

The Effect of Hurricane Maria on the Surgical Workload of the UPR-affiliated Hospitals

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Objective: The Caribbean islands are regularly affected by hurricanes in a seasonal manner, but major (category 4 and 5) hurricanes are infrequent, and what happens in their aftermath is important for future planning.

Methods: We reviewed the surgical cases entered into the University of Puerto Rico (UPR) General Surgery Department database from January 1, 2016, through December 31, 2017. This database collects patient and procedural information from the surgical services of the UPR-affiliated hospitals. To analyze the impact that Hurricane Maria had on the surgical population, we compared cases per month using September 2017 (the month that Maria struck Puerto Rico) as the reference month. A chi-square goodness-of-fit test was used to evaluate differences between months.

Results: Information was available for 9,059 cases during the study period. The mean age of the group was 49 ± 14 years, the gender distribution being 56% women, 44% men. The study found a statistically significant difference ($p < 0.001$) in the number of surgical cases per month, with fewer patients in September 2017 ($n = 210$) compared to other months, representing a 57% decline in the number of cases. These patients tended to be sicker, with an increase in the number who had an American Society of Anesthesiologists physical status classification of 3 or greater. Within 3 months after the natural disaster, the volume of patients started to return to normal.

Conclusion: We found that this major hurricane resulted in a decreased surgical workload, mostly because elective surgery cases were fewer, but that the patients that came for surgical care tended to be sicker and had, for the most part, poorly controlled systemic diseases. The volume of surgical cases did not reach normal levels until 3 months after the natural disaster. [*P R Health Sci J* 2020;39:195-199]

Key words: Hurricanes, Natural disasters, Surgery

Hurricane Maria made landfall in Puerto Rico as a category 4 hurricane on September 20, 2017. With the immediate and subsequent islandwide loss of electricity, the widespread loss of access to clean water, the destruction of thousands of homes, and the crippling of the road infrastructure, the people of Puerto Rico suffered privations on a devastating scale (1-3). The direct effects of the hurricane were magnified by a series of catastrophic and cascading infrastructure failures that included the collapse of the island's telecommunications networks, the lack of access to medical care and slow coordination of the aid that had been sent. The elderly and the poor were the most severely affected (4).

With all that, the government of Puerto Rico reported only 64 Maria-related fatalities. In response to mounting criticism regarding the declared number of deaths, an independent investigation of the death toll was ordered and the Milken Institute School of Public Health was contracted. From their study we now know that the number of excess deaths for the time period ranging from September 2017 through February 2018 was approximately 2,975 (95% CI 2,658-3,290) (4 -5). The controversy regarding the number of deaths resulted from the fact that the government of Puerto Rico reported only the

deaths caused directly by the hurricane and not those caused by the indirect effects of the storm (the losses of electricity, communications and other basic services).

It is estimated that Maria caused \$90 billion in damages, ranking it as the third most costly hurricane in recent United States history, following Katrina (2005) and Harvey (2017) (6).

The Caribbean islands are all regularly affected by hurricanes, in a seasonal manner, but major (category 4 and 5) hurricanes are infrequent, and what happens in their aftermaths is important for future planning. In this study we evaluated the number and characteristics of all the cases in the surgery database of the University of Puerto Rico (UPR)-affiliated hospitals for the year of the hurricane and for the year preceding it, to determine what effect Hurricane Maria had on the surgical workload.

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The authors have no conflicts of interest to disclose. Presented in part at the Raffucci Surgical Research Forum, Annual Meeting of the Puerto Rico Chapter of the American College of Surgeons; May 18, 2018, San Juan, PR.

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Methods

To analyze the impact of Hurricane Maria on the previously mentioned surgical workload, we reviewed all the cases entered into the database of the (UPR)-Department of General Surgery from January 1, 2016, through December 31, 2017. This database compiles (by case) the basic demographic information and clinical data of each patient recorded there. It collects information from the surgical services of the UPR-affiliated hospitals (6 participating hospitals: 2 in academic centers and 4 that are community hospitals). The information obtained comes from the weekly reports generated by the residents of the different participating surgical services at the aforementioned hospitals. The data from those reports are extracted and compiled, creating an aggregate of information that describes the general surgical procedures performed at the affiliated institutions as well as characterizing the patients on whom those procedures were performed. Personal identifiers are not included in the aggregated data. For each patient, the following information is collected into the database: age, gender, BMI, and American Society of Anesthesiologists (ASA) physical status classification; the surgical procedure(s) received; and the surgical outcome(s) in terms of both morbidity and 30-day postoperative mortality. Compliant with the Health Insurance Portability and Accountability Act (HIPAA), this database of surgical procedures is both secure and confidential.

For our study, we compared surgical cases per month for all UPR-affiliated hospitals, using September 2017 as the reference month. We also obtained the number of surgical cases performed per month during 2017 by the Trauma Hospital and Veterans Hospital, both located in and forming part of the Medical Center, which is found in Río Piedras, Puerto Rico.

The study's aim was to analyze the changes in the surgical workload (the number of cases, the characteristics of each case, and each case's degree of severity [ASA score]) that resulted from the category 4 hurricane Hurricane Maria and thereby begin to form a method of predicting how such workloads might be affected by future, similarly major events.

Statistical analyses were performed with the software program SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, version 22.0. Armonk, NY: IBM Corp). Quantitative variables were expressed as means plus or minus standard deviations. Categorical variables were presented as frequencies and percentages. Differences between proportions were compared using a chi-squared test. The chi-square goodness-of-fit test was used to evaluate differences between months. Results were considered significant when the p-value was less than 0.05.

This study was approved by the Institutional Review Board of the UPR Medical Sciences Campus.

Results

During the 2-year period selected for evaluation, the database of the UPR General Surgery Department collected information

on 9,059 general surgical cases. The mean age of the group was 49 (± 14) years, the gender distribution being 56% women, 44% men.

The cases managed by the UPR-affiliated hospitals in the aftermath of Hurricane Maria tended to be sicker, as is indicated by the relatively higher (compared to pre-Maria numbers) proportion of patients having an ASA classification of 3 or greater. The percentage of surgical patients with an ASA of 3 or greater from January through August 2017 was 29.4%, while from September through December (2017) it increased to 36.5%, a significant difference ($p < 0.001$).

The variables documented per case (per month 2017) in the database of the UPR Department of General Surgery are shown in Table 1. There was no significant difference in the mean age of the cases during the different months of the year. An analysis of gender distribution showed that there was a significantly higher number of female patients in September, with 58% being women and 42%, men. Outpatient surgery in September was maintained at 32% (67 cases) which compares favorably with the 36% (181 cases) in August, but with fewer cases overall. The proportion of dirty and infected wounds increased from 3% (16 cases) in August to 6% (13 cases) in September. Postoperative 30-day mortality was reported in 1% (3 cases) of the 210 total cases done in September, which falls within the expected range. In August 2017, 88% of the surgeries (440 cases) were elective, which dropped to 69% (144 cases) in September 2017. A slightly higher percentage (40%) of obese patients was found in the surgical population in that same September. However, the percentage of cases with diabetes, hypertension, or both was not significantly different throughout the year.

The study found a statistically significant ($p < 0.001$) difference in the number of surgical cases per month, with fewer patients in September 2017 ($n = 210$) compared to other months (Table 2). This represented a 57% decline in the number of cases, as shown on Figure 1. Three months after the natural disaster the volume of patients started to return to normal. A similar finding was reported by the separate database of the Veterans Hospital (Figure 2) which organization experienced a decline in the number of patient that persisted beyond the 3-months period. The database of the Trauma Hospital (Figure 3) registered a decline in the volume of patients in September (seeing only 72 cases when their average is 100 to 130 cases per month). However, they had a slight surge in workload in October (140 cases) which load returned to normal by November (2017).

Discussion

Our study found that following Hurricane Maria the number of surgical cases decreased significantly. This drop in surgical workload lasted about 3-months in all the UPR-affiliated hospitals except the Trauma Hospital, where the volume of trauma surgery increased within 1-month of the hurricane. Our finding was different from that reported by other medical

Table 1. Characteristics of the surgical cases per month (2017). ANOVA used for the p-value of age and chi-squared test for all other p-values.

Age	Jan n = 368	Feb n = 284	March n = 458	April n = 343	May n = 448	Jun n = 504	July n = 375	Aug n = 502	Sept n = 210	Oct n = 239	Nov n = 357	Dec n = 363	P
Mean age ± SD	49 ± 23	53 ± 22	50 ± 21	48 ± 23	52 ± 22	50 ± 23	49 ± 23	49 ± 23	49 ± 22	51 ± 21	49 ± 22	48 ± 22	0.09
Gender													
Male	144	111	187	145	182	240	184	232	89	107	182	166	0.006
Female	224	173	271	198	266	263	191	269	121	131	174	197	
Admission status													
Inpatient	227	161	281	237	285	310	245	315	143	173	209	244	0.001
Outpatient	141	123	177	106	163	192	126	181	67	64	148	118	
Wound class													
Clean	193	154	234	153	243	208	188	284	93	115	172	171	<0.001
Clean-contaminated	123	88	177	152	171	202	125	165	78	80	110	126	
Contaminated	17	15	26	12	23	54	43	35	23	34	55	48	
Dirty/Infected	11	1	20	25	10	39	17	16	13	9	12	4	
Outcome													
Uneventful	338	269	437	327	413	484	360	494	203	231	347	343	0.001
Minor morbidity	18	6	14	7	15	10	8	5	2	3	6	8	
Major morbidity	6	7	4	3	10	5	6	1	2	5	4	8	
Mortality	2	1	3	2	10	2	1	2	3	0	0	2	
Surgery type													
Elective	313	262	418	281	367	431	318	440	144	180	302	288	<0.001
Emergency	51	21	39	62	81	72	57	60	66	59	55	73	
American Society of Anesthesiology (ASA) classification													
ASA <3	284	219	330	222	313	362	218	349	145	155	223	217	<0.001
ASA ≥ 3	79	64	128	117	131	135	148	153	65	82	133	145	
Body Mass Index (BMI) categories*													
Underweight													
<18.5 kg/m ²	4	1	7	5	9	15	15	19	24	17	35	32	<0.001
Normal													
18.5--24.9 kg/m ²	86	58	104	62	93	125	89	147	52	70	107	106	
Overweight													
25.0--29.9 kg/m ²	130	114	183	121	148	163	101	156	50	82	115	126	
Obese >30.0 kg/m ²	88	82	117	100	151	150	137	133	84	68	98	93	
Risk factors													
Diabetes (yes)	90	52	117	76	118	121	105	133	48	63	86	81	0.3
Diabetes (no)	271	232	341	267	329	383	266	369	161	176	271	280	
Hypertension (yes)	42	26	51	42	60	60	48	48	19	19	37	36	0.5
Hypertension (no)	317	249	402	295	387	441	326	453	191	219	319	324	

services, for example the Obstetrics-Gynecology Department reported a 33% increase in deliveries for September 2017 compared to September 2016 (7). Of course women in labor cannot wait for services to be reinstated, and things to return to normal. In addition, the UPR-affiliated hospitals normally have a workload in which 87% of the surgeries are elective (8); in the aftermath of Hurricane Maria, many patients scheduled to receive such surgeries opted to postpone them.

It is also possible that in the wake of this natural disaster, with the subsequent loss of communication, electricity and other basic necessities, some of the sick and elderly died in their isolated communities without the benefit of access to the larger hospitals. The death toll can be difficult to evaluate in the aftermath of a major hurricane, but currently at least 3 studies have tried to give us the best estimates. A recent study using a representative, stratified sample, surveyed 3,299 randomly chosen house-holds across Puerto Rico to produce an

Table 2. The number of surgical case by month during 2017. Chi-square goodness-of-fit test shows that there was a statistically significant ($p<0.001$) difference in the number of cases per month, with fewer cases in September ($n=210$) compared to the other months.

	Observed N	Expected N	Residual
January	368	370.9	-2.9
February	284	370.9	-86.9
March	458	370.9	87.1
April	343	370.9	-27.9
May	448	370.9	77.1
June	504	370.9	133.1
July	375	370.9	4.1
August	502	370.9	131.1
September	210	370.9	-160.9
October	239	370.9	-131.9
November	357	370.9	-13.9
December	363	370.9	-7.9
Total	4451		

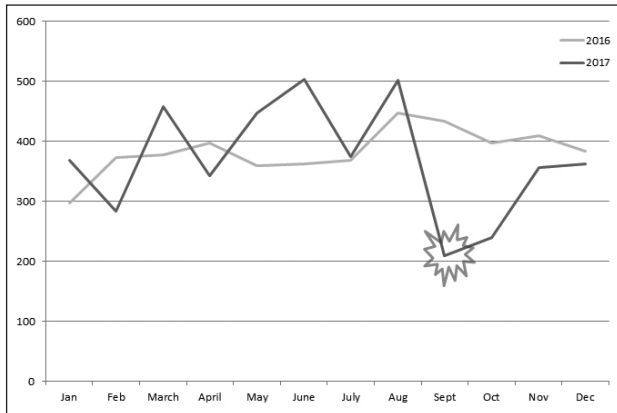


Figure 1. Number of surgical cases performed at the UPR-affiliated hospitals during 2016 and 2017.

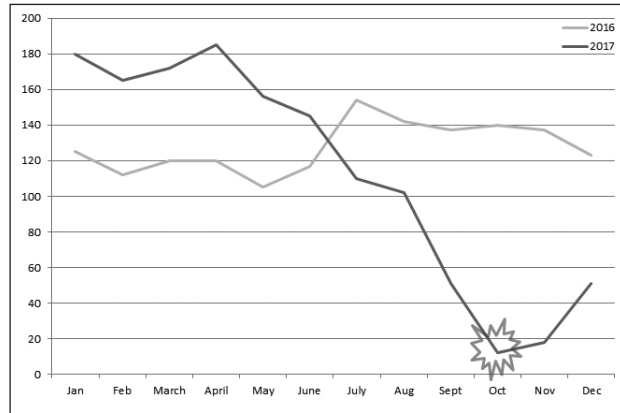


Figure 2. Number of surgical cases performed at the Veterans Hospital during 2016 and 2017.

independent estimate of all-cause mortality after the hurricane (9). The study group estimated a total of 4,645 (95% CI, 793 - 8,498) excess deaths from September 20 through December 31, 2017. The results of the survey study have been criticized because of the large confidence Interval (CI), which indicates a high level of uncertainty. Using death counts from vital statistics records the number of excess deaths has been calculated to be 1,139 by Santos-Lozada (10) and 2,975 by Santos Burgos (4-5), which latter is the figure that is accepted by the government at this time.

The causes of death on the vital statistics records have been evaluated, with the top causes being diseases of the circulatory, endocrine, and respiratory system (11). These are chronic diseases that are generally not managed by surgery, except for the occasional complications. Perhaps when more detailed information becomes available, we will be able to determine how many surgical candidates died without access to our hospital facilities.

Among the limitations of our study is that the post-hurricane population exodus from Puerto Rico, reported to have been as high as 14%, makes comparing the September 2016 and 2017 number of cases problematic (12-13).

Our study indicated that Hurricane Maria resulted in a decreased volume of surgery cases, probably caused by the lack

of access to hospitals because of blocked roads and fallen debris and because patients struggling with the twin lack of electricity and water tend to postpone any elective surgery.

Conclusion

Major hurricanes result in a decreased volume of surgery, an effect that is likely to be prolonged for several months after this kind of natural disaster. Though the surgical workload decreased, mostly because there were fewer elective surgeries, the patients that came were sicker and had, for the most part, poorly controlled systemic diseases (indicated by an ASA score of 3 or higher).

Resumen

Objetivo: Las islas del Caribe regularmente se ven afectadas por huracanes durante ciertas épocas del año, pero huracanes mayores (categorías 4 y 5) son poco frecuentes y saber lo que ocurre a consecuencia de ellos es importante para la planificación futura. Método: La investigación se llevó a cabo usando los datos recopilados en el banco de datos del Departamento de Cirugía General de la Universidad de Puerto Rico (UPR) entre el 1 de enero del 2016 y el 31 de diciembre del 2017. Este banco de datos contiene información sobre características de los pacientes y cirugías realizadas por los hospitales afiliados a la UPR. Para analizar el impacto que el Huracán Maria tuvo en la población quirúrgica, comparamos los casos por mes, usando septiembre del 2017 (mes en que Maria pasó por Puerto Rico) como el mes de referencia. El análisis de los datos para evaluar la diferencia entre los meses se realizó con la prueba ji-cuadrada de bondad de ajuste. Resultados: La información de 9,059 casos estaba disponible para el período de estudio. La edad media de los pacientes fue de 49±14 años, con una distribución por género de 56% mujeres y 44% hombres. Encontramos una diferencia estadísticamente significativa ($p < 0.001$) en el número de casos mensuales, con una disminución en septiembre de 2017

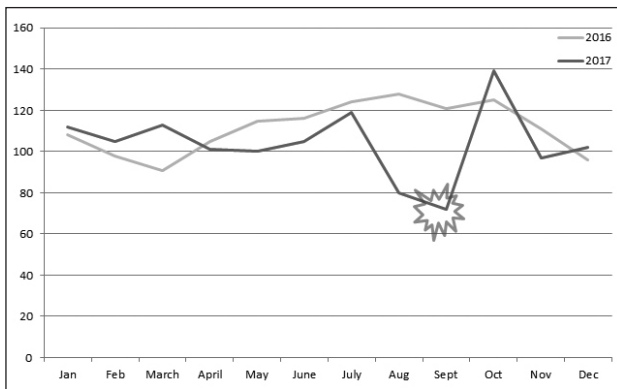


Figure 3. Number of cases managed at the Trauma Hospital of the Medical Center in Río Piedras during 2016 and 2017.

(n=210) al compararlo con otros meses, representado 57% menos casos. Estos pacientes tendían a estar más enfermos, notando un aumento en los casos con clasificación de la Asociación Americana de Anestesiólogos ≥ 3 . Después de tres meses, el volumen de cirugía comenzó a regresar a lo normal. Conclusión: La investigación encontró que éste huracán resultó en una disminución en el volumen total de casos quirúrgicos, debido principalmente a la pérdida de casos electivos, pero los pacientes que acudieron a los hospitales tendían a estar más severamente enfermos y con condiciones sistémicas pobremente controladas. El volumen de casos tardó tres meses en regresar a lo normal después del huracán.

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