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Incidence of leptospirosis in the French armed forces from 2004 to 2018: retrospective analysis

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Background

The French military personnel may be exposed to leptospirosis during their training or on duty on the field in continental France, and most of all, in intertropical areas in the French departments and in Africa. The aim of this study was to assess the incidence of leptospirosis from epidemiological surveillance and cases data from 2004 to 2018, and to propose tools to assess leptospirosis risk prior to any mission or leisure activity.

Method

A retrospective epidemiological study on leptospirosis cases among French Armed Forces was conducted. More data were collected for 2 clusters in Martinique, as most of leptospirosis cases among French military personnel were identified in Martinique.

Results

Eighty-eight cases of leptospirosis were reported, 15 cases in continental France and 73 cases in overseas (including 42 cases in the French West Indies). The global leptospirosis incidence rate in continental France was 0.3/100,000 person-years and in overseas 24/100,000 person-years with the higher incidence rate in Martinique (99/100,000 person-years) and in Mayotte (36.9/100,000 person-years).

For the clusters in Martinique, between January and June 2009, 7 cases were declared; between 2016 and 2018, 16 cases were reported, high proportions of severe cardiac, renal and neurological forms (6/16) and hospitalizations (9/16).

Conclusion

The occupational risk is real in French Armed Forces, particularly in malaria-free intertropical areas where chemoprophylaxis by doxycycline is not applied. Prevention can be optimized by the use of practical tools such as tables and cartographies,

leading to a better leptospirosis risk assessment and application of preventive recommendations.

ABBREVIATIONS

CESPA: French Armed Forces Centre for Epidemiology and Public Health

HIA: Military teaching hospital

IR: Incidence rate

FAF: French Armed Forces

FMMS**:** French Military Medical Service

MAT: Microscopic agglutination test

NRCL: National Reference Center for leptospirosis

OPEX: Military Operation Outside France

PY: Person-years

INTRODUCTION

Every year, leptospirosis would affect more than one million people worldwide, leading to more than 58,000 deaths [1]. Most of cases are observed in young male adults in rural intertropical areas. Leptospirosis is a zoonosis is caused by a spirochetal bacterium with numerous species, serogroups and serovars. *Leptospira interrogans* is the most common pathogenic species in the world [2]. In continental France, serogroup icterohaemorrhagiae accounts for about 30% of the cases [3]. These bacteria are well adapted to survive in the natural medium as they can resist for months in a moist environment, in fresh water down to 4°C [4]. Rodents are the main reservoir, although some domestic animals (dogs, horses, cattle) can be chronic carriers and transmitters [5]. Although humans can get infected *via* inadvertent contact with infected urine on a damaged skin or mucosa, most of the human infections develop less than two weeks after an indirect exposure with water or soil contaminated by rodents' urines. There is a seasonal increase of leptospirosis in summer in continental Europe and after the rain season in intertropical areas [6,7]. In developed countries, most cases of leptospirosis are associated with leisure activities in fresh water: canoe, swimming, rafting [8,9] or returning travellers [10]. Nevertheless, the disease is rare in continental France, but its incidence is much higher in the French intertropical departments [6]. Less than one third of the cases in France are occupational: sewer workers, fish farmers, professional divers, vets, gamekeepers, military personal, etc. [6].

The French military personnel may be exposed to leptospirosis during their training or on duty on the field in continental France, and most of all, in intertropical areas in the

French departments and in Africa [11,12]. They may have to train or work in highly rustic conditions in natural environment: assault course in mud, commando training in mangroves, canyoning on rivers, etc. [13-17]. The risk for leptospirosis in the French armed forces (FAF) has been known for a long time [18], as illustrated by some cases reports [19-21].

It appears useful to update the epidemiological situation of leptospirosis in the FAF. The aim of this study was to assess the incidence of leptospirosis in this population from epidemiological surveillance and cases data from 2004 to 2018, and to propose tools to assess leptospirosis risk prior to any mission or leisure activity.

METHODS

A retrospective epidemiological study on leptospirosis cases among FAF was conducted. More data were collected from 2 clusters in Martinique 2 clusters in Martinique, as most of leptospirosis cases among French military personnel were identified in Martinique.

1. Surveillance and cases data

We used surveillance data from the FAF Centre for Epidemiology and Public Health (CESPA) from January 2004 to December 2018. The CESPA is responsible for the epidemiological surveillance of French military personnel' health state stationed in continental France and overseas in the context of Military Operation Outside France (OPEX). The epidemiological surveillance covers all the military medical sites, including the military hospitals. It is selective about health events (60 events, including nationally notifiable diseases, leptospirosis being part of monitored events). Regarding leptospirosis, the number of cases is collected weekly, but no clinical data is collected routinely, unlike other events with declaration form. Additional information

about cases or case aggregates investigated were obtained from the CESPA charts records. The inclusion criteria were the association of clinical compatible signs (chills, headache, myalgia, conjunctival suffusion, skin and mucous membrane bleeding, rash, jaundice, myocarditis, meningitis, renal failure, respiratory symptoms such as hemoptysis), with a biological confirmation: at least one of the following criteria (nucleic acid detection by polymerase chain reaction [22], or isolation of *L. interrogans* or any other pathogenic Leptospira species from a clinical sample [23]; positive ELISA serology (elevation * 4 in < 2 weeks of specific antibodies for *L. interrogans* or any other species of Leptospira) or positive microscopic agglutination test (MAT) serology with titer of specific antibodies > 1/100)[24].

Severe leptospirosis was defined by the presence of >1 of the following: shock treated with vasoactive drugs, acute renal failure requiring dialysis, internal bleeding requiring blood transfusion, respiratory insufficiency requiring mechanical ventilation, or death [25].

2. Specific investigation of two clusters of leptospirosis cases among military personnel in Martinique

2.1. Clustered cases in 2009

During this investigation, all cases identified answered a standardized questionnaire to describe symptoms, materials used, details of the domestic, professional, sportive, geographical exposure (identified by location on a map and use of list of rivers, gullies, falls) and a veterinarian team investigated suspected places. Blood samples were tested by the French national reference center for leptospirosis (Institut Pasteur, Paris) using MAT serology, which is the reference test for diagnosis of leptospirosis. In 2009, the criterion used for a positive MAT was a conversion from seronegativity to

a titer of 1/100 (two samples tested with 2- or 3-weeks delay) or a single titer of >1/400.

2.2. Clustered cases between 2016-2018

The following characteristics about leptospirosis cases identified in Martinique between 2016 and 2018 among French service members were collected: socio-demographic characteristics, clinical forms, suspected contamination place, at-risk activity, biological confirmation techniques and serogroups.

Incidence rate (IR) in FAF were given per 100,000 PY because the population monitored in each territory is unstable. In general population, incidence rates were given per 100,000 persons, which is equivalent with per 100,000 PY as the general population is considered as stable. This allows the comparison of the IR between military and general populations.

RESULTS

1. Military personnel in the FAF from 2004 to 2018

During the study period, the personnel military in continental France was 296,830, and 23,458 in overseas.

2. French military epidemiological surveillance (CESPA)

The present study used aggregated data from CESPA that are approved by the French national ethical authorities (*Commission nationale pour l'informatique et les libertés*).

During the study period, between January 2004 and December 2018, 88 cases of leptospirosis were reported to the CESPA, including 15 cases in continental France (Figure 1). Of the 73 cases reported overseas, 42 cases occurred in the French West Indies (n=37 in Martinique, n= 5 in Guadeloupe). The other cases occurred in French

Guiana (n=10), in New Caledonia (n=7), in Mayotte (n=6), Reunion Island (n=4), French Polynesia (n=3) and Gabon (n=1) (Figure 2).

The French leptospirosis IR in FAF between 2004 and 2018 in continental France was 0.3/100,000 PY, with 0 to 3 cases reported every year. In overseas territories, the French leptospirosis IR in FAF was 24.7/100,000 PY, with 0 to 13 cases reported every year. The higher leptospirosis IR in FAF in this period were observed in Martinique (IR = 99/100,000 PY) and in Mayotte (IR = 36.9/100,000 PY), the lower leptospirosis IR were in Reunion Island (IR = 7.2/100,000 PY) and in French Polynesia (IR = 7.7/100,000 PY).

3. Specific investigation of two clusters of leptospirosis cases among military personnel in Martinique

3.1. Between January and June 2009 (n=7)

Seven cases (including 2 women) of confirmed leptospirosis were declared to the disease surveillance system at the same period in Martinique, 4 of them were related to the Tchimbé Raid. The diagnosis was confirmed by MAT serological assay (5 cases = 5 c.) or PCR (2 c.); serogroups associated with the strongest MAT immunoreactivity was *L. tarassovi* (3 c.), *L. canicola* (2 c.) and *L. pyrogenes* (1 c.).

All of them had participated in canyoning activity during their week-end free time. No other at-risk exposure was found. The median age of cases was 27 years (range 21-47 years). The most commonly symptoms and biological damage were reported (Table A). No severe manifestations of leptospirosis or sequelae were reported.

The study on risk exposure identified a preexisting skin lesion (abrasion, insect bite) (6 c.), insufficient use of mechanical barriers (neoprene clothing, shoes, helmet) during canyoning (3 c.). The median duration of water exposition was 6 hours in the last 3 weeks (range 1-120 hours). The geographical analysis suggested great risk

exposure to contaminated water from one area (Piton Carbet), and especially one river: Absalon (upstream) then Dumauzé (downstream) River, possibly linked to the presence of coconuts rats, stagnant water on canyoning school and domestic farms directly above.

3.2. Between the years 2016 and 2018 (n=16)

Between 2016 and 2018, almost half of all leptospirosis cases reported to the French army epidemiological surveillance occurred in Martinique (16/34). All cases were men.

High proportions of severe cardiac, renal and neurological forms (6/16) and hospitalizations (9/16) were observed. The serogroups associated with the strongest MAT immunoreactivity realized in 3 patients were *L. australis, L. celledoni*, and both *L. mini* and *L. hebdomadis* for one patient. Most of the cases occurred in duty (10/16), 5 of them during military training, the 5 others during team-building trip. The suspected places of contamination were Cascade Didier (9/16) and Colson (4/16).

DISCUSSION

1. The epidemiology in the FAF

From 2004 to 2018, the French leptospirosis IR in the FAF in overseas territories was more than 70 times that in continental France. Due to the place of their deployment and the nature of their activities, service members are more exposed to leptospirosis, especially in highly endemic areas, as French Polynesia, Mayotte, French West Indies (Martinique, Guadeloupe) and French Guiana (Figure 2). Some of these areas are also malaria-endemic areas, as French Guiana and Mayotte. French service members deployed in malaria-endemic areas benefit of the use of doxycycline as an antimalarial chemoprophylaxis. This doxycycline chemoprophylaxis could explain that

Martinique, as a non-malaria endemic territory (99/100,000 PY) has higher IR in FAF than malaria-endemic territories as French Guiana (16.8/100,000 PY), or Mayotte (36.9/100,000 PY) [26]. The French leptospirosis IR in FAF in Mayotte seems to be relatively high, with 3 out of the 6 total cases reported diagnosed in 2018. This could be explained by several factors: the recent end of chemoprophylaxis for FAF in Mayotte in late 2017 because of the diminution of malaria-transmission risk, the systematic research of leptospirosis at the hospital of Mayotte for all dengue-like syndromes, leptospirosis is still present in Mayotte, an overseas department with the highest incidence of 66.3/100,000 PY [26] and the small number of cases (6 cases), that may easily vary the IR. The absence of leptospirosis cases reported among French service members under doxycycline in the Sahel-Saharan strip and in central Africa underlines the protector effect of doxycycline, in addition to operational context (prohibition of recreational submersion in fresh water due to the high risk of schistosomiasis) [27].

The leptospirosis IR in the French service members may underestimated for several reasons: under-diagnosis because of paucisymptomatic forms (isolated fever) recovered spontaneously [28], because of lack of diagnosis means, especially on navy boats; no mandatory report for this disease; no recommendation for retrospective microbiological screening.

2. **Leptospirosis IR in the FAF *versus* in general population, in continental *France versus* French overseas territories (data from 2014 to end of 2017)**

According to the data of the National Reference Center for leptospirosis (NRCL), from 2014 to end of 2017, about 600 cases of leptospirosis were identified every year

in continental France, amounting to an IR of 0.9/100,000 PY, the military profession is well recognized by the NRCL as an "exposed" profession [29].

Therefore, France is one of the industrialized countries with the highest (between 0,5 and 1/ 100,000 PY) reported IR [24,30].

During the same period, leptospirosis is endemic in many French overseas territories (Martinique, Guadeloupe, French Guyana, Reunion Island, New Caledonia, Mayotte, French Polynesia) where its incidence can be 50 times higher than in mainland France [24].

In FAF, during the same period, similar data were found: in continental France, 6 cases with 0.5/100,000 PY and in French overseas territories, 30 cases with 38.3/100,000 PY) (Table B).

We cannot strictly compare data from military personnel and in general population because of methodological bias, especially low numbers of cases in FAF may vary the IR. However, during this period, leptospirosis IR is lower in FAF in Mayotte, Guadeloupe, French Polynesia and New Caledonia, while it is higher in Martinique, French Guiana and Reunion Island.

A “lack of cases” can be observed among military personnel deployed in Mayotte (IR 37.8/100,000 PY, vs 66.5/100,000 persons in general population). As previously indicated, the use of doxycycline as an antimalarial chemoprophylaxis for these malaria-endemic areas, could play a preventive role.

The very low military leptospirosis IR observed in French Polynesia (9.2/100,000 PY, vs 53.7/100,000 persons in general population) can partly be explained by under-diagnosis and underreporting [24]. However, the main expositions found during investigations led among 99 patients in 2017 were swimming and activities in sweet water (80%), walking barefoot in water or mud (78%) and presence of rats in or

around houses (70%) [31]. Walking barefoot in water or mud is not allowed in military personnel.

On the contrary, during this period, the military leptospirosis IR observed in Martinique in FAF was high (145.8/100,000 PY in FAF, 31.1/100,000 persons in general population) [24]. Due to the use of different reporting systems, we cannot exclude some overlap between military and civilian data. However, due to the very little size of military population compared to the civilian one, this overlap may have little impact on the comparison, which is here provided for discussion purpose but does not use a formal statistical test. For this reason, the comparisons between civil and military population have to be interpreted with caution. The 7 cases cluster in 2009 may have increased vigilance about leptospirosis in Martinique and help to consider canyoning as an at-risk activity for military staff during personal leisure in Martinique, and on duty as well. A better military physicians' awareness probably improved diagnosis of cases and detection of other cases around confirmed cases as well, as shown by the clusters that followed (4 cases exposed during a commando training in 2016, 5 cases during team-building activity in summer 2017 at Cascade Didier).

3. Current prevention in the FAF

The reality of the risk for leptospirosis in the armed forces on the field, the potential severe outcome of this disease [32-34], and its preventability call altogether for a better prevention, particularly during missions in intertropical areas [1,4]. To limit the occupational risk, there are recommendations for general protection and at the individual level [35]. According to FMMS experts in 2015, the most efficient measures to prevent leptospirosis in the FAF were collective and individual measures.

3.1. Health education

Considering the observed IR, health education regarding leptospirosis prevention should target the military personnel deployed overseas and the professional divers who are highly exposed. For all of the armed forces, the risk of leptospirosis needs to be integrated into the health education messages that are systematically delivered prior to leaving for any mission in an intertropical area. During this time, providing notices or information booklets is a way to optimize this education.

3.2. Chemoprophylaxis by doxycycline

The preventive efficacy of doxycycline against leptospirosis is suggested by few retrospective studies of clustered cases [36-38]. The benefit may include the reduction of the incidence of severe forms and the prolongation of the incubation period. For years, the FMMS recommended a timely chemoprophylaxis by 200 mg per week of doxycycline during exposure in case of at-risk exposure [34]. This schedule is used in a non-systematic manner by military professionals who are not divers. As explained, the substantial difference between the IR in Martinique *vs.* French Guiana and Mayotte in French service members is another point in favor of the efficacy of doxycycline at 100 mg/d for prevention of leptospirosis during the exposure period.

3.3. Environmental measures

The military dogs are vaccinated by the vets and the animal mascots are prohibited. The environmental measures are mainly based upon combating the reservoirs of the disease, particularly by regular and rigorous application of “rat-proofing” measures. There is a real risk in France, as indicated by the study performed at the Naval Base of Toulon in October 2006 that revealed a prevalence of more than 17% of rats carrying *L. interrogans* [39]. Of note, the application of such measures is not

straightforward in an operational setting. To reduce human-animal proximity and contact to a minimum, the FMMS and the military commanders need to give careful consideration to the site and the enclosures for the camps, organize how waste is managed (landfill, incineration) [15], and ensure water sanitation by the usual treatment processes that effectively eliminate Leptospira.

3.4. Vaccination in humans

In France, the Spirolept® vaccine only protects against the serogroup *L. icterohaemorrhagiae*, has a heavy vaccination schedule and has to be renewed every 2 years [40]. In the FAF, this vaccine is only devoted to certain high-risk engagements [40]. This strengthens the non-generalization of the vaccination for the FAF.

4. Perspective for a more effective prevention against leptospirosis in the FAF

Our study highlighted the reality of the risk of leptospirosis for the French service members, sometimes on an anadaemic mode, the enhanced risk in overseas territories, and a perfectible application of the preventive measures that have been validated or presumed to be effective. Therefore, the FMMS decided to optimize the application of the 2005 recommendations of the Supreme Council for Public Health in France for prevention of leptospirosis in the general population and for at-risk professional activities [41], taking into account the specificities of the military profession [41]. An implemented strategy to better prevent leptospirosis in the FAF is proposed, based upon synergistic actions according to a prioritized action plan (Table C). First of all, the specific continuous training will be strengthened for the military units at higher risk (divers, firefighters, missions involving submersion in intertropical places), highlighting the efficiency of good individual preventive practices and

promoting prophylactic prescription of doxycycline by the military doctors of these units. Early 2019, a booklet was produced and distributed to French military personnel deployed in Martinique, with cartography about suspected leptospirosis-contaminated sites in Martinique and preventive measures to be taken prior, during and after at-risk exposure. Three practical Tables (Tables D.1[42], D.2, and D.3) were also been specifically built to optimize the essential risk assessment prior to any mission or leisure activity. These complementary tools may improve knowledge and adherence on preventive measures on military personnel.

CONCLUSION

Although leptospirosis is an uncommon infection and fortunately rarely severe in the FAF, the occupational risk is real, particularly in malaria-free intertropical areas where chemoprophylaxis by doxycycline is not applied. Prevention can be optimized by the use of practical tools such as Tables and cartographies, leading to a better leptospirosis risk assessment and application of preventive recommendations.

CONFLICT OF INTEREST: none in relation with the topic.

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Figure 1: Leptospirosis annual incidence and incidence rate (/100 000 persons) in the French armed forces in continental France and overseas territories from 2004 to 2018 (n=88).

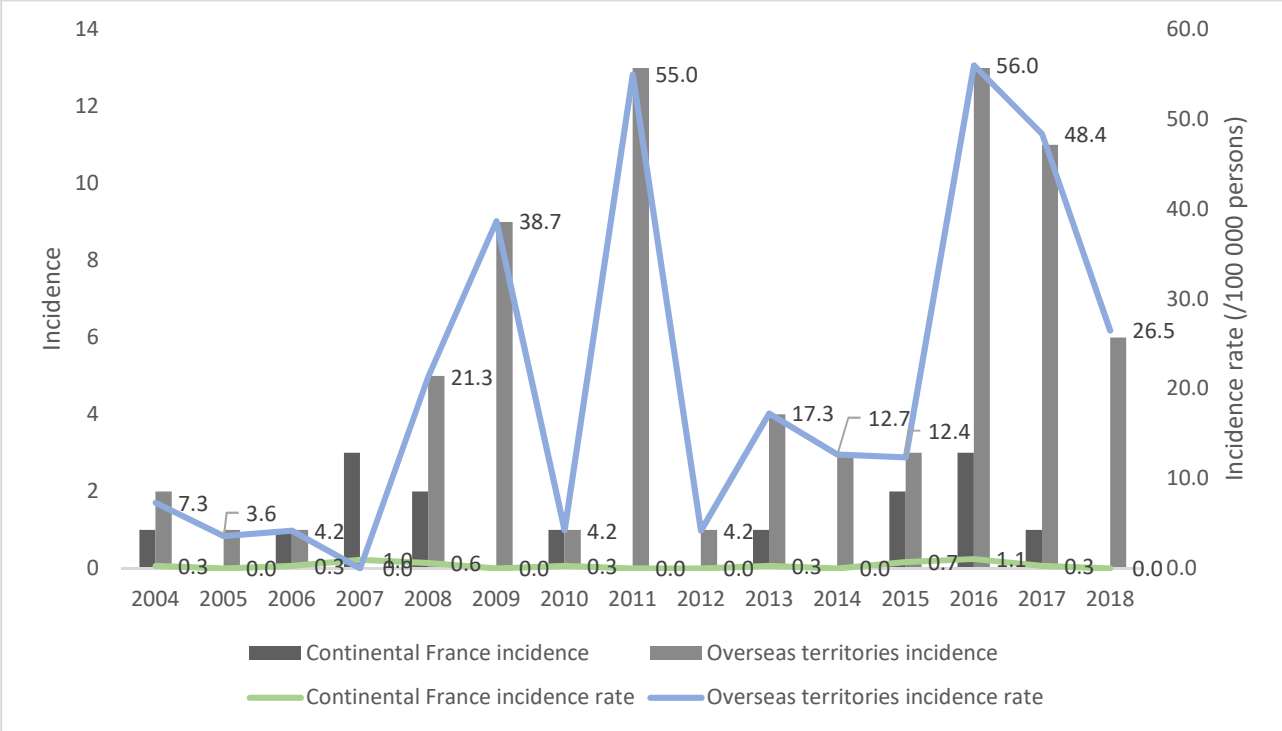
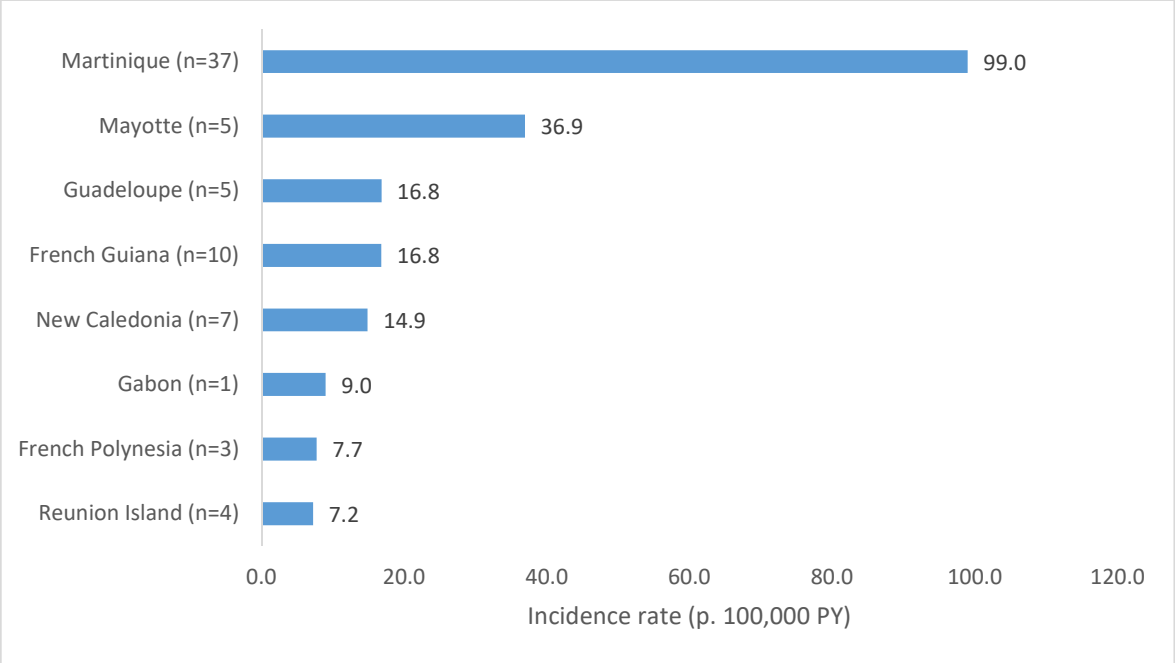


Figure 2: Leptospirosis incidence and incidence rate by overseas territories in the French Armed Forces between 2004 and 2018 (n=73).



FAF: French Armed Forces; IR: incidence rate; PY: person-years

Table A: Average leptospirosis incidence rate in French Armed Forces
and in general population diagnosed by National Reference Center for Leptospirosis in 2014-2017.

Overseas territories	Average leptospirosis IR in FAF in 2014-2017 (/100,000 PY)	Average leptospirosis IR in general population diagnosed by National Reference Center for Leptospirosis in 2014-2017 (/100,000 PY)
Martinique	145.8	31.1
Guadeloupe	11,1	31.9
French Guiana	55.0	26.8
Reunion Island	13.6	6.2
Mayotte	37.8	66.5
French Polynesia	9.2	53.7
New Caledonia	7.9	20.0
Total French overseas territories	**38.3**	**27.1**

Table A: cluster of leptospirosis cases among military personnel in Martinique between January and June 2009 (n=7): Clinical symptoms and laboratory abnormalities.

Clinical symptoms and laboratory abnormalities	Number (n=7)
High fever (>39°)	7
Myalgia	7
Joint aches	6
Loss of appetite	6
Headache	5
Vomiting	4
Diarrhea	3
Asthenia	3
Decrease in visual acuity	3
Retro-orbital pain	3
Vertigo,	2
Stiffness neck	2
Moderatic hepatic cytolysis	5
Thrombocytopenia	3
Facial paralysis	1

n= number of cases

Table B: Strategy to improve the prevention of leptospirosis in the French Armed Forces.

Axes	***Proposed actions***	***Priority***	***Feasibility***
Consolidation of expertise	Setting up a multidisciplinary team of experts on leptospirosis	+++	+++
Additional epidemiological studies	Specific analysis of health data	+	+
	Seroprevalence study	+	+
	Retrospective analysis of hospitalized cases	++	++
Strengthening environmental control	Specific training for military personnel on preventive measures: establishment and maintenance of settlements	++	++
Risk Assessment	Mapping of risk areas in France and overseas	++	+++
	Literature review about the level of risk during immersion	++	+++
	Elective identification of high-risk units	+++	+++
Evaluation of the application of preventive measures in the field	Survey of knowledge-attitudes-practices among professional Army divers deployed in inter-tropical areas	++	++
Health education	In-service training for military caregivers on leptospirosis	++	+++
	Creation of specific brochures on pre-dive risk assessment and individual preventive measures	+++	+++
	Targeted training of high-risk units	+++	++
	Diffusion to the defense community in partnership with the National Military Social Security Fund	++	+++
	Specific information before any overseas mission or assignment	+++	+++
Chemoprophylaxis	Case-control study to assess efficiency	+	+
	Clinical trial of a simplified doxycycline prophylactic regimen	++	++
Vaccination	Evaluation of the application of leptospirosis vaccination in the French armed forces	+	++
Regulatory framework	Drafting of a ministerial circular on the prevention of leptospirosis in the French armed forces	+++	+++

Table B: Average leptospirosis incidence rate in French Armed Forces
and in general population diagnosed by National Reference Center for Leptospirosis in 2014-2017.

Overseas territories	Average leptospirosis IR in FAF in 2014-2017 (/100,000 PY)	Average leptospirosis IR in general population diagnosed by National Reference Center for Leptospirosis in 2014-2017 (/100,000 PY)
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Mayotte	37.8	66.5
French Polynesia	9.2	53.7
New Caledonia	7.9	20.0
Total French overseas territories	**38.3**	**27.1**

PY : Person-years
IR : incidence rate
FAF : French Armed Forces

Table C: Strategy to improve the prevention of leptospirosis in the French Armed Forces.

Axes	***Proposed actions***	***Priority***	***Feasibility***
Consolidation of expertise	Setting up a multidisciplinary team of experts on leptospirosis	+++	+++
Additional epidemiological studies	Specific analysis of health data	+	+
	Seroprevalence study	+	+
	Retrospective analysis of hospitalized cases	++	++
Strengthening environmental control	Specific training for military personnel on preventive measures: establishment and maintenance of settlements	++	++
Risk Assessment	Mapping of risk areas in France and overseas	++	+++
	Literature review about the level of risk during immersion	++	+++
	Elective identification of high-risk units	+++	+++
Evaluation of the application of preventive measures in the field	Survey of knowledge-attitudes-practices among professional Army divers deployed in inter-tropical areas	++	++
Health education	In-service training for military caregivers on leptospirosis	++	+++
	Creation of specific brochures on pre-dive risk assessment and individual preventive measures	+++	+++
	Targeted training of high-risk units	+++	++
	Diffusion to the defense community in partnership with the National Military Social Security Fund	++	+++
	Specific information before any overseas mission or assignment	+++	+++
Chemoprophylaxis	Case-control study to assess efficiency	+	+
	Clinical trial of a simplified doxycycline prophylactic regimen	++	++
Vaccination	Evaluation of the application of leptospirosis vaccination in the French armed forces	+	++
Regulatory framework	Drafting of a ministerial circular on the prevention of leptospirosis in the French armed forces	+++	+++

Tables C: Proposed tables for risk assessment of leptospirosis in the French Armed Forces.

Table C.1: Risk levels according the environment and activities [34].

Environment / Activities	Sea		Running fresh water	Stagnating fresh water	Ground waters
	Seaside	Off the coast			
Crossing	+	0	+	Dry 0 Moist +	+++
Canoeing, kayaking	0	0	0	+	0
Hardening exercises, commando training	+	0	0	+++	+++
Diving	+	0	0	++	+++
Canyoning	0	0	+	+++	0
Swimming with flippers	+	0	0	++	+++
Physical training in natural environment: Running, press-ups, push-ups…	+	0	0	+++	+++

Risk levels. 0: no risk; +: low risk; moderate risk: ++; high risk: +++

Table C.2: Risk levels according to daytime visibility of rats and temperature of the environment [35].

Temperature of the environment \ Visibility of rodents during daytime		
 < 19°C	+	++
 > 19°C	++	+++

Risk level. Low risk: +; moderate risk: ++; high risk: +++.

 : visible rats;  : non visible rats;  : temperature

Table C.3: Risk levels according the area and antimalarial chemoprophylaxis with doxycycline.

Military conditions	Risk level
French Guiana or Mayotte with antimalarial chemoprophylaxis by doxycycline	+
French Guiana or Mayotte without antimalarial chemoprophylaxis by doxycycline	+++
Martinique, Guadeloupe, Réunion, French Polynesia, New Caledonia	+++
Africa with antimalarial chemoprophylaxis by doxycycline	+
Africa without antimalarial chemoprophylaxis by doxycycline	++

Risk level. Low risk: +, moderate risk:++ ; high risk: +++.

Tables D: Proposed tables for risk assessment of leptospirosis in the French Armed Forces.

Table D.1: Risk levels according the environment and activities [42].

Environment / Activities	Sea		Running fresh water	Stagnating fresh water	Ground waters
	Seaside	Off the coast			
Crossing	+	0	+	Dry 0 Moist +	+++
Canoeing, kayaking	0	0	0	+	0
Hardening exercises, commando training	+	0	0	+++	+++
Diving	+	0	0	++	+++
Canyoning	0	0	+	+++	0
Swimming with flippers	+	0	0	++	+++
Physical training in natural environment: Running, press-ups, push-ups…	+	0	0	+++	+++

Risk levels. 0: no risk; +: low risk; moderate risk: ++; high risk: +++

Table D.2: Risk levels according to daytime visibility of rats and temperature of the environment [42].

Temperature of the environment \ Visibility of rodents during daytime		
 < 19°C	+	++
 > 19°C	++	+++

Risk level. Low risk: +; moderate risk: ++; high risk: +++.

 : visible rats;  : non visible rats;  : temperature

Table D.3: Risk levels according the area and antimalarial chemoprophylaxis with doxycycline.

Military conditions	Risk level
French Guiana or Mayotte with antimalarial chemoprophylaxis by doxycycline	+
French Guiana or Mayotte without antimalarial chemoprophylaxis by doxycycline	+++
Martinique, Guadeloupe, Réunion, French Polynesia, New Caledonia	+++
Africa with antimalarial chemoprophylaxis by doxycycline	+
Africa without antimalarial chemoprophylaxis by doxycycline	++

Risk level. Low risk: +, moderate risk:++ ; high risk: +++.