



Rabies post-exposure prophylaxis of international travellers - Results from two major German travel clinics

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ARTICLE INFO

Keywords:

Rabies exposure
Travel medicine
Post-exposure prophylaxis
Rabies immunoglobulin

ABSTRACT

Background: Travel to regions with rabies risk has increased. However, data on adequate rabies post exposure prophylaxis (PEP) abroad is scarce. The aim of this study was to assess the appropriateness of medical management following suspected rabies exposure (SRE) in international travellers.

Method: A cross-sectional questionnaire-based study in returning travellers with reported SRE who sought post-exposure medical care was conducted in two large German travel clinics.

Results: The 75 included SRE cases had a median age of 34 years (range 26–43) and showed a female predominance (59%, 44/75). Most participants returned from Asia (47%, 34/72). About 28% had received pre-exposure prophylaxis (PrEP, ≥ 2 vaccine doses) (20/71). In 51% the animal was actively approached (34/67). All patients had category II/III exposure according to the World Health Organization (65% category III, 49/75). With 78% (52/67), most patients cleaned the wound after SRE; 36% (24/67) used water and soap. Only 57% (41/72) of participants sought medical care during their trip. Overall, 45% (33/74) received rabies vaccination abroad which corresponds to 80% out of those who sought healthcare (33/41).

Conclusions: Awareness for appropriate first aid and the urgency of seeking timely professional treatment including PEP after an SRE seems to be insufficient in German travellers. Travel practitioners need to educate travellers about rabies risk, prevention measures and the correct behaviour after SRE including adequate wound treatment and seeking immediate medical help for PEP. PrEP should be offered generously especially to travellers with high rabies-exposure risk and those visiting areas with limited healthcare access.

1. Introduction

Annual human rabies deaths are estimated to range between approximately 14,000 to 59,000 worldwide. Disability-adjusted life years are estimated to range between 782,000 to over 3,700,000 [1,2]. Rabies is a public health concern mainly in African and Asian countries where the majority of human rabies cases occurs [2–4].

Although rabies cases among international travellers are rare, travellers may be exposed to rabid animals during their trips abroad [5–7]. In a previous study of our group, 2% of returning travellers had a

suspected rabies exposure (SRE) during their journey [8]. The number of international travellers requiring rabies post-exposure prophylaxis (PEP) at GeoSentinel clinics increased four times between 2003 and 2012 [9] which may be due to increased travel to rabies-endemic countries or due to an increased number of reported incidents. While rabies is always fatal once clinical symptoms occur, it is preventable by appropriate rabies pre-and post-exposure prophylaxis [10]. In rare cases, rabies has been reported despite appropriate PEP. To our knowledge, all these cases had never received a previous PrEP or PEP [11]. The World Health Organization (WHO) and the German Robert Koch Institute (RKI) recommend immediate post-exposure treatment for

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Abbreviations

IQR	interquartile range
PEP	post exposure prophylaxis
PrEP	pre-exposure prophylaxis
RIG	rabies immunoglobulin
RKI	Robert Koch Institute
SRE	suspected rabies exposure
WHO	World Health Organization

travellers after an SRE [10,12]. Following WHO category II or III exposure, post-exposure treatment consists of rigorous wound washing with soap and plenty of water and a series of rabies vaccinations. In case of category III exposure of previously insufficiently vaccinated immunocompetent individuals rabies immunoglobulin (RIG) is recommended additionally [10,12,13].

During pre-travel advice, the decision for anti-rabies pre-exposure prophylaxis (PrEP) should be based on an individual risk assessment. Factors determining decision-making include planned activities with increased risk of animal exposure, rabies endemicity and access to appropriate medical care in the country of SRE. However, information is especially limited for the last two determinants in many regions [5,14]. Previous studies have given rise to concern that treatment guidelines are inadequately followed in international travellers who seek healthcare following SRE abroad [8,15]. Therefore, the aim of this study was to obtain information about travellers' health seeking behaviours after SRE and on the appropriateness of PEP in respective travellers' destinations.

2. Material and methods

2.1. Study design and data collection

We carried out a cross-sectional questionnaire-based study at the Bernhard-Nocht outpatient clinic of the University Medical Center Hamburg-Eppendorf and at the outpatient department of the Division of Infectious Diseases and Tropical Medicine of the University Hospital of the Ludwig Maximilian University Munich, Germany, between March 2019 and June 2020.

We included returning travellers aged above 18 years, requiring PEP due to SRE abroad and willing to participate in this study. Patients with PEP after an animal-associated incident in Germany were excluded. The physician in charge handed out the questionnaire to the participant following oral informed consent and was available to assist the participant whenever necessary during questionnaire completion. No personal data were collected.

The questionnaire included demographics and travel information, information on pre-travel advice, knowledge about rabies, rabies exposure characteristics, actions taken after rabies exposure and treatment in the health care system abroad. A rabies knowledge score was calculated based on questions about the rabies risk as published previously by Piyaphanee et al. [16]. Depending on the number of correctly answered questions, a maximum score of 12 could be reached.

A version of the questionnaire translated into English is appended in the supplement.

2.2. Definitions and treatment guidelines

According to the WHO and the RKI, SRE was defined as a bite, scratch or licking of a wound or mucous membrane by a mammal [10, 12]. The categorisation was determined by two physicians following the 4-eyes-principle based on the questionnaire. If the exposure could not be distinguished between category II or III, the case was assigned conservatively into category III. Indication for PEP was evaluated using the RKI

recommendations. According to the German RKI recommendations, PrEP is completed after a series of at least three vaccine doses administered in the appropriate interval [12]. The treatment recommendations from RKI are shown in [Supplementary Table S1](#) in detail. If an indicated administration of RIG was missed at first vaccination, it can still be given until 7 days after the first dose of rabies vaccine according to the German recommendations [12].

2.3. Ethics

The ethics committee Hamburg ("Ethik Kommission der Ärztekammer Hamburg") reviewed and approved the study protocol and the questionnaire (PV5970). Given the ethics committee's judgement that a participant's agreement to be part of the study and to fill in the questionnaire was considered an oral informed consent, no additional written informed consent was considered necessary prior to participant enrolment. In accordance with the decision of the local ethics committee, using this simplified procedure, we did not include individuals under the age of 18 in the study. We did not collect person-identifiable data and data collection and analysis were kept anonymous.

2.4. Statistical analysis

Medians and interquartile ranges (IQR) were calculated for continuous data and counts and percentages were used for categorical data.

All statistical analyses were performed using R Statistical Software (version 3.6.2; The R Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Demographic characteristics of returning travellers potentially exposed to rabies

Over a 16-month period, 84 patients aged above 18 years sought PEP at the two German travel clinics. Nine patients reporting animal contact in Germany were excluded from analysis. Thus, 75 adult participants were included in this study. About 59% were female (44/75) and the median age was 34 years (IQR 26–43 years). Most of the participants stayed for 2–3 weeks abroad (58%, 43/74). The most frequent travel reason was tourism (88%, 65/74). Almost half of the travels were categorised as backpacking trips (45%, 33/74) and the main activities included city trips in 61% (42/69). Details on demographics and travel information are presented in [Table 1](#).

3.2. Pre-travel advice

Only a third of travellers had sought pre-travel medical advice (33%, 24/73), whereby the majority of these consulted their family doctor (50%, 12/24) and/or a tropical medicine specialist (46%, 11/24). More than two thirds of the participants (65%, 46/71) had not received anti-rabies PrEP before the trip. Out of 19 participants who had received anti-rabies PrEP with ≥ 2 vaccine doses, 14 (74%) had received at least three doses as regarded necessary for a complete pre-exposure immunisation according to the RKI. More details on pre-travel advice are presented in [Table 2](#).

3.3. Travellers' knowledge about rabies

When questioned about rabies knowledge, almost all travellers (99%, 66/67) knew that they were at risk of rabies through a bite of an infected animal. However, only 84% of them (56/67) believed that being licked by a rabid animal on a broken skin could also transmit rabies. Most of the participants were aware that dogs could carry rabies (94%, 63/67), but only 73% (49/67) knew that bats could be potential carriers. Moreover, 14% of travellers (9/64) assumed that the bite of a

Table 1
Demographic and travel baseline information among 75 returned travellers.

	n	%
Recruitment Centre (n = 75)		
Hamburg	44	58.7
Munich	31	41.3
Gender (n = 75)		
Female	44	58.7
Age in years (n = 70)		
Median (IQR)	33.5 (26.0–42.5)	
18–30	30	42.9
31–45	26	37.1
46–60	10	14.3
>60	4	5.7
Region of birth (n = 75)		
Germany	62	82.7
Europe (Germany excluded)	7	9.3
Other	6	8.0
Region of residence (n = 75)		
Germany	73	97.3
Europe (Germany excluded)	2	2.7
Length of stay (n = 74)		
< 1 week	12	16.2
< 2 weeks	26	35.1
< 3 weeks	17	23.0
< 4 weeks	8	10.8
≥ 4 weeks	11	14.9
Main travel reason ^a (n = 74)		
Tourism	65	87.8
VFR	9	12.2
Work	1	1.4
Study	1	1.4
Travel style ^a (n = 74)		
Backpacking trip	33	44.6
Middle class	32	43.2
Luxury	5	6.8
Other	5	6.8
Main activity during travel ^a (n = 69)		
City trip	42	60.9
Beach	40	58.0
Culture	25	36.2
Trekking	23	33.3
Safari	9	13.0
Diving	6	8.7
Surfing	5	7.2
Bike trip	2	2.9
Other ^b	9	13.0

VFR – visiting friends and relatives.

^a The questionnaire allowed multiple answers.

^b Other activities included the following: river cruise, hospital work, participating in local everyday life, staying in parents' house with children, car journey, racecourse.

healthy-looking animal carried no risk of rabies infection. The median knowledge score was 11 (IQR 10–12). More details on rabies knowledge are presented in Table 3.

3.4. Potential rabies exposure

Nearly 60% of the study participants were bitten (42/71), nearly 40% scratched (27/71) and in 10% a wound was licked (7/71). Five travellers reported more than one exposure-type. More than half of all patients (65%, 49/75) had a category III exposure (Table 4). With 47% (34/72), nearly half of the travellers had been exposed in Asia.

Dogs were most frequently responsible for exposure (34%, 24/71), followed by cats (31%, 22/71) and monkeys (27%, 19/71). More than half of the injured travellers (51%, 34/67) had actively approached animals before the incident, most often by petting, feeding or playing with them. However, almost half of all animal incidents were unprovoked attacks (49%, 33/67). Further details about the SRE characteristics are summarised in Table 4. The most frequent location of animal contact was on the street (23%, 10/43).

SRE occurred already during the first week of travel in 38% (26/68)

Table 2
Pre-travel advice characteristics.

	n	%
Sought travel health information before trip? (n = 73)		
Yes	24	32.9
Source of information ^a (n = 24)		
Family doctor	12	50.0
Expert in tropical medicine	11	45.8
Internal medicine specialist	1	4.2
Other ^b	2	8.3
Received anti-rabies PrEP (n = 71)		
No	46	64.8
Unknown	5	7.0
Yes	20	28.2
2 doses	5	7.0
3 doses	11	15.5
> 3 doses	3	4.2
Number of doses unknown	1	1.5

PrEP – pre-exposure prophylaxis.

^a The questionnaire allowed multiple answers.

^b Other sources of information included the following: consulted a doctor friend of theirs (not further specified).

Table 3
Travellers' knowledge about rabies.

You may be infected with rabies if you (n = 67)		
are bitten by an infected animal (ticked true ^a)	66	98.5
are licked by an infected animal on broken skin (ticked true ^a)	56	83.6
are licked by an infected animal on normal skin (ticked false ^a)	61	91.0
eat contaminated food/drinks (ticked false ^a)	63	94.0
Animals that can transmit rabies (n = 67)		
Dog (ticked true ^a)	63	94.0
Cat (ticked true ^a)	56	83.6
Monkey (ticked true ^a)	53	79.1
Bat (ticked true ^a)	49	73.1
Chicken (ticked false ^a)	62	92.5
Snake (ticked false ^a)	65	97.0
The bite of a healthy-looking animal can transmit rabies (ticked true ^a) (n = 64)	55	85.9
In case of a bite you still need a rabies vaccination booster although you have already had a complete vaccination course of three shots (ticked true ^a) (n = 62)	43	69.4
Median knowledge score (IQR) (N = 61) ^b	11	(10–12)

^a Correct answer.

^b Each correct answer and the recognition of wrong answers resulted in a point. Maximum 12. The score was only calculated for spations who answered all 12 questions.

and within the first four weeks in more than 90% of all patients (62/68). Nearly all injuries affected the extremities (Table 4).

3.5. Behaviour after suspected rabies exposure and treatment in the health care system abroad

About one fifth of the exposed travellers (22%, 15/67) did not clean the wound at all whereas 36% (24/67) cleaned the wound using water and soap. More than half of the patients (52%, 25/48) reported that they could have reached a healthcare facility within 1 h and 92% within 24 h (44/48). Nevertheless, only 47% (15/32) sought medical help on the day of exposure. In total, 57% (41/72) of the exposed travellers sought professional health care after SRE abroad (Table 5). Out of all travellers, 45% reported that they received a rabies vaccine abroad (33/74); out of those who sought medical help, about 80% (33/41) were vaccinated abroad. Of those vaccinated and providing detailed information, 26% received the vaccine only after contacting at least a second healthcare institution (7/27). About 20% (8/41) received no vaccination at all despite seeking medical help.

Thirty-four patients with category III exposure had incomplete anti-

Table 4
Characteristics of suspected rabies exposure during the trip.

	n	%
Exposure ^a (n = 71)		
Bitten	42	59.2
Scratched	27	38.0
Licked	7	9.9
Region exposure (N = 72)		
Asia	34	47.2
Africa	16	22.2
Europa	14	19.4
Latin America and Caribbean	4	5.6
Middle East	4	5.6
Location where exposure happened ^b (N = 43)		
In the street	10	23.3
Beach	9	20.9
Park	7	16.3
Accommodation	6	14.0
Restaurant	3	7.0
Temple	2	4.7
Other ^c	6	14.0
Activity during exposure ^b (N = 41)		
Going for a walk	10	24.4
Eating	8	19.5
Visiting a zoo/national park	7	17.1
Motorcycle/bike riding	2	4.9
Sitting	2	4.9
Jogging	1	2.4
Other ^d	11	26.8
Bitten, scratched or licked by (N = 71)		
Dog	24	33.8
Cat	22	31.0
Monkey	19	26.8
Bat	1	1.4
Rat	1	1.4
Other ^e	4	5.6
Traveller's previous contact to the mammal ^b (N = 67)		
No contact/unprovoked	33	49.3
Yes	34	50.7
Petted the animal	17	25.4
Fed the animal	10	14.9
Played with the animal	10	14.9
Teased the animal	1	1.5
Took care of an injured animal	4	6.0
Visited a zoo ^f	3	4.5
Other ^g	4	6.0
Time point of exposure during the trip (n = 68)		
< 1 week	26	38.2
< 2 weeks	23	33.8
< 3 weeks	10	14.7
< 4 weeks	3	4.4
≥ 4 weeks	6	8.8
Body location of exposure ^b (n = 74)		
Hand	32	43.2
Leg	17	23.0
Arm	18	24.3
Foot	6	8.1
Head	2	2.7
Other ^h	3	4.1
Category of exposure (N = 75) ⁱ		
Category II	26	34.7
Category III	49	65.3

^a Five participants were bitten and scratched at the same time.

^b The questionnaire allowed multiple answers.

^c Other locations of exposure included: at a mountain, by a waterfall, at the shore of the Dead Sea, at the parents' home, at home, on a lawn.

^d Other activities during exposure included: while cleaning the house, while standing around (not further specified), while observing something, while taking pictures, playing, being on a daytrip with guide, taking care of an injured animal, feeding an animal, being at a petrol station.

^e Other animals included: squirrel, elephant, rock hyrax, raccoon.

^f Without petting, feeding, teasing an animal or playing with it.

^g Other animal contacts included: protecting a child from a cat, taking a picture of the animal, grabbing a jacket (animal wanted to play with it), eating.

^h Other body locations of exposure included: neck, buttocks, back.

ⁱ Category determined by 2 physicians (4-eye-principle) based on questionnaire. In some cases with a relevant exposure we could not distinguish between category II or III. These were assigned conservatively into category III.

rabies PrEP (less than three vaccinations according to the German recommendations) or the anti-rabies PrEP status was unclear. Consequently, these 34 patients had an indication for RIG according to the German recommendations. Only 59% of these patients (20/34) reported that they had sought medical care abroad. Of these 20 patients, 17 received vaccination abroad (85%) while three did not (15%). Out of these 17, only two received RIG and active immunisation simultaneously, 12 patients reported that they had received active vaccination only, for two the type of rabies vaccination was not reported, and one patient had only received RIG. Therefore, three out of 20 patients (15%) who sought medical care abroad received RIG in accordance with the German guidelines. A fourth patient had received RIG abroad despite of complete anti-rabies PrEP; i.e. RIG was received while not indicated according to the German RKI recommendations.

3.6. Impact of potential rabies exposure on the journey

Out of 44 travellers, two (5%) cancelled their trip and three others changed the itinerary (7%) upon SRE (Table 6). About 32% of participants who gave information on the financial consequences of the SRE spent more than 100 euros (9/28). About 48% of the participants (14/29) did not know whether their costs could be reimbursed by their insurance at the time of study inclusion. More than 50% of participants (23/42) reported that the situation had frightened them. Nearly 90% of the interviewed travellers (38/43) would advise friends to be vaccinated against rabies before travelling to a rabies-endemic country.

We did not follow-up the patients to assess their health status further or to exclude that a participant died after study inclusion. However, according to an inquiry of SurvStat on 20th of February 2023 [17], the last reported rabies case in Germany occurred in 2007. This goes in line with a recent publication by the RKI [18]. As rabies is a notifiable disease, we are confident that none of the study participants died of rabies.

4. Discussion

In the present study of international travellers with suspected rabies exposure abroad, most patients consulted our travel clinics after an SRE in Asia. Unsurprisingly, the most important animal species involved in SREs were dogs, cats and monkeys and the extremities were mostly affected. The majority had not received anti-rabies PrEP before travelling. Nearly half of the travellers approached the animal actively before the SRE occurred. Only about a third correctly cleaned the wound using water and soap. Most patients did not seek medical help abroad and among those who sought medical help most did not do so on the day of exposure. Rabies vaccination abroad was received by 45% of patients overall, corresponding to about 80% out of those who sought healthcare abroad.

Previous studies have estimated the occurrence of potentially rabies-transmitting animal contacts in travellers with 0.3%–4% per month of stay [16,19–21], highlighting the need to discuss rabies prevention measures and behaviour after SRE during pre-travel consultations.

The rates of travellers receiving pre-travel advice in the pre-COVID-19 era varied across studies with 32%–92%, whereby the source of pre-travel advice included primary care providers, travel specialists, travel agents, employers, books, religious leaders, pharmacists, friends and relatives, and the internet [22]. In a German airport study from the pre-COVID-19 era 55% of the international travellers have reported not to seek pre-travel medical advice [8]. In the present study, only a third of travellers had sought pre-travel medical counselling by a medical doctor. Thus, raising awareness among travellers to seek expert pre-travel advice seems to be an important step to advance prevention and adequate treatment of SRE.

Table 5

Behaviour after suspected rabies exposure and treatment in the health care system abroad.

	n	%
Cleaning of the wound after exposure (N = 67)		
No	15	22.4
Yes ^a	52	77.6
Water	11	16.4
Water + soap	24	35.8
Disinfection	35	52.2
Did the traveller realise at the time of animal contact that it could pose a risk of rabies? (N = 46)		
Yes	28	60.9
No	18	39.1
If no, how did the traveller later gain the information on rabies risk ^b (N = 18)		
Friends/family	9	50.0
Internet	8	44.4
Medical doctor	5	27.8
Travel guide	2	11.1
How many days after animal contact did the traveller realise that rabies could be a risk (N = 40)		
Median (IQR)		1 (0–3.25)
On the same day	14	35.0
1–7 days	18	45.0
8–14 days	5	12.5
>14 days	3	7.5
Sought professional health care after exposure (N = 72)		
No	31	43.1
Yes ^a	41	56.9
Public hospital	26	36.1
Private clinic	8	11.1
Doctor's office	7	9.7
Health centre	3	4.2
Pharmacy	2	2.8
Other ^b	3	4.2
Was the animal followed-up (N = 66)		
No	41	62.1
Unknown	14	21.2
Yes	11	16.7
Alive	6	9.1
Dead	1	1.5
Unknown status	4	6.1
Temporal distance to the next health care station (N = 48)		
< 1 h	25	52.1
1–4 h	15	31.3
5–24 h	4	8.3
2–3 days	4	8.3
When did you seek medical care abroad? (N = 32)		
On the same day	15	46.9
After 1 day	9	28.1
After 2 days	5	15.6
After 3 days	1	3.1
After 4–7 days	1	3.1
After >7 days	1	3.1
Did travellers receive PEP abroad? (N = 74)		
No	41	55.4
Yes ^a	33	44.6
Active vaccination	27	36.5
Passive vaccination	4	5.4
Unknown if active or passive	5	6.7
Availability of PEP abroad in those who sought medical advice (N = 41)		
No vaccine available/no vaccination received	8	19.5
Yes	33	80.5
At first occasion	20	48.8
At second occasion	5	12.2
> 2 occasions	2	4.9
Occasion unknown	6	14.6
Period until PEP was given abroad (N = 30)		
<12 h		
12–24 h	9	30.0
2–3 days	2	6.7
4–7 days	1	3.3

PEP – post-exposure prophylaxis.

^a The questionnaire allowed multiple answers.^b Other sources for professional health care after exposure: veterinarian office, paramedic, medical care in a national park.**Table 6**

Impact of the suspected rabies exposure on the journey.

	N	%
Cancellation of the journey necessary? (n = 44)		
Yes	2	4.5
Change of the itinerary necessary? (n = 44)		
Yes	3	6.8
Costs related to animal contact (n = 28)		
No costs	1	3.6
<50 euros	11	39.3
50–100 euros	7	25.0
100–500 euros	9	32.1
Cost reimbursement by the insurance (n = 29)		
No	6	20.7
Yes	8	27.6
Partially	1	3.4
Unknown	14	48.3
Did the situation cause fear or even panic in the traveller? (n = 42)		
Yes	10	23.8
Rather yes	13	31.0
Maybe	12	28.6
Rather no	5	11.9
No	2	4.7
Would the traveller advise friends to be vaccinated against rabies before travelling to a rabies-endemic country? (n = 43)		
Yes	30	69.8
Rather yes	8	18.6
Maybe	1	2.3
Rather no	3	7.0
No	1	2.3

Overall, 17% of participants with at-risk activities concerning potential rabies exposure had received a rabies vaccine before travelling in a survey from Europe and Canada [23]. In the present study, 28% of participants had received a rabies vaccine before travelling, with only 20% having completed anti-rabies PrEP by receiving at least three vaccines according to the German RKI recommendations [12]. The WHO recommends anti-rabies PrEP especially for people at high risk of exposure [10]. However, rabies risk assessment is complex since it is based on several risk factors such as remote destinations with lack of access to timely and adequate PEP, RIG-availability, rabies endemicity, and individual factors, such as outdoor activities and travel duration [5, 10,12]. While the latter is among the main determinants of anti-rabies PrEP according to several national guidelines, it has been previously suggested that travel duration is not predictive of the risk of rabies exposure [5,24]. Although only 51% of participants travelled for less than two weeks, 72% of SREs occurred during this period in the present study. Considering that most SREs occurred early, anti-rabies PrEP should also be offered to short-term travellers, especially to those with at-risk activities and travel to remote areas with limited access to the healthcare system.

About half of the animal attacks in our study were categorised as unprovoked. The amount of unprovoked SREs in travellers is discussed controversially, ranging from 28% to 85% in previous studies [8,25–27]. Consequently, a relevant amount of SREs might be preventable, pre-travel advice needs to emphasise the strict avoidance of close animal contacts.

Abroad, 43% of participants did not seek medical care after SRE at all in the present study. Even among those seeking medical help in the foreign country, less than half did so within 24 h. In a questionnaire-based airport study, only 19% of travellers reported that they had sought medical care after an animal contact [8]. Our study may overestimate the proportion of individuals seeking healthcare following SRE abroad, since only patients who presented for treatment in German travel clinics were included. This specific cohort might have a higher healthcare-seeking behaviour compared to the average population. The present study highlights that awareness for first aid and the urgency of seeking timely professional treatment including PEP after an SRE is insufficient in German travellers. Thus, awareness among travellers

regarding the necessity of seeking treatment after an SRE should be raised. In this context, it is also important that about 80% out of those who sought medical help received vaccination abroad in our study.

Only a minority of healthcare-seeking patients with category III exposure without sufficient anti-rabies PrEP correctly received active vaccination and RIG simultaneously in our study. This observation is consistent with previous findings of only 4%–25% of international travellers receiving RIG in the country of exposure when indicated [15, 25,28]. Therefore, anti-rabies PrEP should be encouraged for travellers to high-risk areas where RIG might not be widely available or accessible [15,29].

Low vaccination rates among travellers before the trip are likely to be related to costs of vaccination, lack of awareness among travellers and the vaccination schedule [19,30]. Future studies should investigate if the adoption of the abbreviated pre-exposure vaccination schedule according to the WHO recommendations (2 rabies vaccine doses ≥ 7 days apart) would lead to a better acceptance of pre-exposure vaccinations in German international travellers.

Our study has several limitations. First, given the fact that the paper-based questionnaire was administered after returning to Germany may have led to recall limitations. Second, we only included patients actively seeking treatment advice at a travel clinic. This group is a highly selected sub-population and may differ from persons who did not seek post-travel help. Furthermore, a higher percentage of individuals without anti-rabies PrEP may have sought treatment in Germany as they could not complete the simple PEP-vaccination course (day 0 and day 3) abroad. So, selection bias may have occurred. Third, although children are at high risk of rabies exposure [1,31], they were not included in this study as explained in the methods section. Furthermore, the questionnaire was very comprehensive, and not all questions were answered by each participant, which led to a rather high number of missing values. However, we are convinced that the retrieved data are representative for our cohort.

5. Conclusions

Overall, our data suggest that awareness for appropriate first aid and the urgency of seeking timely professional treatment including PEP after an SRE is insufficient in German travellers. Only a minority of travellers with SRE had received anti-rabies PrEP before travelling. Importantly, animals were often actively approached before the incident and a high proportion of travellers neither washed the wound adequately nor sought medical advice in the country of exposure. Among those seeking healthcare, only a fifth did not receive PEP. However, immune globulin was received only in a minority of patients with indication. All these factors demonstrate the importance of raising awareness among travellers; i.e. increasing knowledge on rabies risk, prevention measures, and the correct behaviour including wound cleaning and seeking immediate professional healthcare for PEP after SRE is urgently necessary. Anti-rabies PrEP should be offered generously especially to travellers with high exposure risk and those who might have limited access to healthcare.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. M.H. is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation, 438122637).

CRediT authorship contribution statement

Farah Saffar: Conceptualization, Formal analysis, Writing – original draft. **Melina Heinemann:** Conceptualization, Formal analysis, Investigation, Writing – original draft. **Christian Heitkamp:** Conceptualization, Methodology, Writing – review & editing. **Daniel Robert Stelzl:**

Conceptualization, Methodology, Writing – review & editing. **Michael Ramharter:** Conceptualization, Writing – review & editing. **Mirjam Schunk:** Conceptualization, Investigation, Writing – review & editing. **Camilla Rothe:** Conceptualization, Investigation, Writing – review & editing. **Silja Bühler:** Conceptualization, Methodology, Investigation, Formal analysis, Supervision, Writing – review & editing.

Declaration of competing interest

The authors have declared no conflicts of interest.

Acknowledgements

We would like to thank all travellers for their participation and commitment. We are grateful to the Bernhard-Nocht Clinic staff, especially to Lena Hübl, Friederike Hunstig, Christiane Radt, and Louise Roggelen and to the Medical Centre of the LMU Munich staff for participant recruitment.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.tmaid.2023.102573>.

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