Socioeconomic and Environmental Determinants Associated with Organ Damage in Systemic Lupus Erythematosus: *An Ecological Study*

Martinez-Martinez MU, Roberts K, Quintana R, Scolnik M, Funes Soaje C, Alba P, Saurit V, Garcia MA, Berbotto GA, Bellomio V, Kerzberg EM, Gomez GN, Pisoni CN, Juarez V, Malvar A, da Silva NA, Monticielo OA, Mariz HA, Machado Ribeiro F, Borba EF, Bonfa E, Torres dos Reis-Neto E, Guerra Herrera I, Massardo L, Aroca Martinez G, Gomez Escorcia L, Cañas CA, Quintana-Lopez G, Toro Gutierrez CE, Moreno Alvarez MJ, Saavedra MA, Portela Hernandez M, Fragoso-Loyo H, Silveira LH, Garcia de la Torre I, Abud-Mendoza C, Esquivel Valerio JA, Acosta Colman I, Paats A, Mora Trujillo C, Ugarte-Gil MF, Calvo Quiroz A, Muñoz Louis R, Rebella M, Danza A, Gomez-Puerta JA, Zazzetti F, Orillion A, Pons-Estel G, Pelaez-Ballestas I.

INEQUITIES IN SLE

- **01** *SLE burden is unevenly distributed across populations: socioeconomic position and race/ethnicity are associated with differences in disease activity, organ damage, and access to care.*
- **02** *Environmental exposures such as air pollution have also been associated with lupus outcomes.*
- **03** The role of area-level social and environmental conditions in SLE-related organ damage remains unclear.

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OBJECTIVES

Primary Objective

To evaluate the association of ***individual- and contextual-level socioeconomic and environmental determinants*** *with* ***organ damage*** *in Latin American patients with SLE from the* ***GLADEL cohort****.*

Secondary Objectives

To assess the association of these determinants with:

Disease activity
Patient-reported outcomes (PROs)

STUDY DESIGN AND DETERMINANTS

GLADEL LATIN AMERICA

POPULATION

- *GLADEL 2.0 cohort*
- *10 Latin American countries*
- *Adults ≥18 years*
- *SLE classified by ACR 1982/1997 or SLICC 2012 criteria*

INDIVIDUAL-LEVEL VARIABLES

- *Ethnicity, education, SES (Graffar), healthcare coverage*
- *Disease activity: SLEDAI-2K*
- *Organ damage: SDI*
- *PROs: LupusQoL*

CONTEXTUAL-LEVEL DETERMINANTS

- *Socioeconomic/structural: density, income, unemployment, Gini, HDI/GDI, physicians per 1,000*
- *Environmental: CO_2, PM_{10}, $PM_{2.5}$, NO_2, DNI, GHI*
- *Assigned according to the location of the treating healthcare center*

SES, socioeconomic status;PROs, patient-reported outcomes; LupusQoL, Lupus Quality of Life; HDI, Human Development Index; GDI, Gender Development Index; CO_2, carbon dioxide; PM_{10}, particulate matter ≤10 µm; $PM_{2.5}$, fine particulate matter ≤2.5 µm; NO_2, nitrogen dioxide; DNI, direct normal irradiance; GHI, global horizontal irradiance.

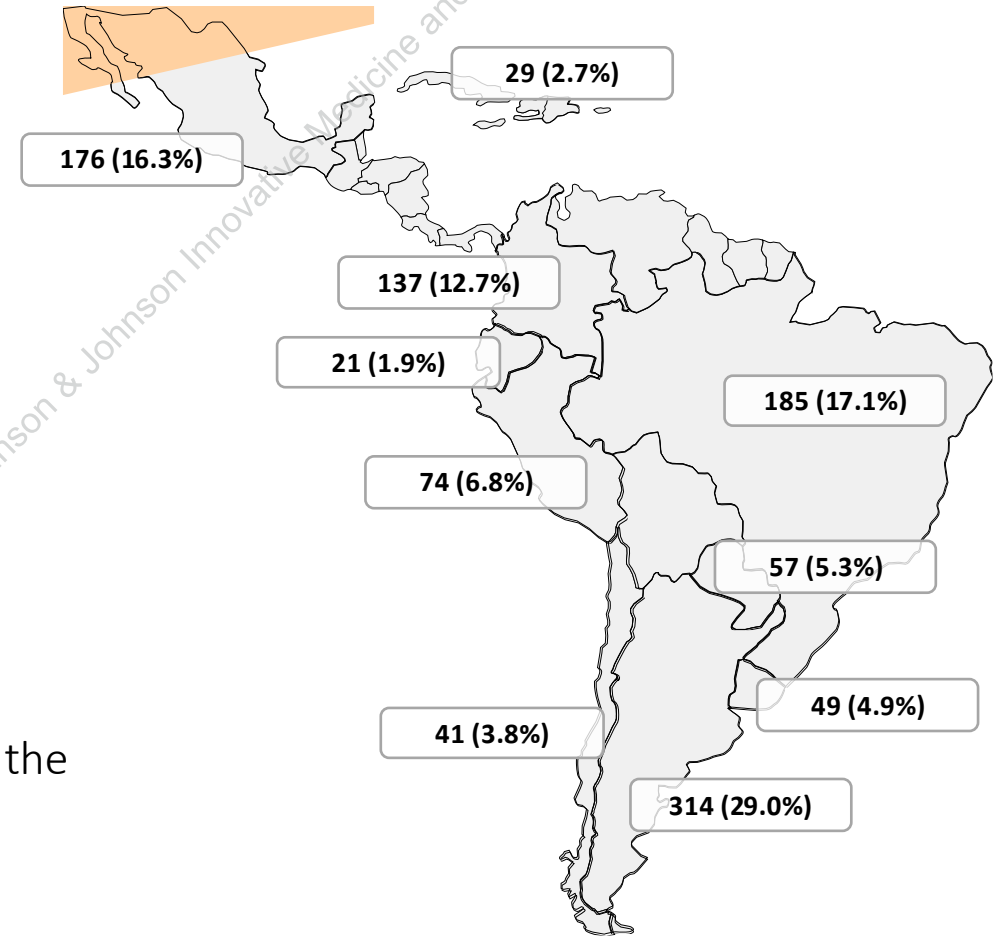
RESULTS

Patients by country

⇢ *1083 patients from 10 countries*

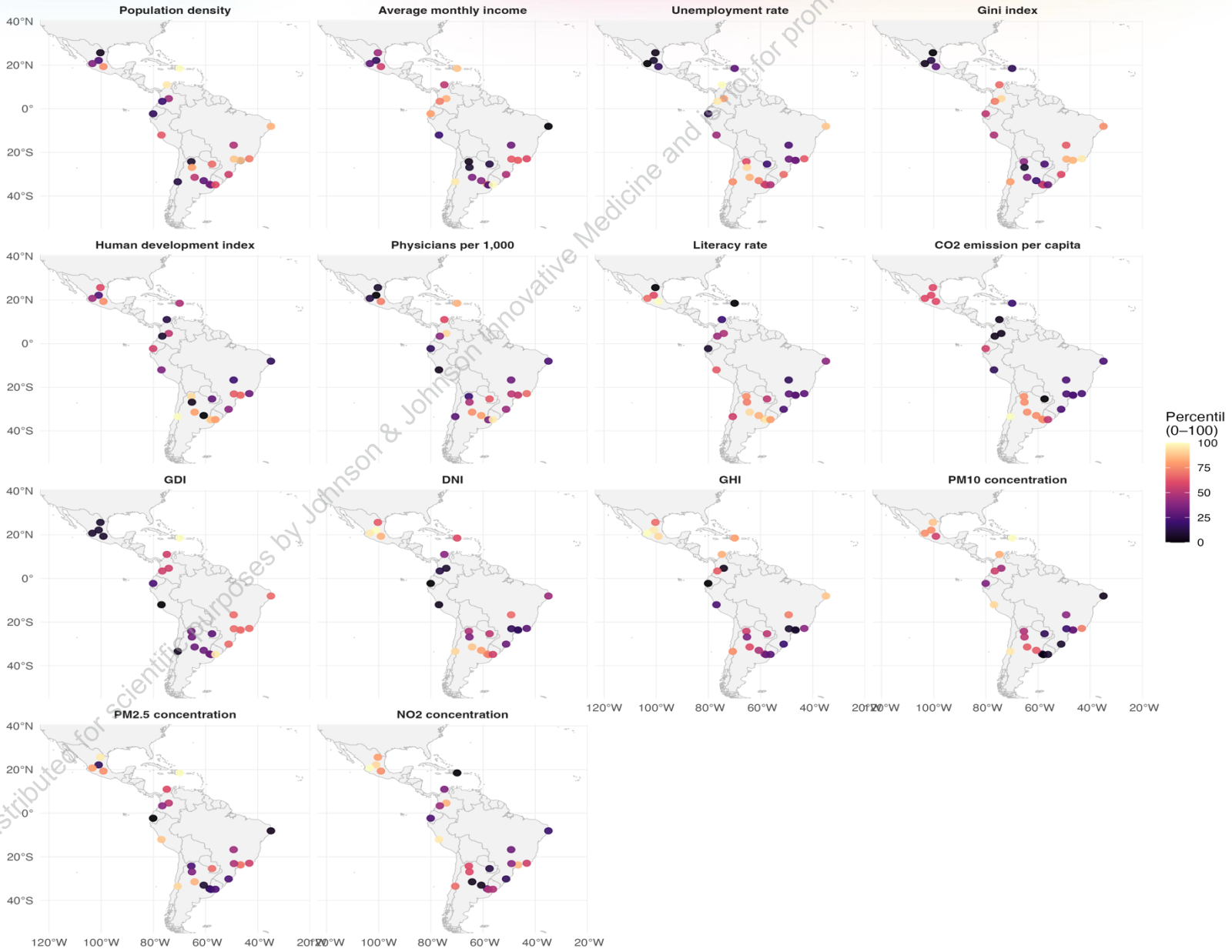
⇢ *970 patients (89.6%) were female*

⇢ *70 patients (64.7%) were Mestizo**



*Mestizo: in Latin America, this term generally refers to individuals of mixed Indigenous American and European ancestry; here, it reflects the ethnic category recorded in the cohort.

CONTEXTUAL LEVEL VARIABLES BY CITY



INDIVIDUAL-LEVEL CORRELATES OF ORGAN DAMAGE

Signals associated with higher damage

Variable	SDI ≤1	SDI >1	p
Education >13 years	54.0%	44.1%	0.023
Full healthcare coverage	54.6%	64.5%	0.004
Baseline SLEDAI-2K	7.5 (7.6)	6.1 (7.7)	0.008

Interpret carefully: coverage may reflect access/referral structure rather than protection.

No clear differences in age at diagnosis, ethnicity, or SES categories in this unadjusted comparison.

CONTEXTUAL CORRELATES OF ORGAN DAMAGE

Variable	SDI ≤1	SDI >1	p
CO_2 emissions, mean (SD)	2.9 (1.0)	3.1 (1.0)	0.006
NO_2, mean (SD)	23.1 (12.9)	24.7 (12.5)	0.058
HDI, mean (SD)	0.789 (0.063)	0.796 (0.069)	0.067
Unemployment rate, mean (SD)	7.2 (2.6)	7.5 (2.3)	0.087

No signal in this comparison for PM_{10}, $PM_{2.5}$, DNI, or GHI.

Abbreviations: SDI, SLICC/ACR Damage Index; SD, standard deviation; CO_2, carbon dioxide; NO_2, nitrogen dioxide; HDI, Human Development Index; PM_{10}, particulate matter ≤10 µm; $PM_{2.5}$, fine particulate matter ≤2.5 µm; DNI, direct normal irradiance; GHI, global horizontal irradiance.

Interpretation

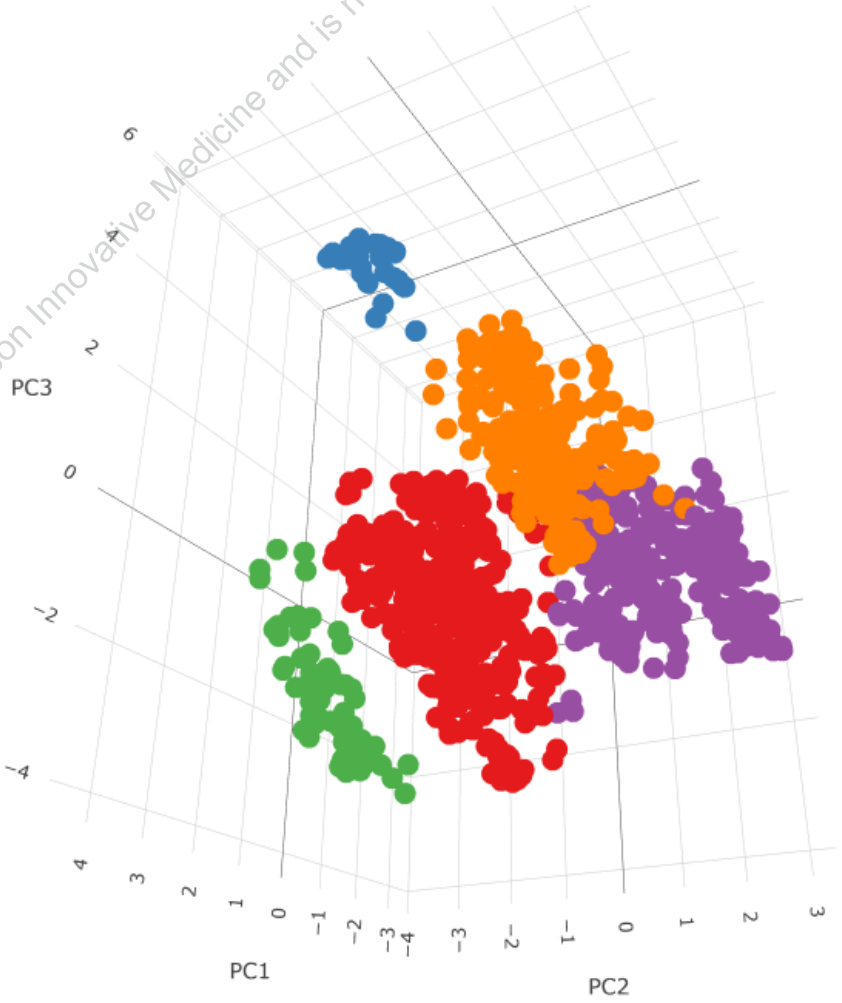
- *The clearest contextual signal was higher CO_2 exposure in the higher-damage group.*
- *NO_2 and HDI showed borderline differences.*
- *These are ecological associations linked by treating-center location, not direct personal exposure estimates*

PRINCIPAL COMPONENT ANALYSIS

GLADEL LATIN AMERICA

⇢**Individual and contextual** variables were included.

⇢**The five clusters** were identified based on the first three principal components.



CLUSTER PROFILES: Clinical, social, and environmental context.

Cluster 1 — Protective resources

- Moderate activity & damage
- PROs: moderate–favorable
- Higher education, middle SES, full coverage
- High HDI, ↑ physicians, ↓ pollution

Cluster 2 — Early disease in urban high-income

- High activity, lowest damage
- Best PROs
- Young, urban; high income/low inequality
- High pollution exposure

Cluster 3 — Cumulative damage vulnerability

- Moderate activity, highest damage
- Oldest patients
- Low HDI, ↓ income, ↓ healthcare access
- ↑ NO_2 levels

Cluster 4 — Compounded social disadvantage

- Moderate activity & damage
- Worst PROs
- Low education, limited coverage, unemployment
- Highest inequality

Cluster 5 — Environmental–social interplay

- Moderate activity & damage
- Intermediate PROs
- Modest SES
- Highest CO_2 emissions and elevated NO_2 levels

STRENGTHS LIMITATIONS AND CONCLUSIONS

GLADEL LATIN AMERICA

Strengths

- Large Latin American multicenter cohort
- Integration of clinical, social, and environmental contextual data
- Dimensionality reduction with PCA plus clustering

Caveats

- Possible ecological misclassification and ecological fallacy
- Cross-sectional design: no longitudinal inference or causality
- Some clusters may partly reflect country-level structure

CONCLUSIONS

In this cohort, organ damage tracked with both individual educational/coverage measures and contextual environmental signals, supporting multilevel prognostic research and context-sensitive public health strategies in SLE.

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