



Housing Stability Index

Measuring the Risk of Housing Disruption During the COVID-19 Pandemic

National Preparedness Analytics Center
Decision and Infrastructure Sciences Division

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May 2021

Housing Stability Index: Executive Summary

What is the Housing Stability Index (HSI)?

The availability of affordable housing has been a challenge for communities across the United States long before COVID-19. In locations across the country, many low and moderate-income households commit a significant portion of their monthly earnings to housing costs.¹ The COVID-19 pandemic exacerbated this issue given the widespread decrease in employment as non-essential businesses closed and consumer patterns changed. Argonne National Laboratory (Argonne) developed the HSI to better understand the changes in housing stability for owners and renters during the COVID-19 pandemic. While Argonne developed the HSI to assess impacts from COVID-19, this methodology can be applied to future shocks that result in widespread economic disruption dependent on continued data availability.

What Does the HSI Measure?

The HSI quantifies the decreased stability of housing (renter or owner occupied) across the United States due to missed or deferred housing payments (rent or mortgage payments) or serious delinquency. This is done through calculating the ratio of the near real-time percentage of occupied housing units not at risk of eviction or foreclosure to the baseline percentage of occupied housing units not at risk by county. For purposes of this index, “at risk” indicates a higher percentage of residents unable to make rent or mortgage payments. An HSI value of 1 indicates no additional housing instability (above housing instability before the start of the COVID-19 pandemic) due to COVID-19 while declining values indicate increasing housing instability. For example, a jurisdiction with a stability score of 0.96 would indicate that approximately 4% fewer households in that jurisdiction are stable (i.e., not at risk of eviction or foreclosure) than in the baseline period (January, 2020). Argonne also created two sub-indices, Owner-Occupied Housing Units at Risk and Renter Occupied Housing Units at Risk to differentiate risk between homeowners and renters. To better visualize the results, Argonne binned the data into 5 relative bins (darker colored bins means less stable housing and lighter colors indicate greater stability) and created maps [available here](#).

Why is the HSI Important?

The COVID-19 pandemic has increased concerns about housing insecurity, specifically ability for renters and owners to retain their current housing. Evictions and foreclosures cause significant personal and economic disruptions. For example, the loss of stable housing is strongly linked to food insecurity and impacts to mental health. An increase in evictions from rental housing, or foreclosures of owner-occupied housing, will increase demand for community-based housing and homelessness

¹ Joint Center for Housing Studies of Harvard University, The State of the Nation’s Housing 2020, <https://www.jchs.harvard.edu/state-nations-housing-2020>

support programs and resources. Foreclosures and evictions also affect landlords and banks that rely on predictable and consistent mortgage and rent payments to service debt and obligations.

How to Use the HSI

The goal of the HSI is to provide a basis to identify areas of the country at greater risk of housing instability. The HSI can help local, state, and federal policymakers assess in near-real time the varied impacts to housing stability, to better understand potential individual and family needs and to evaluate the need for eviction relief policies. Maps of different time periods during the pandemic allow users to visualize how housing stability has affected different areas of the country over time.

Go to the HSI storymap [located here](#). HSI data can be [downloaded here](#).

Introduction

The availability of affordable housing has been a challenge for communities across the United States long before COVID-19. Many low and moderate-income households must commit a significant portion of their monthly earnings to housing costs.² This is especially true for households who rent. According to the U.S. Census, approximately 40 percent of households who rent dedicate 35 percent or more of their income to rent.³ The COVID-19 pandemic exacerbated this issue given the widespread decrease in employment as non-essential businesses closed. The COVID-19 pandemic has increased concerns about housing insecurity. Eviction and foreclosures cause significant personal and economic disruptions. For example, the loss of stable housing is strongly linked to food insecurity and mental health needs. An increase in evictions from rental housing, or foreclosures of owner-occupied housing, increases demand for community-based housing and homelessness support programs and resources. Foreclosures and evictions also affect landlords and banks that rely on predictable and consistent mortgage and rent payments to service debt and obligations.

Argonne National Laboratory (Argonne) developed the Housing Stability Index (HSI) to better understand the changes in housing stability during the COVID-19 pandemic. While Argonne developed the HSI to assess impacts from COVID-19, this methodology can be applied to future shocks that result in widespread economic disruption dependent on continued data availability.

Goal of the HSI

The HSI quantifies the decreased stability of housing (renter or owner occupied) across the United States due to missed or deferred housing payments (rent or mortgage payments) or serious delinquency. This is done through calculating the ratio of the near real-time percentage of occupied housing units not at risk of eviction or foreclosure to the baseline percentage of occupied housing units not at risk by county. For purposes of this index, “at risk” indicates a higher percentage of residents unable to make rent or mortgage payments. An HSI value of 1 indicates no additional housing instability (above housing instability before the start of the COVID-19 pandemic) due to COVID-19 while declining values indicate greater housing instability. For example, a jurisdiction with a stability score of 0.96 would indicate that approximately 4% fewer households in that jurisdiction are stable (i.e., not at risk of eviction or foreclosure) than in the baseline period (January, 2020).

Specifically, this analysis establishes a county-level HSI as the ratio of *near real-time* housing units at low risk of disruption (e.g., eviction, serious delinquency, or foreclosure) to *baseline* housing units at low risk of disruption. Several additional metrics are evaluated in this analysis, as listed below.

- The **baseline percentage of occupied housing units** (i.e., both owner-occupied and renter-occupied) **at-risk of disruption in each county** is the ratio of the *baseline* number of owner- and renter-occupied housing units at-risk of disruption in a county to the total number of

² Joint Center for Housing Studies of Harvard University, The State of the Nation’s Housing 2020, <https://www.jchs.harvard.edu/state-nations-housing-2020>

³ United States Census Bureau. Selected Housing Characteristics. 2019 American Community Survey 5-Year Estimates. <https://data.census.gov/cedsci/table?d=ACS%205-Year%20Estimates%20Data%20Profiles&tid=ACSDP5Y2019.DP04>

occupied housing units in a county. To allow more granular analysis Argonne also presents the following sub-indices.

- The **baseline percentage of owner-occupied housing units at-risk of disruption in each county** is the ratio of the *baseline* number of owner-occupied housing units in a county that are at-risk of disruption to the total number of owner-occupied housing units in a county.
- The **baseline percentage of renter-occupied housing units at-risk of disruption by county** is the ratio of the *baseline* number of at-risk renter-occupied housing units in a county to the total number of renter-occupied housing units in a county.
- The **near real-time percentage of occupied housing units (i.e., both owner-occupied and renter-occupied) at-risk of disruption in each county** is the ratio of the *near real-time* number of owner- and renter-occupied housing units at-risk of disruption in a county to the total number of occupied housing units in a county. To allow more granular analysis, Argonne also presents the following sub-indices.
 - The **near real-time percentage of owner-occupied housing units at-risk of disruption by county** is the ratio of the *near real-time* number of owner-occupied housing units at-risk of disruption in a county to the total number of owner-occupied housing units in a county.
 - The **near real-time percentage of renter-occupied housing units at-risk of disruption by county** is the ratio of the *near real-time* number of at-risk renter-occupied housing units in a county to the total number of renter-occupied housing units in a county.

Housing Stability Index by County

The HSI by county, HSI_{Co} , is computed as the ratio of the *near real-time* percentage of occupied housing units not at-risk of disruption to the *baseline* percentage of occupied housing units not at-risk to disruption, as shown in the following equation. The data and processes for calculating the *near real-time* percentage of occupied housing units at-risk of disruption (POR) by county, $POR_{NRT,Co}$, and the *baseline* percentage of occupied housing units at-risk to disruption by county, $POR_{B,Co}$, are described in subsequent sections of this methodology documentation.

$$HSI_{Co} = \min \left(\frac{100\% - POR_{NRT,Co}}{100\% - POR_{B,Co}}, 1 \right)$$

| Acronyms* | Description |
|---|---|
| GRAPI | Gross rent as a percentage of household income |
| ROHU | Renter Occupied Housing Units |
| OOHU | Owner Occupied Housing Units |
| NRO | Number of ROHU |
| NOO | Number of OOHU |
| NROPR | Number of ROHU paying rent |
| NOOM | No. OOHU with a mortgage |
| NROR | Number of at-risk ROHU |
| NOOR | Number of at-risk OOHU |
| POOR | Percent of OOHU at risk of disruption |
| PROR | Percent of ROHU at risk of disruption |
| SMOCAPI | Selected monthly owner costs as a % of household income |
| *A complete list of acronyms is found in Appendix A | |

Baseline Housing Risk for Homeowners and Renters

For the *baseline* analysis, Argonne used the US Census Bureau 2019 5-year aggregate American Community Survey (ACS) data.⁴ The following data sets are available at the county level:

- The number of owner-occupied housing units (OOHU) and renter-occupied housing units (ROHU) is available in the Census Bureau's *Selected Housing Characteristics* data profile.⁵
- To identify OOHU and ROHU at-risk, Argonne used the number of OOHU identified by Selected Monthly Owner Costs as a Percentage of Household Income (SMOCAPI)⁶ and the number of ROHU delineated by Gross Rent as a Percentage of Household Income (GRAPI),⁷ both found in *Selected Housing Characteristics* data profile.

Percentage of At-Risk Owner-Occupied Units by County, Baseline

The *baseline* percentage of OOHU at-risk of disruption (POOR) in each county (Co), $POOR_{B,Co}$, is the ratio of the *baseline* number of OOHU in a county that are at-risk (NOOR), $NOOR_{B,Co}$, to the total number of OOHU (NOO) in a county, NOO_{Co} , as shown in the equation below.

$$POOR_{B,Co} = \frac{NOOR_{B,Co}}{NOO_{Co}} * 100\%$$

To estimate $NOOR_{B,Co}$, SOMCAPI categories were first established by binning SMOCAPI values, shown in the table below. Next, a percentage, $\alpha_{SMOCAPI\ Cat}$, of OOHU in each SMOCAPI category were assumed at risk of foreclosure. Argonne assumed a positive correlation between housing vulnerability and SCOCAPI; in other words, it was assumed that $\alpha_{SMOCAPI\ Cat}$ increases as SMOCAPI increases.⁸ For households where SMOCAPI is less than 20%, Argonne used a factor of 0.2%, growing to 5% for households with a negative household income. The *baseline* number of at-risk OOHU in each SMOCAPI category is computed as the product of $\alpha_{SMOCAPI\ Cat}$ and the number of OOHU in each SMOCAPI category in each county ($NOO_{Co,SMOCAPI\ Cat}$). Finally, $NOOR_{B,Co}$ is computed by summing the *baseline* number of at-risk OOHU in each SMOCAPI category across all SMOCAPI categories, as shown in the equation below.

⁴ <https://www.census.gov/programs-surveys/acs>

⁵ <https://data.census.gov/cedsci/table?q=dp04&g=0100000US.050000&tid=ACSDP5Y2019.DP04>

⁶ From the ACS 2019 *Subject Definitions* document, “Selected monthly owner costs are the sum of payments for mortgages, deeds of trust, contracts to purchase, or similar debts on the property (including payments for the first mortgage, second mortgages, home equity loans, and other junior mortgages); real estate taxes; fire, hazard, and flood insurance on the property; utilities (electricity, gas, and water and sewer); and fuels (oil, coal, kerosene, wood, etc.). It also includes, where appropriate, the monthly condominium fee for condominiums (Question 16) and mobile home costs (Question 24) (personal property taxes, site rent, registration fees, and license fees).” (https://www2.census.gov/programs-surveys/acs/tech_docs/subject_definitions/2019_ACSSubjectDefinitions.pdf)

⁷ From the ACS 2019 *Subject Definitions* document, “Gross rent is the contract rent plus the estimated average monthly cost of utilities (electricity, gas, and water and sewer) and fuels (oil, coal, kerosene, wood, etc.) if these are paid by the renter (or paid for the renter by someone else).” (https://www2.census.gov/programs-surveys/acs/tech_docs/subject_definitions/2019_ACSSubjectDefinitions.pdf)

⁸ The fraction of housing units at-risk in each SMOCAPI category was established by reviewing historical annual foreclosure rates and then using expert judgement to adjust this historical rate for different SMOCAPI categories.

$$NOOR_{B,Co} = \sum_{SMOCAPI\ Cat} (\alpha * NRO_{Co})_{SMOCAPI\ Cat}$$

| SMOCAPI Cat | SMOCAPI Range | $\alpha_{SMOCAPI\ Cat}$ |
|-------------|---|-------------------------|
| 1 | <20% | 0.2% |
| 2 | 20-24.9% | 0.35% |
| 3 | 25-29.9% | 0.5% |
| 4 | 30-34.9% | 0.65% |
| 5 | $\geq 35\%$ | 0.8% |
| 6 | Owner-occupied units with a negative household income | 5.0% |
| 7 | Owner-occupied units without a mortgage | 0% |

Percentage of At-Risk Renter-Occupied Units by County, Baseline

The *baseline* percentage of ROHU at-risk of disruption (PROR) by county, $PROR_{B,Co}$, follows the same logic used for calculating $POOR_{B,Co}$. $PROR_{B,Co}$ is the ratio of the *baseline* number of at-risk ROHU (NROR) in a county, $NROR_{B,Co}$, to the total number of ROHU (NRO) in a county, NRO_{Co} , as shown in the following equation.

$$PROR_{B,Co} = \frac{NROR_{B,Co}}{NRO_{Co}} * 100\%$$

Similar to the process used to estimate $NOOR_{B,Co}$, GRAPI categories were first established by binning GRAPI values, shown in the table below. Next, a percentage, $\alpha_{GRAPI\ Cat}$, of ROHU in each GRAPI category were assumed at risk of eviction. Argonne assumed a positive correlation between housing vulnerability and GRAPI; in other words, it was assumed that $\alpha_{GRAPI\ Cat}$ increases as GRAPI increases.⁹ For households where GRAPI was less than 15% of household income, a 0.5% rate was applied, growing to 25% for those with negative household income. The *baseline* NROR in each county is computed as shown in the following equation.

$$NROR_{B,Co} = \sum_{GRAPI\ Cat} (\alpha * NRO_{Co})_{GRAPI\ Cat}$$

| GRAPI Cat | GRAPI Range | $\alpha_{GRAPI\ Cat}$ |
|-----------|-------------|-----------------------|
| 1 | <15% | 0.5% |
| 2 | 15-19.9% | 0.75% |
| 3 | 20-24.9% | 1.0% |

⁹ The fraction of housing units at-risk in each GRAPI category was established by reviewing historical annual evictions rates and then using expert judgement to adjust this historical rate for different GRAPI categories.

| | | |
|----------|--|-------|
| 4 | 25-29.9% | 2.0% |
| 5 | 30-34.9% | 3.0% |
| 6 | ≥35% | 4.0% |
| 7 | Renter-occupied units with negative household income | 25.0% |
| 8 | Renter-occupied units paying no rent | 0% |

Percentage of At-Risk Occupied Units by County, Baseline (owner occupied and renter occupied)

The *baseline* percentage of occupied housing units (i.e., both OOHU and ROHU) at-risk of disruption in each county, $POR_{B,Co}$, is the ratio of the sum of $NOOR_{B,Co}$ and $NROR_{B,Co}$ to the total number of occupied housing units in a county, NO_{Co} , as shown in the following equation.

$$POR_{B,Co} = \frac{NOOR_{B,Co} + NROR_{B,Co}}{NO_{Co}} * 100\%$$

Near Real-Time Housing Risk Sub-Indices

The *near real-time* vulnerability of occupied housing throughout the Nation is assessed using biweekly results from the US Census Bureau Household Pulse Survey (HPS).¹⁰ The first release of *near real-time* housing sub-indices used housing data collected as part of HPS Phase 1, published in week 3 HPS housing data tables (corresponding to data collected by the Census Bureau between May 14 and May 19, 2020 and published on May 27).¹¹ HPS Phase 1 concluded in July 2020, and was subsequently followed by the kickoff of HPS Phase 2 in August 2020 and HPS Phase 3 in October 2020. Household data collected in HPS Phases 2 and 3 include information on whether a household is current on previous rent or mortgage payments, confidence in ability to pay next month's mortgage or rent, and anticipated likelihood of needing to move in the next two months due to foreclosure or eviction. The current release of the *near real-time* housing risk sub-indices aggregates successive biweekly (corresponding to 4 week moving averages) housing data published in Week 13-27 HPS public use files (PUFs), corresponding to data collected by the Census Bureau between August 19, 2020 and March 29, 2021.¹² The HPS data is published at the state level, therefore the analysis of the *near real-time* housing risk sub-indices at the county level, detailed below, maps HPS data delineated by household income category to the county level using ACS county-level household estimates delineated by household income category, published in the *Financial Characteristics for Housing Units with a Mortgage* subject table.¹³

¹⁰ <https://www.census.gov/householdpulsedata>

¹¹ <https://www.census.gov/data/tables/2020/demo/hhp/hhp3.html>

¹² <https://www.census.gov/programs-surveys/household-pulse-survey/datasets.html>

¹³ <https://data.census.gov/cedsci/table?q=S2506&g=0100000US.050000&tid=ACSST5Y2019.S2506>

Percentage of At-Risk Owner-Occupied Units by County, Near Real-time

The *near real-time* POOR by county, $POOR_{NRT,Co}$, is the ratio of the *near real-time* NOOR in a county, $NOOR_{NRT,Co}$, to NOO_{Co} , as shown in the equation below. Steps detailing the calculation of this sub-index are detailed in Appendix B.

$$POOR_{NRT,Co} = \frac{NOOR_{NRT,Co}}{NOO_{Co}} * 100\%$$

Percentage of At-Risk Renter-Occupied Units by County, Near Real-time

The *near real-time* PROR by county, $PROR_{NRT,Co}$, is computed as the ratio of the *near real-time* NROR by county, $NROR_{NRT,Co}$, to NRO_{Co} , as shown in the equation below. Steps detailing the calculation of this sub-index are detailed in Appendix C.

$$PROR_{NRT,Co} = \frac{NROR_{NRT,Co}}{NRO_{Co}} * 100\%$$

Detailed documentation of the steps required to calculate the near-real time sub-indices is available in Appendix B and Appendix C.

Percentage of At-Risk Occupied Units by County, Near Real-time

The *near real-time* percentage of occupied housing units (i.e., both OOHU and ROHU) at-risk of disruption in each county, $POR_{NRT,Co}$, is the ratio of the sum of $NOOR_{NRT,Co}$ and $NROR_{NRT,Co}$ to NO_{Co} , as shown in the equation below.

$$POR_{NRT,Co} = \left(\frac{NOOR_{NRT} + NROR_{NRT}}{NO} \right)_{Co} * 100\%$$

Future Analysis

Argonne and stakeholder have identified several potential improvements and expansions of the current set of housing indices, including:

- Development of a near-real time housing stability indicator that can be used in multiple contexts, including other disasters.
- Breakdown of very low income (as defined by the United States Department of Housing and Urban Development) renters by county.
- Statistical/regression/correlation analysis of historical eviction data, published by the Evictions Lab at Princeton University,¹⁴ to refine eviction rates for different GRAPI categories.
- Statistical/regression/correlation analysis of historical data on mortgages in serious delinquency or mortgage foreclosures and/or review of published research on serious delinquency and foreclosure likelihood, to refine foreclosure rates for different SMOCAPI categories.

¹⁴ <https://data-downloads.evictionlab.org/>

Appendix A: Acronym List

| Acronym | Description |
|----------------|---|
| ACS | American Community Survey |
| EL | Reported likelihood of having to leave the residence within two months due to eviction |
| FL | Reported likelihood of having to leave the residence within two months due to foreclosure |
| GRAPI | Gross rent as a percentage of household income |
| HPS | U.S. Census Bureau Household Pulse Survey |
| HSI | Housing stability index |
| IC | Income category |
| NMPS | Reported confidence in ability to make the next mortgage payment |
| NOO | Number of OOHU |
| NOOM | Number of OOHU with a mortgage |
| NOOMB | Number of OOHU who are behind on mortgage payments |
| NOOMBR | Number of OOHU who are behind on mortgage payments at-risk of housing disruption |
| NOOMC | Number of OOHU who are current on mortgage payments |
| NOOMCR | Number of OOHU who are current on mortgage payments at-risk of housing disruption |
| NOOMR | Number of OOHU with a mortgage at-risk of disruption |
| NOOR | Number of at-risk OOHU |
| NRO | Number of ROHU |
| NROPR | Number of ROHU paying rent |
| NROPRB | Number of ROHU who are behind on rent payments |
| NROPRBR | Number of ROHU who are behind on rent payments at-risk of housing disruption |
| NROPRC | Number of ROHU who are current on rent payments |
| NROPRCR | Number of ROHU who are current on rent payments at-risk of housing disruption |
| NROPRR | Number of ROHU paying rent at-risk of disruption |
| NROR | Number of at-risk ROHU |
| NRPS | Reported confidence in ability to make the next rent payment |
| OOHU | Owner-occupied housing units |
| POOMR | Percentage of at-risk OOHU with a mortgage |
| POOR | Percentage of OOHU at-risk of disruption |
| POR | Percentage of occupied housing units at-risk of disruption |
| PROPRR | Percentage of ROHU paying rent at risk of disruption |
| PROR | Percentage of ROHU at-risk of disruption |
| PUF | Public use file |
| PVR | Percentage of vacant rental housing units |
| ROHU | Renter-occupied housing units |
| SMOCAPI | Selected monthly owner costs as a percentage of household income |

Appendix B: Percentage of At-Risk Owner-Occupied Units by County, Near Real-time Methodology

The *near real-time* POOR by county, $POOR_{NRT,Co}$, is the ratio of the *near real-time* NOOR in a county, $NOOR_{NRT,Co}$, to NOO_{Co} , as shown in the equation below.

$$POOR_{NRT,Co} = \frac{NOOR_{NRT,Co}}{NOO_{Co}} * 100\%$$

Step 1: Estimating $NOOR_{NRT,Co}$ starts with HPS data on reported status of previous mortgage payments. The MORTCUR variable in the HPS PUF delineates OOHU with a mortgage as being caught up or behind on mortgage payments. The FORCLOSE variable in the HPS PUF further delineates OOHU that are behind on mortgage payments by household reported likelihood of having to leave the residence within two months due to foreclosure (FL, delineated in the table below). Quantitative FL values, γ_{FL} , were assigned for each qualitative FL category as shown in the table below.¹⁵ The product of γ_{FL} and the *near real-time* number of OOHU who are behind on mortgage payments (NOOMB) delineated by FL, income category (IC), and state, $NOOMB_{NRT,FL,IC,St}$, is summed across all FL categories to calculate the total *near real-time* NOOMB who are at-risk of housing disruption (NOOMBR) in each IC and state, $NOOMBR_{NRT,IC,St}$, as shown in the equation below.

$$NOOMBR_{NRT,IC,St} = \sum_{FL} (\gamma * NOOMB_{NRT,IC,St})_{FL}$$

| FL | FL Name | γ_{FL} |
|----|-------------------|---------------|
| 1 | Very Likely | 75.0% |
| 2 | Somewhat Likely | 50.0% |
| 3 | Not Very Likely | 25.0% |
| 4 | Not at all Likely | 15.0% |

Step 2: The next step of the analysis evaluates the risk of disruption of OOHU who are current on mortgage payments based on the reported confidence in ability to make the next mortgage payment (NMPS, delineated in the table below) as reported by the MORTCONF variable in the HPS PUF. The *near real-time* number of OOHU who are current on mortgage payments (NOOMC) delineated by NMPS, IC, and state, $NOOMC_{NRT,NMPS,IC,St}$, was estimated from the HPS PUF. A fraction, γ_{NMPS} (delineated in the table below), of each $NOOMC_{NRT,NMPS,IC,St}$ is assumed at-risk of disruption.¹⁶ These at-risk OOHU current on mortgage payments are summed across all NMPS categories to compute the total *near real-time* NOOMC at-risk of housing disruption (NOOMCR) in each state and IC, $NOOMCR_{NRT,IC,St}$, as shown in the equation below.

¹⁵ <http://www2.mitre.org/work/sepo/toolkits/risk/StandardProcess/definitions/occurrence.html>

¹⁶ The fraction of OOHU current on mortgage payments that are at-risk in each NMPS category was established by reviewing historical annual foreclosure rates and then using expert judgement to adjust this historical rate for different NMPS categories.

$$NOOMCR_{NRT,IC,St} = \sum_{NMPS} (\gamma * NOOMC_{NRT,IC,St})_{NMPS}$$

| NMPS | NMPS Name | γ_{NMPS} |
|------|---------------------|-----------------|
| 1 | Deferred | 1.0% |
| 2 | No Confidence | 5.0% |
| 3 | Slight Confidence | 3.0% |
| 4 | Moderate Confidence | 1.0% |
| 5 | High Confidence | 0.5% |

Step 3: The *near real-time* percentage of at-risk OOHU with a mortgage (POOMR) in each IC and state, $POOMR_{NRT,IC,St}$, is calculated as the ratio of the sum of NOOMBR and NOOMCR to the sum of NOOMB and NOOMC as shown in the equation below.¹⁷

$$POOMR_{NRT,IC,St} = \left(\frac{NOOMBR + NOOMCR}{\sum_{FL} NOOMB_{FL} + \sum_{NMPS} NOOMC_{NMPS}} \right)_{NRT,IC,St} * 100\%$$

Step 4: The next step converts the state level estimates of housing risk to county level estimates. The *near real-time* number of OOHU with a mortgage at-risk of disruption (NOOMR) in each IC and county, $NOOMR_{NRT,IC,Co}$, is estimated by multiplying the number of OOHU with a mortgage (NOOM) in each IC and county, $NOOM_{IC,Co}$, by the *near real-time* POOMR for the corresponding IC and state in which the county is located, as shown in the following equation. The $NOOM_{IC,Co}$ is published by the Census Bureau in the *Financial Characteristics for Housing Units with a Mortgage* subject table.¹⁸

$$NOOMR_{NRT,IC,Co} = \frac{POOMR_{NRT,IC,St}}{100\%} * NOOM_{IC,Co}$$

Step 5: The *near real-time* NOOMR in each IC and county is summed across each IC to compute the *near real-time* NOOMR in each county, $NOOMR_{NRT,Co}$, as shown in the following equation.

$$NOOMR_{NRT,Co} = \sum_{IC} NOOMR_{NRT,IC,Co}$$

Step 6: Finally, the *near real-time* NOOR by county, $NOOR_{NRT,Co}$, is computed by adding a fraction, $\alpha_{SMOCAPI\ Cat=7}$, of the NOO without a mortgage in each county, $NOO_{Co,SMOCAPI\ Cat=7}$, assumed to be at-risk of disruption to $NOOMR_{NRT,Co}$ as shown in the equation below.

$$NOOR_{NRT,Co} = NOOMR_{NRT,Co} + (\alpha * NOO_{Co})_{SMOCAPI\ Cat=7}$$

¹⁷ In a few instances, no households results were reported for households in an IC in a state in successive bi-weekly HPS PUFs. In these circumstances, the analysis used households results for that IC and state combination reported in the PUF nearest before the period of interest in which these results were reported.

¹⁸ <https://data.census.gov/cedsci/table?q=S2506&g=0100000US.050000&tid=ACSST5Y2019.S2506>

Appendix C: Percentage of At-Risk Renter-Occupied Units by County, Near Real-time Methodology

The *near real-time* PROR by county, $PROR_{NRT,Co}$, is computed as the ratio of the *near real-time* NROR by county, $NROR_{NRT,Co}$, to NRO_{Co} , as shown in the equation below.

$$PROR_{NRT,Co} = \frac{NROR_{NRT,Co}}{NRO_{Co}} * 100\%$$

Step 1: Estimating $NROR_{NRT,Co}$ starts with HPS data on the reported status of previous rent payments. The RENTCUR variable in the HPS PUF delineates ROHU paying rent as being caught up or behind on rent payments. The EVICT variable in the HPS PUF further delineates ROHU that are behind on rent payments by the reported likelihood of having to leave the residence within two months due to eviction (EL, delineated in the table below). Quantitative EL values, γ_{EL} , were estimated for each qualitative EL category as shown in the table below.¹⁹ The product of γ_{EL} and the *near real-time* number of ROHU who are behind on rent payments (NROPRB) delineated by EL, IC, and state, $NROPRB_{NRT,EL,IC,St}$, is summed across all EL categories to calculate the total *near real-time* NROPRB who are at-risk of housing disruption (NROPRBR) in each IC and state, $NROPRBR_{NRT,IC,St}$, as shown in the equation below.

$$NROPRBR_{NRT,IC,St} = \sum_{EL} (\gamma * NROPRB_{NRT,IC,St})_{EL}$$

| EL | EL Name | γ_{EL} |
|----|-------------------|---------------|
| 1 | Very Likely | 75.0% |
| 2 | Somewhat Likely | 50.0% |
| 3 | Not Very Likely | 25.0% |
| 4 | Not at all Likely | 15.0% |

Step 2: The next step of the analysis evaluates the risk of disruption of ROHU who are current on rent payments based on the reported confidence in ability to make the next rent payment (NRPS, delineated in the table below) as reported by the MORTCONF variable in the HPS PUF. The *near real-time* number of ROHU who are current on rent payments (NROPRC) delineated by NRPS, IC, and state, $NROPRC_{NRT,NRPS,IC,St}$, was estimated from the HPS PUF. A fraction, γ_{NRPS} (delineated in the table below), of each $NROPRC_{NRT,NRPS,IC,St}$ is assumed at-risk of disruption.²⁰ These at-risk ROHU current on rent payments are summed across all NRPS categories to compute the total *near real-time* NROPRC at-risk of housing disruption (NROPRCR) in each state and IC, $NROPRCR_{NRT,IC,St}$, as shown in the equation below.

¹⁹ <http://www2.mitre.org/work/sepo/toolkits/risk/StandardProcess/definitions/occurrence.html>

²⁰ The fraction of ROHU current on rent payments that are at-risk in each NRPS category was established by reviewing historical annual eviction rates and then using expert judgement to adjust this historical rate for different NRPS categories.

$$NROPRCR_{NRT,IC,St} = \sum_{NRPS} (\gamma * NROPRC_{NRT,IC,St})_{NRPS}$$

| NRPS | NRPS Name | γ_{NRPS} |
|------|---------------------|-----------------|
| 1 | Deferred | 5.0% |
| 2 | No Confidence | 25.0% |
| 3 | Slight Confidence | 10.0% |
| 4 | Moderate Confidence | 5.0% |
| 5 | High Confidence | 1.0% |

Step 3: The *near real-time* percentage of ROHU paying rent at risk of disruption (PROPRR) in each IC and state, $PROPRR_{NRT,IC,St}$, is calculated as the ratio of the sum of NROPRBR and NROPRCR to the sum of NROPRB and NROPRC as shown in the equation below.

$$PROPRR_{NRT,IC,St} = \left(\frac{NROPRBR + NROPRCR}{\sum_{EL} NROPRB_{EL} + \sum_{NRPS} NROPRC_{NRPS}} \right)_{NRT,IC,St} * 100\%$$

Step 4: The next step converts the state level estimates of housing risk to county level estimates. The *near real-time* number of ROHU paying rent at-risk of disruption (NROPRR) in each IC and county, $NROPRR_{NRT,IC,Co}$, is estimated by multiplying the number of ROHU paying rent (NROPR) in each IC and county, $NROPR_{IC,Co}$, by the *near real-time* PROPRR for the corresponding IC and state in which the county is located, as shown in the following equation.

$$NROPRR_{NRT,IC,Co} = \frac{PROPRR_{NRT,IC,St}}{100\%} * NROPR_{IC,Co}$$

The $NROPR_{IC,Co}$ is not directly published by the Census Bureau. Instead this attribute was estimated by multiplying the NRO in each IC and county, $NRO_{IC,Co}$ (published by the Census Bureau in the *Financial Characteristics* subject table),²¹ by the ratio of the NROPR in a county, $NROPR_{Co}$ (published by the Census Bureau in the *Selected Housing Characteristics* data profile),²² to NRO_{Co} , as shown in the following equation. This approach assumes the percentage of renters paying rent by IC in a county is constant across all ICs.

$$NROPR_{IC,Co} = \left(NRO_{IC} * \frac{NROPR}{NRO} \right)_{Co}$$

Step 5: The *near real-time* NROPRR in each IC and county is summed across all ICs to compute the *near real-time* NROPRR in each county, $NROPRR_{NRT,Co}$, as shown in the following equation.

²¹ <https://data.census.gov/cedsci/table?q=S2503&g=0100000US.050000&tid=ACSST5Y2019.S2503>

²² <https://data.census.gov/cedsci/table?q=dp04&g=0100000US.050000&tid=ACSDP5Y2019.DP04>

$$NROPRR_{NRT,Co} = \sum_{IC} NROPRR_{NRT,IC,Co}$$

Step 6: Finally, the *near real-time* NROR by county, $NROR_{NRT,Co}$, is computed by adding a fraction, $\alpha_{GRAPICat=8}$, of the NRO not paying rent in each county ($NRO_{Co,GRAPICat=8}$) assumed to be at-risk of disruption to $NROPRR_{NRT,Co}$ as shown in the equation below.

$$NROR_{NRT,Co} = NROPRR_{NRT,Co} + (\alpha * NRO_{Co})_{GRAPICat=8}$$



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