they are more susceptible to infection and increased pathogen shedding (or releasing pathogens into the environment via excrement or saliva) (Plowright et al., 2024). Many of these threats also increase the potential for contact between bats and humans, which also increases the risk for zoonotic spillover (Eby et al., 2023; Plowright et al., 2024).

One Health, which recognizes that animal, human, and environmental health are interdependent and must be promoted simultaneously, can be used to promote biophilia, or a desire to connect with nature. As the world emerges from the COVID-19 pandemic, bat and biodiversity conservation must be promoted writ large to reduce zoonotic spillover risks and prevent pandemics before they begin (Eby et al., 2023; Weber et al., 2023; Plowright et al., 2024; Reaser et al., 2024). Protecting bat populations and their habitats offers significant co-benefits for people and bats; these activities reduce stress and viral shedding in bats while also reducing human-bat interactions. This provides primary prevention of pandemics by reducing the risk of pathogens emerging in the first place. This protection also preserves functioning ecosystem services like pollination and insect control. As key ecosystem players often persecuted due to fear of disease, bats exemplify the need for a One Health approach and biophilia promotion.

Bat diversity is highest in equatorial regions, which are also hotspots for zoonotic diseases and where the bat species known to be zoonotic reservoirs are most commonly found (Schneeberger and Voigt, 2015; Guth et al., 2022).

Activities such as hunting bats for meat consumption or wildlife trade (Latinne et al., 2020; Tanalgo et al., 2023), guano harvesting (Thet and Mya, 2015), cave tourism (Chiarini et al., 2022), and persecution (Schneeberger and Voigt, 2015), which bring people into close proximity with bats, are prevalent in these regions. To address the risks posed by these activities, researchers emphasize the need for integrated approaches that combine biodiversity conservation and public health efforts (Glidden et al., 2021). Strengthening the capacity of conservation and public health leaders in these regions is crucial not only for protecting these species but also for preventing zoonotic spillover (Amuguni et al., 2017). While programs exist that promote either conservation or public health, few address both simultaneously, highlighting a critical gap in the integration of these efforts. Education and collaboration between conservationists and other sectors are crucial for preventing future zoonotic outbreaks and protecting bat populations.

MENTOR-Bat is a fellowship program that builds upon previous U.S. Fish and Wildlife Service (USFWS) MENTOR conservation initiatives, focusing on enhancing the technical, research, and leadership capacities of early-career professionals from the Global South in promoting both conservation and public health. Co-designed with Bat Conservation International (BCI), a science-based, not-for-profit, non-governmental organization (NGO), the program aims to equip fellows with the skills needed to design, implement, and sustain One Health conservation initiatives that protect bats and their habitats while reducing pandemic risks.

The United States Fish and Wildlife Service MENTOR model

Since 1989, the USFWS International Affairs Program has supported over 700 partner organizations to protect wildlife and key wildlife strongholds while developing conservation champions. Recognizing that capacity development is critical for conservation success, USFWS International Affairs launched the Mentoring for Environmental Training in Outreach and Resource Conservation (MENTOR) Program in 2008 to train professionals in technical competencies to promote evidence-based approaches to conservation (Abu-Bakarr et al., 2022). The MENTOR model combines academic and field-based approaches through experiential learning, training, conservation planning, project implementation, mentoring, and problem solving. Fellows earn post-graduate degrees, diplomas, or certificates from national and regional colleges and universities.

Through seven programs, USFWS MENTOR has supported 61 fellows from 11 African countries, fostering conservation leadership across issues including the bushmeat trade, extractive industries, fisheries management, and manatee, great ape, and pangolin conservation (Abu-Bakarr et al., 2022). Alumni of the program have gone on to lead conservation initiatives within governments, NGOs, and the private sector; perform research; manage national parks; and become mentors themselves for new conservationists. They are contributing to long-term conservation leadership and capacity development within program countries and internationally (Abu-Bakarr et al., 2022).

MENTOR-Bat is the first multiregional iteration of the USFWS MENTOR Programs and spans three continents with cohorts from Cameroon, Colombia, and Indonesia. Under the American Rescue Plan Act that the U.S. government enacted in response to the COVID-19 pandemic, USFWS received funding "for research and extension activities to strengthen early detection, rapid response, and science-based management to address wildlife disease outbreaks before they become pandemics and strengthen capacity for wildlife health monitoring to enhance early detection of diseases that have capacity to jump the species barrier and pose a risk in the

United States". USFWS International Affairs recognized the opportunity to apply the MENTOR model by establishing transdisciplinary teams aimed at reducing high-risk interactions between humans and bats while promoting bat conservation (The American Rescue Plan Act, 2023). The program advances the established USFWS MENTOR Model of connecting transdisciplinary teams of fellows with long-term mentors, senior conservation leaders, and international experts who guide the fellows, teach problem solving techniques, and foster the development of creative solutions in learning partnerships that continue throughout the careers of both mentors and fellows.

MENTOR-Bat program structure

Each country MENTOR-Bat cohort consists of three fellows and one mentor, selected through a competitive application and interview process. Each mentor is a bat ecology, behavior, and conservation expert while fellows come from an array of backgrounds, including ecology, wildlife conservation, veterinary medicine, virology, environmental education, geology, and public health. The eighteen-month program consists of virtual learning; in-person workshops; pilot project design and on-the-ground project implementation in program countries; educational outreach about bat conservation and One Health in program countries; a final in-person MENTOR-Bat Outcomes Workshop; and a MENTOR Forum on conservation leadership. The project structure is as follows:

1. During the initial five months of virtual curriculum, experts present on topics including bat conservation, One Health, human dimensions of conservation, outreach and communications, adaptive management, conservation leadership, and others.
2. Fellows complete assignments on the major themes of the curriculum that are reviewed by their national mentors.
3. Punctuating the first five months of virtual learning are two workshops that emphasize team building, including a launch workshop in Colombia and a workshop in Indonesia where the cohorts will learn the conservation standards and adaptive management to design their pilot conservation projects.
4. During the remaining thirteen months of the program, fellows conduct field site visits, design and implement field-based pilot conservation projects and meet with government ministries and NGOs to mobilize their projects in their respective countries.
5. They will educate domestic stakeholders in their country about MENTOR-Bat and their projects, and advance conservation and educational outreach about bat conservation and One Health during Bat Week in October 2024 and International Bat Appreciation Day in April 2025.
6. The final step in the program will be the MENTOR-Bat Outcomes Workshop and USFWS MENTOR Forum. This will take place in Cameroon where MENTOR-Bat cohorts will present their pilot project outcomes and earn a certificate from Garoua Wildlife College, the leading regional Francophone training institution for wildlife managers. Fellows from previous MENTOR programs will attend with MENTOR-Bat fellows to discuss implementing conservation leadership to address threats to wildlife and grow the active MENTOR Network of conservation champions. Since many mentors and fellows are advanced in their careers as well-recognized conservation leaders, they design and lead the Forum as an opportunity to share lessons, technical expertise, learning on conservation leadership and threats to wildlife, networking and to inform recommendations for future MENTOR programs and similar capacity development initiatives. This will also grow the active MENTOR Network of conservation champions.
7. Upon completion of the program, fellows are encouraged to build upon their network and skills gained in MENTOR-Bat to maintain connections with USFWS and BCI to continue as bat conservation and One Health champions in their countries.

MENTOR-Bat launched in Colombia in April 2024 and cross-cutting themes emerged across the cohorts, including a passion for community education on bat conservation and healthy coexistence; understanding how ecological pressure on bats can increase zoonotic disease spillover risks; and building an international network of professionals who are interested in and passionate about bat conservation and community outreach for coexisting with bats.

Why MENTOR-Bat is needed

Many bat conservation programs do not incorporate public health initiatives or zoonotic spillover risk reduction messaging. Conversely, many public health campaigns advise people to avoid contact with bats without also educating about their ecological benefits and how safe coexistence is possible, which ultimately hinders conservation efforts. Few programs simultaneously promote biophilia and enhance pandemic prevention, despite their interconnection.

Successfully promoting conservation and zoonotic spillover risk reduction together is challenging. After bats were identified as the potential source for spillover of SARS-CoV-2 that led to the COVID-19 pandemic, some countries culled bats (Lu et al., 2021). While these actions were intended to reduce bat populations near people, they created additional risk by elevating the potential for bat-human contact during culling (Lu et al., 2021). While there was no report of a second spillover of SARS-CoV-2 from bats, this strategy likely increased the risk of this happening rather than reduced it. Bolstering global health security is often framed within strategies such as stockpiling medical countermeasures and building health systems capacity. While these are certainly needed to strengthen disease outbreak and pandemic response, they are downstream, secondary prevention approaches that focus on responding to an outbreak long

after a disease has emerged and is spreading through a human population (Plowright et al., 2024). With 75% of emerging infectious diseases originating in animals, the world must also advance upstream strategies to prevent spillover and pandemics from occurring in the first place (Shaheen, 2022). Such nature-based primary prevention strategies for pandemics have significant shared benefits for humans, animals, and the environment and are estimated to cost a mere 1% of what it costs to respond to a pandemic (Bernstein et al., 2022; Plowright et al., 2024). Primary prevention of pandemics also costs less than 1/20th of the value of human lives lost each year to emerging viral zoonoses (Bernstein et al., 2022).

Nature-based strategies to prevent the spillover of bat-borne pathogens and consequent disease emergence can be broadly grouped into three countermeasures: protecting where bats roost, protecting where bats forage, and protecting people at risk (Plowright et al., 2024). These countermeasures function through two general mechanisms: 1) reducing the risk of pathogen infection and shedding in bats by ensuring that access to high-quality food and shelter is readily available and that they are not under allostatic overload, and 2) reducing opportunities for pathogen exposure to people or livestock in close proximity to bats that could serve as potential pathogen reservoirs (Kessler et al., 2018; Eby et al., 2022; Plowright et al., 2024). Examples of these countermeasures include protecting and restoring bat foraging and roosting habitats, working with stakeholders who have close contact with bats through economic and livelihood activities (e.g., guano harvesters, cave tourists, people who hunt and consume bats) to adopt safe practices that reduce both stress and disturbance in bats while minimizing opportunities for pathogen exposure, and raising awareness about the ecological and economic roles of bats. Involving stakeholders in the strategy development and decision-making process, as well as raising awareness can inform people's attitudes toward bats, encouraging them to become stewards of bats and their ecosystems rather than persecuting them out of fear of disease. By implementing strategies grounded in bat and ecosystem conservation, as well as education on safely coexisting with bats, MENTOR-Bat aims to build capacity for the primary prevention of potential future pandemics.

Discussion

Program evaluation of previous MENTOR programs

In a previous study, mixed methods including a survey, key informant interviews, and a document review were used to evaluate the efficacy and impact of the series of USFWS MENTOR programs. The study found that: 1) previous MENTOR programs played an important role in helping fellows establish and expand their professional networks, 2) all participating fellows confirmed that they acquired new skills and knowledge, and 3) all fellows felt that their MENTOR participation improved their professional development (Abu-Bakarr et al., 2022). Adaptive management was found to be a consistently improved competence, as well as use of information and communication technology, leadership, and conservation outcomes. The transdisciplinary focus of MENTOR programs was found to enhance team building and inspire fellows to develop long-term professional networks. To address One Health challenges, building enduring multidisciplinary networks across sectors is crucial for sustainable capacity development. By exposing fellows to the complexity of challenges at the One Health interface, MENTOR-Bat aims to enable fellows to become competent professionals who will be capable of fostering connections across sectors. In MENTOR-Bat, 51 instructors and supporters from 33 different organizations provide guidance and link cohorts to additional professional networks like the Global Union of Bat Diversity Network (GBatNet), further enhancing their professional growth and network expansion.

Evaluation of One Health core competences

MENTOR-Bat's curriculum is based on the nine One Health core competences identified by the United States Agency for International Development (USAID)/RESPOND project multiagency working group as necessary to include in One Health training programs (Amuguni et al., 2019).[1,2] These are project management; communication; gender, culture, and beliefs; leadership; collaboration and partnership; values and ethics; systems thinking; policy and advocacy; and research (Amuguni et al., 2019). MENTOR-Bat has designed its program curriculum and evaluation methodology around these One Health core competences, and conducted a knowledge, attitudes, and skills (KAS) survey during the launch workshop in Colombia in April 2024 that evaluated the fellows on these core competences.

Program evaluation methodologies

To evaluate program efficacy, MENTOR-Bat is using Kirkpatrick's Hierarchy, which consists of four levels of evaluation: reaction, learning, behavior, and results (Alsalamah and Callinan, 2021). Reaction measures fellows' engagement and how well training content was received by administering post-training evaluation surveys that will provide feedback to MENTOR-Bat staff on the program's content and delivery. Learning measures how the training has developed fellows' knowledge, skills, attitudes, and their confidence in implementing what they have learned. Learning will be measured at the beginning and end of the program through surveys and will test MENTOR-

1 RESPOND was a component of the USAID Emerging Pandemic Threats (EPT) Program.

2 The Africa One Health University Network (AFROHUN), formerly One Health Central and Eastern Africa (OHCEA), collaborated with the Southeast Asia One Health Network (SEAOHUN) and a multiagency Global One Health Core Competency Working Group to determine and establish a list of core competencies that One Health training programs should include.

Bat's pre-defined core competences. Behavior measures whether the fellows have applied their learning, which is best measured several months after the training has been completed and can be done in the form of interviews. Results measures the outcomes of the program and will be based on the implementation of national cohorts' projects and two programmatic activities: the MENTOR-Bat Outcomes Workshop and the national cohorts' presentations to relevant stakeholders (i.e., NGOs, government agencies, local communities, and others) (Alsalamah and Callinan, 2021).

Post-training evaluation surveys will be delivered at the end of the academic training. There are four surveys grouped by the following themes: bat conservation, One Health, human dimensions, and outreach. The Conservation Leadership Programme (CLP) will lead the conservation leadership training portion of the program and will implement their own post-training survey. The survey results will be used to inform future MENTOR programs and can inform future One Health capacity development programs and other similar programs. Results from these surveys will be analyzed and published in a peer-reviewed journal and MENTOR-Bat fellows and mentors will be invited to participate in the publication. Fellows were notified at the beginning of the program about the goals of the post-training evaluation surveys and the intended use of the associated data. Fellows who decide to participate were asked to sign acknowledgement of the goals of the surveys, intended use of the data, and willingness to participate in the surveys. Anonymity and confidentiality will be maintained and ensured, with unique identifier codes used when responding to surveys. The unique identifier codes will be used throughout the program to evaluate fellows' individual progress throughout the program without disclosing their identity. International human subjects research standards will be followed.

Anticipated impacts on One Health capacity development

MENTOR-Bat is designed to promote primary prevention of pandemics that aims to stop outbreaks before they start by mitigating spillover risks through a One Health approach. The world currently prioritizes biomedical responses to existing disease outbreaks over primary prevention, which can be costly and ineffective. This approach naturally lacks a focus on achieving co-benefits for conservation and sustainable development, whereas MENTOR-Bat aims to prioritize these co-benefits.

Embedded within the strategies for promoting primary pandemic prevention, one of the goals of MENTOR-Bat is to reduce the stigmatization of bats and promote their conservation. Achieving this can create a positive feedback loop for spillover prevention strategies, as many situations that bring people into close contact with bats result from the persecution of bats due to fear of disease (MacFarlane and Rocha, 2020; Rocha et al., 2021). Additionally, encouraging people to safeguard the ecosystems they share with bats can support efforts to maintain healthy bat populations with a low risk of pathogen infection and shedding (Plowright et al., 2024). Focusing on the benefits of bats through outreach and education campaigns can improve uptake of public health messaging without stigmatizing these species, while simultaneously promoting conservation. For example, a U.S. National Park Service study showed that educating the public about benefits of bats promoted the uptake of public health messaging and implementation of rabies risk reduction behaviors (Lu et al., 2016). With its reach across three continents, MENTOR-Bat could strengthen this positive awareness and maximize co-benefits on a larger scale. Similarly, following the COVID-19 pandemic a study found that public health messaging that prioritized educating citizens and enhancing general appreciation of biodiversity improved bat-related attitudes and beliefs. MENTOR-Bat aims to help reframe and mobilize conservation efforts as a pandemic prevention strategy and as a method to improve public health, education, and ecosystem function.

As a multi-country conservation fellowship program, MENTOR-Bat is uniquely positioned to develop a team of conservation and One Health champions who can foster the development of long-term, multisectoral frameworks for enhancing public education and awareness around bat conservation and zoonotic disease spillover risks. It also gives fellows an opportunity to take their training and background and apply it in new areas with transdisciplinary teams. Ultimately, this can enhance multisectoral capacity while normalizing transdisciplinary work around One Health challenges at the conservation-health-development interface. MENTOR-Bat aims to serve as a programmatic template for additional programs and information sharing networks to continue building long-term, sustainable One Health capacity for bat conservation and zoonotic spillover risk reduction.

Data availability statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

Author contributions

LS: Writing – original draft, Writing – review & editing. NG: Writing – original draft, Writing – review & editing. MO'M: Writing – original draft, Writing – review & editing. WF: Writing – original draft, Writing – review & editing. ER: Writing – original draft, Writing – review & editing. KC: Writing – original draft, Writing – review & editing. AG: Writing – original draft, Writing – review & editing. JC: Writing – original draft, Writing – review & editing. JR: Writing – original draft, Writing – review & editing. LW: Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This activity was supported by an AAAS Science & Technology Policy Fellowship served at the United States Fish and Wildlife Service International Affairs Program in the Division of Scientific Authority.

Conflict of interest

Author LS was employed by AAAS Fellowship Programs, Inc.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer JRO declared a past co-authorship with the author WFF to the handling editor.

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