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Evaluating the public health response to a mass bat exposure—Wyoming, 2017

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Abstract

Mass bat exposures (MBEs) occur when multiple people are exposed to a bat or a bat colony, often over an extended period. In August 2017, a public health investigation was started in response to an MBE that occurred during May–August 2017 at a national park research station in Wyoming. We identified 176 people who had slept primarily in two lodges (Lodges A and B) at the research station, and successfully contacted 165 (93.8%) of these individuals. Risk assessments (RAs) were administered to all 165 individuals to determine degree and type of exposures to bats (e.g., biting or scratching). Exposure status for research station guests was classified as "non-exposed," "low risk" or "high risk," and counselling was provided to guide post-exposure prophylaxis (PEP) recommendations. Prior to public health notification and intervention, 19 persons made the decision to pursue PEP. The healthcare-seeking behaviours of this group were taken to represent outcomes in the absence of public health intervention. (These persons received a RA, and their risk classification was retrospectively assigned.) Approximately 1–2 weeks after conducting the RAs, we conducted a follow-up survey to determine whether recommendations regarding PEP were ultimately followed. The proportion of individuals that unnecessarily pursued PEP was higher among the 19 individuals that sought health care prior to receiving the RA ($p < 0.00001$). Among those receiving the RA first, all persons classified as high risk followed public health guidance to seek PEP treatment. Despite this, upon re-interview, only 21/79 (26.6%) of guests could accurately recall their risk classification, with most people (55.7%) overestimating their risk. Study findings demonstrate that early public health interventions such as RAs can reduce unnecessary use of PEP and that messaging used during rabies counselling should be clear.

KEYWORDS

counselling, mass bat exposure, post-exposure prophylaxis, rabies, risk assessment

1 | INTRODUCTION

In the Western hemisphere, bats are a widespread wildlife reservoir for zoonotic diseases (Calisher, Childs, Field, Holmes, & Schountz, 2006). Since 2008, rabid bats have been reported in all contiguous states in the United States and were responsible for at least 12 domestically acquired human rabies deaths during 2003–2017 (Centers for Disease Control & Prevention, 2017; Ma et al., 2018; de Serres, Dallaire, Côte, & Skowronski, 2008). Most autochthonous human rabies deaths in the U.S. occur after exposure to bats. Special attention to bat exposures is warranted because a person can be unaware of his or her exposure and evidence of bite wounds might be difficult to perceive (Manning et al., 2008).

In some instances, multiple people are exposed to a bat or a bat colony, known as a mass bat exposure or MBE. Across the United States, MBEs have occurred in different settings such as university housing facilities, private residences, campgrounds, elementary schools and military barracks (Griffin et al., 2009; Schroeder et al., 2018; Thoroughman et al., 2013; Webber et al., 2014). Public health responses to these events vary widely. Previously, some state or local health departments have elected to encourage all persons who were potentially exposed to rabies to pursue post-exposure prophylaxis (PEP), whereas other jurisdictions adopted triaged approaches to identify persons who required PEP based on clearly defined risk (Hsu et al., 2016). Some states have also confined their investigation of exposures to those within a 6-month window of MBE notification, while others elected to investigate exposures beyond 1 year (Hsu et al., 2016). These differences in approach have the potential to lead to overuse of PEP, or missed identification of people exposed to rabies, highlighting the need for more formal, standardized approaches to investigating MBEs.

For individual human–bat interactions, the Advisory Committee on Immunization Practices (ACIP) recommends capturing the bat and conducting rabies testing whether potential human exposure to a bat occurs. If testing is not possible, PEP is indicated for any known direct contact events where a bite or scratch cannot be reasonably denied (Manning et al., 2008). However, when the nature of contact is unknown (i.e., waking to a bat in the room), ACIP recommends considering additional factors before recommending PEP. These include consumption of medications, other drugs or alcohol that might decrease awareness of bat contact, sleep disorders, sleep habits (e.g., heavy/deep sleeper, sleeping with bare skin exposed or sleeping covered) or, as in the case of young children, inability to communicate about a bat encounter (Manning et al., 2008; Rupprecht et al., 2010). Capturing and testing bats are not always possible or feasible after an MBE—therefore, risk assessments (RAs) should guide PEP recommendations for potential rabies exposure. Otherwise, potentially exposed persons might overwhelm the healthcare system, and indiscriminate recommendation of PEP could lead to temporary supply depletion or shortages and high expenses (Cheng, 2012). Further, the over-administration of PEP could also lead to vaccine-adverse events in individuals who may not have needed prophylaxis in the first place. Although adverse reactions are rare, signs and symptoms include local pain at the injection site, fever, headache and gastrointestinal illness (Centers for Disease Control & Prevention, 2011).

Impacts

- In response to a mass bat exposure (MBE), a standardized risk assessment (RA) tool was used to assess individual exposures to bats. This was designed both to give persons exposed to bats information concerning whether to seek post-exposure prophylaxis (PEP), and to ensure that non-exposed persons did not pursue treatment unnecessarily.
- Systematic data on public health responses to MBEs are rarely collected, although MBEs occur frequently. We present a detailed analysis of a public health response to an MBE and compare the actions of persons who did or did not receive an RA before deciding whether to pursue rabies PEP.
- Rapid response and communication among public health jurisdictions was crucial to identify persons who had stayed at the bat-infested facilities and to conduct rabies RAs.

On 2 August 2017, a local health department notified the Wyoming Department of Health (WDH) of a group of people who had potential contact with bats. These persons were guests at a research station within a national park; the MBE began in May when the research station opened for the season. When the guests arrived, research station managers notified them about bat colonization and encouraged guests to notify authorities if they subsequently had contact with a bat. After learning about numerous human exposures to bats (and potential exposure to rabies), the research facility with National Park Service (NPS) concurrence closed the lodges and areas used for sleeping (primarily Lodge A and Lodge B) where bat colonization was observed. WDH, NPS and the Centers for Disease Control and Prevention (CDC) launched a response effort to identify people exposed to bats from the time the research station opened (May 2017) until it closed (August 2017) to conduct RAs, characterize bat exposures and provide counselling to recommend PEP as appropriate.

Here, we describe the public health response to the MBE (including the characteristics of the exposed persons and the approach employed to conduct RAs) and evaluate how the RAs influenced the PEP-seeking behaviours of the research guests. In so doing, we offer some tools that may be adapted by other public health jurisdictions responding to MBEs.

2 | MATERIALS AND METHODS

2.1 | Identification of exposed persons

We identified persons who stayed at the research station from 19 May to 2 August 2017 (75 days). Eleven research groups totalling 176 people (consisting of college and graduate students, family

members and faculty) had slept overnight at the research station during the period of concern. The research station managers provided NPS with contact information for leaders of each research group, who in turn provided contact information of all people associated with groups that slept at the research station. At this stage of the investigation, health officials were made aware of 19 individuals who sought health care (and PEP) prior to public health intervention. (The leader of this group of 19 individuals encouraged them to seek health care immediately; one of the attending physicians later notified public health authorities).

Wyoming Department of Health collaborated with state health departments, NPS, CDC and the national focal point network maintained by the World Health Organization International Health Regulations to ensure RAs were conducted for each person who slept at the research station, regardless of whether they sought PEP before administration of the RA during 3 August 2017–8 February 2018. We only included U.S. residents in this analysis, because RAs for the four international researchers (from England, Mexico, France and Australia) were conducted by their respective governments.

2.2 | Risk assessments: Public health intervention

A standardized RA tool adopted from a 2012 MBE was modified for this event by subject matter experts from CDC and WDH (see Data S1; Thoroughman et al., 2013). Investigators contacted research station managers by telephone, email or text message, and RAs were conducted confidentially with guests by telephone (preferred) or email. Because RAs were carried out by 17 public health investigators around the United States, trainings were conducted in person or by telephone to familiarize them with the tool. During the RAs, we collected information about demographics (name, age, sex), length of time spent at the research station, sleeping location within the research station, bat exposures and history of rabies vaccination. Because untreated rabies is approximately 100% fatal, we assumed a high-risk scenario when participants could not recall certain events (e.g., shutting the bedroom door).

Research station guests were placed into 1 of 3 rabies exposure-risk categories: non-exposed, low risk or high risk (Cote et al., 2018). Persons who were non-exposed were those who had no direct contact with bats, did not observe bats and slept with the bedroom door closed. (Research station guests reported sightings of multiple bats in the communal living spaces; therefore, shutting the door was considered to have effectively prevented bats from entering the bedroom.) Those classified as having a low-risk exposure also had no direct contact with bats, did not observe bats, had no conditions associated with heavy sleeping, but had slept with the bedroom door open. Lastly, persons classified as having a high-risk exposure were those who reported direct contact with a bat or who might have had bat contact they were unaware of because of medications, deep sleep, sleeping with skin exposed or alcohol consumption, and sleeping with the bedroom door open (Figure 1).

We notified research station guests of their assigned risk category immediately upon completion of the RA and provided counselling regarding the interpretation of risk categories and direction about whether PEP was advisable (see Data S1). Unless they had already completed PEP before the RA, people classified as having a high risk were advised to seek medical care immediately to initiate the PEP series; people having a low risk were advised to speak to a public health department or healthcare provider for further assessment. All people, regardless of risk, were encouraged to consult with a public health department or healthcare provider should they have further concerns. (In some cases, RAs were conducted by federal partners).

2.3 | Follow-up survey: Evaluation of public health response

To evaluate the impact of public health intervention on PEP-seeking behaviour, the same 17 investigators conducted a follow-up survey approximately 1–2 weeks after the rabies RA (see Data S2). Investigators asked whether research station guests recalled their assigned risk classification, if they consulted with a healthcare provider, if they sought or completed PEP, and which factors influenced their decision-making process.

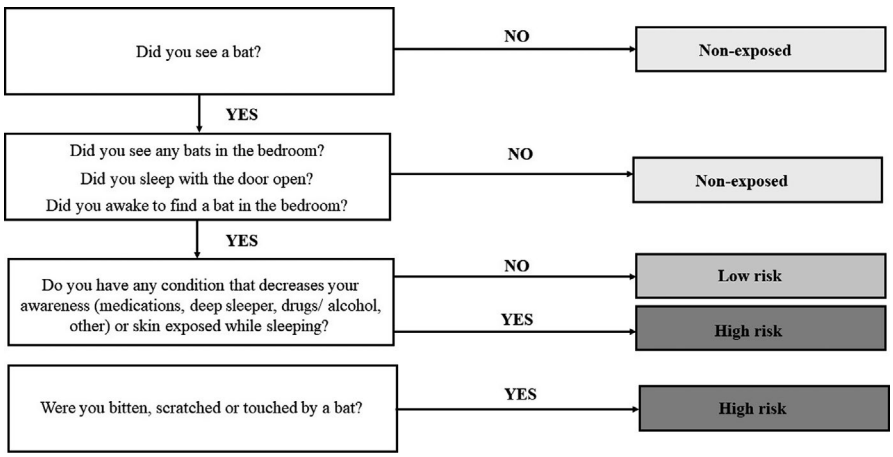

FIGURE 1 Algorithm used to assign rabies risk classification of research station guests

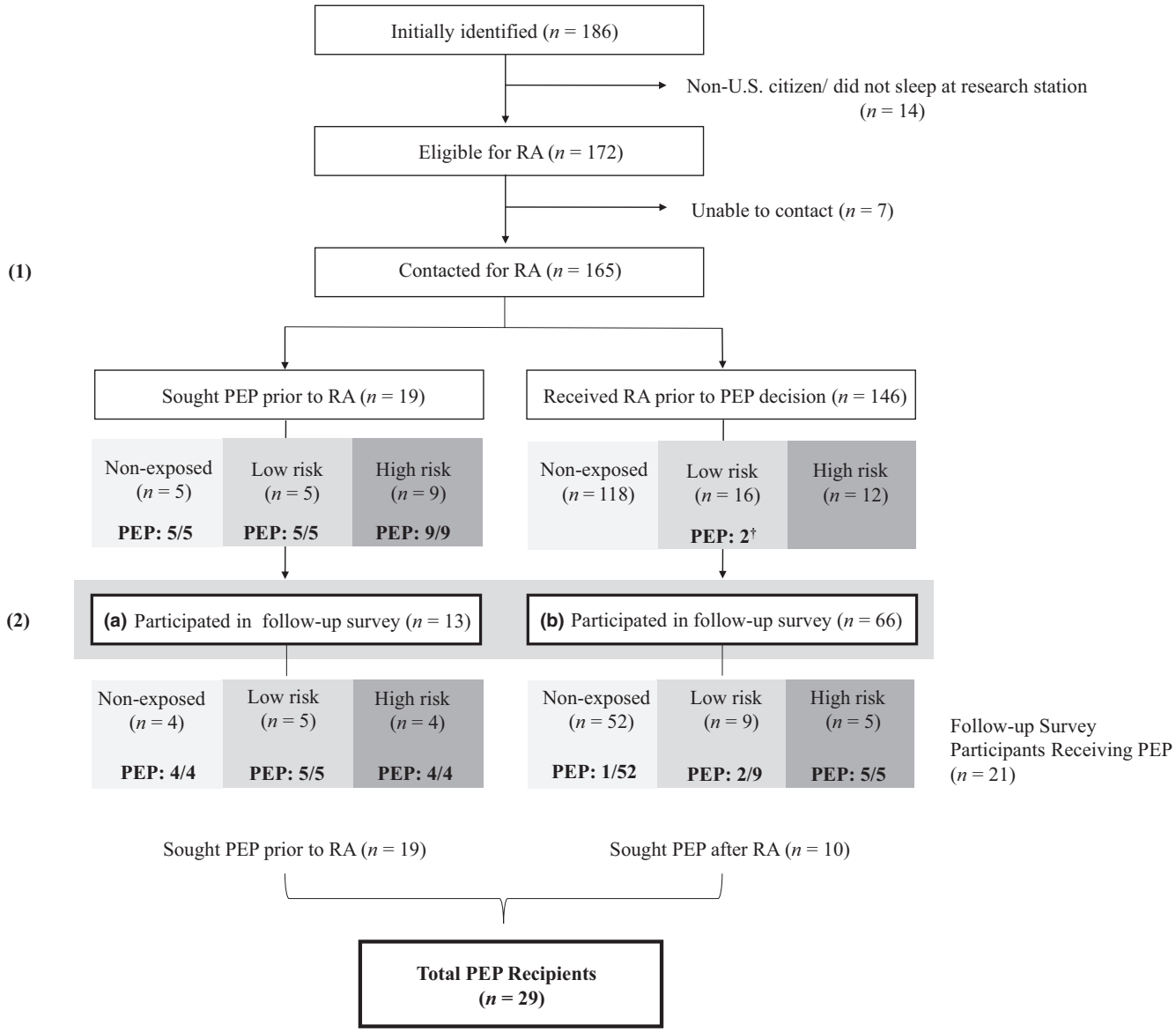

FIGURE 2 Risk assessment and follow-up survey enrolment diagram. †Two people completed PEP but did not participate in the follow-up survey.The major subgroups analyzed in this manuscript include those contacted for an RA (*n* = 165); follow-up survey participants, and as a sub-comparison (Section 2A) 13 follow-up survey participants who sought PEP prior to the RA and (Section 2B) 66 follow-up survey participants who received the RA before decision making about PEP

Using the survey responses, we compared the 19 individuals who completed PEP before the RAs were administered with the remaining individuals who made healthcare decisions after receiving the RA. Consultation with healthcare providers and PEP-seeking behaviours occurring before RA completion were taken to represent healthcare outcomes in the absence of a public health MBE intervention.

2.4 | Data analysis

From data collected during the RAs, SAS® 9.4 (SAS Institute, Incorporated) was used to calculate frequencies of people classified in the three risk categories (non-exposed, low and high) by age, sex, primary state of residence and sleeping location within the research station (chi-square or Fisher's exact test; significance cut-off $p < 0.05$).

Next, the follow-up survey participants were characterized and the number of persons who completed PEP by risk category was tallied. To evaluate the RA and public health response, we determined whether individuals classified as high risk followed our PEP recommendations, and calculated the proportion of people that accurately recalled their risk classification (non-exposed, low, high) as assigned by investigators. We also tallied reasons listed for how the RA affected healthcare-seeking behaviours by risk category (chi-square or Fisher's exact test; significance cut-off $p < 0.05$). Lastly, to determine the influence of the individual public health investigator on participants' recall ability, we calculated the proportion of participants with incorrect recall by investigator.

TABLE 1 Characteristics of research station guests by risk classification

Select variables	No. (%)	Non-exposed *N* = 123 No. (%)	Low risk *N* = 21 No. (%)	High risk *N* = 21 No. (%)	χ^2	*p*
Sex						
Male	63 (38.7)	45 (71.4)	8 (12.7)	10 (15.9)	0.84	0.65
Female	100 (61.3)	76 (76)	13 (13)	11 (11)		
No response	2	2 (100)	0	0		
Age (years)						
15–30	72 (57.6)	50 (69.4)	9 (12.5)	13 (18.1)	NA	0.69*
31–40	23 (18.4)	19 (82.6)	2 (8.7)	2 (8.7)		
>40	30 (24.0)	22 (73.3)	5 (16.7)	3 (10)		
No response	40	32 (80.0)	5 (12.5)	3 (7.5)		
Sleeping location						
Lodge A	101 (61.2)	67 (66.3)	17 (16.8)	17 (16.8)	NA	**0.016***
Lodge B	20 (12.1)	16 (80)	3 (15)	1 (5)		
Other	44 (26.7)	40 (90.9)	1 (2.3)	3 (6.8)		
Primary residence						
Wyoming	49 (29.7)	41 (83.7)	5 (10.2)	3 (6.1)	NA	0.20*
Other U.S. State	116 (70.3)	82 (70.7)	16 (13.8)	18 (15.5)		

*Fisher's exact test *p*-value. Bold denotes statistical significance.

2.5 | Confidentiality and ethics statement

All paper records were securely stored; digitized data were stored on a restricted CDC server. Copies of RAs were shared with state health departments by secure fax or encrypted email. This investigation was a public health response and was given a non-research determination by the Human Subjects Office at CDC's National Center for Emerging and Zoonotic Infectious Diseases (081117RW). All participant recruitment materials, data collection instruments and methods were reviewed and approved by the Human Subjects Office before use.

3 | RESULTS

3.1 | Risk assessments: Public health intervention

We were able to contact and conduct RAs on 165 (95.9%) of 172 eligible U.S. residents who were identified by park staff or group leaders as having slept at the research station during the period of concern (19 May–2 August 2017; Figure 2, subgroup 1). Of the 186 people initially identified, we excluded 10 people who did not sleep at the research station and four international researchers whose risks were assessed by their respective governments.

Most people were ultimately classified as being non-exposed (123, 74.5%); 21 (12.7%) as having a low risk; and 21 (12.7%) as having a high risk (Table 1). The 13 research station guests who reported that they had direct bat contact were either touched, bitten or scratched by a bat and were classified as having a high risk. (Three people who had contact with a bat also reported glove use or other protective clothing that prevented direct skin contact. Still, they were ultimately classified as having a low risk because they interacted with a bat.)

3.2 | Follow-up survey: Evaluation of public health response

In total, 47.9% (*n* = 79) of the research station guests completed the follow-up survey (Figure 2, subgroup 2). Participants were generally representative of all research station guests in terms of demographics (age, sex) except that they were more likely to be from Wyoming (chi-square = 10.03; $p < 0.01$) and less likely to have received PEP (Fisher's $p < 0.01$).

In total, 29 people completed PEP, 19 of whom sought PEP before the RA (five were classified as being non-exposed, five having a low risk and nine as having a high risk). The remaining 10 persons who sought PEP after the RA included one classified as being non-exposed, four having a low risk and five having a high risk. The proportion of individuals that (likely) unnecessarily pursued PEP was higher among the 19 individuals (10/19 non-exposed or low risk) that sought healthcare before receiving the RA in comparison with those who received the RA first (3/66 non-exposed or low risk; $p < 0.01$).

When we strongly encouraged high-risk exposed persons to seek health care, they followed our guidance: 100% of individuals at high risk consulted with a healthcare provider and ultimately pursued PEP. Still, some confusion was observed when we evaluated the recall accuracy of the specific risk categories (non-exposed, low, high) assigned to each individual. Only 26.6% (*n* = 21) of follow-up survey participants accurately recalled their risk classification (Figure 3), and

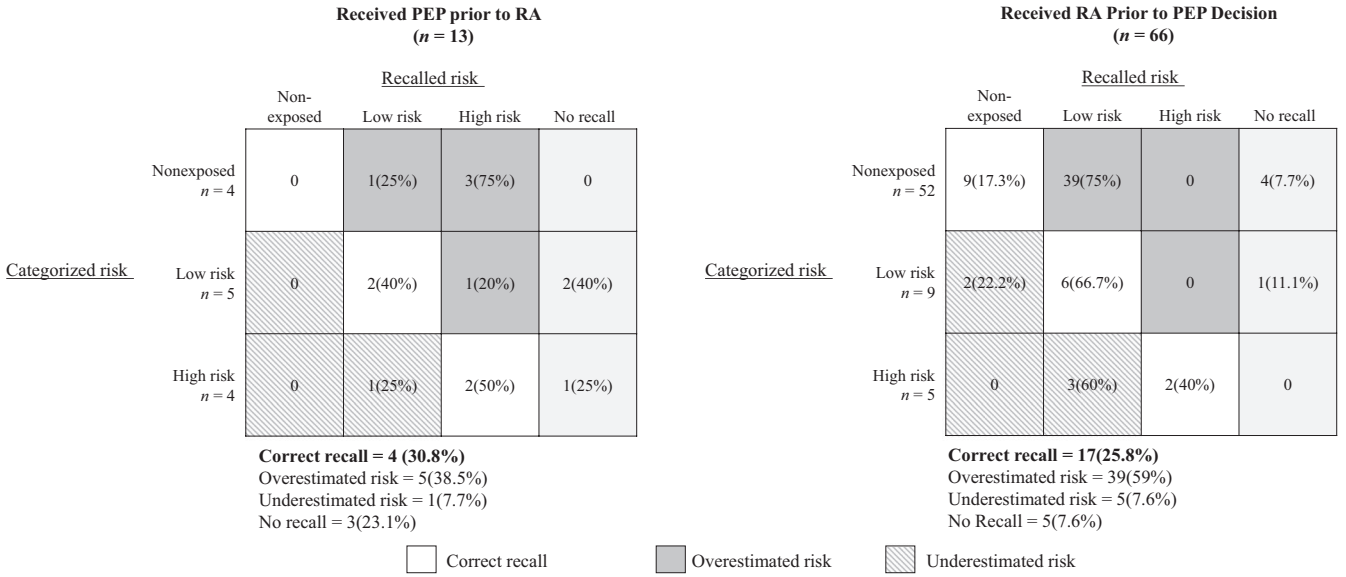

FIGURE 3 Actual versus recalled risk classification among 79 follow-up survey participants by whether they sought PEP prior to the RA or received the RA prior to PEP decision. (Row percentages are reported.). RA, risk assessment

TABLE 2 Influence of RA on healthcare-seeking behaviour by risk category, as indicated by participant responses

Influence of RA		Non-exposed *n* = 52	Low risk *n* = 9	High risk *n* = 5	
	No. (%)	No. (%)	No. (%)	No. (%)	Fisher's *p*
None	25 (41.1)	21 (44.7)	4 (44.4)	0	<0.001
Not to seek PEP	26 (42.6)	22 (46.8)	3 (33.3)	1 (20)[a]	
To consult a physician	7 (11.5)	4 (8.5)	1 (11.1)	2 (40)	
To seek PEP	3 (4.9)	0	1 (11.1)	2 (40)	
No response	5 (8.2)				

Note: Column percentages are reported.
Abbreviation(s): PEP, post-exposure prophylaxis.
[a]Although this person indicated that the RA influenced them not to seek PEP, PEP treatment was pursued and completed.

a similar proportion of accurate recall (25.6%) was observed among those who received the RA before deciding about PEP (subgroup 2B in Figure 2). During the RA, we suggested that *all* persons consult with healthcare providers if they had further questions or concerns, yet only 46 (58%) follow-up survey participants remembered this suggestion. Approximately two-thirds of the total errors in recall were attributable to RAs conducted by 2 of 10 (20%) investigators (Table S1). The majority of these errors were an overestimation, rather than underestimation of risk.

When asked about the influence of the RA on PEP decision-making (Figure 2, subgroup 2B), significant differences were observed by risk category (Fisher's $p < 0.01$) (Table 2). Those who responded that the RA had no influence or that the RA influenced them not to seek PEP were more likely to have been classified as non-exposed. Although one person in the high risk category reported that the RA influenced them not to seek PEP, they did eventually pursue and complete PEP treatment. The remaining people classified as having a high risk (correctly) stated that the RA encouraged them to seek PEP or consult with a physician.

4 | DISCUSSION

On average, MBE consultations occur approximately once per month per state public health agency (Hsu et al., 2016); however, thorough analysis of investigation and follow-up data is rare (Griffin et al., 2009). We employed a systematic approach that allowed us to assess the influence of the RA, thereby offering the opportunity to formulate evidence-based recommendations for future MBE responses. Here, we discuss the findings of our evaluation of the public health response, ways that future MBE responses can be improved and special considerations for public health communication regarding MBEs in national park settings.

Public health responses to MBEs accomplish two major goals. First, they ensure that people with high risk exposures are identified,

counselled and strongly encouraged to seek PEP. A second, more subtle function is to ensure that those failing to meet risk criteria to warrant PEP do not pursue unneeded treatment. The public health response described here was successful. We identified five people classified as having a high risk for rabies exposure who may have otherwise gone untreated, and among persons classified as high risk, 100% followed our guidance and ultimately pursued PEP treatment. At the same time, we also prevented the unnecessary use of PEP in 136 people, saving a maximum of $1,144,440 in possible PEP costs. (Estimated as follows: 136 × average cost of PEP/person [$8,415], including costs associated with the vaccine itself, and hospital or healthcare costs (Dhankhar, Vaidya, Fishbien, & Meltzer, 2008)). The 19 persons who sought health care prior to the RA serve as a comparison group to represent healthcare-seeking behaviours in the absence of public health intervention: all of these individuals sought PEP, even though over half were retrospectively classified as non-exposed or low risk. This may reflect the risk-averse approach that many health institutions adopt when faced with a universally fatal disease such as rabies. However, ACIP provides clear guidance that simply being in the same space as a bat does not warrant PEP treatment and that a risk assessment should be conducted (Manning et al., 2008). Based on this subset of research guests, we presumed that had all guests been referred to the nearest healthcare facility in the absence of public health intervention, all would have received PEP.

Our evaluation of the public health response revealed incorrect recollection of assigned risk category among most people in this highly educated population of researchers, students and other university faculty. Most of the observed confusion was among persons in the non-exposed and low risk categories, suggesting that greater care must be taken when explaining risk categories and providing guidance to members of the public on whether to seek health care. During post-RA counselling, we also uniformly recommended that people seek further guidance from healthcare providers should they feel concern (see Data S1). In so doing, we may have inadvertently obscured the difference between non-exposed (no risk for rabies) and a low risk for exposure to rabies. We also found that the rate of incorrect recall was higher for respondents who were interviewed by 2 of the 10 counsellors who conducted the RAs. This might be attributable to random error or differences among the groups of research guests, but it also might reflect variation in counsellor training or ability to effectively communicate the RA determination guidance.

Several relevant findings from this analysis can be applied to future public health responses. First, MBE investigators should carefully craft language regarding risk classification and potentially consider more clearly discernable RA outcomes. Two risk classifications (rather than three) could clarify confusion, for example those who require PEP versus those who do not, or those who require additional healthcare assessment versus those who do not. However, PEP recommendations can vary widely by health jurisdiction, and this level of prescriptive advice may not be possible in all situations. Clearer ACIP guidance for responding to MBEs could also aid clinicians and health authorities responsible for providing rabies exposure guidelines to the public. Second, we suggest that investigators are well-trained in order to avoid misinterpretation of risk messaging and to ensure that appropriate steps are taken. Third, several tools used in this response can be adapted to other MBEs, including the initial RA, the follow-up survey and corresponding scripts (Data S1 and S2). Additionally, graphing the proportion of daily bat sightings (Figure S1) may help determine the exposure period of interest, characterize changes in bat colony size over time and identify intermittent roosts, such as those of migratory bat species. In many MBE investigations, the exposure period is often unclear, particularly when they occur in historic buildings that have been colonized by bats for many years. Further, the longest reported incubation period for bat-acquired rabies is 9 months (de Serres et al., 2008), yet a definitive upper boundary for the incubation period has not been established.

The long-term coexistence of bats and people (reportedly, a bat colonization existed for approximately 30 years at this site) is common in national parks and other natural settings, which can result in desensitization about risks posed by bats. Responses to MBEs can only be triggered if public health authorities are alerted, which in turn rests on awareness of those involved in the MBE. After arrival, guests were informed of the presence of bats, but were not necessarily aware of the rabies risk associated with bats. During the investigation, inconsistencies were recognized between recommendations provided by public health and research station managers. (The research station was operated by a different party under an agreement with NPS, but was not operated directly by NPS). To address these inconsistencies, public health investigators worked with park managers to strengthen education and communication about bats and rabies within the park. A new, internal NPS website was created to provide educational resources (e.g., fact sheets and a "bat contact card") that can be used by park employees and distributed to visitors as needed. Additionally, an external NPS health and safety website was also created that can be publicly accessed and includes information on rabies (National Park Service, 2018a, 2018b), ways to prevent other diseases (National Park Service, 2018a, 2018b) and contact information for visitors to reach NPS public health if they have concerns. Although major mitigation efforts were undertaken to prevent further colonization, investigators also encouraged facility managers to provide bed nets to overnight guests, and to educate guests on preventative measures (e.g., checking the room for bats prior to sleeping). In national and local parks, it may be beneficial to introduce educational materials to raise awareness among park staff, facility managers, visitors and overnight guests, particularly in historic buildings and other remote settings within parks.

Specific limitations should be noted when interpreting our data. Had we completed follow-up surveys for all those who received an RA, we might have identified additional people receiving PEP and could have more fully understood risk recall and healthcare-seeking behaviours. Follow-up survey participants were less likely to have received PEP and more likely to be from Wyoming—this group therefore may not be representative of all exposed individuals. The follow-up survey results are additionally subject to recall bias.

Despite these limitations, the approaches and findings from this investigation point to clear improvements needed for future public health responses to MBEs. In this investigation, governmental agencies at different administrative levels (i.e., local, state, federal or international)

collaborated to establish a clear and consistent MBE response plan to ensure uniform public health risk messaging. Ultimately, future MBE responses could be greatly improved with the development of standardized ACIP guidance for MBEs. The template RA used for this investigation can be easily adapted for different MBE scenarios.

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CONFLICT OF INTEREST

There are no conflicts of interest to disclose.

DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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