

INTEGRATING EQUITY AND COMMUNITY PERSPECTIVES IN SEISMIC RETROFIT DECISIONS

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Project Goals

- Interdisciplinary Purdue team that consist civil engineers, agricultural economists, and industrial engineers.
- Different from engineering-centric focus on structural vulnerability → socio-technical perspective of how structures function and how they are used by community
- Analyzing holistic value of infrastructure services associated with retrofits for non-ductile concrete structures.
 - **Non-ductile reinforced concrete buildings** are termed “*killer buildings*” (Seymour et al., 2009)

Non-ductile reinforced concrete buildings are “killer buildings”



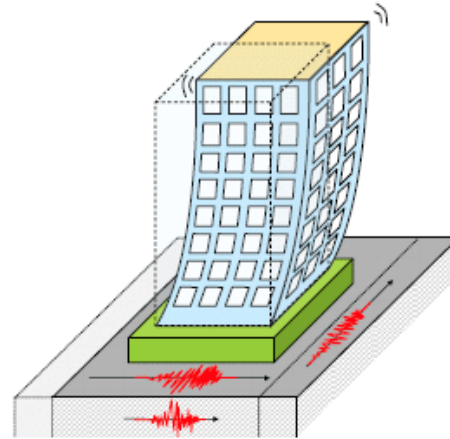
Photo: Gary B. Edstrom, Kaiser Permanente Building after the 1994 Northridge Earthquake. Public domain, via Wikimedia Commons.



Photo: San Fernando VA Hospital, Sylmar – non-ductile RC hospital buildings that collapsed in the 1971 San Fernando earthquake, killing 49 patients and staff (USGS / LA Times).

Seismic Risk: Buildings carry most of the risk

Non-ductile reinforced concrete buildings (NDRCB) are risky due to their brittle design (they are unable to deform and dissipate energy)



SCIENCE NEWS

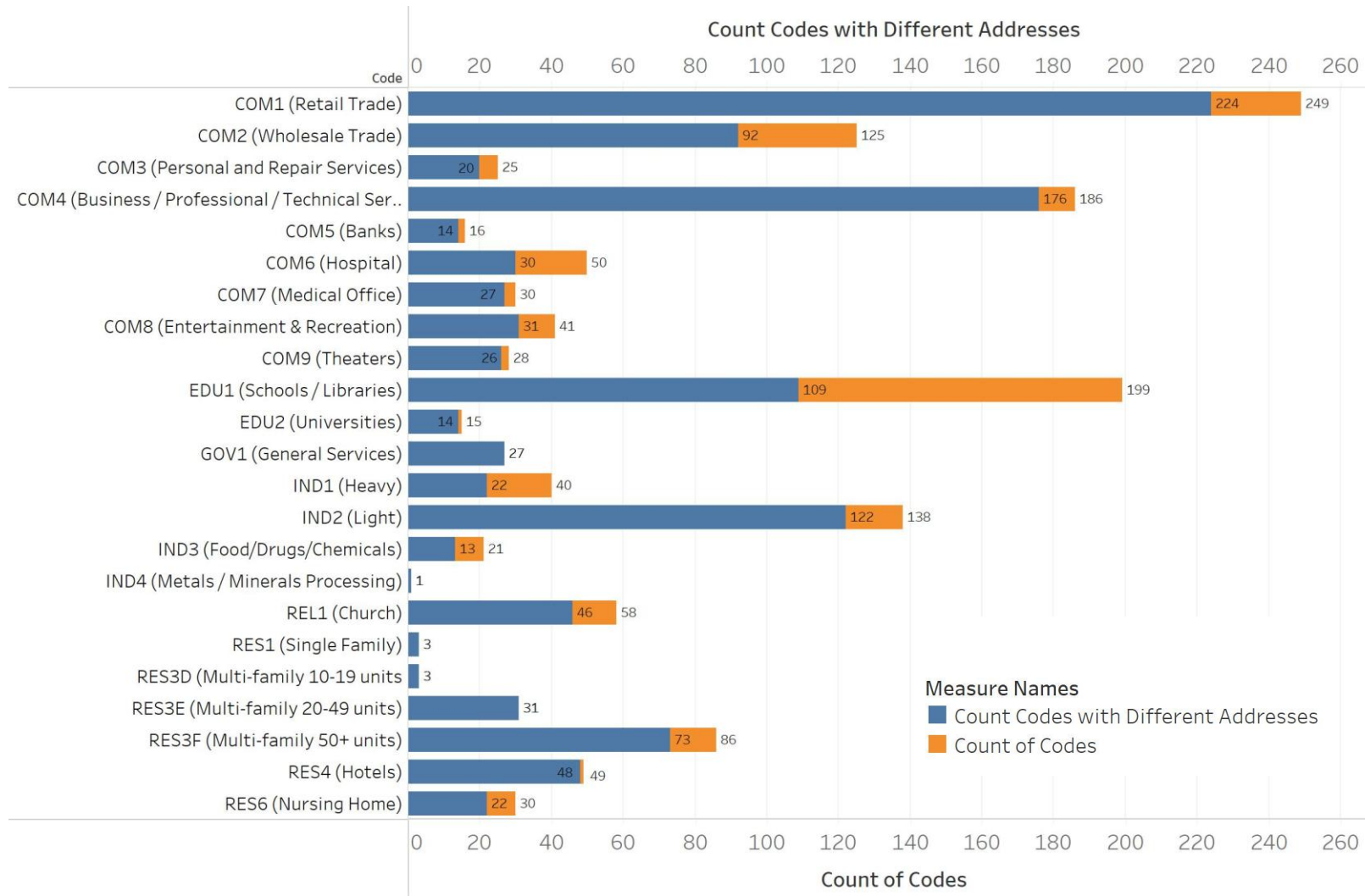
Unpublished list reveals 3,400 San Francisco buildings may be at severe earthquake risk

A draft list of San Francisco concrete buildings reveals properties that the city says could be vulnerable to earthquakes and may need costly upgrades.

CALIFORNIA

L.A. County moves to require quake retrofits as Turkey-Syria death toll exceeds 50,000

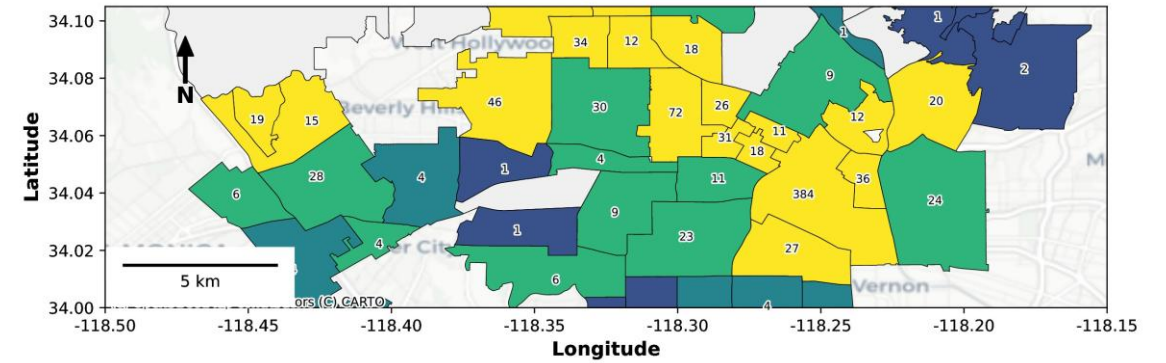
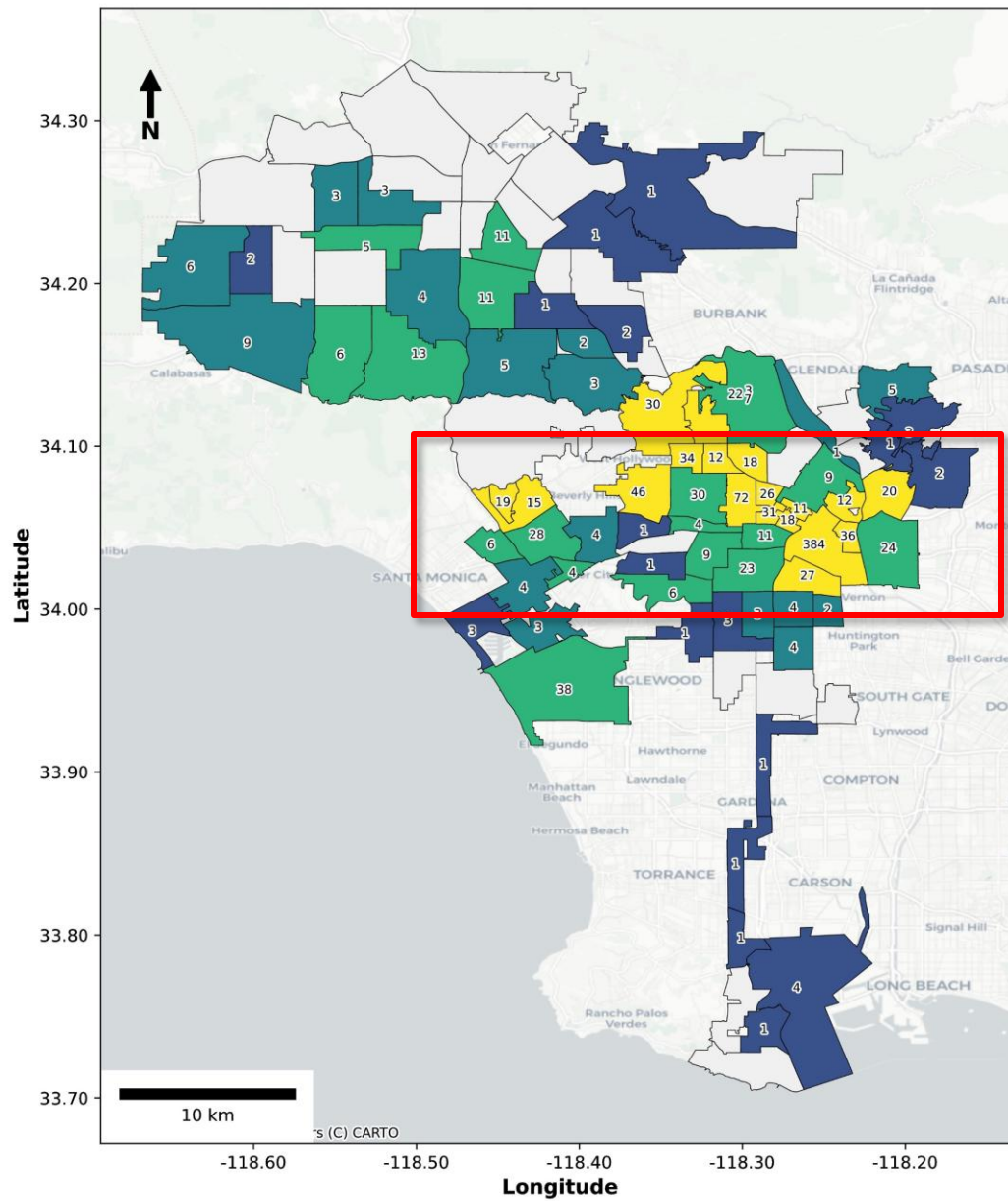
Los Angeles has over 1500 risky buildings

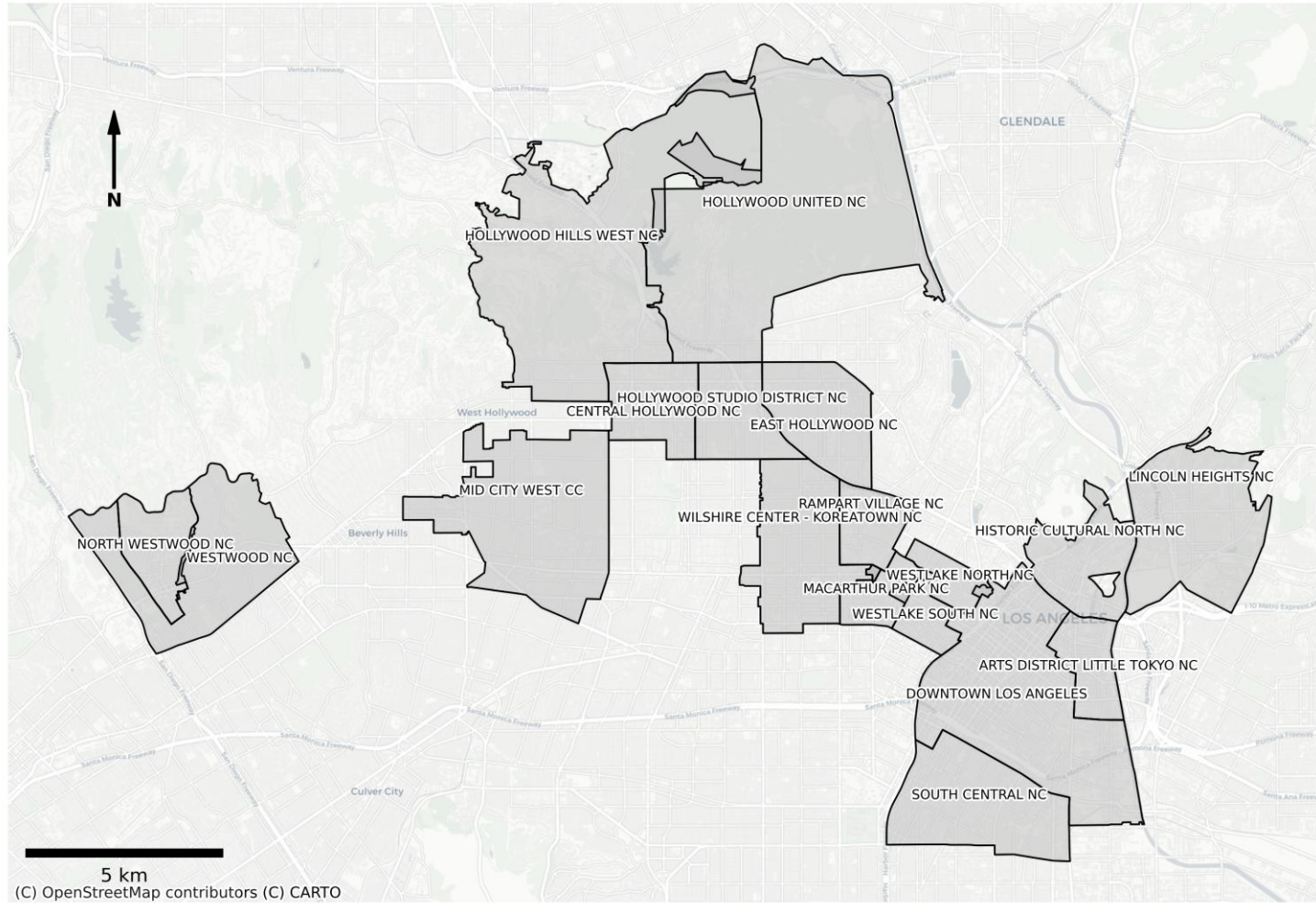


Neighborhood councils are essential partners because they represent residents most exposed to risk due to NDRCB

We want to reach people who will be most impacted by damage to risky buildings (NDRCB) during an earthquake.

- Neighborhood Councils (NCs) are grassroots, volunteer-led bodies that represent local communities across Los Angeles.
- NC members live in these buildings and neighborhoods and will directly experience earthquake impacts.
- They know local vulnerabilities and old infrastructure that requires seismic retrofiting





How to measure differences in distributional risk

The risk is not same for every demographic group

Residential Buildings

- NDRCB dataset has information about night occupancy of each building.
- We spatially match the NDRCB with census block group boundaries and calculate the total night occupancy of each census block group.
- The goal is to calculate if certain demographic groups are overrepresented in areas where risky residential buildings are located.

	Population Group	Population at Risk Percentage (BG)	Actual Population Percentage (BG)
0	Hispanic Pop.	28.82	47.48
1	Black Pop.	6.91	7.44
2	Native American Pop.	1.27	1.17
3	Asian Pop.	24.98	14.49
4	Pacific Islander Pop.	0.00	0.07
5	White Pop.	36.39	32.06
6	Other Pop.	17.68	27.30
7	2+ Pop.	10.09	14.37
8	Low Income	33.27	22.97
9	Medium Income	53.23	59.47
10	High Income	12.13	15.99
11	Gini Index	43.82	37.14

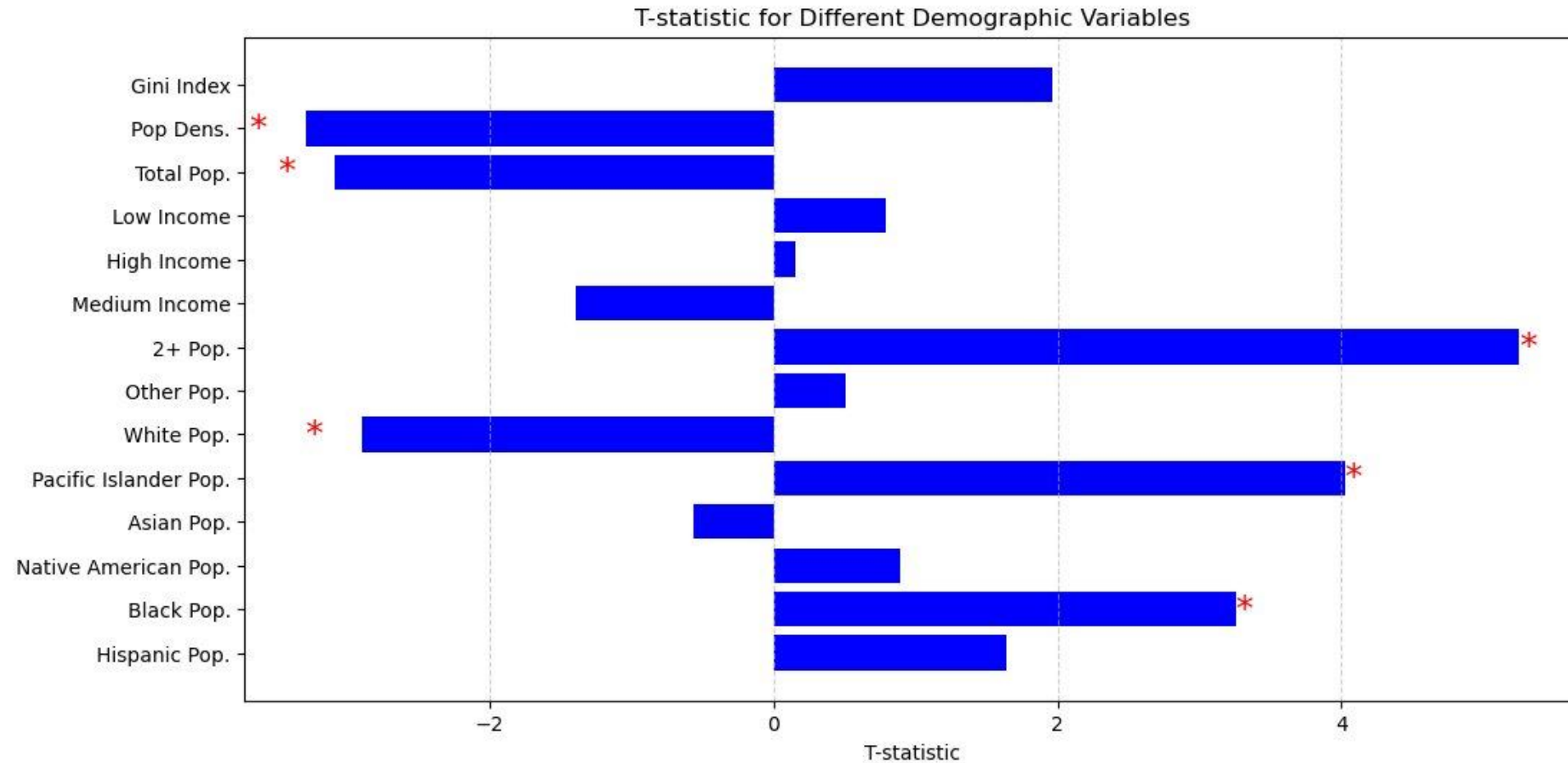
*Preliminary findings, subject to change

How to measure differences in distributional risk

Hospitals and Schools

- Divide hospitals and schools by at-risk and not at-risk As long as one building is non-ductile reinforced concrete, we define that hospital as “at-risk”
 - There are total 68 hospitals that are 911 receiving:
 - 13 at-risk, 55 safe
 - There are total 863 schools in the LA Unified School District
 - 92 at-risk, 771 safe
- T-test between census block groups where closest hospital is non-ductile reinforced concrete compared to other hospitals
- T-test between students who study in non-ductile reinforced concrete schools compared to students who study in other schools

The risk is not same for every demographic group, hospitals



*Preliminary findings, subject to change

The risk is not same for every demographic group, schools

		Census			Census_Risk
	Demographic Characteristic	Weighted_Average	Demographic Characteristic	Weighted_Average	
0	African American or Black	6.942412	African American or Black	7.851536	
1	American Indian or Alaska Native	0.072008	American Indian or Alaska Native	0.078112	
2	Asian	3.183322	Asian	5.566766	
3	Filipino	1.560066	Filipino	2.081679	
4	Hispanic or Latino	74.928727	Hispanic or Latino	69.059925	
5	Not Reported	1.519801	Not Reported	1.068829	
6	Pacific Islander or Hawaiian	0.224252	Pacific Islander or Hawaiian	0.161431	
7	Two or More Races	1.983000	Two or More Races	2.399333	
8	White	9.586412	White	11.732389	
9	Low_Income_Percentage	80.684311	Low_Income_Percentage	77.467349	

How can community perspectives be incorporated into the seismic retrofitting of civic infrastructure?

How is it usually done?

- Engagement happens rarely, and mostly through workshops or town halls
- Preferences are captured informally, so there are no directly quantifiable metrics
- As a result, community input is seldom integrated into policy and funding decisions
- Meanwhile, cities face many types of civic infrastructure (schools, libraries, clinics, etc.) competing for limited retrofit resources

How to prioritize which buildings to protect?

There are a lot of civic infrastructure

- | | |
|------------------------------------|---|
| 1. Bank | Facility |
| 2. Community Center | 15. Office Building |
| 3. Daycare | 16. Pharmacy |
| 4. EMS | 17. Places of Worship |
| 5. Fire Station | 18. Police Station |
| 6. Gas Station | 19. Recreational Facilities (theater, concert hall, gyms) |
| 7. Government Offices | 20. School |
| 8. Grocery Store | 21. Public Transit Station (Bus / Train Station) |
| 9. Hardware Store | 22. Urgent Care / Health Clinic |
| 10. Hospital | 23. Veterinary Clinic |
| 11. Hotel / Motel | |
| 12. Laundromat | |
| 13. Library | |
| 14. Nursing Home / Assisted Living | |

Best-Worst Scaling with Balanced Incomplete Block Design

Best-Worst Scaling: Show people small sets of items and ask them to pick the **most** and **least** important

Balanced Incomplete Block Design: Each item appears the same number of times, every pair of items together appears together λ times $\rightarrow$ to ensure we can use smaller sets but still create a definitive ranking of items in the list

BIBD conditions: $bk = vr$ and $\lambda(v - 1) = r(k - 1)$

v items, set size k , number of blocks b , appearances per item r , pair co-occurrence λ .

Survey Questions

How often do you or anyone you live with visit or use Bank?

- ☐ Every day
- ☐ A few times a week
- ☐ Once a week
- ☐ Few times a month
- ☐ Once a month
- ☐ Once a year
- ☐ Never

For each set of services shown, please select the one service that is most important for the community to have working in a disaster (most important) and the one that is the least important (least important).

	Daycare	Nursing Home / Assisted Living Facility	Public Transit Station (Bus / Train Station)	Pharmacy
Most important / disruptive if unavailable	☐	☐	☐	☐
Least important / disruptive if unavailable	☐	☐	☐	☐

Some civic infrastructure is perceived as more disruptive if damaged (preliminary pairwise results)

Civic Infrastructure	Pair Exposures	Wins	Ties	Losses	Avg Win Share	Net Margin
Hospital	78	66	8	4	20.641026	62
Urgent Care / Health Clinic	69	48	14	7	18.333333	41
EMS	66	39	18	9	16.000000	30
Fire Station	75	39	24	12	15.640000	27
Pharmacy	66	33	22	11	14.666667	22
Police Station	84	33	34	17	13.690476	16
Grocery Store	93	36	38	19	13.602151	17
Nursing Home / Assisted Living Facility	72	27	30	15	12.833333	12
Gas Station	69	24	30	15	12.434783	9
Public Transit Station (Bus / Train Station)	63	15	32	16	11.317460	-1

Conclusion

- Partnerships with local organizations are key to reaching people who are most impacted by seismic events.
- For each type of civic infrastructure, risk is not shared equally across demographic groups.
- Best–worst scaling helps quantify community perspectives for optimizing seismic retrofit priorities for civic infrastructure.

THANK YOU!

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