Causal Forecasting of Regional HIV Opportunistic Infections with Improved Insurance Coverage Simulations

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Catherine G. Bielick[1,2], Michael D. Porter[3], Douglas Krakower[1,2], Kathleen A. McManus[3]
[1]Beth Israel Deaconess Medical Center, Boston, MA, USA, [2]Harvard Medical School, Cambridge, MA, USA, [3]University of Virginia, Charlottesville, VA, USA

BACKGROUND

- **Hypothesis**: Regional differences in uninsured rates contribute to OI disparities, and expanding insurance coverage would reduce Oi burden disproportionately in the South.
- Despite antiretroviral treatment (ART), HIV-related OIs cause significant morbidity, mortality, and high costs.
- Preventable OIs signal failure along HIV care continuum
- OIs are declining nationally, but regional heterogeneity in health disparities and insurance coverage challenges this
- Region-specific contributions of improved insurance coverage for OI incidence/costs are poorly characterized

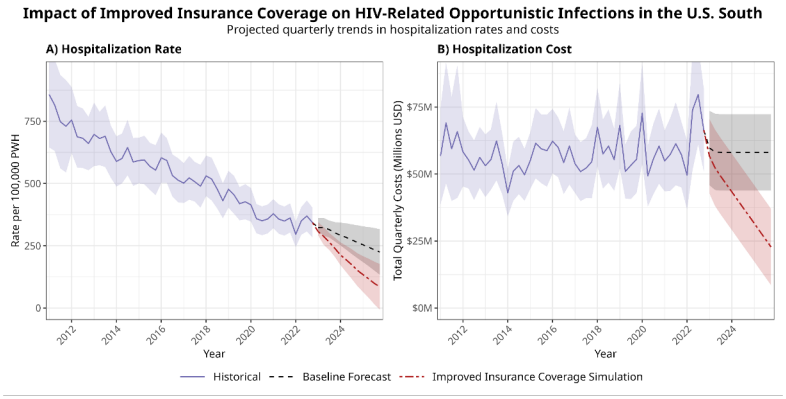
METHODS

- **Objective**: Quantify regional OI trends (2011-2022 [most recent year available]), insurance coverage effects using causal inference, and simulate projected outcomes years into the future.
- **Data**: National Inpatient Sample (NIS) ~7 million hospitalizations per year, ICD-9/10-CM codes flagged, incidence estimated with survey weights
- Three-stage causal forecasting framework:
  - **Stage 1, Denominators**: spline-fitted quarterly people with HIV (PWH) prevalence from CDC AtlasPlus
  - **Stage 2, Causal Effects**: Generalized Random Forests (causal forests) estimated Average Treatment Effect on the Treated (ATT) of uninsured status on OI outcomes
    - Treatment = self-pay; covariates = region, age, sex, race/ethnicity, urban/rural, income quartile
  - **Stage 3, Forecasting & Simulation**: Bivariate VAR models on first differences after stationary testing, 12-quarter forecasts with bootstrap prediction intervals
    - Simulated by benchmarking regional uninsured rates to the Region with lowest uninsured rate including linear ATT ramp-up

Insurance coverage expansion simulations project a 62% reduction in Southern OI hospitalizations, 20% in-hospital mortality, and $35.4 million quarterly savings after three-year linear ramp-up.

RESULTS

- From 2011-2022, 2,524,806 HIV-related hospitalizations; 216,571 (8.6%) with an OI
- The **South: 51.3%** of all OI hospitalizations with highest uninsured rate (17.5% vs NE 4.4%, 4-fold)
- **Midwest surpassed South** for OI hospitalization rates by 2022 (1,382 vs 1,374 per 100,000 PWH)
  - Rebounded from 2020 nadir
- In the West, overall OI mortality was not significantly declining (p=0.09) and hospitalization rates for cryptococcosis (p=0.41), tuberculosis (p=0.05), and esophageal candidiasis (p=0.11)
- OI hospitalization **costs nearly double** non-OI hospitalization costs in all regions
- **Simulation results** for the South, Q4 2025 (Midwest/West had comparable %PWH without insurance)
  - Hospitalizations ↓ 62.2% (225.0 in 2025 → 85.1 per 100,000 PWH)
  - Mortality ↓ 19.7% (ATT not significant)
  - **Quarterly** costs: ↓$35.4M ($58.1M → $22.7M)



CONCLUSIONS

- Regional OI disparities persist despite overall declines.
- The South's disproportionate burden reflects structural inequities in insurance coverage
- The Midwest's 2022 rebound raises concerns about rural healthcare infrastructure and HIV workforce in the wake of the pandemic
- Simulated insurance coverage expansion to match the Northeast benchmark projects substantial reductions in South hospitalizations (62%), mortality (20%), and costs ($123.6M annually accounting for linear ramp)
- The West showed concerning stagnation in multiple OI-specific trends (cryptococcosis, tuberculosis, esophageal candidiasis)
- Limitations: no patient identifiers for repeated hospitalizations, no clinical data, NIS processing lag time

OI-related hospitalizations are proxy indicators of which PWH we are failing to identify, engage, or retain in care. Addressing these disparities will require region-specific interventions: expanded insurance coverage, bolstered rural infrastructure, and consistent access to ART and OI prophylaxis.

ADDITIONAL KEY INFORMATION

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Author contact: cbielick@bidmc.harvard.edu
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People with HIV who lack health insurance are more likely to be hospitalized with serious but preventable OIs. The US South has the most uninsured patients and highest rate of OIs; improved insurance coverage would save lives and money.