Eradication & Control Programs:
Guinea Worm

Sharon Roy, MD MPH
Centers for Disease Control and Prevention

&

Ernesto Ruiz-Tiben, PhD
The Carter Center

February 2009

Prepared as part of an education project of the Global Health Education Consortium and collaborating partners
Learning objectives

1. Understand the life cycle of Guinea worm disease (GWD) and how it affects program activities.
2. Appreciate the morbidity caused by GWD and its social consequences.
3. Outline the risk factors for GWD and its transmission patterns.
4. List the criteria for an eradicable disease and explain how GWD meets these criteria.
5. Outline the key program strategies and interventions used by the Guinea Worm Eradication Program.
Dracunculiasis — Guinea Worm Disease (GWD)

- Ancient parasitic infection
  - Referred to in ancient texts
  - Found in Egyptian mummies
- Waterborne disease
- Caused by the roundworm *Dracunculus medinensis*
- There is no vaccine, nor medical cure, and no immunity to infection.
- Latin name means “little dragon from Medina”
Lifecycle of *Dracunculus medinensis*

Copepod with ingested *D. medinensis* larva. Photo credit: WHO Collaborating Center at CDC archives.

Notes on Lifecycle of Dracunculus medinensis

(1) The cycle of transmission begins when a person drinks water containing copepods (tiny water fleas) that are themselves infected with the larvae of Dracunculus medinensis. (2) Once ingested by humans, the copepods are digested, releasing the D. medinensis larvae that then move to the small intestine. The larvae penetrate the host’s intestinal wall and travel to the connective tissues. (3) The larvae mature and mate 60-90 days after infection. (4) Approximately 10-14 months later, the pregnant adult female worm, now measuring up to one meter in length, creates a painful, burning blister on the skin. (5) When the person immerses this affected body part in cool water to ease the symptoms, the worm detects the temperature change and emerges from the blister to deposit hundreds of thousands of first-stage larvae in the water. Therefore, a single emerging Guinea worm can contaminate a water supply serving many people, resulting in potentially widespread transmission and many new cases of disease. (6) Within three days, the newly-deposited larvae are ingested by certain species of copepods in the water. (7) Over the next 14 days, the first-stage larvae develop within the copepods to become infective (third-stage) larvae. (1) A person who drinks water containing infected copepods starts the cycle anew.

Reference

Infection

• Generally infected with a single worm but infection with multiple worms simultaneously is possible
• No immunity conferred by infection
• Annual re-infection commonly occurs in highly-endemic areas

Guinea worm emerging from a foot (Benin). Photo credit: WHO Collaborating Center at CDC archives.
Clinical Course

• Asymptomatic for about 1 year after infection
  – 1-year incubation period
• Painful blister develops and enlarges over several days
• Worm emergence preceded by systemic symptoms
  – Slight fever, itchy rash, nausea, vomiting, diarrhea, dizziness

Emergence of a Guinea worm from a foot.
Clinical Course

- Pain relief sought by immersion in water
- Blister breaks exposing worm
- Worm emerges most commonly from lower limb
  - However, worms can emerge anywhere on the body

Clinical Course of GWD

People infected with Guinea worm are unaware of their infection for 10-14 months (average, 1-year incubation period). When the pregnant adult worm is ready to emerge, acute systemic symptoms develop (e.g., slight fever, an urticarial rash with intense itching, nausea, vomiting, diarrhea, dizziness), which are related to the formation of a blister. The blister induces a burning pain that causes the patient to seek relief by immersing the affected body part in water. Water immersion also helps to slough off the skin over the blister and expose the worm. When the blister ruptures, the worm emerges and releases her larvae into the water. In 80-90% of the cases, the worm emerges from the lower extremities. However, a Guinea worm can emerge anywhere on the body.

Morbidity

• Pain
• Wound complications
  – Wound infections
  – Cellulitis
  – Abscesses
  – Sepsis
  – Septic arthritis
  – Joint deformities
  – Tetanus

**Morbidity Associated with GWD**

In addition to the pain of the blister, manual extraction of the worm is also exceedingly painful. This process is often further complicated by secondary bacterial infection of the wound. These wound infections can result in cellulitis, abscess formation, systemic sepsis, septic arthritis, deformities or contractures of joints, and even tetanus. If the worm breaks during extraction, an intense inflammatory reaction can occur with more pain, swelling, and cellulitis along the worm tract.


Disability

• Functional disability
  – Impaired mobility
  – Inability to work or attend school

• Disability averages 8.5 weeks
  (range 2–16 weeks)

• Economic losses in the millions of dollars annually

• School absenteeism can exceed 60%

• Disease of poverty and cause of poverty

Boy disabled by Guinea worm disease. Photo credit: WHO Collaborating Center at CDC archives.
Disability Associated with GWD

While the mortality rate is low, functional disability is a common outcome of GWD. Impaired mobility prevents people from working in their fields, tending their animals, going to school, and caring for their families during the worm removal and recovery periods. This disability lasts 8.5 weeks on average but sometimes can be permanent. Negative impacts on agricultural and animal husbandry activities due to disability result in economic losses in the millions of dollars each year. School absenteeism can exceed 60% in some highly endemic villages, not only because children are disabled themselves but also because they are needed to work the fields or tend the animals in place of disabled family members. Therefore, dracunculiasis is both a disease of poverty and also a cause of poverty; 100% of cases occur in the poorest 10% of world’s population without access to safe drinking water and health care.

References


Management of GWD --- Once the blister breaks and the worm is exposed, extraction can take place. This process involves several steps. First, each day the affected body part is immersed in water to encourage further worm emergence. Next, the wound is cleaned. Then, gentle traction is applied to the worm to slowly pull it out; pulling stops when resistance is met to avoid worm breakage. Because the worm can be as long as one meter in length, full extraction can take several days to weeks. The worm is then coiled around a rolled piece of gauze or a stick to maintain some tension on the worm and encourage further worm emergence and also to prevent the worm from slipping back inside. Topical antibiotics are applied to the wound to prevent secondary bacterial infections and the affected body part is then bandaged with fresh gauze to protect the site. Analgesics are given to help ease the pain of this process.

Treatment

- Worm extraction
- General wound care
- No specific treatment for GWD
  - No drug
  - No vaccine

Only way to prevent infection is to prevent exposure.

Guinea worm extraction from leg.
Photo credit: 2001 The Carter Center.
Epidemiology of GWD — Part 1. Because *D. medinensis* larvae need a period of 12-14 days to develop inside the copepods and become infective, GWD is not normally caught from drinking flowing water, like rivers and streams. Instead, infection occurs by drinking stagnant untreated water such as ponds, cisterns, pools in drying riverbeds, and shallow unprotected wells. Anyone who drinks from these water sources can become infected.

**References**
Epidemiology

- Risks for disease vary and reflect how and where people get drinking water
  - Sex
    - Roughly equal risk for male and females
  - Age
    - Can affect any age group but more common in young adults
  - Occupation
    - Farmers and those who fetch water at greater risk
  - Ethnicity
    - Some groups at higher risk

**Epidemiology of GWD — Part 2.** The risk for GWD varies by sex, age, occupation, and ethnicity. These differences reflect how and where people get their drinking water in different areas, countries, and cultures. For the most part, GWD is distributed roughly equally between males and females and occurs in all age groups although, in general, it is more common among young adults (ages 15-45 years). This may be a reflection of the types of work persons in this age range perform. Farmers and those fetching drinking water for the household generally become infected more frequently, perhaps because they are more likely to drink from stagnant potentially-contaminated water sources while away from the household. In certain endemic areas, GWD disproportionally burdens particular ethnic groups.

Epidemiology

• Greatest risk for GWD is having had GWD in the previous year
  • Recurrent contamination of water supply?
  • Host susceptibility?

GW extraction. Photo credit: Emily Staub, 2001, The Carter Center.
Notes on the Epidemiology of GWD — Part 3

The greatest risk for developing GWD is having had GWD in the previous year. Infection does not produce immunity, and many people in affected villages suffer disease year after year. This increased risk is likely because the same water source used in the current year was also used and contaminated in the previous year and because conditions favoring transmission have remained unchanged. It may also be related to host susceptibility. Not everyone drinking from the same water supply will contract GWD; a minority of people seem to develop recurrent infection while others drinking from the same water supply do not.

References
Epidemiology

- **Seasonality of Transmission in Africa**
  - **Arid regions**
    - Ethiopia, Mali, Niger, northern Nigeria, and Sudan
    - Transmission occurs in rainy season when stagnant surface water is available
  - **Wet Regions**
    - Ghana and southern Nigeria
    - Transmission occurs in dry season when surface water is drying up and becoming stagnant

**Seasonality** ---- GWD occurs mostly in the dry savannah areas of countries in the Sahel region of Africa. November–April, the dry season, are the peak transmission months in countries in the southern Sahel, e.g., Ghana. June–October, the rainy season, are the peak transmission months in countries on the northern fringe of the Sahel, e.g., Sudan.

Global Eradication Campaign

1980

US Centers for Disease Control and Prevention (CDC) suggested that eradication of GWD, a disease only transmitted via drinking water, would be the ideal indicator of the success of the United Nations 1981–1990 International Drinking Water Supply and Sanitation Decade (IDWSSD)
Global Eradication Campaign

1981

GWD eradication adopted as a sub-goal of the United Nations 1981–1990 International Drinking Water Supply and Sanitation Decade (IDWSSD)
Global Eradication Campaign

1984

The Centers for Disease Control and Prevention designated the WHO Collaborating Center for Research, Training, and Eradication of Dracunculiasis.
Global Eradication Campaign

1986

World Health Assembly adopted a resolution to eradicate GWD

- Eradication defined as confirmed absence of clinical manifestations (interruption of transmission) for 3 or more years
Disease Incidence in 1986

• 20 GWD-endemic countries
• Global incidence of GWD estimated to be 3.5 million cases annually
• Most cases occurring in sub-Saharan Africa
  – Estimated 3.2 million cases annually
  – Additional 120 million people at risk for GWD
Global Eradication Campaign

• Criteria for eradication
  – Biologically and technically feasible
    • Natural history of *D. medinensis* known
    • No known animal reservoir
    • No human carrier state beyond 1-year incubation period
    • Easily diagnosed, facilitating identification in place and time
      – Unique clinical presentation
      – Well-known name in local languages
      – Seasonal occurrence
    • Field-proven interventions and surveillance strategies
Notes on the Criteria for Disease Eradication — Part 1

GWD was selected by the World Health Assembly (WHA) as a target for eradication because it met specific criteria. First, it is biologically and technically feasible to eradicate this disease. The natural history of *D. medinensis* has been described and it has no known animal reservoir and no human carrier state beyond the 1-year incubation period. Therefore, there would be no chance for the disease to return after the last human case is eliminated. GWD is easily diagnosed because of its unique clinical presentation. In fact, it is so well-known and recognized by the general population that it usually has its own unique name in the local languages of endemic areas. The ease of diagnosis and the seasonal occurrence of GWD make it is easily identified in place and time, thereby facilitating disease surveillance and intervention activities. Prior to the WHA resolution to eradicate this disease, GWD had already been deliberately eliminated from parts of the former USSR during the 1920s and from endemic areas of Iran in the 1970s by using three proven ways to prevent disease: (1) provision of safe water, (2) health education about water treatment through filtration or boiling and about prevention of water contamination, and (3) chemical treatment of contaminated water.

References


Global Eradication Campaign

• Criteria for eradication

  – Costs and benefits
    • 29% economic rate of return for GWD eradication
    • Coincidental benefits
      – Safer water supplies
      – Trained community health workers
    • Intangible benefits
      – Culture of disease prevention
      – Social equity
Notes on the Criteria for Disease Eradication — Part 2

In considering the second set of criteria for eradication, the benefits of eradicating GWD were judged to outweigh the costs. In 1997, the socio-economic impact of GWD was quantified by the World Bank in an assessment of the benefits of eradication. This study compared the estimated costs of the eradication campaign with the estimated increase in agricultural productivity resulting from prevention of GWD transmission. Using a campaign horizon of 10 years and a conservative assumption about the average incapacitation caused by GWD (5 weeks), the Economic Rate of Return (ERR) for GWD eradication was calculated to be 29%. The World Bank considers ERRs in excess of 10% to indicate a sound economic return.

Other benefits of GWD eradication, in addition to morbidity reduction, would include improvements in water supplies (which would no longer be contaminated with D. medinensis) and the development of a cadre of trained health workers established in communities as part of the eradication program who would also be capable of delivering other basic health services.

The direct benefits of eradication would be limited almost exclusively to countries and communities in which GWD is endemic. However, the global community would also benefit indirectly from the enhanced culture of disease prevention and social equity that this disease eradication program would provide. Countries and organizations supporting the eradication effort would be helping to reduce the suffering of some of the world’s most underprivileged people.

References

Global Eradication Campaign

• Criteria for eradication
  – Societal and political considerations
    • Strong support in endemic communities
    • Variable political will, even in endemic countries
    • Limited international donor support

Nevertheless, World Health Assembly adopted a resolution to eradicate GWD.
While support for eradication was felt to be strong in endemic communities, there were political and societal barriers to eradication that were also considered in the WHA deliberations. Political support for GWD eradication was and continues to remain variable even in endemic countries and international donor support for eradication efforts was and is difficult to maintain for this neglected tropical disease (NTD). NTDs disproportionately affect the poorest populations, frequently living in remote rural areas or conflict zones. These people often have little political voice and, therefore, diseases such as GWD generally have a low profile and status in the list of public health priorities.

Nevertheless, WHA adopted a resolution to eradicate GWD.

Reference

Global Eradication Campaign

1986

- The Carter Center took the lead for the global Guinea Worm Eradication Program (GWEP)
  - Coalition of partners
  - Thousands of village volunteers and supervisory health staff
  - Supported by numerous donor agencies, foundations, institutions, and governments
GWEP Interventions

• All interventions focus on prevention of GWD transmission
  – Surveillance (case detection and case containment)
  – Health education and community mobilization
  – Vector control using a chemical larvicide (temephos)
  – Provision of safe sources of drinking water
Safe Water

• Borehole well
• Protected deep well/spring
  – Has surrounding wall and cap to prevent people from entering water
• Stream/river
  – Flowing water

Borehole well in Sierra Leone.
Photo credit: Sharon Roy, 2006, CDC.
Safe Water

- GWEP advocates for provision and rehabilitation of safe water supplies

- GWEP monitors status of safe water in each endemic village

Safe water supply. Photo credit: WHO Collaborating Center at CDC archives.
Water Treatment with Cloth Filters

• Fine, 100x100 micron nylon mesh cloth filters provided to households in endemic communities

• Copepods strained from unsafe water sources before water is consumed

Guinea worm filter cloths. Photo credit: WHO Collaborating Center at CDC archives.
Water Treatment with Pipe Filters

• Pipe filters provided for drinking water while away from household
Case Containment

• Patient is prevented from contaminating water and transmitting GWD
• 4 criteria for successful containment
  – Case detected within 24 hours of worm emergence
  – Patient did not entered water
  – Patient received proper treatment
  – Case and treatment verified by supervisor within 7 days of worm emergence
Vector Control

• Abate® larvicide (temephos) applied to selected unsafe (contaminated) sources of drinking water to kill copepods

Applying Abate® to a water supply. Photo credit: WHO Collaborating Center at CDC archives.
Health Education & Community Mobilization

- Educate communities about GWD
- Empower villagers to take action
  - Preventing water contamination
  - Using water filters
- Inform communities about Abate® and its use

GWEP Village Volunteers

- Identify, contain, and treat cases
- Distribute filters
- Provide health education
- Report cases

Educating Ghanaian children about GWD.
GWEP Village-Based Surveillance

- Monthly reporting of cases by village volunteers
- Data transmitted to national GWEP headquarters through supervisors
- Surveillance data used to monitor program
  - Assess case distribution and areas of transmission
  - Target program resources
Number of Reported GWD Cases by Year 1989–2008*

* Provisional data
Notes on Progress Towards GWD Eradication

This graph represents data gathered through this village-based surveillance system and shows the annual number of reported cases worldwide since 1989. The number of annual cases has decreased by more than 99% since the beginning of the GWEP. In 2008, there were 4,643 provisional GWD cases reported: 4,639 indigenous cases in endemic countries and 4 cases exported to non-endemic countries. Of the 4,643 cases, more than 98% were reported from three countries (Sudan, Ghana, and Mali). Sporadic violence and insecurity in GWD-endemic areas in Sudan and Mali currently pose the greatest challenges to the success of the global eradication campaign.

Reference
Notes on the Endemic and Formerly-Endemic Countries in 2008

Among the 20 countries that were GWD-endemic at the beginning of the GWEP in 1986, only six countries remained endemic at the end of 2008: Sudan, Ghana, Mali, Ethiopia, Nigeria, and Niger. More than three quarters of the remaining GWD cases occurred in Sudan, a country that until recently has been plagued by a civil war that decimated the infrastructure in the southern part of the country where GWD is still endemic. As peace and stability slowly come to Sudan and as infrastructure is built, the GWEP is gaining greater access to endemic areas and intensifying its activities.

In 2008, 14 of the original 20 endemic countries no longer had GWD transmission within their borders. The year the last indigenous case was reported in each of these countries in indicated on the graph.

In 2008, GWD transmission was confined to three areas in sub-Saharan Africa, with the greatest intensity of transmission occurring in southern Sudan, northern Ghana, and eastern Mali. The goal of global eradication is in sight.

* Provisional; excludes 4 cases of Guinea worm disease exported from one country to another (Niger 1, Burkina 1, Ethiopia 2). Sudan only includes data from Jan - Aug.
International Commission for the Certification of Dracunculiasis Eradication (ICCDE)

- Established by WHO in 1995
- Includes a panel of international GWD specialists
- Advises WHO on criteria and procedures to verify absence of GWD transmission in a country
- Recommends certification of eradication for countries that fulfill those criteria
Demonstration of Interrupted GWD Transmission

1. Adequate active surveillance has confirmed absence of GWD for $\geq 3$ years
2. Rumor log of suspected cases maintained for $\geq 3$ years
   – All alleged cases investigated and contained (if confirmed)
3. Any imported cases have been traced and contained

Notes on the Demonstration of the Interruption of GWD Transmission

The International Commission for the Certification of Dracunculiasis Eradication (ICCDE) considers transmission of GWD to have been halted in a country when:

1. Adequate active surveillance system has confirmed the absence of GWD for three or more years, based on careful annual searches carried out during the expected transmission season. Additionally, the GWD surveillance system must be capable of detecting any cases of GWD, should they occur;
2. A rumor log of suspected cases has been maintained for a 3-year period detailing the particulars of each case, the origin of each case, and whether the suspect case was determined to be GWD or some other condition; and
3. Any confirmed cases imported from endemic countries have been traced to their origins and have been fully contained.

Process for Eradication Certification

1. Country must demonstrate interrupted GWD transmission
2. International Certification Team must visit country, assess surveillance, review records, conduct case search, and write report for consideration by ICCDE
3. Country must submit additional report to ICCDE detailing history of national GWD eradication campaign
4. ICCDE recommends to WHO Director General whether country should be certified free of GWD
5. WHO Director General makes formal announcement
Notes on the Process for Eradication Certification

There are five steps in the process of certifying a country as being free of GWD:

1) The country must demonstrate that transmission of GWD has been halted by meeting the criteria described on the previous slide.
2) An International Certification Team (ICT) must visit the country, assess the sensitivity of the surveillance system, review the historical records, visit the most likely places where GWD might be occurring and conduct case searches, and write a report for consideration by the International Commission for Certification of Dracunculiasis Eradication (ICCDE).
3) In addition to the ICT report, the country must also submit a report to the ICCDE detailing the history of the national GWD eradication campaign.
4) If the ICCDE determines that the first three steps have been successfully completed, it recommends to the WHO Director General that the country be certified as being free of GWD.
5) The WHO Director General then makes a formal announcement of GWD eradication certification for that country.

Once certification is achieved, GWEP interventions and preventive measures can be reduced to a minimum.

Reference
Certification of GWD Eradication as of January 2008

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

© WHO 2008. All rights reserved.
Status of GWD Eradication Certification as of January 2008

As of January 2009, the ICCDE had certified 180 countries free from GWD, including 6 of the 20 countries that were GWD-endemic at the beginning of the GWEP in 1986:

• Pakistan — last indigenous case 1993; certified in 1996
• India — last indigenous case 1996; certified in 2000
• Senegal — last indigenous case 1997; certified in 2004
• Yemen — last indigenous case 1997; certified in 2004
• Cameroon — last indigenous case 1997; certified in 2007
• Central African Republic — last indigenous case 2001; certified in 2007

Of the remaining 14 countries originally in the GWEP, eight are under pre-certification surveillance and six remained endemic (Ethiopia, Ghana, Mali, Niger, Nigeria, Sudan) as of January 2009. Ethiopia suffered an outbreak of GWD in 2008 and is again considered to be an endemic country.

Reference

Conclusion - Slaying the Little Dragon

- GWD poised to be next disease eradicated after smallpox
- Eradication achieved without vaccines or medicines
- Symbol of medicine will have new significance

Many believe symbol of medicine (caduceus) shows GW wrapped around stick.

Extracting a Guinea worm from the ankle by wrapping it around a stick. Photo credit: WHO Collaborating Center at CDC archives.
Credits

• **Sharon Roy**, MD MPH
  Director, WHO Collaborating Center for Research, Training, and Eradication of Dracunculiasis
  Centers for Disease Control and Prevention

• **Ernesto Ruiz-Tiben**, PhD
  Director, Guinea Worm Eradication Program
  The Carter Center
The Global Health Education Consortium gratefully acknowledges the support provided for developing these teaching modules from:

Margaret Kendrick Blodgett Foundation  
The Josiah Macy, Jr. Foundation  
Arnold P. Gold Foundation

This work is licensed under a Creative Commons Attribution-Noncommercial-No Derivative Works 3.0 United States License.