



NWIRP Research Study of Recovery from Hurricane Maria's Impacts on Puerto Rico

Recovery of Business and Supply Chains Post-Hurricane Maria

Project Leader: Jennifer Helgeson

Objective:

- Identify the underlying characteristics and conditions associated with recovery of supply chains from disturbance from Hurricane Maria in Puerto Rico.
- Examine the recovery trajectories of sampled small- and medium-sized businesses, including manufacturing, retail, and service sectors in Puerto Rico, to provide greater understanding of business continuity resilience planning and supply chain continuity and how these may differ between industries/affected regions.



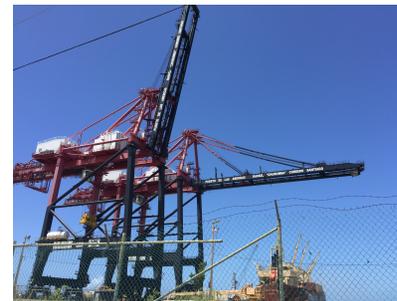
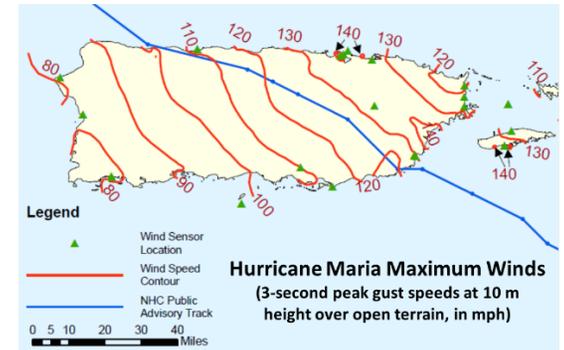
Goals and Authorities of NWIRP Study

Under the National Windstorm Impact Reduction Act Reauthorization of 2015 (Public Law 114-52), NIST is conducting a scientific study of Hurricane Maria's impacts on Puerto Rico and subsequent recovery processes, with the goals of characterizing:

- (1) *The impacts to and recovery of small and medium-sized manufacturers (SMMs), as well as businesses in retail and service industries;*
- (2) *The impacts to and recovery of education and healthcare services;*
- (3) *The impacts to and recovery of infrastructure systems in Puerto Rico, with a focus on infrastructure that supports the functioning of critical buildings (i.e., hospitals and schools) and emergency communications.*

7 Projects Related to Hurricane Maria (NCST & NWIRP)

1. Hazard Characterization
2. Performance of Critical Buildings
3. Public Response to Emergency Communications
4. Characterization of Morbidity and Mortality
5. Recovery of Business and Supply Chains
6. Recovery of Social Functions
7. Impacts to and Recovery of Infrastructure Systems Supporting Critical Buildings and Emergency Communications



For more information on these projects, please see:
<https://www.nist.gov/topics/disaster-failure-studies/hurricane-maria/hurricane-maria-projects-0>

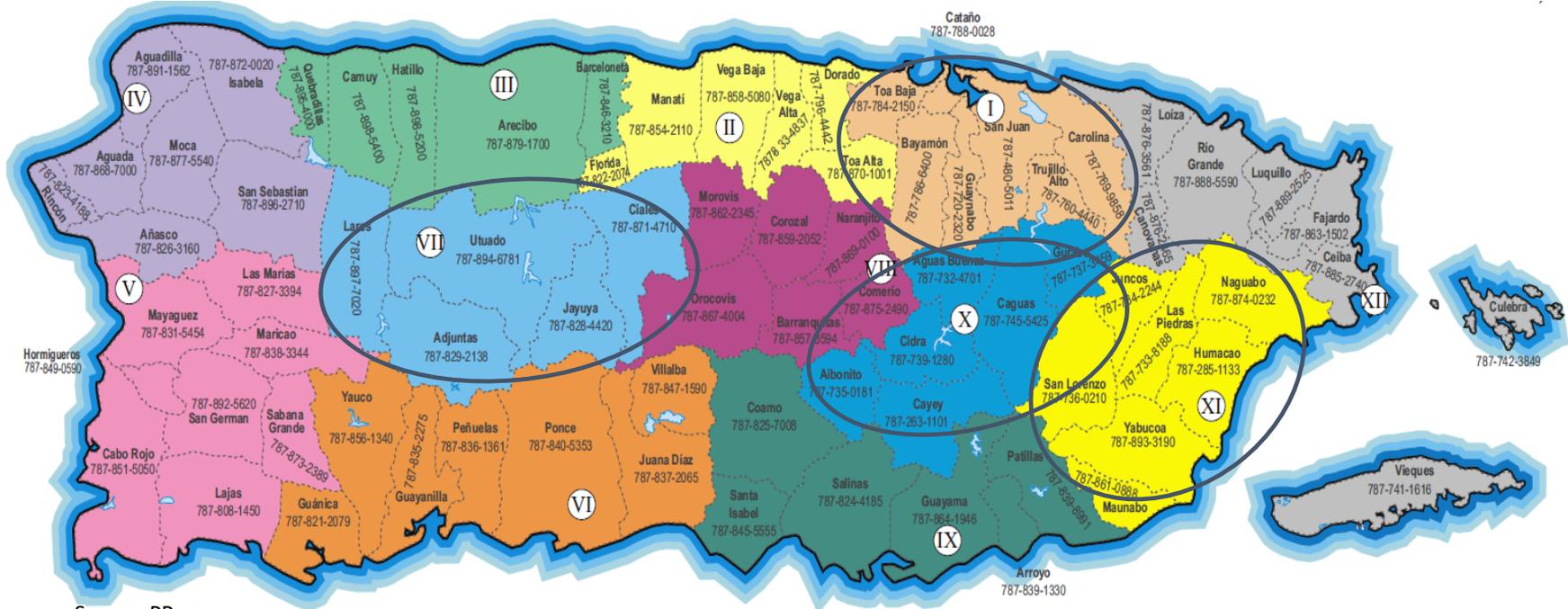
The logo for the Engineering Laboratory, featuring a blue square with a white gear, a yellow flame, and a white circuit board. The words "engineering" and "laboratory" are written in white on either side of the square.

Project Goals

The goal of this project is: To characterize the recovery of small- and medium-sized businesses, including manufacturing, retail, and service sectors in Puerto Rico to provide greater understanding of business continuity resilience planning and supply chain continuity and how these may differ between industries/affected regions.

Regions Selected for NIST Study

- Includes Emergency Regions: I, VII, X, and XI – Common across all NIST projects in the Hurricane Maria Program.
- The Supply Chain project will assess additional regions, as required (e.g., company placement, utility placement, infrastructure supply chain availability).



Source: PR.gov

<http://prfaa.pr.gov/wp-content/uploads/2017/09/Oficinas-Regionales.pdf>

Project Plan

Two-part plan and analysis outcomes:

1. Sampling and Surveying individual small- and medium-sized enterprises (SMEs):

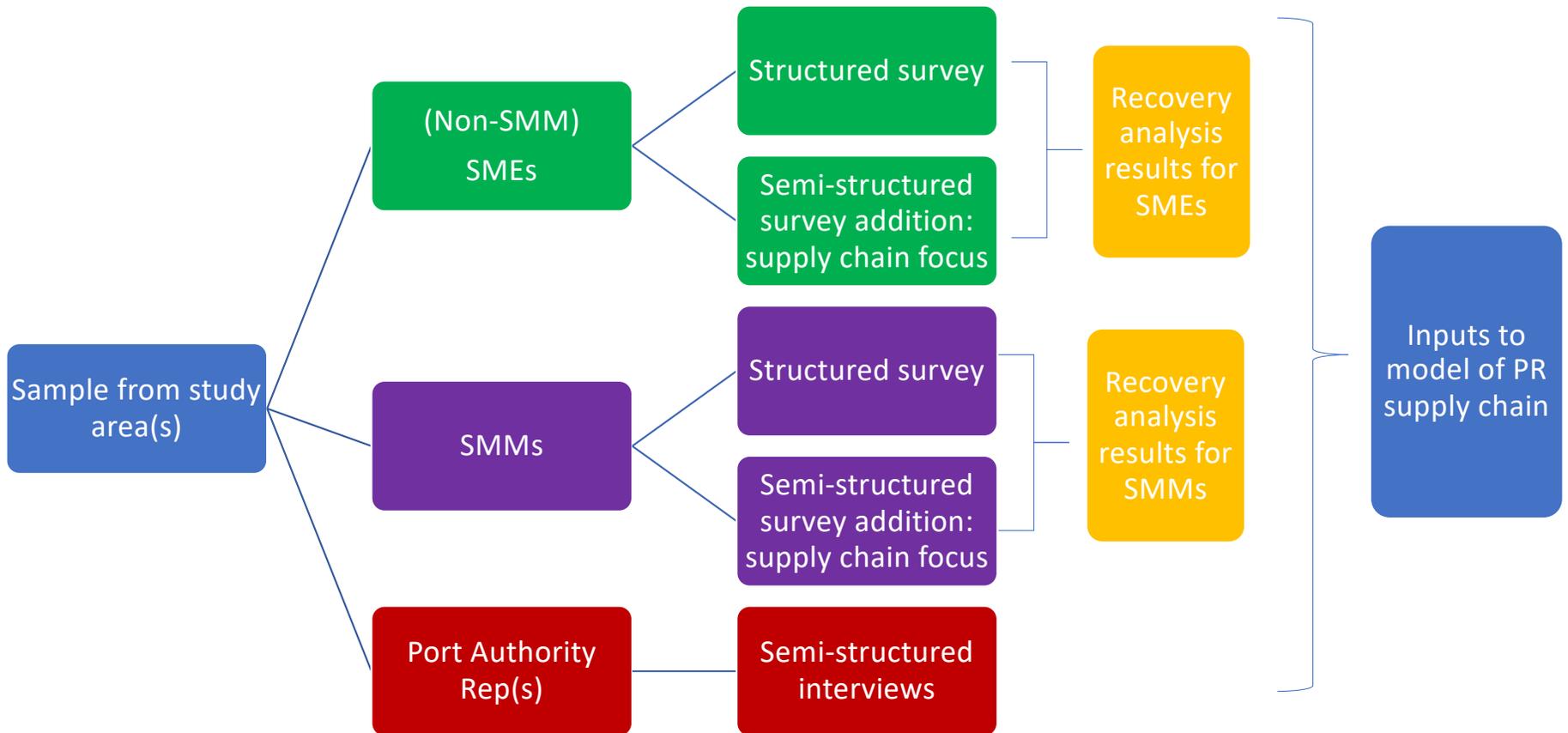
- Small- and medium-size manufacturers (SMMs) and
- Small- and medium-sized businesses in the retail and services sectors (e.g., grocery, clothing, and restaurants)

2. Full supply chain modeling (including infrastructure) for key Puerto Rico-based industries:

- Medical Device Manufacturing
- Food Preparation Manufacturing



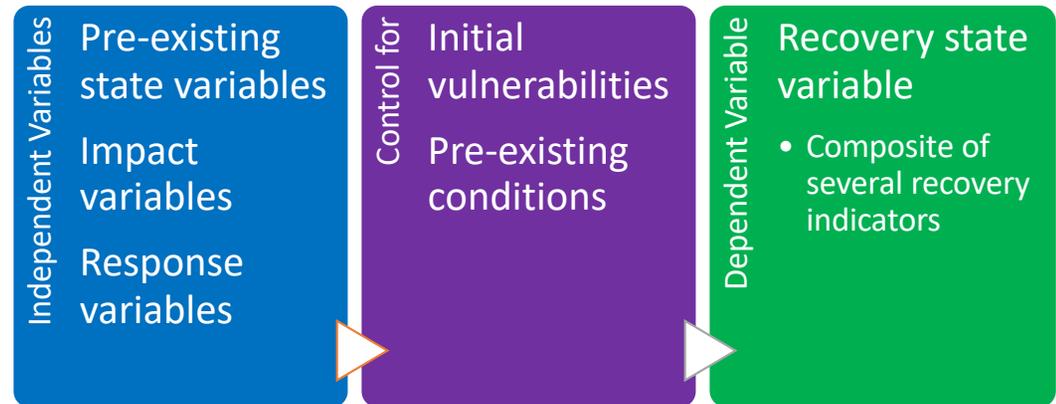
Sampling and Surveying individual SMEs: Overview (1/2)



Sampling and Surveying individual SMEs: Overview (2/2)

Modeling to consider the following variables:

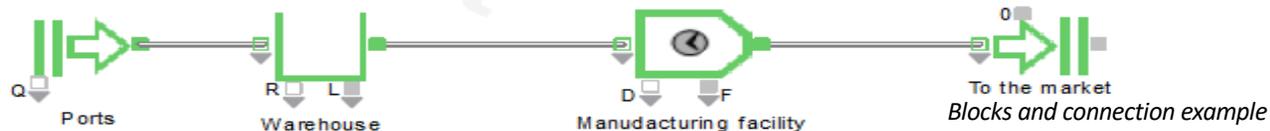
- Pre-existing state
 - Resilience characteristics – e.g., flexible decision making structures, economic security of the business
 - Initial vulnerability
- Impacts (direct and indirect)
 - Physical damage – e.g., building, infrastructure, contents, inventory, machinery, functionality
 - Non-physical – e.g., impact on employees, service/supply providers (up- and down-stream), management
 - Interdependencies (infrastructure, households, critical functions)
- Response
 - Decision-making and delays
 - Resources (recovery assistance)
 - Plans in place
 - Policies
- Recovery
 - Physical repair/restoration status
 - Recovery of services (e.g., electricity, water)
 - Delays and Decision-making in relation to delays
 - Infrastructure interdependencies
 - Employee-related recovery
 - Recovery finance (e.g., applications and funds received)



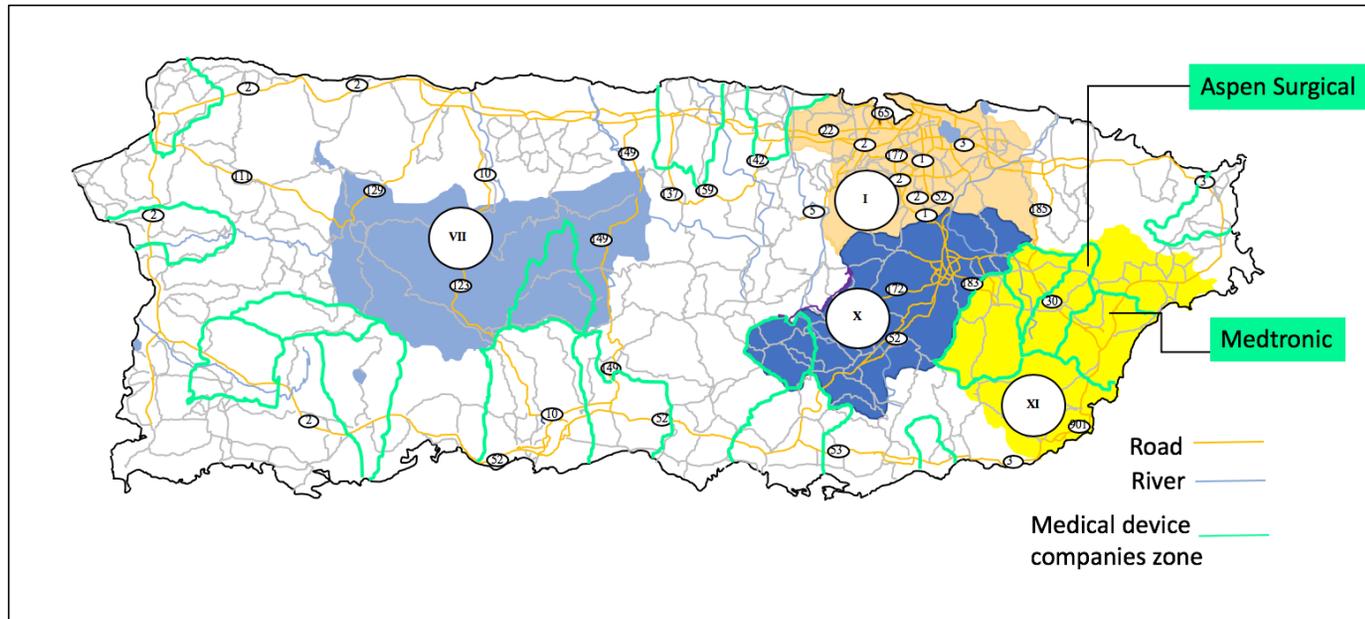
Linking Physical Infrastructure & Supply Chain for an Industry

Two modeling methods:

1. Complex Network Theory (CNT) is modeling a real system of interest in a graphical form with non-trivial topological elements.
2. Discrete Event Simulation (DES) is a simulation process that is used to model event-based systems. DES is a technique to understand how a specific system works in the real world, and how its different components will act under different conditions.



Linking Physical Infrastructure & Supply Chain for an Industry: *Medical Device Manufacturing example (1/3)*

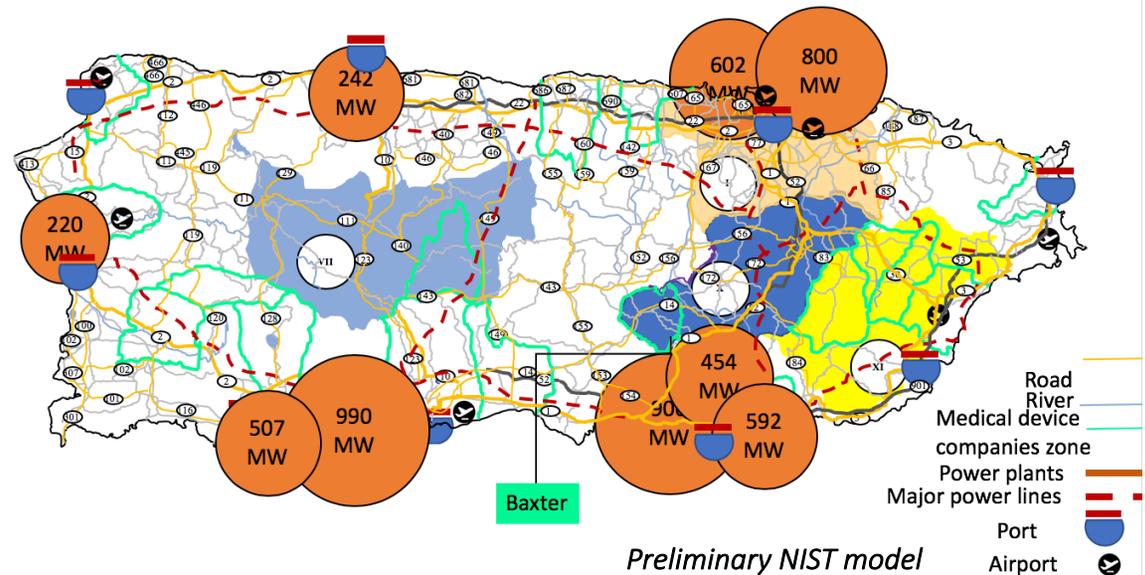


Mapping of the medical device companies around Puerto Rico, with specific focus on those in Regions: I, IV, X, XI.

- Rationale for selecting the Medical Device Manufacturing sector: Puerto Rico is home to at least 70 medical devices manufacturing companies (ranging in size) that cover: surgical and medical and supplies, orthodontic goods, dentures and appliances, laboratory equipment, and even office furniture. → Additional growth is possible in the sector.
- According to the Puerto Rico Industrial Development Company (PRIDCO), nearly 18,000 employees currently work in the medical equipment and supplies manufacturing industry in Puerto Rico. (<https://www.ddec.pr.gov/vision-estrategica/>)

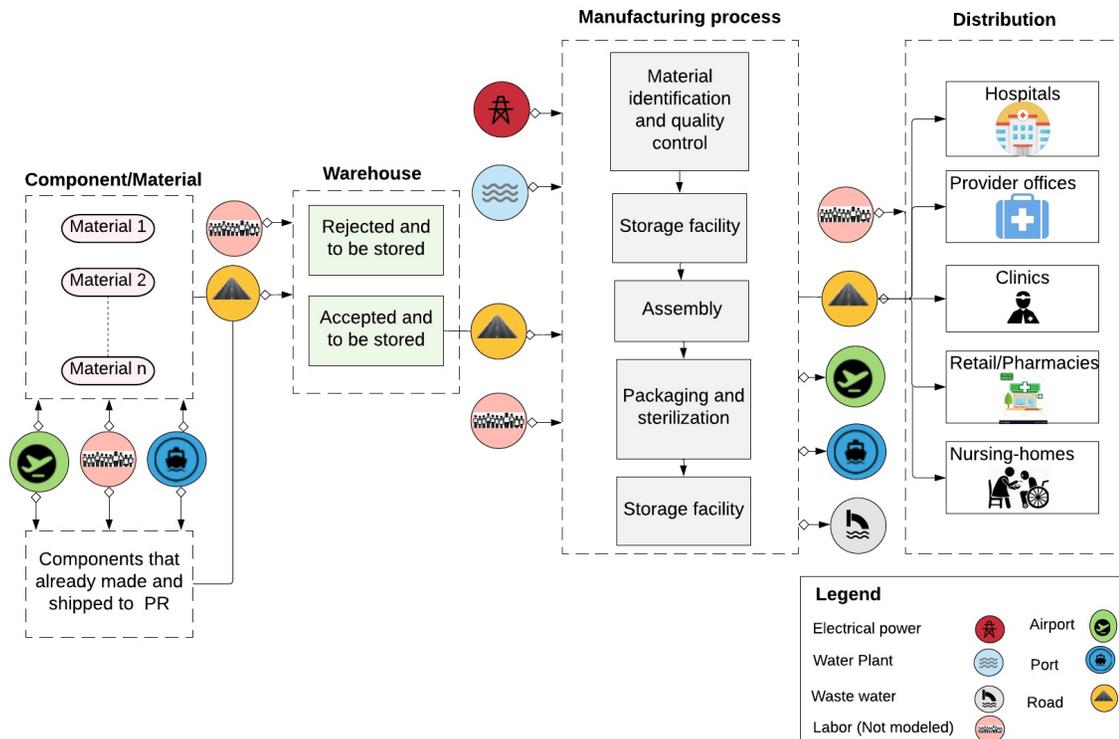
Linking Physical Infrastructure & Supply Chain for an Industry: *Medical Device Manufacturing example (2/3)*

- Use of Complex Network Theory (CNT)
- As more data is collected via Puerto Rico-based interviews, expert elicitation round tables, and surveys, independencies and the strength of nodes can be further developed.
- Additionally, economic data can be associated with the generalized supply chain models.
- Goals include: determining processes that support sustainable economic and social development in **KEY** Puerto Rican sectors and that motivate growth in SMEs in addition to larger companies that attract investment from abroad.



Linking Physical Infrastructure & Supply Chain for an Industry: *Medical Device Manufacturing example (3/3)*

Infrastructure and supply for medical device



- Flow chart shows the connections between medical device supply chain network entities and physical infrastructure.
- It is constructed to show the connection between infrastructure systems and medical device supply chain entities in a generic manner.



Thank you!

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