



HURRICANE MARÍA: FORGING THE FUTURE OF SCIENCE IN PUERTO RICO

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Outline

Description of the situation

Devastation to

education

research

pharmaceutical industry

Recovery

Lessons learned

Acknowledgements



Hurricane Irma

September 6, 2017

- Brought heavy rains and wind gusts up to 100 mph in parts of the Island.
- Around two-thirds of the population were without electricity.
- Around one-third of the population were without clean water.
- High deforestation (debris contributed to the flooding caused by hurricane Maria).

Preparations

- Being an island, massive evacuation was not feasible.
- People were initially prepared with food, water, medicines, and fuel for several days, but not for weeks or even months.
- People secured their houses and properties as best as they could.
- The government, the private sector, educational institutions, medical care facilities, etc. all reviewed and implemented their emergency plans and protocols.
- Schools and some public buildings were converted into shelters.
- Hospitals, hospices and medical facilities were evacuated as patient conditions permitted.
- Airplanes and ships were moved out of harms way.

Hurricane María

September 20, 2017

- Was a strong Category 4 (150 mph) hurricane at landfall. The meteorologists had no land-based records of maximum winds because the hurricane damaged most of Puerto Rico's wind sensors.



Typical NEXRAD Doppler radar tower



NEXRAD Doppler radar after Hurricane Maria

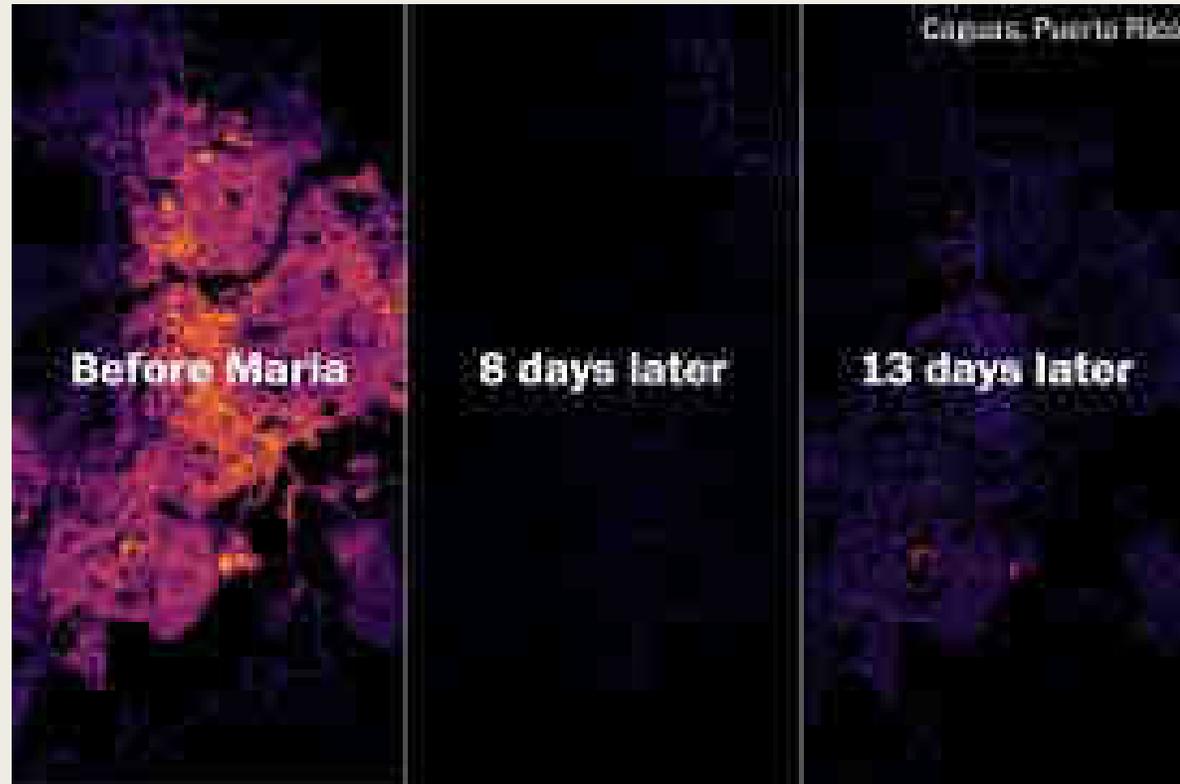
- This included the weather radar operated by the FAA and the NWS. The radar was designed to withstand winds of 133 mph, so this value provides a low-end estimate of the hurricane's winds.

Maria's path across the Island



<https://www.nytimes.com/interactive/2017/09/18/world/americas/hurricane-maria-tracking-map.html>

Electric Power and Drinking Water



- María destroyed what was still working from the electric grid after Irma. After the hurricane, all the Island was completely without power.
- The power-dependent drinking water system was virtually shot down.

Telecommunications

Maria severely damaged 95 percent of cell towers, cutting off nearly all cell phone communication.

As in previous hurricanes, land lines were more resilient.



Maria's Aftermath



- Winds were not the only destructive force.
- It rained over 48 hours (25 to 30 inches) in most areas, with some spots receiving even higher amounts.
- Thirty rivers reached major flood stage, and 13 of those reached or exceeded record-flood stage.
- High-wind water sprays and roof leakages also caused extensive damaged.

Maria's Aftermath

The hurricane caused structural damage to :

- Unknown number of house and buildings.
- Destroyed nearly all road signs and traffic lights.
- Wiped out many roads, leaving them closed for months after the hurricane.
- Agriculture was extensively damaged.
- Very long lines (4-5 hrs in some instances) to obtain water, food, fuel, cash and hardware materials. Supplies rapidly diminished.



FEMA: Good Faith, Material Resources, Red Tape and Blunders

- Basically confiscated all diesel reserves provoking an artificial fuel shortage.
- This not only affected the operation of generators, but also affected the transportation of goods stalling the recovery of the private sector.
- Basically controlled all shipping and storage facilities provoking unnecessary food and supplies delays. Ships full of the much needed water, food and general supplies could not be unloaded, nor transported.
- People that were less affected by the hurricane and relatively self-sufficient, artificially became part of the people requiring assistance.



EDUCATION & RESEARCH

Public Schools



- 255 public schools were permanently closed at the end of the 2017-2018 school year. (That leaves 856 schools in operation, according to the Department of Education.)
 - Kids from impoverished neighborhoods, were more likely to have their homes destroyed, lost relatives or endured food insecurity and homelessness in the aftermath of a storm.
 - They were also more likely to be impacted by school closures, since low-income neighborhoods are more reliant on schools that depend on government support.

Higher Education

- University of Puerto Rico System (11 campuses) and many of the private universities were strongly impacted by the hurricane.
 - No water or electricity for weeks and in many cases months.
 - Many buildings were severely damaged and some even destroyed.
 - Flooding caused mold everywhere.
 - Trees and debris had to be removed to regain access.
 - No internet available.
 - Laboratory fume hoods were extensively damaged and some instruments were lost due to floods, water or leaking roofs.
 - Dorms and student facilities were closed due to the damages.

Research Laboratories

- Some research laboratories were severely damaged and some even flooded.
- Communication with students was a challenge.
- Many instruments were lost because of water damage.
- The administrative offices were not working at full capacity, so purchases and other support services were not available.
- No compressed gases were available in Puerto Rico. The priority was to supply hospitals.
- Generators were another challenge, because fuel or diesel were controlled by FEMA, an unnecessary scarcity was generated.



CAPE SAN JUAN ATMOSPHERIC OBSERVATORY - CSJAO (BEFORE HURRICANE MARIA)



Safety

- Many hoods were severely damaged
- Refrigerator with chemicals were off for many days
- Mold was everywhere
- Nothing can start without water

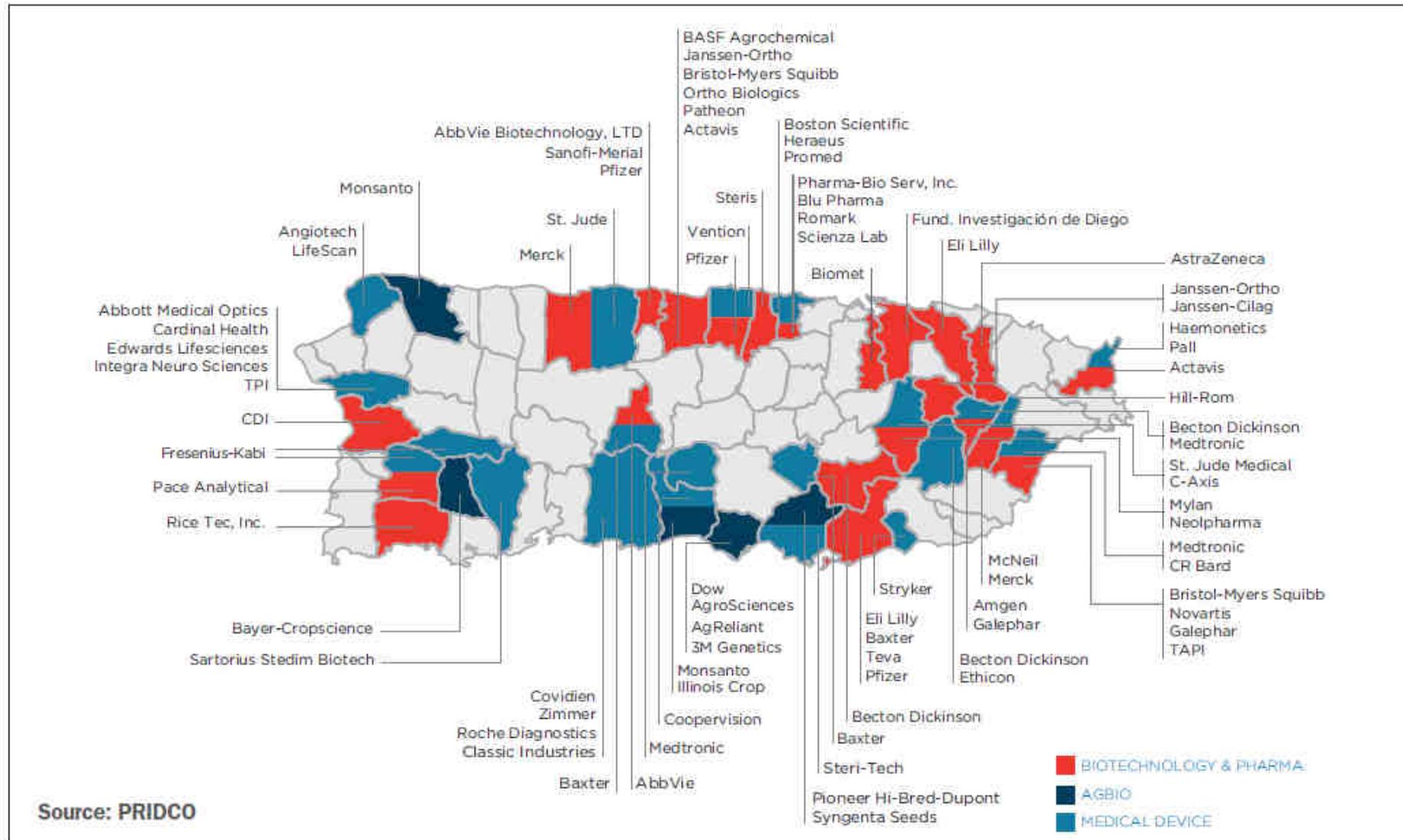




PHARMA INDUSTRY

50 Pharmaceuticals Manufacturing sites

Map of Puerto Rico's life science manufacturing facilities



Source: PRIDCO



1 Juncos

Amgen's Juncos site is the largest in its manufacturing network, with roughly 2,700 people working across its five plants to produce 13 of the company's drugs.

2 Las Piedras

Merck & Co., which employs roughly 600 people on the island, shipped over a 1,500-kW generator from its West Point, Pa., site to support operations in Las Piedras.

3 Jayuya

Many employees living near **AbbVie's** site in Jayuya were still without power 11 months after the hurricane.

4 Barceloneta

AbbVie's Barceloneta site benefited from a cogeneration plant, which allowed it to power another company and the local bakery after the storm.

5 Vega Baja

Pfizer's Vega Baja site, one of three that collectively employ about 1,900 people plus contractors, packed its first batch of medicines on Nov. 2, about six weeks after the storm.

6 Guaynabo

J&J's Guaynabo site, home to corporate and commercial functions, is part of a broad network on the island, with some 3,700 employees working across six manufacturing sites.

7 Carolina

Eli Lilly & Co. is one of six companies to manufacture biologic products, like the insulin made at its Carolina site.

Sources: Company interviews

C&EN

OF THE TOP 20
MEDICINES SOLD
WORLDWIDE,
COMPONENTS OF 11
ARE MANUFACTURED
IN PUERTO RICO

Industry major challenges



Assessment of damages



Communication with employees



Electric service and generators



Delivery of supplies, chemicals and gases



Internet and communication for protocols, procedures, reports and regulations

RECOVERY

Higher Education

- The general community helped to clean the campuses.
- All universities were opened within the first month after the hurricane. Many had no water or electric services. Scheduled night classes were moved to weekends.
- Many students left the Island and continued the semester in US because many Institutions welcomed them and even provided some economic assistance.
- Recovery trainings and workshops were offered to faculty and staff.
- Classes were offered in makeshift spaces outside the buildings.
- Announcements were posted in bulletin boards.

Higher Education

- Laboratory experiences were adapted according to the specific conditions of the campus.
- Drives for foods and money to help students and personnel were undertaken.
- Professors and other personnel prepared free breakfast and lunch for students.
- Oasis were installed for the students and the general community in the campuses that had running water
- Hotspots to access internet were available for students, personnel, and the community.
- The first semester was finished in February 2018. The school year was completed by the second week of June 2019.



Research

- Many researchers had ongoing collaborations with US researchers and were able to temporally move some students to the US to continue their research work.
- Researchers shared their supplies until the system of purchases was stabilized.
- Researchers also shared their laboratory space, instruments, and even refrigerators.

Research

- Research reports and proposal deadlines were extended by Federal Agencies.
- Special supplemental grants were offered by some Federal Agencies.
- Special grants sponsored by Puerto Rico Science Trust, AAAS-Caribbean Division and ACS-Puerto Rico were offered to graduate students to help with supplies that were lost as a consequence of the hurricane.

The Molecular Sciences Center (MSRC)

- MSRC is a 152,000 sq. ft. advanced research facility with laboratories conducting basic and translational biomedical research.
- It was designed to withstand catastrophic events such as Hurricane Maria. The Center never ceased operations, not even during the hurricane.
- A 1.25 MW diesel electric generator operated 24/7 for four week before the electricity was reestablished. The grid remained unstable, therefore the generator continued providing its service as required. The city water supply was not interrupted.
- The MSRC became a center of support for different university offices, operations and programs. Around 150 university employees used the facilities to continue operating as their facilities were being assessed for damages.
- MSRC provided secure WIFI internet services to students and the community in general 24/7.
- The MSRC provided not only space for some of the displaced students and researcher, but also low temperature refrigerators saved important biological samples, constructs and enzymes.

LESSONS LEARNED



Preparation

- The emergency plan needs to be regularly updated: Prepare as much as you can in terms of food, water, and medicines. If possible prepare a generator and fuel for your immediate needs.
- Copy, print and waterproof important documents. Have emergency contact information of neighbors, relatives, staff and students, including telephone numbers and addresses.
- Assess the vulnerable points such as doors, windows, equipment and the infrastructure on roofs (hood motors, air conditioners and drainages).

Preparation

- Get satellite phones
- Strengthen the generators backup. (eg. Amgen invested \$40M in a cogeneration plant that provides heat and power)
- Take a closer look of the supply chain and its contingency plan.

Very First - After a Disaster

- Mitigate the immediate humanitarian crisis.
- Assess specific needs of your family, neighbors and community to effectively respond to people and the entities that want to help.
- Cooperate and collaborate as much as possible (personal and professional) with all involved.
- Take care of your needs and try to recover your routine as soon as possible.

Industry

- Establish a communication plan with the employees to find out their status and needs, and that of their communities.
- Collaborate and cooperate with all companies to help them recover, no time or space for competition.
- Keep record and printed materials (protocols, procedures, etc.).
- Managers and trained personnel should stay at the plant to deal with problems within the facilities.

Industry

- Create an oasis for employees to ensure their safe return to work
 - water
 - hot food
 - ice
 - baths with hot water!
 - fuel

This was an exceptional effort to restore the motivation, commitment and emotional stability of everybody.

Managing Disasters

Key takeaways from industry leaders in Puerto Rico

- **Stock up:** Make sure your water and energy reserves are always full and have enough to keep your facility operating off the grid for a prolonged period of time.
- **Have spare parts:** Be ready to fix broken generators or other key machinery on your own.
- **Have IT know-how:** As many systems are now automated and online, it's crucial to have a professional available who can quickly solve IT- related hiccups.
- **Establish a clear chain of command:** Know who's going to be in charge in case of an emergency.
- **Track employees:** Have a plan to account for everyone at your facility as phone service will be disrupted.
- **Line up contractors:** Establishing good relationships with contractors will help with rebuilding when you need them to prioritize working with you over other companies.

Final Reflections

- Puerto Rico has come a long way from total disaster to a recovered functioning society. Even some people that left the Island have returned.
- The electric grid has totally recovered and all debris have been cleared.
- Life has normalized for people, tourism has recovered and the surviving companies and industries are back to normal.
- The education sector has adjusted to the lost of students and facilities. Schools and universities are back to normal.
- Now the big projects remain. Rebuilding houses, roads, bridges and infrastructure has been disappointingly slow.
- The general economy has not reached the pre-Maria stage yet.
- The general population continues to work hard towards total recovery.



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