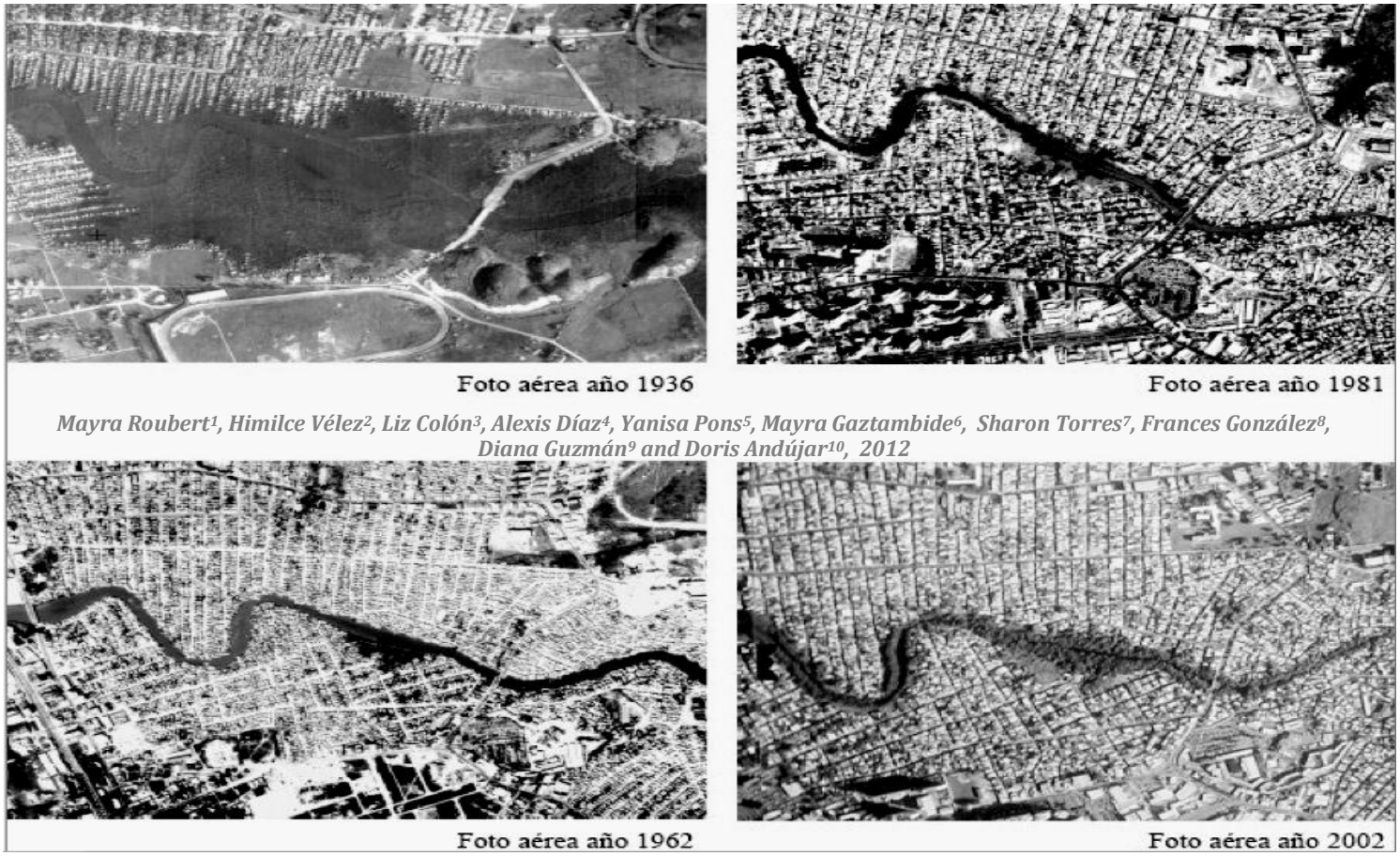
Prevalence of Gastrointestinal Symptoms among Residents of the Caño Martin Peña Communities, San Juan, Puerto Rico



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Introduction

Water bodies, in general, are vital for the environment sustainability, health and welfare of all living beings on the planet. Environmental pollution, which is defined as the presence in the environment of any agent (physical, chemical or biological) that is or may be harmful to health, safety or welfare of the population, should be avoided to prevent health concerns (Frers, 2009).

Caño Martín Peña (CMP) is a natural tidal channel with an span of approximately 3.75 miles (6 km), and with a width that varies from 6 (2mts) to 400 feet (122mts). This water channel is located at the heart of the San Juan Bay National Estuary, connecting the San Juan Bay with San José Lagoon, in Puerto Rico (ENLACE, 2003).

During the first half of the 20th Century there was an extensive migration of impoverished squatters. They built their houses in the mangroves bordering the water channel (Figures 1-2). These settlements grew by disposal of solid wastes to the water body. This practice had dramatic consequences in the water channel characteristics: high sedimentation and its correspondent hydraulic flow reduction. These two are directly related to the fact that the channel is incapable of assimilating flooding events, including low precipitation episodes. Extraordinary precipitation events are expected to be worse in terms of health and safety.

Figure 1-2. Caño Martín Peña water channel location, San Juan, Puerto Rico

Another problem which concerns CMP residents of the nearby communities is related to the large amount of houses built without proper storm/wastewater recollection systems. These discharges, which carry microbiological and chemical agents, are being perceived by the residents as an important risk factor which could be related to several public health diseases they had been suffering for a long time.

During the month of December 2011, students and faculty of the Public Health Program (PHP) at Ponce School of Medicine and Health Sciences (PSMHS), collected CMP water samples from different sites for bacteriological analysis. The selection of sampling sites was made by consulting with the Environmental Quality Board (EQB) and ENLACE staff (CMP NGO). The bacteriological analysis was performed and certified by EQB laboratory staff to ensure it was performed in an EPA-certified laboratory.

We found that all samples violated the standard for fecal coliforms and enterococci by a large margin. The sample taken from the Israel-Bitumul community registered the highest value for fecal coliform and enterococci, with concentrations of 1,500,000 colonies/100 ml and 500,000 colonies/100 ml respectively. The standard states that fecal coliforms and enterococci should not exceed 200 col/100 ml and 35 col/100mL respectively. Fecal coliforms and enterococci are bacteria considered as indicators for human and animal fecal pollution. Exposition to these wastewater discharges has been related to gastrointestinal diseases. Water samples were also analyzed for other physical parameters including dissolved oxygen, turbidity, conductivity, pH, and temperature. All samples violated the dissolved oxygen standard with levels below 1.0 mg/l (Figures 3-5).

Figure 3-4. PSMHS students and faculty during channel water sampling

Figure 5. PSMHS student taking pH measures from CMP

In conclusion, it is evident that CMP high sedimentation levels and its corresponding decrease of the channel hydraulic flow create serious flooding issues for residents of nearby communities. This problem worsens due to the serious bacteriological pollution that is mobilized into the neighborhood by these flooding events. There is no way to prevent being exposed to this bacteriological pollution because pollution reaches residents by the flooding itself (Figure 6-7).

Figures 6-7. Polluted CMP water channel

For all the reasons above, an environmental epidemiology study to link environmental pollution with public health outcomes was urgently needed. The relationship between gastrointestinal symptomatology with floods events and wastewater exposure among residents nearby CMP communities was assessed.

Epidemiology of Gastrointestinal Diseases

Gastrointestinal diseases (GID) are the leading cause of medical consultation worldwide, affecting people regardless of age. However, the most vulnerable population are children and the elderly.

The World Health Organization (2011) indicated that the most important public health risk factor related to water exposure is associated with the consumption of drinking water contaminated with human and animal feces. Other sources and routes of exposure may be significant. Mortality rates related to diseases linked to water pollution exceed 5 million people per year. Of these, over 50% die from intestinal microbial infections.

Globally, water pollution, sanitation, and poor hygiene are responsible for approximately 1.9 million annual deaths, which mean 4.2% of the disease global burden and 90% of diarrheal pathogens transmission (Carlton, et. Al., 2012).

Gastrointestinal diseases can be linked to water pollution exposure. This exposure could include: unsafe drinking water; wastewater discharged into water bodies used for primary contact, and flood events. Waterborne organisms usually grow in the intestinal tract and are then eliminated through the feces, and then return to the water supply. If water is not properly treated, the pathogen can re-enter and contaminate the host's gastrointestinal system. Since water is ingested in large quantities, it can still be contaminated even when it contains a small number of pathogenic organisms.

Other factors may include the development of associated gastrointestinal disease by malfunctioning sewage systems collections, as well as drinking water distribution system. Since pipes can have leaks it leads to vulnerability to wastewater cross contamination containing fecal coliforms and other pathogenic bacteria (Babu & Kumar, 2002; Bhatta et al. 2007; Shrivastava et al. 2004).

Diseases such as cholera, salmonellosis, and shigellosis can be acquired by drinking unsafe water. All these bacteria cause gastroenteritis events with acute diarrhea episodes. The most common diseases that occur through contact with recreational waters are gastrointestinal and skin rashes, acute febrile infections, ear, eye, and urinary tract infections, diarrhea, vomiting, sore throat, and respiratory diseases.

In the United States and Puerto Rico, the overall goal of the current criteria for bacteriology in water supplies is to protect the public health from gastroenteritis (gastrointestinal disease) associated with exposure to fecal contamination during recreational contact. Because feces contamination may be a major source of pathogens in aquatic ecosystems, and because it is not practical or feasible to monitor and identify the full spectrum of pathogens that exist in the water, a water quality criterion is achieved through detection of organisms' indicators. For decades, these indicators have served as surrogates for potential pathogens and thus to assess the associated health risks in recreational waters as well as in drinking water (EPA, 2009).

Materials and Methods

Study Population and Areas

A cross-sectional study was conducted from December 27, 2011 until April 15, 2012, to determine the prevalence of gastrointestinal symptoms among residents in seven communities near Caño Martín Peña (CMP). This "Special District" is constituted by the following communities nearby CMP, these are: Barrio Obrero Marina, Buena Vista Santurce, Barrio Obrero, Parada 27, Las Monjas, Buena Vista Hato Rey and Israel-Bitumul (Peña, 2008). The Península Cantera community was not included in the present study since it is organized and managed by another District since 1995 (Figure 8).

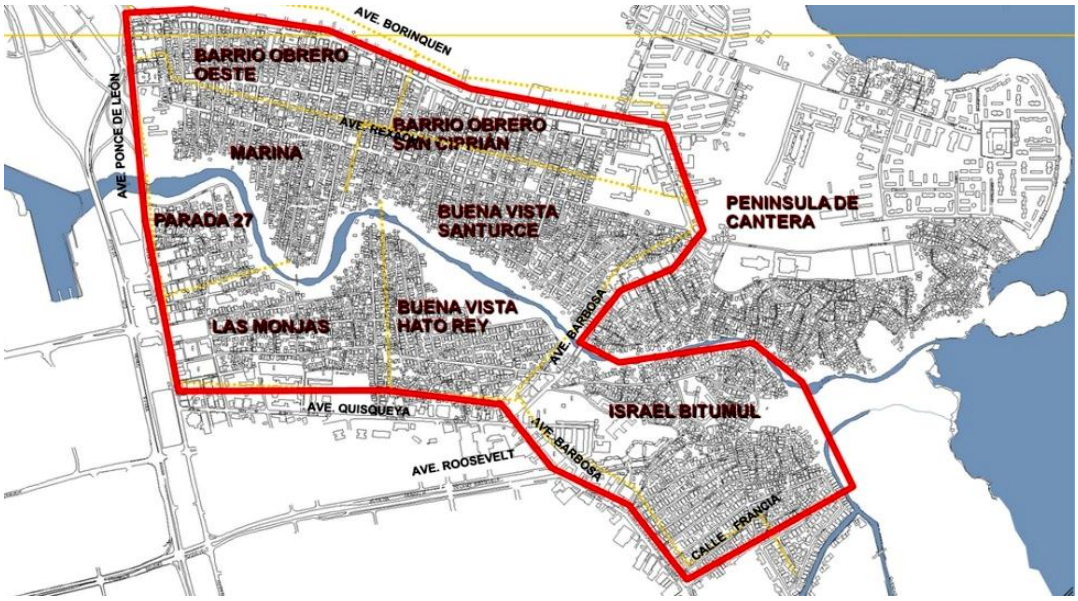

Figure 8. Caño Martín Peña Special District and communities included in the study.

The sampling design took into consideration wastewater exposure by two routes: related to flooding frequency and to connections to a sewer system. The data was obtained from Census 2000 (Figure 9). After assessing these characteristics, CMP communities were categorized into three areas, from lower to higher exposition levels. The areas are defined as follows:

- Area 0 - Communities with a lower percentage of homes subject to flooding and a higher percentage of homes connected to the sanitary sewer. The area was constituted by Barrio Obrero, Parada 27 and Buena Vista-Hato Rey. The exposure level is expected to be less than the other two areas.
- Area 1 - Communities with a lower percentage of homes with flooding issues and lower percentage of households connected to the sanitary sewer. This area includes Barrio Obrero Marina and Las Monjas. Intermediate exposure levels are expected.
- Area 2 - Communities with a higher percentage of homes with flooding issues and lower percentage of homes connected to the sanitary sewer. This area includes Israel-Bitumul and Buena Vista-Santurce. The exposure levels are expected to be higher than the other two areas.

COMMUNITY	# HOUSES	% FLOODS	% SEWER CONECTIONS
Buena Vista Hato Rey	812	36.1	89.2
Buena Vista Santurce	1,105	62.2	74.9
Barrio Obrero Marina	579	30.1	79.2
Barrio Obrero	1,564	26.6	97.7
Israel-Bitumul	1,213	48.9	49.8
Las Monjas	517	36.1	78.9
Parada 27	241	26.6	99.6
Total	6,031		

Figure 9. Caño Martín Peña flooding and sewer connections by community, Census 2000.

The Epidemiology Surveillance Unit at Puerto Rico Department of Health (PRDOH) states that GID rate was 5.6%. It is estimated that for every GID case that it is reported to PRDOH, there are three that are not reported. It is thought this is due to those patients not seeking medical services. Taking this into account, the GID prevalence for Puerto Rico in this epidemiological study was estimated as 21%.

According to Prüss, (1998) the relative risk range for gastrointestinal illness by drinking water and recreational water exposure is 1.60 to 3.0. For the present study a relative of 1.60 will be used, with a confidence interval of 95% and a statistical power of 80%. An oversampling of 40% was added to ensure achieving statistical power and acquiring the necessary size sampling. EpiInfo7 statistical software was used to calculate the sample.

Sampling Type

The sampling type was a random cluster sampling. The CMP community map was divided into grids of 50 x 50 m2 (superscript). Each grid was considered a block. Each block was assigned a number. The blocks were selected using a random number list. To determine how many clusters were needed to meet the sample size, 2000 Census data was assessed. According to this information there were a total of 19,876 homes in the seven communities of interest. Figure 10 shows areas, number of residents interviewed and inclusion criteria data for each community.

Participants were selected based on the following criteria: over 21 years in age, minimum of three months in housing, and availability of participation. Pregnant women were excluded from participation. Participants responded to a structured questionnaire composed mostly of closed questions including household characteristics, community health conditions, symptoms, lifestyle, smoking, alcohol consumption, occupational history of the individual respondent, socio-demographic characteristics and information overview of those under 21 who reside in the selected clusters.

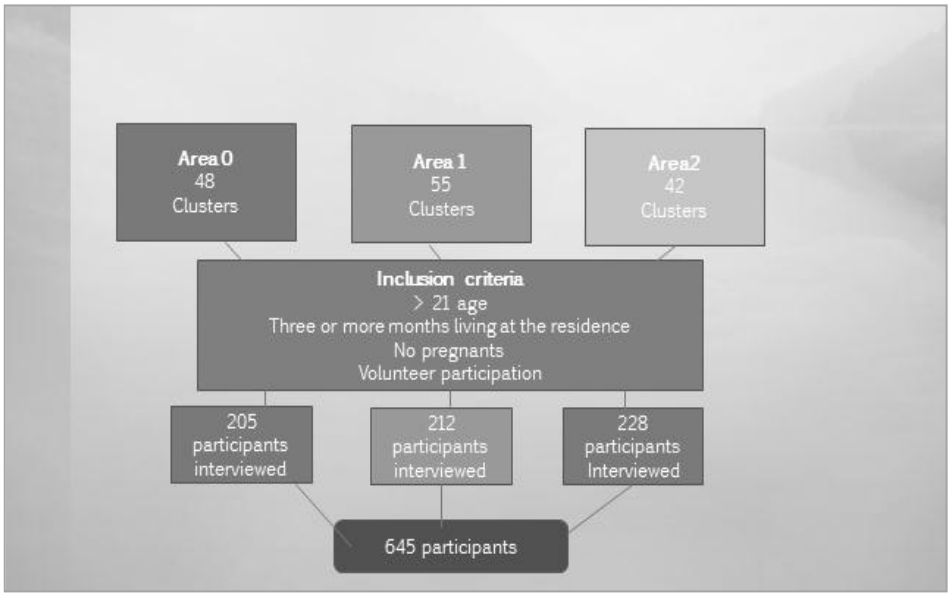

Figure 10. Cluster numbers, participants interviewed, and inclusion criteria

Descriptive and inferential analysis was performed by using SPSS 19 ® statistical software. The odd ratio (OR) was calculated to measure the association between floods/wastewater exposition and GID, with an interval of confidence at 95%. Chi square was calculated to evaluate OR statistical significance and also variables independency. The variables independency was achieved by obtaining a *p* value lower than 0.05.

Results

Socio-demographic & Exposure Profile

A total number of 645 participants were interviewed at the health survey conducted at Caño Martín Peña communities. The objective of the study was to determine if there was an association between gastrointestinal diseases (GID) with wastewater/flooding exposition among their residents.

The gender frequency distribution was 64.3% (409) for females and 35.7% (227) for men. The median age was 57 years (21 and 96 years). Other socio-demographic characteristics like marital status, education and country of origin achieved 61.5% not married, 44% have less than a high school degree, and 26.3% were from the Dominican Republic. The health insurance frequency distribution was 19.4% (120) don't have any health insurance, 39.2% (243) for state health insurance (Mi Salud) and only 24.2% (150) for a private insurance. The bigger frequency for more than 20 hours inside the house was 60.7% (381). The socio-demographic and exposure profile in detail are shown in the Figures 11-13.

SOCIO-DEMOGRAPHIC CHARACTERISTICS		FRECUENCY (n)	PERCENT (%)
GENDER	Male	227	35.7
	Female	409	64.3
AGES	21 a 49	223	35.5
	50 a 64	212	33.7
	≥ 65	194	30.8
MARITAL STATUS	Not Married	390	61.5
	Married	244	38.5
EDUCATION	< High School	278	44.0
	High School	189	29.9
	> High School	165	26.1
COUNTRY OF ORIGIN	Puerto Rico	447	70.5
	United States	16	2.5
	Dominican Republic	167	26.3
	Others	4	0.6
	(Cuba)	2	0.3
	(Haití)	1	0.2
MONTHLY INCOME	<500	120	25.6
	500 – 999	145	31.0
	1,000 – 1,499	105	22.4
	≥5000	98	20.9

Figure 11. Frequency distribution of socio-demographic characteristics among residents of the communities surrounding Caño Martín Peña, 2012

SOCIO-DEMOGRAPHIC CHARACTERISTICS		FRECUENCY (n)	PERCENT (%)
Health Insurance	No	120	19.4
	Public (Mi Salud /State Insurance)	243	39.2
	Private	150	24.2
	Medicare	82	13.2
	Other	20	3.2

Figure 12. Health insurance profile among CMP residents

CHARACTERISTIC		FREQUENCY (n)	PERCENT (%)
living in the residence (years)	≤ 5	169	27.7
	6 a15	125	20.5
	16 a 25	79	12.9
	>25	238	39.0
hours inside residence (weekly)	< 20	355	56.8
	> 20	270	43.2
hours inside residence (weekend)	< 20	247	39.3
	> 20	381	60.7

Figure 13. Exposition time profile among residents at Caño Martin Peña communities

The frequency distribution for unemployment was 63.1% (347). Only 33.3% (183) have one paid employment.

From the participants witch are employed, 50.0% (97) work more than 40 hours during the week (Figure14).

OCCUPATIONAL HISTORY		FRECUENCY (n)	PERCENT (%)
Paid Employment	0	347	63.1
	1	183	33.3
	≥ 2	20	3.6
Worked Hours	< 20	50	25.8
	21-39	47	24.2
	≥ 40	97	50.0

Figure 14. Occupational history profile among residents at Caño Martín Peña communities, 2012

75.2% (472) of the participants smoked more than 100 cigarettes in their life but only 47.4% (73) were currently smokers at the time of the health survey (Figure 15).

had you smoke more tan 100 cigarrets in your whole life?	No	472	75.2
	Yes	156	24.8
do you smoke at this momento?	No	81	52.6
	Yes	73	47.4

Figure15. Smoking profile among CMP residents 2012

Environmental Profile:

Regarding **flooding**, 16.4% of the participants' homes or yards were flooded even without a raining event. 21.9% (140) of the participants indicated that the street flooded without raining. 53.4% (339) of the participants' homes or yards flooded during raining events. The highest frequency, 69.5% (444), was obtained for the street or any house at the street flooded at raining events (Figure 16).

FLOOD AT CMP PARTICIPANTS RESIDENCES	**FREQUENCY**	
	NO	**YES**
	n (%)	**n (%)**
Your house or yard flooded even without raining?	530 (83.6)	104 (16.4)
Your Street flooded even without raining event?	498 (78.1)	140 (21.9)
Your house o yard flooded with raining event?	296 (46.6)	339 (53.4)
Your Street or any house in the street flooded with raining event?	195 (30.5)	444 (69.5)
Your house or yard flooded during 2001?	291 (46.4)	336 (53.6)
Your house or yard flooded during the past three months?	424 (66.9)	210 (33.1)
your Street or any house at the Street flooded during the past three months?	306 (48.6)	323 (51.4)

Figure 16. Flooding frequency distribution in houses or streets at Caño Martín Peña, 2012

For the variables related to the **sewer system,** 74.1% (432) of residents reported being connected to PRASA (Puerto Rio Aqueduct and Sewer Authority); and 24.7% (158) of the participants indicated that wastewaters backflow through bathtubs, toilets or sinks. Figure 17 shows how participants that are not connected to PRASA dispose of their wastewaters.

Disposition of wastewater	FRECUENCY (n)	PERCENT (%)
Private Septic Tank	32	23.9
Communal Septic Tank	18	13.4
Stormwater System	22	16.4
Combined System	16	11.9
discharged directly to Caño Martín Peña water channel	32	23.9
Do not remember / Do not know	14	10.4

Figure 17. Frequency distribution for wastewater disposal for Martin Peña participants who are not connected to the sanitary sewer system, 2012

Drinking water: The frequency distribution of variables related to drinking water exposure is: 38.8% have sink or refrigerator filters; 14.5% boil their drinking water; and 17% experience episodes of interrupted service to the water service at their residences. It was noted that half of the participants (49.2%) never drink tap water while 39.7% of respondents drink bottled water. 31.9% of participants used ice to cool their drinks while 60.7% make the ice from tap water. Figure 18 shows drinking water practices.

Participants answered that water appearance after rain events achieved the following distribution: 52.9% (323) reported the appearance was transparent; 43.0% (263) reported cloudy; and 4.1% (25) reported a different appearance. When asked about the smell of their tap water after a rain event, 18.8% indicated that water smells like grass or earthy odor; 13.3% reported water having a fishy odor; and the highest frequency, 19.5%, reported a chlorine-like smell.

PRACTICES RELATED TO DRINKING WATER		FRECUENCY (n)	PERCENT (%)
Residences	drink filter water (refrigerator or sink)	244	38.8
	drink boiled water	93	14.5
	dont have water service	108	17.0
	Never drink tap water	309	49.2
They drink tap water	Rarely drinks tap water	27	4.3
	Sometimes	29	4.6
	Almost Always	26	4.1
	Always	237	37.7
They drink bottled water	Never	94	14.8
	Rarely	64	10.1
	Sometimes	166	26.1
	Almost Always	59	9.3
	Always	252	39.7
They used ice to cool drinks	Never	176	27.7
	Rarely	47	7.4
	Sometimes	144	22.6
	Almost Always	65	10.2
	Always	203	31.9
They used Ice prepared using tap water	Never	124	26.2
	Rarely	17	3.6
	Sometimes	18	3.8
	Almost Always	27	5.7
	Always	287	60.7
They Washed hands during the day	$\leq$ 6 times	245	47.3
	$\geq$ 7 times	273	52.7

Figure 18. Frequency distribution of practices related to water in residents of Caño Martin Peña, 2012.

The Figures 19-20 shows the frequency distributions for practices related to preparation of foods and beverages with tap water and their perception related to water service and drinking water quality.

PREPARATION OF FOOD AND DRINKS		FRECUENCY	
		NO n (%)	YES n (%)
Drinks with tap water	Juice for concentrate	498 (77.2)	147 (22.8)
	Powdered Juice	519 (80.5)	126 (19.5)
	Coffee	288 (44.7)	357 (55.3)
	Tea	475 (73.6)	170 (26.4)
	Chocolate	563 (87.3)	82 (12.7)
Preparation of food with tap water	to wash some foods	41 (6.4)	566 (89.3)
	for cooking	68 (10.7)	599 (92.9)

Figure 19. Frequency distribution of the practice of using tap water for the preparation of food and beverages for residents of Caño Martín Peña, 2012

SERVICES OR FACILITIES		FRECUENCY (n)	PERCENT (%)
Pressure of Drinking Water	Very Bad	94	14.8
	Bad	85	13.3
	Regular	219	34.4
	Good	199	31.2
	Very Good	40	6.3
	Excellent	37	5.9
Drinking Water Quality	Good	267	42.7
	Regular	228	36.4
	Bad	48	7.7
	Dreadful	46	7.3

Figure 20. Frequency distribution on participants perception related to water services and drinking water quality in Caño Martin Peña, 2012

Gastrointestinal diseases results (GID)

Reflux (37.9%), constipation (26.2%), stomach ache (27.6%) and indigestion (15.3%), were the symptoms or health conditions having the higher frequencies during the last three months. Stomach cramps gathered a prevalence of 9.6%. 10.9% of participants responded they suffered at least once from stomach ache, nauseous, vomit or diarrhea episodes during the past three months witch kept them going to their work (Figure 21).

GASTROINTESTINAL SYMPTOMS IN THE PAST THREE MONTHS	PREVALENCE	
	NO n (%)	YES n (%)
Stomach ache	460 (72.4)	175 (27.6)
Vomiting blood	628 (99.2)	5 (0.8)
Black excretion	614 (97.5)	16 (2.5)
Blood in the excretion	619 (97.9)	13 (2.1)
Indigestion	535 (84.7)	97 (15.3)
Acidity	394 (62.1)	240 (37.9)
Constipation	464 (73.8)	165 (26.2)
Stomach Cramp	572 (90.4)	61 (9.6)
Some stomach pain, nausea, vomiting or diarrhea that kept from going to work	570 (89.1)	70 (10.9)

Figure 21. Prevalence of gastrointestinal symptoms in the past three months from the time of interview between residents of Caño Martin Peña from December 2011 to April 2012

The assessment of gastrointestinal disease prevalence was using EPA's definition. Figure 22 includes gastrointestinal symptomatology which defines GID according to EPA. The highest frequency for GID symptoms includes nausea with stomach pain at the same time (20.3%); and nausea or stomach pain affecting the participant's capacity to carry out daily activities (19.2%). These results indicate a prevalence of 31.0% for gastrointestinal diseases among Caño Martin Peña participants for the study period. This prevalence among CMP residents is really high in comparison with the rest of Puerto Rico in a year (PR Health Department). A CMP resident equals PR GID prevalence in 24 hours and get higher than PR in three months (Figure 23).

GASTROINTESTINAL SYMPTOMATOLOGY	FREQUENCY	
	NO	**YES**
	n (%)	**n (%)**
vomit	536 (84.3)	100 (15.7)
nauseous with stomach ache at the same time	**507 (79.7)**	**129 (20.3)**
nauseous or stomach ache interfering with daily activities	**518 (80.0)**	**123 (19.2)**
3 diarrhea episodes in a period of 24 hours	560 (87.8)	78 (12.2)

Figure 22.Gaastrointestinal symptomatology frequency distribution

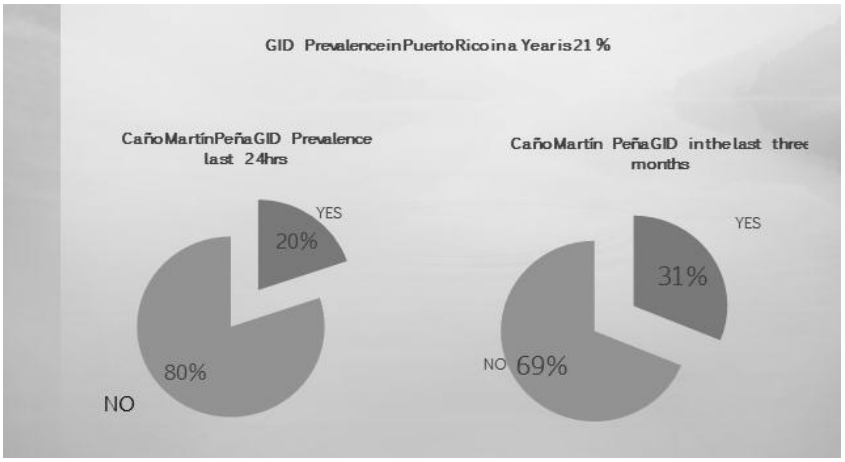

Figure 23. Gastrointestinal symptoms frequency according to EPA definition for CMP participants for the past 3 months/24 hours from December 2011 to April 2012).

Participants were asked if a doctor had diagnosed gastrointestinal diseases from December 2011 to April 2012. The most frequent diagnosis according to respondents was reflux or heartburn with 28.4% and gastritis with 24.5%. The frequency for gastroenteritis was 8.3%, polyps 6.8%, ulcers 6.0%, colitis 2.9%, diverticulitis 8.7%, Crohn's disease 1.6% and irritable bowel syndrome was 4.7 (Figure24). Figure 25 shows participants medication and health practices and diagnostics.

	PREVALENCE	
DIAGNOSED GID	**NO**	**YES**
	n (%)	**n (%)**
Gastritis	**482 (75.5)**	**156 (24.5)**
Gastroenteritis	584 (91.7)	53 (8.3)
Polips	591 (93.2)	43 (6.8)
Ulcers	599 (94.0)	38 (6.0)
Colitis	609 (97.1)	18 (2.9)
Diverticules	576 (91.3)	55 (8.7)
Crohm's disease	623 (98.4)	10 (1.6)
Irritable colom symdrome	603 (95.3)	30 (4.7)
Reflux o heartburn	**454 (71.6)**	**180 (28.4)**

Figure 24. Gastrointestinal health profile at CMP residents

Prevalence of gastrointestinal symptoms among the community residents of Caño Martín Peña in San Juan, Puerto Rico

GASTROINTESTINAL SYMPTOMS IN THE PAST 3 MONTHS	PREVALENCE	
	NO n (%)	YES n (%)
Do you take home remedies to relieve stomach symptoms such as stomach pain, nausea, vomiting or diarrhea?	471 (73.7)	168 (26.3)
Do you take nonprescription medications to relieve symptoms such as stomach pain, nausea, vomiting or diarrhea?	459 (71.8)	180 (28.2)
Do you had visited the doctor for stomach pain, nausea, vomiting or diarrhea?	508 (79.3)	133 (20.7)
Do you have been prescribed medication to relieve symptoms such as stomach pain, nausea, vomiting or diarrhea?	491 (76.5)	151 (23.5)
Do you had visited the emergency room for stomach pain, nausea, vomiting or diarrhea?	559 (87.6)	79 (12.4)
Had you been hospitalized for any gastrointestinal condition such as stomach pain, nausea, vomiting or diarrhea?	617 (96.1)	25 (3.9)

Figure 25. CMP participants medication practices and diagnostics 2012

The following figure shows the prevalence of gastrointestinal diseases in CMP linked to socio-demographic variables during 24 hours/3 months period (Figure 26).

Prevalence of gastrointestinal symptoms among the community residents of Caño Martín Peña in San Juan, Puerto Rico

	VARIABLE	CATEGORY	GASTROINTESTINAL DISEASES (%)	OR	95% IC	*p VALUE*
**** achieve statistical significance***						
gastrointestinal diseases in previous 24 hours	gender	male	14.7	1.0		
		female	22.7	1.70	1.09-2.65	0.018 *
	age	21 a 49 years	13.0	1.0		
		50 - 64 years	27.5	2.53	1.53-4.19	0.001 *
		≥ 65 years	19.8	1.65	0.96-2.82	
	hours at residence (weekends)	less than 20	14.8	1.0		
		more than 20	22.3	1.65	1.06-2.56	0.025 *
	monthly income	less than $ 1000	25.7	1.82	1.32-2.91	0.056 *
		more than $ 1000	33.3	1.0		
gastrointestinal diseases en last three months	gender	male	23.9	1.0		
		female	35.3	1.74	1.20-2.51	0.003 *
	age	21 - 49 years	29.6	1.0		
		50 - 64 years	37.1	1.61	1.07-2.41	0.059 *
		≥ 65 years	29.4	1.13	0.74-1.73	0.57
	paid job	0	35.8	1.96	1.32-2.92	0.001 *
		≥ 1	22.2	1.0		
	hours worked (week)	≤ 20	18.0	1.0		
		21-39	31.9	2.37	1.05-5.36	0.03 *
		> 40	16.5	1.11	0.45-2.73	0.82

Figure 26. Prevalence of gastrointestinal diseases in CMP for socio-demographic variables

Prevalence of gastrointestinal symptoms among the community residents of Caño Martín Peña in San Juan, Puerto Rico

Gastrointestinal diseases **<u>in the previous 24 hours</u>** linked to socio-demographic variables get the following important results:

1. GID prevalence in females was 22.7% while males was 14.7%. This means that females have 70% more probability of developing GID than males. This prevalence achieved statistical significance (95% IC=1.09-2.65) and a *p* value = 0.018.
2. For residents aged 50-64, GID prevalence was 27.5%, while for people older than 65 it is 19.8%. This means that 50-64 year olds have 2.53 more probability of developing GID symptoms than other age groups. This association achieved statistical significance (95% IC=1.53-4.19) with a *p* value = 0.001.
3. Residents staying at their residences more than 20 hours on weekends showed a prevalence of 22.3%. They have 65% more probability than staying less than 20 hours at their homes. This association achieved statistical significance (95% IC= 1.06-2.56) and a *p* value = 0.025.
4. Residents whose monthly income is less than $ 1,000 have a GID prevalence of 25.7%. They have 82% more probability of developing GID (95% IC= 1.32-2.91) and a *p* value = 0.056. This association achieved statistical significance.

Gastrointestinal diseases **<u>in the last three months</u>** linked with socio-demographic variables get the following important results:

1. GID prevalence for females was 35.3%, while it was 23.9% for males. Females have 74% more probability of developing GID than males. This prevalence achieve statistical significance (95% IC=1.20-2.51) and a *p* value = 0.003.
2. For residents aged 50-64, GID prevalence was 37.1%, while for people older than 65, prevalence was 29.6%. This means that people in the range of 50-64 years have 61% more probability of developing GID symptoms than other age groups. This association achieved statistical significance (95% IC=1.07-2.41) with a *p* value = 0.059.

3. Residents with no jobs (unemployed) showed a prevalence of 35.8%. They have 96%% more probability of developing GID than residents with paid jobs (employed). This association achieved statistical significance (95% IC= 1.32-2.92) and a *p* value = 0.001.
4. Residents with paid jobs and working between 21-39 hours a week have a GID prevalence of 31.9%. They have 2.37 more probability of developing GID (95% IC= 1.05-5.36) and a *p* value = 0.03. This association achieved statistical significance.

The following figure shows the prevalence of gastrointestinal diseases in CMP linked to flood event variables. Statistical significance was obtained.

Prevalence of gastrointestinal symptoms among the community residents of Caño Martín Peña in San Juan, Puerto Rico

	VARIABLE	YES /NO	GID (%)	OR	95% IC	*p value*
**statistical significance*						
gastrointestinal diseases in previous 24 hours	flood events 2011 (houses)	YES	22.9	1.53	1.01-2.31	0.043*
		NO	16.2			
	floods during last 3 months (houses)	YES	26.5	1.81	1.20-2.72	0.004*
		NO	16.6			
	floods without rain events (houses)	YES	32.0	2.19	1.36-3.54	0.001*
		NO	17.7			
	floods during rain events (houses)	YES	22.8	1.60	1.05-2.40	0.028*
		NO	15.7			
	floods without rain events (street)	YES	31.6	2.33	1.51-3.60	<0.001*
		NO	16.6			
	VARIABLE	YES/NO	GID (%)	OR	95% IC	*p value*
gastrointestinal diseases during last three months	floods during 2011 (houses)	YES	37.2	1.84	1.30-2.60	0.001*
		NO	24.4			
	floods in last three months (houses)	YES	41.3	1.96	1.40-2.80	<0.001*
		NO	26.5			
	floods in last three months (street)	YES	38.6	2.00	1.42-2.83	<0.001*
		NO	23.6			
	floods without rain events (houses)	YES	51.0	2.74	1.78-4.21	0.000*
		NO	27.5			
	floods during rain events (houses)	YES	35.6	1.54	1.09-2.17	0.013*
		NO	26.4			
	floods without rain events (street)	YES	47.9	2.50	1.7-3.7	<0.001*
		NO	26.9			
	floods during rain events (street)	YES	34.7	1.67	1.14-2.45	0.008*
		NO	24.1			

Figure 27. Prevalence of gastrointestinal diseases in CMP linked to flooding variables

Prevalence of gastrointestinal symptoms among the community residents of Caño Martín Peña in San Juan, Puerto Rico

Gastrointestinal diseases **in the previous 24 hours** linked to flooding events get the following important results:

1. Residents who experienced flooding events during 2001and their houses flooded have a GID prevalence of 22.9%. This means that these residents have 53% more probability of developing GID than people that didn't experience flooding during that year. This prevalence achieve statistical significance (95% IC=1.01-2.31) and a *p* value = 0.043.
2. Residents whose houses flooded during the past three months have a GID prevalence of 26.5%. This means that these residents have 81% more probability of developing GID symptoms than people whom houses didn't flood. This association achieved statistical significance (95% IC=1.20-2.72) with a *p* value = 0.004.
3. Residents whose houses flooded without experiencing a raining event showed a GID prevalence of 32%. They have 2.19% more probability of developing GID symptoms than people whose houses did not flood. This association achieved statistical significance (95% IC= 1.36-3.54) and a *p* value = 0.001.
4. Residents whose houses flooded during raining events showed a GID prevalence of 22.8%. They have 60% more probability of developing GID symptoms than people whom houses didn't flood. This association achieved statistical significance (95% IC= 1.05-2.40) and a *p* value = 0.028.
5. Residents whose street flooded without experiences a raining event showed a GID prevalence of 31.6%. They have 2.33% more probability of developing GID symptoms than people whom houses didn't flood. This association achieved statistical significance (95% IC= 1.51-3.60) and a *p* value < 0.001.

Prevalence of gastrointestinal symptoms among the community residents of Caño Martín Peña in San Juan, Puerto Rico

Gastrointestinal diseases **in the last three months** linked to flooding events get the following important results:

1. Residents whose houses flooded during 2001 have a GID prevalence of 37.2%. This means that these residents have 84% more probability of developing GID than people whose houses didn't flood during that year. This prevalence achieve statistical significance (95% IC=1.30-2.60) and a *p* value = 0.001.
2. Residents whose houses flood during the last three months have a GID prevalence of 41.3%. This means that these residents have 96% more probability of developing GID symptoms than people whose houses didn't flood during that period. This association achieved statistical significance (95% IC=1.40-2.80) with a *p* value < 0.001.
3. Residents whose street flooded in the last three months showed a GID prevalence of 38.6%. They have 2 times more probability of developing GID symptoms than people whose street didn't flood during the past three months. This association achieved statistical significance (95% IC= 1.42-2.83) and a *p* value < 0.001.
4. Residents whose houses flooded without experiencing a raining event showed a GID prevalence of 51%. They have 2.74% more probability of developing GID symptoms than people whom houses did not flood. This association achieved statistical significance (95% IC= 1.78-4.21) and a *p* value = 0.000.
5. Residents whose houses flooded during a raining event showed a GID prevalence of 35.6%. They have 54% more probability of developing GID symptoms than people whom houses did not flood. This association achieved statistical significance (95% IC= 1.09-2.17) and a *p* value = 0.013.
6. Residents whose street flooded without experiencing a raining event showed a GID prevalence of 47.9%. They have 2.50% more probability of developing GID symptoms than people whom street did not flood. This association achieved statistical significance (95% IC= 1.7-3.7) and a *p* value < 0.001.
7. Residents whose street flooded during a raining event showed a GID prevalence 34.7%. They have 67% more probability of developing GID symptoms than people whom street did not flood . This association achieved statistical significance (95% IC= 1.14-2.45) and a *p* value = 0.008.

Prevalence of gastrointestinal symptoms among the community residents of Caño Martín Peña in San Juan, Puerto Rico

In conclusion, Caño Martín Peña water channel high sedimentation and low hydraulic flow is causing residents at nearby communities to suffer from constant flooding events harming their health and security. These floods carry out polluted water from the channel due to wastewater discharges from CMP communities without sewer connections. There is evidence that high levels of coliform and enterococci bacteria are being identified at all sites sampled in the water channel. These bacteria are linked to gastrointestinal diseases and some other health conditions.

It is evident that the exposition to floods carrying bacteria is linked to the development of high gastrointestinal disease (GID) prevalence among residents living near the water channel. Also, residents experiencing flooding at their homes or streets without raining events get the highest prevalence percents. This could be explained by the fact that CMP water channel low hydraulic flow favors the reproduction of bacteria during no precipitation period, but when it rains, that high bacteria levels are washed throughout the neighborhood, flooding streets and houses at nearby communities.

For all these reasons, residents at Caño Martín Peña communities are at a higher risk that all the rest of Puerto Rico from getting sick by gastrointestinal diseases due to flooding events. Residents in CMP get the same GID prevalence than the rest of Puerto Rico in a whole year (21%), in just a 24 hour period; and they exceed it in three months (31%). For those reasons, the dredging of the water channel is the best public health intervention strategy to improve CMP residents' health status and to restore the aquatic ecosystem natural flow and quality.

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