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Access to Care in a Capacity-Constrained System: Do Coverage Expansions Improve Health Outcomes? Evidence from U.S. States, 2006–2023

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Abstract

Coverage expansions and affordability reforms often presume that improved access to care yields better population health. We examine this premise in a capacity-constrained healthcare system, where congestion and throughput determine whether potential access translates into realized care. Using U.S. state-year panel data from 2006 to 2023, we study (i) how healthcare workforce density relates to multiple access margins and (ii) whether the mortality effects of access improvements depend on local delivery capacity. Reduced-form estimates show that higher workforce density is associated with higher insurance coverage and fewer cost-related barriers to care, while associations with having a usual source of care are weaker. With full controls these relationships attenuate, and Medicaid expansion and poverty explain much of the remaining variation. Instrumental variable models suggest that policy-driven improvements in effective access are associated with lower mortality, although the first-stage strength varies across specifications. Interaction-IV estimates indicate capacity dependence: for all-cause and external-cause mortality, implied benefits are larger in lower-capacity settings and diminish as workforce density increases; for endocrine mortality, benefits are concentrated in higher-capacity settings, while respiratory effects are not detectable. Overall, the results support a systems perspective in which the health returns to access expansions depend on local delivery capacity, underscoring the importance of aligning access reforms with constraints in healthcare production and flow.

Keywords: access to care; health system capacity; healthcare workforce density; congestion; throughput; Medicaid expansion; cause-specific mortality

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1. Introduction

Health policy debates often treat "access" as the decisive lever for improving population health. When financial barriers fall—through broader eligibility, larger subsidies, or lower net premiums—more people can obtain coverage and, in principle, obtain care. Yet a persistent finding in health economics is that coverage expansions do not always translate into proportional improvements in population health outcomes such as mortality. A straightforward but often underappreciated reason is that coverage creates potential access, while care requires delivery capacity. If demand rises faster than the delivery system can respond, insured patients may still face delays, limited appointment availability, or

weakened continuity of care, and the resulting health gains may be muted or uneven across places and populations.

This question is especially salient given uncertainty around extending the Affordable Care Act's (ACA) enhanced premium tax credits beyond 2025 [1]. Recent analysis suggests that allowing these subsidies to lapse would substantially increase net premium payments for Marketplace enrollees and reduce coverage, with effects concentrated among low- and middle-income households and older adults [2]. As the debate intensifies, the policy question extends beyond whether subsidies raise enrollment: if affordability worsens and coverage declines for millions, what are the likely health consequences, and how much would those consequences depend on local healthcare capacity? Even if subsidies are extended, and coverage remains high, the complementary question remains: do affordability expansions reliably generate measurable health improvements, or do capacity constraints weaken the translation of potential access into effective care?

The literature offers two guideposts. First, landmark studies show that expansions in public insurance can improve access and, in some settings, reduce mortality [3–5]. Second, a related body of evidence indicates that coverage expansions can increase pressure on parts of the delivery system, affecting appointment availability and wait times in ways that depend on provider supply and reimbursement incentives [6,7]. Related work also highlights broader capacity strains, including slower emergency response times in certain circumstances [8]. Taken together, this evidence implies that insurance expansion can be consequential, but that the presence, magnitude, and even direction of its health effects may vary across locations depending on whether local delivery capacity can accommodate increased demand.

This paper contributes to that debate by developing a capacity-conditioned access perspective and testing the central hypothesis that the health effects of improved access depend on healthcare delivery capacity and baseline system conditions. Using U.S. state-level panel data spanning 2006–2023, we examine access across multiple margins (coverage, affordability barriers, and connection to a usual source of care) and study how these margins relate to mortality. By explicitly allowing the relationship between access and health outcomes to depend on local delivery capacity, this perspective provides a structured way to understand why the health impacts of coverage and affordability policies may differ across states with different healthcare systems.

The remainder of the paper is organized as follows. Section 2 develops the conceptual framework and states the testable hypotheses. Section 3 reviews the related literature. Section 4 presents the theoretical model and empirical strategy. Section 5 describes the data and measurement. Section 6 reports the results. Section 7 concludes with implications, limitations, and directions for future research.

2. Conceptual Framework

Health insurance policy is often evaluated through the lens of access: who is covered, how affordable care is, and whether financial barriers are reduced. The implicit assumption in much policy discourse, and in parts of the empirical literature, is that improvements along these margins translate into better health outcomes. However, this assumption can conflate potential access with delivered care. Coverage can lower effective prices and expand eligibility, but care ultimately requires time, labor, and organizational capacity within the healthcare delivery system. Distinguishing access from delivered care clarifies why delivery capacity is a central conditioning factor in understanding when improvements in measured access translate into health gains.

Insurance expansions and premium subsidies primarily operate on the demand side. By lowering out-of-pocket prices and reducing financial risk, they increase the likelihood

that individuals seek care, fill prescriptions, and adhere to recommended treatments. A large literature documents gains in coverage, affordability, and self-reported access following public insurance expansions and subsidy enhancements [3,9]. These changes expand potential access by relaxing financial constraints and increasing engagement with the healthcare system.

Potential access, however, does not guarantee that care is delivered. Demand-side changes alone do not ensure timely appointments, continuity of care, or appropriate follow-up. In addition, insurer network design and provider participation can constrain effective access even when coverage expands, limiting the set of clinicians and facilities that patients can realistically use [10]. These downstream steps depend on the system's ability to absorb and respond to increased utilization.

Healthcare delivery is inherently capacity-constrained. Clinical services require trained labor, physical infrastructure, equipment, medications, and organizational coordination. Among these inputs, healthcare workers (physicians, nurses, and allied professionals) are often among the most binding constraints in the short to medium run. Training pipelines are long, geographic mobility is imperfect, and scope-of-practice regulations limit the rapid substitution of providers. As a result, demand increases induced by insurance expansions may outpace the system's ability to supply care locally, even when coverage improves.

Standard economic reasoning predicts that when demand rises while short-run supply is relatively fixed, adjustment occurs partly through non-price mechanisms such as waiting times, congestion, and rationing by inconvenience [11]. In healthcare markets, this may manifest as longer appointment delays, reduced time per visit, or difficulty establishing and maintaining a regular source of care. Empirical evidence is consistent with this channel: several studies find that coverage expansions can strain provider capacity, with heterogeneous effects across markets depending on baseline supply conditions [6,8].

From this perspective, delivery capacity shapes whether improvements in access translate into services received, continuity, and effective treatment. Where capacity is relatively sufficient, increases in coverage and affordability are more likely to translate into delivered care. Where capacity is limited, access expansions may increase unmet demand or shift congestion rather than generate measurable improvements in health outcomes.

Access itself is multidimensional. Some margins, such as insurance coverage and affordability, can respond quickly to policy changes. Other margins, such as establishing a usual source of care and maintaining continuity, reflect longer-term relationships between patients and providers and are more tightly linked to delivery capacity. These distinctions matter for interpretation: improvements in coverage and affordability may be necessary to initiate care-seeking, but they are less likely to generate durable health benefits if the system cannot support ongoing treatment and follow-up.

This capacity-constrained access framework helps reconcile mixed findings in the literature. Studies that focus on coverage or utilization often find sizable effects of insurance expansions. In contrast, studies examining mortality and other long-run outcomes frequently report more heterogeneous or attenuated effects [12]. This discrepancy is not a contradiction; it reflects different points along the access-to-care continuum and differing assumptions about delivery capacity.

The framework also has direct policy relevance. Enhanced premium subsidies under the Affordable Care Act have reduced net premiums and increased enrollment in recent years. Whether these gains translate into improved population health depends not only on maintaining affordability but also on health systems' ability to deliver care at scale. Conversely, if subsidies expire and coverage declines, health consequences may vary across states depending on baseline delivery capacity and on how coverage losses interact with already constrained systems.

Importantly, the framework implies that workforce and access policy are complements rather than substitutes. Expanding coverage without paying attention to delivery capacity risks limited health returns, whereas expanding capacity without addressing financial barriers can leave unrealized potential for care. A complete evaluation of access-oriented policies, therefore, requires explicit attention to how delivery capacity conditions the effectiveness of access reforms.

This framework yields three testable hypotheses:

H1 (Capacity and access margins): *In a reduced form, healthcare workforce capacity is more strongly associated with financial access margins (insurance coverage and affordability barriers) than with provider attachment (having a usual source of care).*

H2 (Average effect of access on mortality): *Policy-driven improvements in access do not necessarily produce uniform reductions in mortality, particularly when care delivery is constrained.*

H3 (Capacity-conditioned access effects): *The health effects of improved access vary with healthcare workforce capacity; the translation of access gains into mortality improvements depends on local delivery capacity.*

Subsequent sections situate this framework within the broader literature on insurance expansions, provider capacity, and health outcomes. We then develop the theoretical model and empirical strategy and test these hypotheses using U.S. state-level panel data with harmonized measures of access, workforce capacity, and mortality.

3. Related Literature

This study sits at the intersection of three strands of the literature: (i) evidence on insurance expansions and changes in access to care [13,14]; (ii) work examining whether access improvements translate into objective health gains such as mortality reductions [3,4,15]; (iii) research emphasizing that policy effects can vary systematically with local delivery constraints, including healthcare workforce capacity [6,7]. While this literature collectively suggests that access policies can alter coverage and utilization and may affect health outcomes, it also implies that the translation of potential access into improved health outcomes depends on delivery conditions. A key gap is that existing work rarely tests this capacity-conditioning directly using an instrumental-variables framework that identifies both access and its interaction with healthcare workforce capacity.

A central finding in the access literature is that coverage expansions increase insurance coverage and reduce financial barriers to care. Randomized evidence from the Oregon Health Insurance Experiment shows that gaining Medicaid coverage increases utilization and improves financial protection and self-reported health [9,13]. Quasi-experimental evidence from large-scale reforms similarly documents sizable gains in insurance coverage and improvements in multiple access margins following coverage expansions [16]. Together, these studies show that policy can move coverage and affordability at scale, while also underscoring that access is multidimensional. Improvements in coverage and affordability need not translate immediately into provider attachment or continuity, which may adjust more slowly.

Whether improvements in access to care lead to measurable reductions in mortality remains a subject of debate. Early work on Medicaid expansions reported associations with reduced mortality alongside improved access [3]. More recent evidence using linked survey and administrative data finds that mortality reductions are concentrated among groups most likely to gain coverage under Medicaid expansions [17]. At the same time, the broader literature emphasizes that objective health outcomes may respond slowly to coverage

changes, particularly for chronic conditions, and that average effects can be attenuated when delivery frictions limit the translation of potential access into delivered care.

The emerging picture is therefore not simply that "coverage helps" versus "coverage does not help." Instead, the realized health effects of access expansions may depend on institutional and delivery environments, including capacity constraints and baseline health risks. Complementary work highlights that healthcare delivery systems face capacity limits that shape how demand shocks are absorbed, affecting appointment availability, delays, and the ability to convert expanded coverage into timely treatment [6,7]. This perspective implies that constant-effect estimates may mask heterogeneity across capacity regimes: access expansions can raise overall utilization, yet improvements in population health outcomes may be concentrated in settings where clinician availability and system throughput enable timely and effective care.

Our contribution is to integrate these insights by explicitly treating healthcare workforce capacity as a conditioning factor in the access–health relationship. By doing so, we provide a framework for understanding why access expansions reliably improve coverage and affordability while producing more heterogeneous effects on mortality across settings with different delivery capacities.

4. Theoretical Model

This section presents a parsimonious framework linking healthcare delivery capacity, access to care, and population-level health outcomes. The key distinction is between potential access, which reflects financial and structural conditions that shift care-seeking, and realized care, which depends on services delivered in a capacity-constrained system. Policy and socioeconomic conditions influence demand for care; delivery capacity governs congestion and throughput; and mortality responds to the realized care. This structure provides a systems-level interpretation of how access reforms translate into delivered care and health outcomes, yielding the testable hypotheses stated in Section 2.

The purpose of the model is not to fully describe the dynamics of the healthcare system, but to formalize a capacity-constrained access mechanism and establish comparative-static restrictions linking access, delivered care, and health outcomes. The model is assessed by whether these restrictions, especially the prediction that the health return to access depends on delivery capacity, are borne out in the estimable relationships among access, workforce capacity, and mortality.

4.1. Care-Seeking Under Financial and Nonfinancial Barriers

Access, prices, and delivery capacity vary primarily at the state-year level. Accordingly, we represent individual care-seeking behavior within a state-specific healthcare system. Consider a state s in year t. Individuals experience health needs and decide whether to obtain medical care.

Let $m_{i,s,\,t} \in \{0,1\}$ indicate whether individual i in state s and year t initiates a needed episode of care (care-seeking). Utility depends on consumption c_{st} and next-period health $h_{i,\,s,\,t+1}$, as in the health-capital model [17].

$$U_{ist} = u(c_{ist}) + \beta v(h_{i,\,s,\,t+1}),\ \beta \in (0,1).$$

Next-period health depends on baseline health, the health benefit from care, and underlying risk:

$$h_{i,\,s,\,t+1} = h_{ist} + \Delta(m_{ist}) - \xi_{ist},\ \Delta(1) > \Delta(0),$$

where ξ_{ist} denotes exogenous health shocks or underlying risk burdens in the state s and year t, and $\Delta(m_{ist})$ captures the health improvement associated with initiating care.

Obtaining care entails an effective out-of-pocket price p_{st} reflecting insurance coverage, cost-sharing, and subsidies, and a nonfinancial friction cost, τ_{st}, expressed in utility-equivalent units, capturing travel time, administrative burden, appointment delays, and related access frictions. A reduced-form representation of the net benefit from initiating care is:

$$\beta[v(h_{ist} + \Delta(1) - \xi_{ist}) - v(h_{ist} + \Delta(0) - \xi_{ist})] - \lambda p_{st} - \tau_{st},$$

where $\lambda > 0$ scales the salience of out-of-pocket costs. Care is initiated when this expression is positive.

To connect individual decisions to state-year outcomes, let N_{st} denote the population in state s and year t. Aggregating care-seeking decisions yields a state-year care-seeking (potential demand) index:

$$Q_{st} = \frac{1}{N_{st}} \sum_{i=1}^{N_{st}} m_{ist} = Q(p_{st}, \tau_{st}, X_{st}), \ \frac{\partial Q}{\partial p_{st}} < 0, \frac{\partial Q}{\partial \tau_{st}} < 0.$$

Here Q_{st} captures potential demand for healthcare services in the state s and year t. The vector X_{st} summarizes state-year socioeconomic conditions, demographics, and baseline risk factors shaping care-seeking and health outcomes, capturing predisposing, enabling, and need-related factors [18].

This framework clarifies why policy and structural variables can be strong predictors of measured access and utilization-related access indices. Coverage expansions and affordability reforms primarily operate by lowering p_{st} while poverty and related constraints can raise barriers and reduce care-seeking. These mechanisms are consistent with evidence that out-of-pocket prices influence healthcare utilization [19].

In the next subsection, we distinguish this potential demand Q_{st} from realized care, which depends on delivery capacity and congestion, and motivates our capacity-conditioned empirical specifications.

4.2. Delivery Capacity, Congestion, and Realized Care

Care-seeking demand does not automatically translate into delivered care. Let the delivery capacity in state s and year t be S_{st}, determined by healthcare workforce density H_{st} (healthcare workforce per 1000 residents) and complementary infrastructure B_{st} (e.g., hospital beds per 1000 residents):

$$S_{st} = \kappa(H_{st}, B_{st}),$$

where $\kappa(\cdot)$ is increasing and concave in its arguments. Let realized (delivered) care per capita be D_{st}. Delivered care is limited by the minimum of potential demand and capacity:

$$D_{st} = \min\{Q_{st}, S_{st}\}.$$

When potential demand exceeds capacity, adjustment occurs through congestion rather than immediate quantity expansion, consistent with nonprice rationing through waiting [20]. We represent this by allowing nonfinancial frictions to rise with excess demand:

$$\tau_{st} = \tau_0 + \tau_1 \max\{0, Q_{st} - S_{st}\}, \ \tau_1 > 0,$$

Thus, policy-driven increases in care-seeking can create congestion when capacity is binding, whereas increases in workforce capacity relieve congestion by expanding throughput. In turn, excess demand raises nonfinancial frictions that dampen subsequent care-seeking and attenuate the conversion of potential access into realized care. This

underscores a systems perspective: policy and socioeconomic conditions shift potential access, but realized care is governed by delivery capacity.

4.3. Access to Care as a Multi-Dimensional Object

Observed access to care comprises distinct margins that map differently to the model primitives. Let insurance coverage A_{st}^{ins} and cost barriers A_{st}^{cost} (the prevalence of individuals reporting cost prevented needed care) capture financial access, both primarily linked to the effective out-of-pocket price, p_{st}:

$$A_{st}^{ins} = a_{ins}(p_{st}, X_{st}),\ A_{st}^{cost} = a_{cost}(p_{st}, X_{st}).$$

Provider attachment, measured based on having a usual source of care (has a doctor), A_{st}^{doc} depends more directly on congestion, capacity, and continuity:

$$A_{st}^{doc} = a_{doc}(\tau_{st}, S_{st}, X_{st}).$$

We summarize these margins using a composite measure of effective access:

$$E_{st} = E\left(A_{st}^{ins}, -A_{st}^{cost},\ A_{st}^{doc}\right),$$

where higher values indicate better overall access. This formulation highlights that short-run changes in access may be concentrated in financial margins, while provider attachment adjusts more slowly because it depends on delivery capacity and continuity.

4.4. Mortality and Capacity-Conditioned Health Returns to Access

Let Y_{st} denote the population-level mortality rate in the state s and year t, measured alternatively as all-cause mortality or cause-specific mortality (endocrine, respiratory, and external causes). Mortality depends on delivered care and underlying risks:

$$Y_{st} = \Omega(D_{st},\ X_{st}) + \mu_s + \delta_t + \epsilon_{st},\ \frac{\partial \Omega}{\partial D_{st}} < 0,$$

where μ_s and δ_t represent state and year fixed effects, and ϵ_{st} is an idiosyncratic error term.

Since delivered care D_{st} arises from the interaction of potential access and capacity constraints, the marginal effect of access on mortality depends on delivery capacity. Policy-driven improvements in access increase care-seeking, but their translation into realized care, and thus into mortality reductions, depends on workforce capacity and congestion. Health returns to access are therefore capacity conditioned.

4.5. Mapping the Mechanism to H1–H3

The model's capacity-constrained structure has two components. Delivered care is $D_{st} = \min\{Q_{st}, S_{st}\}$. Congestion rises when demand exceeds capacity, so $\tau_{st} = \tau_0 + \tau_1 \max\{0,\ Q_{st} - S_{st}\}$. This structure yields three restrictions corresponding to H1–H3 and clarifies the empirical objects of interest.

First, financial access margins, A_{kst} are closely linked to the effective price p_{st}, whereas provider attachment depends more directly on congestion and capacity through τ_{st} and S_{st}; this delivers H1. Second, mortality responds to delivered care D_{st}, so policy-driven increases in potential access that raise Q_{st} need not translate one-for-one into improved outcomes when capacity is binding; this supports H2. Third, the marginal health return to access is increasing in capacity: when $Q_{st} < S_{st}$, improvements in access raise delivered care, but when $Q_{st} > S_{st}$, additional access primarily increases congestion rather than treatment. This delivers H3 and motivates an empirical specification in which the effect

of E_{st} (the composite effective-access index constructed from the access margins) on Y_{st} varies systematically with workforce capacity $H_{s,\,t-1}$, captured by the interaction term $E_{st} \times H_{st,\,t-1}$.

4.6. Empirical Strategy and Identification

To estimate the relationships implied by the framework, we use U.S. state-level panel data from 2006 to 2023 and exploit within-state variation over time. We begin with a two-way fixed-effect model relating workforce capacity to different access margins:

$$A_{kst} = \mu_s + \delta_t + \beta H_{s,\,t-1} + X'_{st}\gamma + \epsilon_{kst}$$

where A_{kst} represents access margin k ∈ {insurance, cost barriers, usual source of care, E}, $H_{s,\,t-1}$ is lagged healthcare workforce density (workers per 1000 residents), X_{st} includes time-varying covariates (e.g., demographics, socioeconomic factors). Standard errors are clustered at the state level.

The workforce variable is lagged to account for timing and mitigate simultaneity concerns. Workforce density and organizational throughput adjust with delays (e.g., training pipelines, hiring, and allocation), and access and mortality may respond with lags as well. Using $H_{s,\,t-1}$ imposes a transparent timing structure and mitigates contemporaneous feedback from outcome shocks to measured workforce density.

To address endogeneity in effective access, we instrument the (E_{st}) with a vector of policy and system-level instruments Z_{st}, comprising Medicaid expansion status, hospital beds per 1000 residents, and CMS personal health care spending per capita. The first-stage regression is:

$$E_{st} = \mu_s + \delta_t + \lambda Z_{st} + \beta_1 H_{s,\,t-1} + X'_{st}\gamma_1 + v_{st}$$

Instrument relevance (strength) is assessed using Kleibergen–Paap statistics.

To test whether the health effects of access vary with workforce capacity, we estimate an interaction-IV model, treating both E_{st} and the interaction term $E_{st} \times H_{s,t-1}$ as endogenous:

$$Y_{st} = \mu_s + \delta_t + \beta_2 \hat{E}_{st} + \beta_3 (\hat{E}_{st} \times H_{s,t-1}) + \beta_4 H_{s,t-1} + X'_{st}\gamma_2 + \epsilon_{st}$$

where Y_{st} is the mortality rate (all-cause or cause-specific), and predicted values $\hat{E}_{st}$ and $\hat{E}_{st} \times H_{st-1}$ are obtained using Z_{st} and $Z_{st} \times H_{st-1}$ as instruments, respectively. The marginal effect of access $(\hat{E}_{st})$ on mortality, $\beta_2 + \beta_3 H_{st-1}$, varies with workforce capacity, allowing us to assess whether the health returns to access change systematically with delivery capacity. Identification requires that Z_{st} and its interactions are exogenous conditional on controls, and we report Hansen J tests to assess the validity of the overidentifying restrictions.

These equations provide a structured framework for estimating relationships among access to care, workforce capacity, and health outcomes (as measured by mortality). The fixed-effect approach leverages within-state variation over time to control for time-invariant unobserved heterogeneity, while the IV approach isolates policy-driven variation in access, reducing potential endogeneity concerns. The interaction term enables the relationship between access to care and health outcomes to vary with workforce capacity, capturing differences across delivery environments.

5. Data and Measurement

5.1. Data and Sources

We assemble an unbalanced panel of U.S. states observed annually from 2006 to 2023. The unit of observation is the state-year. Access-to-care outcomes are drawn from the

Behavioral Risk Factor Surveillance System (BRFSS), which provides nationally consistent, state-representative measures of insurance coverage, usual source of care, and cost-related barriers. Healthcare workforce capacity and workforce composition are constructed from American Community Survey (ACS)-based workforce counts and harmonized to the state-year level. Mortality outcomes are drawn from nationally harmonized vital statistics series and expressed as state-year rates (per 100,000 population), harmonized across states and years. Policy and health-system variables used to characterize institutions and system capacity are drawn from nationally comparable administrative sources, including the Kaiser Family Foundation (KFF) for Medicaid expansion status, the Area Health Resources File (AHRF) for hospital bed capacity, and public spending files used to construct CMS personal health care spending per capita.

All inputs are converted into a common state-year structure keyed by state and year. Where source definitions change over time, variables are harmonized to preserve comparability across years and avoid mechanically induced breaks in trends.

5.2. Measures

Access. We measure access along three margins that reflect financial protection, provider attachment, and affordability. Insurance coverage is defined as the share of BRFSS respondents reporting current health insurance coverage. Having a usual source of care ("has a doctor") is defined as the share reporting a personal doctor or usual healthcare provider. Cost-related barriers are defined as the share reporting that cost prevented needed care. Higher values of insurance coverage and usual source of care indicate better access, whereas higher cost-barrier values indicate worse access.

To summarize these dimensions, we construct an Effective Access to Care Index (EACI). The EACI is computed as the unweighted mean of standardized values (z-scores) of insurance coverage, usual source of care, and the reverse-coded cost barrier measure (so that higher values consistently indicate better access). Standardization places each margin on a common scale and reduces sensitivity to differences in units and variance across components; equal weighting avoids imposing a priori restrictions on the relative importance of the three access margins.

Workforce capacity. We use healthcare workforce density (healthcare workers per 1000 residents) as a proxy for healthcare delivery capacity. This measure captures an important throughput-related input that is plausibly binding in the short to medium run, given long training pipelines and limited short-run substitutability across provider types. At the same time, workforce density does not capture all dimensions of system capacity, including equipment, medications, organizational efficiency, referral networks, and quality of care. We therefore interpret workforce density as a parsimonious indicator of delivery capacity rather than a comprehensive measure of health-system capability, and we treat omitted capacity dimensions as part of the study's limitations.

To examine composition, we disaggregate workforce capacity into native and foreign-born (immigrant) components and analyze specifications using the foreign-born share of the healthcare workforce. Immigrant healthcare workers are defined as foreign-born in the ACS (regardless of where they trained).

Mortality. Population health outcomes are measured using state-year mortality rates (all-cause and cause-specific). Cause-specific outcomes (endocrine-related, respiratory-related, and external-cause mortality) are used to assess heterogeneity across conditions that differ in their sensitivity to timely and continuous medical care. Mortality measures are expressed as rates per 100,000 residents and harmonized across states and years.

This study focuses on mortality rather than morbidity. Comparable state-year morbidity measures are not consistently harmonized across long panels and may be endogenous to

access, as coverage expansions increase the diagnosis and reporting of chronic conditions. Mortality, by contrast, often responds with substantial lags, especially for chronic disease. We therefore interpret the cause-specific mortality results with this timing in mind and view the absence of direct morbidity outcomes as a limitation and a direction for future work.

5.3. Controls

All models include a standard set of time-varying covariates capturing demographic composition, socioeconomic conditions, and other observable risk factors that may jointly influence access and outcomes. These controls account for changes in underlying population risk and broader economic conditions, as detailed in the Empirical Strategy. Descriptive statistics, variable definitions, and data sources are reported in Appendix A, Table A1.

6. Results and Discussion

We present the results in five steps, aligned with the conceptual framework linking workforce capacity, access to care, and population-level health outcomes. These steps correspond directly to the three testable hypotheses stated in Section 2. First, we report baseline two-way fixed-effect models relating healthcare workforce density to multiple access margins, highlighting which dimensions of access move most strongly with capacity (H1). Second, we decompose total healthcare workforce density into native-born and foreign-born components as a diagnostic, reflecting cross-state differences in how workforce capacity expands. Third, we add a comprehensive set of demographics, socioeconomic, behavioral, and policy controls to evaluate sensitivity to structural confounding. Fourth, we estimate instrumental-variable specifications that link population-level health outcomes (mortality) to effective access to care, thereby addressing endogeneity in access (H2). Fifth, we estimate interaction-IV models that allow the access–mortality relationship to vary with healthcare workforce capacity, providing a direct test of capacity-conditioned effects (H3).

Throughout, we interpret healthcare workforce density as a parsimonious indicator of delivery capacity, capturing an important throughput-related input, while recognizing that it does not reflect all dimensions of system capability (e.g., infrastructure, equipment, organizational efficiency, or referral networks). Accordingly, "capacity-conditioned" results should be interpreted as reflecting heterogeneity in workforce-related delivery constraints rather than as a complete characterization of health-system capacity.

6.1. Capacity and Access: Baseline Fixed-Effect Results

We begin by estimating baseline fixed-effect regressions relating healthcare workforce density (per 1000 residents) to access to care. Using state-level panel data from 2006 to 2023, we examine four access outcomes: Usual Source of Care, Cost Barriers to Care, Health Insurance Coverage, and the Effective Access to Care Index (EACI). All models include state- and year-fixed effects, with standard errors clustered at the state level. These baseline estimates characterize within-state co-movement between workforce density and access margins before introducing additional controls or quasi-experimental identification.

Table 1 presents the baseline estimates. The results indicate that workforce density is most strongly associated with financial access margins. A one-unit rise in current healthcare workforce density is associated with a 0.0012 increase in Health Insurance Coverage and a 0.0005 decrease in Cost Barriers to Care. Consistent with these findings, the Effective Access to Care Index (EACI) also improves, rising by 0.0133. Conversely, the immediate association with Usual Source of Care is essentially negligible. This pattern suggests that baseline workforce–access co-movement mainly occurs through coverage and affordability, rather than through the more structural provider-attachment margin. This distinction is important for understanding the composite index because it indicates that short-term changes in

measured access are driven mainly by financial margins, while provider attachment adjusts more gradually.

Table 1. Panel Fixed-Effect Estimates of the Effects of Healthcare Workforce Density on Access to Care (Contemporaneous and Lagged).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Usual Source of Care (has_doc)	Usual Source of Care (has_doc)	Cost Barriers to Care (medcost)	Cost Barriers to Care (medcost)	Health Insurance (has_ins)	Health Insurance (has_ins)	Effective Access to Care Index (EACI)	Effective Access to Care Index (EACI)
HCW density	0.0000		−0.0005 **		0.0012 ***		0.0133 **	
	(0.0005)		(0.0003)		(0.0004)		(0.0060)	
Lagged HCW density		0.0009 *		−0.0007 **		0.0008 **		0.0056 **
		(0.0005)		(0.0003)		(0.0003)		(0.0031)
Constant	0.8522 ***	0.8926 ***	0.1488 ***	0.1435 ***	0.8251 ***	0.8438 ***	−0.5429 **	−0.1927
	(0.0207)	(0.0212)	(0.0107)	(0.0110)	(0.0165)	(0.0124)	(0.2444)	(0.2347)
Dep. Mean	0.8533	0.8562	0.1268	0.1269	0.8744	0.8759	0.0000	0.0222
Obs.	914	863	914	863	914	863	914	863
Within R2	0.000	0.004	0.009	0.005	0.023	0.010	0.010	0.002
Clusters	51	51	51	51	51	51	51	51
State FE	Yes	Yes	Yes	Yes	Yes		Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses. Usual source of care corresponds to has_doc; cost barriers to care to medcost; health insurance coverage to has_ins; and the effective access to care index (EACI) is a standardized composite of coverage, usual source of care, and cost barriers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Odd-numbered columns report contemporaneous workforce density; even-numbered columns report one-year lagged workforce density.

Lagged specifications (one-year lag of workforce density) show a similar qualitative pattern: the lagged coefficients remain most evident for the financial access measures and EACI, while the usual-source-of-care margin remains comparatively muted. We view these results as consistent with H1: workforce capacity is most tightly linked to access dimensions that can move in the near term (coverage/affordability), whereas provider attachment reflects slower-moving constraints.

Taken together, the baseline and controlled results are consistent with H1: healthcare workforce capacity is more strongly associated with financial access margins (insurance coverage and affordability) than with provider attachment, which appears to adjust more slowly and reflects deeper delivery constraints.

6.2. Workforce Composition: Native-Born vs Foreign-Born (Diagnostic)

We next assess whether workforce–access relationships differ by workforce composition. We decompose total healthcare workforce density into native-born and foreign-born healthcare workers per 1000 residents and include both measures simultaneously in state- and year-fixed-effect specifications. Table 2 reports contemporaneous associations (odd-numbered columns) and specifications that use one-year-lagged workforce density (even-numbered columns). The decomposition proxies for differences in how states expand delivery capacity as demand rises. Some expand through domestic training and the relocation of U.S.-born clinicians, while others rely more on recruiting, licensing, and retaining foreign-born clinicians. These channels face distinct frictions, including training

lags, credentialing and licensure requirements, and mobility constraints. Our goal is not to study nativity differences per se, but to distinguish adjustment pathways and clarify whether access–capacity–health relationships reflect broad workforce growth or reliance on specific staffing channels in capacity-constrained settings.

Table 2. Panel Fixed-Effect Estimates of the Effects of Native and Foreign-Born Healthcare Workforce Density on Access to Care (Contemporaneous and Lagged).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Usual Source of Care (has_doc)	Usual Source of Care (has_doc)	Cost Barriers to Care (medcost)	Cost Barriers to Care (medcost)	Health Insurance (has_ins)	Health Insurance (has_ins)	Effective Access to Care Index (EACI)	Effective Access to Care Index (EACI)
Native HCW density	−0.0001		−0.0008 ***		0.0016 ***		0.0177 ***	
	(0.0005)		(0.0003)		(0.0004)		(0.0061)	
Lagged Native HCW density		0.0009 **		−0.0007 **		0.0012 ***		0.0099
		(0.0004)		(0.0003)		(0.0003)		(0.0060)
Foreign-Born HCW density	0.0007		0.0011		−0.0018		−0.0194	
	(0.0015)		(0.0009)		(0.0013)		(0.0205)	
Lagged. Foreign-Born HCW density		0.0017 **		−0.0019 **		0.0021 *		0.0320 ***
		(0.0083)		(0.0009)		(0.0012)		(0.0134)
Constant	0.8520 ***	0.8924 ***	0.1483 ***	0.1420 ***	0.8260 ***	0.8461 ***	−0.5331 **	−0.1637
	(0.0209)	(0.0211)	(0.0111)	(0.0112)	(0.0168)	(0.0125)	(0.2477)	(0.2340)
Dep. mean	0.8533	0.8562	0.1268	0.1269	0.8744	0.8759	0.0000	0.0222

Odd-numbered columns report contemporaneous workforce density; even-numbered columns report one-year lagged workforce density. Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In contemporaneous models, access margins that are most responsive to workforce density are those that plausibly reflect near-term financial access. Higher native healthcare workforce density is associated with lower cost-related barriers and higher insurance coverage, resulting in a higher EACI. A one-unit increase in native workforce density is associated with a 0.0008 decline in cost barriers ($p < 0.01$), a 0.0016 increase in insurance coverage ($p < 0.01$), and a 0.0177 increase in the composite index ($p < 0.01$). In contrast, contemporaneous foreign-born density is not statistically related to any access outcome in the same year. Neither workforce component is associated with having a usual source of care contemporaneously, consistent with provider attachment reflecting longer-horizon relationships and organizational capacity rather than immediate changes in workforce counts.

Lagged models sharpen this distinction. Lagged native workforce density remains associated with insurance coverage, lower cost-related barriers, and having a usual source of care. Lagged foreign-born workforce density is systematically related to access across

multiple dimensions: it is negatively associated with cost barriers ($p < 0.05$), positively associated with having a usual source of care ($p < 0.05$) and insurance coverage ($p < 0.10$), and strongly positively associated with EACI ($p < 0.01$). Taken together, Table 2 suggests a timing asymmetry: native workforce density is more visible in same-year access variation, whereas the foreign-born component is associated with broader access gains that emerge with a lag.

6.3. Access Models with Full Controls

We next examine whether baseline workforce–access relationships persist after accounting for time-varying institutional, demographic, socioeconomic, behavioral, and policy factors. We add controls for healthcare system capacity and spending, demographic composition (including age structure), educational attainment, racial/ethnic composition, health behaviors and risk factors, and Medicaid expansion status. Healthcare workforce density is lagged by one year to mitigate simultaneity concerns and align with the capacity-to-access channel. Table 3 reports the results.

Table 3. Panel Fixed-Effect Estimates of the Effects of Lagged Healthcare Workforce Density on Access to Care, with Controls.

	(1)	**(2)**	**(3)**	**(4)**
Variables	Usual Source of Care (has_doc)	Cost Barriers to Care (medcost)	Health Insurance (has_ins)	Effective Access to Care Index (EACI)
Lagged Native HCW density	0.0006 ***	−0.0005 **	0.0004	0.0064 **
	(0.0002)	(0.0002)	(0.0003)	(0.0031)
Lagged. Foreign-born HCW density	0.00021 **	−0.0007	0.0024 **	−0.0229
	(0.0002)	(0.0007)	(0.0011)	(0.0185)
Hospital beds per 1000 Population	0.0226	−0.0029	0.0129	0.2129
	(0.0162)	(0.0043)	(0.0082)	(0.1364)
CMS personal health care spending per capita ($1000)	0.0043	−0.0015	0.0025	0.0499
	(0.0106)	(0.0027)	(0.0042)	(0.0821)
% population age 65+	−0.2432 **	−0.2295	0.2264	−2.6406 ***
	(0.1038)	(0.2179)	(0.3166)	(0.3659)
% population: Female	1.0515	0.0841	−0.0863	3.2012
	(0.8442)	(0.2663)	(0.3662)	(6.7304)
Share of adults age 25+ with BA or higher (weighted)	0.3812 **	−0.1927 **	0.4085 ***	6.2247 **
	(0.1171)	(0.0889)	(0.1408)	(2.5926)
% population: White	0.2101 *	0.0676 **	0.0248 **	1.7247 *
	(0.1186)	(0.0267)	(0.0109)	(0.9059)
% population: Black	−0.6690	0.4301 ***	−0.5367 **	−10.5965 ***
	(0.4319)	(0.1372)	(0.2024)	(3.2316)
Hispanic share (ACS ethnicity category)	−1.4640 ***	−0.5442 **	0.2672	−8.2952 **
	(0.3769)	(0.0323)	(0.2484)	(3.3181)
Poverty rate (≤100% of federal line)	−0.1706	0.3334 ***	−0.3241 **	−6.0853 ***
	(0.2471)	(0.0815)	(0.1232)	(2.2115)

Table 3. *Cont.*

	(1)	(2)	(3)	(4)
Unemployment rate	0.5716	0.3446 **	−0.0061	−0.8372
	(0.4260)	(0.1675)	(0.2588)	(4.1309)
Current smoker share (BRFSS)	−0.0293	0.2136 ***	−0.0552	−2.5331 *
	(0.1756)	(0.0598)	(0.0704)	(1.2751)
Obesity (BMI â‰¥30) share (BRFSS)	0.2485	−0.0525	0.1068	2.2958
	(0.2187)	(0.0478)	(0.0827)	(1.7411)
Diagnosed diabetes share (BRFSS)	−0.2575	−0.1472	0.1446	1.2478
	(0.2718)	(0.1056)	(0.1826)	(2.9347)
Medicaid expansion in force (Dummy = 1)	−0.0049	−0.0052 **	0.0174 ***	0.1448 **
	(0.0084)	(0.0025)	(0.0040)	(0.0696)
Constant	0.4806	−0.0748	1.0050 ***	1.1713
	(0.5680)	(0.1518)	(0.2633)	(4.3999)
Dep. mean	0.8604	0.1324	0.8657	−0.0797
Obs.	713	713	713	713
Within R2	0.109	0.171	0.200	0.160
Clusters	51	51	51	51
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

All specifications include state- and year-fixed effects; standard errors are clustered at the state level. Workforce density enters lagged by one year; all controls X are included as listed in the text. Usual Source of Care corresponds to has_doc; Cost Barriers to Care to medcost; Health Insurance to has_ins; and the Effective Access to Care Index (EACI) is a standardized composite of coverage, usual source of care, and cost barriers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

With the full set of controls, lagged native healthcare workforce density remains statistically linked to selected access measures. Higher lagged native HCW density is associated with a higher probability of having a usual source of care (0.0006, $p < 0.01$), lower cost barriers (−0.0005, $p < 0.05$), and a higher EACI (0.0064, $p < 0.05$), while its effect on insurance coverage is not statistically distinguishable from zero. For the foreign-born component, lagged HCW density has a positive association with having a usual source of care (0.00021, $p < 0.05$) and insurance coverage (0.0024, $p < 0.05$), but its effects on cost barriers (−0.0007) and EACI (−0.0229) are not statistically distinguishable from zero.

Policy and structural variables account for substantial within-state variation in access. Medicaid expansion is associated with higher insurance coverage (0.0174, $p < 0.01$), lower cost barriers (−0.0052, $p < 0.05$), and a higher EACI (0.1448, $p < 0.05$). Poverty is strongly associated with worse access, including higher cost barriers (0.3334, $p < 0.01$), lower insurance coverage (−0.3241, $p < 0.05$), and substantially lower EACI (−6.0853, $p < 0.01$). A higher proportion of residents with a college education is positively associated with access across all four measures. Overall, Table 3 indicates that institutional and socioeconomic factors account for a substantial share of within-state changes in access, whereas workforce density remains a statistically significant predictor of selected access margins.

6.4. IV Estimates: Access and Health Outcomes

In Table 4, we estimate IV models relating mortality rates to the Effective Access to Care Index (EACI) to assess whether improvements in access to care translate into improved population-level health outcomes, recognizing that effective access may be endogenous to economic conditions and underlying population-level health. Identification uses Medicaid expansion, hospital beds per 1000 residents, and CMS personal health care

spending per capita (in $1000s) as instruments. Lagged total healthcare workforce density (per 1000 residents) and the full set of control variables are included in both stages, along with state and year fixed effects and state-clustered standard errors.

Table 4. Panel Fixed-Effect IV (2SLS) Estimates of the Effects of Access on Mortality Outcomes.

	(1)	**(2)**	**(3)**	**(4)**
Variables	All-Cause Mortality	Endocrine Mortality	Respiratory Mortality	External-cause Mortality
Effective Access to Care Index (EACI)	−6.6674 *	−10.1633 **	−9.6051 **	−14.2879 *
	(4.5137)	(5.4060)	(5.5901)	(8.2222)
Lagged. Total HCWs per 1000	−0.0931 *	−0.0810	−0.0555	−0.0820 **
	(0.0526)	(0.1019)	(0.0409)	(0.0479)
% population age 65+	62.7193 **	46.2057 *	99.5219 **	101.0763 **
	(31.1668)	(27.6785)	(36.2858)	(46.5688)
% population: Female	−368.4193	107.2530	−22.0167	−430.9540 *
	(247.5423)	(166.4282)	(91.3852)	(230.3230)
Share of adults with a BA or higher	−59.7517 **	−76.7087	−100.1579 *	172.3475 **
	(26.8114)	(54.0110)	(51.8717)	(82.0851)
% population: White	25.7040	−22.0785	−9.8971	45.4805
	(34.5294)	(20.8727)	(13.9188)	(29.4900)
% population: Black	−138.2223	−39.2558	−85.8400	−42.8431
	(107.8061)	(66.2911)	(67.1997)	(99.9830)
Hispanic share	−331.9147 **	27.8338	4.7795	−326.2278 ***
	(141.0012)	(76.0888)	(63.7283)	(102.3402)
Poverty rate (≤100% of federal line)	88.9002	76.0942 **	63.8749 *	196.2927 **
	(93.2679)	(38.4657)	(32.1188)	(86.5406)
Unemployment rate	201.1836 *	0.7487	−98.0407	−128.8095
	(114.1106)	(70.4521)	(59.3290)	(84.6912)
Current smoker share	18.3827 ***	39.2736 *	0.4746	−2.1273
	(7.8029)	(22.2067)	(20.9205)	(50.6842)
Obesity (BMI ≥ 30) share	124.6245 ***	71.3100 **	44.9185 *	43.7493
	(37.8531)	(29.9122)	(22.8909)	(36.2422)
Diagnosed with diabetes share	148.0442 **	54.1685	86.6992 **	14.7763
	(57.6287)	(42.4870)	(38.2856)	(61.6322)
Dep. mean	179.6553	45.4614	86.1031	74.4216
Obs.	713	713	713	713
Clusters	51	51	51	51
Root MSE	6.267	3.736	3.488	5.959
Kleibergen–Paap Wald F	3.15	3.15	3.15	3.15
Kleibergen–Paap LM *p*-value	0.0504	0.0504	0.0504	0.0504
Hansen J *p*-value	0.649	0.688	0.520	0.442

Notes: The dependent variables are state-level age-adjusted mortality rates (per 100,000 population) for all causes, endocrine diseases, respiratory diseases, and external causes. Access to care is measured by the Effective Access to Care Index (EACI) and is treated as endogenous. EACI is instrumented using Medicaid expansion in force, CMS personal health care spending per capita (in $1000s), and hospital beds per 1000 residents. Lagged healthcare workforce density is included as a control in both stages, along with demographic controls (share aged 65+, female share, college BA share, race/ethnicity shares: White, Black, Hispanic), socioeconomic controls (poverty rate, unemployment rate), and health behavior/risk controls (smoking prevalence, obesity prevalence, diabetes prevalence). All specifications include state and year fixed effects. Standard errors are clustered at the state level. Kleibergen–Paap statistics are reported to assess identification and instrument strength. Hansen's J *p*-value is reported as an overidentification test. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The constant-effect IV estimates suggest that better access to care is associated with lower mortality, on average, across the outcome categories examined. The coefficients on instrumented access to care are negative and statistically significant for all-cause mortality (-6.67, $p < 0.10$), endocrine mortality (-10.16, $p < 0.05$), respiratory mortality (-9.61, $p < 0.05$), and external-cause mortality (-14.29, $p < 0.10$). Lagged total healthcare workforce density is also negative and statistically significant for all-cause mortality (-0.093, $p < 0.10$) and external-cause mortality (-0.082, $p < 0.05$), consistent with a capacity channel operating alongside an access channel.

However, diagnostics indicate that identification is near conventional significance levels (Kleibergen–Paap LM $p = 0.0504$), and the first–stage Wald F statistic is 3.15. We therefore interpret the constant-effect IV estimates cautiously and place greater emphasis on the interaction-IV specifications and weak-instrument-robust inference reported next. Taken together, Table 4 provides suggestive evidence consistent with H2: policy-driven improvements in effective access are associated with lower mortality on average, but the modest first-stage strength cautions against treating these constant-effect estimates as definitive, motivating the interaction-IV and weak-instrument-robust results that follow.

6.5. Interaction-IV Estimates: Capacity-Conditioned Effects

The constant-effect IV models assume a single average relationship between access and mortality across states and over time. We relax this assumption by allowing the access–mortality relationship to vary with healthcare delivery capacity, reflecting the possibility that access improvements reduce mortality primarily when the delivery system can translate potential access into realized care. We therefore estimate interaction-IV models that include both EACI and an access-by-capacity term (EACI $\times$ lagged healthcare workforce density), treating both as endogenous. We use the same policy and system instruments to instrument EACI and instrument the interaction term by interacting these instruments with lagged workforce density.

Table 5 reports the interaction-IV estimates. For all-cause mortality, instrumented access to care is large, negative, and precisely estimated (-22.08, SE = 5.58, $p < 0.001$), while the interaction term is positive and statistically significant (0.4749, SE = 0.1897, $p < 0.05$). The main effect of lagged total healthcare workforce density is moderate and imprecisely estimated at -0.1279 (SE = 0.1520). Together, the negative access coefficient and positive interaction imply that the marginal association between access and all-cause mortality attenuates with workforce density.

These estimates imply that the marginal effect of access on all-cause mortality is $-22.08 + 0.4749 \times$ (lagged workforce density). The implied marginal effect changes sign at approximately 46.5 healthcare workers per 1000 residents. Thus, the access–mortality relationship is negative in lower-capacity settings and becomes positive at higher workforce densities in the fitted model, highlighting systematic heterogeneity in the relationship between access and mortality across delivery environments.

For endocrine mortality, the access coefficient is positive but not statistically significant (6.29, SE = 3.82), while the access–capacity interaction is negative and statistically significant (-0.2552, SE = 0.1282, $p = 0.047$). The implied marginal effect, $6.29 - 0.2552 \times$ (lagged workforce density), becomes negative above roughly 24.6 healthcare workers per 1000 residents, suggesting that access improvements are more protective for endocrine mortality in higher-capacity settings.

Table 5. Panel Fixed-Effect IV (2SLS) Estimates with Endogenous Interaction: Access × Lagged Healthcare Workforce Density.

	(1)	(2)	(3)	(4)
Variables	All-Cause Mortality	Endocrine Mortality	Respiratory Mortality	External-cause Mortality
Effective Access to Care Index (EACI)	−22.0799 ***	6.2927	−3.7618	−19.5063 ***
	(5.5795)	(3.8212)	(2.6134)	(4.6162)
Lagged Total HCWs Density	−0.1279	−0.0047	−0.0235	−0.1118
	(0.1520)	(0.1183)	(0.0995)	(0.1497)
EACI x Lagged HCW Density	0.4749 **	−0.2552 **	−0.1017	0.6636 ***
	(0.1897)	(0.1282)	(0.0998)	(0.1468)
% population age 65+	129.6761	−35.9462	−107.5288 *	188.8279 *
	(111.0022)	(76.0028)	(57.9366)	(105.3161)
% population: Female	−103.8797	−34.7776	−78.5156	−61.4492
	(199.9539)	(153.2758)	(86.6641)	(148.9860)
Share of adults with a BA or higher	−1.8654	−48.6733	−92.1138 **	90.9743 **
	(65.2564)	(39.8756)	(39.0986)	(43.2456)
% population: White	−12.1338	−3.3066	−3.3801	−5.9360
	(30.6581)	(13.7096)	(13.4694)	(18.4966)
% population: Black	−293.2995 ***	36.3908	−60.4375	−252.3729 ***
	(72.6802)	(46.9715)	(47.6435)	(58.2131)
Hispanic share	−193.8506	−39.1230	−17.4399	−140.0484 *
	(128.1534)	(55.8816)	(51.3863)	(74.9639)
Poverty rate (≤100% of federal line)	14.0867	−40.1685	−52.1961 *	95.7381 **
	(55.6752)	(37.2436)	(29.5846)	(41.0692)
Unemployment rate	−234.1318 **	16.7530	−92.7124	−173.2638 **
	(114.8215)	(62.2774)	(59.3976)	(75.1697)
Current smoker share	35.9386 *	−26.6388	4.1704	38.6087 **
	(17.2588)	(20.4297)	(16.9503)	(14.8922)
Obesity (BMI ≥ 30) share	145.6104 ***	62.0655 **	42.4868 **	71.1813 ***
	(40.3718)	(24.1093)	(19.0901)	(25.6495)
Diagnosed with diabetes share	170.5204 ***	43.8674	83.6894 **	44.5284
	(55.4476)	(37.3031)	(35.8232)	(44.7114)
Dep. mean	179.6553	45.4614	86.1031	74.4216
Obs.	713	713	713	713
Clusters	51	51	51	51
Root MSE	6.093	3.399	3.395	4.612
Kleibergen–Paap Wald F	4.35	4.35	4.35	4.35
Kleibergen–Paap LM *p*-value	0.0095	0.0095	0.0095	0.0095
Hansen J *p*-value	0.512	0.147	0.212	0.384
Anderon-Rubin (AR) Test (F)	5.56 ***	5.56 ***	5.56 ***	5.56 ***
Stock–Wright LM test (Chi-Square)	21.30 ***	21.30 ***	21.30 ***	21.30 ***

Notes: The dependent variables are state-level age-adjusted mortality rates (per 100,000 population) for all causes, endocrine diseases, respiratory diseases, and external causes. Access to care is measured by the Effective Access to Care Index (EACI). Both EACI and its interaction with lagged healthcare workforce density are treated as endogenous regressors. EACI is instrumented using Medicaid expansion in force, CMS personal health care spending per capita (in $1000s), and hospital beds per 1000 residents; the interaction term is instrumented using these same instruments interacted with lagged healthcare workforce density. All other controls, fixed effects, clustering, and variable definitions are as described in the notes to Table 4. Anderson–Rubin and Stock–Wright tests are reported for weak-instrument-robust inference. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

For respiratory mortality, neither instrumented access (−3.76, SE = 2.61) nor the interaction term (−0.1017, SE = 0.0998) is statistically distinguishable from zero, indicating

no detectable capacity-conditioned relationship in these specifications. For external-cause mortality, the interaction-IV estimates again show strong heterogeneity: instrumented access is large and negative (−19.51, SE = 4.62, $p < 0.001$), while the interaction term is positive and highly significant (0.6636, SE = 0.1468, $p < 0.001$), implying a change in sign at approximately 29.4 healthcare workers per 1000 residents.

Interaction-IV models can be sensitive to instrument strength, so we supplement conventional inference with weak-instrument-robust procedures. Identification tests reject under-identification (Kleibergen–Paap LM $p = 0.0095$), while first-stage strength remains moderate (Kleibergen–Paap Wald F = 4.35). Overidentification tests do not reject instrument validity (Hansen J p-values range from 0.147 to 0.512). Weak-instrument-robust tests reject the joint null hypothesis that instrumented access and its interaction with workforce capacity have no effect across the regressions (Anderson–Rubin F = 5.56, $p < 0.001$; Stock–Wright $\chi^2 = 21.30$, $p < 0.001$), supporting the interpretation that observed heterogeneity is unlikely to be driven solely by weak first-stage variation.

Overall, the interaction-IV evidence provides direct support for H3: the health effects of improved access vary systematically with healthcare workforce capacity. In lower-capacity settings, access gains are associated with larger mortality reductions; as workforce density increases, the implied marginal association attenuates and, in some cases, changes sign. This pattern is consistent with a capacity-constrained access mechanism in which policy-driven improvements in effective access translate into population health gains in different ways across delivery environments.

7. Conclusions and Implications

This study examines how healthcare workforce capacity shapes the relationship between access to care and health outcomes across U.S. states from 2006 to 2023. Using state-level panel data, fixed-effect models, and an instrumental-variables strategy that exploits policy- and system-level variation, we show that access expansions do not operate uniformly across delivery environments. Instead, the health implications of access depend critically on whether the healthcare system can translate potential access into timely, delivered care under capacity constraints.

Three findings stand out. First, access is inherently multidimensional. In reduced-form models, healthcare workforce density is associated with improvements in insurance coverage and affordability, but not with having a usual source of care. Once institutional, socioeconomic, and policy factors are accounted for, the workforce–access relationships attenuate and become more selective across access margins. Medicaid expansion and poverty emerge as dominant determinants of access to care, whereas lagged workforce capacity remains statistically associated with selected access measures. These results underscore that coverage and affordability are shaped significantly by policy design and economic conditions, even when delivery capacity continues to matter for specific margins of access.

Second, exogenous improvements in access do not translate into a uniform mortality response when access is modeled with a constant effect. IV estimates indicate that policy-driven increases in effective access to care are, on average, associated with lower mortality across the categories examined. However, first-stage strength is moderate in some specifications, and inference warrants care. This finding reinforces a key distinction between potential access and realized care: lowering financial barriers may increase incentives to seek care, but it does not ensure continuity, timeliness, or clinical throughput. Mortality outcomes remain shaped by underlying risk burdens and by the delivery system's ability to convert increased demand into effective treatment.

Third, allowing the effect of access to vary with healthcare workforce capacity reconciles these patterns. Interaction-IV results provide direct evidence that workforce capacity conditions the relationship between access and health outcomes. The marginal association between access and mortality varies systematically with workforce density: it attenuates at higher density levels and can change sign across delivery environments, highlighting heterogeneity in how potential access translates into realized care. Cause-specific results further indicate that capacity-conditioning differs across outcomes, suggesting that some conditions are more sensitive than others to the interaction between access and delivery capacity.

These findings have clear implications for health policy. Current debates over insurance subsidy extensions, affordability reforms, and coverage expansions often treat financial access as the primary lever for improving population health. The evidence here suggests that such policies are likely to increase coverage and reduce cost barriers. However, their effect on health outcomes depends on whether healthcare delivery systems can accommodate the resulting demand and translate potential access into timely care.

From a policy perspective, access-oriented reforms and workforce investments should be viewed as complements rather than substitutes. Expanding coverage may be necessary to improve population-level health, but it may not be sufficient without adequate healthcare workforce capacity and complementary delivery infrastructure. Aligning insurance expansions with policies that strengthen the healthcare workforce is, therefore, critical to ensuring that gains in access translate into meaningful and sustained health improvements.

Several limitations should be acknowledged. The state-year design is well-suited to identifying system-level heterogeneity in how access relates to health outcomes, but it does not directly observe individual mechanisms or within-state disparities. Measures of access (including the EACI) capture potential access and do not fully reflect the timeliness and quality of delivered care or non-financial dimensions of access (e.g., physical, cultural, and behavioral barriers). Moreover, prior evidence suggests that utilization and self-reported health can respond more quickly to coverage expansions than mortality outcomes [21], motivating attention to intermediate outcomes that may register earlier responses. The IV strategy leverages policy- and system-level variation, and first-stage strength is moderate in some specifications; accordingly, the results should be interpreted as evidence of capacity-conditioned effects rather than as precise point estimates.

Future research should test these mechanisms using outcomes that precede mortality, such as morbidity and preventable hospitalizations, as well as measures of timeliness and quality of care. It should also examine sub-state heterogeneity (urban–rural differences and within-state disparities) and incorporate more granular capacity measures beyond workforce density, such as specialty mix, provider turnover, clinic and hospital throughput, referral networks, and organizational efficiency. These extensions may help clarify the conditions under which workforce capacity and access reforms are most likely to produce meaningful and sustained health improvements.

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System (BRFSS) (https://www.cdc.gov/brfss (accessed on 5 December 2025)); the U.S. Census Bureau American Community Survey (ACS) Public Use Microdata Sample (PUMS) (https://www.census.gov/programs-surveys/acs/microdata.html (accessed on 5 December 2025)); CDC WONDER Multiple Cause of Death mortality data (https://wonder.cdc.gov (accessed on 5 December 2025)); KFF Medicaid expansion status (https://www.kff.org/medicaid/status-of-state-medicaid-expansion-decisions/ (accessed on 5 December 2025)); the HRSA Area Health Resources File (AHRF) (https://data.hrsa.gov/topics/health-workforce/ahrf (accessed on 5 December 2025)); and CMS National Health Expenditure Accounts (https://www.cms.gov/data-research/statistics-trends-and-reports/national-health-expenditure-data (accessed on 5 December 2025)).

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Appendix A

Table A1. Descriptive Statistics and Definitions for State-Level Health Outcomes, Effective Access Measures, Healthcare Workforce Density, and Control Variables Used in Panel and Instrumental-Variable Analyses (2006–2023).

Category/ Variable	Mean	Std. Dev	Min	Max	N	Source (URL)	Definition
Health Outcome Measures:							
Age-adjusted mortality rate (All causes)	288.99	252.12	120.20	1229.10	918	https://wonder.cdc.gov/mcd.html (accessed on 5 December 2025)	State-level age-adjusted all-cause mortality rate per 100,000 population, state-year.
Age-adjusted mortality rate (Endocrine)	45.01	9.00	24.60	91.60	918	https://wonder.cdc.gov/mcd.html (accessed on 5 December 2025)	State-level age-adjusted mortality rate from endocrine diseases per 100,000 population, state-year.
Age-adjusted mortality rate (Respiratory)	82.55	17.11	38.90	128.80	918	https://wonder.cdc.gov/mcd.html (accessed on 5 December 2025)	State-level age-adjusted mortality rate from respiratory diseases per 100,000 population, state-year.
Age-adjusted mortality rate (External causes)	77.79	19.43	33.00	166.00	918	https://wonder.cdc.gov/mcd.html (accessed on 5 December 2025)	State-level age-adjusted mortality rate from external causes per 100,000 population, state-year.
Treatment Variables: (A) Access to Care Measures:							
Effective Access to Care Index (EACI), z-score mean	0.24	0.17	0.12	0.34	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Effective Access to Care Index (EACI): a standardized composite measure combining coverage, usual source of care, and cost barriers; higher values indicate better effective access.

Table A1. *Cont.*

Category/ Variable	Mean	Std. Dev	Min	Max	N	Source (URL)	Definition
Share of adults with personal doctor (%)	0.85	0.07	0.53	0.96	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population reporting a usual source of care or personal healthcare provider, state-year.
Share of adults w/ health insurance (%)	0.87	0.05	0.69	0.97	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population with any form of health insurance coverage, state-year.
Could not afford needed care (%)	0.12	0.03	0.05	0.23	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population reporting that cost prevented during the past 12 months.
EACI x Lagged HCW density	4.19	32.31	−106.62	80.39	863	https://www.cdc.gov/brfss/ (accessed on 5 December 2025); https://usa.ipums.org/usa/ (accessed on 5 December 2025)	Interaction between the Effective Access to Care Index (EACI) and lagged healthcare workforce density, capturing capacity-conditioned effects of access.
(B) Healthcare Workforce Capacity							
Total HCWs per 1000 population	40.94	6.99	21.92	62.85	918	https://usa.ipums.org/usa/ (accessed on 5 December 2025)	Total healthcare workforce density per 1000 residents, state-year.
Native-born HCWs per 1000 population	35.72	7.34	15.08	58.06	918	https://usa.ipums.org/usa/ (accessed on 5 December 2025)	Number of native-born healthcare workers per 1000 residents, state-year.
Foreign-born HCWs per 1000 population	5.22	4.02	0.21	23.44	918	https://usa.ipums.org/usa/ (accessed on 5 December 2025)	Number of immigrant (foreign-born) healthcare workers per 1000 residents, state-year.
Lagged total HCW density per 1000 residents	40.50	6.82	21.92	62.85	867	https://usa.ipums.org/usa/ (accessed on 5 December 2025)	One-year lagged total healthcare workforce density per 1000 residents.
Lagged native HCW density per 1000 residents	35.39	7.23	15.08	58.06	867	https://usa.ipums.org/usa/ (accessed on 5 December 2025)	One-year lagged number of native-born healthcare workers per 1000 residents.
Lagged foreign-born HCW density per 1000 residents	5.11	3.95	0.21	21.94	867	https://usa.ipums.org/usa/ (accessed on 5 December 2025)	One-year lagged number of immigrant (foreign-born) healthcare workers per 1000 residents.
Control Factors:							
Share of adults age 25+ with a BA or higher	0.30	0.06	0.16	0.66	918	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of adults with a bachelor's degree or higher, state-year.

Table A1. *Cont.*

Category/ Variable	Mean	Std. Dev	Min	Max	N	Source (URL)	Definition
% population age 65+	0.15	0.02	0.06	0.22	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population aged 65 years and older, state-year.
% population: White	0.74	0.14	0.22	0.96	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population identifying as White, state-year.
% population: Black	0.11	0.10	0.02	0.55	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population identifying as Black, state-year.
% Hispanic	0.06	0.08	0.02	0.33	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population identifying as Hispanic, state-year.
% population: Female	0.50	0.01	0.46	0.53	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Share of the population that is female, state-year.
Diagnosed with diabetes, share	0.09	0.02	0.05	0.18	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Prevalence of diagnosed diabetes among adults, state-year.
Obesity (BMI $\geq$ 30) share	0.29	0.04	0.18	0.43	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Prevalence of adult obesity (BMI $\geq$ 30), given state-year.
Current smoker share	0.17	0.04	0.05	0.28	914	https://www.cdc.gov/brfss/ (accessed on 5 December 2025)	Prevalence of current smoking among adults, state-year.
Poverty rate <=100% of the federal line	0.14	0.03	0.07	0.25	918	https://usa.ipums.org/usa/ (accessed on 5 December 2025)	Share of the population living at or below the federal poverty line, state-year.
Unemployment rate	0.03	0.01	0.01	0.07	918	https://www.bls.gov/lau/ (accessed on 5 December 2025)	State-level unemployment rate, state-year.
Instrumental Variables:							
Hospital beds per 1000 population	3.24	1.01	1.88	9.15	867	https://data.hrsa.gov/topics/health-workforce/ahrf (accessed on 5 December 2025)	Number of hospital beds per 1000 residents, state-year.

Table A1. *Cont.*

Category/ Variable	Mean	Std. Dev	Min	Max	N	Source (URL)	Definition
CMS personal health care spending per capita ($1000s)	8.12	1.76	4.63	14.38	765	https://www.cms.gov/data-research/statistics-trends-and-reports/national-health-expenditure-data/state-residence (accessed on 5 December 2025)	CMS personal health care spending per capita across all payers (in thousands of dollars), state-year.
Medicaid expansion in force (Dummy = 1; 0 otherwise)	0.37	0.48	0.00	1.00	918	https://www.kff.org/medicaid/issue-brief/status-of-state-medicaid-expansion-decisions-interactive-map/ (accessed on 5 December 2025)	Dummy variable equal to 1 if Medicaid expansion under the Affordable Care Act is in force, state-year, and 0 otherwise.

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