The Impacts of Urban Vs. Rural Poverty on Brain Network Functional Connectivity and Mental Health

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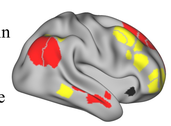
1. Introduction

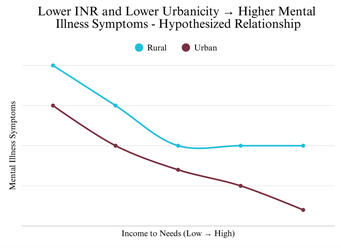
- In the United States, 20% of children live in poverty at some point in their childhood, which is the highest rate of child poverty among developed countries[4].
- Childhood poverty has been linked to a variety of negative developmental outcomes throughout the lifespan, including elevated risk for poor mental health outcomes[2].
- Poverty experiences vary. Many children grow up in urban areas while others are raised in rural settings (population < 2,500)[5]. These environments typically differ in their availability of resources and poverty conditions.
- Previous literature shows that poverty experiences influence brain development, as observed in the Triple Brain Network: default mode (DMN; red), fronto-parietal (FPN; yellow) and salience (SAL; black) networks. These networks and their interactions are critical for cognitive control and mental health[3].



- However, it remains unclear whether different poverty urbanicity (urban vs. rural) are associated with distinct patterns of functional connectivity within these networks.

2. Hypotheses

- We predicted that urbanicity will moderate the relationship between Income-to-needs ratio (INR) and Functional Connectivity (FC).
- We also predicted that due to lower levels of social support and community, children who developed in rural settings would exhibit more mental health problems overall, regardless of INR changes. This is graphed in the hypothetical relationship chart below.

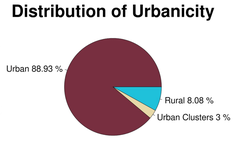


3. Methods

- This study utilized data from the Adolescent Brain Cognitive Development (ABCD) Study[1], a longitudinal study that tracks the development of a large group of youth in the United States.

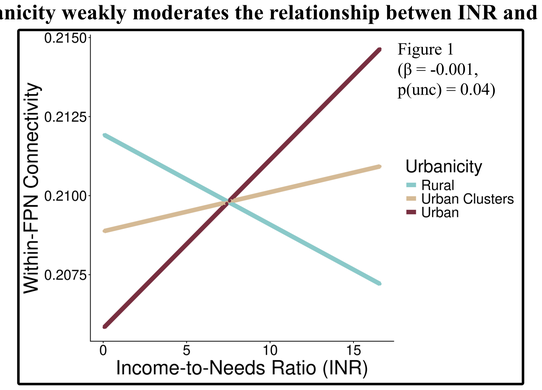
Number of Participants	Male	Female	Mean Age at Baseline	Mean Age at Year Four
9,452	4,973 (52.6%)	4,479 (47.4%)	9.95	14.17

- Income-To-Needs Ratio (INR) = $\frac{\text{Total Annual Family Income}}{\text{Federal Poverty Threshold (for family size)}}$
- We ran linear models predicting resting state FC from INR and tested for a moderating effect of urbanicity level.
- To test mental health predictive outcomes, we ran a linear model that utilized the parent-reported CBCL internalization score to predict mental health problems at age 14 from INR at age 10.
- We also utilized the neighborhood safety adolescent self-report as a measure of crime perception to contextualize urban and rural environments.



4. Results

Urbanicity weakly moderates the relationship betwen INR and FPN



INR is negatively related to CBCL internalizing symptoms

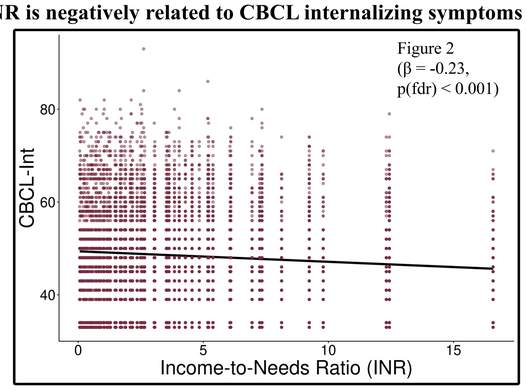


Figure 1: We found a significant interaction of INR and urbanicity predicting within-network FC of the FPN (β = -0.001, p(unc) = 0.04). However, this effect did not survive fdr correction.
Figure 2: We found a significant negative correlation between INR at age 10 and CBCL internalizing symptoms scores at age 14. P(fdr) < 0.001.
fdr = false discovery rate, unc = uncorrected

Urbanicity moderates the relationship betwen INR and perceptions of neighborhood safety

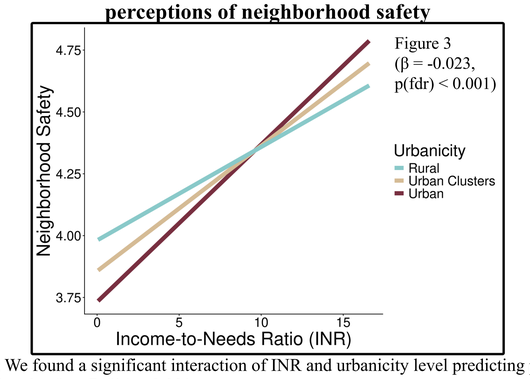


Figure 3: We found a significant interaction of INR and urbanicity level predicting perceived neighborhood safety. P(fdr) < 0.001.

Additionally, we found

- A significant positive correlation between INR and between SAL and DMN connectivity (β = 0.0001, p(fdr) < 0.001).
- A significant positive correlation between INR and within SAL connectivity (β = 0.001, p(fdr) < 0.003).
- A significant positive correlation between INR and within DMN connectivity. (β = 0.001 p(fdr) < 0.001).

5. Discussion

- Our findings show that INR and urbanicity interact to predict connectivity of the FPN. Those in rural areas with a lower INR are shown to have increased within-FPN connectivity, as compared to those in urban areas with low INR having decreased connectivity. However, this finding was relatively weak and needs further examination in follow-up studies - ideally with larger samples from rural areas.
- Our findings are in line with previous literature, which supports the correlation between lower INR and increased mental health symptoms. Specifically, we found that higher levels of internalizing symptoms, such as anxious/depressed and withdrawn, are significantly correlated with a lower INR across both urban and rural conditions.
- Interestingly, our findings show that INR is a significant predictor of urban neighborhood safety, but not of rural. This suggests that in rural areas, income is not a determining factor in neighborhood safety.
- Our additional findings show that within DMN connectivity, DMN-SAL connectivity, and within SAL connectivity have a positive significant correlation with INR. This suggests that INR has a significant impact on the development of particular brain networks.

6. Limitations and Next Steps

- One of the primary aims of this study was to observe the impacts of rural and urban poverty. However, the rural population in the ABCD dataset was not of comparable size or income to the larger urbanicity groups, which limited comprehensive comparisons.
- Future studies should prioritize recruiting participants in hard-to-reach areas to better represent these groups, particularly in cognitive neuroscience research.
- The significant findings of this study have future societal implications. We hope that future studies will study children in a variety of settings to ensure that youth across environments and demographics are included.
- Increased outreach to children in low INR environments across urbanicity levels will reduce the current limitations and provide more far-reaching data that can guide future understandings of the sensitive development of the brain.

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