

**Did the Millennium Development Goal Target 7c (to halve between 1990 and 2015 the proportion of the global population without sustainable access to safe drinking water) Reduce the Prevalence of Diarrheal Illness in the Dominican Republic**

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# **Did the Millennium Development Goal Target 7c (to halve between 1990 and 2015 the proportion of the global population without sustainable access to safe drinking water) Reduce the Prevalence of Diarrheal Illness in the Dominican Republic.**

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## **Summary**

### **Background:**

Waterborne diseases are caused by a variety of microorganisms, biotoxins, and toxic contaminants, which lead to devastating illnesses. According to the World Health Organization, diarrheal illnesses are the ninth leading cause of death worldwide. Developing countries are at especially high risk due to the lack of quality infrastructure and the Dominican Republic is no exception. Access to a quality public water supply has been shown to significantly reduce the incidence of diarrheal illnesses worldwide and in 2012, the Dominican government celebrated as achieved the completion of the Millennium Development Goal Target 7c (to halve between 1990 and 2015 the proportion of the global population without sustainable access to safe drinking water). Our aim was to determine whether the initiative was successful at reducing the prevalence of diarrheal illnesses across the country.

### **Methods:**

This is a cross-sectional study that obtained data using the Demographic and Health Surveys Database. Census data from the Dominican Republic was obtained from 2002, 2007 and 2013. Since the Millennium Development Goal Target 7c was celebrated as complete in 2012, data from 2002 and 2007 censuses were used to compare the change in prevalence of diarrheal illness in the 2013 census data. Odds ratio values and 95% confidence intervals were then calculated to evaluate various demographics and outcomes.

### **Findings:**

Census data from the Dominican Republic including the years 2002, 2007, and 2013 actually revealed a steadily increasing prevalence when participants were asked if they had, “Diarrhea within the last 2 weeks (2002: 15.6%, 2007: 16.5%, and 2013: 17.7%;  $p=0.03$ ).” This increase was observed throughout the course of the Millennium Development Goal Target 7c, which began in 1990 and was celebrated as accomplished in 2012. Before 2012, a total of 16.1% of participants reported that they had, “Diarrhea within the last 2 weeks”, while after 2012, 17.7% of participants reported that they had ( $p<0.0001$ ). This resulted in an odds ratio of 1.23 ( $p<0.0001$ ) with the current water supply. Other data that supports the poor state of the current water supply is the increased odds of having diarrhea when water is piped into the dwelling or

brought in by a tanker, with odds ratios of 1.24 ( $p < 0.0001$ ) and 1.11 ( $p = 0.043$ ) when compared to a bottled water source respectively. Higher education decreased the odds of contracting diarrheal illness with an odds ratio of 0.77 ( $p = 0.003$ ). Secondary and higher education also decreased the risk of blood in the stool with odds ratios of 0.44 ( $p = 0.01$ ) and 0.45 ( $p = 0.03$ ) respectively.

### **Interpretation:**

It appears the Millennium Development Goal Target 7c (to halve between 1990 and 2015 the proportion of the global population without sustainable access to safe drinking water), was ineffective at reducing the prevalence of diarrhea in the Dominican Republic. In fact, the prevalence has increased throughout the course of the initiative. The increase was especially notable in populations that used water piped into dwellings and tanker truck water sources. This is precisely the water supply that the initiative set out to improve. Using diarrhea as a single factor to determine the water quality in the Dominican Republic, it appears that the state of the country's water is significantly worse than before.

### **Funding:**

None

### **Translations:**

None

## **Introduction:**

Waterborne diseases are caused by a variety of microorganisms, biotoxins, and toxic contaminants, which lead to devastating illnesses such as cholera, schistosomiasis and other gastrointestinal problems ([Percival et al. 2004](#)). According to the World Health Organization, diarrheal illnesses are the ninth leading cause of death worldwide ([The top 10 causes of death](#)). Regions of the world that lack basic water infrastructure are at higher risk for such illnesses ([Fischer Walker et al. 2012](#)). The island of Hispaniola, including the Dominican Republic, is no exception to this trend ([Morillo Perez 1993](#)).

An example of an outbreak due to the underdeveloped public water supply in the Dominican Republic occurred in 2010 after the deadly earthquake that struck the island of Hispaniola. Although the earthquake affected mainly the country of Haiti, the vibrio cholera outbreak following the earthquake posed a great threat to the Dominican Republic as well. In March of 2012, around the peak of the outbreak, the Dominican Republic recorded 21,432 cholera cases and 363 deaths. These numbers were dwarfed when compared with the 522,335 cases and 7,001 deaths that were recorded in Haiti, but still raised significant concern ([Csisorg et al. 2018](#)).

In 2012, the Dominican government celebrated as achieved the completion of the Millennium Development Goal Target 7c (to halve between 1990 and 2015 the proportion of the global population without sustainable access to safe drinking water). They stated that 82 percent of Dominicans now had access to the improved supply ([Baum et al. 2014](#)). After an extensive literature search, no singular study has been identified that assesses the efficacy of the Millennium Development Goal Target 7c in reducing rates of diarrheal illness in the Dominican Republic.

Prevalence of diarrheal illness is a measure of water quality in an area and this research set out to evaluate the quality of the Dominican water supply by analyzing census data of rates of diarrheal illness prior to 2012 and after 2012. After systematic review of various articles, we hypothesized that the rates of diarrheal illness will not have significantly reduced since the completion of the initiative in 2012 and in fact may be increasing over time.

## **Methods:**

This is a cross-sectional study that obtained data using the Demographic and Health Surveys database. The DHS database uses, “Nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition ([The DHS Program](#)).” The DHS website also states, “Standard DHS surveys have large sample sizes (usually between 5,000 and 30,000 households) and typically are conducted about every 5 years, to allow comparisons over time.” Census data for the study was obtained for the Dominican Republic and included the years of 2002, 2007 and 2013, which included 26,225 survey responses. Since the Millennium Development Goal Target 7c was celebrated as complete in 2012, data from 2002 and 2007 censuses were used to compare the change in prevalence of diarrheal illness in the 2013 census data. Odds ratio values and 95% confidence intervals were then calculated to evaluate various demographics and outcomes.

## **Results:**

Census data from the Dominican Republic including the years 2002, 2007, and 2013 actually revealed a steadily increasing prevalence when participants were asked if they had, “Diarrhea within the last 2 weeks (2002: 15.6%, 2007: 16.5%, and 2013: 17.7%;  $p=0.03$ ).” This increase was observed throughout the course of the Millennium Development Goal Target 7c, which began in 1990 and was celebrated as accomplished in 2012. Before 2012, a total of 16.1% of participants reported that they had, “Diarrhea within the last 2 weeks”, while after 2012, 17.7% of participants reported that they had ( $p<0.0001$ ). This resulted in an odds ratio of 1.23 ( $p<0.0001$ ) with the current water supply. Other data that supports the poor state of the current water supply is the increased odds of having diarrhea when water is piped into the dwelling or brought in by a tanker, with odds ratios of 1.24 ( $p<0.0001$ ) and 1.11 ( $p=0.043$ ) when compared to a bottled water source respectively. Higher education decreased the odds of contracting diarrheal illness with an odds ratio of 0.77 ( $p=0.003$ ). Secondary and higher education also

decreased the risk of blood in the stool with odds ratios of 0.44 (p=0.01) and 0.45 (p=0.03) respectively. Results can be seen in images 1-4 below.

Image 1

Demographics					
	Overall N=26,225	2002 N=11,362	2007 N=11,149	2013 N=3,714	p-value
Respondent's Age, years (mean, 95% CI; N=26,225)	26.5 (26.5, 26.6)	26.4 (26.3, 26.5)	26.6 (26.5, 26.7)	26.7 (26.5, 26.9)	0.02
Respondent Highest Level of Education (%; 95% CI; N=26,225)					<0.0001
None	6.10 (5.82, 6.40)	6.28 (5.85, 6.74)	6.67 (6.22, 7.15)	3.87 (3.30, 4.54)	
Primary	47.4 (46.8, 48.0)	55.2 (54.3, 56.1)	44.2 (43.3, 45.1)	33.1 (31.6, 34.6)	
Secondary	32.2 (31.6, 32.7)	27.3 (26.5, 28.1)	34.7 (33.8, 35.6)	39.3 (37.8, 40.8)	
Higher	14.3 (13.9, 14.8)	11.1 (10.6, 11.8)	14.4 (13.7, 15.1)	23.7 (22.3, 25.1)	
Head of Household Age, years (mean, 95% CI; N=26,224)	38.3 (38.1, 38.4)	38.1 (37.8, 38.3)	38.5 (38.3, 38.8)	37.9 (37.6, 38.4)	0.01
Head of Household Gender (male, %; N=26,225)	73.1 (72.6, 73.6)	79.4 (78.6, 80.1)	70.3 (69.5, 71.2)	62.1 (60.5, 63.7)	<0.0001
Total Number in Household (mean, 95% CI; N=26,225)	5.32 (5.29, 5.34)	5.47 (5.42, 5.51)	5.26 (5.22, 5.30)	5.04 (4.97, 5.11)	<0.0001
Household Marital Status (%; 95% CI; N=26,225)					<0.0001
Never Married	2.53 (2.34, 2.72)	2.07 (1.83, 2.36)	2.76 (2.47, 3.08)	3.23 (2.71, 3.85)	
Married	78.7 (78.2, 79.2)	81.7 (80.9, 82.3)	77.0 (76.2, 77.8)	74.8 (73.3, 76.1)	
Other	18.8 (18.2, 19.2)	16.2 (15.6, 16.9)	20.2 (19.5, 20.9)	21.9 (20.7, 23.3)	
Source of Water (%; 95% CI; N=26,212)					<0.0001
Bottled/Small Tank	44.1 (45.4, 46.7)	39.4 (38.5, 40.3)	45.1 (44.1, 45.9)	69.5 (67.9, 70.9)	
Surface water, spring, river, stream, or Well Water	7.01 (6.70, 7.32)	8.83 (8.32, 9.36)	6.56 (6.11, 7.03)	2.77 (2.29, 3.35)	
Rainwater	7.73 (7.41, 8.06)	9.26 (8.74, 9.80)	8.02 (7.52, 8.53)	2.18 (1.76, 2.70)	
Piped into Dwelling, Yard/Lot	30.1 (29.5, 30.7)	36.6 (35.7, 37.5)	28.7 (27.9, 29.6)	14.7 (13.6, 15.8)	
Tanker Truck /other	9.05 (8.71, 9.40)	5.93 (5.51, 6.38)	11.6 (11.0, 12.3)	10.8 (9.91, 11.9)	
Time Taken to get to the water source, minutes (mean, 95% CI; N=4,764)	20.2 (19.4, 21.0)	22.0 (20.7, 23.4)	19.4 (18.2, 20.5)	17.3 (15.4, 19.2)	<0.0001

Kruskal Wallis Test to compare continuous variables. Chi-squared to compare categorical variables.

Image 2

Outcomes					
	Overall N=26,225	2002 N=11,362	2007 N=11,149	2013 N=3,714	p-value
Diarrhea within the last 2 weeks, yes (% 95% CI) (N=25,330)	16.3 (15.8, 16.7)	15.6 (14.9, 16.3)	16.5 (15.8, 17.2)	17.7 (16.5, 18.9)	0.03
Blood in Stool Sample, yes (% 95% CI) (N=2,384)	7.88 (6.87, 9.04)	N/A	8.00 (6.82, 9.37)	7.56 (5.74, 9.89)	0.89
Place of Medical Treatment for Diarrhea (%, 95% CI) (N=3,634)					<0.0001
None/other	56.9 (55.3, 58.5)	67.1 (64.8, 69.3)	53.6 (51.3, 55.9)	0	
Public hospitals	34.2 (32.7, 35.8)	25.9 (23.9, 28.1)	34.5 (32.3, 36.8)	100.0	
Private hospitals	8.47 (7.61, 9.42)	6.71 (5.61, 8.01)	11.1 (9.75, 12.7)	0	
Both	0.44 (0.27, 0.71)	0.18 (0.06, 0.55)	0.74 (0.43, 1.28)	0	

Chi-squared to compare categorical variables.

Image 3

Association between Time and Diarrhea

Variables		Diarrhea within the last 2 weeks N=26,225 % (95% CI)	OR (95% CI)	p-value
Time period				
	<2012	16.1 (15.6, 16.5)	REF	
	>2012	17.7 (16.4, 18.9)	1.23 (1.11, 1.35)	<0.0001
Respondent's Age, years			0.95 (0.95, 0.96)	<0.0001
Respondent Highest Level of Education			REF	
	None			
	Primary		1.04 (0.89, 1.21)	0.58
	Secondary		0.88 (0.75, 1.03)	0.11
	Higher		0.77 (0.64, 0.91)	0.003
Head of Household Age, years			0.99 (0.99, 1.00)	0.99
Head of Household Gender (male)			1.04 (0.96, 1.13)	0.35
Total Number in Household			1.01 (0.99, 1.03)	0.21
Household Marital Status			REF	
	Never Married			
	Married		1.02 (0.82, 1.27)	0.85
	Other		1.11 (0.88, 1.37)	0.37
Source of Water			REF	
	Bottled/Small Tank			
	Surface water, spring, river, stream, or Well Water		1.09 (0.95, 1.26)	0.22
	Rainwater		0.94 (0.82, 1.08)	0.41
	Piped into Dwelling, Yard/Lot		1.24 (1.14, 1.35)	<0.0001
	Tanker Truck /other		1.14 (1.00, 1.29)	0.043

Logistic regression adjusting for all other variables within the model.

Image 4

Association between Time and Diarrhea

Variables	Blood in Stool Sample		OR (95% CI)	p-value
	N=2,384 % (95% CI)			
Time period				
	<2012	8.00 (6.80, 9.37)	REF	
	>2012	7.55 (5.74, 9.89)	1.03 (0.72, 1.47)	0.86
Respondent's Age, years			0.99 (0.97, 1.02)	0.56
Respondent Highest Level of Education				
	None		REF	
	Primary		0.66 (0.37, 1.20)	0.18
	Secondary		0.44 (0.23, 0.83)	0.01
	Higher		0.45 (0.22, 0.94)	0.03
Head of Household Age, years			1.00 (0.98, 1.01)	0.74
Head of Household Gender (male)			0.84 (0.58, 1.22)	0.36
Total Number in Household			0.98 (0.91, 1.06)	0.65
Household Marital Status				
	Never Married		REF	
	Married		0.89 (0.37, 2.14)	0.79
	Other		0.87 (0.35, 2.16)	0.76
Source of Water				
	Bottled/Small Tank		REF	
	Surface water, spring, river, stream, or Well Water		0.94 (0.48, 1.86)	0.87
	Rainwater		0.87 (0.43, 1.80)	0.70
	Piped into Dwelling, Yard/Lot		1.10 (0.75, 1.60)	0.62
	Tanker Truck /other		1.07 (0.65, 1.76)	0.78

Logistic regression adjusting for all other variables within the model.

## Discussion:

Overall, it appears the Millennium Development Goal Target 7c (to halve between 1990 and 2015 the proportion of the global population without sustainable access to safe drinking water), was ineffective at reducing the prevalence of diarrhea in the Dominican Republic. In fact, the prevalence has increased throughout the course of the initiative. The increase was especially notable in populations that used water piped into dwellings and tanker truck water sources. This is precisely the water supply that the initiative set out to improve.

A recent study set out to analyze microbial drinking water quality of the new water supply in 409 separate households and 33 different communities throughout the major northern city of Puerto Plata. The results showed that 47 percent of the newly improved drinking water sources were of high to very-high risk water quality, and therefore unsafe for drinking ([Baum et al. 2014](#)). Another study carried out in a rural Dominican clinic after 2012 showed that of 128 fecal samples examined, 127 were positive for one or more parasites. Percent infection rates were 43.8% for *Ascaris lumbricoides*, 8.5% for *Enterobius vermicularis*, 21.1% for *Entamoeba histolytica*, and 22.7% for *Giardia duodenalis*, showing that a high percentage were from

contaminated water. Of the children examined, 7.8% had double infections as well ([Palmieri et al. 2014](#)).

The extent of the contamination is alarming due to a high amount of Dominicans who continue to use the public water supply. In 2016, a study revealed that around 27.8% of children were reported to have some exposure to untreated tap water ([McLennan 2016](#)). The prevalence is even more extreme amongst the more impoverished Haitian population. Another study set out to determine the prevalence of coliform contamination in local water supplies and found that Haitian neighborhoods had 88% contaminated samples, while Dominican had 59% contaminated samples ([Rogers-Brown et al. 2015](#)).

It is evident, that even with the supposed improvement, many Dominicans still do not have access to clean public drinking water sources and may be drinking contaminated water with a false sense of security. The only statistically significant data found in the censuses to reduce diarrhea or bloody diarrhea, was higher amounts of education. This may be due to increased income or educational awareness of the poor water quality, which allowed them to drink from bottled water sources. Additional research will be needed to determine the impact of education on choice of drinking water sources.

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