



**CEN
TRO**
HUNTER^{RV}

REPORT

THE PUERTO RICO CHILDREN VULNERABILITY INDEX, 2021

JENNIFER HINOJOSA
LAURA COLÓN-MELÉNDEZ
JORGE SOLDEVILA-IRIZARRY
DAMAYRA I. FIGUEROA-LAZU

JENNIFER HINOJOSA
LAURA COLÓN-MELÉNDEZ
JORGE SOLDEVILA-IRIZARRY
DAMAYRA I. FIGUEROA-LAZU

EXECUTIVE SUMMARY

Recent natural hazards and resulting disasters in Puerto Rico have drawn attention to the social vulnerability of children in the archipelago. We created the Children Vulnerability Index (CVI) to identify the scale and patterns of children vulnerability in the archipelago, and provide insights to mitigate the effects that hazardous events may cause. The index was created using 2017-2021 American Community Survey (ACS) data pertaining to three broad themes: Personal characteristics of children, Characteristics of households with children, and Overall household characteristics for all Municipios, Barrios, and Census Tracts in Puerto Rico. The CVI is a two-pronged tool consisting of an ESRI Enterprise dashboard and open source Python code that enables stakeholders to increase their understanding of the vulnerability of children in the archipelago and improve their resilience to hazardous events. Our analysis shows that the Municipio with the highest overall CVI in 2021 was Jayuya and the Barrio with the highest CVI in 2021 was Barrio Pueblo in Comerío. All Municipios except Culebra had at least one Barrio with CVI greater than 0.5, and 59 out of the 78 municipios in the archipelago had Barrios with CVIs in all quartiles. These results showcase the widespread and geographically uneven distribution of children vulnerability in Puerto Rico. We performed statistical hypothesis testing to examine statistical evidence for regional differences in relative child vulnerability at Municipio, Barrio, and Census Tract level. The results show that children living in the Municipios, Barrios, and Census Tracts in the Vega Baja Operational Zone of the Negociado para el Manejo de Emergencias y Administración de Desastres (NMEAD), collectively experience greater relative vulnerability than children living elsewhere. Researchers have noted several limitations to the use of Social Vulnerability Indexes (SVI) for disaster management and response. Notwithstanding these limitations, the development of the Children Vulnerability Index is a step towards understanding and quantifying the children vulnerability landscape in Puerto Rico.



INTRODUCTION

Children in Puerto Rico – here defined according to the U.S. Census Bureau as all persons below the age of 18 – have traditionally been overlooked by academics and policymakers in the archipelago and in the U.S., which has led to the marginalization of an already vulnerable population group.¹ Recent events in the archipelago have drawn attention to children and the effects social conditions such as family structure, living arrangements, and migration can have on their capacity to cope during situations of distress, as in the case of hurricanes or earthquakes.² Natural hazards and resulting disasters, which are expected to become more common as the planet warms, are known to exacerbate or create psychological distress and mental health emergencies among young people.³ Children, who will bear the burden of the future effects of climate change, face today's challenges while not having fully developed their physical and emotional capacities and relying on adults for their safety and well-being.

In Puerto Rico, children have experienced outstanding levels of poverty for decades. According to the U.S. Census Bureau, in 2021, 18.0% of the total population in Puerto Rico was below the age of 18.⁴ Of that age group, 56.3% lived below the federal poverty level, the highest percentage across the United States. Simultaneously, 62.2% of children in the archipelago lived in households with one parent present while 56.2% lived in households receiving some form of public assistance. Of the children-aged population, 8.3% lived with some type of disability. Of those children living in households, 14.7% had no access to a vehicle, 8.0% had no access to the internet, and 8.3% had no access to a computer. *These social vulnerabilities experienced by children in Puerto Rico are a symptom of the structural failures of local and federal governments to meet the basic needs of those who are most marginalized.* Social vulnerabilities are understood as the socioeconomic and demographic characteristics that affect a person or group's resilience.⁵ They are known to increase susceptibility to adverse outcomes of hazardous events limiting individual's capacities to prepare, withstand, and recover from disasters.⁶ Social vulnerabilities are dynamically complex phenomena that exhibit varying spatial and temporal patterns.⁷

Among the social vulnerabilities that children in the archipelago experience, poverty remains the determinant factor influencing their overall well-being. Growing up in poverty can have negative health, educational, and employment consequences throughout a person's lifetime.⁸ Nevertheless, governments have the capacity to implement

public policies to reduce poverty among children and lessen their vulnerabilities.⁹ Across the globe, children face a number of hazardous scenarios due to climate change and environmental degradation. For example, in recent years, hazardous events, including the COVID-19 pandemic, have sparked mental health emergencies among young people (including children), prompting an advisory notice by the U.S. Surgeon General to protect youth mental health.¹⁰ Identifying where and how children are vulnerable is important when responding to the global climatic crisis and local hazardous events.¹¹

In Puerto Rico, while much post-disaster research on children has focused on mental health effects, less has focused on how the vulnerabilities of children vary across the archipelago.¹² Identifying the scale and patterns of children vulnerability in the archipelago can provide valuable insight in mitigating the effects that climate change and other hazardous events may cause. To this end, the Center for Puerto Rican Studies, in collaboration with the U.S. Census Open Innovation Labs' Opportunity Project 2022 Sprint, developed the Puerto Rico Children Vulnerability Index for 2021 (CVI). Vulnerability Indexes are widely used measures by policy makers and those who seek to reduce vulnerability in the face of disaster.¹³ The CVI is a multifaceted tool consisting of an interactive dashboard and open sourced Python code, which provides users with granular information at multiple geographic levels and the flexibility to generate broader analyses. This will allow communities, state and federal government agencies, and on-the-ground organizations to identify and map regions where children might be at higher risk or in need of support before, during, and after hazardous events. With this Puerto Rico Children Vulnerability Index we seek to equip practitioners to enhance family and community resilience and preparedness in the advent of future disasters and the effects of global climate change.

In subsequent sections, this report describes the variables that comprise the CVI as well as the methods used to construct the index. We then demonstrate how the CVI can be used by showcasing its applicability in dashboard form and discussing CVI results across the landscape at different geographic levels. Finally, we show how the code used to create the index can be expanded and leveraged to extract insights about child vulnerability in Puerto Rico that local stakeholders may employ in risk mitigation and disaster preparedness efforts.



8735 001 148 1004
WORLD WIDE
375 251 7 05 8 00
THE
375 251 7 05 8 00
CHANGING THE COMPANY
THE COMPANY
COMMERCIAL RESALE IN SOLE AGENT

Photo from the U.S. Department of Agriculture

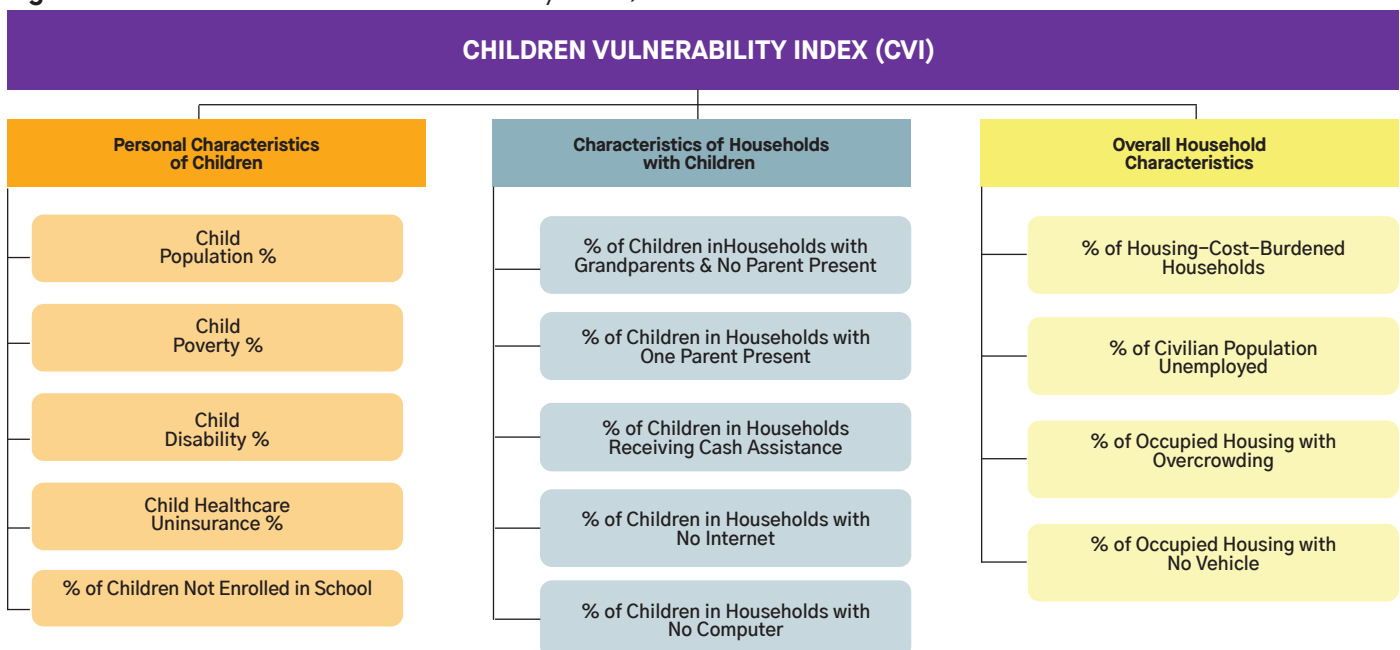
DATA AND METHODS

The Puerto Rico Children Vulnerability Index for 2021 (CVI) is a measure of the relative vulnerability of children in the archipelago. The CVI is a child-targeted adaptation of the Social Vulnerability Index (SVI) developed by the Centers for Disease Control and Prevention (CDC) in collaboration with the Agency for Toxic Substances and Disease Registry (ATSDR).¹⁴ The SVI measures the capacity communities have to prepare and respond to natural or anthropogenic events, which may be affected by certain social conditions, including poverty, age composition, and disability. Similarly, the CVI provides social and spatially relevant children-targeted information for use in emergency preparedness and response. Indexes such as the SVI are widely used in the field of disaster management. Nevertheless, use of nationwide indexes may result in parameters that do not correspond to the realities of determined locations, as in the case of Puerto Rico.¹⁵

Emergency planning and disaster mitigation requires identifying socially vulnerable areas and communities. Geographic scale greatly influences the capacity to identify the location of vulnerable population groups and reveal patterns of vulnerability.¹⁶ While the SVI is geared towards Census Tract level analysis, the CVI proposes a multi-level approach that spans three distinct geographic levels: Municipios, Barrios, and Census Tracts. Census Tracts are statistical

subdivisions of counties with demographically homogeneous populations, ranging from 1,200 to 8,000 people, for which the U.S. Census Bureau collects statistical data. Census Tracts are commonly used in the U.S. for government planning and policy. As in the U.S., Census Tracts in Puerto Rico have the capacity to reveal geographic patterns that can improve public policy and emergency response. Nevertheless, Census Tracts may not be representative of local community boundaries upon which people commonly organize themselves. In this scenario, information aggregated at the Municipio or Barrio level may better serve the needs of communities and disaster managers in the archipelago. In Puerto Rico, Municipios are the primary legal divisions and are treated as county equivalents for statistical purposes. Municipios have functioning governmental units and have shown to have the capacity to provide immediate disaster response, even when the central government fails to. Barrios, or County Subdivisions, are administrative divisions of Municipios that more closely represent the geographic boundaries upon which Municipios are divided and locals organize themselves. Creating the CVI at three geographic levels provides stakeholders with information that allows them to identify patterns and more closely distinguish those who suffer the impacts of disaster the most.

Figure 1. The Puerto Rico Children Vulnerability Index, 2021



DATA

The variables used to construct the CVI are classified along three broad themes: (See Figure 1)

- 1 - Personal Characteristics of Children,
- 2 - Characteristics of Households with Children
- 3 - Overall Household Characteristics

Variable selection followed literature on children vulnerability and the variables used in the SVI. The variables selected were further analyzed with scholars and on the ground workers participating in The Opportunity Project 2022 Sprint.¹⁷ The variables are meant to characterize the population of children at Municipio, Barrio, or Census Tract level, as well as to describe qualities of their caretakers and their communities at large. A list of the variables used and a description of each variable can be found in Appendix B of this report.

Theme 1 describes the social and economic characteristics of children and consists of 1) Children Population Percent, 2) Children Poverty Percent, 3) Children Disability Percent, 4) Children Healthcare Uninsurance Percent, and 5) Percent of Children Not Enrolled in School.¹⁸ Poor socioeconomic conditions for children as they grow up have been linked to poor health outcomes, including physical and cognitive impairment, low educational attainment, and negative employment outcomes.¹⁹ The vast majority of children do not live on their own, but rather in households and families. Thus, children living in poverty are subject to household and family economic conditions, which may either hinder or support their capacity to prepare and recover after hazardous events. The presence of children with disability increases vulnerability because many require assistance, which may not be provided during a crisis. Lack of healthcare insurance also increases the vulnerability of children because they may not be able to receive medical assistance if they are injured and their family is incapable of covering the costs.²⁰

Theme 2 describes the characteristics of households with children and consists of: 1) Percent of Children in Households with Grandparents and No Parent Present, 2) Percent of Children in Households with One Parent Present, 3) Percent of Children in Households Receiving Cash Assistance, 4) Percent of Children in Households with No Internet, 5) Percent of Children in Households with No Computer. Children are dependent on their families and

communities for economic well-being. Household and family structure have been found to be key determinants of children's poverty and vulnerability.²¹ Children and elders are among the most vulnerable population groups because they are more likely to depend on other members of their families or communities. Children living with grandparents are among the poorest in Puerto Rico and are highly vulnerable to hazardous events because both children and grandparents can be dependent on others.²² Similarly, children living in households with one parent, particularly single mothers, are more likely to live below the poverty level, which hinders their capacity to cope during a disaster.²³ Other household characteristics such as lack of computer or internet access also limit the capacity of households to withstand disasters by inhibiting communication and access to vital information. Disruption of life after a disaster can have detrimental effects on children's academic functioning and overall well-being.²⁴ Following recent natural hazards that affected the archipelago, reports have shown that children have had to continue their education under distress while lacking adequate equipment to perform school work.²⁵

Theme 3 encompasses overall housing and community characteristics and consists of: 1) Percent of Housing-Cost-Burdened Households, 2) Percent of Civilian Population Unemployed, 3) Percent of Occupied Housing with Overcrowding, and 4) Percent of Occupied Housing with No Vehicle. While children are mostly dependent on their immediate families, the conditions of their communities impact disaster preparedness and response. The variables that comprise Theme 3 are closely related to wealth, as communities with populations experiencing high housing-cost-burden or high unemployment are more likely to be poor and not be able to cope when disaster occurs. Similarly, overcrowding can cause heightened vulnerability, particularly in densely populated areas where large evacuating crowds can be dangerous.²⁶ A low rate of automobile ownership in a community also hinders evacuation efforts, thus increasing their vulnerabilities and putting their lives in danger.²⁷

METHODS

Following the methodology proposed for the CDC SVI, each of the fourteen variables listed above were ranked from lowest to highest across all Municipios, Census Tracts, and Barrios where a higher rank indicates greater relative children vulnerability.²⁸ All data used to calculate the fourteen variables were extracted from the U.S. Census APIs for 2017-2021 American Community Survey (ACS) 5-year estimates²⁹ using custom written Python code. Municipios, Census Tracts, and Barrios where the number of children living in households was equal to zero were excluded from the ranking process. According to 2017-2021 ACS 5-year estimates, 845 out of the 939 Barrios had children living in households, 919 out of 981 Census Tracts had children living in households, and all 78 Municipios had children living in households. Barrios and Census Tracts that were removed for the ranking process were added back into the database after ranking and assigned null CVI values.

Percentile ranks were then calculated across all three geographies – Municipios, Barrios, and Census Tracts – for all fourteen individual variables.³⁰ Percentile ranks for all variables were summed within each theme and percentile ranks were calculated again on the resulting sum to generate percentile ranks for each theme for all Municipios, Barrios, and Census Tracts. Then, to generate the overall CVI for each Municipio, Barrio, and Census Tract, the values generated for each theme were summed and a percentile rank was calculated for the resulting value. The resulting CVI indicated the relative children vulnerability of each Municipio, Barrio, and Census Tract on a scale of 0 to 1, where a value of 1 represented the highest relative children vulnerability.³¹ To analyze the results, the CVI was broken down into quartiles, with scores less than or equal to 0.25 indicating low children vulnerability, scores greater than 0.25 and less than or equal to 0.50 indicating low-medium children vulnerability, scores greater than 0.5 and less than or equal to 0.75 indicating medium-high children vulnerability, and scores greater than 0.75 indicating high vulnerability. *Municipios, Barrios, or Tracts that rank lower do so in comparison with the rest of the Municipios, Barrios, or Tracts in the archipelago, respectively, but are not exempt from being vulnerable within specific themes or determined characteristics.*

The code used to obtain the data, calculate the variables, and generate the CVI has been made available via [GitHub](#) and can be found at The Center for Puerto Rican Studies' [CVI project website](#).

LEVERAGING THE TOOL

The CVI was created to help communities, state and federal agencies, and local organizations improve their understanding of the vulnerability of Puerto Rican children in the archipelago and improve their resilience to hazardous events. To facilitate access and use, the index was mapped and built into an ESRI Enterprise Dashboard. The dashboard allows users to choose between English or Spanish, and can be accessed through a computer or mobile device. Users also have the capability to switch between geographic levels, and apply different filters to target specific areas. The dashboard provides users with the overall CVI, all three individual theme indices, and the values of the variables used by theme for the selected geography. Detailed tutorials of how to use the tool and how to access it can be found in CENTRO's [CVI website](#) along with a link to the code used to gather the data and generate the index. Users with the technical knowledge can adapt and modify the code to conduct further descriptive and statistical analyses at distinct geographic regions, as shown later in this section.

“The CVI was created to help communities, state and federal agencies, and local organizations improve their understanding of the vulnerability of Puerto Rican children in the archipelago...”

EXTRACTING INSIGHTS FROM THE DASHBOARD

Users of the CVI Dashboard are initially prompted with an overall view of children’s vulnerability in the archipelago at the Municipio level. Figure 2 shows that, at the Municipio level, there is a concentration of high vulnerability across the Central region and parts of the South. The top 15 Municipios with the highest CVI are Jayuya (1.00), Barranquitas (0.99), Mayagüez (0.97), Manatí (0.96), Cataño (0.95), Ponce (0.94), San Juan (0.92), Peñuelas (0.91), Maricao (0.90), Arroyo (0.880), Comerío (0.87), Orocovis (0.86), Corozal (0.85), Naranjito (0.83), and Santa Isabel (0.82). Seven of the top 15 Municipios are in the Central region, followed by four in the South, two in the

Metro, one in the West, and one in the North. For many of these Municipios the social vulnerabilities of children may be compounded with physical hazards such as landslides or flooding. Municipios that rank low in the CVI still have vulnerable children populations and endure physical hazards. Consider the Municipios of Rincón and Culebra, which in Figure 2 are shown to rank low in the CVI. While it may be that the social characteristics used to develop the CVI result in low vulnerabilities for the two Municipios, Rincón has experienced significant shoreline erosion for decades, and experiences storm surge both during the hurricane season and during the winter period.

Figure 2. Child Vulnerability Index at the Municipio Level, 2021

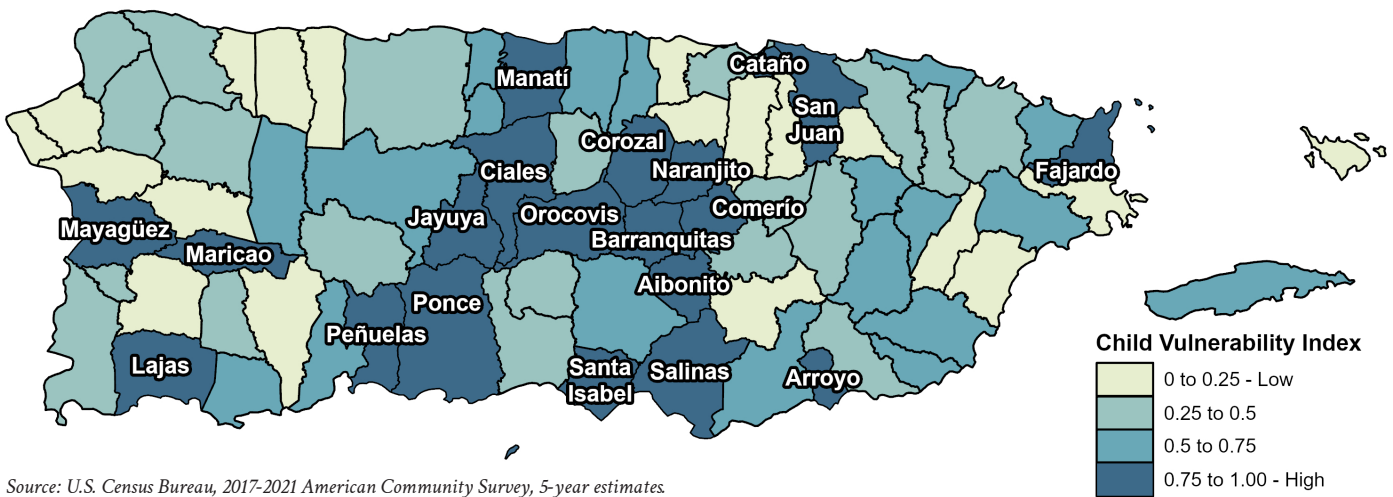


Figure 3. Child Vulnerability Index at the Barrio Level, 2021

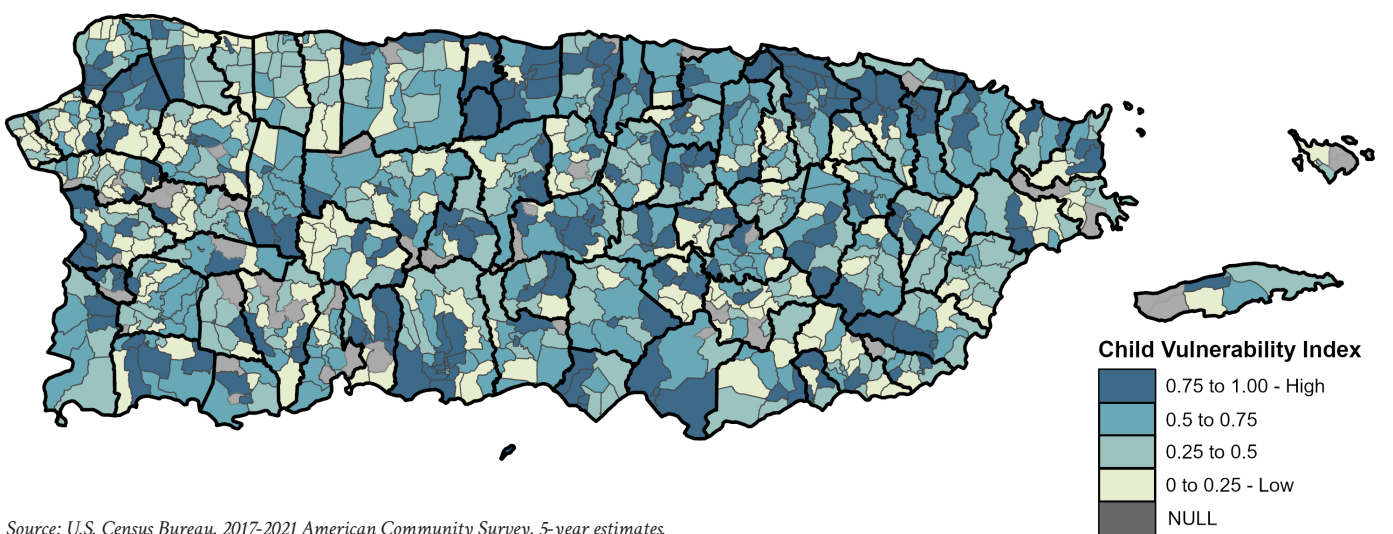
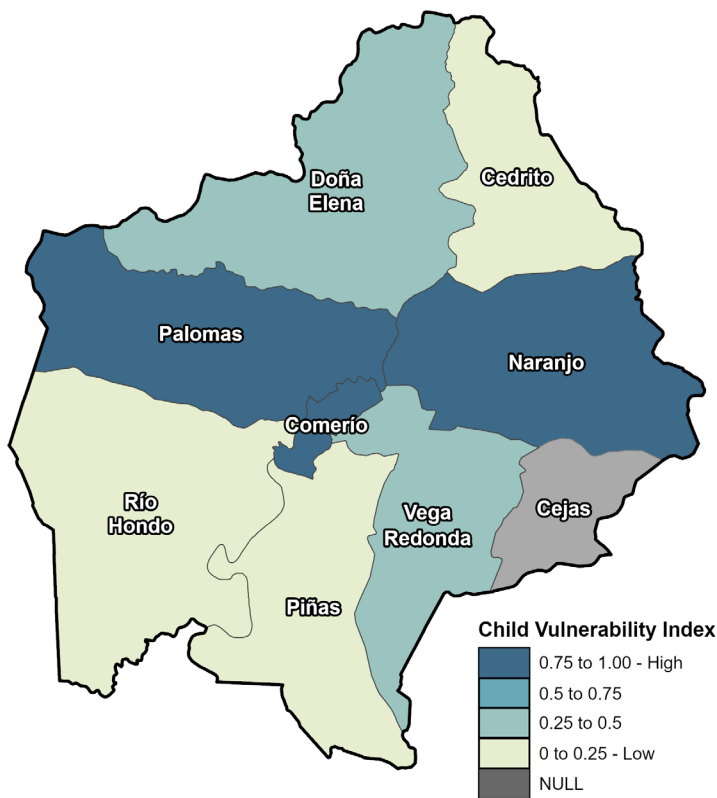


Figure 4. Comerío by Barrio Child Vulnerability Index, 2021

Source: U.S. Census Bureau, 2017-2021 American Community Survey, 5-year estimates

Meanwhile, Culebra, which also faces a number of natural hazards, has an inadequate transportation system to and from the mainland and lacks basic infrastructure like a hospital or medical center.

Understanding vulnerability at the Municipio level is useful for state agencies to take initial action and allocate resources. Nevertheless, the information provided may be insufficient to identify particular communities where children are most vulnerable or experience particular vulnerabilities. *Dashboard users interested in identifying particular communities in a predetermined region or exploring the landscape of vulnerability at lower geographies can select between Census Tracts and Barrios to further their analyses.*

When assessing the CVI at the Barrio level, we find that 5 of the top 15 Barrios by CVI are located in the North region of the archipelago, three are located in the South, three in the West, two in the Metro region, two in the Central region, and one in the East. *By exploring children's vulnerability at lower geographies, different spatial patterns from*

the ones observed at the Municipio level become evident. As seen in Figure 3, many Barrios in the North and Metropolitan regions have medium-high to high CVIs, and all Municipios except Culebra have at least one Barrio with CVI greater than or equal to 0.5. *Moreover, 59 out of all the 78 Municipios have Barrios with CVIs in all quartiles, showcasing the widespread and geographically uneven distribution of children vulnerability across the archipelago.*

The CVI Dashboard not only provides the overall CVI, but also includes detailed information of the variables used to build the CVI and that describe the population within each geographic boundary. In 2021, the Barrio with the highest CVI was Barrio Pueblo in the Municipio of Comerío. Comerío is located in the Central region of Puerto Rico and consists of nine Barrios: Cedrito, Cejas, Pueblo, Doña Elena, Naranjo, Palomas, Piñas, Río Hondo, and Vega Redonda (Figure 4). It is located along the Cordillera Central of the archipelago near the Río de la Plata, which bisects the Barrio. Due to this proximity to the river and surrounding topography, riverine flooding resulting from intense precipitation and flash flooding present significant risk in the event of future hazardous events.

At the Municipio level, Comerío had a total population of 18,990 in 2021, of which 19% were under 18 years old (3,591). The CVI for the Municipio is 0.87, which is among the highest in the archipelago. Within Comerío, 73% of the children live below poverty, 73% live with one parent in the household, and 70% live in a household receiving cash assistance. Children in Comerío also experience a lack of internet and computing needs: 16% have no access to a computer in their homes and 17% do not have access to the internet.

Three of the nine Barrios in Comerío have a CVI greater than 0.90: Barrio Pueblo, 1.00; Palomas, 0.93; and Naranjo, 0.92. Barrio Pueblo is Comerío's main downtown area and includes the Municipio's administration offices, schools, and emergency response teams (police, fire, and EMTs), as well as local businesses. Of the total population in Barrio Pueblo in 2021, 25% was under the age of 18 years; of them, 94% lived below poverty, 2% did not have health insurance, and 2% had some form of disability. Lastly, 14% of the school-age population (children aged 3 to 17 years old) was not enrolled in school, which is relatively higher compared to other Barrios in Puerto Rico.

Among children living in households in Barrio Pueblo, 5% lived with a grandparent without the presence of a parent, 98% lived in a one-parent household, 78% lived in households receiving SSI or cash assistance, at least 33% of children lived in households without a computer available, and 24% lived in households without any internet access. Of the overall population living in Barrio Pueblo, at least 4% lived in overcrowded households, 35% of occupied housing units lacked a vehicle, 17% were living in housing cost-burdened homes, and 12% of the Barrio's population was unemployed.

The profile of the children population in Barrio Pueblo described above through the variables used to build the CVI points towards a population in need of assistance and highly vulnerable in case a disaster occurs. While Barrio Pueblo is the most vulnerable Barrio relative to all Barrios in Puerto Rico, it is important to note how child vulnerability manifests across themes. Different rankings across themes provide a clearer picture of the needs of children within determined areas and point towards best policies to improve their conditions. In the case of Comerío, Barrio Pueblo has the highest overall CVI while Naranjo ranks highest in Theme 2 - Characteristics of Households with Children.³² This suggests that lowering the vulnerabilities of children in Naranjo would require policies that target household needs such as infrastructure or increasing government assistance. In case of an emergency, children may be left to care for their grandparents, and streams of income into the household may be limited if the single householder loses employment or if access to government assistance is interrupted. In an event like the COVID-19 pandemic, children in Naranjo are more likely than children in Barrio Pueblo to find themselves caring for older household members, dealing with lack of basic necessities due to lost of household income, and struggling to continue their daily routines and education because of lack of internet or computer access, according to the index for Theme 2. These disruptions may hinder their mental health during moments of distress.

“**59**
out of all the 78
Municipios have
Barrios with CVIs in all
quartiles, showcasing
the widespread and
geographically uneven
distribution of child
vulnerability across
the archipelago.”

APPLYING STATISTICAL ANALYSIS TO THE CVI

Figure 5. NMEAD Operational Zones



Source: *Negociado para el Manejo de Emergencias y Administración de Desastres (NMEAD)*.³⁴

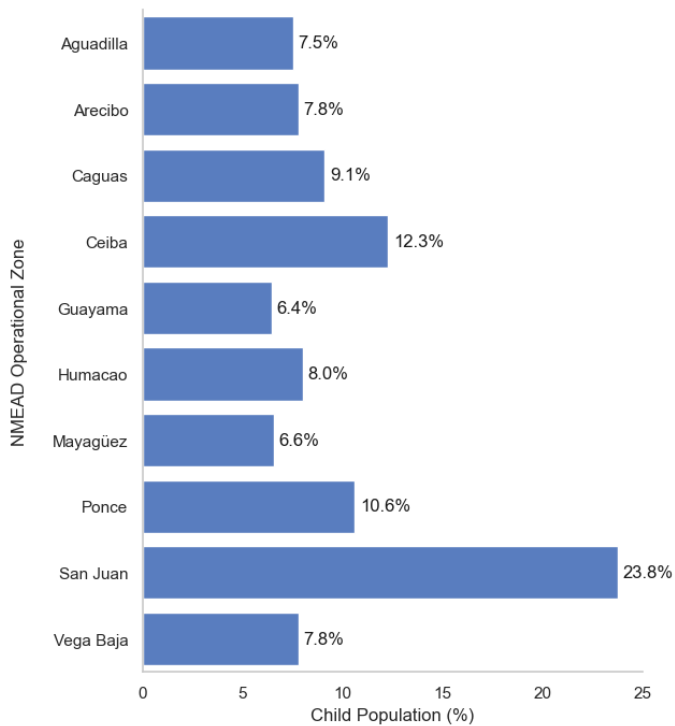
As mentioned above, the CVI tool includes the ESRI Enterprise dashboard and open sourced Python code written to extract the data from the U.S. Census, define the fourteen variables, and construct the CVI for each Municipio, Barrio, and Census Tract in Puerto Rico. To demonstrate how the code could be customized for targeted use by local government decision makers, we augmented the code to compare the CVI of different regions of the archipelago by performing statistical analysis, including statistical hypothesis testing. In Puerto Rico, the government agency tasked with emergency management response is the *Negociado para el Manejo de Emergencias y Administración de Desastres (NMEAD)*. Under Puerto Rico's Law 20-2017, NMEAD is responsible for implementing and maintaining the 2021 Puerto Rico All-Hazards Plan (PRAHP).³³ This plan establishes processes to coordinate emergency management program operations across the archipelago. As shown in Figure 5, NMEAD has split Puerto Rico's municipios into ten different Operational Zones, each reporting to NMEAD's Commissioner.

To demonstrate how NMEAD could leverage the CVI to assess risk to the children population in Puerto Rico, we analyzed the socioeconomic profile of all the NMEAD Operational Zones by children vulnerability variable theme. Then, using statistical hypothesis testing, we compared the mean CVI of Municipios, Barrios, and Census Tracts within

an Operational Zone to the mean CVI of Municipios, Barrios, and Census Tracts within all other Operational Zones. Such analysis can provide actionable insights to inform pre-disaster risk mitigation efforts for the children population in Puerto Rico, as well as post-disaster resource allocation and emergency responses specifically targeted to children.

In 2021, there were an estimated 597,277 children in Puerto Rico. As shown in Figure 6, nearly a quarter (23.8%) of Puerto Rico's population under 18 years old resided in the San Juan Operational Zone (142,001 children), which is composed of the municipios of San Juan (58,165 children), Bayamón (31,563), Guaynabo (13,972), Toa Baja (13,808), Toa Alta (12,895), Dorado (7,160), and Cataño (4,438). The NMEAD Operational Zone with the second largest children population is Ceiba, which is home to 12.3% of children in the archipelago (73,455 children). The Ponce Operational Zone contains 10.6% of the children-age population with 63,413 children, followed by the Caguas Operational Zone, which contains 9.1% of the children-age population, with 54,471 children. Humacao (8%), Arecibo (7.8%), Vega Baja (7.8%), Aguadilla (7.5%), Mayagüez (6.6%), and Guayama (6.4%) represent the Operational Zones that contain the least children-aged population.

Figure 6. Percent of Child Population by NMEAD Operational Zone



Source: U.S. Census Bureau, 2017-2021 American Community Survey, 5-year estimates.

Table 1 shows the socioeconomic variables of the children-age population used to create the CVI aggregated for each of the NMEAD Operational Zones. In 2021, the poverty rate for children between Operational Zones was highest in the Ponce Operational Zone (64.7%), followed by Mayagüez (64.1%), Guayama (62.5%), Arecibo (60.2%), Aguadilla (58.5%), Vega Baja (58.4%), and Caguas (57.2%), all of which were higher than the overall state level child poverty rate (56.3%). Child disability percentages were the highest in the Guayama Operational Zone (14.1%), followed by 11.6% in the Caguas Operational Zone, 9.8% in Mayagüez, 9.3% in Ceiba, 8.5% in Ponce, and 7.7% in the San Juan Operational Zone. These Zones also experienced earthquake disasters in 2020, specifically southwest region zones, and flooding as a result of the major hurricanes. As shown in Table 1, the Vega Baja Operational Zone (5.5%) had among the highest child health uninsurance percentages compared to other regions. This Operational Zone includes the Municipios of Vega Baja, Vega Alta, Corozal, Orocovis, Ciales, Morovis, Manatí, and Florida. Health uninsurance percentages for children under 19 in Manatí (10.8%) and Vega Baja (9.2%) were over two times higher than the state average (3.3%), while children residing in Morovis (2.9%),

Vega Alta (2.7%), Orocovis (2.6%), Florida (1.1%), and Ciales (1.0%) had lower health uninsurance percentages.³⁵ In our study, we found that the Operational Zones of Aguadilla (9.0%), Arecibo (8.2%), Caguas (7.8%), Humacao (7.8%), and Vega Baja (7.3%) had the highest percentage of children who were not enrolled in school in 2021. Of the Municipios that comprise the Aguadilla Operational Zone, which had the highest percentage of children between the ages of 3 and 17 not enrolled in school, Rincon (12.8%) had the highest percentage of school unenrollment, followed by Añasco (10.3%), Isabela (10.2%), San Sebastián (9.4%), Aguada (9.1%), and Moca (8.7%), while Aguadilla (6.6%) had the lowest percentage of unenrolled children in school.

In 2021, the percentage of children living in a single parent household for all of Puerto Rico was 62%. At the NMEAD Operational Zone scale, the percentage of children living in single parent households was highest in the Ponce Operational Zone, with 67% of children living in single parent households, followed Guayama (65%), Caguas (64.7%), Ceiba (63.3%), Mayagüez (63.2%), and Vega Baja (62.5%). Lower rates of children living in single parent households were seen in the San Juan Operational Zone (61.9%), Humacao (61.9%), Aguadilla (58.4%), and Arecibo (52.6%). Rates of children under 18 years old living with a grandparent with no parents present were higher in the Humacao (2.5%), Mayagüez (2.4%), and Caguas (2.0%) NMEAD Operational Zones.

Children living in households receiving some type of government assistance (Social Security Income, Cash Public Assistance, or SNAP) are also vulnerable when a disaster hits their communities. The rate of Children living in households receiving government assistance was the highest in the NMEAD Operational Zone of Ponce (64.9%), followed by Mayagüez (63.9%), Arecibo (62.2%), Caguas (58.8%), Aguadilla (58.2%), Guayama (58.1%), while this was lower in Vega Baja (57.7%), Humacao (54.2%), Ceiba (51.5%), and San Juan (48.5%). The rates of occupied housing with no internet access was highest in the Vega Baja NMEAD Operational Zone, with 17.3%, followed by 11.5% in Aguadilla, 11.3% in San Juan, 7.6% in Arecibo, 7.2% in Mayagüez, 6.6% in Caguas, 6.5% in Ponce, 2.8% in Humacao, and 2.7% in both Guayama and Ceiba. The rate of occupied housing with no computer in the household was highest in Mayagüez, with 17.1%, followed by 13.9% in Guayama, 11.2% in both Aguadilla and San Juan, 7.8% in Ponce, 6.1% in Caguas, 5.8% in Arecibo, 4.1% in Vega Baja, 3.1% in Humacao, and 2.7% in Ceiba.

Table 1. Socioeconomic Characteristics by NMEAD Operational Zone**Theme 1: Children Personal Characteristics**

NMEAD Operational Zone	Child population %	Child poverty %	Child Healthcare Uninsurance %	Child Disability %	% of Children Not Enrolled in School
Aguadilla	17.7%	58.5%	2.5%	5.1%	9.0%
Arecibo	17.8%	60.2%	2.9%	5.2%	8.2%
Caguas	18.5%	57.3%	2.6%	11.6%	7.8%
Ceiba	17.9%	49.3%	3.3%	9.3%	5.4%
Guayama	18.8%	62.5%	3.2%	14.1%	4.4%
Humacao	18.6%	52.8%	3.3%	5.2%	7.8%
Mayagüez	17.1%	64.1%	2.0%	9.8%	7.2%
Ponce	19.3%	64.7%	2.7%	8.5%	6.1%
San Juan	17.2%	50.5%	3.7%	7.7%	7.0%
Vega Baja	19.1%	58.4%	5.5%	7.6%	7.3%

Theme 2: Characteristics of Households with Children

	% of Children in Households with Grandparents and No Parent Present	% of Children in Households with One Parent Present	% of Children in Households Receiving Cash Assistance	% of Children in Households with No Internet	% of Children in Households with No Computer
Aguadilla	1.2%	58.4%	58.2%	11.5%	11.2%
Arecibo	1.3%	52.6%	62.2%	7.6%	5.8%
Caguas	2.0%	64.7%	58.8%	6.6%	6.1%
Ceiba	1.7%	63.3%	51.5%	2.7%	2.7%
Guayama	1.7%	65.0%	58.1%	2.7%	13.9%
Humacao	2.5%	61.9%	54.2%	2.8%	3.1%
Mayagüez	2.4%	63.2%	63.9%	7.2%	17.1%
Ponce	1.3%	67.0%	64.9%	6.5%	7.8%
San Juan	1.6%	61.9%	48.5%	11.3%	11.2%
Vega Baja	1.7%	62.5%	57.7%	17.3%	4.1%

Theme 3: Overall Household Characteristics

	% of Civilian Population Unemployed	% of Occupied Housing with No Vehicle	% of Occupied Housing with Overcrowding	% of Housing-Cost-Burdened Households
Aguadilla	5.3%	12.9%	1.5%	18.4%
Arecibo	5.9%	12.8%	1.4%	20.1%
Caguas	5.0%	13.7%	2.3%	21.7%
Ceiba	8.2%	12.2%	3.4%	26.4%
Guayama	3.4%	15.4%	2.3%	23.3%
Humacao	5.6%	12.3%	3.3%	22.4%
Mayagüez	7.1%	16.7%	2.5%	20.3%
Ponce	6.8%	15.4%	2.3%	20.0%
San Juan	6.8%	16.9%	2.2%	28.8%
Vega Baja	8.2%	14.8%	3.8%	21.7%

Source: U.S. Census Bureau, 2017-2021 American Community Survey, 5-year estimates

The percent of the civilian population that is unemployed was highest in both Vega Baja and Ceiba, with 8.2%, followed by 7.1% in Mayagüez, 6.8% in San Juan, and 6.8% in Ponce. At the state level, the percent of unemployed civilians was 6.2%, and the following regions had lower rates: 5.9% in Arecibo, 5.6% in Humacao, 5.3% in Aguadilla, 5% in Caguas, and 3.4% in Guayama. Children living in cost-burdened households, where their caregivers are spending 30% or of their income towards rent or mortgage,

was highest in the San Juan region, with 28.8%, followed by Ceiba (26.4%), Guayama (23.3%), and Humacao (22.4%). Additionally, overcrowding in the household was highest in Vega Baja (3.8%), followed by Ceiba (3.4%), and Humacao (3.3%). Access to a vehicle is also important, as a means of transportation to prepare or to move to shelters or family and/or friends during pre- and post-disaster. No vehicle present was highest in San Juan 16.9%, followed by 16.7% in Mayagüez, and 15.4% in both Ponce and Guayama.

Table 2. Mean CVI of NMEAD Operational Zones by Geographic Level

NMEAD Operational Zone	Mean CVI by Municipio	Mean CVI by Barrio	Mean CVI by Census Tract
Aguadilla	0.263	0.410	0.430
Arecibo	0.347	0.446	0.461
Caguas	0.619	0.547	0.536
Ceiba	0.409	0.523	0.456
Guayama	0.596	0.475	0.533
Humacao	0.465	0.465	0.427
Mayagüez	0.533	0.494	0.530
Ponce	0.638	0.510	0.557
San Juan	0.428	0.612	0.491
Vega Baja	0.723	0.594	0.631

Table 2 contains the mean CVI for each NMEAD Operational Zone, computed at Municipio, Barrio, and Census Tract levels. When measured at Municipio level, Municipios in the Vega Baja Operational Zone have the highest CVI mean and Municipios in the Aguadilla Operational Zone have the lowest mean. When measured at Barrio level, Barrios in the San Juan Operational Zone have the highest mean CVI and Barrios in the Aguadilla Operational Zone, the lowest. Finally, when measured at Census Tract level, we see that tracts in the Vega Baja Operational Zone have the highest mean CVI and tracts in the Humacao Operational Zone have the lowest mean CVI.

We assessed statistical evidence to state, for example, that at Municipio level, the Vega Baja Operational Zone has a statistically significantly greater mean CVI than the rest of the NMEAD Operational Zones in Puerto Rico. One-sided pairwise statistical hypothesis tests were performed to assess if a NMEAD Operational Zone's CVIs was significantly higher or lower than the rest of the Operational Zones' CVIs combined, the results of which are shown in Table 3.³⁶

We found that, when measuring relative children vulnerability at Municipio level, municipios in NMEAD's Vega Baja Operational Zone have statistically significantly higher CVIs than municipios elsewhere, whereas

municipios in the Aguadilla Operational Zone have lower relative children vulnerability than municipios elsewhere. When measuring CVI at Barrio level, barrios in the San Juan and Vega Baja Zones have higher CVIs than Barrios elsewhere, whereas Barrios in the Aguadilla and Arecibo Operational Zones have lower CVIs than Barrios elsewhere. When measured at Census Tract level, we find that Census Tracts in the Ponce and Vega Baja Operational Zones have higher CVIs than Tracts elsewhere in the archipelago, and that Census Tracts in the Aguadilla, Ceiba, and Humacao Zones have lower CVIs than Census Tracts elsewhere.

The Vega Baja Operational Zone, which includes the Municipios of Vega Baja, Vega Alta, Corozal, Orocovis, Ciales, Morovis, Manatí, and Florida, consistently tested as having a statistically significant greater mean CVI than the rest of the Operational Zones in the archipelago. On the other hand, the Aguadilla Operational Zone (containing Aguadilla, Isabela, Moca, Aguada, San Sebastián, Añasco, and Rincón) consistently tested as having a statistically significant smaller mean CVI than the rest of the Zones in the archipelago. According to these results then, *children living in NMEAD's Vega Baja Operational Zone collectively experience greater relative vulnerability than children living elsewhere.*

Table 3. Statistical analysis results by NMEAD Operational Zones

NMEAD Operational Zones		
Geographic Level	Lower mean CVI	Higher mean CVI
Municipios	Aguadilla	Vega Baja
Barrios	Aguadilla, Arecibo	San Juan, Vega Baja
Census Tracts	Aguadilla, Ceiba, Humacao	Ponce, Vega Baja

CONCLUSION

As mentioned above, the CVI tool includes the ESRI Enterprise dashboard and open sourced Python code written to extract the data from the U.S. Census, define the fourteen variables, and construct the CVI for each Municipio, Barrio, and Census Tract in Puerto Rico. To demonstrate how the code could be customized for targeted use by local government decision makers, we augmented the code to compare the CVI of different regions of the archipelago by performing statistical analysis, including statistical hypothesis testing.

Our analysis of the CVI shows that Municipios in the Central and South regions of the archipelago had higher levels of children vulnerability than Municipios in other regions. At lower level geographies, our analysis showcases the ubiquitous and unevenly distributed nature of children vulnerability in Puerto Rico: all Municipios except Culebra had at least one Barrio with CVI greater than or equal to 0.5, and 59 out of the 78 Municipios in the archipelago had Barrios with CVIs in all quartiles. Moreover, we demonstrated how the tool can be used to conduct custom analyses for government agencies such as the *Negociado de Manejo de Emergencias y Administración de Desastres (NMEAD)*, which has divided the Municipios in Puerto Rico into ten Operational Zones tasked with assisting in emergency preparedness and response. For instance, statistical analysis of the CVI showed that Municipios, Barrios, and Census tracts in the Vega Baja Operational Zone have statistically significantly higher CVIs than elsewhere, an actionable insight for the Bureau to consider as they prepare for risk mitigation and disaster response.

SVIs are used by disaster managers and researchers to identify the locations of vulnerable populations with hopes of reducing vulnerabilities and inequalities associated with disasters. Researchers have also noted several limitations to the use of SVIs for disaster management and response. Some of the limits or critiques associated with SVIs are the absence of key sociodemographic characteristics associated with disaster vulnerability, such as racial minority status, disability, and gender.³⁷ To this end, the CVI might be limited in its capacity to measure children vulnerability in Puerto Rico by not including measures of gender and race. Other measures not traditionally included in SVIs are those that account for the physical and built environment. Although the CVI does include measures of infrastructures, such as internet access and presence of vehicles in the

household, other metrics such as flooding or distance to key infrastructure are not accounted for. As previously mentioned, SVIs are generally created by aggregating distinct social factors derived from national surveys or other publicly accessible data, such as the U.S. Census Bureau American Community Survey. These approaches have been debated for not including survey errors into their estimates, which are important for interpreting results, particularly in small areas.³⁸ Our use of the 2017-2021 ACS 5-year estimates for the CVI without including survey errors might hinder the index's capacity to measure vulnerability of children. The use of the 2021 ACS 5-year estimates is also limiting in that it includes data for 2020 that might be skewed because of interruptions in the data collection due to the COVID-19 pandemic. Use of ACS data, which considers children as those under 18 years of age, is also limited in the context of Puerto Rico, where the "Children's Bill of Rights" defines children as those under 21 years of age. Fully incorporating these children into the CVI requires expanding the data sources. Furthermore, data from other sources such as other federal or Commonwealth agencies, or even ACS microdata, could elucidate child vulnerability in greater detail. Future iterations of the Child Vulnerability Index could include additional variables, such as the educational attainment of householders in households where children live, the geographic isolation of their community,³⁹ and the food insecurity children are subject to, in order to understand child vulnerability in more depth.

Notwithstanding these limitations, the development of the Child Vulnerability Index is a step towards understanding and quantifying the child vulnerability landscape in Puerto Rico. Those who utilize the CVI will be able to identify and aid communities that are in need of attention and support, so as to safeguard the well-being of Puerto Rican children in the archipelago before, during, and after natural hazards occur.

ACKNOWLEDGEMENTS

We would like to thank Dr. Carlos Vargas-Ramos, Dr. Yerís Mayol-García, Dr. Fernando A. Tormos-Aponte, Dr. Fernando I. Rivera, Enery López Navarrete, and Dr. Alison Chopel for reviewing our work and providing feedback.

NOTES

- ¹ “Children” is a general term used by disaster researchers and social vulnerability scholars to refer to at-risk populations in their early stages of life. Although many disaster management plans subdivide children into multiple groups based on their stage of development, children are more commonly defined as all persons under the age of 18 by most international and national organizations, i.e., the U.N. and the U.S. Census Bureau. Nonetheless, in Puerto Rico, Act 338 of 1998, better known as the “Children’s Bill of Rights”, defines children as everybody under 21 years old. Defining the threshold of children’s age groups is important for understanding and improving the conditions of vulnerable communities and caring for those that are most vulnerable. See Lori Peek, David M. Abramson, Robin S. Cox, Alice Fothergill, et. al., “Children and Disasters,” in *Handbook of Sociology and Social Research*, eds. H. Rodriguez et. al. (Springer International Publishing, 2018), 243-263. Yeris Mayol-García, “Pre-hurricane linkages between poverty, families, and migration among Puerto Rican-origin children living in Puerto Rico and the United States,” *Population and Environment* 42, (2020): 57-78, <https://doi.org/10.1007/s11111-020-00353-7>.
- ² See Mayol-García, “Pre-hurricane linkages between poverty, families, and migration among Puerto Rican-origin children living in Puerto Rico and the United States,” 57-78; Raúl Figueroa-Rodríguez, “Children Poverty in Puerto Rico,” in *Poverty in Puerto Rico: A socioeconomic and demographic analysis with data from the Puerto Rico Community Survey (2014)*, ed. Carmen Nazario (Humacao: Model Offset Printing, 2016), 247-262; Ericka Felix, Lino A. Hernández, Milagros Bravo, Rafael Ramirez et. al., “Natural Disaster Risk of Psychiatric Disorders in Puerto Rican Children,” *Journal of Abnormal Child Psychology* 39, (2011): 589-600; Gabriela R. Guerra Velázquez, “Hurricane María and Public Health in Puerto Rico: Lessons Learned to Increase Resiliency and Prepare for Future Disasters,” *Ann. Glob. Health* 88, 1 (2022): 1-9.
- ³ See Carolyn Kousky, “Impacts of Natural Disasters on Children,” *The Future of Children* 26, 1 (2016): 73-92, <https://www.jstor.org/stable/43755231> and Annette M. La Greca, Betty S. Lai, Maria M. Llabre, Wendy K. Silverman et. al., “Children Postdisaster Trajectories of PTSD Symptoms: Predicting Chronic Distress,” *Child Youth Care Forum* 42, (2013): 351-369.
- ⁴ See Appendix A and Appendix B for more details regarding variables related to children vulnerability in Puerto Rico in 2021.
- ⁵ Barry E. Flanagan et. al., “A Social Vulnerability Index for Disaster Management,” *Journal of Homeland Security and Emergency Management* 8, 1 (2011): 1-22, [10.2202/1547-7355.1792](https://doi.org/10.2202/1547-7355.1792).
- ⁶ Jocelyn West, “Social vulnerability and population loss in Puerto Rico after Hurricane Maria,” *Population and Environment* 45, 8 (2023): 1-22, <https://doi.org/10.1007/s11111-023-00418-3>.
- ⁷ Susan L. Cutter and Christina Finch, “Temporal and spatial changes in social vulnerability to natural hazards,” *PNAS* 105, 7 (2008): 2301-2306, <https://doi.org/10.1073/pnas.0710375105>.
- ⁸ María E. Enchautegui, Brayan L. Rosa, and Caridad A. Arroyo, *Un futuro de pobreza infantil en Puerto Rico: Cuánto nos cuesta y qué podemos hacer* (San Juan: Instituto del Desarrollo de la Juventud, 2019).
- ⁹ Enchautegui et. al., *Un futuro de pobreza infantil en Puerto Rico*: 22-40.
- ¹⁰ *Protecting Youth Mental Health: The U.S. Surgeon General’s Advisory*, (2021).
- ¹¹ *The Climate Crisis is a Child Rights Crisis: Introducing the Children’s Climate Risk Index*. (New York: United Nations Children’s Fund (UNICEF), 2021).
- ¹² See Irene Lafarga Previdi et. al., “The Impact of Natural Disasters on Maternal Health: Hurricanes Irma and María in Puerto Rico,” *Children* 9, 7 (2022): 1-9; Rosaura Orengo-Aguayo, Regan W. Stewart, and Michael A. de Arellano, “Disaster Exposure and Mental Health Among Puerto Rican Youth After Hurricane Maria,” *JAMA Network Open* 2, 4 (2019): 1-9; and Erika Felix, Sukkyung you, Eric Vernberg, and Glorisa Canino, “Family Influences on the Long Term Post-Disaster Recovery of Puerto Rican Youth,” *J Abnorm Child Psychol* 41, 1 (13): 111-124.
- ¹³ Jocelyn West, “Social vulnerability and population loss,” 1-22.
- ¹⁴ Barry E. Flanagan et. al., “A Social Vulnerability Index.”

¹⁵ Social Vulnerability Indexes (SVI) are generally used to reflect a system's capacity to respond to impact or describe the characteristics of a person or group and their capacity to respond to hazardous events. SVIs are generally created by aggregating distinct social indicators. While beneficial for adding categories of social factors into a comprehensive framework, they commonly fail at addressing key factors of vulnerability such as gender, race, or age group. Moreover, use of nationwide indexes risks not accounting for local contexts that influence vulnerability differently. Consider the CDC SVI, which takes into account minority status based on race or ethnicity and English language proficiency as a measure of vulnerability. In the context of Puerto Rico, Hispanics or Latinos are not minorities and cannot be thought of being vulnerable based on this characteristic. Similarly, people who are not proficient in English are not more vulnerable in the archipelago because the predominant language is Spanish. This does not negate that other minority groups are vulnerable or that there are people who speak languages other than English or Spanish that are more vulnerable if disaster occurs. See Fernando Tormos-Aponte, Gustavo García-López, and Mary Angelica Painter, "Energy inequality and clientelism in the wake of disasters: From colorblind to affirmative power restoration," *Energy Policy* 158 (2021): 1-16; Barry E. Flanagan et. al., "A Social Vulnerability Index," 1-22; Jocelyn West, "Social vulnerability and population loss," 1-22; and Lori Peek et. al. "Children and Disasters," 243-263.

¹⁶ Barry E. Flanagan et. al., "A Social Vulnerability Index," 1-22.

¹⁷ See The Opportunity Project 2022 Sprints: <https://opportunity.census.gov/sprints/2022-sprints/#2022-sprints>.

¹⁸ To calculate the percent of uninsured children uninsured, we computed the percentage of the civilian noninstitutionalized population under 19 years of age that does not have any type of health insurance. The U.S. Census Bureau's American Community Survey collects child health insurance data in this fashion, based on existing Children's Health Insurance Program (CHIP) eligibility standards. See Medicaid.gov's CHIP Eligibility website: <https://www.medicaid.gov/chip/eligibility/index.html>

¹⁹ Carolyn Kousky, "Impacts of Natural Disasters on Children," 73-92.

²⁰ Barry E. Flanagan et. al., "A Social Vulnerability Index," 1-22.

²¹ See Mayol-García, "Pre-hurricane linkages between poverty, families, and migration among Puerto Rican-origin children living in Puerto Rico and the United States," 57-78, and Raúl Figueroa-Rodríguez, "Children Poverty in Puerto Rico," 247-262.

²² Raúl Figueroa-Rodríguez, "Children Poverty in Puerto Rico," 247-262

²³ See Mayol-García, "Pre-hurricane linkages between poverty, families, and migration among Puerto Rican-origin children living in Puerto Rico and the United States," 57-78, and Raúl Figueroa-Rodríguez, "Children Poverty in Puerto Rico," 247-262.

²⁴ Annette M. La Greca, "School-based studies of children following disasters," in *Methods for disaster mental health research*, ed. Fran H. Norris (Guilford Publications, 2006): 141-157.

²⁵ See Taiana Díaz Ramos, Jesús Jank Curbelo, Mariela Mejía, and Freeman Rogers, "Sin rumbo los sistemas de educación pública en el Caribe y el coronavirus," *Centro de Periodismo Investigativo*, 6 de agosto 2020, <https://periodismoinvestigativo.com/2020/08/sin-rumbo-los-sistemas-de-educacion-publica-en-el-caribe-ante-el-coronavirus/>; and "Estudiantes relatan cómo viven las clases en línea: 'No me gusta, prefiero ir a la escuela'", ENDI, 2 de septiembre 2020, <https://www.elnuevodia.com/noticias/locales/videos/estudiantes-relatan-como-viven-las-clases-en-linea-no-me-gusta-prefiero-ir-a-la-escuela-267695/>.

²⁶ Barry E. Flanagan et. al., "A Social Vulnerability Index," 1-22.

²⁷ See Barry E. Flanagan et. al., "A Social Vulnerability Index," 1-22, and Diana Ramírez-Ríos, William Wallace, Jordan Kinsler, and Paola Méndez, "Exploring Post-Disaster Transportation Barriers to Healthcare of Social Vulnerable Puerto Rican Communities," *Natural Hazards Center Public Health Disaster Research Report Series 17*, 2022, <https://hazards.colorado.edu/public-health-disaster-research/exploring-post-disaster-transportation-barriers-to-healthcare-of-socially-vulnerable-puerto-rican-communities>.

²⁸ See CDC SVI Data Documentation. https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2020.html.

²⁹ The 2017-2021 American Community Survey 5-year estimates include data from 2020. In 2020, the ACS faced data collection challenges due to the COVID-19 pandemic. As a result, 2017-2021 ACS 5-year estimates had larger margins of error. See the following U.S. Census Bureau online publications for more information: "Adapting the American Community Survey Amid COVID-19," <https://www.census.gov/newsroom/blogs/random-samplings/2021/05/adapting-the-acs-amid-covid-19.html>, and "Increased Margins of Error in the 5-Year Estimates Containing Data Collected in 2020," <https://www.census.gov/programs-surveys/acs/technical-documentation/user-notes/2022-04.html>.

³⁰ All data analysis and computations were performed using custom written Python code. Percentile ranks were calculated using the “pandas.Series.rank” function with default parameters except for the pct parameter, which was set to True.

³¹ The Children Vulnerability Index is the percentile rank of the sum of the percentile rank of each of the fourteen variables. Values range from greater than 0 to 1, with higher values indicating higher relative children vulnerability. If a Municipio has a CVI of 1, this means that of all the 78 Municipios, it is the 78th municipio in order of increasing relative children vulnerability. Similarly, the Barrio with a CVI of 1 is the 845th Barrio in order of increasing relative children vulnerability. The Census Tract with a CVI of 1 is the 919th Census Tract in order of increasing relative children vulnerability.

³² Barrio Naranjo is the highest ranking Barrio for Theme 2 - Characteristics of Households with Children, with a rank of 1.00, while Barrio Comerío is the second highest ranking Barrio for Theme 2, with a rank of 0.999.

³³ Puerto Rico Department of Public Safety (DPS) and Puerto Rico Emergency Management Bureau (PREMB), “Puerto Rico All-Hazards Plan,” 2020, <https://manejodeemergencias.pr.gov/wp-content/uploads/2021/05/PRhazardsplanoctober2020version1-1-min.pdf>

³⁴ See *Plan Operacional de Emergencias 2023-2024: Salud Pública y Servicios Médicos*.

³⁵ See Press Release - Nation’s Public School Enrollment Dropped 3 Percent in 2020-21 - June 28, 2021.

³⁶ Statistical hypothesis testing is a method of statistical inference used to assess evidence for a hypothesis with sample data. In our case, we test the hypothesis that CVIs for Municipios, Barrios, or Census Tracts in an NMEAD Operational Zone are higher or lower than CVIs in Municipios, Barrios, or Census Tracts in all other Operational Zones. To this end, one-sided pairwise Mann-Whitney U tests were performed, and results deemed statistically significant at a significance level of $\alpha = 0.05$. The two samples we test are: (1) the values of the sum of all fourteen variables’ percentile ranks belonging to Municipios, Barrios, Census Tracts in the Operational Zone of interest and (2) the values of the sum of all percentile ranks belonging to all the Municipios, Barrios, or Census Tracts in all other Operational Zones. The one-sided Mann-Whitney U test first combines the two samples into one, and orders the combined sample from smallest to largest value. It ranks all the values in the combined sample. After this step, it computes the mean ranks of each of the two samples of values and compares them to each other. The test assesses if the mean rank of one group is statistically significantly greater or less than the mean rank of the other group. Given that the CVI is defined as the percentile rank of the sum of all variable percentile ranks, this is equivalent to assessing if the mean CVI of one group is statistically significantly greater or less than the other group’s mean CVI

³⁷ Lori Peek et. al. “Children and Disasters,” 243-263.

³⁸ Katherine Ann Willyard, James Scurry, Heather King, Benjamin Gurrentz, and Bethany DeSalvo, “Developing a Data-Driven System for Identifying the Most Vulnerable Communities in Puerto Rico,” SEHSD Working Paper Series, 2023-17, U.S. Census Bureau, Washington D.C., 2023.

³⁹ For example, the population in the island-municipios of Vieques and Culebra experience ongoing heightened vulnerability due to lack of access to healthcare facilities and reliance on transportation of goods, such as food and medicine, from the Puerto Rican mainland. Disruption of maritime and air transportation leaves these municipios isolated from the rest of Puerto Rico and other surrounding islands, increasing their vulnerability before, during, and following natural hazards.

APPENDIX A. STATE, MUNICIPIO, BARRIO, AND CENSUS TRACT CVI VARIABLE STATISTICS, 2021**Table A1.** State Level Statistics for All Variables in the CVI for Puerto Rico, 2021

	Puerto Rico (%)
Child Population Percent	18.0
Child Poverty Percent	56.3
Child Healthcare Uninsurance Percent	3.2
Child Disability Percent	8.3
Percent of Children Not Enrolled in School	6.9
Percent of Children in Households with Grandparents and No Parent Present	1.7
Percent of Children in Households with One Parent Present	62.2
Percent of Children in Households Receiving Cash Assistance	56.2
Percent of Children in Households with No Internet	8.0
Percent of Children in Households with No Computer	8.3
Percent of Civilian Population Unemployed	6.4
Percent of Occupied Housing with No Vehicle	14.7
Percent of Occupied Housing with Overcrowding	2.5
Percent of Housing-Cost-Burdened Households	23.6

Table A2. Descriptive Statistics for all Variables in the CVI at the Municipio Level, 2021

Variable (n = 78)	Mean (%)	SD (%)	Min (%)	Max (%)
Child Population Percent	18.4	1.3	15.5	21.2
Child Poverty Percent	58.9	11.3	21.7	86.0
Child Healthcare Uninsurance Percent	2.8	1.9	0.0	10.8
Child Disability Percent	7.9	4.3	0.0	19.8
Percent of Children Not Enrolled in School	7.0	2.8	1.3	15.6
Percent of Children in Households with Grandparents and No Parent Present	1.8	1.4	0.0	8.2
Percent of Children in Households with One Parent Present	62.4	8.4	34.6	82.7
Percent of Children in Households Receiving Cash Assistance	59.3	10.5	33.3	80.4
Percent of Children in Households with No Internet	8.1	8.9	0.0	39.5
Percent of Children in Households with No Computer	8.1	8.4	0.5	37.3
Percent of Civilian Population Unemployed	6.3	3.0	0.9	12.8
Percent of Occupied Housing with No Vehicle	13.9	3.3	6.9	24.5
Percent of Occupied Housing with Overcrowding	2.8	1.6	0.5	9.4
Percent of Housing-Cost-Burdened Households	20.8	4.5	12.2	32.9

Source: U.S. Census Bureau, 2017-2021 American Community Survey, 5-year estimates.

Table A3. Descriptive Statistics for all Variables in the CVI at the Barrio Level, 2021

Variable (n = 845)	Mean (%)	SD (%)	Min (%)	Max (%)
Child Population Percent	18.3	7.3	1.6	75.6
Child Poverty Percent	60.6	25.6	0.0	100.0
Child Healthcare Uninsurance Percent	3.2	8.3	0.0	100.0
Child Disability Percent	7.5	10.7	0.0	100.0
Percent of Children Not Enrolled in School	7.5	11.9	0.0	100.0
Percent of Children in Households with Grandparents and No Parent Present	1.9	6.9	0.0	100.0
Percent of Children in Households with One Parent Present	60.9	26.3	0.0	100.0
Percent of Children in Households Receiving Cash Assistance	61.2	26.0	0.0	100.0
Percent of Children in Households with No Internet	8.8	17.1	0.0	100.0
Percent of Children in Households with No Computer	10.2	18.7	0.0	100.0
Percent of Civilian Population Unemployed	6.2	5.5	0.0	36.2
Percent of Occupied Housing with No Vehicle	13.9	9.7	0.0	83.0
Percent of Occupied Housing with Overcrowding	2.9	4.7	0.0	56.0
Percent of Housing-Cost-Burdened Households	19.2	10.3	0.0	89.6

Table A4. Descriptive Statistics for all Variables in the CVI at the Census Tract Level, 2021

Variable (n = 919)	Mean (%)	SD (%)	Min (%)	Max (%)
Child Population Percent	17.7	5.5	0.7	45.1
Child Poverty Percent	56.1	22.6	0.0	100.0
Child Healthcare Uninsurance Percent	3.6	5.7	0.0	49.1
Child Disability Percent	8.4	7.6	0.0	49.0
Percent of Children Not Enrolled in School	7.1	7.7	0.0	100.0
Percent of Children in Households with Grandparents and No Parent Present	1.9	4.0	0.0	30.3
Percent of Children in Households with One Parent Present	62.8	19.5	0.0	100.0
Percent of Children in Households Receiving Cash Assistance	55.3	23.6	0.0	100.0
Percent of Children in Households with No Internet	7.7	11.4	0.0	70.1
Percent of Children in Households with No Computer	8.7	12.9	0.0	73.2
Percent of Civilian Population Unemployed	6.8	4.5	0.0	29.1
Percent of Occupied Housing with No Vehicle	15.9	10.9	0.0	74.0
Percent of Occupied Housing with Overcrowding	2.5	2.4	0.0	16.1
Percent of Housing-Cost-Burdened Households	23.9	8.8	3.1	56.1

APPENDIX B. DEFINITION OF THE VARIABLES USED TO CONSTRUCT THE CHILD VULNERABILITY INDEX

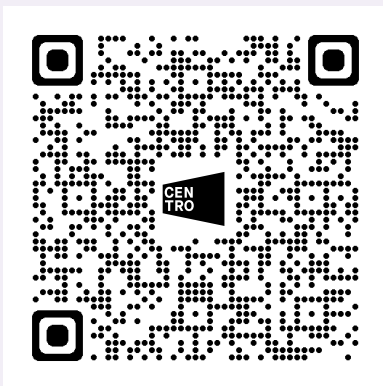
Theme	Variable	Description	ACS 2017-2021 5-year Tables
Personal Characteristics of Children	Child population percent	The total population under 18 years old is divided by the total population for a given geography	B09001 Population under 18 years old by age; B01003 Total Population
	Child poverty percent	The population under 18 years old for whom poverty status is determined and who is living below the poverty line is divided by the total population under 18 years old for whom poverty status is determined	B17001 Poverty status in the last 12 months by sex and by age
	Child healthcare uninsurance percent	Percentage of the civilian noninstitutionalized population under 19 years of age that does not have any type of health insurance	B27010 Types of health insurance coverage by age
	Child disability percent	Percentage of the civilian noninstitutionalized population under 18 years old with a disability	B18101 Sex by age by disability status
	Percent of children not enrolled in school	Percentage of children ages 3 to 17 years old that are not enrolled in school	B14003 Sex by school enrollment by type of school by age for the population 3 years and over
Characteristics of households with children	Percent of children in households with grandparents and no parent present	Percentage of children under 18 years old living in households that live in grandparent households with no parent present	B10002 Grandchildren under 18 years living with a grandparent householder by grandparent responsibility and presence of parent

Theme	Variable	Description	ACS 2017-2021 5-year Tables
Characteristics of households with children	Percent of children in households with one parent present	Percentage of own children of the householder under 18 years old living in families and subfamilies with one parent	B23008 Age of own children under 18 years in families and subfamilies by living arrangements by employment status of parents
	Percent of children in households receiving cash assistance	Percentage of children under 18 years old living in households receiving cash assistance, food stamps, etc	B09010 Receipt of Supplemental Security Income (SSI), Cash Public Assistance Income, or Food Stamps/SNAP in the past 12 months by household type for children under 18 years in households
	Percent of children in households with no internet	Percentage of children under 18 years old living in households with no internet	B28005 Age by presence of a computer and types of internet subscription in household
	Percent of children in households with no computer	Percentage of children under 18 years old living in households with no computer	B28005 Age by presence of a computer and types of internet subscription in household
Overall household characteristics	Percent of civilian population unemployed	Percentage of the civilian population 16 years and over that is unemployed (actively seeking work)	DPO3 Selected economic characteristics
	Percent of occupied housing with no vehicle	Percentage of occupied households with no vehicle	DP04 Selected housing characteristics
	Percent of occupied housing with overcrowding	Percentage of occupied households with more than 1 person living per room	DP04 Selected housing characteristics
	Percent of housing-cost-burdened households	Percentage of households that spend 30% or more of their income towards covering housing costs	DP04 Selected housing characteristics

CHECK OUT OUR OTHER REPORTS

Puerto Rico's 2020 Race/Ethnicity Decennial Analysis (July 2022)

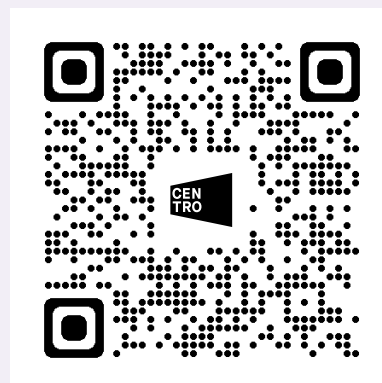
In this report, we provide an overview of the population changes and dramatic shift in racial self-identification in Puerto Rico revealed from the 2020 decennial census. The 2020 Decennial Census unveiled a stark demographic reality for Puerto Rico that has been unfolding in the past decade. According to the 2020 Decennial Census, there were about 3.29 million people living in Puerto Rico, a notable decline of 439,915 individuals from 2010 (-11.8%). In comparison, the United States population grew by 7.4% between 2010 and 2020. In terms of race, the 2020 decennial census has shown a dramatic shift from how Puerto Ricans identify themselves now from 10 years ago. Most of the total population in Puerto Rico identified as 'White and Some Other Race' (38.5%) followed by 'Some Other Race alone' (25.5%) in 2020 compared to a majority of the total population identifying as 'White alone' in both 2000 (80.5%) and 2010 (75.8%).



Redistricting NYC Demographic Change and The Hispanic Community (September 2022)

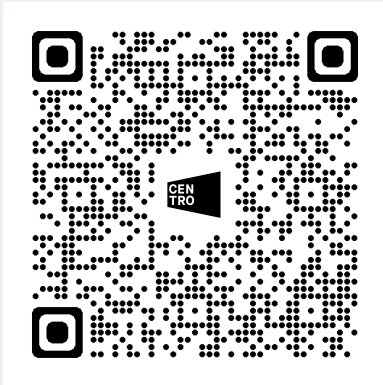
In this report, we provide a portrait of demographic changes in New York City between 2010 and 2020, examining overall population dynamics as well as looking more closely at the ethnoracial composition of the city and its constituent boroughs and council districts. We rely on decennial census data for 2010 and 2020 provided by the U.S. Census Bureau in their Redistricting Files. We also examine changes in the distribution of language use, particularly among New Yorkers who do not speak English well or at all since this may be an impediment to their effective participation in the political process, including registering to vote and voting. Furthermore, we provide information on the geographical distribution of income as this is another important variable for participation in the political process. We also analyze the demographic changes of the different national origin groups that make up the Hispanic population in New York City; a population of particular interest for us. These additional analyses are produced from survey data also derived from the U.S. Census Bureau (i.e., the American Community Survey). We conclude by assessing the council districts preliminarily drawn by the New York City Districting Commission in light of the ensuing descriptive analyses.

Redistricting 2020: The Prospects of Increasing Hispanic Legislative



Representation in Florida (November 2021)

Hispanics are driving population growth across the United States. This lead in population growth affords Latinos the opportunity to increase their political power by potentially increasing the number of legislative districts that can be represented by them. This report provides an overview of population changes in the state of Florida, showing how Hispanic population growth outpaces that of other groups in the state and across counties. The addition of one congressional seat to the state's delegation improves the chances of increasing Hispanic congressional representation in Central Florida as well as in county legislatures (i.e., boards of commissioners) across the state. Puerto Ricans are a leading group driving this population growth, especially as they continue to settle in Central Florida counties.



Redistricting Threats to New York's Hispanic Congressional Representation (November 2021)

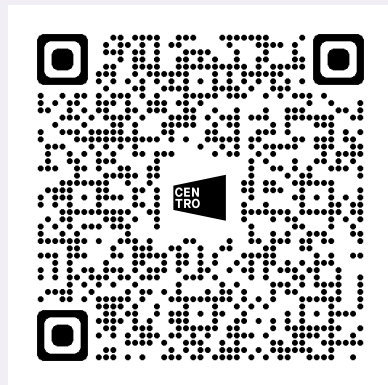
The Center for Puerto Rican Studies (CENTRO) at Hunter College, CUNY has issued a revealing report, "Redistricting Threats to New York's Hispanic Congressional Representation," analyzing the New York Independent Redistricting Commission's draft plans for redistricting and its impact on Hispanic representation. The Independent Redistricting Commission has released two versions of congressional maps: one identified with "Names" and another labeled "Letters". While not final, some of the proposed maps threaten Hispanic congressional representation by eliminating one congressional district currently held by a Hispanic member of the House of Representatives, by diluting Hispanic population in several Hispanic majority districts, and by reducing the likelihood of continuing Hispanic representation in neighborhoods that have just achieved Hispanic representation. Paradoxically, the attempts to dilute Hispanic political representation come on the heels of large Hispanic population increases across the state that have prevented New York State from losing even more congressional seats in the apportionment process.



Four Year Anniversary of Hurricane Maria Series (September 2021)

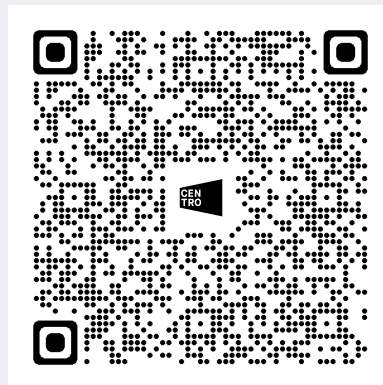
For the fourth anniversary of Hurricane Maria in Puerto Rico the Center for Puerto Rican Studies at Hunter College has prepared a new report focusing on questions

of social vulnerability. We have focused specifically on aging and disabled populations to help better understand how these groups are disproportionately impacted by disasters like Hurricane Maria, the 2020 earthquakes, power outages, flooding, and the COVID-19 pandemic. These events have had a compounding mental, physical, and socioeconomic effect on vulnerable populations like the elderly and the disabled.



Redistricting 2020: Population Change and Hispanic Congressional Representation in Connecticut (August 2021)

On April 26, 2021, the U.S. Census Bureau delivered to the president of the United States results from the 2020 decennial census to be used for apportionment in the House of Representatives. Those apportionment results showed that the state of Connecticut's delegation would remain unchanged at five representatives for the next ten years beginning with the 118th Congress (2023-2025). While the apportionment process has assigned Connecticut five seats in the House of Representatives, there will be changes in the boundaries of existing congressional seats within the state because of internal population dynamics.



LINK TO THE CVI ONLINE PROJECT DASHBOARD



PRODUCED BY:

CARLOS VARGAS-RAMOS, LAURA COLÓN-MELÉNDEZ,
JORGE SOLDEVILLA-IRIZARRY, DAMAYRA FIGUEROA-LAZU,
JENNIFER HINOJOSA, & YARIMAR BONILLA

