



# HURRICANE MARÍA: FORGING THE FUTURE OF SCIENCE IN PUERTO RICO

Ingrid Montes, Ph.D  
University of Puerto Rico  
Río Piedras Campus  
ingrid.montes2@upr.edu

# 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 María

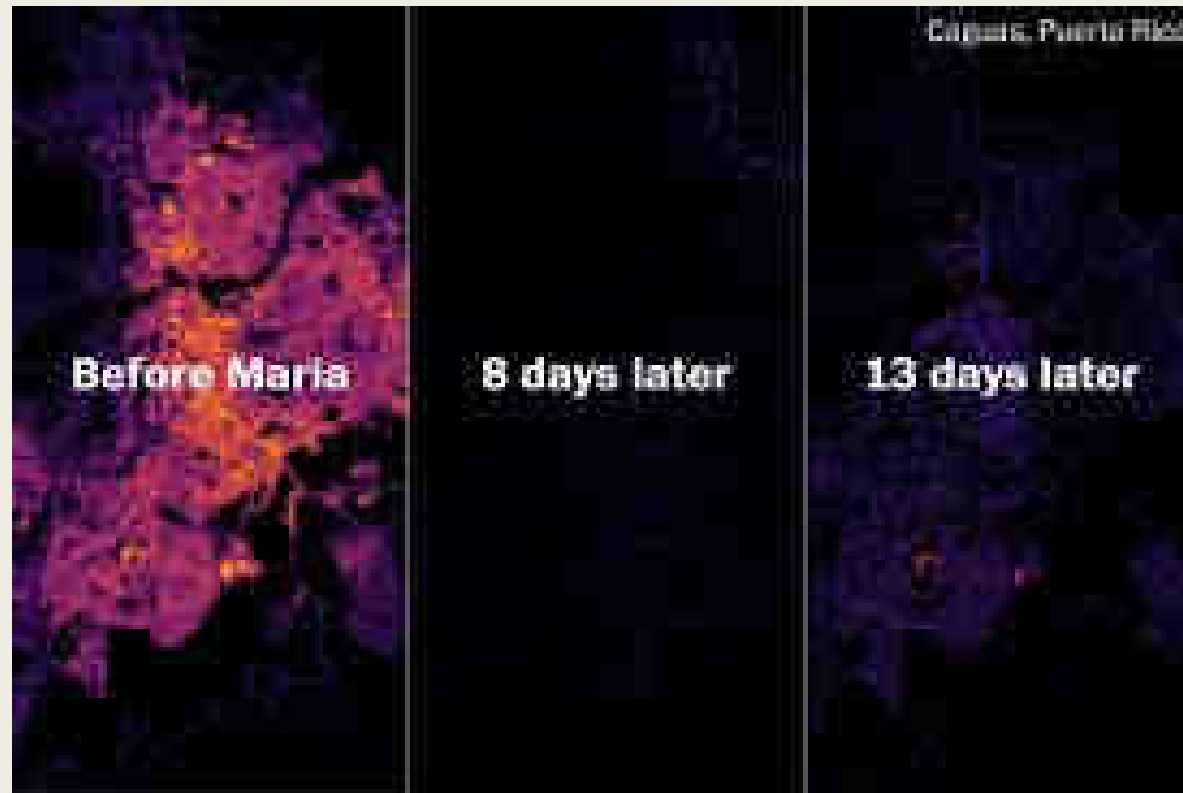
- This included the weather radar operated by the FAA and the NWS. The radar was designed to withstand winds of 133 mph, so this value provides a low-end estimate of the hurricane's winds.

# 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

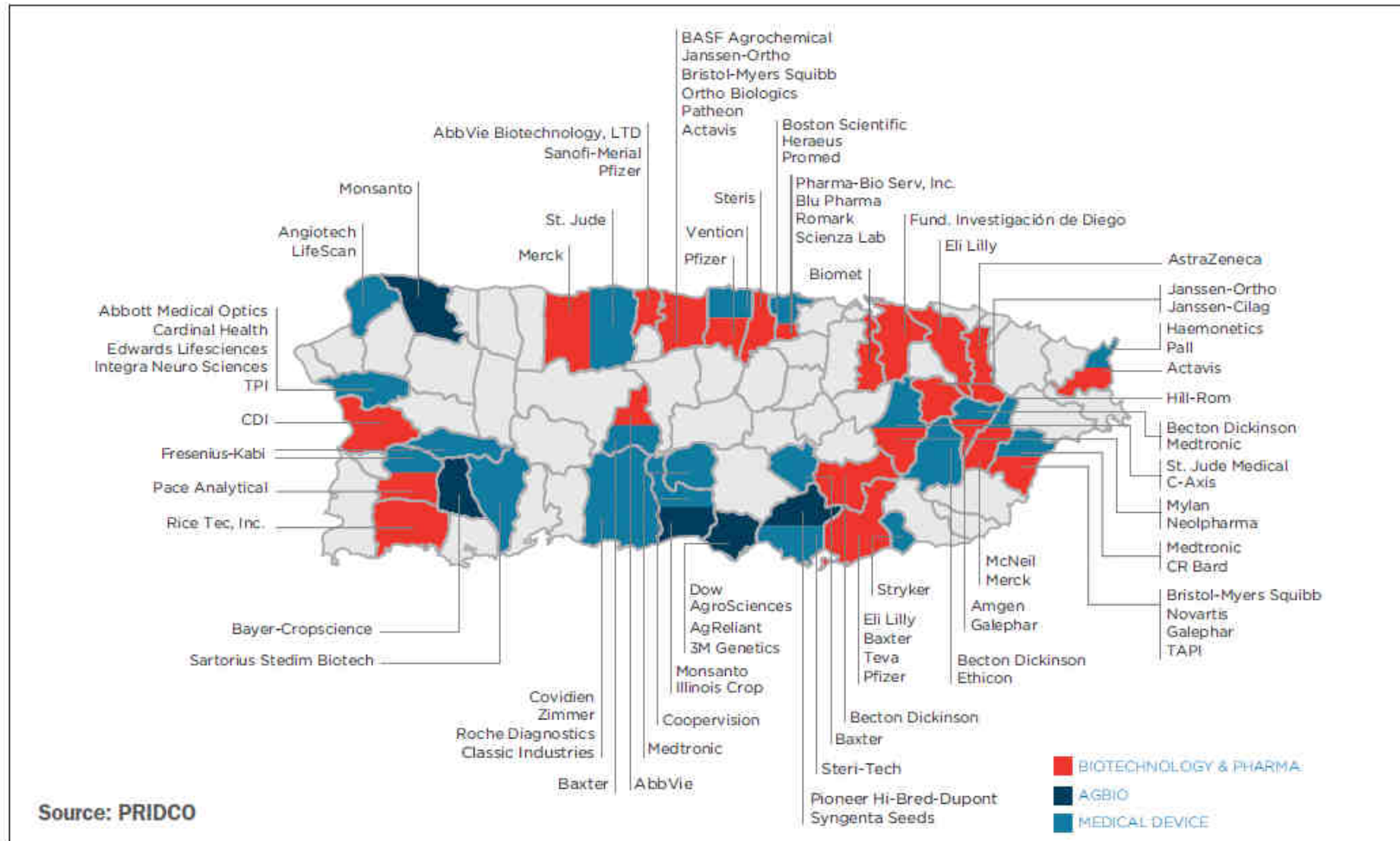




# PHARMA INDUSTRY

# 50 Pharmaceuticals Manufacturing sites

Map of Puerto Rico's life science manufacturing facilities





**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.

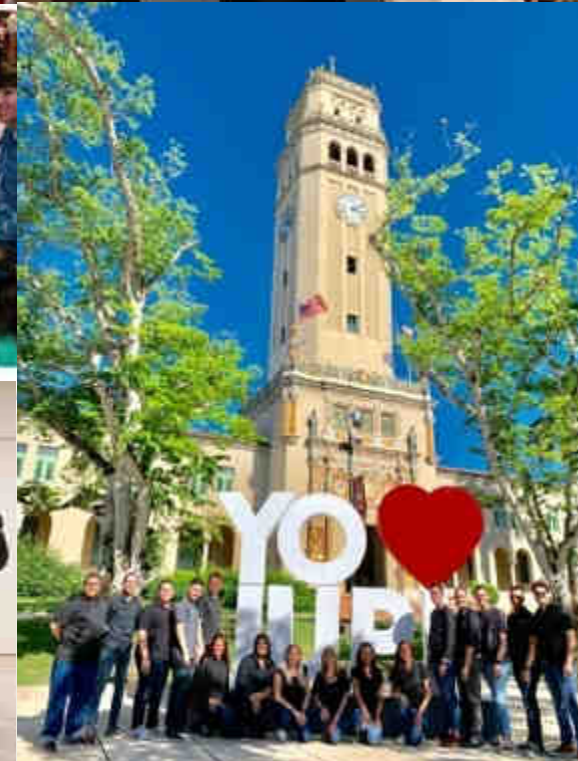
# Final Reflections

- 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.



# Acknowledgements

- Bonnie Charpentier, ACS President
- Symposium Organizers  
*Joseph Pickel*
- American Chemical Society
- University of Puerto Rico
- My mentors & friends
- My students
- My family
- You!



# References and photo credits

- *Chemical & Engineering News*, 96(37), September 17, 2018.
- Martinez-Sánchez, O. (2018). Impacts from hurricanes Irma and María in the Caribbean. Sidebar 7.1. [in *State of the Climate in 2017*] Bulletin of the American Meteorological Society, 99(8), S202–S203.
- Meyer, R. (2017, October 4). María Timeline. *The Atlantic*.
- Samenow, J. (2017, September 25). Hurricane Maria destroyed Puerto Rico's radar, a critical tool for forecasting. *The Washington Post*.
- Images & Photo credits:
  - Google
  - Jose A. Prieto
  - Carlos Pereira
  - Juan C. Aponte-Santini