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POTENTIAL IMPACT OF A DIAGNOSTIC TEST FOR DETECTING PREPATENT GUINEA WORM INFECTIONS IN DOGS

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ABSTRACT

Cases of Guinea worm disease (or dracunculiasis) in domestic dogs in Chad have declined substantially in recent years but more tools may be required to accelerate elimination of the disease. We investigate the possible benefits of a proposed diagnostic test which could detect prepatent infections in dogs. We adapt an agent-based simulation model for analyzing disease transmission to examine the interaction of multiple test factors including sensitivity and specificity, infection detection timing, dog selection, and tethering compliance behaviors. When combined with existing interventions, we find that a diagnostic test could be impactful. With 80% or higher test sensitivity, 90% or higher specificity, systematic testing of each dog biannually, and long-term tethering of test-positive dogs, elimination can be achieved within two years. Due to the long incubation period (10-14 months) and lack of treatment, the testing rollout and response of dog owners are critical to the benefits of the test.

1 BACKGROUND

In 2021, there were 8 humans and 767 dogs reported to be infected with Guinea Worm disease (or dracunculiasis) in Chad. While these reported cases of Guinea worm (GW) infections represent reductions in recent years, the large number of dog infections continue the cycle as infections are passed through shared water sources. No treatment or vaccine exists; current methods to reduce infections among dogs include tethering of dogs to minimize access to water sources, adequate disposal of aquatic waste, and Abate® larvicide applications to kill infectious copepods in the water sources. While these interventions have helped to reduce infections, additional tools may be required to achieve disease elimination.

We study the potential impact of a diagnostic test for detecting prepatent GW infections in dogs. If prepatent infections could be detected before external signs appear near the end of the incubation period (signs which can be missed), then test-positive dogs could be targeted for tethering. Using an agent-based simulation model, we analyze GW infections in dogs over time, accounting for currently used interventions and a diagnostic test. We consider performance factors including test accuracy (i.e., sensitivity and specificity), deployment, and dog owner behaviors. Cost and ease of use are important considerations under resource-limited field conditions, and how dog owners respond when a dog tests positive will have a

substantial impact. We simulate the number of infections after multiple years for different testing strategies and provide recommendations with respect to minimum necessary test characteristics, deployment features, and owner behaviors for a diagnostic test to support faster GW elimination.

2 METHODS

We adapt an agent-based GW simulation model (Perini 2020, Wang 2023) to incorporate a diagnostic test (Smalley 2023). The model captures the life cycle of GW, including water infectivity levels as they are impacted by Abate® and weather, and tethering of dogs, and simulates day-to-day interactions between dogs, worms, and multiple water sources. We use the model to evaluate diagnostic testing factors including test sensitivity (rate of true positives) and specificity (rate of true negatives), timing of when the test can detect infection (immediately or within 30 days of worm emergence), dog selection methods (random or systematic), and dog-owner behaviors (i.e., compliance with tethering recommendations following a positive test result). Dogs have a daily tethering probability following a positive test result for different time periods (from one month to one year). We also consider the possibility that a positive test result could include an estimated time interval until worm emergence.

3 RESULTS

We find that selecting dogs for testing systematically is more beneficial than selecting dogs randomly. If test sensitivity is 90% or higher, then fewer infections can be achieved by systematically testing 10% of dogs monthly than randomly testing 20% of dogs monthly. Infections can be reduced by increasing test sensitivity, increasing tethering time periods following a positive test result, or increasing the percentage of dogs tested monthly. Lower test specificities can lead to lower infections long term for some cases due to the higher number of dogs tethered because of increases in false positive test results; however, higher test specificity is associated with reductions in infections in general. With 80% or higher test sensitivity, 90% or higher specificity, systematic testing of each dog biannually, and long-term tethering of test-positive dogs (over 90% compliant for one year), elimination can be achieved within two years. If the test could return an estimate of worm emergence timing, the requirement for long-term tethering could be eliminated; test-positive dogs would only need to be tethered when worms are expected. If infections are undetectable until 30 days prior to worm emergence, then at least 50% of dogs must be tested monthly to reduce dog infections long-term, regardless of dog selection method.

4 CONCLUSION

We conclude that a diagnostic test could be successful if used in conjunction with existing interventions. Given that no treatment exists for Guinea worm disease and because of the long incubation period, the deployment of the test and response of dog owners (e.g., length of tethering following a positive test result) are critical factors impacting the benefits of the test. The ability to estimate the timing of worm emergence could eliminate the need for long-term tethering and minimize the related resources (human and financial) to support the intervention. If infection is only detectable within 30 days of worm emergence, then the testing burden to reach elimination is too high to be feasible.

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