Neighborhood Deprivation and Risk of Gestational Diabetes Mellitus in Arizona

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LAND ACKNOWLEDGMENT

We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally-recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

Learning Objectives

1. Describe the role of neighborhood deprivation on GDM risk among the birthing population in Arizona.

2. Explain the use of secondary data (i.e., statewide birth certificates and US Census Data) to understand the relationship between neighborhood deprivation, a nonmodifiable factor, and GDM risk.

3. Discuss neighborhood deprivation and potential strategies to address SES-related systemic issues and social determinants of health which influence GDM risk.

Gestational Diabetes Mellitus (GDM)

Glucose intolerance disorder during pregnancy (ACOG et al., 2018)

- Diagnosed during pregnancy at 24-28 weeks

GDM has been rising worldwide and nationally (Gregory et al., *Natl Vital Stat Rep*, 2022)

- 7.8 cases of GDM per 100 births in 2020
- GDM increased substantially approx. 30% from 2016 to 2020

Maternal health crisis

Mothers with GDM are the most at-risk group for Type 2 diabetes

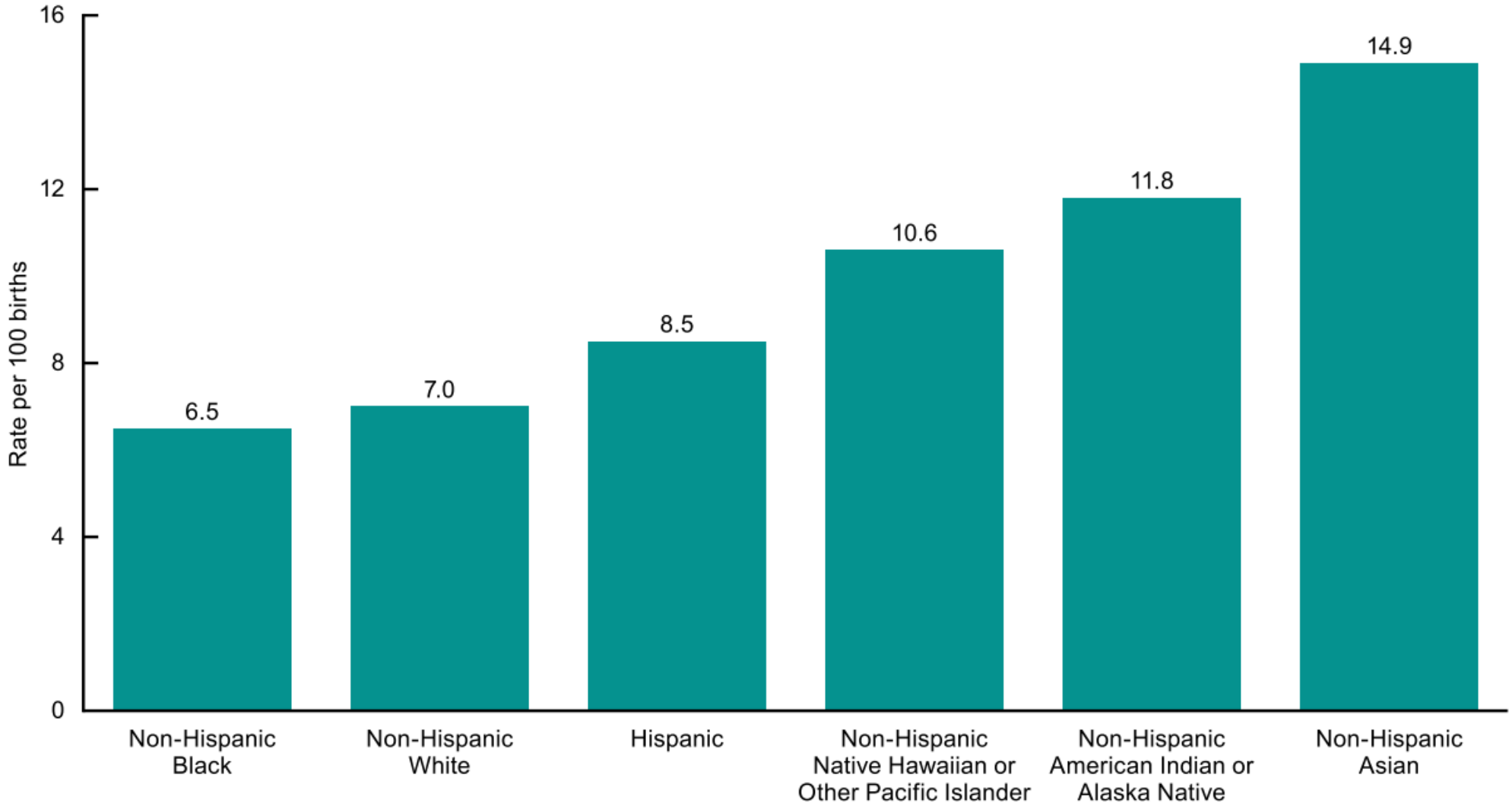
8.3-fold increase in risk

Type 2 diabetes is one of the leading causes of premature and preventable death and disability in the USA

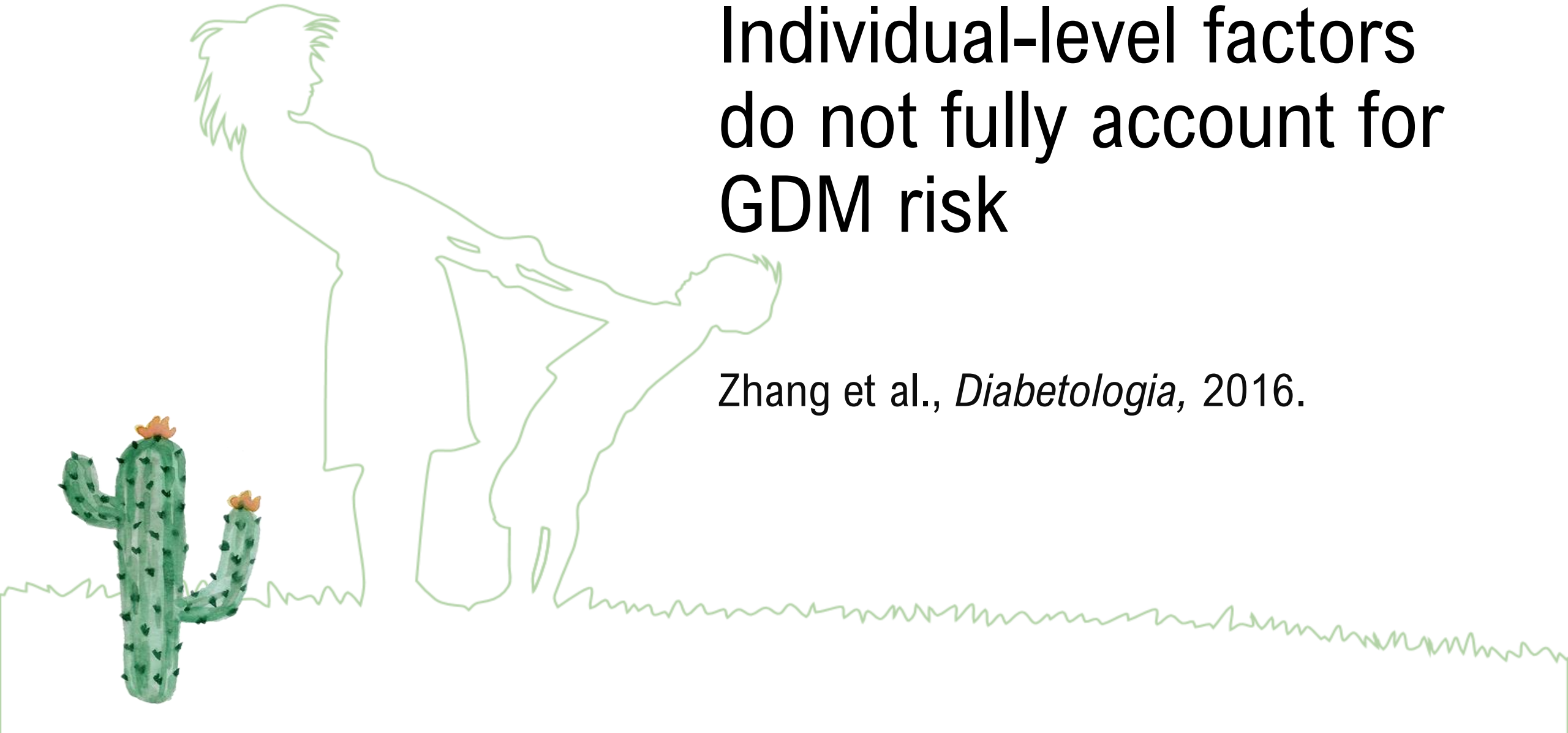
Ethnic groups are the most at-risk for GDM

Dennison et al., *DRCP,* 2020.

Figure 2. Rate of gestational diabetes, by race and Hispanic origin of mother: United States, 2020



NOTE: Significant difference between all groups ($p < 0.05$).
SOURCE: National Center for Health Statistics, National Vital Statistics System, Natality.



Individual-level factors do not fully account for GDM risk

Zhang et al., *Diabetologia,* 2016.

Neighborhood Deprivation

Social and economic disadvantages – such as unemployment, poor housing quality, high crime, and low educational attainment – in a geographically bounded area

MATERNAL STRESSORS

Living in a deprived neighborhood can negatively influence the health trajectory of pregnant mothers increased risk for cardiometabolic risk factors post-pregnancy (Kramer et al., *Ann Behav Med*, 2014).

Chronic stress among mothers of low-social status is attributed to neighborhood deprivation (Steptoe et al., *Ann Behav Med,* 2010).

OBJECTIVE

To characterize the risk of gestational diabetes from neighborhood deprivation in Arizona.

AZPEARS Study: Arizona Prenatal Environment And Reproductive Outcomes Study

ARIZONA PUBLIC HEALTH

ARIZONA DEPARTMENT OF HEALTH SERVICES

United States Census Bureau

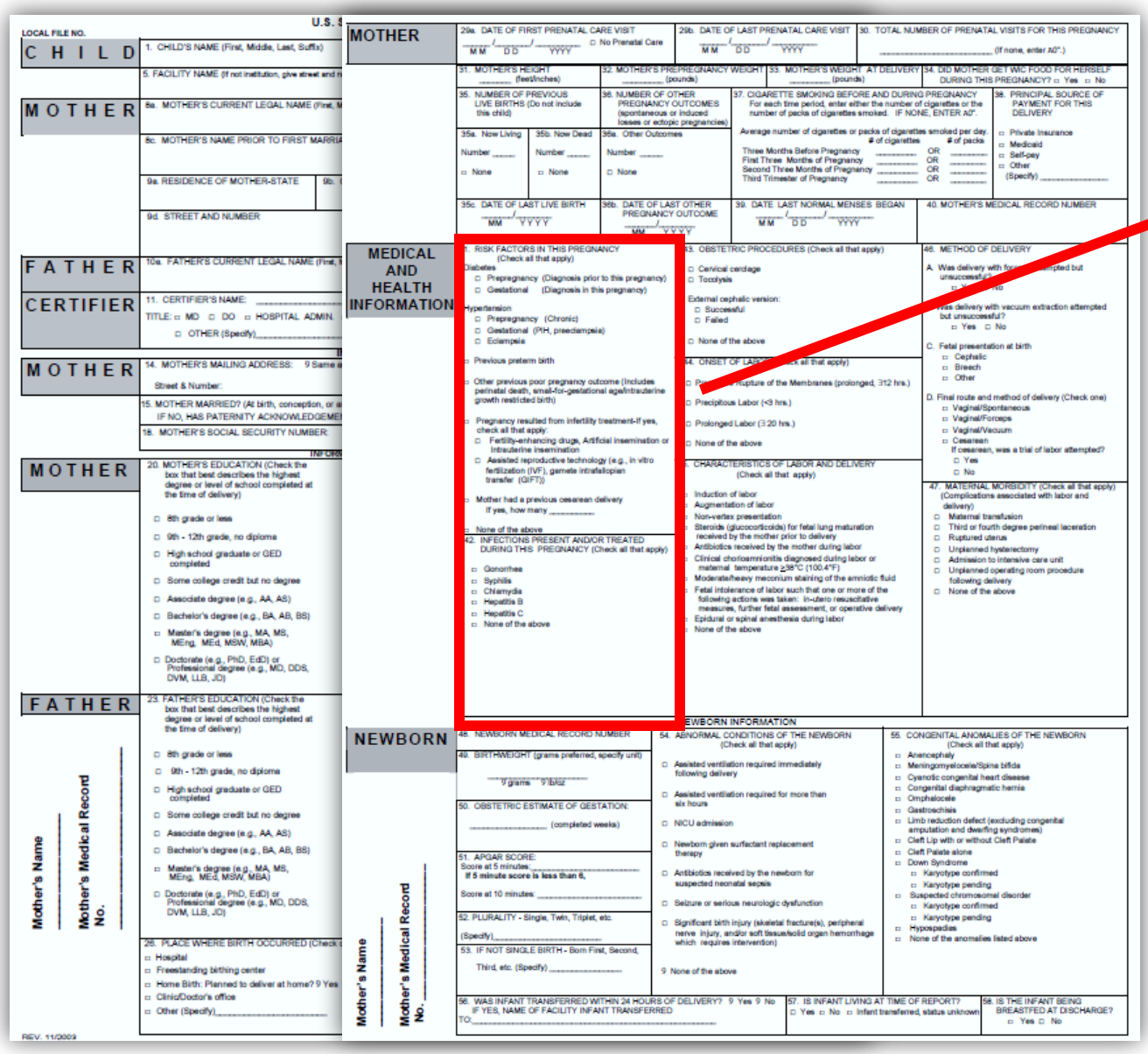
AZDA ARIZONA DEPARTMENT OF AGRICULTURE

Birth Certificates

US Census 2010

Pesticide Use Reports

2003 US Birth Certificate revision (adopted in 2014)



ARIZONA DEPARTMENT OF HEALTH SERVICES

Phoenix

Photo Credit: Robyn Beck, AFP via Getty Images, 2023

Tucson

Photo Credit: Carol M. Highsmith, https://www.loc.gov/item/2018703695/

Photo Credit: Lindsay Robinson, Cronkite News, 2016

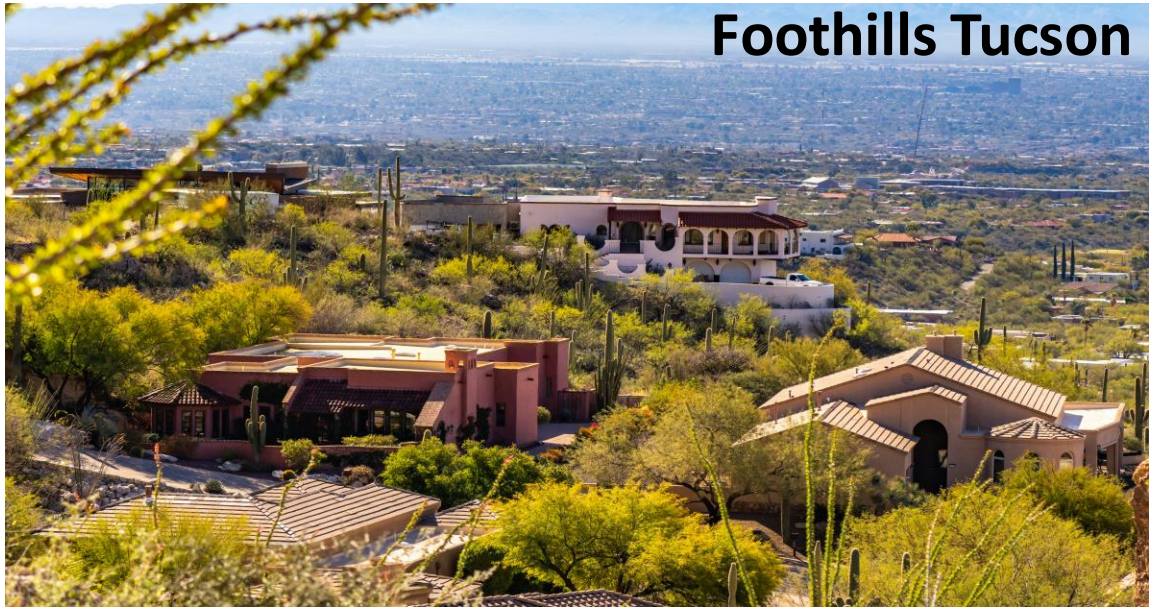


Photo Credit: JC Cervantes on Unsplash

Photo Credit: Berkshire Hathaway HomeServices Arizona Properties

Photo Credit: Kelly Presnell. Arizona Daily Star 2022.

Yuma

Photo credit: Luke Runyon, KUNC, 2021

US-Mexico border (Nogales)

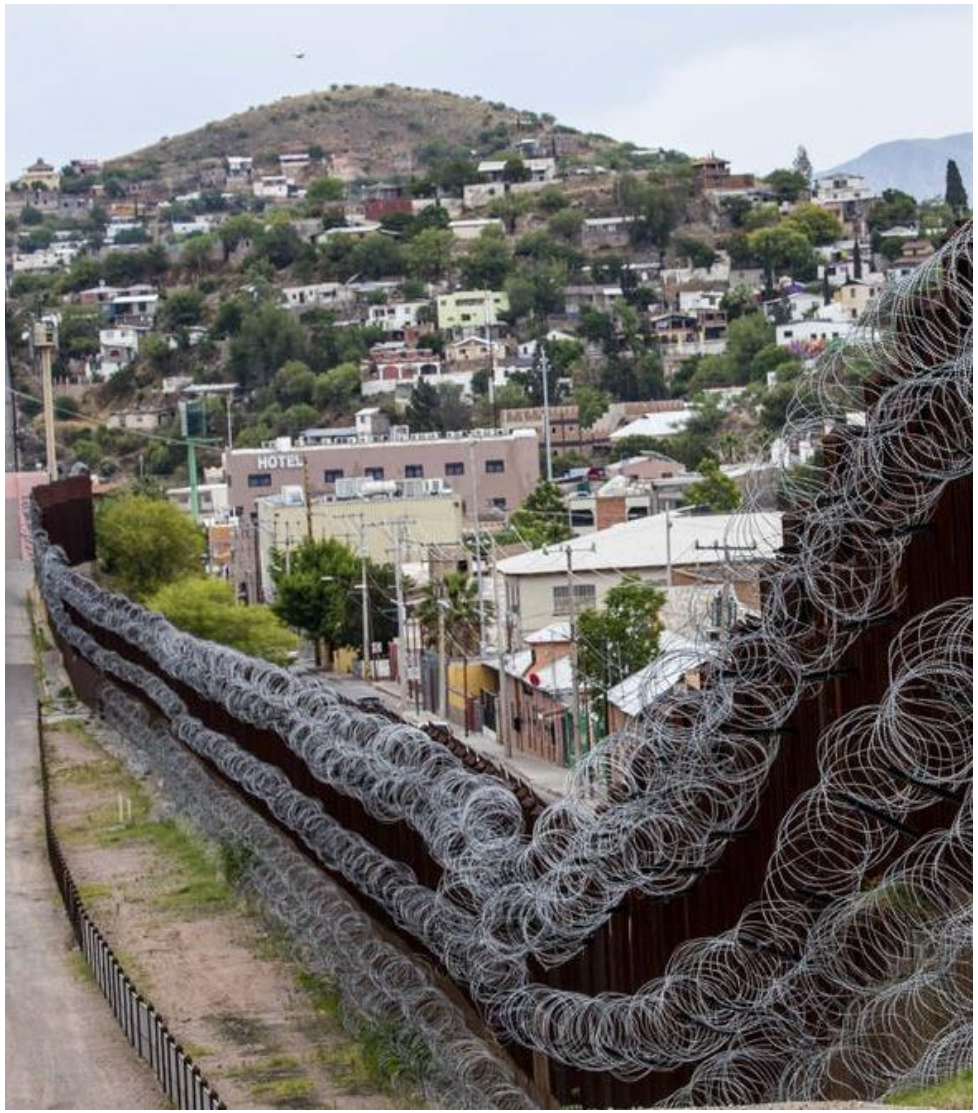


Photo Credit: Rita Danks, The Arizona Republic, 2019

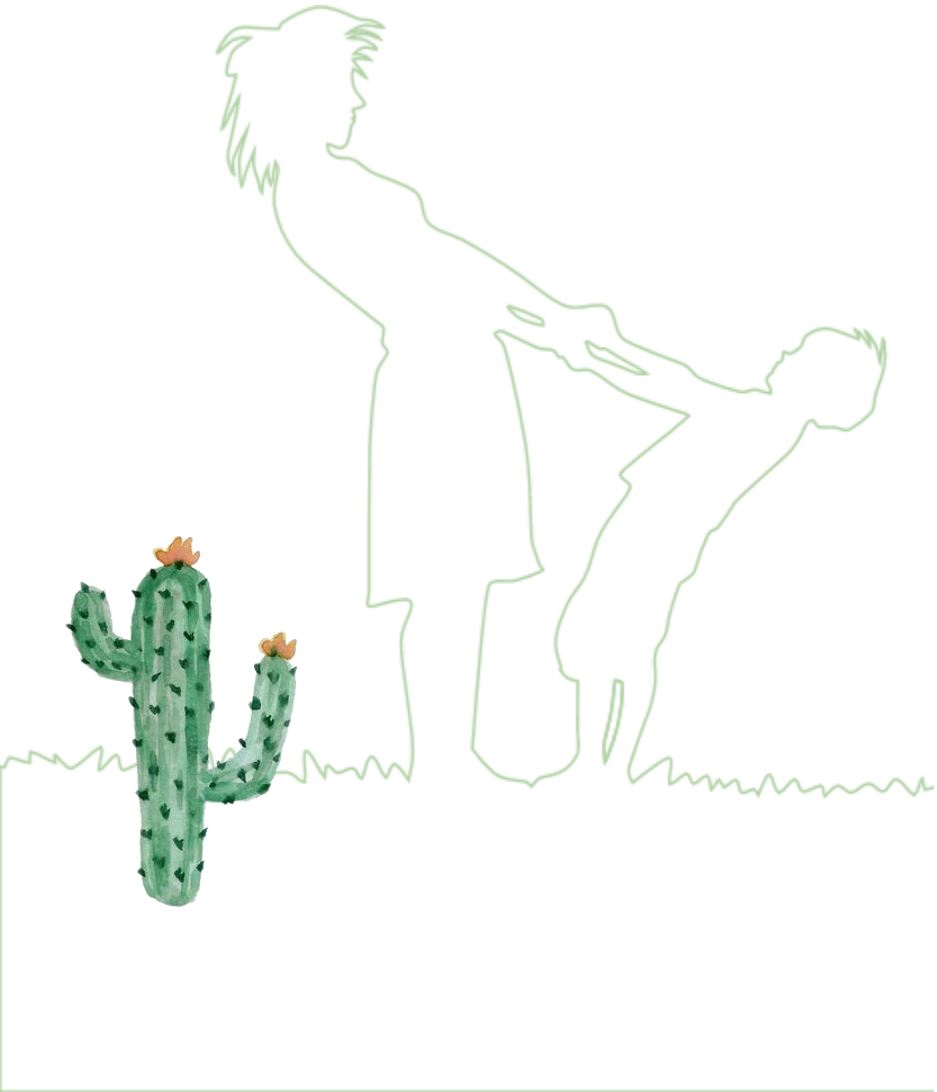
Rural (Camp Verde)

Photo Credit: Unknown 2024

Tribal Land (Navajo)

Photo Credit: Carol M. Highsmith

SELECTION OF DEPRIVATION INDEX



1) Neighborhood as the unit of analysis and implications for ecological bias.
2) Indicators used to measure poverty are relevant to the local context.
3) Potential interactions/collinearity with other individual-level variables during statistical analysis.
4) Validity for pregnancy and maternal health outcomes.

Neighborhood Deprivation Index (NDI)

Messer et al., *J Urban Health,* 2006.

A validated score that uses a weighted composite of eight census-based area-level economic parameters at the census tract level

% unemployed

% households earning <$30,000 per year

% households in poverty

% less than a high school education

% female headed households with dependents

% households on public assistance

% crowded housing

% males in management, science, arts occupation

NEIGHBORHOOD DEPRIVATION INDEX

Calculated NDI by census tracts “neighborhoods”

Data reduction technique principal component analysis to create a continuous score (-3 to 3) and quartiles (Q1, Q2, Q3, Q4).

Linked to maternal address 1,526 census tracts within 15 counties

US 2010 Census data using the tigris package in R.

METHODS

Complete case analysis

n = 481,113

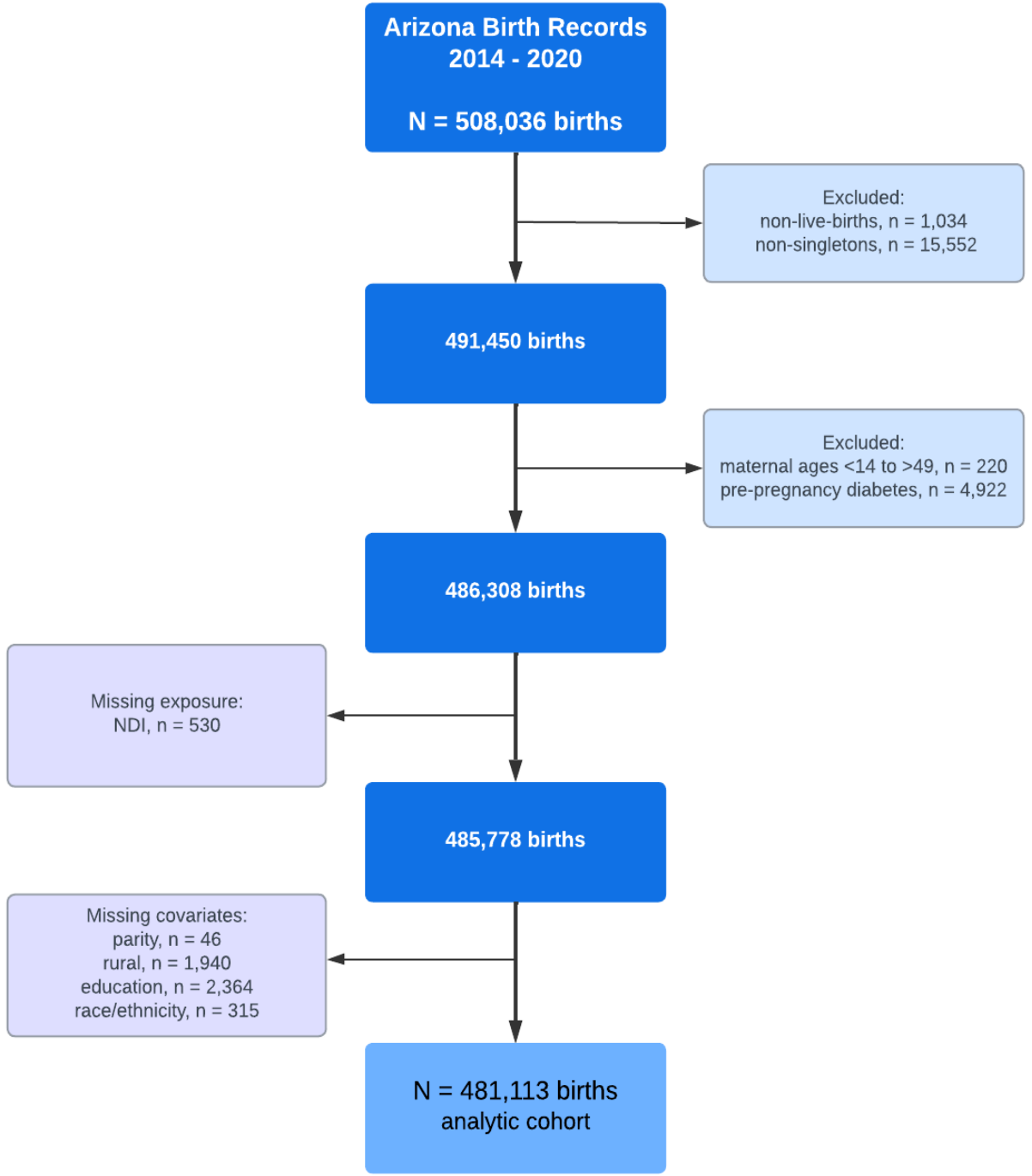
Covariate selection

Directed acyclic graph (DAG)
Adjusted for maternal age, education, race/ethnicity, parity, rurality, and birth year.

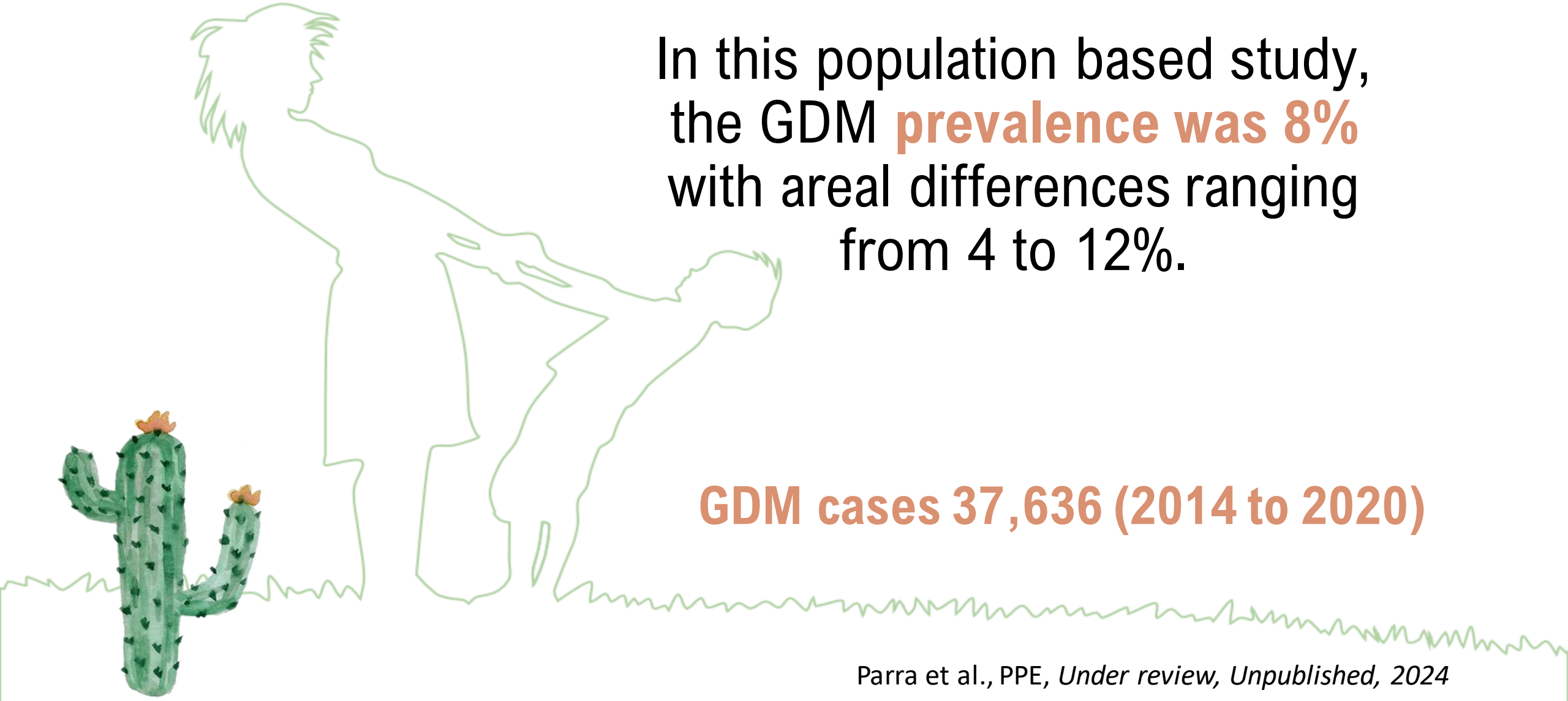
Statistical analysis

Principal component analysis (PCA) to compute neighborhood deprivation index (NDI)

Multivariable log-binomial models (Risk Ratios and 95% Confidence Intervals)



Parra et al., PPE, *Under review, Unpublished, 2024*



In this population based study, the GDM **prevalence was 8%** with areal differences ranging from 4 to 12%.

GDM cases 37,636 (2014 to 2020)

Parra et al., PPE, *Under review, Unpublished, 2024*

Statewide incidence of Gestational Diabetes Mellitus by County in Arizona from AzPEARS study (2014 to 2020)

County Name	GDM cases	Population	Incidence
Apache	377	2,668	12.4
Navajo	784	5,600	12.3
Coconino	770	7,470	9.3
Pinal	2,285	23,900	8.7
Pima	5,331	60,508	8.1
Yuma	1,195	13,783	8.0
Maricopa	24,778	292,893	7.8
Cochise	594	7,745	7.1
Greenlee	44	576	7.1
Graham	174	2,611	6.3
Gila	135	2,198	5.8
La Paz	50	834	5.7
Mohave	485	9,388	4.9
Yavapai	492	9,807	4.8
Santa Cruz	142	3,496	3.9

Parra et al., PPE, *Under review, Unpublished, 2024*

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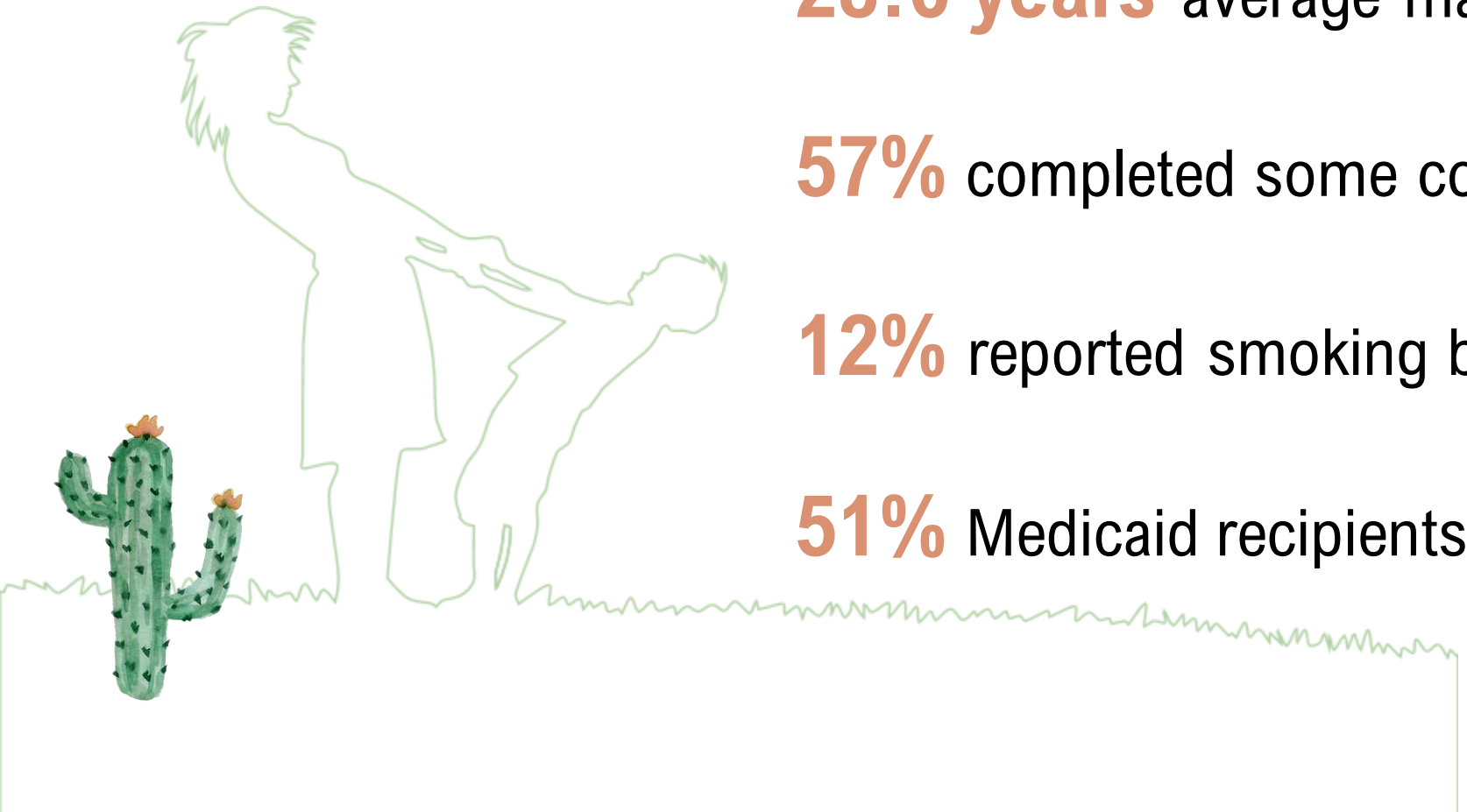
Results: Overall maternal population



28.6 years average maternal age

57% completed some college or higher

12% reported smoking before/during pregnancy

51% Medicaid recipients/AHCCCS

Parra et al., PPE, *Under review, Unpublished, 2024*

Results: GDM cases by NDI

NDI scores ranged from **−0.68 to 1.79.**

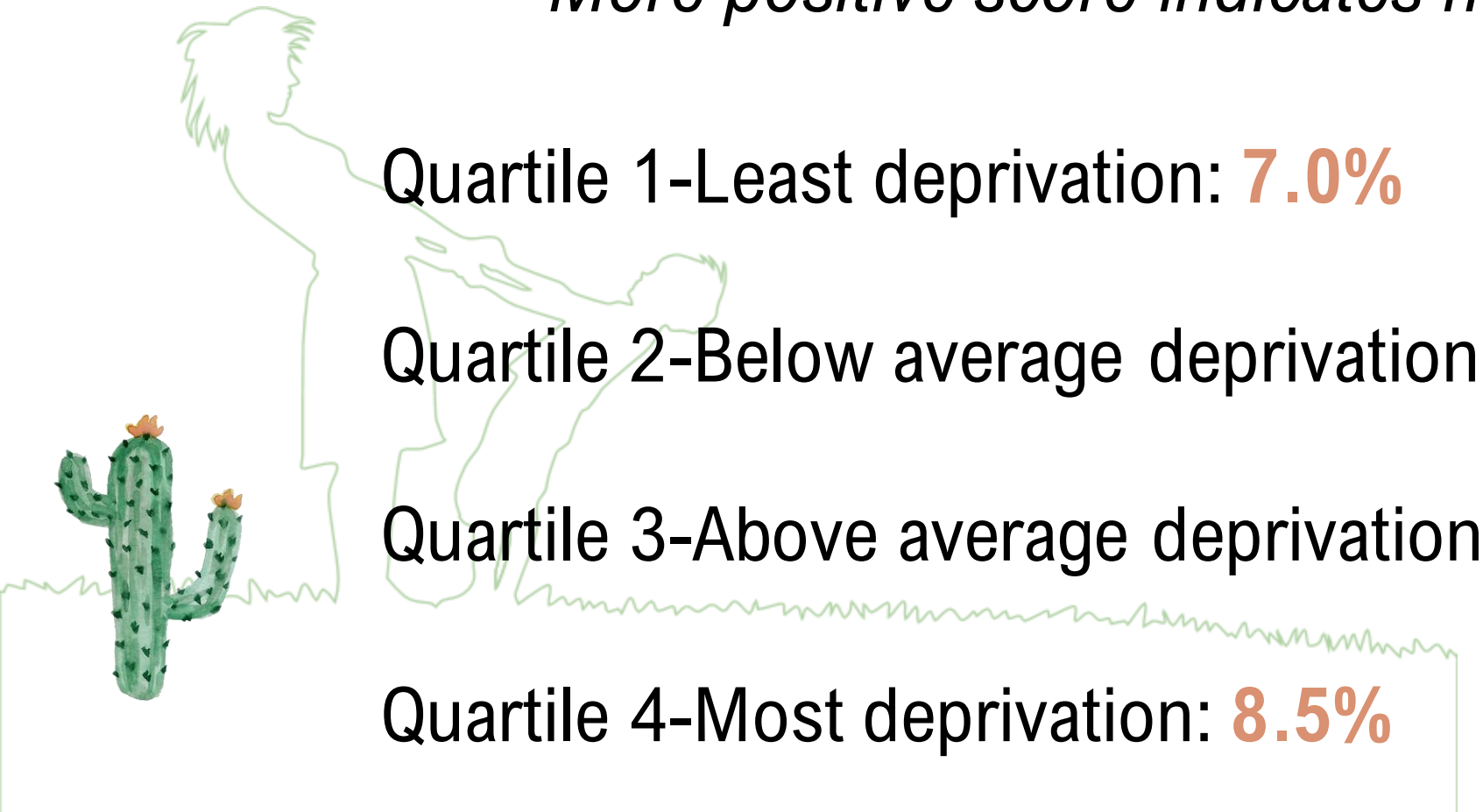
More positive score indicates more deprivation.

Quartile 1-Least deprivation: **7.0%**

Quartile 2-Below average deprivation: **7.7%**

Quartile 3-Above average deprivation: **7.7%**

Quartile 4-Most deprivation: **8.5%**



Parra et al., PPE, *Under review, Unpublished, 2024*

Results: NDI by Race/Ethnicity

Race/Ethnicity (n, %)	Q1 Least Deprivation	Q2 Below Avg Deprivation	Q3 Above Avg Deprivation	Q4 Most Deprivation	Total
Non-Hispanic White	59,315 (67.3)	70,039 (59.1)	54,549 (44.2)	25,202 (16.7)	209,105 (43.5)
Hispanic/Latina	17,931 (20.3)	34,772 (29.4)	53,718 (43.6)	100,301 (66.3)	206,722 (43.0)
NA/AI	819 (0.9)	2,584 (2.2)	4,163 (3.4)	12,189 (8.1)	19,755 (4.1)
Blacks	2,898 (3.3)	5,362 (4.5/21.0)	6,686 (5.4)	10,553 (7.0)	25,499 (5.3)
API	6,765 (7.7)	5,275 (4.5)	3,787 (3.1)	2,713 (1.8)	18,540 (3.8)
Other	436 (0.5)	402 (0.3)	361 (0.3)	293 (0.2)	1,492 (0.3)

Parra et al., PPE, *Under review, Unpublished, 2024*

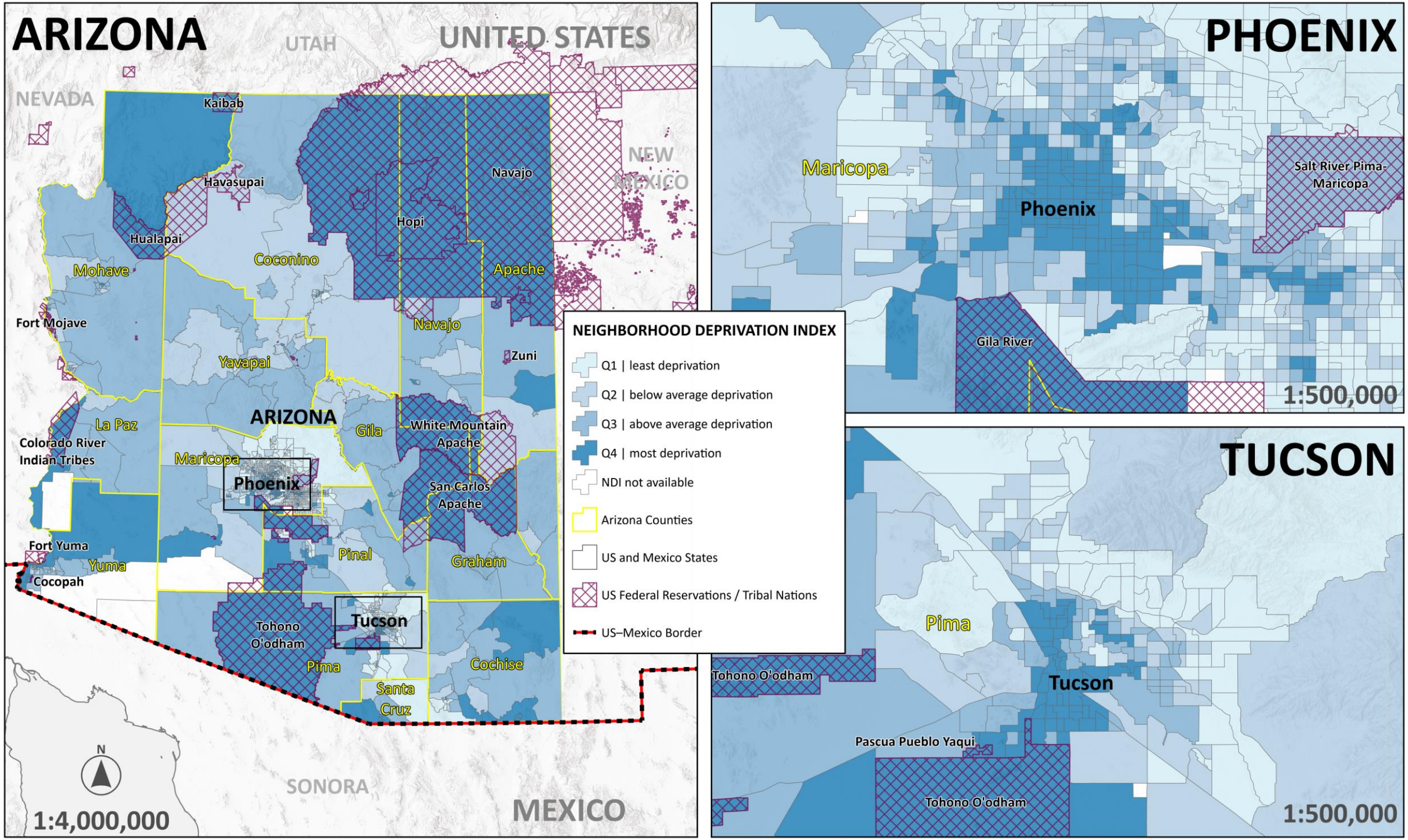
Results: GDM vs. non-GDM

Older age: 31.3 vs. 28.4 years

Obese: 49.3% vs. 24.8%

Multiparous >3 pregnancies

Larger neonates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NEW MEXICO
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Hualapai
Navajo
Hopi
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Fort Mojave
Navajo
Zuni
Yavapai
ARIZONA
La Paz
Gila
White Mountain Apache
Colorado River Indian Tribes
Maricopa
Phoenix
San Carlos Apache
Fort Yuma
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Cocopah
Pinal
Graham
Tohono O'odham
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Cochise
Santa Cruz
SONORA
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NEIGHBORHOOD DEPRIVATION INDEX
Q1 | least deprivation
Q2 | below average deprivation
Q3 | above average deprivation
Q4 | most deprivation
NDI not available
Arizona Counties
US and Mexico States
US Federal Reservations / Tribal Nations
US–Mexico Border
PHOENIX
Maricopa
Phoenix
Salt River Pima-Maricopa
Gila River
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Pascua Pueblo Yaqui
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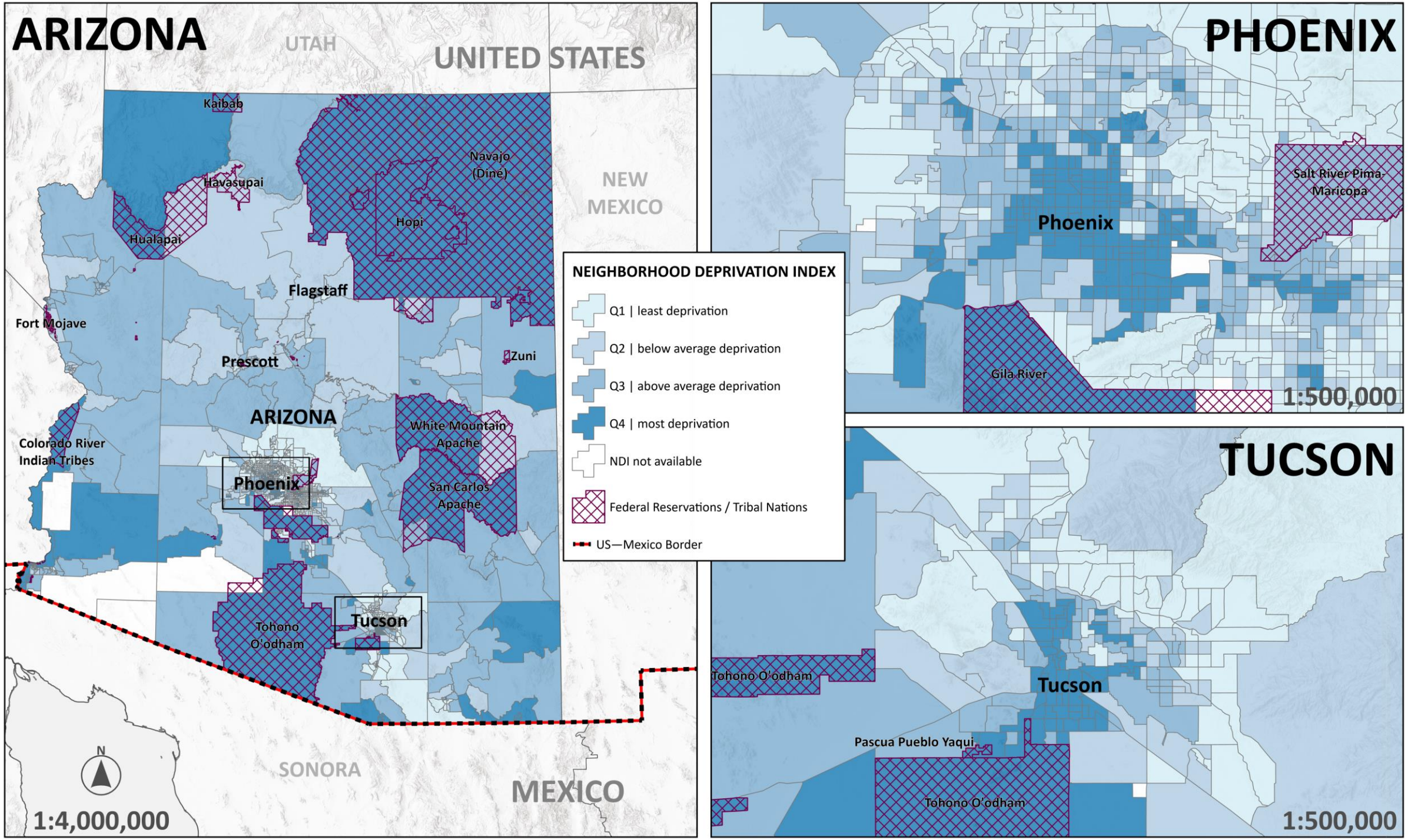
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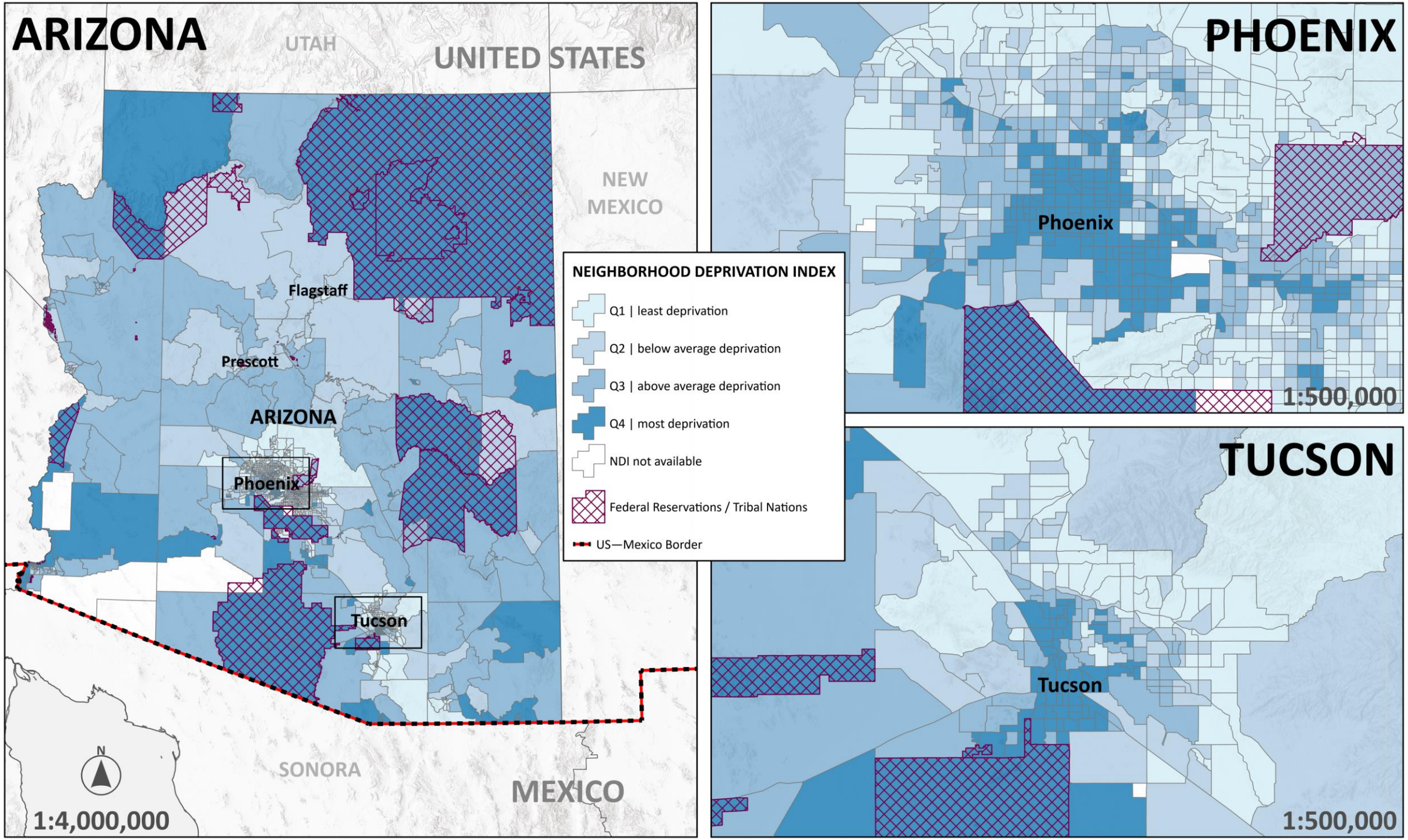
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TUCSON
Tucson
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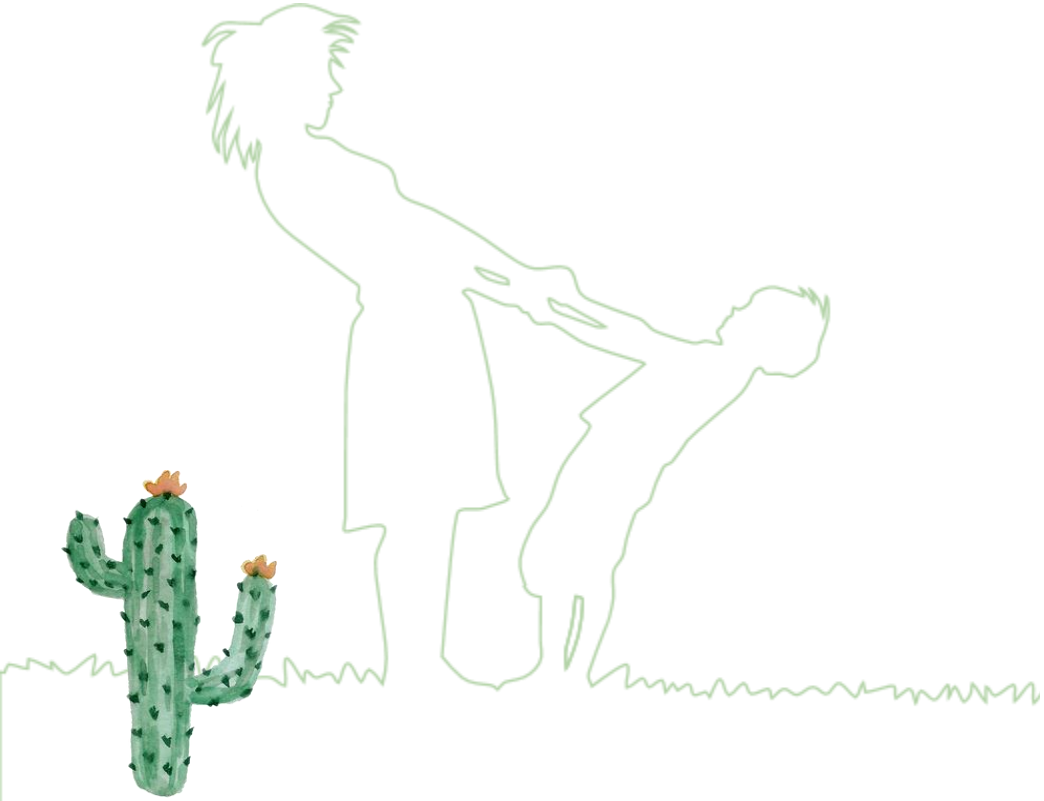
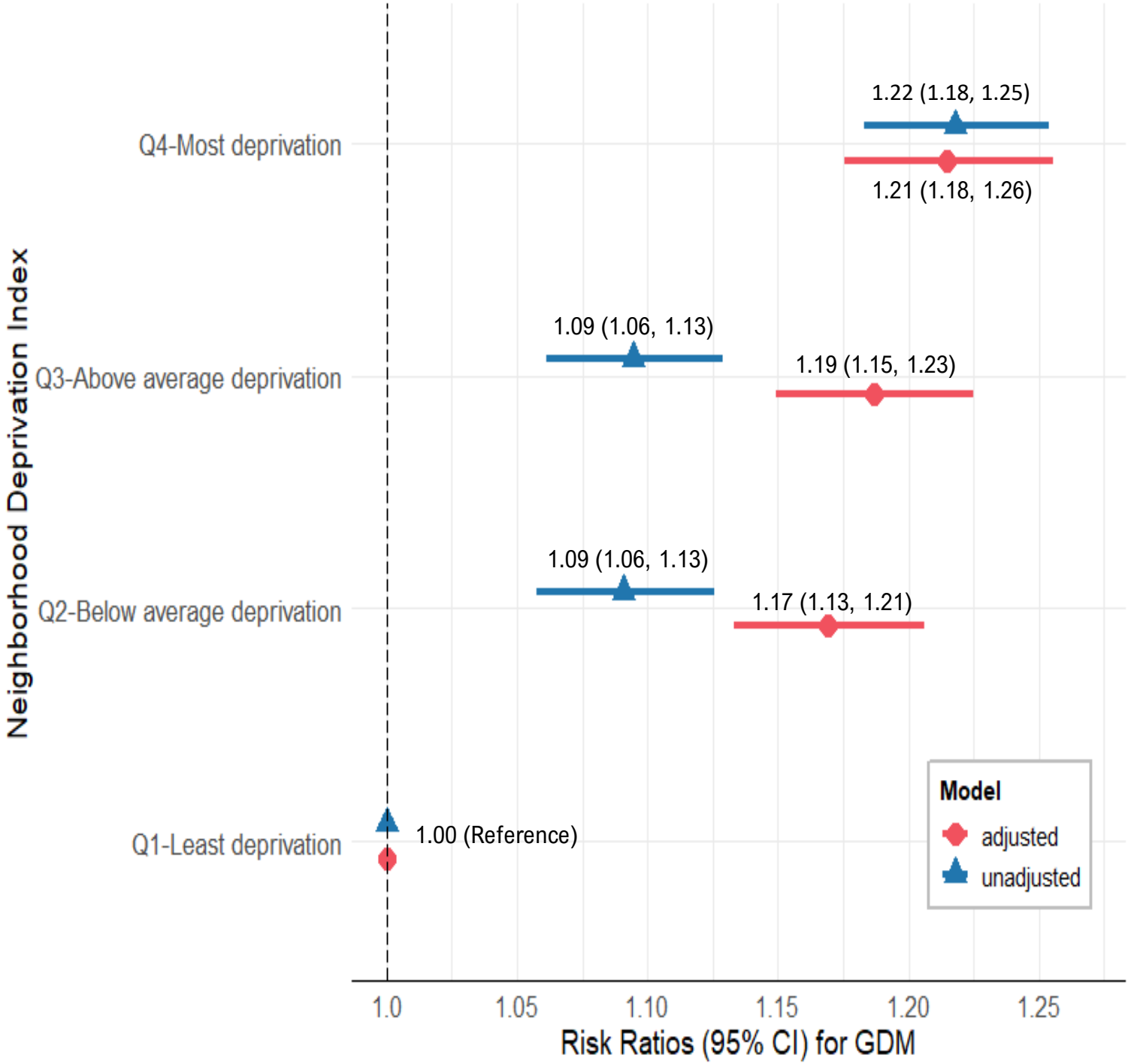
MAIN RESULTS

Adjusted for maternal age, education, race/ethnicity, parity, rurality, and birth year.

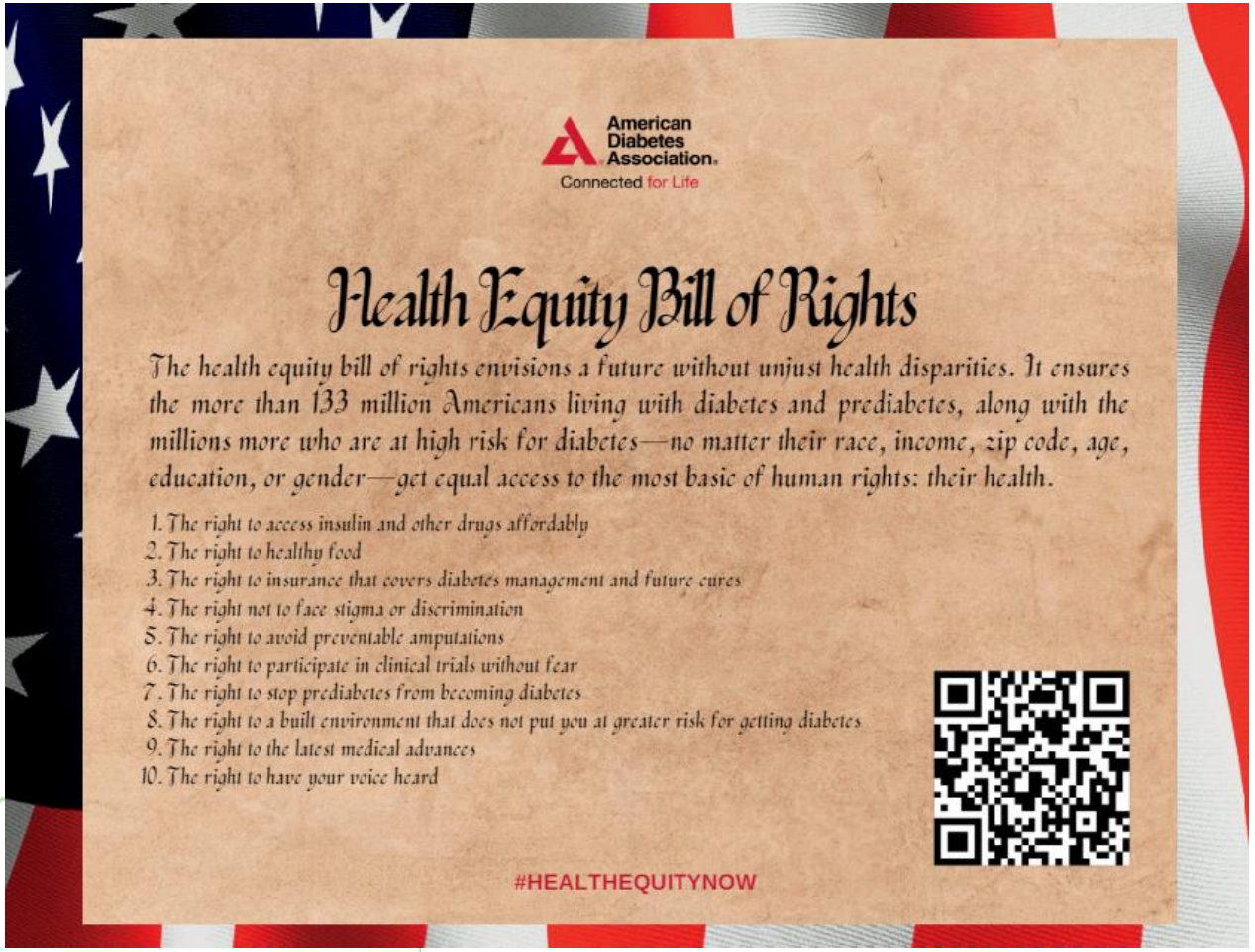




Parra et al., PPE, *Under review, Unpublished, 2024*

A Viable Path to Health Equity for Maternal Populations

#8 "The right to a built environment that does not put you at a greater risk for getting diabetes."



Neighborhood Context and Diabetes Risk: Centering Health Equity

Current Evidence

Neighborhood Socioeconomic Status (NSES)

- Neighborhood deprivation (NSES) is linked to higher diabetes incidence and complication, though primarily in cross-sectional studies
- Experimental and quasi-experimental studies confirm higher type 2 diabetes incidence in low-NSES neighborhoods

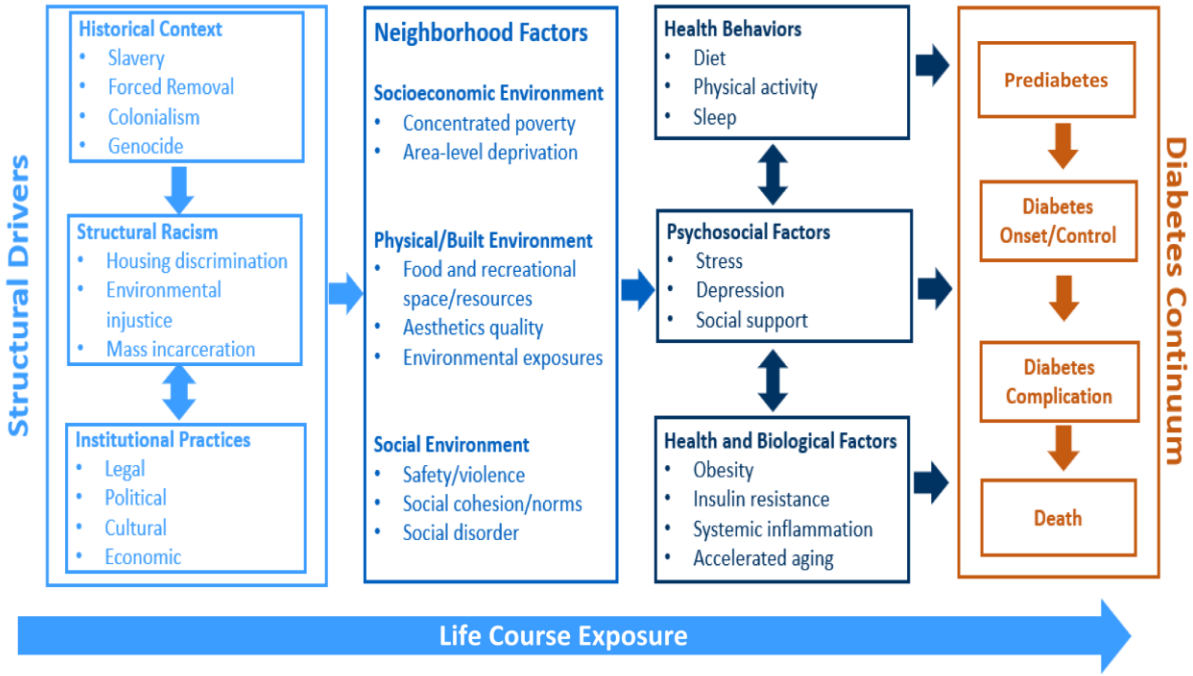
Built and Physical Environment

- Longitudinal studies consistently link poor neighborhood walkability and greenspace to higher diabetes incidence, while findings on healthy food access and availability are mixed
- Limited experimental and quasi-experimental studies were conducted on neighborhood physical environment and diabetes risk and outcomes

Neighborhood Social Environment

- Findings are mixed regarding social environment (e.g., social cohesion, crime, violence, and safety) and diabetes risk and outcomes
- Limited research exists on experimental studies assessing the impact of improving neighborhood social conditions on diabetes risk

Conceptual Framework



Muhasin et al., *Diabetes Care*, 2023

Future Interventions & Research

Observational Studies

- Address methodological challenges through observational studies and longitudinal design
- Incorporate life course and intergenerational investigations
- Consider social determinants of health in clinical care

Interventions

- Leverage natural experiments
- Consider neighborhood-level factors in diabetes prevention interventions
- Examine the effectiveness of place-based strategies and interventions in improving diabetes

Centering Health Equity

- Investigate historical and contemporary structural drivers, including structural racism, of place-based inequities
- Promote equitable research practices
- Provide funding and leadership for researchers from communities most impacted by health inequities

LIMITATIONS

1. Misclassification of the Outcome: underreporting, diagnostic criteria

2. Selection bias from live-birth, mothers contributing to more than >1 pregnancy

3. Misclassification of Exposure: residential address at delivery

STRENGTHS

1. Well-powered sample over a 7-year period.

2. NDI is a validated measure used widely in perinatal research.

3. Administrative data is cost-effective, non-invasive, and practical.

CONCLUSION

Mothers living in the area with the greatest deprivation had **21% greater risk of GDM** compared to mothers living in areas with the lowest levels of deprivation (95% CI: 1.18, 1.26).

NDI as an indicator of risk for GDM has the potential to be used to select for pregnant individuals for interventions that target individual behaviors.

Strategies to mitigate neighborhood deprivation must address policy and systemic issues related to poverty and inequity -- food insecurity, poor housing quality, unwalkable neighborhoods.

Next steps for AZPEARS Study (PI: Melissa Furlong, UA)

Race and Ethnicity

Ambient Pesticide Exposure

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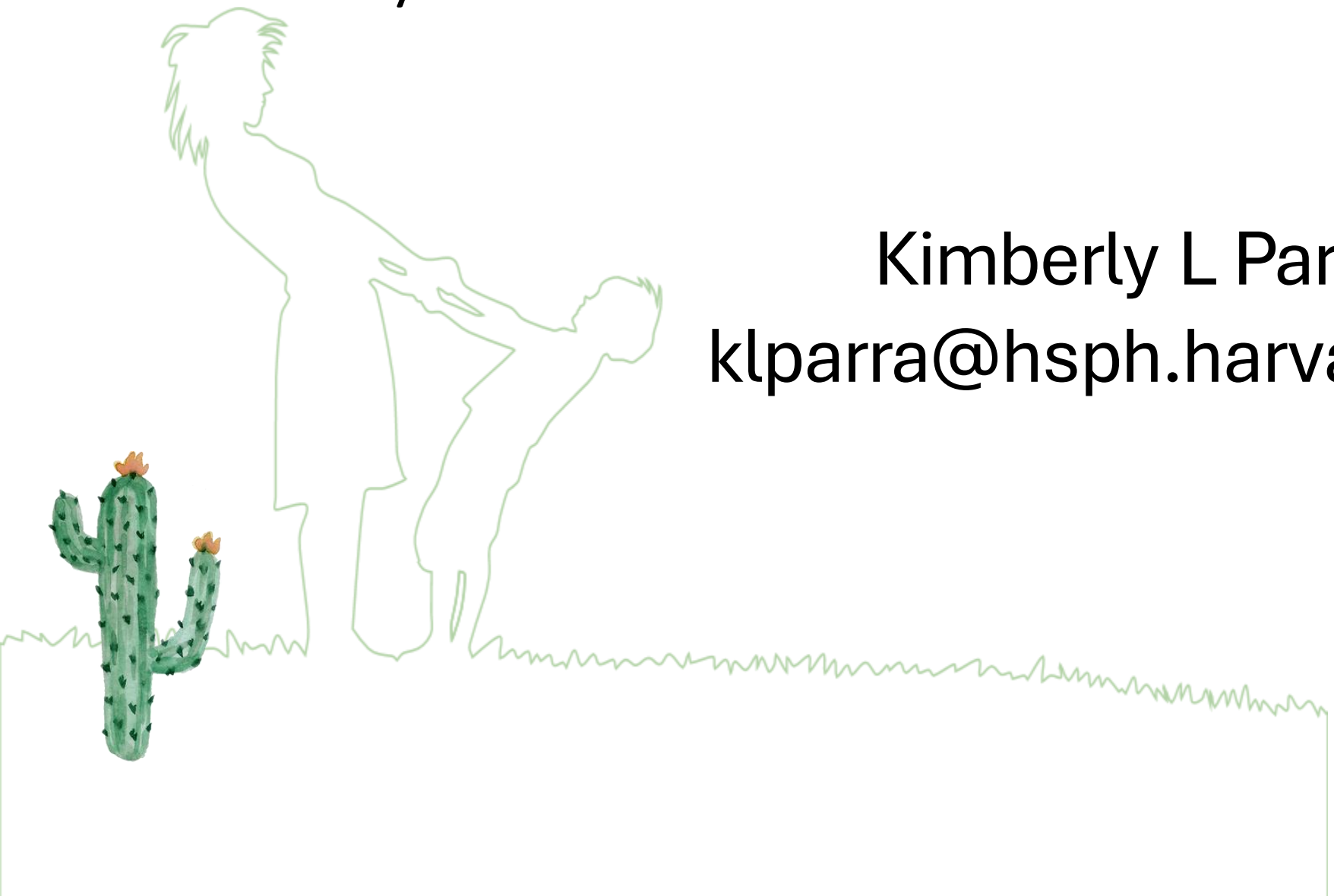

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References

ACOG. Gestational Diabetes Mellitus: Practice Bulletin No. 190. *Obstet Gynecol*. 2018;131(2):e49-e64. doi:10.1097/aog.0000000000002501

Dennison RA, Chen ES, Green ME, et al. The absolute and relative risk of type 2 diabetes after gestational diabetes: A systematic review and meta-analysis of 129 studies. *DRCP,* 2021;171:108625.

Geronimus AT. Black/white differences in the relationship of maternal age to birthweight: a population-based test of the weathering hypothesis. *Soc Sci Med*. 1996;42(4):589-597.

Gregory EC, Ely DM. Trends and Characteristics in Gestational Diabetes: United States, 2016-2020*. Natl Vital Stat Rep*. 2022;71(3):1-15.

McEwen BS. Stress, adaptation, and disease: Allostasis and allostatic load. *Ann N Y Acad Sci*. 1998;840(1):33-44.

Messer LC, Laraia BA, Kaufman JS, et al. The development of a standardized neighborhood deprivation index. *J Urban Health*. 2006;83(6):1041-62. doi:10.1007/s11524-006-9094-x

Mujahid, M. S., Maddali, S. R., Gao, X., Oo, K. H., Benjamin, L. A., & Lewis, T. T. (2023). The impact of neighborhoods on diabetes risk and outcomes: centering health equity*. Diabetes Care*, 46(9), 1609-1618.

Steptoe A, Feldman PJ. Neighborhood problems as sources of chronic stress: development of a measure of neighborhood problems, and associations with socioeconomic status and health. *Ann Behav Med*. 2001;23(3):177-185. doi:10.1207/S15324796ABM2303_5

Zhang C, Rawal S, Chong YS. Risk factors for gestational diabetes: is prevention possible? *Diabetologia*. 2016;59(7):1385–90. 10.1007/s00125-016-3979-3