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Dogs on the move: Estimating the risk of rabies in imported dogs in the United States, 2015–2022

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Abstract

Background: Dog-mediated rabies virus variant (DMRVV), a zoonotic pathogen that causes a deadly disease in animals and humans, is present in more than 100 countries worldwide but has been eliminated from the United States since 2007. In the United States, the U.S. Centers for Disease Control and Prevention has recorded four instances of rabies in dogs imported from DMRVV-enzootic countries since 2015. However, it remains uncertain whether the incidence of DMRVV among imported dogs from these countries significantly surpasses that of domestically acquired variants among domestic U.S. dogs.

Aim: This evaluation aimed to estimate the number of dogs imported from DMRVV-enzootic countries and compare the risk of rabies between imported dogs and the U.S. domestic dog population.

Materials and Methods: Data from the CDC's dog import permit system (implemented during 2021 under a temporary suspension of dog importation from DMRVV-enzootic countries) and U.S. Customs and Border Protection's Automated Commercial Environment system, each of which records a segment of dogs entering the U.S. from DMRVV-enzootic countries, was analysed. Additionally, we estimated the incidence rate of rabies in dogs imported from DMRVV-enzootic countries and compared it to the incidence rate within the general U.S. dog population, due to domestically acquired rabies variants, over the eight-year period (2015–2022).

Results: An estimated 72,589 (range, 62,660–86,258) dogs were imported into the United States annually between 2015 and 2022 from DMRVV-enzootic countries. The estimated incidence rate of rabies was 16 times higher (range, 13.2–19.4) in dogs imported from DMRVV-enzootic countries than that estimated for domestically acquired rabies in the general U.S. dog population.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest.

DISCLAIMER

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

Conclusions: Preventing human exposure to dogs with DMRVV is a public health priority. The higher risk of rabies in dogs imported from DMRVV-enzootic countries supports the need for importation requirements aimed at preventing the reintroduction of DMRVV into the United States.

Keywords

dogs; public health; rabies incidence; rabies virus; zoonoses

1 | INTRODUCTION

Rabies, a deadly zoonotic disease, is almost always fatal once clinical signs appear (Fooks et al., 2014; WHO, 2018). It is estimated that 59,000 people die from rabies each year, which equals roughly one death every 9 min (WHO, 2018). In approximately 98% of these cases, death was caused by the dog-mediated rabies virus variant (DMRVV) (Fooks et al., 2014). Since 2007, the U.S. has been DMRVV-free and rabies in domestic U.S. dogs has only been attributed to wildlife variants of the rabies virus (Velasco-Villa et al., 2017). DMRVV, however, remains enzootic in more than 100 countries. Preventing dogs with DMRVV from entering the United States is a public health priority to prevent human exposures as well as the reestablishment of DMRVV in U.S. domestic animals and wildlife (CDC, 2023).

Four rabid dogs infected with DMRVV were imported into the United States between 2015 and 2022 (Hercules et al., 2018; Raybern et al., 2020; Sinclair et al., 2015; Whitehill et al., 2021). All four rabid dogs were imported by rescue organizations for the purposes of adoption. These four cases required substantial public health resources to investigate, respond to and mitigate the public health threat posed by the importation of rabid dogs infected with DMRVV. In each importation event, multiple people were exposed to the rabid dog and required public health intervention due to rabies exposures. The public health investigations of and rabies post-exposure prophylaxis for persons exposed to just one rabid imported dog in 2019 cost more than $400,000 (Raybern et al., 2020).

In addition to the human health risks associated with rabies exposures, there would be significant economic impacts should DMRVV re-establish itself in a domestic animal or wildlife reservoir in the United States. DMRVV is highly adaptive to novel hosts, as evidenced by the fact that five of the current rabies wildlife variants circulating in the United States evolved from DMRVV (Velasco-Villa et al., 2017). In a recent survey, more than half of dog owner survey respondents displayed some level of vaccine hesitancy, which could lead to declines in rabies vaccination coverage in domestic dogs (Mota et al., 2023). This would potentially create a susceptible pet population primed for DMRVV re-introduction. While many dogs and cats in the United States are owned by a single owner or family, there are approximately 70 million stray pets in the United States that freely roam and are not confined to a single-family dwelling (Stancheva, 2022). Stray animals wander in communities, interacting with people, pets and wildlife, creating the potential for the spread of DMRVV if it were to be re-introduced into U.S. communities. The U.S. Centers for Disease Control and Prevention (CDC) currently recommends that specimens from dogs and other animals meeting specific criteria testing positive for rabies in the United States be

submitted to the CDC for virus characterization in order to monitor circulating variants in domestic pet and wildlife populations (Pieracci et al., 2020).

A DMRVV importation event has significant impacts on human health (including mental or physical trauma from a dog bite, financial burdens from healthcare costs or lost productivity, injury and death), increases the risk of re-establishment of DMRVV in the United States and strains public health agencies that investigate and contain a DMRVV introduction event. For example, the re-emergence of DMRVV in Texas in the 1970s led to two human deaths, hundreds of domestic animal and wildlife deaths and tens of millions of dollars for mitigation efforts by public health and animal health agencies (Sterner et al., 2009; Thomas et al., 2005).

The CDC regulates the importation of dogs into the United States, requiring that all dogs be healthy upon arrival and those from DMRVV-enzootic countries be accompanied by a valid rabies vaccination certificate. On July 14, 2021, the CDC implemented a temporary suspension of importation of dogs from DMRVV-enzootic countries (defined as high-risk countries under the suspension) based on the CDC's assessment that the risk of importation of a rabid dog was elevated in the context of the COVID-19 pandemic (CDC, 2021). The risk was believed to be elevated due to an increase in fraudulent rabies vaccination certificates (Pieracci et al., 2021) and lower dog vaccination coverage in DMRVV-enzootic countries. This could have resulted in more imported rabid dogs, had the suspension not been implemented. However, prior to this analysis, there was no known quantifiable risk increase. From the start of the suspension, individuals seeking to import a dog from a DMRVV-enzootic country were required to obtain a *CDC Dog Import Permit*. However, beginning December 2021, the CDC allowed U.S.-vaccinated dogs from DMRVV-enzootic countries to enter the United States if they were accompanied by a valid U.S.-issued rabies vaccination certificate. U.S. regulatory oversight does not extend to animal rabies vaccines produced and administered outside the United States. Due to a lack of U.S. regulatory oversight and concerns about the quality of some internationally produced animal rabies vaccines, the CDC continued to require importers of foreign-vaccinated dogs to obtain a *CDC Dog Import Permit* (Rathnadiwakara et al., 2023). Issuing permits enabled the CDC to track the number of imported dogs from DMRVV-enzootic countries that were vaccinated against rabies in a foreign country. These importers provided the method of transport (checked baggage, cargo, or hand-carried baggage) as part of the *CDC Dog Import Permit* application process prior to importing dogs into the United States (CDC, 2023). If the method of transport changed, importers were required to submit a request to receive an updated permit.

In addition to the CDC, multiple U.S. government agencies track various aspects of dog importation; however, no U.S. federal agency tracks the total number of dog importations in a single data system. For example, U.S. Customs and Border Protection (CBP) tracks the number of dogs imported into the United States if the dogs are transported as cargo, meaning that dogs are flown in crates in the cargo or luggage area of a plane. Dogs can also be flown in the cargo or luggage area of the plane as checked baggage if an individual traveller is flying in the cabin of the plane and the dog is accompanying the traveller on the flight. CBP does not track dogs that fly as checked baggage in the cargo area of the plane

or dogs that fly in the cabin with passengers (hand-carried baggage). All dogs imported as cargo have paperwork filed in CBP's Automated Commercial Environment system, whereas when airlines transport dogs as checked baggage, they are not required to declare the dogs to CBP and the dogs are not tracked (U.S. Customs and Border Protection, 2022). The CDC regulates the importation of dogs regardless of transport method and has additional requirements in place for dogs imported from DMRVV-enzootic countries.

The basis of the regulatory measures to prevent human rabies exposures as well as the reestablishment of DMRVV in the United States should be determined by strong evidence of the increased risk for rabies in dogs arriving from DMRVV-enzootic countries. However, as the total number of dogs imported is not currently documented, it is challenging to assess the risk of rabies in dogs from DMRVV-enzootic countries compared to the domestic U.S. dog population. This evaluation used multiple data sources to estimate the total number of dogs imported into the United States from DMRVV-enzootic countries and evaluated the incidence rate of rabies in imported dogs arriving from DMRVV-enzootic countries compared to the incidence rate of domestically acquired rabies in the general U.S. dog population from 2015 to 2022.

2 | MATERIALS AND METHODS

Dog import data from CBP's Automated Commercial Environment system were used to determine the number and countries of origin of dogs arriving via cargo into the United States between January 1, 2015 and December 31, 2022 (Figure 1). These data are an underestimate of imported dogs because they exclude dogs imported as checked baggage or as hand-carried baggage, and anecdotal reports from U.S. ports of entry and CDC dog import permit data suggest that dogs are primarily imported into the United States as hand-carried or checked baggage (Table 1).

Data from the CDC's dog import permit system were reviewed to assess the number of dogs imported from DMRVV-enzootic countries with foreign-issued rabies vaccination certificates from January 1, 2022 to December 31, 2022 (Figure 1). These data are also believed to be an underestimate since they do not include U.S.-vaccinated dogs that had travelled to DMRVV-enzootic countries. Data are available upon request.

Transport method information was incomplete in the CDC permit data; therefore, we extrapolated the 2022 CDC data using the CBP data as the "true" estimate of dogs imported as cargo. The CDC permit data were used to estimate the number of dogs flown as checked baggage and hand-carried baggage that were not captured by CBP's cargo system. For the upper bound estimate of all dogs imported into the United States, we assumed that all cargo imports from DMRVV-enzootic countries ($N = 3308$) from CBP data were granted CDC permits. This assumption implies that there were no U.S.-vaccinated dogs imported as cargo from DMRVV-enzootic countries. Consequently, out of those dogs issued CDC permits, a maximum of 20.4% (calculated as 3308 divided by 16,232 (the total number of permits)) were imported using cargo transportation. For the lower bound estimate, we considered that none of the instances with missing transport method information involved cargo transport. Consequently, the lower bound estimate for the total number of permits

associated with cargo transport is 2403, constituting 14.8% of the overall permits. The best estimate was derived by averaging the upper bound and lower bound estimates, resulting in a value of 17.6%. Finally, since we lacked data for U.S.-vaccinated dogs imported from DMRVV-enzootic countries, we assumed the same percentage of U.S.-vaccinated dogs would be imported as cargo as we had previously calculated for foreign-vaccinated dogs (i.e., 17.6%, range, 14.8%–20.4%). We applied these fractional proportions to the total number of dogs imported as cargo from 2015 to 2022.

CBP historical data on the annual number of dogs imported as cargo from DMRVV-enzootic countries were divided by these estimates of the fractions of dogs imported from DMRVV-enzootic countries as cargo to estimate the total number of imported dogs from DMRVV-enzootic countries. These figures were used as denominators to estimate the incidence rate of rabies among these dogs.

Data on the number of rabid dogs in the U.S. dog population for 2015–2022 were gathered from the North American rabies surveillance articles in the Journal of the American Veterinary Medical Association (Birhane et al., 2017; Ma et al., 2018, 2019, 2020, 2021, 2022, 2023; CDC Rabies Branch, 2022). U.S. dog population estimates were gathered from the pet population survey conducted by the American Veterinary Medical Association (AVMA) (AVMA, 2023). The AVMA estimated that the number of pet dogs in the United States was 76.8 million in 2016 and 86.3 million in 2020. We estimated an annual increase of 2.37 million dogs between 2016 and 2020. We used the 2016 and 2020 reported numbers and then applied this annual increase to estimate the pet dog population for 2015, 2017–2019 and 2021–2022. We assumed lower and upper bound estimates representing 97% and 103% of the baseline estimates, respectively.

Given the high mortality rate of rabies and the short duration of illness before death occurs, the incidence of rabies within a dog population was assumed to be equal to the prevalence; 1 year after importation, dogs that were still alive and healthy were considered part of the domestic U.S. dog population. The dog population data were used to calculate the annual incidence rates of domestically acquired rabies in the U.S. dog population (AVMA, 2023; Birhane et al., 2017; Ma et al., 2018, 2019, 2020, 2021, 2022, 2023; CDC Rabies Branch, 2022). We calculated annual incidence rates of rabies in imported dogs over an eight-year time span (2015–2022) and compared them to the annual incidence rates of domestically acquired rabies in U.S. dogs during the same period.

This project protocol was conducted consistent with applicable federal law and CDC policy under 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; and 44 U.S.C. §3501 et seq.

3 | RESULTS

Data from the CDC’s dog import permit system indicated that a total of 16,232 permits were issued to dogs imported from DMRVV-enzootic countries with foreign-issued rabies vaccination certificates in 2022 (Table 1).

The estimated number of dogs imported into the United States annually over the eight-year period from DMRVV-enzootic countries was 72,589 (range, 62,660–86,258). There were an estimated 82,890 dogs imported annually from DMRVV-enzootic countries between 2015 and 2019. Dog importations from these countries decreased in 2020 to an estimated 43,384 annually but increased in 2021 to an estimated 104,077 dogs. Only an estimated 18,804 dogs were imported in 2022, after the implementation of the importation suspension (Table 2). There was a cumulative total of 580,713 (range, 501,277–690,006) dogs imported from DMRVV-enzootic countries over the 8-year period (Table 3). There was an estimated annual average of 82.7 million (range, 74 million–91 million) pet dogs living in the United States between 2015 and 2022. There was a cumulative total of 661.9 million (range, 642.1 million–681.8 million) pet dog life years during the same eight-year period (Table 3).

Between 2015 and 2022, there were 281 dogs with domestically acquired rabies reported in the 50 U.S. states and four dogs infected with DMRVV imported over the 8-year period. From 2015 to 2022, the average annual incidence rate of DMRVV in imported dogs was 6.9 per 1 million dogs imported. During the same period, the average annual incidence rate of domestically acquired rabies in pet dogs was 0.4 per 1 million dogs. The estimated incidence rate of DMRVV-infected dogs imported into the United States from DMRVV-enzootic countries was approximately 16 times higher (range, 13.2–19.4) than the incidence of domestically acquired rabies among the U.S. domestic dog population (Table 3).

There were an average of 21 people and 21.5 animals exposed to every imported rabid dog, requiring subsequent post-exposure prophylaxis, animal vaccination and animal quarantine or home confinement (Table 4).

4 | DISCUSSION

Importing dogs from DMRVV-enzootic countries involves a significant public health risk, not only for those involved in the importation event but also for the community into which the dog was imported. Further, the nation is at risk of the re-establishment of DMRVV if the variant establishes sustained spread in a competent animal host. This risk to human and animal health has been long recognized by international organizations, such as the World Organization for Animal Health (WOAH) and has led to longstanding global health standards to ensure that dogs imported from DMRVV-enzootic countries are vaccinated, have an adequate antibody titre or undergo quarantine and are healthy at the time of importation (WOAH, 2023).

The rescue and adoption of dogs arriving from DMRVV-enzootic countries involves numerous interactions with people during the adoption process: the initial rescue from the street or other location can involve multiple people to catch, restrain and transport the dog; in-processing at a facility can include people involved in feeding, bathing, medical care (if available), health and behaviour assessments and other daily husbandry activities; dogs are frequently fostered in homes with families while awaiting adoption or transport to another location. The rescue and adoption processes are stressful for dogs, and some dogs can display aggression in response to their changing environment or because they are rabid. The rescue environment creates opportunities for traumatized or rabid dogs to interact repeatedly

with people who may or may not be trained to recognize signs of fear, illness, or pain in dogs, resulting in an increased risk of bites or scratches. Furthermore, international air or ground transportation can be a traumatic experience for dogs. In addition to the stresses of transportation, rescue dogs are not used to being confined or restrained to a leash, leading to documented instances where dogs imported from DMRVV-enzootic countries have escaped from their transporters or foster homes, placing the community, domestic pets and wildlife at risk for rabies exposures (WTAE Channel 4 News (ABC affiliate), 2021; KSHB, 2019).

The risk of bites or scratches from frightened or rabid dogs to foster families, airline staff, cargo handlers, ground transporters, veterinary clinic staff and rescue volunteers is high. Two of the most recent rabid dog importations involved volunteers or staff who were bitten by the dogs they were helping to transport or care for, resulting in the need for expensive rabies post-exposure prophylaxis (Hercules et al., 2018; Raybern et al., 2020). The risk of rabies exposure for people from dogs is higher than it is with wildlife strains of rabies due to more frequent contact between people and dogs compared to people and wildlife. Proper confinement and observation of dogs that have bitten people in accordance with state or territory jurisdictional laws is important for protecting human health and safety. Additionally, animal shelters and rescue groups that import dogs from overseas should maintain a high index of suspicion for rabies in dogs that develop neurologic signs after arrival.

The importation of just one dog infected with DMRVV risks the health and safety of humans and the reestablishment of the virus in domestic animal and wildlife populations, resulting in the loss of human and animal life and significant economic impact (CDC, 2023; Jeon et al., 2019; Sterner et al., 2009; World Bank, 2012). DMRVV has been highly successful at adapting to new host species, including U.S. wildlife such as mongoose, grey fox, arctic fox, red fox and skunks. One imported DMRVV-infected dog could result in a new variant with the potential to become established within a new host species in the United States. When a DMRVV found in Mexico began spreading in coyote populations, it spread to wildlife and dogs in Texas, where DMRVV had been previously eliminated. Wildlife and domestic dog vaccination programmes were implemented over a 10-year period, costing more than $60 million (in 2022 USD) to re-eliminate DMRVV; before the virus was eliminated, two people died from rabies (CDC, 2023; Sterner et al., 2009; Thomas et al., 2005; Velasco-Villa et al., 2017). Additionally, the immediate public health investigation associated with an imported rabid dog can be significant for local jurisdictions, with state and healthcare resource costs exceeding $400,000 (Raybern et al., 2020).

Our analysis suggests the risk of rabies in imported dogs is significantly greater than rabies in domestically acquired dogs, and due to the close relationship between dogs and people, rabid dogs often lead to numerous human exposure scenarios and high healthcare sector costs. Because the incidence among dogs imported from DMRVV-enzootic countries is significantly greater, the human exposure risk is higher for individuals with recently imported dogs from DMRVV-enzootic countries compared to owners of dogs that are only exposed to domestic wildlife. From 2015 to 2022, the U.S. averaged nearly one imported rabid dog for every 100,000 dogs imported from a DMRVV-enzootic country. Furthermore, these cases occurred under the context of a regulation that required that dogs have a valid

rabies vaccination certificate and be healthy at the time of importation. Assuming this rate is relatively constant over time, any significant increase in importation rates or decrease in importation requirements would almost certainly lead to more rabies importation events, human and animal exposures and possibly the re-introduction of DMRVV.

A notable decrease in dog imports from DMRVV-enzootic countries was seen in 2020, likely due to the decrease in international flights during the COVID-19 pandemic (McMichael, 2023). The reduced number of dogs imported from DMRVV-enzootic countries into the United States since the CDC's suspension was enacted in July of 2021 may have been due to several factors, including the suspension itself. It is also possible that people shifted to purchasing dogs from DMRVV-free countries or from within the United States, or that importers routed dogs from DMRVV-enzootic countries through DMRVV-free countries to avoid U.S. entry requirements, or all three.

Dog importation trends are challenging to analyse when there is no single data collection system available to monitor all dog imports. A federal importation tracking system could be helpful in tracking trends and identifying imports from areas of concern, such as regions experiencing a rabies outbreak. Additionally, a global animal transportation data collection system to track the movement of dogs could be helpful in monitoring the overall health of the animals and detecting the illegal movement of dogs by importers attempting to circumvent the country of destination's import requirements.

This evaluation had several limitations. The data used to estimate the fraction of dogs imported as cargo do not represent the entire population of imported dogs because the CDC did not issue permits for U.S.-vaccinated dogs returning from DMRVV-enzootic countries after November 2021, and the CDC does not track U.S.-vaccinated dogs travelling to and returning from DMRVV-enzootic countries. The ratios estimated using these data may not be representative of dogs imported from these countries that had been vaccinated in the United States or during the years preceding the implementation of the CDC's temporary suspension. Similarly, CBP does not track dogs imported in the passenger environment (hand-carried or as checked baggage), so the data provided in this evaluation could be an over- or under-representation of the true number of dogs imported. This potential under-representation biases the results and artificially increases the risk of rabies in imported dogs; however, we accounted for this bias by providing a range of upper and lower bound import estimates. If dogs originated in DMRVV-enzootic countries and importers moved them to DMRVV-free or low-risk countries to avoid U.S. entry requirements, this could have artificially lowered the number of dogs arriving from DMRVV-enzootic countries, which would decrease the true incidence and risk ratio. However, given the much higher incidence rate of rabies in imported dogs, this effect may be minimal.

Despite incorporating a range of estimates of the number of dogs imported from DMRVV-enzootic countries to account for the potential bias, we still found the incidence rate of rabies in imported dogs to be nearly 16 times greater than that of the U.S. general dog population. There may be inadequate detection of dogs with domestically acquired rabies; however, the United States has a robust public health rabies detection system that tests nearly 100,000 animal samples annually, so this is unlikely. We also used pet population

estimates from previously published surveys, which may overestimate or underestimate the number of dogs in the U.S. dog population.

Comparing dogs imported from DMRVV-enzootic countries to dogs that live in the United States (a DMRVV-free country) has limitations because the risk of rabies is higher in dogs that live in a DMRVV-enzootic country due to multiple factors (e.g., lack of vaccine availability, inadequate vaccine quality or administration, vaccine hesitancy, greater chance of exposure due to higher rates of free-roaming dogs in some communities). However, the goal of this evaluation was to describe the incidence rate of rabies in imported dogs from DMRVV-enzootic countries and characterize the potential impact on human health. There are limited data available on the incidence of rabies in DMRVV-enzootic countries. Furthermore, the data that are available vary widely between countries. Many countries lack national rabies control programmes and do not have rabies surveillance or laboratory testing capacity, making it challenging to accurately describe the risk. This evaluation is the first attempt to assess the rabies risk between dogs from DMRVV-enzootic countries and compare the risk to dogs residing in a DMRVV-free country (the United States). The greater incidence of rabies in dogs imported from DMRVV-enzootic countries supports enhanced importation requirements for dogs arriving in the United States from DMRVV-enzootic countries.

Understanding the public health risks associated with dogs imported from DMRVV-enzootic countries is important for U.S. federal agencies when evaluating dog importation policies and assessing the need to update regulations. This risk is not theoretical, as evidenced by two human deaths and tens of millions of dollars for mitigation associated with DMRVV after the re-emergence of this variant in Texas in the 1970s (Sterner et al., 2009; Thomas et al., 2005). A better understanding of the human rabies exposure risks associated with dogs imported from DMRVV-enzootic countries is critical for establishing an evidence base for regulatory requirements as well as ensuring that appropriate risk-communication is available to importers, airline staff, health departments and the veterinary professionals who care for these dogs upon their arrival in the United States.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

REFERENCES

American Veterinary Medical Association. (2023, July 2). Pet ownership and demographics sourcebook. May 2022. https://ebusiness.avma.org/files/ProductDownloads/eco-pet-demographic-report-22-low-res.pdf

Birhane MG, Cleaton JM, Monroe BP, Wadhwa A, Orciari LA, Yager P, Blanton J, Velasco-Villa A, Petersen BW, & Wallace RM (2017). Rabies surveillance in the United States during 2015. Journal of the American Veterinary Medical Association, 250(10), 1117–1130. 10.2460/javma.250.10.1117. Erratum in: Journal of the American Veterinary Medical Association, 146, [PubMed: 28467751]

Centers for Disease Control and Prevention (CDC). (2021). Temporary suspension of dogs entering the United States from high-risk rabies countries. Federal Register, June 10, 2021, 86FR 32041, 32041–32049.

Centers for Disease Control and Prevention (CDC). (2023). Extension of temporary suspension of dogs entering the United States from countries with a high risk of rabies. Federal Register, July 10, 2023, 88FR 43570, 43570–43581.

Centers for Disease Control and Prevention, Rabies Branch *Unpublished data for* 2022. Provided by R. Wallace.

Fooks AR, Banyard AC, Horton DL, Johnson N, McElhinney LM, & Jackson AC (2014). Current status of rabies and prospects for elimination. Lancet, 384(9951), 1389–1399. 10.1016/S0140-6736(13)62707-5 [PubMed: 24828901]

Hercules Y, Bryant N, Wallace R, Nelson R, Palumbo G, Williams J, & Brown C (2018). Rabies in a dog imported from Egypt—Connecticut, 2017. Morbidity and Mortality Weekly Report, 67, 1388–1391. 10.15585/mmwr.mm6750a3 [PubMed: 30571670]

Jeon S, Cleaton J, Meltzer M, Kahn E, Pieracci E, Blanton J, & Wallace R (2019). Determining the post-elimination level of vaccination needed to prevent reestablishment of dog rabies. PLoS Neglected Tropical Diseases, 13(12), e0007869. 10.1371/journal.pntd.0007869 [PubMed: 31790398]

KSHB Channel 41 News. (2019, March 1). Dog imported from Egypt by Kansas shelter infected with rabies; others quarantined. www.kshb.com/news/local-news/dog-imported-from-egypt-by-kansas-shelter-infected-with-rabies-others-quarantined

Ma X, Bonaparte S, Corbett P, Orciari LA, Gigante CM, Kirby JD, Chipman RB, Fehlner-Gardiner C, Thang C, Cedillo VG, Aréchiga-Ceballos N, Rao A, & Wallace RM (2023). Rabies surveillance in the United States during 2021. Journal of the American Veterinary Medical Association, 261(7), 1045–1053. [PubMed: 36884381]

Ma X, Bonaparte S, Toro M, Orciari LA, Gigante CM, Kirby JD, Chipman RB, Fehlner-Gardiner C, Cedillo VG, Aréchiga-Ceballos N, Rao AK, Petersen BW, & Wallace RM (2022). Rabies surveillance in the United States during 2020. Journal of the American Veterinary Medical Association, 260(10), 1157–1165. 10.2460/javma.22.03.0112 [PubMed: 35522584]

Ma X, Monroe BP, Cleaton JM, Orciari LA, Gigante CM, Kirby JD, Chipman RB, Fehlner-Gardiner C, Gutiérrez Cedillo V, Petersen BW, Olson V, & Wallace RM (2020). Public veterinary medicine: Public health: Rabies surveillance in the United States during 2018. Journal of the American Veterinary Medical Association, 256(2), 195–208. [PubMed: 31910075]

Ma X, Monroe BP, Cleaton JM, Orciari LA, Li Y, Kirby JD, Chipman RB, Petersen BW, Wallace RM, & Blanton JD (2019). Rabies surveillance in the United States during 2017. Journal of the American Veterinary Medical Association, 253(12), 1555–1568.

Ma X, Monroe BP, Cleaton JM, Orciari LA, Yager P, Li Y, Kirby JD, Blanton JD, Petersen BW, & Wallace RM (2018). Rabies surveillance in the United States during 2016. Journal of the American Veterinary Medical Association, 252(8), 945–957. 10.2460/javma.252.8.945 [PubMed: 29595389]

Ma X, Monroe BP, Wallace RM, Orciari LA, Gigante CM, Kirby JD, Chipman RB, Fehlner-Gardiner C, Cedillo VG, Petersen BW, Olson V, & Bonwitt J (2021). Rabies surveillance in the United States during 2019. Journal of the American Veterinary Medical Association, 258(11), 1205–1220. 10.2460/javma.258.11.1205 [PubMed: 33978439]

McMichael C (2023, August 8). Nightmare scenarios as travelers attempt to fly with pets amid coronavirus. https://abcnews.go.com/US/nightmare-scenarios-travelersattempt-fly-pets-amid-coronavirus/story?id=70494962

Mota M, Motta G, & Stecula D (2023). Sick as a dog? The prevalence, politicization, and health policy consequences of canine vaccine hesitancy (CVH). Vaccine, 41, 5946–5950. [PubMed: 37640567]

Pieracci EG, Chipman RB, Morgan CN, Brown CM, Kirby JD, Blanton JD, Velasco-Villa A, Martin AD, Nelson KM, Singh A, LeMasters E, Weiner Z, & Wallace RM (2020). Evaluation of rabies

virus characterization to enhance early detection of important rabies epizootic events in the United States. Journal of the American Veterinary Medical Association, 256(1), 66–76. [PubMed: 31841088]

Pieracci EG, Williams CE, Wallace RM, Kalapura CR, & Brown CM (2021). U.S. dog importations during the COVID-19 pandemic: Do we have an erupting problem? PLoS One, 16(9), e0254287. 10.1371/journal.pone.0254287 [PubMed: 34492037]

Rathnadiwakara H, Gunatilake M, Servat A, Wasniewski M, Thibault J-C, & Cliquet F (2023). Potency of veterinary rabies vaccines marketed in Sri Lanka. Vaccine, 11(5), 961.

Raybern C, Zaldivar A, Tubach S, Ahmed F, Moore S, Kintner C, & Garrison I (2020). Rabies in a dog imported from Egypt-Kansas, 2019. Morbidity and Mortality Weekly Report, 69(38), 1374–1377. [PubMed: 32970659]

Sinclair J, Wallace R, Gruszynski K, Bibbs Freeman M, Campbell C, Semple S, & Murphy J (2015). Rabies in a dog imported from Egypt with a falsified rabies vaccination certificate—Virginia. Morbidity and Mortality Weekly Report, 64, 1359–1362. 10.15585/mmwr.mm6449a2 [PubMed: 26678293]

Stancheva T (2022, January 9). Stray animal statistics-What are the actual numbers in 2022. pawsomeadvice.com/pets/stray-animal-statistics/

Sterner R, Meltzer M, Shwiff S, & Slate D (2009). Tactics and economics of wildlife oral rabies vaccination, Canada and the United States. Emerging Infectious Diseases, 15(8), 1176–1184. 10.3201/eid1508.081061 [PubMed: 19757549]

Thomas S, Wilson P, Moore G, Oertli E, Hicks B, Rohde R, & Johnston D (2005). Evaluation of oral rabies vaccination programs for control of rabies epizootics in coyotes and gray foxes: 1995–2003. Journal of the American Veterinary Medicine Association, 227(5), 785–792.

U.S. Customs and Border Protection. (2022, August 10). ACE and automated systems. www.cbp.gov/trade/automated

Velasco-Villa A, Mauldin M, Shi M, Escobar L, Gallardo-Romero N, Damon I, & Emerson G (2017). The history of rabies in the Western hemisphere. Antiviral Research, 146, 221–232. 10.1016/j.antiviral.2017.03.013 [PubMed: 28365457]

Whitehill F, Bonaparte S, Hartloge C, Greenberg L, Panayampalli SS, Orciari L, et al. (2021). Rabies in a dog imported from Azerbaijan-Pennsylvania, 2021. Morbidity and Mortality Weekly Report, 71, 686–689.

Bank World. (2012). People, pathogens and our planet: The economics of one health. https://openknowledge.worldbank.org/handle/10986/11892

World Health Organization (WHO). (2018). WHO expert consultation on rabies (WHO technical report series 1012). https://www.who.int/publications/i/item/WHO-TRS-1012

World Organisation of Animal Health (WOAH). (2023). OIE terrestrial code: Chapter 8.15 infection with rabies virus. https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/2023/chapitre_rabies.pdf

WTAE Channel 4 News (ABC affiliate). (2021, June 25). Quarantined rescue dog escapes Bridgeville area home. www.wtae.com/article/quarantined-rescue-dog-escapes-bridgeville-area-home/36847025#

Impacts

- This evaluation provides updated estimates of the total number of dogs imported into the United States from rabies-enzootic countries.
- This evaluation highlights the elevated risk of rabies in dogs that are imported into the United States from rabies-enzootic countries.
- This evaluation discusses the elevated risk of rabies exposure for people engaged in international dog rescue because of the frequency of contact with high-risk dogs.

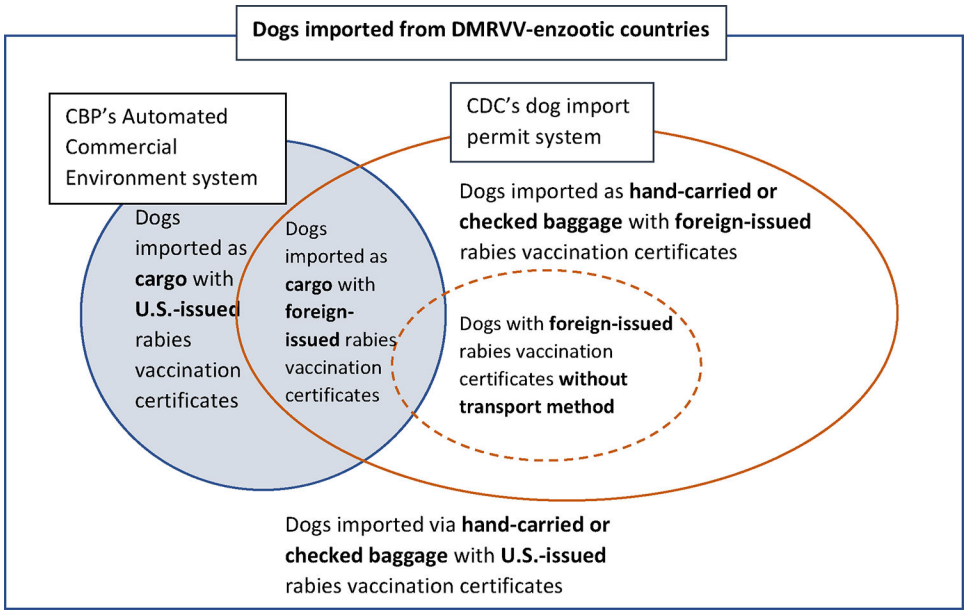

FIGURE 1.

Diagram of data availability for the number of dogs imported from DMRVV-enzootic countries via CBP's Automated Commercial Environment system and CDC's dog import permit system, 2022. The CBP's Automated Commercial Environment system records the number of dogs imported via cargo from DMRVV-enzootic countries but does not include information on rabies vaccination certificates. While all dogs imported from DMRVV-enzootic countries with foreign-issued rabies vaccination certificates were required to be registered in the CDC's dog import permit system during 2022, the transport method was an optional component to report. Thus, some dogs in the missing category (i.e., dogs in the orange dotted circle) from the CDC's dog import permit system may have been imported via cargo, and their information may be included in CBP's Automated Commercial Environment system. The CDC's dog import permit system was implemented on August 1, 2021, and we only report data from the calendar year 2022. Data from CBP's Automated Commercial Environment system is available for multiple years, and we focused on the period from 2015 through 2022. For the period from 2015 through 2022, we assumed the fraction of dogs imported as cargo each year would be similar to the estimated fraction of foreign-vaccinated dogs from DMRVV-enzootic countries imported as cargo during 2022. CBP, U.S. Customs and Border Protection; CDC, Centers for Disease Control and Prevention; DMRVV, Dog-mediated rabies virus variant.

TABLE 1

Number of CDC dog import permits issued for foreign-vaccinated dogs arriving in the United States from DMRVV-enzootic countries by transportation method, 2022.

Transport method	Number of permits issued by CDC (%)
Hand-carried baggage	6475 (39.9)
Checked (oversized) baggage	2615 (16.1)
Cargo	2403 (14.8)
Missing	4739 (29.2)
Total permits	16,232

Abbreviations: CDC, Centers for Disease Control and Prevention; DMRVV, dog mediated rabies virus variants.

TABLE 2

Estimated number of dogs imported into the United States from DMRVV-enzootic countries, 2015–2022.

Year	DMRVV-enzootic country cargo imports	Best estimate of all dogs imported from DMRVV-enzootic countries (assume 17.6% of dogs arrive as cargo)	Lower bound estimate of all dogs imported from DMRVV-enzootic countries (assume 20.4% of dogs arrive as cargo)	Upper bound estimate of all dogs imported from DMRVV-enzootic countries (assume 14.8% of dogs arrive as cargo)
2015	10,049	57,123	49,309	67,880
2016	12,857	73,085	63,088	86,848
2017	15,794	89,780	77,499	106,687
2018	10,008	56,890	49,108	67,603
2019	24,201	137,570	118,752	163,475
2020	7632	43,384	37,449	51,553
2021 (pre-suspension)[a]	11,676	66,372	57,293	78,870
2021 (post-suspension)[a]	6633	37,705	32,547	44,805
2022	3308	18,804	16,232	22,345
Average (all years)	12,770	72,589	62,660	86,258
Average 2015–2019	14,582	82,890	71,551	98,499
Average 2020–2022	9750	55,422	47,840	65,858

Abbreviation: DMRVV, dog-mediated rabies virus variants.

[a]On July 14, 2021, CDC implemented a suspension prohibiting dogs to enter the United States from DMRVV-enzootic countries (CDC, 2021).

TABLE 3

Estimated incidence rate of rabies in dogs imported to the United States compared to U.S. dogs, 2015–2022.

Year	Number of imported rabid dogs from DMRVV-enzootic countries	Estimated number of imported dogs from DMRVV-enzootic countries [range]	Number of rabid dogs with domestically acquired rabies (enzootic wildlife variants)	Estimated U.S. dog population [range]
2015	1	57,123 [49,309–67,880]	47	74.4 million [72.2–76.7 million]
2016	0	73,085 [63,088–86,848]	36	76.8 million [74.5–79.1 million]
2017	1	89,780 [77,499–106,687]	36	79.2 million [76.8–81.6 million]
2018	0	56,890 [49,108–67,603]	35	81.6 million [79.1–84.0 million]
2019	1	137,570 [118,752–163,475]	33	83.9 million [81.4–86.4 million]
2020	0	43,384 [37,449–51,553]	25	86.3 million [83.7–88.9 million]
2021 (pre-suspension)[a]	1	66,372 [57,293–78,870]	28	88.7 million [86.0–91.3 million]
2021 (post-suspension)[a]	0	37,705 [32,547–44,805]		
2022	0	18,804 [16,232–22,345]	41	91.0 million [88.3–93.8 million]
Total	4	580,713 [501,277–690,006]	281	661.9 million [642.1–681.8 million]
2015–2022 incidence rate per 1 million dogs	6.9 [5.8–8.0]		0.42 [0.41–0.44]	
2015–2022 risk ratio of rabies in imported dogs compared to domestically acquired rabies in U.S. dogs	16.2 [13.2–19.4]			

[a]On July 14, 2021, CDC implemented a suspension prohibiting dogs to enter the United States from DMRVV-enzootic countries (CDC, 2021).

TABLE 4

Summary of human and animal exposures to imported rabid dogs—United States, 2015–2022.

Case year	Number of persons receivinxg rabies post-exposure prophylaxis	Number of animals requiring revaccination and quarantine (45 days–6 months)[a]	Method of transportation
2015	18	8	Cargo
2017	4 (+ unknown number in Egypt)	8	Checked baggage
2019	44	37	Land-border
2021	18	33	Cargo
Total (Average)	84 (21 persons per rabid dog importation)	86 (21.5 animals per rabid dog importation)	

[a]Quarantine timeframes varied based on local jurisdictional laws.