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A Retrospective Review of the Guinea Worm Eradication Program's Contribution to the Achievement of the Millennium Development Goals

By
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Degree to be awarded: M.P.H.
Career MPH

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Abstract

A Retrospective Review of the Guinea Worm Eradication Program's Contribution to the Achievement of the Millennium Development Goals

By Birgit Bolton

This thesis provides a forum to discuss the contribution of The Carter Center's (TCC) Guinea Worm Disease Eradication Program (GWDEP) to selected Millennium Development Goals (MDGs). In 2000, the United Nations Millennium Summit convened with 189 Heads of State committed to improving the health of the global population, and promulgated the MDGs.[1-3] The MDGs consist of eight goals encompassing 21 targets that address hunger and poverty, education, gender equality, child and maternal health, disease burden, the environment and global partnerships.[4] At the time of the MDGs inception, there were 14 GWD endemic countries: Benin, Burkina Faso, Cameroon, Central Republic Africa, Cote D'Ivoire, Ethiopia, Ghana, Mali, Mauritania, Niger, Nigeria, Sudan, Togo, and Uganda.[3,5] NTDs are not specifically addressed in the MDGs, but instead fall under the rubric of "other diseases".[4]

Infectious diseases have influenced the development of human species more than any other biological or non-biological factor.[6] NTDs are considered the most common infectious diseases of the world's poorest people.[7] An estimated 1.2 billion people are infected with one and sometimes more than one NTD. Most of these infected individuals are among the billion people who live on less than $1 per day, a population often referred to as the "bottom billion".[8]

Even though NTDs can be cost effectively prevented, the international health community has historically directed more resources, funds and efforts to combating the "big three" – HIV/AIDs, tuberculosis (TB), and malaria.[9,10] There is currently no formal forum that focuses on the control and/or elimination of NTDs as one strategy for achieving some of the MDGs. Researching this topic and publishing an article provides an opportunity to highlight the significance of combating NTDs and the impact this effort has on global health issues, and the attainment of the MDGs.

A Retrospective Review of the Guinea Worm Eradication Program's Contribution to the Achievement of the Millennium Development Goals

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## CHAPTER I: INTRODUCTION

### *SIGNIFICANCE OF THE PROJECT*

This thesis provides a forum to discuss the contribution of The Carter Center's (TCC) Guinea Worm Disease Eradication Program (GWDEP) on selected Millennium Development Goals (MDGs). Though some studies show the MDGs to be insufficiently articulated and documented, they are nonetheless universally recognized and accepted by the global health community as a benchmark of progress.[11] Given the prominence of MDGs in the development of global health agendas, it is therefore important to consider how a data-driven public health program, such as GWDEP, can contribute to the attainment of the MDGs. Currently literature searches conclude that very little has been published on how combating a Neglected Tropical Disease (NTD) such as Guinea Worm Disease (GWD) can result in measureable contributions towards achieving the MDGs.

### *RATIONAL FOR ARTICLE AND TARGETING JOURNAL*

There is currently no formal forum that focuses on the control and/or elimination of NTDs as one strategy for achieving some of the MDGs. Researching this thesis topic and publishing an article provides an opportunity to further highlight the significance of combating NTDs and the impact this effort has on global health issues, and the attainment of the MDGs. It is hopeful this publication will promote interest with public health advocates, donors and global health entities, as well as further intellectual discussion, additional research efforts, and publications on the importance of alleviating and preventing NTDs as a strategy for achieving MDGs.

The five journals targeted for the publication of the attached draft article are: International Journal of Infectious Diseases, Journal of American Medical Association (JAMA), Public Library of Science (PLoS), Scientific American, and The Lancet. Publication in one of these journals ensures this research reaches the most receptive public health audience such as public health advocates, program implementers and managers, policy related agencies, infectious disease scientists, and private donors (i.e. The Gates Foundation). In researching the journal guidelines, notes for authors and publication statistics on the research topic, the five aforementioned journals were deemed appropriate periodicals to target for publication in the immediate future. Submission efforts will begin immediately after the supporting authors' final comments and approval of the draft article. At that time, the article will be submitted to the journal determined to be the most relevant. If the article is not accepted, the next appropriate of the four journals will be approached. The journals under consideration allow for 3,000 words, several tables and graphics in Research or Perspective sections of the journals.

*BACKGROUND*

*Millennium Development Goals*

In 2000, the United Nations Millennium Summit attended by 189 Heads of State, committed to improving the health of the global population, and promulgated the MDGs.[1-3] The MDGs consist of eight goals encompassing 21 targets that address hunger and poverty, education, gender equality, child and maternal health, disease burden, the environment and global partnerships (See Table 1).[4] When the MDGs were adopted, there were 14 GWD endemic countries: Benin, Burkina Faso, Cameroon, Central

Republic Africa, Cote D'Ivoire, Ethiopia, Ghana, Mali, Mauritania, Niger, Nigeria, Sudan, Togo, and Uganda.[3]

*TABLE 1: MDGS and TARGETS*

| Millennium Development Goals (MDGs) | Targets |
|---|---|
| **Goal 1: Eradicate Extreme Hunger and Poverty** | Target A: Halve, between 1990 and 2015, the proportion of people whose income is less than US $1 a day<br><br>Target B: Achieve full and productive employment and decent work for all, including women and young people<br><br>Target C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger |
| **Goal 2: Achieve Universal Primary Education** | Target A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling |
| **Goal 3: Promote Gender Equality and Empower Women** | Target A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015 |
| **Goal 4: Reduce Child Mortality** | Target A: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate |
| **Goal 5: Improve Maternal Health** | Target A: Reduce by three quarters the maternal mortality ratio<br><br>Target B: Achieve universal access to reproductive health |
| **Goal 6: Combat HIV/AIDs, Malaria and Other Diseases** | Target A: Have halted by 2015 and begun to reverse the spread of HIV/AIDs<br><br>Target B: Achieve, by 2010, universal access to treatment for HIV/AIDs for all those who need it<br><br>Target C: have halted by 2015 and begun to reverse the incidence of malaria and other major diseases |
| **Goal 7: Ensure Environmental** | Target A: Integrate the principles of sustainable development into country policies and programs and reverse |

| | |
|---|---|
| **Sustainability** | the loss of environmental resources<br><br>Target B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss<br><br>Target C: Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation<br><br>Target D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers |
| **Goal 8: Develop a Global Partnership for Development** | Target A: Develop further an open, rule-based, predictable, nondiscriminatory trading and financial systems<br><br>Target B: Address the special needs of least developed countries<br><br>Target C: Address the special needs of landlocked developing countries and small island developing States<br><br>Target D: Deal comprehensively with the debt problems of developing countries<br><br>Target E: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries<br><br>Target F: In cooperation with the private sector, make available benefits of new technologies, especially information and communication technologies |

*Significance of Neglected Tropical Diseases*

Infectious diseases have influenced the development of human species more than any other biological or non-biological factor. They have influenced not only our biology, but also history and political development, from the outcome of wars to success of empires, and from the pace of technological advance to the structure of society itself.[6]

NTDs are considered the most common infectious diseases of the world's poorest people.[7]

An estimated 1.2 billion people are infected with one and sometimes more than one NTD, with most of these individuals among the billion people who live on less than $1 per day, a population often referred to as the "bottom billion".[8] NTDs are a group of parasitic and bacterial diseases that cause substantial illness by impairing physical and cognitive development; of which, seven can be controlled or potentially eliminated through mass administration of safe and effective medicines or other effective interventions.[7] The toll of NTDs on individuals, communities, and societies extends beyond physical suffering to the economic burden of medical expenses, as well as the indirect cost of lost productivity, ultimately hampering economic development where it is most needed and trapping the poor in a cycle of poverty and disease.[12] Moreover, affected individuals often suffer from multiple NTDs, compounding their personal burden and disability.[13] This hinders a country's progress, rendering it unable to affectively address issues and establish the necessary public health infrastructure required to combat the underlying issues of poverty such as disease burden, hunger, and the provision of consistent clean water and sanitation systems.[12]

NTDs are not specifically addressed in the MDGs, but instead fall under the rubric of "other diseases", Goal 6: Combat HIV/AIDs, Malaria and Other Diseases.[4] Even though NTDs can be cost effectively prevented, the international health community has historically directed more resources, funds and efforts to combating the "big three" – HIV/AIDs, tuberculosis (TB), and malaria.[9,10] Emerging evidence shows people infected with NTDs are more susceptible to becoming infected with the "big three".[14]

Additionally, this evidence also indicates that co-infection with one or more NTDs may adversely and exponentially affect the health outcome of having one of the "big three" diseases.[14]

Only in recent years have NTDs received significant attention from the global health community. In 2008, President Bush announced the Presidential Initiative for Control of NTDs. This five-year initiative made $350 million available for integrated treatment of seven major NTDs. This initiative builds on USAID's existing NTD Control Program and will ultimately treat 300 million people in Africa, Asia, and Latin America.[15] Additionally, President Obama delivered his July 11, 2009 speech in Accra, Ghana that reiterated his Administration's pledge of $63 billion for a new Global Health Initiative, which includes support for the fight against NTDs.[16] Other initiatives include GET2020, which is the Alliance for Global Elimination of Trachoma by the year 2020, and the inception of the SAFE (Surgery, Antibiotics, Facial Cleanliness and Environmental change) strategy, an innovative public health approach designed to treat and prevent trachoma.[17,18]

*Guinea Worm Disease Eradication Program and Epidemiology*

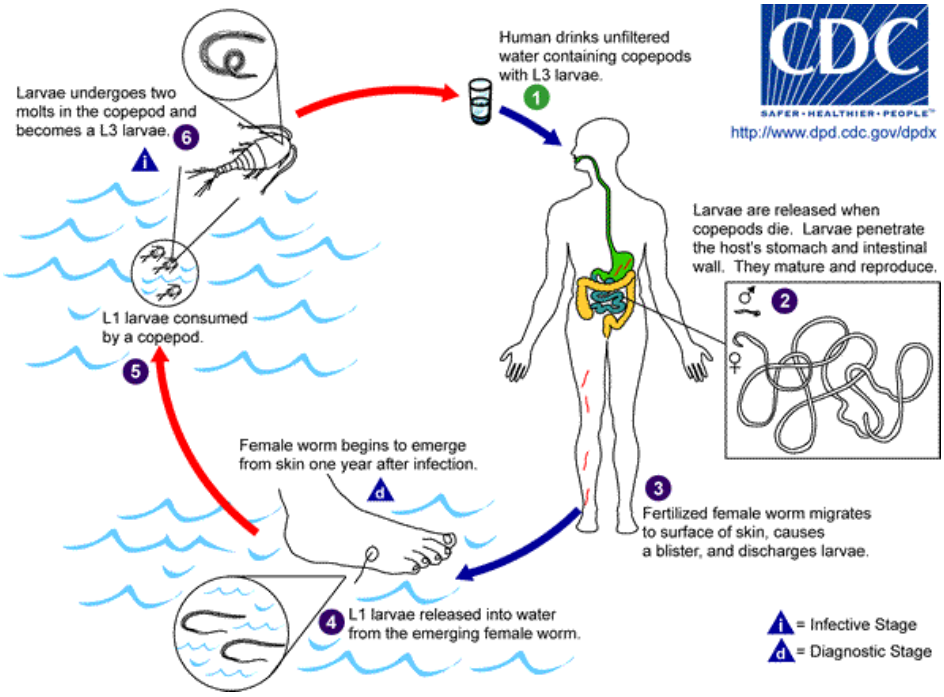
The Carter Center's International Health Programs are dedicated to alleviating unnecessary suffering by fighting and preventing diseases with a particular focus in NTD implementation, research and impact.[19,20] "TCC health programs are data-driven and seek to help fill gaps in health care by seeking out opportunities to eliminate or eradicate disease where possible, and to control diseases that cannot be completely eliminated".[20] TCC partners with Ministries of Health (MOH) from African and Latin American countries to implement eradication, elimination, and control programs for the most

debilitating NTDs by offering intervention and research expertise, cutting edge technical support and material assistance. TCC's international health programs specifically address health issues that provide a positive health and development return for affected individuals, communities and countries. While all of the TCC international health programs are instrumental in making progress towards achieving the MDGs by the 2015 deadline, this paper will specifically focus on TCC's flagship health program – the Guinea Worm *(dracunculiasis)* Disease Eradication Program (GWDEP) and its contributions towards achieving certain MDGs.

Dracunculiasis, or GWD, is a disease of the poor, debilitating many in the most remote and disadvantaged communities in Sub-Saharan Africa, where access to potable water is limited and health care and education are lacking.[21] GWD is a preventable, painful, incapacitating, water-borne helminthic disease with multiple adverse consequences on health, agriculture, school attendance, and overall quality of life.[22] GWD affects people living in many rural areas of Africa who do not have access to protected water supplies.[23] GWD is transmitted when humans drink water, usually from stagnant ponds, containing tiny copepods that have ingested immature larva of the parasite. Once consumed the male and female larvae mate, and unbeknownst to their host, grow to an average of two to three feet in length. A year later, the fully-grown female worm rises to the skin in search of a water source to lay her eggs.[21] When the emerging worm is exposed to water, it ejects hundreds of thousands of larvae into the water to continue the cycle. Infected persons may be incapacitated for 2-3 months by an emerging worm (See Image 1).[24] GWD takes its toll not through death, as the disease is rarely fatal, but rather through devastating pain and infection. The pain is so long-lasting

that infected individuals can experience pain 12 to 18 months after the GW emerges. The disease's other symptoms include nausea, vomiting, diarrhea, and dizziness, which further exacerbates the burden. Furthermore, secondary bacterial infections occur in about half of all cases and can lead to arthritis, tetanus, and permanent crippling. GWD is, therefore, considered a perpetrator (and indicator) of extreme poverty.[21,25]

*IMAGE 1: GUINEA WORM LIFE CYCLE*




There is no effective treatment, cure or vaccine, and people do not become immune to this parasite.[24] However, since there is no evidence that animals have ever acted as reservoir hosts for GWD, it is deemed a good candidate for eradication.[26] The global eradication campaign began at the Centers for Disease Control and Prevention (CDC) in 1980, and was then adopted as a sub-goal of the United Nations International Drinking-Water Supply and Sanitation Decade (1981-1990). Since 1986, TCC has led the

effort with the help of the CDC, and many other donors and nongovernmental organizations, as well as governments of the countries where GWD is endemic.[24] GWD has been suggested as one of the most cost-effective health interventions available.[27] However, since the disease generally occurs in isolated rural areas and is usually not fatal, it is often considered to be a mild affliction that does not warrant a widespread public health campaign.[27] Nonetheless, the public health effort to eradicate GWD is producing greater effects than just the eradication of the disease, namely contributions towards attaining certain MDGs.

## *RESEARCH QUESTIONS*

### *Research Objective*

This research effort, a multi-method review of the GWDEP's contribution to the achievement of the MDGs, focused on the GWDEP's positive impact on MDGs 1-8. After careful review, this research utilized the word 'contribution' to denote positive impact towards achieving the MDGs. In Webster's dictionary, 'contribute' is defined as "to play a significant part in bringing about the end or result", and is therefore utilized in this research as a term of measurement relating to achievement, development, impact and progress.

### *Research Questions*

Research questions considered in this investigation are:

- Is TCC's GWDEP making a beneficial contribution towards achieving the MDGs?
- What indicators and measures of success are used to determine this contribution?

- Will the GWDEP continue to positively impact the MDGs after the eradication effort is complete?
- Can the eradication of one NTD, such as GWD, make a contribution towards improved global health as defined in the MDGs?

## CHAPTER II: METHODOLOGY

### *LITERATURE REVIEW*

This thesis required a retrospective review of three separate areas in the scientific literature of both peer reviewed and non-peer reviewed literature. The first was a review of the MDGs; the second GWD and the GWDEP; the third a review of indictors used by selected global health initiatives such as MDGs, TCC and UNICEF.

Literature and journal searches were performed using databases PubMed and ScienceDirect. Keywords included, but were not limited to: *Agriculture, Big Three, Cost, Cost Effectiveness, Dracunculiasis, Economic Impact, Education, Eradication, Gender Equality, Guinea Worm, Impact, Indicators, Millennium Development Goals (MDGs), Neglected Tropical Diseases (NTDs), Poverty, Productivity, School-Absenteeism* and *The Carter Center.* References listed in articles were also reviewed to ensure that all relevant articles were considered.

#### *Millennium Development Goals*

The investigator conducted a systematic literature review of the MDGs and the respective targets. Country specific data published by the United Nations Children Fund (UNICEF) in the State of the World's Children reports and the MDGs progress reports were reviewed and assessed against the internationally recognized health objectives of the MDGs to evaluate the progress made by the countries receiving GWD assistance from TCC.

#### *Guinea Worm Disease and Guinea Worm Disease Eradication Program*

The investigator reviewed literature describing GWD in order to understand the dynamics of the disease. Additionally, a review of the GWDEP program literature and documentation was conducted. The investigator also reviewed and assessed program data from TCC's GWDEP, beginning with the inception of the program in 1986 through 2010 (pre and post 2000 inception of the MDGs). Data were culled from partnering countries' MOH and TCC's GWDEP's yearly progress reviews, yearly summary proceedings and twenty-four years of monthly Guinea Worm Wrap-up reports. The literature reviews and program reports were examined for quantitative, qualitative and anecdotal information on program implementation, status, progress and impact. Seven in-person interviews using an informal key informant questionnaire consisting of twenty-seven open-ended questions were conducted and recorded with various experts, including resident epidemiologists, program managers and directors from TCC (See Appendix for questionnaire).

*Global Health Indicators*

The investigator conducted a review of global health indicators used by several global health initiatives. Indicators and reports from the MDGs, The Training and Eradication of Dracunculiasis (TCC), WHO Collaborating Center for Research on GWD, and UNICEF's State of the World's Children were researched and assessed.

*METHODS*

*Selection of Relevant Indicators*

For the purpose of this research, relevant indicators are defined as indicators that are deemed measureable in relation to the MDGs and GWDEP. The following indicators were initially considered: proportion of population below $1 per day (MDG 1), reduction

in the number of new GWD cases reported (MDG 1), prevalence of underweight children under-five years of age (MDG 1), net enrollment ratio in primary education (MDG 2), increase in women in wage employment (non-agricultural sector) (MDG 3), decrease in under-five mortality rate (MDG 4), decrease in maternal mortality (MDG 5), number of new GWD cases averted (MDG 6), proportion of population using an improved drinking water source (MDG 7), and increase in global partnerships (MDG 8).

After a thorough review of the indicators and the research objectives, it was only possible to use the following indicators: data on population impacted (MDGs 1-8), reduction in the number of new GWD cases reported (MDG 1 & 6), increase in primary education enrollment (MDG 2), increase in women in wage employment (non-agricultural sector) (MDG 3), decrease in under-five mortality rate (MDG 4), decrease in maternal mortality (MDG 5), number of new GWD cases averted (MDG 6), and increase in population using an improved drinking water source (MDG 7).[28] After careful review of MDG 8 and its targets, it was determined the GWDEP efforts do not fully meet the definition of global partnerships, and was therefore removed as a measureable indicator. Subsequent details on this decision are provided in the Results section. Furthermore, the word 'proportion' was also removed from the definition of elected indicators, as current data are not available to make this analysis. The eight indicators that were ultimately selected were derived from the MDGs, TCC's GWDEP and UNICEF's State of the World's Children as a basis to calculate results on how GWDEP outputs contribute to public health impacts and ultimately the MDGs.

*Geographic Focus:*

This paper's research encompassed the twenty countries where TCC has worked to eradicate GWD: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Ethiopia, Ghana, India, Kenya, Mauritania, Mali, Niger, Nigeria, Pakistan, Senegal, Sudan/South Sudan, Togo, Uganda and Yemen.

## CHAPTER III: RESULTS

Results described in this section are the culmination of investigative efforts and include an overview of the data collected and the beneficial health impacts on the target population. Furthermore, these results provide supporting evidence on how the indicators selected can show a correlation between GWDEP's health outcomes (i.e., reduction in the number of new GWD cases reported and averted) as contributions that can make progress towards attaining the MDGs. Analysis of this data is organized and presented by each MDG and the respective indicators. MDGs referenced outside of the MDG in review are notated by (MDG X).

### *ANALYSIS OF DATA COLLECTED*

#### *MDG 1: Eradicate Extreme Hunger and Poverty*

At the inception of the MDGs in 2000, there were 14 African countries still endemic to GWD reporting a total of 75,223 cases. However, it is believed that actual case numbers were significantly higher than reported due to access issues in many of the 14 countries, specifically Central Republic of Africa, Ethiopia and Sudan.[29] The economic burden inflicted on poor rural communities is severe and is compounded by the seasonal nature of GWD and its high prevalence in affected communities. Cyclical weather patterns and planting and harvesting seasons lead to peak periods when water in contaminated ponds and wells is widely consumed. A year later, an entire community can be debilitated and unable to work – a period that often coincides with the busiest agricultural seasons. This phenomenon explains the disease's nickname "disease of the empty granary."[21] Before current GWD eradication efforts got underway in 1970s and 1980s, some settlements in Nigeria and Ghana experienced GWD in 70% of the

population during peak periods affecting all aspects of life: agricultural production, child health and childcare (MDG 4), school attendance (MDG 2), and other daily social and economic activities.[30] Because few alternative labor sources are available for incapacitated farmers, a marked reduction in agricultural output occurs.[31] In 1989, researchers documented that in one area of Nigeria, 58% of GWD patients were disabled for an average of 12.7 weeks during the yam and rice harvest season. Most of these victims were of school or working age, between 15 and 49 years old.[26] Furthermore, research in Mali linked a 5% decrease in production of two critical subsistence food crops of sorghum and peanuts due to GWD, and the annual economic losses to GWD in the three rice growing Nigerian states has been estimated to be over $20 million.[21,24] By the end of 2010, eradication efforts resulted in only four remaining countries (Sudan 1,698, Mali 57, Ethiopia 21, and Ghana 8) endemic to GWD reporting fewer than 1,800 GWD cases.[20]

*MDG 2: Achieve Universal Primary Education*

Poor school attendance has been associated with GWD in Sub-Saharan Africa.[32] Students do not receive a consistent education because they are either too malnourished to attend class, have an emerging GW, or are forced to drop out of school to assist their stricken parents in agricultural or household chores (MDG 1).[26] This is supported by a study that took place in a rural southwest Nigeria community which observed high absentee rates during GWD transmission season. GWD was present in 21% of pupils and was responsible for 25% of days missed throughout the year.[33] However, the provision of alternative potable drinking water sources or access to filters (MDG 7) caused a significant reduction in the prevalence of GWD within three years of intervention. In ten

primary schools in villages that were later provided with boreholes, pre-intervention surveys conducted during peak GWD season in 1983-84 showed GWD related school absences comprised 88% of all absences. The post intervention survey in the 1986-87 revealed only 2.6% of students were absent because of GWD.[32] Furthermore, parents who previously suffered from GWD were now healthy and no longer recalling their children from school for domestic support. Similarly, parents were willing to send their children back to school without the fear that the children would become victims of GWD.[32]

*MDG 3: Promote Gender Equality and Empower Women*

In endemic communities, such as those found in Sub-Saharan Africa, it is traditional for women to perform domestic related roles such as childcare, cooking and cleaning, as opposed to holding jobs outside of the household. In instances where women perform tasks outside of the household, it is typically related to crop production and the subsequent selling of the produce. Women in these poor rural communities are also responsible for water-related activities and health care for their households. Though these responsibilities have been viewed as low status and income related errands, it has been instrumental in providing opportunities that result in improved equality for women.[23] Using this informal yet crucial network of water collection, GWDEP has trained women to carry out GWD surveillance and community education in order to discourage people with emerging worms from entering water sources.[19,20,34] More specifically, Ghana significantly increased its GWD eradication efforts by recruiting more than 6,800 female Red Cross volunteers to help combat GWD, and 2008 program data indicates that 47% of community-based volunteers were women.[20] In Benin, networks of women have been

created for GWD education campaigns to help stop transmission of the disease (MDG 6).[20,24] This effort has also helped improve the quality of water sources for communities that previously lacked access to clean and safe water (MDG 7), created jobs for unemployed and empowered volunteers, and frequently inspired them to pursue health-related employment.[24] Training and networking of women will far outlast the GWD eradication campaign because it can be used for other health programs and interventions.[20]

*MDG 4: Reduce Child Mortality*

In Africa, GWD has been shown to have an adverse impact on cognitive abilities of children, primarily due to malnutrition.[8,35] Furthermore, the decreased access to a dependable food source due to diminished farming productivity also adversely impacts child mortality rates (MDG 4). A study in South Kordofan, Sudan, found that children were almost three times more likely to be malnourished if more than half of the household adults had been affected by GWD the previous year.[26,36]

Research also indicates that a mother with GWD can contribute toward a decline in a child's health or compound existing health issues. For example, GWD and its lesions can hamper the holding, breast feeding and bathing of a child.[23] In most cases mothers reported reducing their children's diet, just as they had decreased their own diet, due to financial constraints imposed by GWD.[37] Furthermore, mothers miss opportunities to immunize their children because they are not mobile enough to make appointments.[23] Schulman (1985) reviewed the impact GWD may have on nutrition, and suggested that improved control of GWD would result in an improvement of nutritional status in affected areas (MDG 1) and thus improved child health.[27]

*MDG5: Improve Maternal Health*

Poor rural African women face a multitude of difficulties as a result of living in a disadvantaged environment. Some of those difficulties include inadequate access to healthcare, subpar nutritional status due to a harsh agricultural environment that limits crop production, and scarce drinkable water sources.[37] Studies on the effects of GWD specific to women have documented that having GWD prevents a woman from performing her basic maternal duties such as household management, childcare and paying jobs outside the home.[37] The financial loss for these women and their families is substantial. Aside from a woman's maternal duties, GWD also impacts her overall health and self-care.[37]

A qualitative study conducted in Oyo and Kwara states of Nigeria shows that gender specific maternal roles such as self-care which is defined as washing, eating, defecating, and treatment of GWD, child care and household tasks are negatively impacted when a mother is inflicted with GWD. Of the maternal functions, self-care was likely to be the most neglected as the mothers were typically reluctant to ask for help. They did not wash themselves or their clothes if it meant asking someone to fetch water for them. And, they often ate sparingly due to the nausea associated with the disease or because they were not mobile enough to go outside to defecate.[23] Moreover, care during pregnancy is also detrimental to the mother in that GWD makes it difficult to travel to a maternity center for prenatal care and delivery. In the aforementioned study, it was reported that four women gave birth during the study period. None of the four women were able to receive adequate antenatal care nor delivered in a healthcare setting. One woman, in particular, was not mobile at all due to a painful GWD ulcer on her buttocks.[37]

*MDG 6: Combat HIV/AIDs, Malaria and Other Diseases*

TCC's GWDEP works with and through MOH in each endemic country in Africa to provide GWD health education interventions. Since a vaccine does not exist for GWD, the GWDEP is an eradication effort that owes the majority of its success to behavioral change health education and interventions. By providing education on the biological causes of the disease, the GWDEP helps people understand how to manage and prevent it.[38] The GWDEP has witnessed that when people are given the proper tools, health education, and supervision there is a dramatic drop in cases.[38]

The possible benefits gained from controlling or eliminating GWD in a community is supported by a study conducted in three villages in Asa, Nigeria, which formerly had prevalence levels of 50% or more, but reduced GWD cases to zero after the implementation of boreholes as a safe drinking water source. Focus group discussion reveled that after the boreholes were introduced none of the women attending had experienced GWD and they all agreed they were healthier than before, and able to better care for their children (MDG 4 and 5), and were able to grow produce for their family and to sell (MDG 1).[23]

*TABLE 2: ERADICATION STATUS*

| Name of Country | Eradication Start Date | Number of Cases Reported at Start Date | Year with highest Reported cases | Number of Cases Reported 2000 (inception of MDGs) | Number of Cases Reported 2010 |
|---|---|---|---|---|---|
| **Benin** | 1987 | 400 | 37,414 | 187 | 0 |
| **Burkina Faso** | 1985 | 458 | 45,004 | 1,262 | 0 |
| **Cameroon** | 1985 | 168 | 871 | 3 | 0 |
| **Central** | 1987 | 1,322 | 1,322 | 33 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| **African Republic** | | | | | |
| **Chad *** | 1986 | 314 | 1,231 | 0 | 0 |
| **Cote d'Ivoire** | 1985 | 1,889 | 8,034 | 290 | 0 |
| **Ethiopia** | 1986 | 3,885 | 3,885 | 59 | 21 |
| **Ghana** | 1985 | 4,501 | 179,556 | 6,567 | 8 |
| **India** | 1983 | 44,818 | 44,818 | 0 | 0 |
| **Kenya** | 1989 | 5 | 53 | 0 | 0 |
| **Mauritania** | 1985 | 1,291 | 8,301 | 84 | 0 |
| **Mali** | 1985 | 4,072 | 16,024 | 292 | 57 |
| **Niger** | 1985 | 1,373 | 32,829 | 1,165 | 0 |
| **Nigeria** | 1886 | 2,821 | 653,492 | 7,818 | 0 |
| **Pakistan** | 1987 | 2,400 | 2,400 | 0 | 0 |
| **Senegal** | 1985 | 62 | 1,341 | 0 | 0 |
| **Sudan*** | 1986 | 822 | 118,578 | 51,515 | 0 |
| **South Sudan*** | | | | 0 | 1,698 |
| **Togo** | 1985 | 1,456 | 10,349 | 828 | 0 |
| **Uganda** | 1985 | 4,070 | 126,369 | 97 | 0 |
| **Yemen** | 1990 | 0 | 94 | 0 | 0 |

**Chad - Interrupted transmission in 1990, however reported a small outbreak in 2010 that is under investigation.*[5]
** South Sudan - Became an independent country from Sudan in 2010 taking with it the GWD cases.*[5]

*MDG 7: Ensure Environmental Sustainability*

In Africa, protected water supplies in the form of boreholes, can reduce prevalence of GWD in affected communities from a standpoint prevalence of ≥ 50% to 0% or near 0% within three years of intervention. The inception of the UNICEF-Assisted Rural Water and Sanitation Project in 1984 marked the first initiative geared towards the elimination of GWD on a permanent basis. GWD is the only disease that can be completely eradicated by provision of protected water supplies, provided these sources are used at all times.[32] In a study conducted in the Kwara state of Nigeria, baseline data taken in 1983-84 indicated 5,134 (59.6%) of the 8,608 individuals surveyed had active

GWD. In a post study evaluation taken 1986-87 after the borehole water intervention, only 742 (11.3%) of the 6,425 participants reported active GWD, a reduction of 81%.[32]

Construction of safe water sources is the most expensive long-term option of all the available interventions. The cost of constructing a borehole well can exceed $10,000 (i.e., $40 per person plus additional maintenance) so it is not always cost effective in many villages with small and/or nomadic populations.[21] Instead another effective and cost efficient way to prevent GWD is to use filters to remove the copepods from drinking water.[19,20] In 2001, TCC's GWDEP and its partners, which included more than 39 implementing international agencies, 16 working groups composed of more than 1,300 people, and many supporting industries, spearheaded the Sudan Pipe Filter Project.[39] In only a few months, the project manufactured for distribution more than 9.2 million GW pipe filters. Between 2001-2010 a total of 16,939,563 household cloth filters and 17,915,000 individual plastic pipe filters were distributed to endemic areas.[20] Additionally, water sources were treated with ABATE©, a safe chemical larvicide, to control the copepods that harbor GW larvae.[19,20,34] By providing trained volunteers, filters for filtering water as well as advocating for safer water sources to international organizations, such as World Vision International, UNICEF and the WHO, for improved drinking water sources, TCC has significantly increased the population using an improved drinking water source in affected areas.

*MDG 8: Develop a global partnership for development*

After careful review of the MDG 8 and its targets, it was determined that the GWDEP only had a weak correlation to MDG 8, Target E which is defined as "in cooperation with pharmaceutical companies, provide access to affordable essential drugs

in developing countries." TCC's GWDEP only distributes ibuprofen and paracetamol to GWD victims for the purpose of reducing inflammation associated with GWD.[40,41] It was therefore decided for the purposes of this research effort that the GWDEP efforts did not fully meet the definition of global partnerships and was removed as a measurable indicator.

## CHAPTER IV: DISCUSSION

*KEY POINTS*

The inception of the MDGs has increased the global commitment to confront the inescapable links between poverty and health, a link that undermines development. When TCC took the leading role in GWD eradication in 1986, a cumulative total of 4.8 million GWD cases were estimated worldwide.[42] At the inception of the MDGs in 2000, there were14 countries still endemic to the disease reporting a total of 75,223 cases. At the end of 2010, there were only four remaining countries (Sudan 1,698, Mali 57, Ethiopia 21, and Ghana 8) endemic to the disease reporting fewer than 1,800 GWD cases.[20] It is estimated TCC's efforts has adverted more than 79 million cases of GWD.[43]

GWD is expected to be the first parasitic disease to be eradicated, and the first disease to be eradicated without vaccines or medications.[44] Eradication is the ultimate 'sustainable' improvement in public health.[45] Had the GWDEP not been initiated, it is estimated that 3.5 million new GWD cases would have occurred annually for a cumulative total of 84 million cases from 1986-2010.[20] The dramatic reduction and eventual eradication of GWD contributes discernible progress to global health for eternity.[46] Aside from GWDEP's contribution to improved water sources in poor and remote communities (MDG 7), the reduction of GWD cases (MDG 6) has, without a doubt, had an advantageous impact on education (MDG 2), disability, agricultural production, income generation and poverty reduction in endemic areas (MDG 1, 4 and 5).[47] Furthermore, the GWDEP is leaving a legacy of progress and development in sync with the MDGs.[24] At a cost of $275 million for the global eradication campaign, the financial cost of the campaign per case averted is estimated to be $3.47. Additionally, the

established GWD community-based surveillance and health education delivery systems are now delivering other health interventions, such as malaria control, diarrheal disease and immunization programs thus making continual contributions towards achieving the MDGs.[47,48] The socio-economic benefits of this global effort will accrue forever, once GWD eradication is achieved.[49]

While it is not possible to make any direct causative pathway between GWD eradication and the progress toward MDGs in countries where GWD was and is endemic, this research has demonstrated that in the absence of the GWDEP, endemic communities would still suffer increased burdens of reduced economic productivity, poor school attendance and scarce drinkable water sources.[50] Moreover, in those communities where there was a high burden of GWD prior to GWDEP, eradication efforts have had a diminishing affect in the aforementioned.

## *STRENGTHS and LIMITATIONS*

### *Strengths*

The GWDEP is a well-established, data driven eradication program with three decades of comprehensive documented baseline, program summary and review data. There is also a significant amount of published literature available on MDGs, NTDs and GWD. The investigator's Graduate Assistantship with TCC provided easy access to conduct in-person interviews with TCC program directors, supervisors and managers.

### *Limitations*

The GWDEP is a very focused, vertical public health intervention effort that cannot allow for any deviation or distraction from its goal. It is not a research program. As a result, there is very little current published literature that shows a direct association

between a decrease in GWD cases to the improvement of global health, and factors surrounding better communal health, such as a decrease in child mortality rates, an increase in maternal health, an increase in agricultural output, etc. Instead counterfactual evidence, defined as 'contrary to fact' (i.e. an assumption),[51] was used to show the correlation between the decrease in GWD cases as a beneficial contribution of the aforementioned and older research articles. Additionally, it is important to note, this research does not include data on whether the communities cited in this research were benefactors of other public health initiatives, such as vaccines or additional clean water programs that may have been on-going during GWDEP efforts. Lastly, due to limited time and resources, it was not feasible to deploy into the field to experience and research in-person GWDEP activities. All data collected was second hand or via literature review.

*FUTURE RESEARCH*

Future research efforts will entail assessing TCC's other international health programs to ascertain their contributions towards achieving the MDGs.

*IMPLICATIONS FOR PUBLIC HEALTH*

Researching this thesis topic and publishing an article provides an opportunity to highlight the significance of combating NTDs and the impact this effort has on global health issues, and the attainment of the MDGs. It is hopeful this publication will promote interest with public health advocates, donors and global health entities, as well as further intellectual discussion, additional research efforts, and publications on the importance of alleviating and preventing NTDs as a strategy for achieving MDGs.

**APPENDIX I:**

*QUESTIONNAIRE*

Informal Key Informant Questionnaire

For Thesis:

A Retrospective Review of the Guinea Worm Eradication Program's Contribution to the Achievement of the Millennium Development Goals

Developed by
Birgit Bolton

Questions were crafted to be open-ended to encourage free flowing conversation between researcher and interviewee.

1. What is your role with TCC?
2. What is your background?
3. How long have you been an integral part of the GWDEP?
4. What is GWD?
5. Why is it a good candidate for eradication?
6. What are the program indicators for TCC's GWDEP?
7. How were these indicators selected?
8. Have the indicators stayed consistent since the inception of the TCC's GWDEP?
9. How do you measure the GWD contamination level in EVS (endemic villages)?
10. Can you explain the significance of the GWDEP's surveillance system?
11. How long does the surveillance effort continue after a village has been certified as GWD free?

12. Can you provide some details on how GWDEP volunteers are trained?
13. What are the volunteer's responsibilities?
14. What is the case definition of GWD?
15. How is a GW case confirmed and verified?
16. How are GWD cases reported and recorded through the GWDEP?
17. How can you determine the program data (i.e. GWD cases) is reliable?
18. What other details do the surveillance volunteers collect from a 'victim' with GWD?
19. What are the case containment standards for a GWD case?
20. How does TCC implement GWD eradication efforts?
21. Who are the partners and entities involved in each endemic country?
22. What is the current goal for eradication?
23. What is the process for determining that a country is GWD free?
24. Can you explain what it will mean to global health to eradicate this disease?
25. What is the cost benefit of this eradication effort?
26. In your opinion, has TCC efforts to eradicate GWD helped to achieve the MDGs?
27. Can you provide any additional insight?

*JOURNAL ARTICLE*

Please note this is only a draft and that the content may appear drastically different after the publication review process and acceptance into a journal.

# A Retrospective Review of the Guinea Worm Eradication Program's Contribution to the Achievement of the Millennium Development Goals

Kelly Callahan, Birgit Bolton, Deborah McFarland, Kat Meagley, Donald Hopkins, Ernesto Ruiz-Tiben, Craig Withers

Summary Despite the seriousness of neglected tropical diseases (NTDs), they are not addressed directly in the Millennium Development Goals (MDGs) but are included indirectly under the rubric "other diseases": Goal 6: Combat HIV/AIDs, Malaria and Other Diseases.[4] Additionally, there is currently no formal forum that discusses the health outcomes related to combating NTDs and how this ultimately impacts the MDGs.

Background Guinea worm disease (GWD), one of the NTDs, is a disabling, painful, debilitating water-borne helminthic disease with multiple adverse consequences on health, agriculture, school attendance, and overall quality of life of affected communities.[22]

Methods GWD was researched and assessed through a retrospective review. Literature searches were conducted and data were collected from the inception of TCC's GWDEP in 1986 through 2010 from partnering counties' MOH and TCC's GWDEP. MDGs and its targets were researched and assessed through a retrospective review. A separate literature search was conducted and data was collected. This information was then compared to country specific data. Furthermore, eleven established program indicators were reviewed as a basis to calculate results to determine how GWDEP outputs contributed to public health impacts and ultimately the MDGs.

Findings At the inception of the MDGs in 2000, there were16 countries endemic to the disease reporting a total of 75,223 cases. At the end of 2010, there were only four remaining countries (Sudan 1,698, Mali 57, Ethiopia 21, and Ghana 8) still endemic to the disease reporting fewer than 1,800 GWD cases.[20] It is estimated TCC's efforts has prevented more than 79 million cases of GWD.[43]

Interpretation As a result of TCC's commitment to eradicate, eliminate and control NTDs, significant public health progress has been made which has increased the potential that some MDGs can be achieved by the 2015 deadline. Because TCC's GWDEP is an eradication effort, it offers weighty and beneficial ramifications in the realm of global health in that it dramatically reduces the burden of disability from GWD for eternity.[46]

Funding The Carter Center

## Introduction

Infectious diseases have influenced the development of human species more than any other biological or non-biological factor. They have influenced not only our biology, but also history and political development; from the outcome of wars to success of empires, and from the pace of technological advance to the structure of society itself.[6] Neglected Tropical Diseases (NTDs) are considered the most common infectious diseases of the world's poorest people. An estimated 1.2 billion people are infected with one and sometimes more than one NTD, with most of these individuals among the billion people who live on less than $1 per day, a population often referred to as the "bottom billion".[8] NTDs are a group of parasitic and bacterial diseases that cause substantial illness by impairing physical and cognitive development, seven of which can be controlled or potentially eliminated through mass administration of safe and effective medicines or

other effective interventions.[52 7] For example, Dracunculiasis (guinea worm) eradication has been suggested as one of the most cost-effective health interventions available. However, since the disease generally occurs in isolated rural areas and is usually not fatal, it is often considered to be a mild affliction that does not warrant a widespread public health campaign.[27] The toll, however, of NTDs on individuals, communities, and societies extends beyond physical suffering to household and health system economic burden as well as the indirect cost of lost productivity ultimately hampering economic development where it is most needed and trapping the poor in a cycle of poverty and disease. Moreover, affected individuals often suffer from multiple NTDs, compounding their personal burden and disability.[13] This hinders a country's development, rendering it unable to affectively address issues and establish the necessary public health infrastructure required to combat the underlying issues of poverty such as disease burden, hunger, and the provision of consistent clean water and sanitation systems. The inception of the Millennium Development Goals (MDGs) has increased global commitment to confront the ineluctable links between poverty and health, a link that undermines development.

NTDs are not specifically addressed in the Millennium Development Goals (MDGs) but fall under the rubric of "other diseases": Goal 6: Combat HIV/AIDs, Malaria and Other Diseases.[4] There is currently no formal forum that focuses on the control and/or elimination of NTDs as one strategy for reaching some of the MDG goals. In 2000, the United Nations Millennium Summit met and 189 Heads of State committed to improving the health of the global population.[1-3] The MDGs consist of eight goals encompassing 21 targets that address hunger and poverty, education, gender equality, health, disease

burden, the environment and global partnerships (See Table 1).[4] Even though NTDs can be effectively and cost effectively prevented, the international health community has historically directed more resources, funds and efforts to combating the "big three" – HIV/AIDs, tuberculosis (TB), and malaria.[9,10] Emerging evidence shows that people infected with NTDs are more susceptible to becoming infected with the "big three". Additionally, this evidence also indicates that coinfection with one or more NTD may profoundly affect the health outcome of having one of the "big three" diseases.[14] By directing more resources and efforts towards combating NTDs greater accomplishments can be made in achieving the MDG 6, though presently this is a noticeable disconnect in this objective.

*Table 1: MDG and Targets*

| Millennium Development Goals (MDGs) | Targets |
|---|---|
| **Goal 1: Eradicate Extreme Hunger and Poverty** | Target A: Halve, between 1990 and 2015, the proportion of people whose income is less than US $1 a day<br><br>Target B: Achieve full and productive employment and decent work for all, including women and young people<br><br>Target C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger |
| **Goal 2: Achieve Universal Primary Education** | Target A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling |
| **Goal 3: Promote Gender Equality and Empower Women** | Target A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015 |
| **Goal 4: Reduce Child Mortality** | Target A: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate |

| | |
|---|---|
| **Goal 5: Improve Maternal Health** | Target A: Reduce by three quarters the maternal mortality ratio<br><br>Target B: Achieve universal access to reproductive health |
| **Goal 6: Combat HIV/AIDs, Malaria and Other Diseases** | Target A: Have halted by 2015 and begun to reverse the spread of HIV/AIDs<br><br>Target B: Achieve, by 2010, universal access to treatment for HIV/AIDs for all those who need it<br><br>Target C: have halted by 2015 and begun to reverse the incidence of malaria and other major diseases |
| **Goal 7: Ensure Environmental Sustainability** | Target A: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources<br><br>Target B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss<br><br>Target C: Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation<br><br>Target D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers |
| **Goal 8: Develop a Global Partnership for Development** | Target A: Develop further an open, rule-based, predictable, nondiscriminatory trading and financial systems<br><br>Target B: Address the special needs of least developed countries<br><br>Target C: Address the special needs of landlocked developing countries and small island developing States<br><br>Target D: Deal comprehensively with the debt problems of developing countries<br><br>Target E: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries<br><br>Target F: In cooperation with the private sector, make |

available benefits of new technologies, especially information and communication technologies

The Carter Center (TCC) International Health Programs is a nonpartisan organization dedicated to alleviating unnecessary suffering by fighting and preventing disease with particular focus in NTD implementation, research and impact.[19,20] "TCC health programs are data-driven and seek to help fill gaps in health care by looking for opportunities to eliminate or eradicate disease where possible, and to control diseases that cannot be completely eliminated".[20] TCC partners with Ministries of Health (MOH) from African and Latin American countries to implement eradication, elimination, and control programs for the most debilitating NTDs by offering intervention and research expertise, cutting edge technical support and material assistance. TCC's health programs specifically address health issues that provide a positive health and development return for affected individuals, communities and countries. While all of the TCC health programs are instrumental in making progress towards achieving the MDGs by the 2015 deadline, this paper will specifically focus on TCC's flagship health program – the Guinea Worm *(dracunculiasis)* Disease Eradication Program (GWDEP) and its contributions to achieving certain MDG targets.

GWD is a disabling, painful, debilitating water-borne helminthic disease with multiple adverse consequences on health, agriculture, school attendance, and overall quality of life of the affected communities. It has considerable health, social, educational and economic cost to the individual, the household and the community.  and its transmission cycle is well documented.[22] Though GWD rarely results in death, eradicating it is a powerful, broad based "engine for development" in that eradication efforts assist in the

improvement of agricultural production and school attendance; in the development of village-based surveillance; in the building of local capacity by training village-based health workers; and by promoting safer drinking water initiatives and sources to the most deprived areas.[34]

## Methods

A review of relevant literature and program data was conducted by the investigator. Information from partnering countries' MOH and TCC's GWDEP's yearly progress reviews, yearly summary proceedings and twenty-four years' worth of monthly guinea worm wrap-up reports were distilled and analyzed. Published literature and program reports were examined for quantitative, qualitative and anecdotal information on program implementation, status, progress and impact. Seven in-person interviews using informal key informant questionnaires consisting of approximately 25 open-ended questions were conducted and recorded with various experts, including resident epidemiologists, program managers and directors from TCC.

A separate literature search focused on the MDGs was conducted and data were collated on MDG progress on each of the countries in which TCC GWDEP has been active or is currently active. . This information was then compared to country specific data published by the United Nations Children Fund (UNICEF) in the State of the World's Children report and The Millennium Development Goals Report Card and then aggregated and compared against the internationally recognized public health objectives of the MDGs in order to evaluate the progress made by the countries receiving GWD assistance from TCC.

Eleven established guinea worm program indicators were reviewed as a basis to calculate results to determine how GWDEP outputs contributed to public health impacts and ultimately the MDGs. Data were collected through 2010 to determine the most appropriate indicators for this purpose. A separate data review was conducted for the indicators using reports from The Training and Eradication of Dracunculiasis, WHO Collaborating Center for Research, UNICEF's State of the World's Children report, Centers for Disease Control and Prevention (CDC) and Department of Health & Human Services. This review was conducted with the following indicators in mind: population impacted, reduction in the number of new GW cases reported, GW cases averted, increase in agricultural outputs, increase in nutritional status for women and children, increase in communal health, increase in gender equality for women, increase in school attendance, increase in safer water sources and increase in global partnerships. However, it was only possible to verify the following indicators for this paper: population impacted, reduction in the number of new GW cases reported, GW cases averted, increase in agricultural outputs, increase in nutritional status for women and children, increase in communal health, increase in gender equality for women, increase in school attendance and increase in safer water sources. As the current definition for MDG 8 stands, it was not possible to find any supporting data for this indicator.

The geographic focus of the analysis was the twenty countries where TCC has worked to eradicate GWD: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Ethiopia, Ghana, India, Kenya, Mauritania, Mali, Niger, Nigeria, Pakistan, Senegal, Sudan/South Sudan, Togo, Uganda and Yemen.

Literature and journal searches were performed using databases PubMed and ScienceDirect. Keywords included, but were not limited to: *Big Three, Cost Effectiveness, Dracunculiasis, Economic Impact, Education, Eradication, Gender Equality, Guinea Worm, Impact, Indicators, Millennium Development Goals (MDGs), Neglected Tropical Diseases (NTDs), Poverty, Productivity, School-Absenteeism* and *The Carter Center.* References listed in articles were also reviewed to ensure that all relevant articles were considered.

## Results

Results described in this section is the culmination of investigative efforts and includes an overview of the data collected from TCC's GWDEP, beneficial health outcomes on the target population and supporting evidence on how the indicators selected prove program impact on the MDGs.

TCC's GWDEP assists MOH in each endemic country to provide GWD health education interventions. Since a vaccine does not exist for GWD, the GWDEP is an eradication effort that owes the majority of its success to behavioral change health education and interventions. By providing education on the biological causes of the disease, the GWDEP helps people understand how to manage and prevent it. The GWDEP has witnessed that when people are given the proper tools and health education, there is a dramatic drop in cases reported.[38]

The most effective and cost efficient way to prevent GWD is to use filters to remove the copepods from drinking water.[19,20] In 2001, TCC's GWDEP and its partners, which included

more than 39 implementing international agencies, 16 working groups composed of more than 1,300 people, and many supporting industries, spearheaded the Sudan Pipe Filter Project.[39] In only a few months, the project manufactured for distribution more than 9.3 million GW pipe filters. In total 16,939,563 household cloth filters and 17,915,000 individual plastic pipe filters were distributed to endemic areas between 2001-2010.[20] Furthermore, water sources were treated with ABATE©, a safe chemical larvicide, to control the copepods that harbor GW larvae, and local village volunteers were trained to provide health education in order to discourage people with emerging worms from entering water sources.[19,20,34] More specifically, Ghana significantly increased its GWD eradication efforts by recruiting more than 6,200 female Red Cross volunteers to help combat GWD. In Benin, networks of women have been created for GW education campaigns to help stop transmission of the disease (MDG 3.A).[20,24] By providing trained volunteers, filters for filtering water as well as advocating for safer water sources to international organizations, such as World Vision International, UNICEF and the WHO, TCC has significantly increased safe water sources in affected areas (MDG 7.C), as well as actively promoted collaboration and development with global partners.

Before current eradication efforts got underway in 1970s and 1980s, in some settlements in Nigeria and Ghana up to 70% of the population were affected during peak periods (Watts, 1986). All aspects of life are affected: agricultural production, child health and childcare, school attendance, and other daily social and economic activities.[30] Because GWD is seasonal, coinciding with peak agricultural activities, and few alternative labor sources are available for incapacitated farmers, a marked reduction in agricultural output occurs.[31] In 1989, researchers documented that in one area of Nigeria, 58% of GWD

patients were disabled for an average of 12.7 weeks during the yam and rice harvest season. Most of the patients were of school or working age, between 15 and 49 years old.[26] Moreover, research in Mali linked a 5% decrease in production of two food crops, and the annual economic losses to GWD in the three rice growing Nigerian states was estimated to be over $20 million.[24]

In addition to hindering agricultural productivity, GWD has been shown to have an adverse impact on cognitive abilities of children, primarily due to malnutrition.[8,35] The decreased access to a dependable food source due to diminished farming productivity also adversely impacts child mortality rates. A study in South Kordofan, Sudan, found that children were almost three times more likely to be malnourished if more than half of the household adults had been affected by GWD the previous year.[26,36] A qualitative study conducted in Oyo and Kwara states of Nigeria documented that gender specific maternal roles such as self-care, child care and household tasks were impacted when a mother was inflicted with GW. Of the maternal functions, self-care was likely to be the most neglected as the mothers were typically reluctant to ask for help. They did not wash themselves or their clothes if it meant asking someone to fetch water for them. And, they often ate sparingly due to the nausea associated with the disease or because they are not mobile enough to go outside to defecate. While these same mothers gave their children priority, research indicated that a mother with GW can contribute toward a decline in a child's health or compound existing health issues. For example, GW and its lesions can hamper the holding, breast feeding and bathing of a child.[23] In most cases mothers reported reducing their children's diet, just as they had decreased their own diet, due to

financial constraints imposed by GW.[37] Furthermore, mothers missed opportunities to immunize their children.[23] Schulman (1985) reviewed the impact the disease may have on nutrition, and suggested that improved control of GWD would result in an improvement of nutritional status in affected areas.[27] The possible benefits which accrue from controlling or eliminating this disease in a community, is supported by a study conducted in three villages in Asa, Nigeria, which formerly had prevalence levels of 50% or more, but where boreholes had reduced GW cases to zero. Focus group discussion reveled that after the boreholes were introduced none of the women who attended the discussion had experienced GW and they all agreed they felt healthier than before, were able to better care for their children (MDG 4 and 5), and were able to grow produce for their family and to sell.[23] (MDG 1)

Furthermore, poor school attendance has been associated with GW infections in West Africa.[32] Students do not receive a consistent education because they are either too malnourish to attend class, have an emerging GW, or are forced to drop out of school to assist their stricken parents in agricultural or household chores.[26] A fact supported by a study that took place in a rural southwest Nigeria community which observed high absentee rates during GW transmission season. GWD was present in 21% of pupils and was responsible for 25% of days missed throughout the year.[33] However, the provision of alternative potable drinking water sources or access to filters, showed a significant reduction in the prevalence of GW within three years of intervention. In ten primary schools in villages that were provided with boreholes as a safer drinking water option, preintervention surveys conducted during peaked GW season in 1983-84 showed GW related school absences comprised 88% of all absences. A similar survey in the 1986-87

season revealed that only 2.6% of students were absent because of GWD.[32](MDG 2) Furthermore, parents who previously had suffered from GWD were now healthy and no longer recalling their children from school for domestic support. Parents were also willing to send their children back to school without the fear that the children would become victims to GWD.[32] (MDG 2)

TCC's GWDEP efforts to eradicate GWD have resulted in documented improvement in agricultural productivity, communal health as well as school attendance.[19] Countries that were certified free of GWD by World Health Organization (WHO) since 2000 (See Table 2) have witnessed progress towards combating poverty and hunger, which directly correlates to access to a dependable food source. The measure of progress that is utilized in the 2010 MDG Report Card is "Absolute Progress" which is defined as a country that has made the largest annual improvement in indicators between two points in time.[41] Based on this definition, 20 countries are listed as achieving the most absolute progress. In 2000, TCC has quantifiable analysis and baseline measurements of GWD cases in the remaining 16 endemic countries, eight of which are now listed in the MDGs aforementioned top 20 countries: Ethiopia, Uganda, Ghana, Mali, Togo, Burkina Faso, Benin and Mauritania.[3] Moreover, Ethiopia which reported 3,885 cases in 1986 compared to 21 cases in 2010, and Mali which reported 16,024 cases in 1991 compared to 57 cases in 2010 (MDG 6.C), are included in the top 20 countries that have made the most absolute progress towards reducing extreme poverty (MDG 1.A.C).[53] Ethiopia is also listed as one of the top ten countries that has made absolute annual percentage progress in reducing the under-five mortality rate (MDG 4.A, MDG 5.A).[53]

*Table 2: Eradication Status*

| Name of Country | Eradication Start Date | Number of Cases Reported at Start Date | Year with highest Reported cases | Number of Cases Reported 2000 (inception of MDGs) | Number of Cases Reported 2010 |
|---|---|---|---|---|---|
| **Benin** | 1987 | 400 | 37,414 | 187 | 0 |
| **Burkina Faso** | 1985 | 458 | 45,004 | 1,262 | 0 |
| **Cameroon** | 1985 | 168 | 871 | 3 | 0 |
| **Central African Republic** | 1987 | 1,322 | 1,322 | 33 | 0 |
| **Chad *** | 1986 | 314 | 1,231 | 0 | 0 |
| **Cote d'Ivoire** | 1985 | 1,889 | 8,034 | 290 | 0 |
| **Ethiopia** | 1986 | 3,885 | 3,885 | 59 | 21 |
| **Ghana** | 1985 | 4,501 | 179,556 | 6,567 | 8 |
| **India** | 1983 | 44,818 | 44,818 | 0 | 0 |
| **Kenya** | 1989 | 5 | 53 | 0 | 0 |
| **Mauritania** | 1985 | 1,291 | 8,301 | 84 | 0 |
| **Mali** | 1985 | 4,072 | 16,024 | 292 | 57 |
| **Niger** | 1985 | 1,373 | 32,829 | 1,165 | 0 |
| **Nigeria** | 1886 | 2,821 | 653,492 | 7,818 | 0 |
| **Pakistan** | 1987 | 2,400 | 2,400 | 0 | 0 |
| **Senegal** | 1985 | 62 | 1,341 | 0 | 0 |
| **Sudan*** | 1986 | 822 | 118,578 | 51,515 | 0 |
| **South Sudan*** | | | | 0 | 1,698 |
| **Togo** | 1985 | 1,456 | 10,349 | 828 | 0 |
| **Uganda** | 1985 | 4,070 | 126,369 | 97 | 0 |
| **Yemen** | 1990 | 0 | 94 | 0 | 0 |

*Chad - Interrupted transmission in 1990, however reported a small outbreak in 2010 that is under investigation.*

** South Sudan - Became an independent country from Sudan in 2010 taking with it the GWD cases*.

## Discussion

Research has determined that TCC's GWDEP has made significant contributions towards attaining lofty internationally recognized global health objectives – the MDGs and its

targets. By targeting a NTD such as GWD, significant progress can be made towards achieving the MDGs. When TCC took the leading role in eradicating GWD in 1986, a cumulative total of 4.8 million GWD cases were reported worldwide.[42] At the inception of the MDGs in 2000, there were 16 countries endemic to the disease reporting a total of 75,223 cases. At the end of 2010, there were only four remaining countries (Sudan 1,698, Mali 57, Ethiopia 21, and Ghana 8) still endemic to the disease reporting fewer than 1,800 GWD cases.[20] It is estimated TCC's efforts has prevented more than 79 million cases of GWD.[43]

Our results also prove that an eradication program, such as GWDEP, provides weighty and beneficial ramifications that go beyond the MDGs and its 2015 deadline. Eradication is the ultimate 'sustainable' improvement in public health.[45] Had the GWDEP not been initiated in 1986, it is estimated that 3.5 million GWD cases would have occurred annually for a cumulative total of 84 million cases from 1986-2010. Hence, 79.2 million cases have been averted. The dramatic reduction and eventual eradication of GWD related morbidity contributes discernible progress to all areas of global health for eternity. A successful disease eradication initiative ultimately benefits the broader spectrum of global health.[46] Aside from GWDEP's contribution to improved water sources in poor and remote communities, the reduction of GWD cases has, without a doubt, had an advantageous impact on disability, agricultural production, income generation and poverty reduction in endemic areas.[47]

GWD is expected to be the first parasitic disease to be eradicated, and the first disease to be eradicated without vaccines or medications.[44] The GWDEP is leaving a legacy of development in sync with the United Nations' MDGs.[24] At a cost of $275 million for the global eradication campaign, the cost per case averted is estimated at a mere $3.47. Furthermore, the established community-based surveillance and health education delivery systems are now delivering other health interventions besides GWD, such as malaria control, diarrheal disease and immunization programs thus making continual contributions towards achieving the MDGs.[47,48] The socio-economic benefits of this global effort will accrue forever, once GWD eradication is achieved.

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