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Guinea Worm Disease in Northern Uganda: A Major Public Health Problem Controllable Through an Effective Water Programme

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A modified cluster survey was conducted in northwestern Uganda in 1984 to provide descriptive epidemiological data on dracunculiasis in a water programme target area. A total of 2014 people participated from 58 randomly selected clusters. Interviewers elicited information on age and sex of household members, number, date of emergence and location of Guinea worms, and type of and distance from water source in an endemic area. The survey yielded an incidence rate of 193 cases/1000 people per year, and a prevalence rate of 43 active cases/1000. Respondents who reported using ponds, reservoirs, valley tanks or rivers as their primary water source had the highest attack rates; those using boreholes, the lowest. Adolescents and adults differed little in risk, but the disease was less common among young children. Guinea worm disease displayed a bimodal seasonal pattern. We concluded that the survey method used for determining dracunculiasis incidence was appropriate in this setting. The incidence of this disease may be significantly reduced in Uganda through the country's commitment to the International Drinking Water Supply and Sanitation Decade.

Dracunculiasis belongs to the group of parasitic diseases that depend on water as the habitat of an intermediate host, in this case *Cyclops*. Several other characteristics make the eradication or control of Guinea worm disease an achievable sub-goal of the current International Drinking Water Supply and Sanitation Decade.[1,2] Unlike other water-related infectious and parasitic agents, people acquire Guinea worm virtually exclusively by drinking contaminated water. Most evidence suggests that dracunculiasis can be entirely prevented by protecting drinking water supplies and convincing the population to use these protected supplies exclusively. Guinea worm disease also has a distinct and obvious presentation, making it easily quantifiable. Thus, it is possible to document an abrupt reduction in the number of new cases, therefore readily demonstrating one health benefit of improved water supplies.

In Uganda, one of the many Guinea worm-endemic countries between West Africa and India, the potential exists to achieve such a reduction. In 1968, Guinea worm was prevalent in West Nile, Madi and Acholi Districts in the northwest part of the country.[3] At that time, endemicity appeared to be decreasing as the provision of boreholes and other protected water supplies increased. However, civil disruption over the past two decades has caused population movements and resulted in many of these supplies falling into disrepair. Guinea worm has now apparently extended throughout Kotido and Moroto Districts to the northeastern border (Figure 1) and into neighbouring areas of northwest Kenya as well.[4–6]

Since the early 1980s the United Nations Children's Fund (UNICEF), in support of the Water and Sanitation Decade, has assisted the Government of Uganda on a borehole drilling and repair programme. Focusing on regions with a deep water table, the project aims to provide one borehole for every 200 people. In 1983, UNICEF decided to use dracunculiasis as a health-related indicator for evaluating this water programme by estimating its endemicity before and after providing functioning boreholes. By using an operationally simple survey, this report describes the epidemiology of Guinea worm disease in a 3000km² area within Kitgum District before the UNICEF programme was initiated there.

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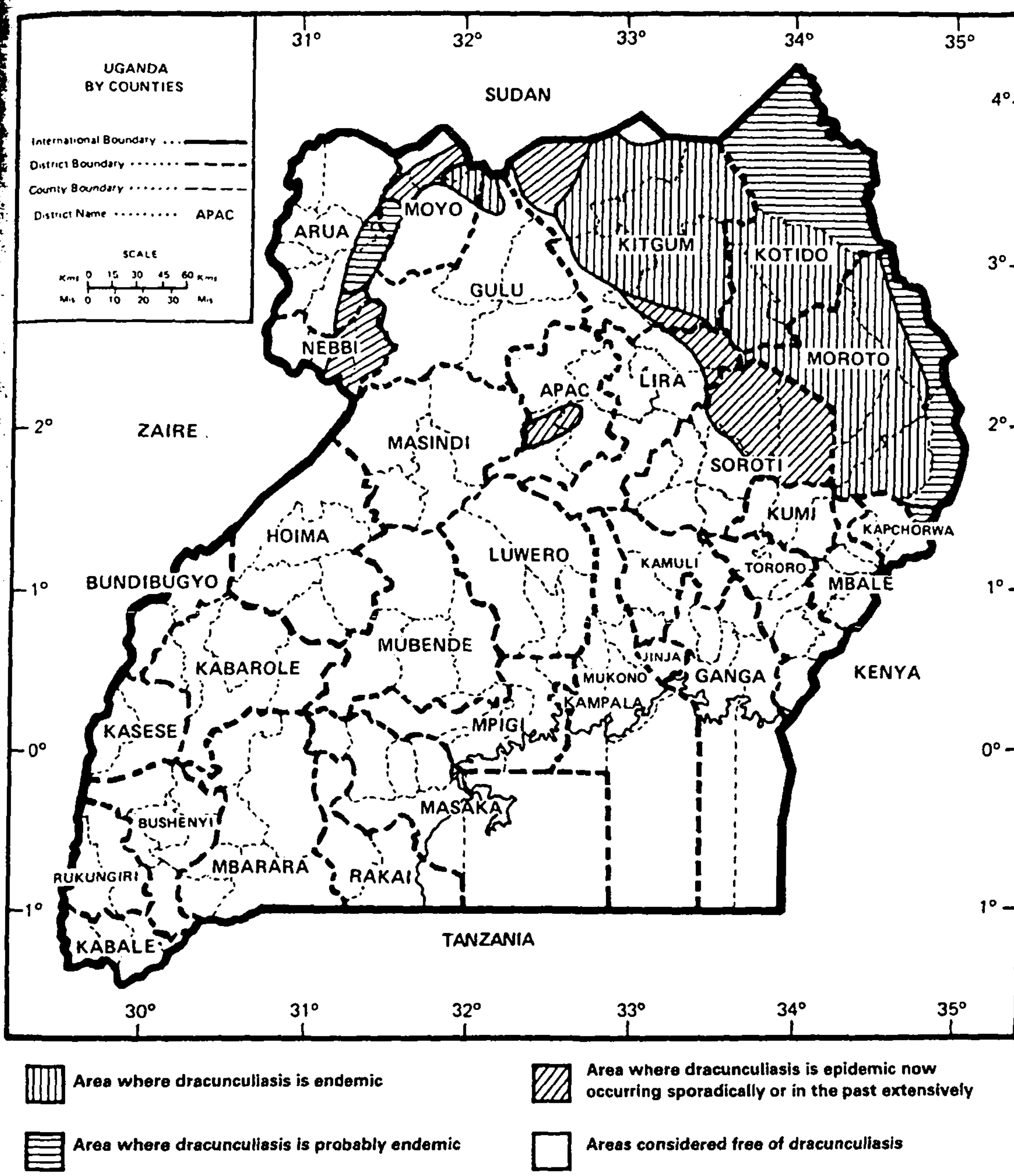

FIGURE 1 *Provisional Geographical limits of Dracunculiasis in Uganda 1983.*

METHODS

To provide baseline descriptive data on dracunculiasis for a one-year interval in the water programme target area, we adapted a cluster survey method developed for assessing nutrition and immunization coverage.[7] Advantages of this approach include cost and feasibility where lists of households are not available, with only a moderate loss of validity.

Local authorities listed all villages (234) in five sub-counties (Labong, Madi Opei, Mucwini, Kitgum Matidi and Nam Okora). These sub-counties had a combined population of 84 645 according to the 1980 census and fell within the provisional boundaries of the area endemic for dracunculiasis in Kitgum District. Administrative chiefs provided demographic data, but where figures were unavailable, populations were estimated from taxpayers' rolls.

We divided the villages into two groups: 47 scheduled to receive boreholes in 1984 (borehole villages), and 187 not yet scheduled to receive boreholes. We selected 29 from each group. To assure post-intervention comparability, as each control village was selected from the list we matched it by sub-county, population (+/− 30%) and existence of a borehole against the borehole villages. Thus, we excluded five villages and continued the selection process until we attained 29 eligible control villages.

In each selected village, an interviewer and a local health worker first went to the proposed borehole site or another recognized central reference point. They then selected a two-digit random number which represented the distance and the direction of the first household to be visited. After interviewing this household, the team continued interviewing residents in contiguous houses in the same direction until it had collected information on all members of the house with the 30th person. No households visited in this fashion refused to participate in the survey.

The questionnaire included age and sex of each household member; number, month of emergence and location of Guinea worms; and type of and distance from water source. Where distance to a source was unknown, interviewers estimated this factor by using the time respondents reported walking to reach it. We constructed a local events calendar to aid in determining correct dates. The events specified included significant points in the agricultural year, such as harvest and sowing of major crops.[8,9] A case of Guinea worm disease was defined as an instance in which a person reported that one or more worms had emerged during the preceding year (April 1983–March 1984). For seasonal and monthly attack rates, a case was defined as an instance in which a person reported one or more worms emerging during the indicated season or month. For computing point prevalence we limited the case definition to people with one or more worms protruding through the skin or easily palpable at the time of the visit.

RESULTS

Among the 2014 surveyed people in 221 households, 389 reported one or more Guinea worms emerging over the previous year, yielding an incidence rate estimate of 193 cases/1000 people per year (standard error = 23.4) for the five sub-county area. Incidence rates did not differ significantly between the borehole ([illegible]/1000) and control villages (176/1000). Eighty-six [illegible]jects had one or more worms at the time of the survey for a prevalence rate of 43 active cases/1000 people (SE = 8.4). The average length of illness computed from the incidence rate over the previous three months and prevalence was 36 days. The demographic structure of the surveyed population paralleled that of Uganda as a whole, as reflected in the 1980 census. Teenagers and adults differed little in risk, but the disease was rarer among young children (Table 1). The small difference between the incidence rates of females and males was not statistically significant by the Mantel-Haenszel test.[10]

Incidence by cluster ranged widely, from 0 to 6[illegible] cases/1000 people, resulting in a high design effect (the ratio of the variance of the cluster estimate to the variance expected under simple random sampling) of 7.3 for the survey. Of the 58 clusters (34.7 people each), 10 had no cases during the preceeding year and 30 had no active cases. For descriptive purposes we therefore defined three incidence categories: 19 clusters with an incidence rate from 0–89.9 infected people/1000, 23 from 90–299.9, and 15 over 300.

One villager reported 14 worms emerging at the time of the survey; the highest number in one person during the previous year was 25. Diseased people reported about the same number of worms on average, however, whether they resided in a high, medium or low incidence village (3.4, 3.5 and 4.1 among adults respectively). Thirty-eight per cent of worms emerged on the foot, 47% on the leg, and 15% elsewhere.

Over one-half of study subjects obtained drinking water primarily from the various water courses in the area (Table 2). The main water course—namely the Pager River and its tributaries—ceases to flow in the dry season when people obtain water by excavating shallow wells in the river bed or exploiting residual pools. During the rainy season inhabitants collect water from shallow excavations for infiltration alongside these streams and from the flowing portion of the

TABLE 1 *Age and sex-specific incidence rates for Guinea worm Kitgum District, Uganda, 1983–84.*

Age group	Guinea worm cases per 1000 people per year (Standard Error)		
	Males	Females	Both sexes*
<10	83.1 (20.7)	53.1 (15.6)	68.8 (15.6)
10–19	250.0 (44.0)	255.6 (36.9)	252.6 (36.7)
>20	260.1 (38.8)	259.3 (30.8)	259.3 (30.7)
All ages	194.3 (27.5)	192.6 (22.9)	193.1 (23.4)

* Sex not recorded for three people.

TABLE 2 *Estimated seasonal attack rates* for dracunculiasis by reported primary drinking water source in five subcounties of Kitgum District, Uganda, 1983–1984.*

Primary drinking water source	Dry season (November–March)			Wet season (April–October)		
	Per cent using (SE)	Attack rate* (SE)	Risk ratio relative to boreholes (p)	Per cent using (SE)	Attack rate* (SE)	Risk ratio relative to boreholes (p)
Boreholes	6.1 (3.2)	4.9 (2.3)	referent	5.2 (3.0)	0.9 (1.1)	referent
Ponds, reservoirs and valley tanks	5.5 (2.3)	24.6 (4.2)	5.01 (<0.01)	13.4 (4.4)	24.9 (7.6)	25.9 (<0.01)
All sources in water courses	62.6 (6.0)	9.7 (2.0)	NS	60.9 (5.9)	12.1 (2.0)	12.5 (<0.01)
Springs	5.4 (3.0)	5.6 (3.4)	NS	7.3 (3.4)	3.4 (1.5)	NS
Swamps	ND	ND	ND	3.8 (2.6)	2.6 (1.8)	NS
Other unsafe sources	22.5 (5.3)	8.4 (1.6)	NS	9.5 (3.3)	4.7 (1.4)	4.9 (<0.05)
All sources	—	9.4 (1.4)	—	—	11.5 (1.9)	—

SE = standard error.
p = p-value based upon the standardized difference (z) between the indicated water source and boreholes.
NS = difference in attack rates not statistically significant.
ND = No person surveyed reported using the water source.
* Attack rate = people with ≥1 guinea worm emerging during the season per 100 people.

streams. The attack rate associated with water courses exceeded that of many other sources. Because most people used these water courses, they accounted for 68% of Guinea worm cases; however, pond, reservoir and valley tank* users had twice the attack rate during both seasons. About four times as many people used these sources in the rainy season as in the dry season.

Borehole users constituted about 5.2% of the population in the rainy season, and slightly more in the dry season. These sources had the lowest attack rates of Guinea worm in the dry season, and only swamps (used seasonally) had lower rates in the rainy season. Five of the six surveyed cases associated with dry season borehole use occurred among soldiers encamped in one of the villages. Borehole users had one-tenth the attack rate of non-users (12.2%, SE = 1.9, $p<0.01$) in the rainy season, and two-fifths the attack rate of non-users (9.7%, SE = 1.5, $p>0.05$) in the dry season. These rates did not change appreciably whether they used these primary sources exclusively or in combination with another source.

The average distance travelled to collect household water increased from 2.1km (SE = 0.18) in the rainy season to 3.9km (SE = 0.32) in the dry season. Some respondents reported walking over 11km each way for water during part of the year. Infection rates demonstrated no apparent correlation with distance from source.

Guinea worm disease displayed a bimodal, seasonal pattern (Figure 2). The peak of cases in August 1983 coincided with the heavy late rainy season rainfall that occurred 12 months before, and the peak in February–March 1984 coincided with the end of the dry season in 1983. Moreover, cases in 1983–84 showed a remarkable parallelism with monthly variation in rainfall one year earlier, as recorded by the Ugandan Department of Meteorology. The high-incidence village group had both seasonal peaks distinctly represented. However, only four individual villages had distinct peaks in incidence during both seasons. The remaining nine high incidence villages had only one or the other of these two seasonal increases. The group of medium incidence had only a dry-season peak, and the low-incidence group had no apparent seasonal pattern.

DISCUSSION

The disease rates found in the present survey are comparable to and in some cases exceed those reported from similar studies in endemic areas.[11-14] Only slightly more rain fell in 1982–83 than normal, and the last drought was several years previously, so there is no reason to believe that 1983–84 was an exceptional year in terms of water supply. Since there were no non-respondents, and few villages were excluded from the survey, we believe that the rates reported here are representative of the surveyed area in Kitgum District, and may provide a reasonable estimate for all areas endemic for Guinea worm in northern Uganda. Applying the incidence rate estimate to the whole of the surveyed area yields over 16 000 infected people during one year. Extrapolating to all infected districts of the country yields an estimate of 120 000 infected people per year. We expect that these estimates would vastly exceed results from passive case detection because most infected people do not seek medical

* A valley tank is a small reservoir formed by constructing an earthen dam across a temporary water course.

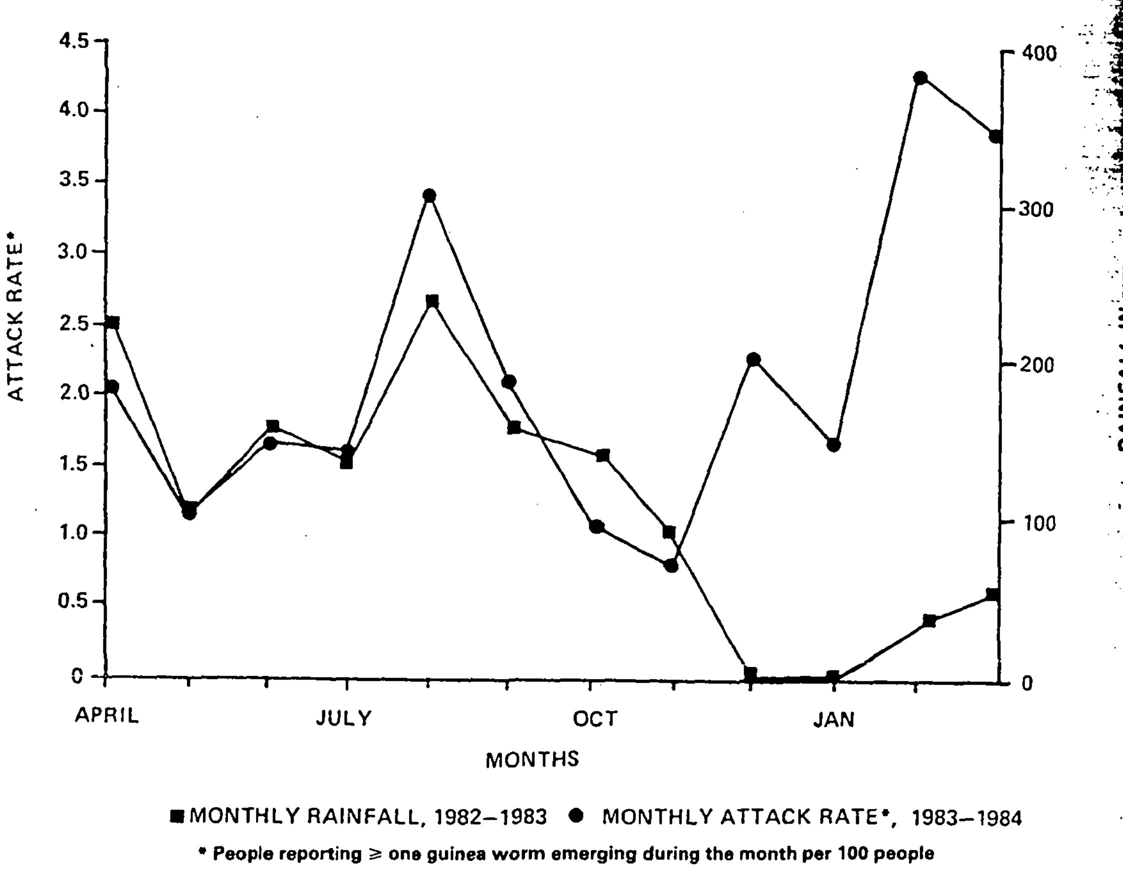

FIGURE 2 *Guinea worm infections 1983–1984 and rainfall 1982–1983 by month, Kitgum District, Uganda.*

attention.[15] Furthermore, these survey estimates can serve as a basis for calibrating passive surveillance. The combination of high incidence and prevalence with the severe morbidity associated with dracunculiasis can result in economic losses for a village by interfering with agricultural production.[1,11,13] Thus, the eradication of this disease from Uganda should produce a significant improvement in both health and productivity.

Most survey findings in Kitgum were similar to those of investigators in other settings. The bodily distribution of emergent worms and the number of worms per person reported here parallel previous work.[15] Somewhat higher infection rates in teenagers and young adults as compared to other age groups have been observed in many studies.[16,17] Similarly, most surveys have found that the sexes were equally affected.[17–19]

The seasonality of Guinea worm disease in northern Uganda did not follow a simple, generalized pattern. Although the middle of the dry season (January–February) was presumed to be the peak transmission season, the annual rainfall of <1500mm would place the surveyed area in the wet-season transmission class.[15] The findings demonstrate that cases occur in both the wet and dry seasons within a small area of Kitgum, and sometimes in the same village. Ponds, reservoirs and valley tanks, and water courses are implicated at both times of year. Ponds and slow-flowing pools in river beds and excavations alongside rivers have been observed to be sources of Guinea worm infection during the rainy season and part of the dry season elsewhere.[4,15] During rainstorms, the Pager River flows full and rapidly, and therefore does not provide a good habitat for *Cyclops*, the intermediate host. However, drinking water is drawn from infiltrated water in excavations alongside the stream as well as from the main current. Also, because we combined smaller tributaries with the Pager into one category, the wet season transmission associated with water courses may also be attributed to sluggish rainy season streams.

This marked and variable seasonality introduces serious difficulties for certain short-term control measures. For instance, chemical control of *Cyclops* requires the timing of applications to the transmission season.[20] The year-round transmission of Guinea worm in this small area would require at the very least continuous monitoring of *Cyclops* populations in all the high-incidence villages. Similary, chemoprophylaxis would require a periodicity determined by the stages of worm development during which a drug is effective. Provision of safe drinking water should limit transmission to all but a few residual foci requiring temporary measures, but parallel seasonality of these foci should not be assumed. Careful epidemiological description of local seasonality must still precede the planning of many auxiliary interventions.

Clearly, a reduced rate of infection accompanies borehole use, even when they are not used exclusively for water collection. This finding is consistent with those of other investigators,[11,12,21] who have shown reduced rates of disease for protected sources of this type in comparison with surface and/or unprotected water sources. Boreholes may have been chosen for convenience rather than any perceived health benefit, since borehole users on average walked less distance to that source than users of other sources travelled. We observed very long queues at most functioning boreholes, which may mean that given their present scarcity they do not always save time. In those villages reporting the use of more than one water source, boreholes were usually among them, indicating that not all those with theoretical access selected them. The river and streams were not necessarily more convenient than other sources in terms of kilometres travelled, but may have been virtually the only place with available water at an acceptable distance at some times of the year. The UNICEF programme goal of one borehole per 200 people is designed to optimize both convenience and use.

A major limitation of surveys for measuring acute diseases is that they yield a snapshot of personal characteristics at a single point in time. They are thus considered more useful for describing permanent or slowly changing personal attributes such as nutritional or immunization status. As an indicator of endemicity, dracunculiasis prevalence suffers from three related problems. The proportion itself is small, resulting in poor precision. The marked seasonality can produce unusually high (as in this survey) or low[12] prevalence estimates. The geographically variable seasonality can result in a survey that misses many endemic villages.

To avoid these problems we relied upon an individual's recall of past disease to yield estimates of past incidence instead of point prevalence. In many ways dracunculiasis lends itself to this approach. A person in an endemic area rarely has any doubt as to the diagnosis[15] since the emergence of a Guinea worm, even in the remote past, is an unforgettable experience.[12] Aided by a local events calendar, we feel that we achieved an accurate estimate of incidence and seasonality from this single survey. These calendars receive broad use as an essential and reliable tool for ascertaining the ages of young children in the absence of documentation.[8,9] Two additional advantages stem from the lack of any obvious acquired immunity to Guinea worm disease. First, since people of virtually all ages can become infected, all those in a cluster are potential subjects, thus minimizing the number of houses to be visited. Second, the incidence estimates closely reflect actual exposure unfettered by variable and unknown levels of immunity characteristic of many infectious diseases.

CONCLUSIONS

1. Within highly endemic areas the cluster survey method used for this study can provide rapid and inexpensive estimates of recent dracunculiasis endemicity.
2. The use of Guinea worm disease incidence as a health status indicator of the impact of UNICEF's borehole drilling programme in Uganda appears appropriate due to the high incidence rates of the disease in the target area and the reduced infection risk associated with borehole use.
3. The variable seasonality and geographical focality emphasize the need for an adequate analysis and understanding of local characteristics of disease transmission before proceeding with supplementary Guinea worm control measures.
4. Because Guinea worm has a clinically distinct presentation, transmission foci can be easily identified and control measures directed at these points.

Borehole drilling in study villages began during October 1984. When possible, a follow-up survey in the same area at the same time of year will be undertaken to demonstrate the impact of the borehole drilling programme on dracunculiasis.

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