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Original article

Spatial-Temporal Distribution and Some Associated Factors of Rabies in Dhamar Governorate, Yemen: A Retrospective Study 2011–2017

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ABSTRACT
Rabies is a fatal zoonotic disease of mammals, including humans. It remains a public health problem in many Asian and African countries, including Yemen. This study aimed to describe the spatial-temporal distributions and associated risk factors of rabies in Dhamar governorate, Yemen. Data on reported rabies cases for the years 2011 to 2017 was obtained from the National Rabies Control Program (NRCP)-Unit of Dhamar Governorate. Three rabies indicators were analyzed, including total bites, positive bites, and the number of deaths. The association of rabies indicators with reporting year, month/season, district, as well as the age and gender of the victims, was assessed. A total of 13,706 bites, 2,555 positive bites, and 49 deaths due to rabies were reported in Dhamar governorate between 2011 and 2017. The annual incidence was averaged at 111.64 bites, 20.80 positive bites, and 0.402 deaths per 100,000 capita. Incidence in some rural areas was as high as in urban areas, and it was significantly higher in the eastern districts than in the western districts. The highest exposure occurred in winter (December–February) while the lowest exposure occurred in summer (June–August). The incidence was significantly higher in males (OR ≥ 2.36) and in age strata 5-14 years (OR ≥ 2.42). Rabies is still endemic in Dhamar governorate, and several factors affect exposure to the disease. Factors associated with higher exposure in some districts need to be clarified, in particular the determination of the local wildlife reservoir(s) and its distribution/mobility. Study the incidence of rabies in animals, like bovine and equine species, and their role in transmission of the disease is also encouraged.

INTRODUTION

Rabies is a zoonotic disease that has been known for thousands of years (Gnanadurai et al., 2013). It is caused by *Lyssavirus* genotype 1 of the family *Rhabdoviridae* (Warrell, 2004). Rabies is a fatal disease of mammals, including humans (Singh et al., 2017); nevertheless, all warm-blooded animals are also susceptible to infection (Oyda and Megersa, 2017). The rabies virus maintains itself in the environment in wildlife reservoirs that vary between contents and subcontinental regions, including dogs, foxes, wolves, hyenas, raccoons, and bats (Warrell, 2004). Dogs are the main vector, and approximately 95% of the human rabies cases arise from dog attacks (WHO., 2018). The virus presents in the saliva of rabid animals, and is most commonly transmitted by the bites of rabid animals (Singh et al., 2017). Administration of post-exposure prophylaxis (PEP) immediately after exposure to the bite was reported to be highly effective, while the disease is invariably fatal after the appearance of clinical manifestations (Warrell, 2004).

Rabies is a neglected tropical disease that mostly affects vulnerable people and poor communities (WHO, 2023). Human rabies is

underestimated due to several factors, such as an immature reporting system and a lack of diagnostic infrastructure (WHO., 2018). Annually, 59,000 human deaths occur globally, with a one death case every 10 minutes or less. It mostly affects Asia and Africa, where 59.6% and 34.6% of the deaths, respectively, occur (WHO., 2018). Annually, 29 million PEPs are received, with an average cost of 108 US dollars for each. The annual global burden of rabies was estimated at 8.6 billion US dollars (WHO, 2023). Elimination of rabies is feasible, and rabies has come under control in most of the developed countries, largely through the vaccination of pet animals, in particular dogs (Gnanadurai et al., 2013, Wallace et al., 2017). In 2016, the World Organization for Animal Health (OIE), the WHO, and the Food and Agriculture Organization (FAO), as well as many other non-governmental organizations, set the goal of eliminating dog-mediated human rabies deaths by 2030 (Wallace et al., 2017).

Control or elimination of rabies in a particular region requires prior knowledge of its epidemiology in that region. Several factors affect the incidence of rabies, including, but not limited to, the presence of wildlife reservoirs, their distribution and mobility (Aiyedun et al., 2017), dog and human densities and the dog-to-human ratio (Babaniyi et al., 2016, FAO., 2014), human behaviors (WHO., 2018), socio-economic factors (Bonilla-Aldana et al., 2022), transportation, and the presence of roads (Song et al., 2009). Accordingly, the incidence of rabies may not evenly distributed over time or space and, in some instances, tend to cluster (Bonilla-Aldana et al., 2022). Spatial temporal distribution allows the identification of regions/periods with higher exposure and paves the way to assign the determining factors.

Little is known about the epidemiology of rabies in Yemen particularly in Dhamar governorate. Nationally, up to 7,000 bites and at least 30 deaths were reported annually (Al-Shamahy et al., 2013). Here, we aimed to describe the spatial-temporal distributions and some associated factors of rabies in Dhamar governorate and to highlight the rabies problem accordingly.

MATERIALS AND METHODS

Study area and population

Dhamar governorate is located in the central west region of Yemen, about 100 km south of the capital, Sana'a, and between latitudes 14° - 15°N and longitudes 43.30° - 44.50°E. Dhamar is an agriculture governorate that produces some crops like potatoes, corn, and others. It also harbors a large number of animals, especially sheep and cattle. Topologically, Dhamar is a mountainous area that is elevated between 760m and 2848 m above sea level. According to the last official census conducted in 2004, the population of Dhamar governorate was 1,330,108 capita. Administratively, the governorate is divided into 12 districts (NIC, 2018) and can be separated by the longitude E44.075°E into an eastern part (Al-Hada, Jahran, Dhowran, Al-Manar, Anss, Maeffa'at Anss, Dhamar City, and Maghreb Anss) and a western part (Jabal Al-Sharq, Utmah, Wisab Al-A'ali, and Wisab Al-Safel).

Data Collection

Data on rabies incidence for the years 2011 to 2017 were obtained from the National Rabies Control Program (NRCP)-Unit of Dhamar Governorate. It consists of monthly records of numbers of positive bites, negative bites, unknown bites, and total bites for males and females, as well as the number of deaths for different age strata (0–4, 5–14, 15–40, and >41 years). The data presented at the district level with records of two districts, Wisab Al-A'ali and Wisab Al-Safel, merged under the name Wisabaen. The estimated population size of Dhamar governorate for the targeted years was obtained from the National Information Center (NIC)-Yemen (NIC, 2018). The population fraction contributed by each district to the overall governorate population was obtained from the last official population census (2004) (NIC, 2018).

Data analysis

The obtained data was tabulated in MS Excel sheet. Assuming a constant growth rate of the district population, the annual population size at the district level was projected from the governorate`s annual population size and the district population fraction.

Three rabies indicators were studied, including total bites, positive bites, and the number of deaths. Temporal and spatial distributions of the rabies indicators were expressed as annual incidence per 100,000 capita at the governorate and district levels, respectively. Mapping spatial distribution was performed using Epi-Info™ 7.2.4.0 (CDC, Atlanta).

The associations of the involved variables with month/season, age strata, and gender were expressed as percentages using the total count of each variable as a denominator. The odd ratio (OR) was also calculated to reflect the effect of population size.

The significance of the differences was judged using the Chi-square test (X^2) in Prism (GraphPad software version 9, San Diego, CA, USA). P-values less than 0.05 were considered statistically

significant..

RESULTS

Annual incidence of rabies indicators in Dhamar governorate

A total of 13,706 bites, 2,555 positive bites, and 49 deaths due to rabies were reported in Dhamar governorate between 2011 and 2017. The annual incidence of total bites in Dhamar governorate ranged between 89.43 bites/100,000 capita in 2014 and 161.41 bites/100,000 capita in 2016, and averaged to 111.64 bites/100,000 capita (Figure 1). The annual incidence of positive bites ranged between 14.97/100,000 capita in 2011 and 32.21/100,000 capita in 2016, and averaged to 20.80/100,000 capita. The annual incidence of death due to rabies ranged between 0.172/100,000 in 2014 and 0.686/100,000 capita in 2017 and averaged to 0.402/100,000 capita. Significant differences were observed between the studied years regarding the number of total bites (p value <0.0001) and positive bites (P value <0.0001), but not for the number of deaths (P value = 0.0923).

Seasonality

Comparing the number of total bites and positive bites on a month/season basis showed significant differences between months/seasons. Exposure was higher in winter (December to February) and lower in summer (June to August), as shown in Table 1. On the other hand, differences in the number of deaths were not significant.

Spatial distribution of rabies indicators in Dhamar governorate

The presented data showed significant differences in the distribution of the three rabies indicators between districts of Dhamar governorate. Anss district showed the highest incidence of the three indicators (290.5 bites, 49.57 positive bites, and 0.914 deaths/100,000 capita). On the other hand, Wisabaen showed the lowest incidence of total bites and positive bites (10.34 total bites and 2.57 positive bites/100,000 capita), while death due to rabies was not reported from Maghreb Anss and Maeffa'at Anss, as shown in Figure 2. For the three rabies indicators, there was a significant difference (P value <0.001) between eastern districts (160.91 bites, 28.59 positive bites, and 0.552 deaths /100,000 capita) and western districts (36.5 bites, 8.98 positive bites, and 0.167 deaths/100,000 capita). The incidence of bites and positive bites in Anss, a rural district, was significantly higher than that in Dhamar city (174 bites, 25.6 positive bites, and 0.435 deaths/100,000 capita) the main urban area in the governorate.

Age of the victims

The present findings showed significant differences between reported age strata over the three rabies indicators. The highest exposure was associated with the age strata 5 to 14 years old, with ≥2.42 times higher than the other strata, as shown in Table 2.

Gender of the victims

The presented findings showed that exposure of males to bites and positive bites (approximately 70%) was significantly higher than that in females (approximately 30%), as shown in Table 3. For both indicators, the odd ratio showed that exposure of males was approximately ≥2.36 times higher than exposure of females. The genders of the dead victims were not specified and, thus, not shown.

DISCUSSION

Analysis of the incidence of bite/rabies cases and evaluating the major associated risk factors are essential to establish a rabies control strategy. The present study highlights the epidemiology of rabies in Dhamar governorate and provides insights into the incidence of bites, rabid bites, and deaths due to rabies in Dhamar governorate, Yemen. The spatial-temporal dynamics of the disease and its association with the age and gender of the victims were assessed. In the present study, average animal bites exposure was 111.64/100,000/year and ranged between 89.43/100,000 in 2014 and 161.41/100,000 in 2016 in Dhamar governorate. The reported rate is at the lower margin of the global estimation of the annual incidence of dog bites cases, which ranged between 100 and 5,000 bites per 100,000 capita (WHO., 2018). In this way, an annual incidence of 42.4, 39.6, and 1500 bites per 100,000 capita were reported from Zambia, Uganda, and the USA, respectively (Fe`vre et al., 2005, Babaniyi et al., 2016, Hiby et al., 2017).

In the current work, exposure to positive bites in Dhamar governorate was averaged at 20.80 per 100,000 capita per year and ranged between 14.97/100,000 capita in 2011 and 32.21/100,000 capita in 2016. Comparable findings were reported from Ethiopia, where exposure to rabid bites was 35.8 to 89.8 per 100,000 capita in Tigray (Teklu et al., 2017) and 1.27 to 4.6 per 100,000 capita in Gondar (Yibrah and Damtie, 2015). At the national level in Ethiopia, the annual incidence of rabid bites was estimated at 12 rabid bites per 100,000 (Beyene et al., 2018). Similarly, exposure to a rabid bite was

estimated at 27/100,000 in New York, USA, and 58/100,000 in Tanzania. Higher rates were reported by active surveillance, for example, rabid bites was estimated at 234/100,000 capita in Kenya (Yibrah and Damtie, 2015).

In the current study, annual mortality due to rabies in Dhamar governorate ranged from 3 deaths (0.172/100,000) in 2014 to 13 deaths (0.686/100,000) in 2016, with an average of 0.402 deaths/100,000 capita. This finding is lower than that reported in Ethiopia, Kenya, and Tanzania, which were estimated at 1.6, 2.5, and 4.9 rabies deaths per 100,000 capita, respectively (Beyene et al., 2018, Taylor et al., 2017). However, rabies in Dhamar governorate and in Yemen is largely underestimated due to a shortage of reporting systems (Al-Shamahy et al., 2013).

Significant differences were found in the incidence of bites/positive bites between months/seasons in Dhamar governorate, which peaks in December–February. This is in agreement with the findings reported by Yibran and Damtie (2015) who showed higher exposure in the fall and winter months (approximately 60%) and lower exposure in the spring and summer in Gondar, Ethiopia (Yibrah and Damtie, 2015). On the other hand, higher exposure to dog bites (60%) was reported to occur between June and October in Zaria, Nigeria (Ehimiyein et al., 2014) and between March and May (40%) in Bhutan (Tenzin et al., 2011).

The present findings showed that 36.73% of the mortalities occurred from September to November. This is in agreement with previous reports from Ethiopia and elsewhere showing that a higher incidence of rabies occurs in late summer and fall and was attributed to the higher mobility of the wild animals in search of food and mating partners during this period (Oyda and Megersa, 2017). Similarly, a study in Zimbabwe showed that the highest incidence of human rabies occurs during the dry season from July to November (Pfukenyi et al., 2007).

In the present work, a significant difference in the incidence of rabies was observed between Dhamar districts, with a higher incidence in the eastern districts. This may be linked to the presence of wildlife animals, including wolves, haynes, hedgehogs, jackals, foxes, leopards, and caracals, that have been reported in Dhamar, especially in the eastern part, due to the presence of water springs in this region (Beck, 1990, USAID-Yemen., 2013). Nevertheless, Utmah district in the western part has also been declared a protected area since June 2, 1999 (USAID-Yemen., 2013). Wild life is a central component of rabies epidemiology, from which infection is transmitted to domestic animals, especially dogs, and humans (Aiyedun et al., 2017). In this regard, the red fox (*Vulpes vulpes*) and golden jackal (*Canis aureus*) have been reported as the main reservoirs of rabies in Yemen and surrounding countries (WHO., 2018). Additionally, bites and transmission of rabies by domestic animals, such as bovines, have also been reported.

However, dogs remain the main attacking animals and the main source of rabies for humans (Babaniyi et al., 2016). Increases in dog and human densities were associated with an increase in rabies transmission. Hence, the incidence of rabies was significantly higher in urban areas than in rural areas (Beyene et al., 2018). No data on the size of the dog population at the district or governorate levels was available. The dog population in Yemen was estimated to be more than 1,000,000, with 10–20% of them owned (Al-Shamahy et al., 2013). The size/management of the dog population, the human-to-dog ratio, the availability of eatable food (for example in garbage contents and carcasses of dead animals/birds), and the mass immunity of the dog population (induced by vaccination) are some of the underlying factors affecting rabies epidemiology (FAO., 2014).

Notably, in the present study, the incidence of bites and positive bites in some rural areas was as high as in urban areas or even higher. The two districts with the highest incidence of total bites, Dhamar city and Anss, contain about 60% of the commercial poultry farms/sheds in Dhamar governorate (Al-Mamari, 2008). Indeed, a significant positive correlation was found between the number of poultry farms/sheds and the number of total bites at district levels (data not shown).

In urban areas, the vast majority of the dogs are stray (Al-Shamahy et al., 2013), while dogs are frequently owned in rural areas to guard cultivations, especially Qat trees which are widely grown in the eastern districts of Dhamar governorate. These are some of the factors with an expected link to the dog population and spread of rabies. Other factors that were reported to affect the incidence of dog bites/rabies include land use, mobility, and the presence of roads (Babaniyi et al., 2016).

In the current investigation, the exposure of age strata 5 to 14 years was ≥2.42 higher than the other strata for the three rabies indicators. Those aged ≤14 years represented 57% to 63% of the total victims. Previous findings from Yemen showed that the age strata ≤10 years represented 56.1% of the victims of the positive bites (Al-Shamahy et al.,

2013). Compatible findings were reported from Tigray-Ethiopia and from Oman, where 56% and 52% of the bitten victims were in age strata 0–15 and 0–19 years, respectively (Abebe et al., 2015, Al-Abaidani et al., 2015). Lower exposure was also reported from Ethiopia, Zimbabwe, and Ghana, where 38.5% to 47.9% of the bites were reported in the age strata <15 years (Yimer et al., 2002, Yibrah and Damtie, 2015, Pfukenyi et al., 2007). On the other hand, a higher exposure of this age strata (0–14 years) to animal bites was reported in Iraq, where it received 63% of the total bites (Horton et al., 2013). The higher exposure of this age strata may be attributed to the higher outdoor activity and close contact with animals, as previously reported by others (Al-Abaidani et al., 2015).

In the present work, males represented 70.66%, while females represented 29.34% of the bitten individuals. Regarding positive bites, males and females represent 69.7% and 31.3%, respectively, of the victims. This is in fine agreement with a previous report from Yemen, where males represented 68.9% of the victims bitten by rabid animals (Al-Shamahy et al., 2013). Similarly, males constitute 70.1% of the bitten victims in Oman (Al-Abaidani et al., 2015). Gender-attributed differences in the exposure to animal bites decrease in some countries like Ethiopia, Bhutan, and Ghana. Out of the bitten victims, males represented 54% to 63% in Ethiopia (Yibrah and Damtie, 2015, Abebe et al., 2015, Aleme and Glmeskel, 2017, Teklu et al., 2017, Yimer et al., 2002, Deressa et al., 2010); 62% in Bhutan (Tenzin et al., 2011); and 50.3% in Techiman, Ghana (Punguyire et al., 2017). On the contrary, 89%, 80%, and 73.8% of the bitten victims in Iraq, India, and Zimbabwe, respectively, were males (Horton et al., 2013, Babaniyi et al., 2016, Pfukenyi et al., 2007). Gender-related differences in exposure to bites may be attributed to differences in outdoor activities between males and females.

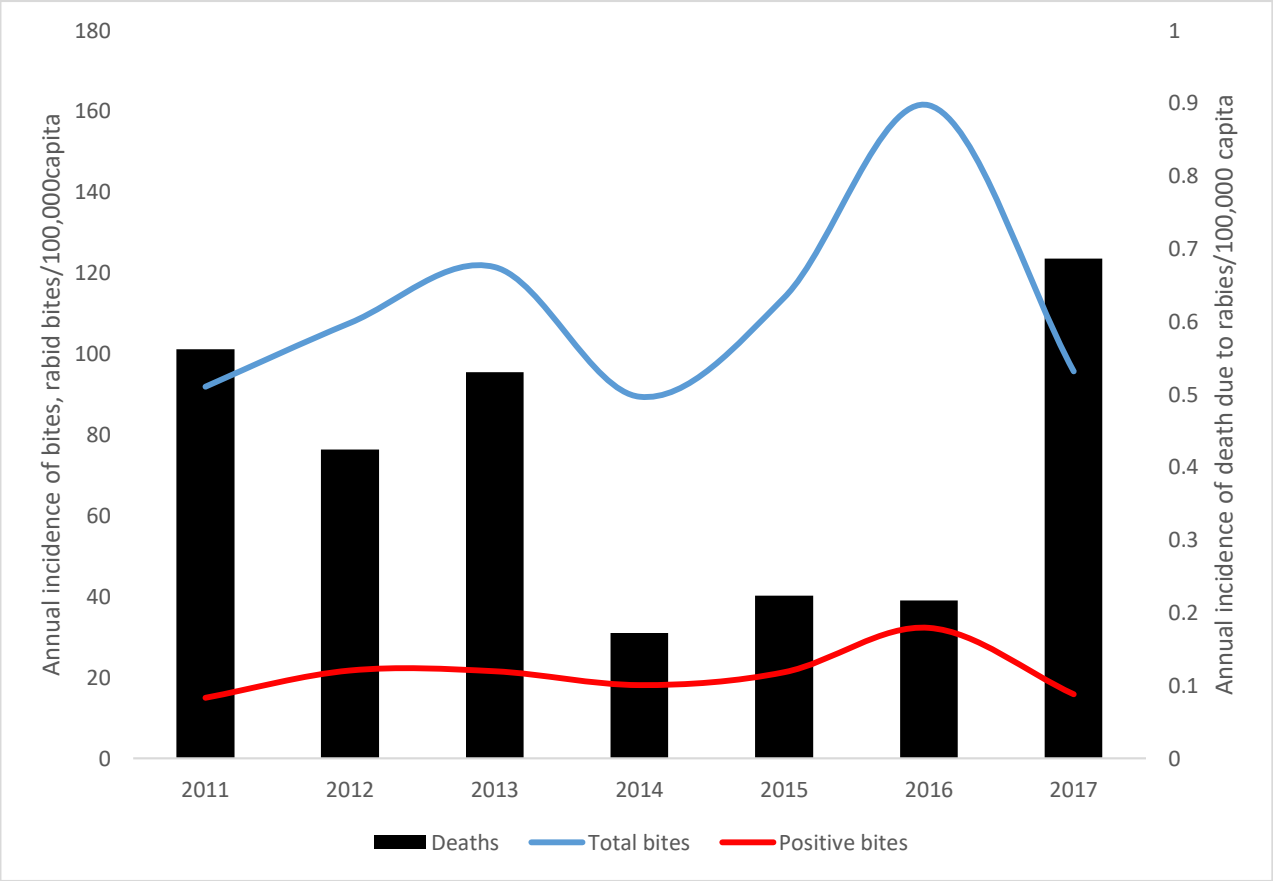

Fig.1. Temporal distribution of rabies cases in Dhamar governorate for the period from 2011 to 2017

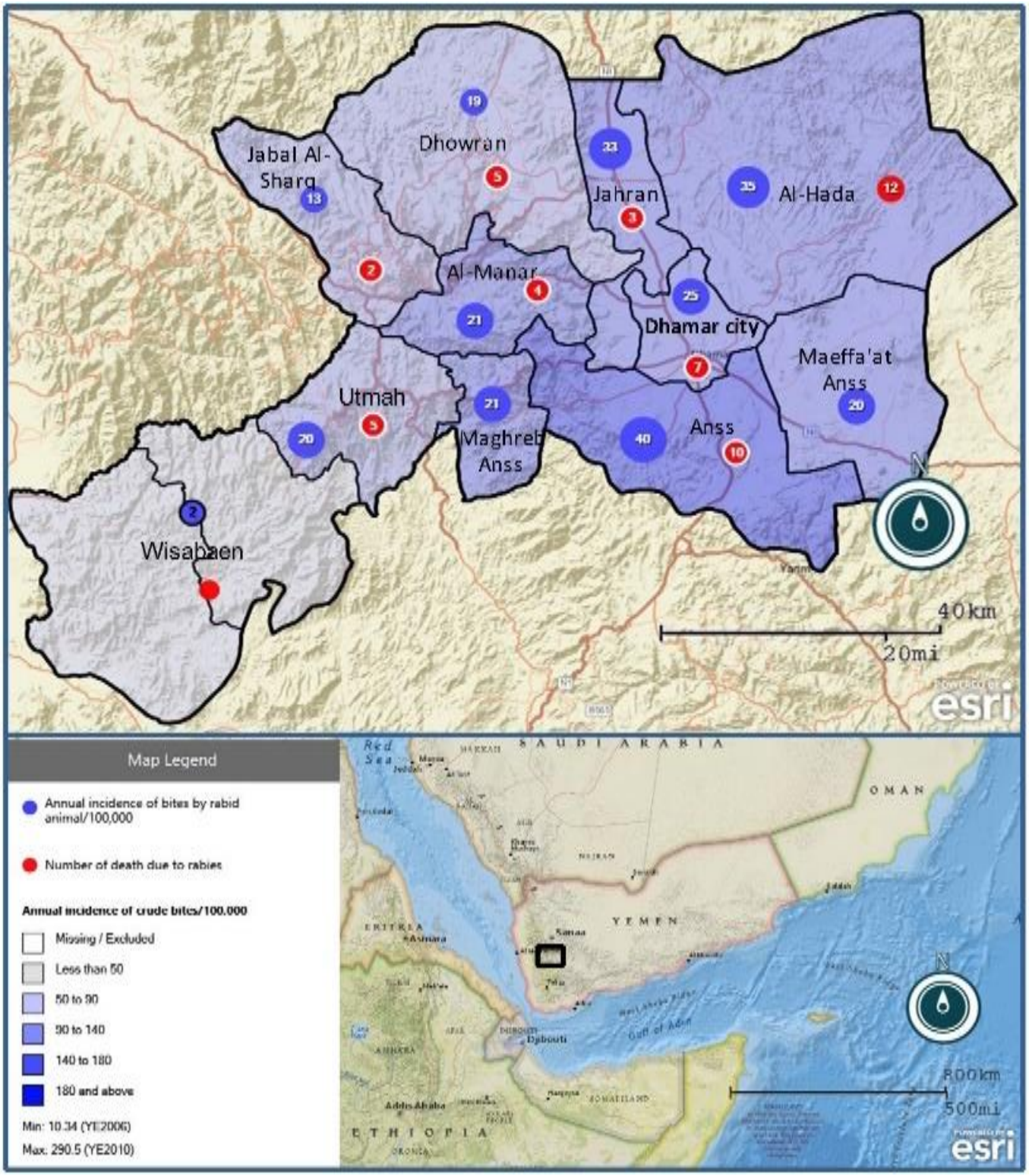

Fig 2. Spatial distribution of rabies in Dhamar governorate at district level. The annual incidence of total bites (choropleth) and of positive bites (case cluster in blue), as well as the total number of deaths due to rabies (case cluster in red). The map was constructed using Epi-Info™ 7.2.4.0. Source of the Map: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, iPC.

Table 2: Comparison of numbers of animal bites, positive bites, and death due to rabies over ages of the victims

Age strata	Population*	Total bites (%; OR; CI95%)	Positive bites (%; OR; CI95%)	Deaths (%; OR; CI95%)
0_4 years	277,734	1769 (12.91; 0.78; 0.74-0.82)$^{\nabla}$	386 (15.11; 0.94; 0.84-1.05)	6 (12.24; 0.74; 0.31-1.73)
5_14 years	440,031	6195 (45.2; 2.47; 2.39-2.55)$^{\Delta}$	1212 (47.44; 2.68; 2.48-2.9)$^{\Delta}$	22 (44.9; 2.42; 1.38-4.25)$^{\Delta}$
15_40 years	755,519	3906 (28.5; 0.52; 0.5-0.54)$^{\nabla}$	714 (27.95; 0.51; 0.47-0.55)$^{\nabla}$	14 (28.57; 0.52; 0.28-0.97)$^{\nabla}$
>40 years	272,265	1836 (13.4; 0.84; 0.8-0.88)$^{\nabla}$	243 (9.51; 0.57; 0.5-0.65)$^{\nabla}$	7 (14.29; 0.9; 0.41-2.01)
Total	1,745,549	13,706	2,555	49

*: Population size of the middle year (2014), $^{\nabla}$: Exposure is significantly lower than that in other strata

$^{\Delta}$: Exposure is significantly higher than that in other strata

Table 1. Comparison of numbers of animal bites, positive bites, and death due to rabies at level of season

Season	Population*	Total bites (%; OR; CI95%)	Positive bites (%; OR; CI95%)	Death (%; OR; CI95%)
Dec. -Feb.	1,745,546	3612 (26.35; 1.08; 1.04-1.12)$^{\Delta}$	698 (27.32; 1.13; 1.03-1.23)$^{\Delta}$	11 (22.45; 0.87; 0.44-1.7)
Mar.-May	1,745,546	3416 (24.92; 1; 0.96-1.04)	686 (26.85; 1.1; 1.01-1.2)$^{\Delta}$	7 (14.29; 0.5; 0.22-1.11)
June-Aug.	1,745,546	3282 (23.95; 0.95; 0.91-0.98)$^{\nabla}$	561 (21.96; 0.84; 0.77-0.93)$^{\nabla}$	13 (26.53; 1.08; 0.57-2.04)
Sep.-Nov.	1,745,546	3396 (24.78; 0.99; 0.95-1.03)	610 (23.87; 0.94; 0.86-1.03)	18 (36.73; 1.74; 0.97-3.11)
Total		13,706 (100;;)	2,555 (100;;)	49 (100;;)

*: Based on the population size of the year 2014 (middle year), $^{\nabla}$: Exposure is significantly lower than that in the rest of the year, $^{\Delta}$: Exposure is significantly higher than that in the rest of the year

Table 3: Comparison of numbers of animal bites and positive bites over gender of the victims			
Gender	Population*	Total bites (%; OR; CI95%)	Positive bites (%; OR; CI95%)
Male	863,190	9685 (70.66; 2.48; 2.39-2.57)$^{\Delta}$	1781 (69.71; 2.36; 2.16-2.56)$^{\Delta}$
Female	882,359	4021 (29.34; 0.4; 0.39-0.42)$^{\nabla}$	774 (30.29; 0.42; 0.39-0.46)$^{\nabla}$
Total	1,745,549	13,706	2,555

*: Population size of the middle year (2014), $^{\nabla}$: Exposure is significantly lower than that in the other group

$^{\Delta}$: Exposure is significantly higher than that in the other group

CONCLUSIONS

Up to our knowledge, this is the first effort to understand the spatial-temporal dynamics of the rabies and underlying factors in Dhamar governorate. Rabies is still an endemic disease in Dhamar governorate. Exposure to bites/rabies varies according to several factors. The incidence of rabies in some rural areas was higher than urban areas. Factors affecting differences in exposure between eastern and western parts need to be studied, including the size of the dog population and the presence/behaviors of the wildlife reservoir(s). The incidence of rabies in domestic animals, like bovine and equine species, and their roles in transmission of the disease also need to be studied. There is a need to enhance surveillance, diagnosis, and public

awareness of the disease. Additionally, management and vaccination of the dog population are also required for the control of rabies.

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التوزيع المكاني والزماني وبعض العوامل المرتبطة بداء الكلب في محافظة ذمار، اليمن: دراسة استرجاعية 2011-2017

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الملخص
داء الكلب مرض حيواني المنشأ قاتل للثدييات، بما في ذلك البشر، ولا يزال يمثل مشكلة صحية عامة متوطنة في العديد من البلدان الآسيوية والأفريقية، بما في ذلك اليمن. هدفت هذه الدراسة إلى وصف التوزع المكاني والزماني وعوامل الخطورة المرتبطة بداء الكلب في محافظة ذمار، الجمهورية اليمنية. أُستمدت البيانات الخاصة بحالات داء الكلب المبلغ عنها للأعوام من 2011 إلى 2017 من البرنامج الوطني لمكافحة داء الكلب - وحدة محافظة ذمار، وحُللت ثلاثة مؤشرات لداء الكلب هي إجمالي العضات، والعضات الإيجابية، وعدد الوفيات. كما قُيم ارتباط مؤشرات داء الكلب بسنة الإبلاغ، والشهر/الموسم، والمنطقة، بالإضافة إلى عمر وجنس الضحايا. تم الإبلاغ عن إجمالي 13706 عضة، و2555 عضة إيجابية، و49 حالة وفاة بسبب داء الكلب في محافظة ذمار بين عامي 2011 و2017. كما بلغ متوسط الحدوث السنوي 111.64 عضة، و20.80 عضة إيجابية، و0.402 حالة وفاة لكل 100000 فرد. و قد كان الحدوث السنوي في بعض المناطق الريفية مرتفعاً و مماثلاً لذلك المسجل في المناطق الحضرية، فيما كان الحدوث في المناطق الشرقية أعلى بكثير عن ذلك المسجل في المناطق الغربية للمحافظة. و اظهر تحليل البيانات ان التعرض يزداد في فصل الشتاء (ديسمبر - فبراير) وينخفض في الصيف (يونيو - أغسطس). كما كان التعرض أعلى بكثير في الذكور (OR ≥ 2.36) وفي الفئة العمرية 5-14 سنة (OR ≥ 2.42) مقارنة بالإناث و الفئات العمرية الاخرى، على التوالي. خلصت الدراسة الى ان داء الكلب لا يزال مرضاً متوطناً في محافظة ذمار، وهناك العديد من العوامل المؤثرة على احتمالية التعرض له. ولازالت هناك حاجة إلى القيام بالعديد من الدراسات حول العوامل المرتبطة بارتفاع التعرض له في بعض المناطق، ولا سيما توافر النواقل والخوازن البرية المحلية وتوزيعها وطبيعة تحركها. كما ان هناك حاجة أكبر لدراسة معدلات الإصابة بداء الكلب في الحيوانات الحقلية كالأبقار وفصيلة الخيليات ودورها في نقل المرض.

كلمات المفتاحية: التعرض، د اء الكلب، التوزيع المكاني والزماني، ذمار، اليمن، معدل الوقوع

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