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not develop immunity to the parasite. There is no effective treatment or vaccine; however, the infection may be prevented by 1) educating villagers about the origin of the disease, 2) preventing infected persons and animals from entering sources of drinking water, 3) filtering all drinking water through a finely woven cloth that removes the copepods, 4) applying Abate larvicide (temphos; BASF Corp., Florham Park, NJ) to kill the copepods in ponds or other stagnant sources of drinking water, and 5) providing clean drinking water from safe sources, such as protected hand-dug or borehole wells.

The global eradication campaign began at the Centers for Disease Control and Prevention (CDC) in 1980. It was adopted as a subgoal of the International Drinking Water Supply and Sanitation Decade (1981–1990), and it has been led since 1986, by The Carter Center, which is at the head of a coalition that includes the ministries of health of the endemic countries, the CDC, the World Health Organization (WHO), and the United Nations Children’s Fund as major partners and thousands of village volunteers and supervisory health staff. The coalition is supported by numerous donor agencies, governments, foundations, and other institutions. When The Carter Center began leading the global campaign after the CDC, there were an estimated 3.5 million cases of dracunculiasis worldwide.<sup>4</sup> At the World Health Assembly (WHA) in 2004, ministers of health set a target to stop transmission of dracunculiasis by the end of 2009.<sup>5</sup> When that target date was not met, partly because of the ongoing civil war in Sudan and unexpected outbreaks in Chad, Ethiopia, and Mali, the global initiative resolved to interrupt transmission as soon as possible.

#### CURRENT STATUS OF THE CAMPAIGN

As of the end of 2017, only 30 cases of dracunculiasis in humans were reported worldwide (down from 542 cases in 2012), in 18 villages (down from 103 villages with indigenous cases in 2012), and only two countries reported cases in humans (down from four countries in 2012) (Figures 1 and 2). A third country reported infections only in animals. Mali and South Sudan each reported their last known cases in humans in 2015 and 2016, respectively. Chad and Ethiopia reported 15 cases each in 2017, whereas Chad, Ethiopia, and Mali reported 830, 15, and 10 infected animals, mostly domestic dogs, respectively. South Sudan reported only one infected domestic dog, in 2015. The Centers for Disease Control and Prevention has confirmed worms from the infected animals as *D. medinensis* by microscopic and/or molecular examination.<sup>3</sup> The number of cases exported from one country to another has fallen from a peak of 154 cases in

affected villages of concern for operational purposes: “1+ case village,” a village with one or more indigenous and/or imported guinea worm infection in a human, dog and/or cat in the current and/or previous calendar year. Most cases in humans peak during the rainy season in June–September, with no marked preponderance in adults versus children or males versus females. Dog infections peak in April–August. The vast majority of infections in humans and dogs occur in villages along the Chari River (Figure 4).

Although the guinea worms found in humans and in dogs in Chad are indistinguishable in the laboratory, the current outbreak has exhibited a “peculiar” epidemiology since it began, with unusually high numbers of infected dogs, few sporadic infections in humans, almost no clusters of cases in families or in villages in successive years, and no large outbreaks of human cases. Evidence to date suggests that transmission of the infection in Chad may involve a paratenic or transport host (intermediate hosts in which the parasite remains viable but does not develop) such as fish, frogs and/or another aquatic animal, and that humans and dogs may be infected by eating such aquatic animals raw or inadequately cooked or cured.<sup>6</sup> Casual disposal of entrails during the mass harvesting of fish at the end of the dry season is believed to contribute to the possible alternative mode of transmission among dogs.<sup>3</sup>

The WHO assisted Chad after transmission was believed to have been interrupted in 2000, but Chad did not sustain its eradication program or surveillance for dracunculiasis. The Carter Center resumed assistance to Chad in 2011 at the request of the Ministry of Public Health, helping to reestablish active surveillance starting in 2012. At the end of 2017 Chad had 1,860 villages under active surveillance, of which 463 were “1+ villages.” It has offered a cash reward equivalent to US\$100 for reporting a case of the disease for over a decade and began offering a reward equivalent to US\$20 for reporting and tethering (containing) an infected dog in January 2015. In 2017, awareness of the cash reward for reporting a case in humans was estimated at 55% of persons queried and about 41% were aware of the reward for reporting an infected dog.

Chad’s Guinea Worm Eradication Program (GWEP) began implementing enhanced health education in 2013, urging villagers to cook their fish well and bury fish entrails. Tethering and daily monitoring of infected dogs and application of Abate in cordoned areas of the large lagoons (e.g., 2.5 × 2.2 km) along the banks of the Chari River in response to the contamination events that began in 2014. Domestic dogs in Chad are associated with specific households, which provide them some of the family’s food, sometimes drinking water, and access to raw fish entrails. The dogs accompany household members while farming, hunting, visits to market, etc. and also forage for food and water. As the river recedes during the dry season, smaller ponds appear in villages. These ponds are used for brick-making and gardening. They often contain fish and frogs, and are also accessible to dogs. More intense Abate application to ponds in communities with multiple dog infections began in 2017, when it was applied in 70 villages that contained 40% of the infected dogs in 2017. The rate of containment of infected dogs rose from 40% in 2014 to 68%, 66% and 76% in subsequent years, whereas the proportion of sampled households that were found to practice safe disposal of fish guts was 88% in 2016 and 83% in 2017. Fully, 72% of 1+ villages had at least one source of safe drinking water in 2017. We believe the reduction in infected dogs and emerging guinea worms in 2017 probably resulted from the impact of tethering infected dogs, burying fish guts, and use of Abate. Chad’s National Assembly convened in June 2017 for a special briefing on the eradication program. The minister of public health launched an intensive nationwide communication campaign in July 2017 to increase awareness of the cash rewards for reporting guinea worm cases and infections and to

publicize information about how to prevent the infection in humans and dogs. Two predecessor

Since 2015, the EDEP has increased the numbers of surface water sources where it has applied Abate in forest areas associated with human and animal infections in Gog district 10-fold, treating 44 surface water bodies in the core endemic subdistrict of Atheti in July 2015, 131 in July 2016, and 484 in July 2017, for example, in addition to providing the villagers health education, cloth filters and pipe filters. Unlike in Chad, most of the surface water bodies of concern here are small enough to be treated with Abate but are numerous and transient. All of the five villages at high risk in Gog district have at least one safe source of drinking water. Insecurity limited activities in some affected areas of Gambella Region in December 2015–January 2016.

In 2017, Ethiopia had 167 villages under active surveillance. The EDEP increased the cash reward for reporting a case of dracunculiasis to the equivalent of US\$100 in 2014 and began offering a reward equivalent to US\$10 for reporting an infected animal in April 2015. In 2018, it plans to increase the rewards for reporting an infected human to US\$360 and the reward for reporting and tethering infected dogs to US\$40. Overall, 83% of persons interviewed in areas under active surveillance in Gambella and Southern Nations, Nationalities and People's Regions in 2017 were aware of the cash reward for reporting a person with dracunculiasis. However, only 22% of persons interviewed in Oromia region, which had not had a case of dracunculiasis since the EDEP began and thus was not under active surveillance, were aware of the reward. Ethiopia's minister of health visited an endemic area in Gambella Region in 2013, the vice president of Gambella Region made a similar visit in support of the EDEP in 2016, and the president of Gambella Region visited the implicated commercial farm in 2017. The National Certification Committee met for the first time in several years in 2015 but has been dormant since then. The EDEP held three press conferences to publicize the program in 2016. In December 2017, it launched an intensive communication campaign to increase awareness of the rewards nationwide. This program had three successive national coordinators in 2013–2017, which hampered program continuity.

### **South Sudan.**

South Sudan, which reported 521 cases of dracunculiasis in 2012, reported 70 cases in 2014 and six cases in 2016. At the end of December 2017, it reached the major milestone of 13 consecutive months with zero reported cases despite submitting 27 worm specimens to CDC during 2017, none of which was confirmed as *D. medinensis*. South Sudan's latest case, a 13-year-old Lou girl from Jur River County in Western Bahr el Ghazal State, had her worm emerge on November 20, 2016. The South Sudan GWEP (SSGWEP) monitored all six cases from 2016 throughout 2017. It has only once detected an infected dog, and this occurred in the household of a patient with dracunculiasis in the Jur River County in 2015.

South Sudan introduced a cash reward of 5,000 South Sudanese Pounds ( US\$100) for reporting a case of dracunculiasis, in April 2014, which it increased to 10,000 SSP ( US\$90) in May 2017, and 50,000 SSP ( US\$400) in January 2018. It began offering a cash reward equivalent to US\$23 for reporting an infected dog in May 2017. The SSGWEP had 4,046 villages under active surveillance in 2017, and it launched a nationwide communication campaign in October 2017 to publicize the rewards and guinea worm disease prevention. A

hours. The World Health Organization is helping to monitor South Sudanese refugees in Ethiopia, Uganda, and other neighboring countries for cases of the disease.

South Sudan experienced significant sporadic insecurity in some areas during the period under review, to a degree that required evacuation of 33 expatriate Carter Center–supported staff during the off-peak season in December 2013–February 2014, and again in July 2016. Only about five expatriate senior staff returned after the second evacuation, but local volunteers and indigenous supervisors continued to function at a high level under the effective leadership of the national program coordinator and continued exceptionally strong political support of the South Sudanese government. The SSGWEP’s indigenous workers included 78 administrative and transport staff, 208 supervisors, and 3,137 village volunteers in 2016, and numbered 2,306 supervisors and 18,169 village volunteers at their peak in 2007. The minister of health visited endemic villages in 2014 and 2016 and launched the nationwide communication campaign mentioned previously in 2017. In 2015, the SSGWEP’s annual review meeting in Juba was opened by the vice president of South Sudan in the presence of the governor of the highest endemic state, three national ministers, six state ministers of health, and four county commissioners.

## **Mali.**

Mali reported only four cases of dracunculiasis in 2012 when it also suffered a coup d’etat in March followed by virtual partition of the country that made much of the northern half of the nation inaccessible to the program for over a year, and very insecure after that. Security improved by 2014 when the national program coordinator visited Kidal region in April. Mali reported 11 cases in 2013, then had an outbreak of 40 cases in three villages in August–November 2014: 29 cases (28 contained) at Tanzikratene in Gao region, 10 cases (seven contained) at Nanguaye in Timbuktu region, and one uncontained case at Fion in Segou region.

After the vigorous response in 2014, Mali reported five cases (three contained) in 2015, of which three were in Tanzikratene, and one each in villages in Segou and Timbuktu regions. The final case was a 45-year-old woman in Timbuktu region whose worm emerged on November 17th. Mali reported no more persons with dracunculiasis in 2016 or 2017.

However, for the first time since the Malian program began, in October 2015 it found one dog with an emerging guinea worm in Tominian district of Segou region. The new minister of public health visited Tominian district in 2016, when Mali reported 11 infected dogs (nine







the robust research agenda in Chad are reasons to expect that this final challenge also will be overcome soon.

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