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: 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.

Background and Motivation

- This project falls under the NWIRP study of the NIST Hurricane Maria Program.
- There are supply chain linkages between Puerto Rico and the rest of the U.S. in critical sectors (e.g., healthcare) (NAS, 2020).
- Businesses are a critical part of community functions and community-level resilience and recovery capacity.
- 99.7 % of businesses in Puerto Rico qualify as "small" (<500 employees at a location); 68 % of which have annual reported revenues of $250K or less; 75 % are micro-enterprises (less than 10 employees) (SBA, 2018, 2019)
- Project outcomes will support development of methods to assess community-level resilience.
- Focus is on empirical relationships between business functions and physical systems with regard for social systems and decision-making.
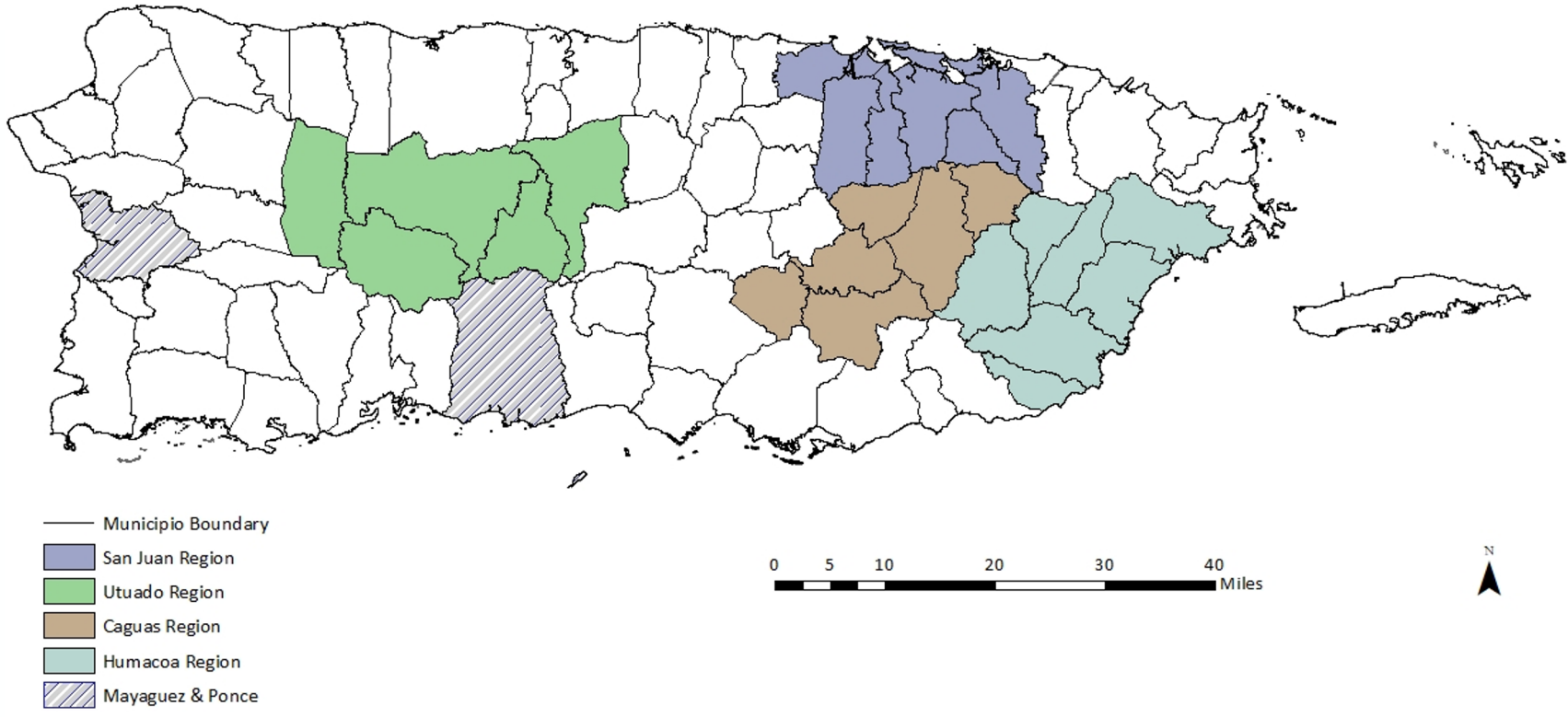
National Academies of Sciences, Engineering, and Medicine. 2020. *Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria.* Washington, DC: The National Academies Press. https://doi.org/10.17226/25490.

Importance of small- and medium-sized businesses in the U.S. (Small Business Administration- Office of Advocacy 2018, 2019)

Background and Motivation: Study Area

- Regions by ZIP code selected as the study unit (NWIRP Projects)
- Municipios selected within the six shaded regions shown below
  - Four common across all NIST projects
  - Addition of Mayagüez and Ponce (concentration of manufacturers)

Study Areas for NIST Hurricane Maria Program

— Municipio Boundary
San Juan Region
Utuado Region
Caguas Region
Humacoa Region
Mayaguez & Ponce

0 5 10 20 30 40 Miles

N

Data Source: US Census Bureau TIGER/Line 2016, FEMA 2017
Developed: NIST 2020; using ESRI software
Coordinate System: GCS NAD 1983
Datum: NAD 1983
Scale: 1:700,000

Project Plan – Overview

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)

    (Contractor supported effort, in progress)

2. Full supply chain modeling (based upon infrastructure, specifically transportation) for key Puerto Rico-based industries:

- Medical Device Manufacturing
- Food Preparation Manufacturing

    (Use of Complex Network Theory and Discrete Event Simulation techniques discussed at the June 2020 NCSTAC Meeting)

Project Plan – Study Design (1/3)

Data Collection Instruments
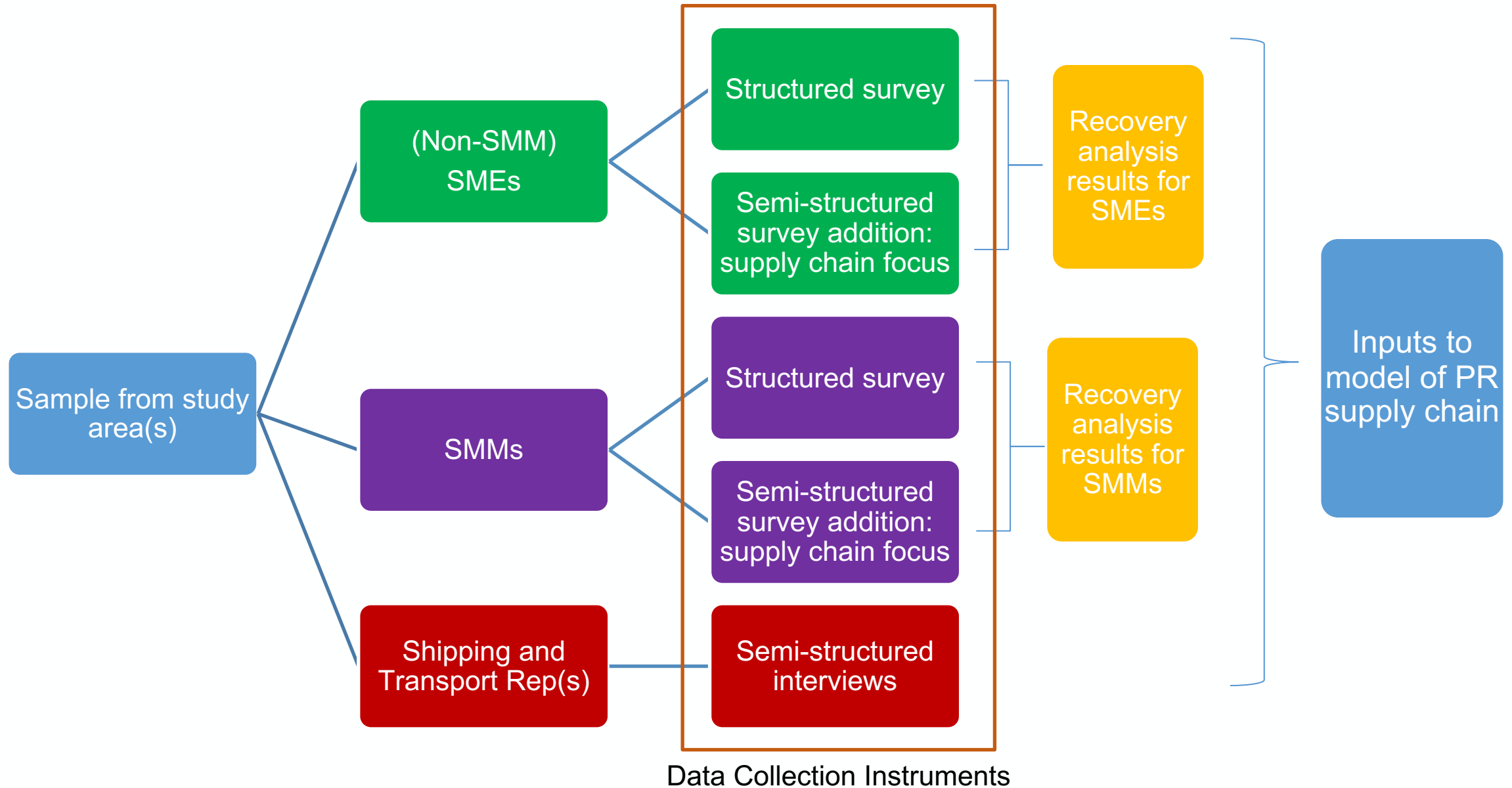
Project Plans: Sample Design (2/3)

ZIP codes without hospitals

ZIP codes with hospitals

ZIP codes selected

ZIP codes selected

10 ZIP codes for the "linking" hospitals

71 ZIP codes without hospitals
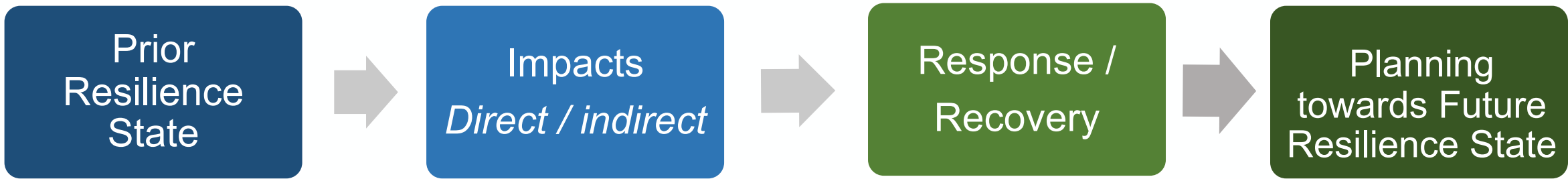
20 ZIP codes with other hospitals
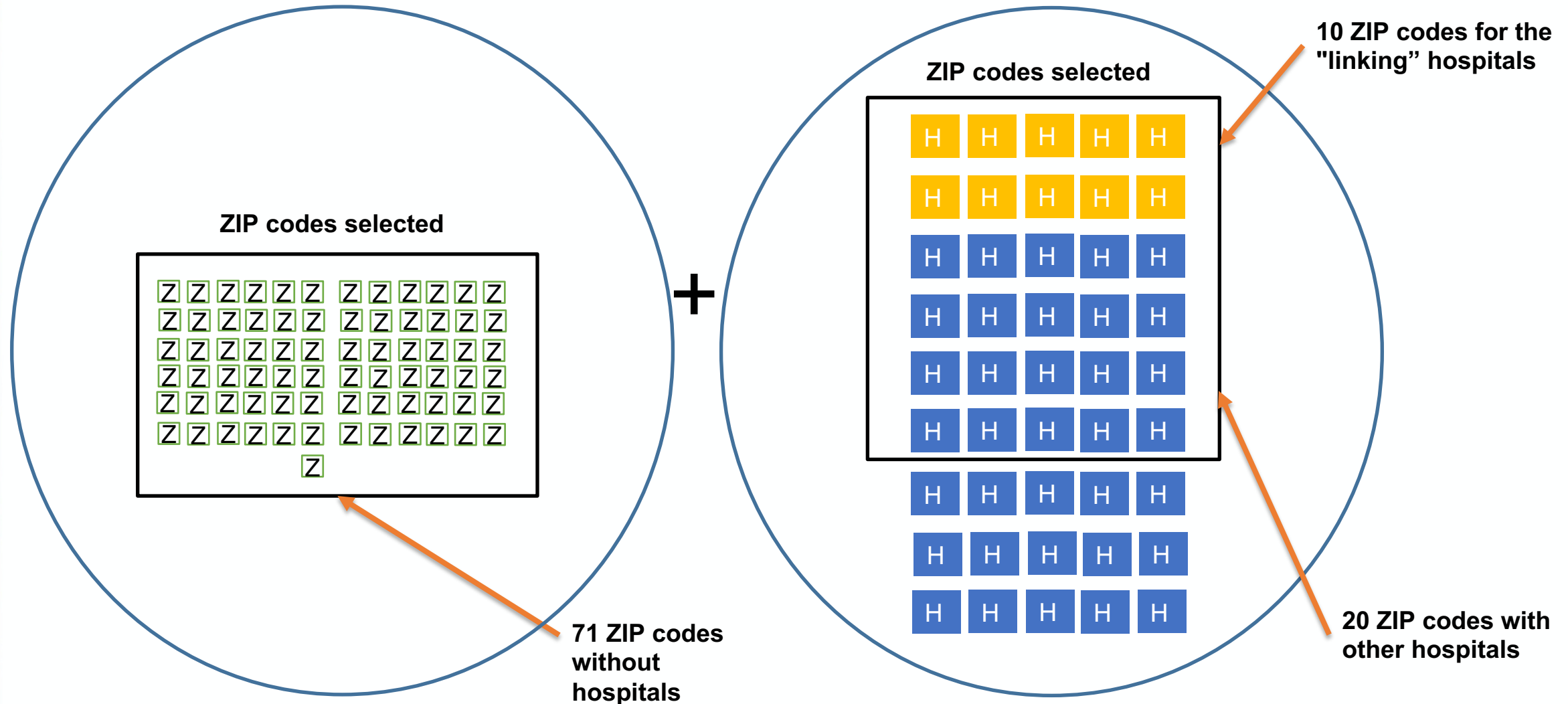
Project Plan: Sample Design (3/3)

- Combined sample design for this project and Social Functions NWIRP project. Integrated to allow for a combined analysis with sufficient sample units within the same geographic area from both tasks.

- Random distribution of businesses proportional to the count of specified NAICS codes in a given ZIP code compared to those business types in ALL in-scope ZIP codes

	# ZIP code areas	"Linking" Hospitals	Other Hospitals	Schools	Manufacturers	Retail/Service
"Linking" Hospitals	10	100 %	26 %	23 %	21 %	20 %
Other Hospitals	20		74 %	25 %	22 %	29 %
No Hospitals	73			53 %	58 %	51 %

Recent Progress (1/3)

Prior Resilience State	→	Impacts *Direct / indirect*	→	Response / Recovery	→	Planning towards Future Resilience State

Prior Resilience State
- Resilience characteristics
- Initial vulnerability

Impacts — Direct / indirect
- Physical damage – e.g., built infrastructure, contents/inventory, machinery,
- Non-physical – e.g., impact on employees, Interdependencies (infrastructure, critical functions)

Response / Recovery
- Plans in place
- Decision-making and delays
- Resources (recovery assistance)

Planning towards Future Resilience State
- Physical repair/restoration status
- Recovery of services
- Decision-making related to delays
- Infrastructure interdependencies
- Recovery finance (e.g., funds received)

Independent Variables
- Pre-existing state variables
- Impact variables
- Response variables

Control for
- Initial vulnerabilities
- Pre-existing conditions
- Earthquakes / COVID

Dependent Variables
- Recovery state variable
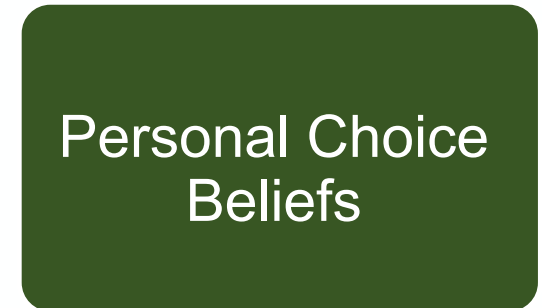- Composite of several recovery indicators

Recent Progress (2/3)

Risk Profile		Circumstances		Personal Choice Beliefs

- Perceived Probability of event
- Perceived risk to life
- Perceived risk to property
- Affective factors
- Risk aversion

- Previous experience
- Knowledge/information
- Social influence
- Social norms

- Self-efficacy
- Perceived Control

$p(A^i = 1)$ is the probability that an SME operator takes an Action (A^i) in hurricane season 2021;

$p^*(A^i = 1)$ is the adjusted probability that an SME operator took an Action (A^i) in 2017;

T_{coef}, RA_{coef} are *Time* and *Risk Aversion* adjustment coefficients .

Recent Progress (3/3)

- Use of preliminary models derived from Complex Network Theory and Discrete Event Simulation to identify areas for structured data collection from business operators

- Rough draft report prepared for Complex Network Theory and Discrete Event Simulation exploratory analyses

- Small- & medium-sized manufacturer survey tools completed
  - IRB-approved (Dec. 2020)
  - Piloted (Complete Feb. 2021)

- Small- & medium-sized retailer survey tools completed
  - IRB-approved (May 2021)
  - Pilot underway (as of May 2021)

- First draft Shipping and Transportation Interview Guide prepared

- Survey / interview data analysis framework developed

- Continued contact with PRiMEX* and additional contact with sector-specific Puerto Rican agencies/associations

HOW TO PARTICIPATE

Haga clic abajo para realizar la encuesta en línea.
EN LÍNEA

Llamar para tomar la encuesta por teléfono.
PHONE #

ANUNCIO DE PARTICIPACIÓN PÚBLICA DEL HURACÁN MARÍA

El Instituto Nacional de Estándares y Tecnología (NIST) y los contratistas de apoyo, Horsley Witten Group, Inc., Eastern Research Group, Issues & Answers y la Universidad de Albizu en Puerto Rico, se encuentran recolectando información a

*PRiMEX: The Puerto Rico Manufacturing Extension Inc. (PRiMEX) is a private non-profit organization, organized in 1996 through the initiative of Puerto Rico Industrial Development Company (PRIDCO) and the Manufacturing Extension Partnership (MEP), a program under the National Institute of Standards and Technology (NIST).

Next Steps

- Complete all data collection instruments and collect "field" data
  - Obtain Institutional Review Board (IRB) and Paperwork Reduction Act (PRA) approvals
  - Account for connections to other NWIRP data collections on recovery of social functions and recovery of infrastructure
  - Conduct final pilot testing of survey and interview instruments
  - Finalize sample of shippers and transportation companies

- Data analysis to be completed
  - Quantitative analysis
  - Qualitative coding of interview data

- Draft "Business and Supply Chain Recovery" for NWIRP Report
  - Update literature/media review of issues in recovery facing SMEs and supply chains following Hurricane Maria
  - Incorporate analyses based in econometric modeling of recovery trajectories and agent-based modeling of intended mitigation and adaptation behavior

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Project Leader: Jennifer Helgeson

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Acknowledgement of past members:
Bilal Ayyub,
Yalda Saadat,
Sally Saleem

Questions?

Please 'raise your hand' using the Blue Jeans Participant window and unmute your audio and video