

Optimization Framework for Equitable Food Access Intervention Planning: A Detroit Case Study

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Abstract

Food environment disparities in urban areas are closely linked to elevated rates of diet-related chronic disease, yet existing policy tools rely primarily on descriptive metrics that offer limited guidance for resource allocation decisions. This study presents an integrated, data-driven decision-support framework for planning food access interventions in Detroit, Michigan — a city characterized by pronounced spatial heterogeneity in food environments, health outcomes, and socioeconomic vulnerability. Using ZIP-code-level data, we first construct a composite Food Access Score combining per-capita availability of healthy food outlets (grocery stores, farmers markets, SNAP retailers, healthy restaurants) with exposure to unhealthy alternatives. Spatial analysis reveals significant clustering of food access disparities, with associations observed between the Food Access Score and neighborhood-level obesity and diabetes prevalence. Social deprivation and historical redlining scores further explain variation in food access conditions, motivating equity-explicit modeling. Building on this empirical foundation, we formulate a mixed-integer linear programming (MILP) model with a weighted objective function that aggregates three outcome dimensions — improvements in healthy food access, reductions in unhealthy food environment exposure, and reductions in neighborhood health burden. The model selects intervention locations and types from a set of candidates, subject to budget constraints, capacity limits, maximum accessibility thresholds, and intervention-count limits per type. Equity constraints enforce minimum service coverage for predefined vulnerable groups, ensuring that cost-efficient solutions do not systematically exclude historically disadvantaged populations. The framework supports transparent scenario analysis across different budget levels and weight configurations, surfacing how shifts in policy priorities affect intervention portfolios. Results demonstrate that optimization-based prioritization yields materially different allocation decisions compared to single-metric rankings. This work advances the application of OR/IE methods to urban public health planning and offers a transferable decision-support architecture for food access policy in resource-constrained settings.

Keywords

Mixed-integer programming, food access, health equity, urban public health, resource allocation

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