Food Insecurity as a Primary Pathway Linking Poverty to Health Outcomes: A Parallel Mediation SEM

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Introduction

Food insecurity sits at the intersection of agri-food systems, public health, and community development, yet empirical evidence on how socioeconomic disadvantage translates into population health disparities remains fragmented. Many studies focus on a single outcome or treat food insecurity as a correlate rather than testing it as part of a broader pathway through which poverty may shape multiple health outcomes simultaneously. To address this gap, the present study specified food insecurity as the focal mediator and included exercise access and air pollution as parallel pathways to benchmark the relative importance of food insecurity and to reduce omitted-context bias. Our analysis was guided by these two primary research questions:
RQ1: To what extent does food insecurity mediate the association between county poverty and adult obesity, adult diabetes, and poor/fair health?
RQ2: After accounting for exercise access and air pollution as parallel pathways, does the mediating role of food insecurity remain robust, and how does its indirect effect compare in magnitude with the other pathways?

Theoretical Framework

Guided by the Social Ecological Model, which conceptualizes health as shaped by interacting influences across societal, community, interpersonal, and individual levels (McLeroy et al., 1988), we position food insecurity as a multi-level condition through which structural disadvantage can translate into population health disparities. Prior research links food insecurity to higher obesity risk and to barriers in diabetes prevention and self-management, suggesting that constrained and unstable food access may contribute to adverse cardiometabolic outcomes (Carvajal-Aldaz et al., 2022; Wylie-Rosett & DiMeglio, 2023). Drawing on this framework, we expect socioeconomic disadvantage to increase food insecurity, and higher food insecurity to be associated with poorer county health outcomes, while other community-level exposures (exercise access and air pollution) may operate alongside this pathway.

Methodology

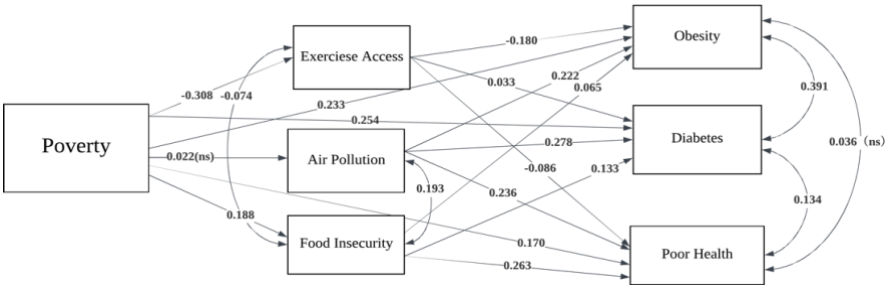
We analyzed county-level secondary data from 3,119 U.S. counties (County Health Rankings & Roadmaps, 2020; USDA ERS, 2019) to test a parallel multiple-mediation model linking poverty to population health. Poverty rate (POVRATE) was the predictor. Parallel mediators were food insecurity (FOOD_INSECURE; focal mediator), exercise access (EXERCISE_ACCESS), and air pollution (PM2.5). Outcomes were adult obesity (OBESITY), adult diabetes (DIABETES_ADULTS), and poor/fair health (POOR_HLTH). We estimated a path-analytic SEM in lavaan (Rosseel, 2012) with paths from poverty to each mediator and outcome, and from each mediator to each outcome (partial mediation). Residual covariances were estimated among outcomes and between FOOD_INSECURE with EXERCISE_ACCESS and PM2.5 to capture shared place-based conditions beyond poverty. Missing data were handled with FIML. Indirect effects were tested using 5,000 bootstrap resamples with 95% CIs. Model fit was evaluated using χ^2, CFI, TLI, RMSEA (90% CI), and SRMR.

Findings

Model fit was excellent, $\chi^2(1) = 2.27$, $p = .132$, CFI = 1.00, TLI = .991, RMSEA = .020 (90% CI [.000, .056]), SRMR = .005. Poverty significantly predicted lower exercise access ($\beta = -0.308$, $p < .001$) and higher food insecurity ($\beta = 0.188$, $p < .001$), but was not significantly associated with air pollution ($\beta = 0.022$, $p = .267$). Controlling for poverty and the other mediators, food

insecurity was positively associated with obesity (β = 0.065, p < .001), diabetes (β = 0.133, p < .001), and poor/fair health (β = 0.263, p < .001). Air pollution also positively predicted all outcomes (βs = 0.222–0.278, all ps < .001). Bootstrap tests supported indirect effects via food insecurity for obesity (ind = 0.108, 95% CI [0.050, 0.171]), diabetes (ind = 0.007, 95% CI [0.005, 0.009]), and poor/fair health (ind = 0.039, 95% CI [0.030, 0.049]). Indirect effects via air pollution were not supported (e.g., obesity: ind = 0.042, 95% CI [−0.030, 0.119]), consistent with the non-significant poverty→air pollution path. Indirect effects via exercise access were significant for obesity (ind = 0.489, 95% CI [0.371, 0.613]) and poor/fair health (ind = 0.021, 95% CI [0.012, 0.030]), but were marginal for diabetes (ind = −0.003, 95% CI [−0.006, −0.000], p = .051). Poverty retained significant direct effects on all outcomes (βs = 0.170–0.254, ps < .001), consistent with partial mediation. Check Figure 1 for details.

Figure 1. Path diagram of the parallel mediation model (standardized coefficients).



Conclusions

Food insecurity emerged as a consistent explanatory pathway linking poverty to adverse population health outcomes at the county level. Across outcomes, poverty was associated with worse health both directly and indirectly, with the most robust mediated pathways operating through higher food insecurity and lower exercise access. In contrast, mediation through air pollution was not supported because the poverty to air pollution path was not statistically significant, even though air pollution independently predicted obesity, diabetes, and poor/fair health. Overall, the results are consistent with partial mediation, indicating that poverty influences health through multiple mechanisms beyond the mediators included in this model.

Implications

From a food-systems perspective, food insecurity reflects how effectively local agricultural, retail, and social support systems translate economic resources into stable access to adequate nutrition. The SEM results suggest that interventions aiming to reduce health disparities in high-poverty counties should prioritize pathways tied to food insecurity and opportunity structures for physical activity (exercise access), given their supported indirect effects. At the same time, air pollution functioned as a parallel risk context: it was strongly associated with all health outcomes but did not operate as a poverty-linked mediation mechanism in this dataset due to the non-significant poverty → air pollution association. Importantly, residual covariances indicate that food insecurity co-occurs with other place-based conditions beyond poverty alone, negatively with exercise access (Std.all = −0.074) and positively with air pollution (Std.all = 0.193), supporting integrated strategies that address food access/affordability alongside broader environmental and community risk contexts. Practically, these findings motivate strengthening food-policy implementation communication (e.g., SNAP/WIC eligibility navigation, stigma-reducing enrollment messaging, community partner coordination, and trusted-messenger strategies) while building cross-sector outreach coalitions (Extension–public health–community

organizations) that align food access efforts with local environmental and built-environment constraints.

Reference

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