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Rabies in the Middle East, Eastern Europe, Central Asia and North Africa: Building evidence and delivering a regional approach to rabies elimination

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ABSTRACT

The Middle East, Eastern Europe, Central Asia and North Africa Rabies Control Network (MERACON), is built upon the achievements of the Middle East and Eastern Europe Rabies Expert Bureau (MEEREB).

MERACON aims to foster collaboration among Member States (MS) and develop shared regional objectives, building momentum towards dog-mediated rabies control and elimination. Here we assess the epidemiology of rabies and preparedness in twelve participating MS, using case and rabies capacity data for 2017, and compare our findings with previous published reports and a predictive burden model.

Across MS, the number of reported cases of dog rabies per 100,000 dog population and the number of reported human deaths per 100,000 population as a result of dog-mediated rabies appeared weakly associated. Compared to 2014 there has been a decrease in the number of reported human cases in five of the twelve MS, three MS reported an increase, two MS continued to report zero cases, and the remaining two MS were not listed in the 2014 study and therefore no comparison could be drawn. Vaccination coverage in dogs has increased since 2014 in half (4/8) of the MS where data are available. Most importantly, it is evident that there is a need for improved data collection, sharing and reporting at both the national and international levels.

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With the formation of the MERACON network, MS will be able to align with international best practices, while also fostering international support with other MS and international organisations.

Introduction

Rabies is a Neglected Zoonotic Disease (NZD) and has the highest case-fatality rate of any known infectious disease [1,2]. *Rabies lyssavirus*, the etiological agent of rabies, causes an acute, progressive fatal encephalitis that can be prevented with prompt administration of post-exposure prophylaxis (PEP). Despite the availability of an efficacious vaccine, those who suffer dog bites may not seek medical advice, due to cost and availability [3–5].

North America, large areas of Latin America, Western Europe and Japan have all demonstrated that dog rabies can be eliminated. However, the disease is still endemic in over 150 countries, with the highest burden in low- and middle-income countries in Asia and Africa [3]. Vaccination of dog populations has been demonstrated to be the most effective method to achieve a significant and lasting reduction in the number of rabies-related human deaths but requires accurate surveillance and information on dog population demographics [6–8]

In 2015, the World Health Organization (WHO), the World Organisation for Animal Health (OIE), the Food and Agriculture Organization of the United Nations (FAO) and the Global Alliance for Rabies Control (GARC), together with all participating Member States (MS), agreed on a global goal of zero human deaths from dog-mediated rabies by 2030. This goal was set to align with the Sustainable Development Goals of the United Nations [9,10] and is supported by a Global Strategic Plan (GSP) for rabies. The GSP aims to save both human and animal lives, and reduce associated costs, [3,11] with a sustainable approach driven by national governments through efficient and effective campaigns.

The FAO and GARC developed the Stepwise Approach towards Rabies Elimination (SARE) tool that helps governments evaluate and assess their current situation, while identifying next steps [12]. With this tool, governments can develop a clear plan for resource mobilisation and sustained implementation. This provides a solid foundation upon which suitable resource allocation can be based [12–14]. Furthermore, the outputs from the SARE tool can act as a motivating benchmark that can help countries move towards the 2030 elimination goal through the provision of a detailed, summary of progress based on internationally developed and standardised indicators. Similar approaches have been applied successfully in the control of African animal trypanosomosis and foot-and-mouth disease [15,16], while the SARE tool has been successfully used to facilitate the development of rabies-specific national strategies, predominantly across Africa and Asia.

In its efforts to drive rabies elimination, GARC has promoted the development of regional rabies networks [17]. To that effect, GARC led the formation of the rabies-specific Pan-African Rabies Control Network (PARACON) in 2015, and the Asian Rabies Control Network (ARACON) in 2018, targeting sub-Saharan Africa and Asian countries respectively [6,14,18]. Similarly, the MS of the Middle East and Eastern Europe Rabies Expert Bureau (MEEREB) – as well as any other interested country within the region – were welcomed into the Middle East, Eastern Europe, Central Asia and North Africa Rabies Control Network (MERACON) in 2018, under the secretariat of GARC.

MERACON aims to bring together rabies focal persons from Algeria, Azerbaijan, Croatia, Egypt, Georgia, Iraq, Iran, Kazakhstan, Lebanon, Libya, Morocco, Palestine, Poland, Romania, Serbia, Tajikistan, Tunisia, Turkey, Ukraine, Uzbekistan and Yemen, as well as any other interested rabies endemic country in the region.

Gathering reliable data to undertake a landscape analysis and inform the burden of rabies is an important first step in control. Elimination efforts can typically take several years; therefore, identifying and securing resources that enable long-term, sustained and systematic planning at the national, regional and global levels remains a critical step. Lastly, political support is required and is based on the recognition by national governments of the need for elimination as a global public good [19,20]. Thus, as the first major outcome of the MERACON network, we review the current epidemiological situation in the MERACON MS that participated in the last MEEREB meeting organised by the Mérieux Foundation and using 2017 data, compared our findings with previous published reports [2,21,22]. We further describe the development and deployment of MERACON and how it aligns with not only the other regional rabies-dedicated networks, but also with the GSP using support tools such as the SARE tool, in the path towards elimination.

Materials and methods

Data were compiled from 2017, presented by country representatives at the fourth MEEREB meeting in April 2018. These data were supplemented with a post-hoc targeted survey sent to rabies focal points at the Ministry of Health, Ministry of Agriculture, and Institutes of Public and Animal Health from the 12 MS that attended the MEEREB meeting. We present descriptive statistics of the data by capacity and country. An equal interval classification approach was used to generate Figs. 1(a–c) and 3. Linear regressions were used in R Version 3.6.1 to assess the relationship between capacities. Human population data for 2017 by country [23] was used to calculate incidence rates per 100,000.

Results

Epidemiological landscape analysis of rabies in Member States that attended the MEEREB meeting

Table 1 presents a summary of the human and dog rabies epidemiology, and the prevention and control capacities in the participating MS. Eleven of the twelve participating MS provided data on the number of animal bite cases ranging from 0 to over 277 per 100,000 population in 2017 (Fig. 1a). Seven MS reported dog-mediated human rabies cases (range: 1–20), and five MS reported zero human deaths as a result of dog-mediated rabies (Fig. 1b). Ten MS reported numbers of confirmed dog rabies cases (range: 0–348). Data for dog rabies cases were not available for the remaining two MS (Fig. 1c).

For the ten MS that reported occurrences of dog rabies cases, seven reported that diagnosis was laboratory confirmed, with three reporting no data available (Table 2). The number of reported dog rabies cases was weakly associated with the number of human deaths as a result of dog-mediated rabies ($R^2 = 0.4$ and $p = 0.051$) (Fig. S1).

Table 1
Epidemiological and capacity data (2017) of animal and human rabies in countries represented at the fourth Middle East, Eastern Europe, Central Asia and North Africa Rabies Expert Bureau meeting in April 2018.

	Eastern Europe			North Africa			Middle East					
	Croatia	Serbia	Ukraine	Algeria	Morocco	Tunisia	Georgia	Tajikistan	Iran	Iraq	Lebanon	Palestine
Number of human rabies cases (2017)	0	0	2	20	15	1	0	14	12	9	1	0
Human rabies cases per 100,000 (2017)	0.00	0.00	0.00	0.05	0.04	0.01	0.00	0.16	0.02	0.02	0.02	0.00
Number of human exposures (2017)	5017	16,989	66,350	116,403	65,000	ND	52,008	13,117	170,000	14,725	5000	[a]1021
Human canine rabies exposure per 100,000 (2017)	120.93	188.77	157.98	277.15	185.71	ND	1405.62	145.74	212.50	38.75	83.33	20.42
Number of canine rabies cases (2017)	0	0	348	315	234	218	20	191	217	8	ND	ND
Vaccine coverage for dogs (%)	ND	80	102	ND	25	64	ND	48	45	0	90	ND
Ratio of PEP doses administered to animal bite cases	0.25	0.02	0.21	1.02	1.00	ND	0.88	1.00	1.00	0.95	0.34	ND
Number of people receiving PEP/100,000 (2017)	30	5	34	284	186	391	1238	146	213	37	28	0
Number of people receiving RIG/100,000	1	4	6	74	0	143	267	0	54	33	3	0
Number of people receiving PrEP (2017)	218	80	174	107	ND	ND	8	ND	3000	40	ND	ND
Number of dog vaccinated/year	366,082	281,010	5,253,500	ND	150,325	429,971	203,712	80,571	450,000	0	120,000	ND
Number of RIG doses administered to total PEP applied	0.03	0.79	0.18	0.26	ND	0.36	0.21	ND	0.25	0.88	0.09	ND
Ratio of RIG doses administered to animal bite cases	0.009	0.02	0.04	0.26	ND	ND	0.18	ND	0.25	0.84	0.03	ND

[a] Inclusive of animals other than dogs.

Table 2
Canine population estimates based on percentage of total number of reported dogs vaccinated during 2017.

Member state	Vaccine coverage for dogs (%) 2017	Number of dogs vaccinated 2017	Canine population estimate for 2017
Croatia	ND	366,082	ND
Serbia	80	281,010	351,263
Ukraine	102	5,253,500	5,150,490
Algeria	ND	ND	ND
Morocco	25	150,325	601,300
Tunisia	64	429,971	671,829
Georgia	ND	203,712	ND
Tajikistan	48	80,571	167,856
Iran	45	450,000	1,000,000
Iraq	0	0	ND
Lebanon	90	120,000	133,333
Palestine	ND	ND	ND

MERACON: Status quo and vision

Continuing from the strong foundation developed over the last decade in the MEEREB [21], the core function of MERACON will be to empower MS through the introduction, training and implementation of the SARE tool to create a clear, well-conceived national strategy aligned with the GSP, with measurable progress [12]. For example, 32/47 (68%) MS in the PARACON network have undertaken a SARE assessment since 2016; 23 MS have undertaken more than one assessment and 12 MS have demonstrated an increase in their SARE score – nine of which were an increase of a full SARE stage [24].

MERACON activities have already been initiated, with Algeria (a member of MERACON) having already undertaken an in-country SARE assessment (2019). As one of many envisioned outputs, MERACON aims to undertake similar such exercises in the remaining MS.

However, without accurate, timely data, MS are unable to make the case for adequate resource mobilisation, advocate continued political will and muster the support of dog owners within the communities. The WHO Rabies Bulletin Europe provides a strong and proven reporting platform for some MS, but this system unfortunately does not include the majority of MERACON MS [25]. Thus, a system such as the Rabies Epidemiological Bulletin (REB) can be provided as a dedicated rabies surveillance system for MS free-of-charge. While this system does facilitate regional surveillance and reporting, its primary function is to improve surveillance within the MS, whereby MS remain owners and managers of their own data [26]. Currently, 34 PARACON MS use the REB and 23 (68%) do it regularly since its release in 2016 [27]. With ever-developing improvements and components, governments from any rabies-endemic country can choose to use this system to track mass dog vaccination programs, rabies laboratory case data, or alternatively utilise the patient tracking or integrated bite case management components [28].

MS also drive the development and improvement of the tools, with the SARE undergoing several iterations and revisions (17 at the time of this publication). Thus, although members of a regional, dedicated rabies control network can directly benefit from other MS' efforts within the same region, the basis of a standardised template across the rabies-endemic world helps MS from other networks to also benefit from those same improvements. Therefore, our aim with the formation of MERACON is to create a unified global community of dog rabies endemic countries that is compartmentalised into smaller, more manageable regional networks based upon shared challenges and experiences.

Rabies capacities

Dog vaccination data

Ten MS provided data on the number of dogs vaccinated in 2017 (range: 0–5,253,500) (Table 1).

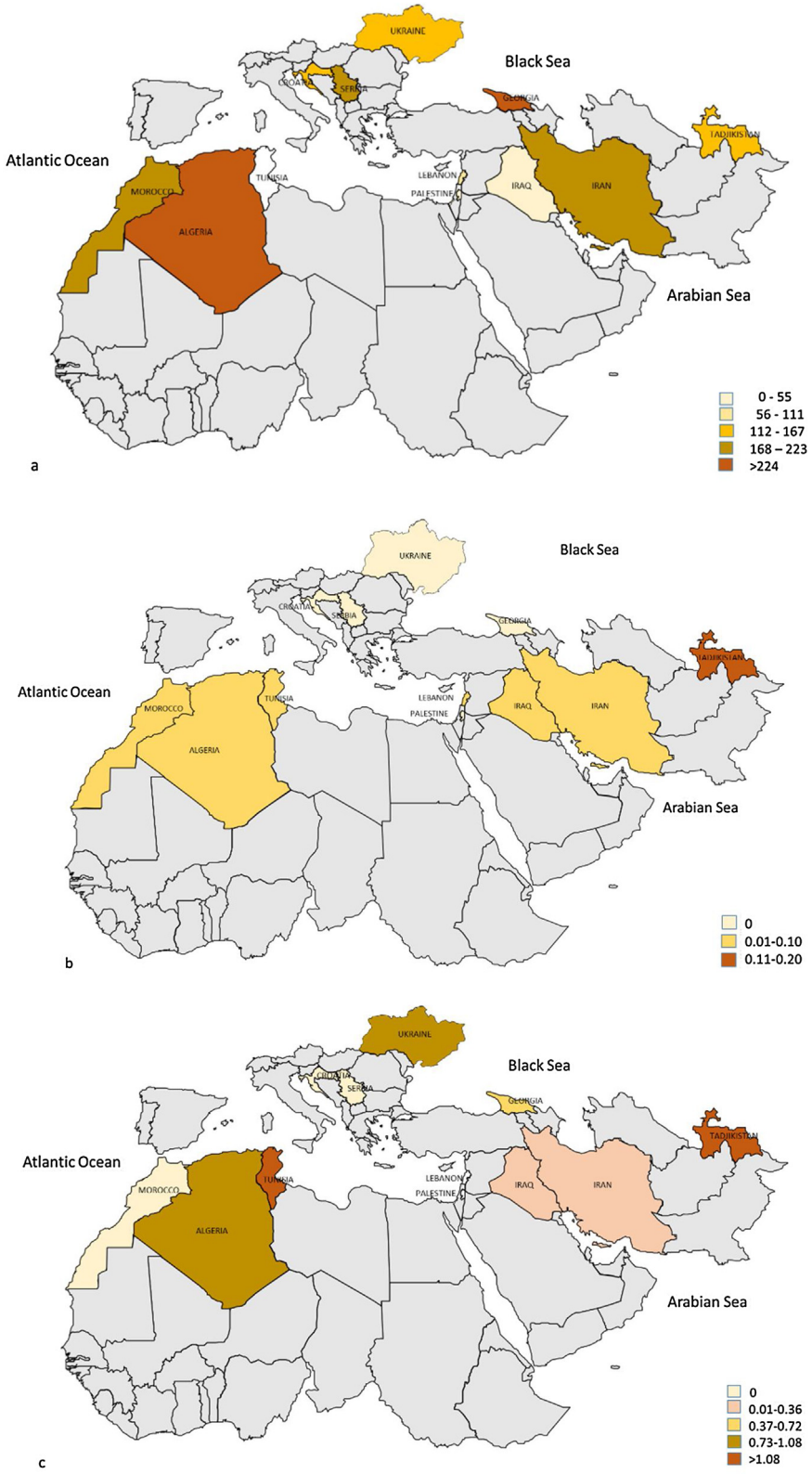

Fig. 1. (a–c). (a) Human dog bites per 100,000 population in 2017 across 12 member states. Palestine reports animal bites not restricted to dogs. (b) Human deaths as a results of dog-mediated rabies per 100,000 population in 2017 across 12 member states. (c) Animal rabies cases in 2017 across 12 member states/100,000 human population. Those countries shown in grey were not part of this study.

In addition to the national, government-driven vaccinations, one MS (Croatia) also included vaccinations taking place at private veterinary clinics. Eight MS reported dog vaccination coverages ranging from 0 to 102% (Fig. 2). Using these reported vaccination coverages, and the number of dogs vaccinated, canine populations have been estimated for seven MS for 2017, ranging from 133,333 (Lebanon) to 5,150,490 (Ukraine). One MS reported zero vaccination coverage and zero number of dogs vaccinated and so no

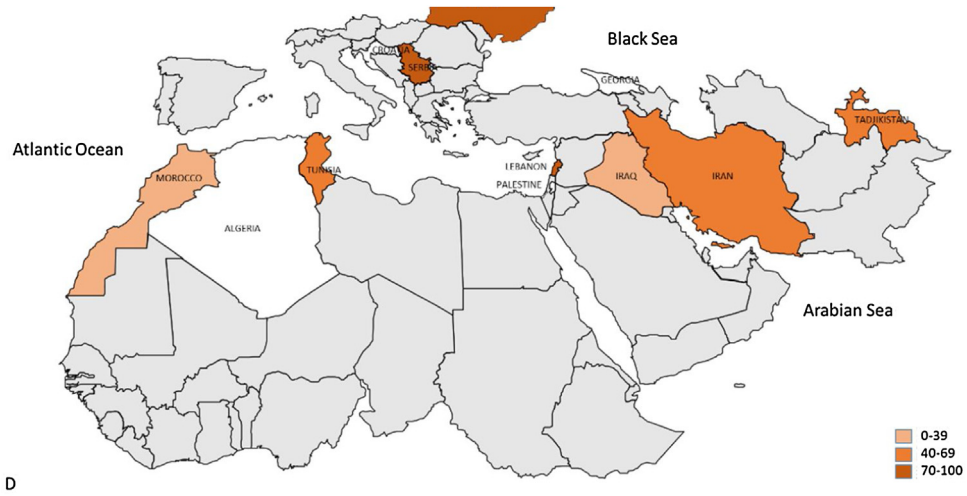

Fig. 2. Percentage of vaccination coverage during vaccination campaigns. The countries which declared no data available are shown in white.

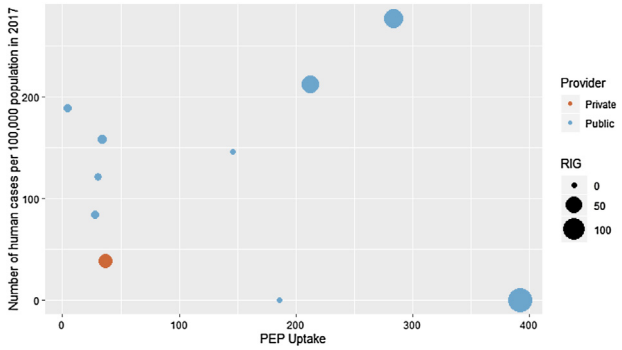

Fig. 3. Number of human cases/100,000, and PEP and RIG uptake and further demonstrates whether PEP is privately or publicly funded.
*Public funding includes MoH, Government.
*Private funding indicates payments made by the patient.

Table 3
Number of reported confirmed canine rabies cases in 2017 and laboratory diagnosis confirmation.

	Number of confirmed canine rabies cases	Laboratory capacity
Croatia	0	Confirmed by laboratory diagnosis
Serbia	0	Confirmed by laboratory diagnosis
Ukraine	348	Confirmed by laboratory diagnosis
Algeria	315	ND
Morocco	234	ND
Tunisia	218	ND
Georgia	20	Confirmed by laboratory diagnosis
Tajikistan	191	76 of total cases confirmed by laboratory diagnosis
Iran	217	155 of total cases confirmed by laboratory diagnosis
Iraq	8	Confirmed by laboratory diagnosis
Lebanon	ND	ND
Palestine	ND	ND

estimation could be made. Data on vaccination coverage and number of dogs vaccinated was unavailable from the remaining four MS (Table 2).

MS that saw the fewest number of human deaths also reported the highest dog vaccination coverage (64% and 1 human death, 80% and 0 human deaths, 90% and 1 human death, and 102% and 2 human deaths), but there was no association between dog vaccination coverage and number of reported human deaths as a result of dog-mediated rabies ($R^2 = 0.069$, p-value = 0.53) or between dog vaccination coverage and the number of reported dog rabies cases ($R^2 = 0.028$, p-value = 0.69).

Human vaccine usage

Seven MS (Algeria, Croatia, Georgia, Iran, Iraq, Serbia, Ukraine) reported PrEP use (range: 8–3000 people), while eleven MS reported PEP data (range: 430 to 170,000 people receiving PEP throughout 2017). Data on RIG uptake were unavailable for three MS, while the remaining nine MS showed a range of 47 to 43,000 individuals receiving RIG in 2017. Seven MS reported that PrEP was freely available, while three reported a cost to the patient of US$3.00 per dose. Costing data for PrEP were available for Palestine and Tunisia, but the number of people receiving PrEP was unavailable. 10 MS reported PEP (consisting of only rabies vaccine) being freely available, one MS reported a cost of US$3.00 per dose, and one MS did not have data available (Fig. 3). The ratio of PEP doses administered to animal bite cases ranged from 0.02 to 3095.2 (Table 1). Data were unavailable from two MS for either PEP administered or animal bite cases. However, the MS that reported no data available for animal bite cases, reported a RIG uptake of 15,809 (143/100,000 population) and PEP uptake of 43,070 (391/100,000 population).

RIG availability

The number of RIG doses administered ranged from 0.03 to 0.88 of the total PEP applied. The ratio of RIG doses administered to animal bite cases ranged from 0.009 to 0.84 in eight MS. The remaining four MS reported no data available (Table 1).

Laboratory capacity

Animal and human laboratory capacity varied between the twelve MS. Seven MS reported that animal rabies cases were laboratory diagnosed. No data were available on laboratory capacity for five MS. Six MS stated that human rabies cases were laboratory confirmed and no data were available for the remaining six MS (Table 3).

Discussion

As can be expected from such a diverse geographical region, we observed great variation in the number of animal- and human-rabies cases reported. As all human cases are a direct result of animal cases, a relationship between the two is expected. Although we found such relationships between the number of dog and human rabies cases, the moderate value of R^2 (0.4) indicates that there is substantial variability in the number of human cases not

explained by the number of dog cases (Fig. S1). This variability could suggest imperfect surveillance in animals, humans or both, but could also be related to the provision and uptake of PEP which varies considerably between MS. When compared to 2014 data [21], a decrease in PEP use was observed in six MS (Algeria, Croatia, Iraq, Serbia, Tunisia, Ukraine). In three MS, reported human exposures also decreased from 2014 to 2017, when compared to data collected to assess the global burden of rabies [3]. PEP use had decreased in six MS since 2015 (Croatia 26.9% reduction, Iraq 1.5%, Lebanon 55.5%, Serbia 73.2%, Tajikistan 6.1%, and Ukraine 32.1%). Although PEP usage can be a good indicator of inadequacies in surveillance and reporting systems, PEP usage also highlights inadequacies in animal rabies interventions and mass vaccination efforts.

There were a total number of 74 human cases in the region in 2017 across 10 MS, compared to the 61 reported in 2014 [21]. Five MS (Ukraine, Morocco, Tunisia, Georgia, Iraq), saw a reduction in human cases, and two MS continued reporting zero cases (Croatia, Serbia). Three MS reported an increase in human rabies cases (Algeria, Tajikistan, Iran), correlating with the reported increase in the number of bites per 100,000 for Algeria and Iran. This increase could be attributed to improved surveillance and reporting, which should be considered as positive progress towards understanding the true disease burden [21]. The remaining two MS were not included in the 2014 study and so comparisons could not be drawn.

Iran reported 297 cases of animal rabies in 2011, mostly seen in cattle, and two to six human rabies cases annually for the period 2001–2012 [2,29]. Our data show 12 human rabies cases occurring in 2017 alone. Continued reporting of human cases of rabies, despite a reported decrease in the number of dog rabies cases, may be attributable to a lack of PEP uptake from those bitten for reasons such as accessibility and location of health facilities, cost of PEP and travel, and awareness of the risk.

A valuable indicator of rabies risk is the number of animal bite cases. In 2014 the reported number of animal bite cases per 100,000 ranged from 15.3 to 1258 across MS. Six MS reported similar rates for 2017 (Croatia, Algeria, Georgia, Iran, Iraq, Morocco), two (Serbia, Ukraine) increased rates, and Tajikistan reported a reduction in animal bite cases. Considering the current progress made by both Serbia and Ukraine in efforts towards elimination, the increased number of animal bite cases per 100,000 could be attributed to improved awareness and education in communities, encouraging people to seek treatment when bitten by a dog. The next step would be to improve risk-assessments in health facilities to reduce unnecessary PEP usage – something that can be achieved with a comprehensive integrated bite case management system such as that offered by the REB system. Although bite data were not available for Lebanon in 2014, Kassir et al. [30], reported 278.81 animal bite cases per 100,000 in 2016. This compares with 83 per 100,000 reported in 2017. Lebanon also reported a 90% dog vaccination coverage in 2017. The density of free roaming dogs is reported to be highest at the border between Volyn and Lviv, which may be explained by the high human population found there. A total of 78 canine rabies cases were reported across three regions (Volyn, Lviv, Zakarpattia) from 2012 to 2016, however there are a total of 24 defined regions in Ukraine of which canine rabies case data is unknown [31,32].

Another useful indicator is the ratio of PEP to the number of animal bite cases, which has decreased in three MS (Croatia, Ukraine) since 2014, and increased in four MS (Serbia, Algeria, Georgia, Tajikistan, Morocco). Two MS (Iran and Iraq) reported human cases despite 100% PEP coverage, suggesting bite victims did not seek treatment and highlighting the importance of awareness. MERACON will assist in providing awareness and educational resources to MS, whilst also promoting World Rabies Day to raise community awareness [9]. Published data for RIG is limited and was not reported for the MEEREB meeting in 2015. However, rabies immunoglobulin stockpiles were noted as a next actionable step at the MEEREB Meeting 2015 [21]. This lack of data on RIG is not unique to the MERACON MS, as this has also been noted in the Americas and Asia [33,34].

Rabies elimination programmes that include dog vaccination have seen significant reductions in human rabies [4,6,7,35]. Vaccination coverage (percentage of total dogs immunised) is a vital measure of the likely success of these campaigns. When compared to previous studies, vaccination coverage is progressively increasing (Table S1). From 2014 to 2015 vaccination coverage in five MS increased marginally (Georgia, Iran, Iraq, Morocco, and Tunisia) [23] and 2017 vaccination coverage was higher still in seven MS (Iran, Lebanon, Morocco, Serbia, Tajikistan, Tunisia, Ukraine) [3] (Table S1).

Vaccination is mandatory for all dogs in the Ukraine [32]. Since 2013, the Ukraine has been conducting mass vaccination campaigns with the goal of vaccinating 100% of dogs and has seen an increase from 3.98 million dogs being vaccinated in 2013, to 5.24 million in 2017. This focused campaign may account for the dramatic increase in vaccination coverage seen between 2014 and 2017. Additionally, it is estimated that 50,000 dogs are unowned in Ukraine, and in 2017 the country introduced an animal welfare act which actively protects unowned animals. Unowned dogs were historically culled but are now being included in vaccination and sterilisation campaigns [36]. Five out of the eight MS that reported vaccination coverage, reported coverage below the WHO recommended 70%. Without reliable dog population data, it is difficult to accurately estimate the levels of coverage achieved. It is likely that the dog vaccination numbers reported by the MS only include owned dogs as reported in previous studies [4].

Although these country level data build an important body of evidence to evaluate the burden of rabies, they will miss heterogeneity within countries. In addition, other sources of data could enhance understanding of the rabies control capabilities and resources in each MS, including the full cost of PEP and dog vaccination, and the level of animal rabies surveillance. Related, we could not ascertain the variant of the rabies cases as reported by the MS. While dogs are considered the main reservoir for human rabies, cases in foxes, golden jackals (*Canis aureus*) and wolves (*Canis lupus lupus*) have been reported in the region [2,21,37]. The reported 45% vaccination coverage in our data for Iran, concurs with the 44% vaccination coverage of owned dogs from previous reports, lending evidence to the fact that this coverage is likely of owned dogs alone. Thus, the true vaccination coverage is likely far lower than that reported, hampering progress where funding and the allocation of resources towards rabies elimination may be determined based on these results [31,38,39]. To address such challenges, MERACON will host expert-led workshops on effective surveillance and reporting tools and technologies. These workshops address international guidelines and procedures with a focus on supporting the improvement of rabies control and prevention, providing a platform to share experience and knowledge that can be translated in to practice [33].

Previous studies have noted that there is limited data available on reported human cases of rabies in Palestine [2]. Our study has similar results (only 'number of human exposures') suggesting that either the surveillance is non-indicative of the current situation or that international reporting and transparency remains a political challenge. To address such challenges, MERACON will highlight the importance of international reporting (especially in terms of obtaining external support), as well as facilitate the implementation of high-quality surveillance systems in the MS.

Increased laboratory training and capacity was recognised as a key area for improvement at the third MEEREB meeting [21]. The number of animal diagnostic laboratories present across the 12 MS was reported in 2014 to range from one to 26 per MS,

while the number of human diagnostic laboratories present across the 12 MS in 2014 ranged from one to five [21]. The OIE World Animal Health Information System (WAHIS) Interface details laboratory diagnostic capacity for countries worldwide, and reports that seven (Algeria, Croatia, Serbia, Ukraine, Tunisia, Iran, Lebanon) of the 12 MS have capacity to diagnose rabies, with five (Georgia, Morocco, Tajikistan, Iraq, Palestinian Territories) MS reporting that they do not have diagnostic capacity [35]. The discrepancies noted between the MERACON data and that of the WAHIS system could be due to discrepant reporting, as was noted previously in Africa [31]. Data regarding the method of diagnosis for both human and animal rabies was not reported.

The variation of PEP uptake seen between MS may be attributed to the range of awareness and education programmes in each MS, as demonstrated by the increase in reported animal bite numbers in some MS despite reductions in canine and human rabies (e.g. Serbia and Ukraine). Additionally, resource allocation and infrastructure, may contribute to the variation seen in the results.

A limitation of this study is that only 12 MS participated in the analysis out of 21 current MERACON members, and a further 18 countries that border MS across Central Asia, Eastern Europe and North Africa. This demonstrates the challenges of rabies control in this culturally and geographically complex region but provides proof of principle that collaboration and data sharing are key to rabies elimination.

Towards rabies control and elimination

Financial barriers, conflict and unrest can all limit access to health care services, and cultural differences in attitudes towards animals further hamper control effects [2,40–42]. Detailed in-country SARE assessments would provide a more comprehensive understanding of the situation within each of the MERACON MS. To further assist, the latest tools and methods will be disseminated through MERACON workshops and other platforms such as the Canine Rabies Blueprint.

Conclusion

This study summarizes the most recent epidemiological data for rabies, providing an essential baseline for MERACON, and highlights the importance of improving data collection and reporting [35]. With a range of MS in different stages of progress towards rabies elimination, a clear and standardised assessment is critical. This study highlights the importance of the inclusion of accessible education material, the availability of dog demographic data to assist planning adequate vaccination coverage, and resource allocation, all of which should be a consideration as part of a rabies control programme. Therefore, the SARE tool and its implementation through MERACON will be one important means to more accurately and objectively determine the status quo, whilst also highlighting both strengths and weaknesses in current rabies elimination plans. Furthermore, by using a standardised and proven approach, a stronger global community can be developed – incorporating all rabies endemic MS as well as international stakeholders such as the United Against Rabies collaboration and the Partners for Rabies Prevention.

Competing interests

None declared.

Ethical approval

Not required.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jiph.2021.02.009.

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