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From the Selected Works of Glen Mays

Summer June 5, 2013

Public Health Delivery Systems and Population Health

Glen Mays, *University of Kentucky*



Available at: https://works.bepress.com/glen_mays/97/

Public Health Delivery Systems and Population Health

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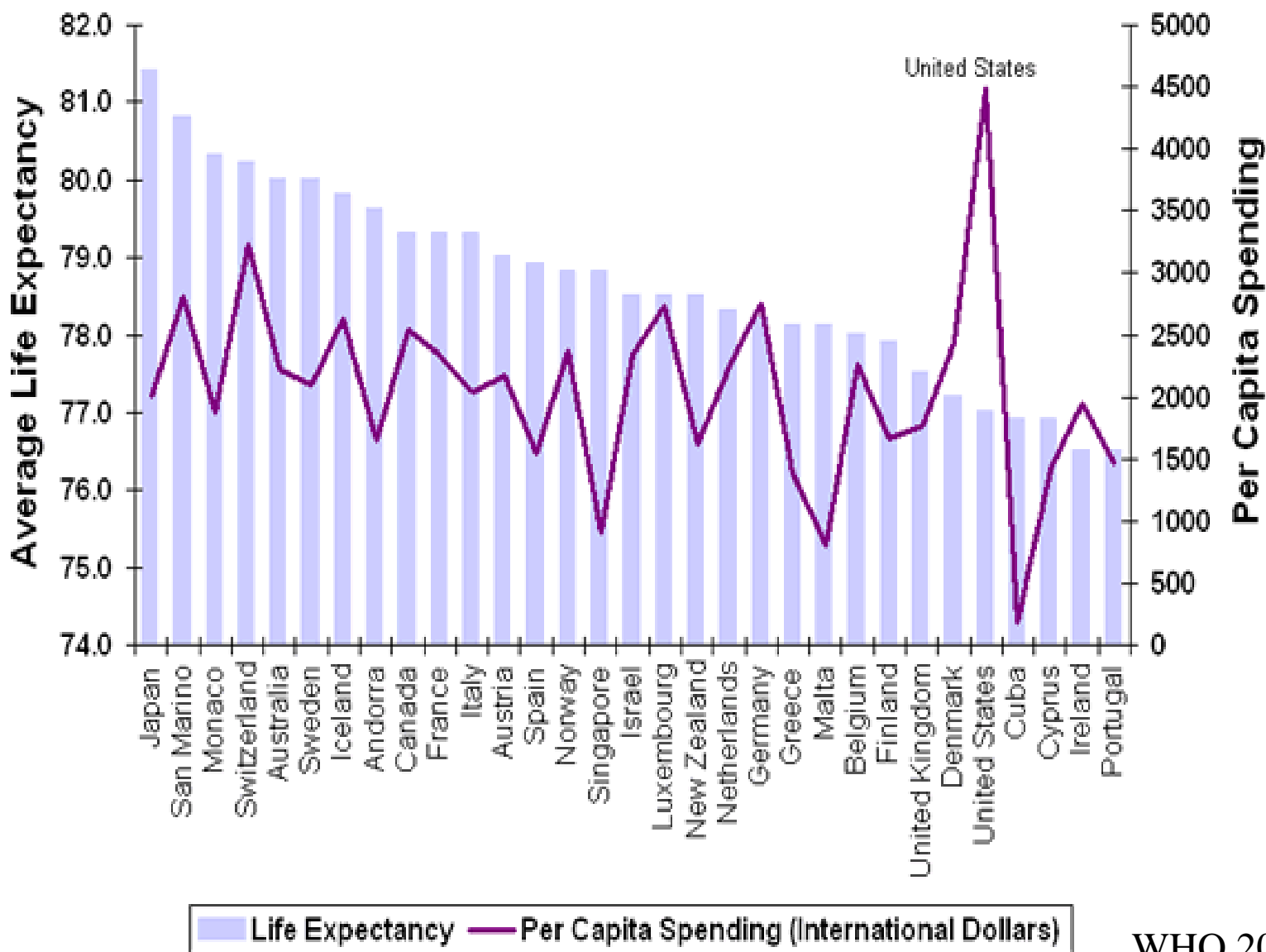
glen.mays@uky.edu



Issues to examine today

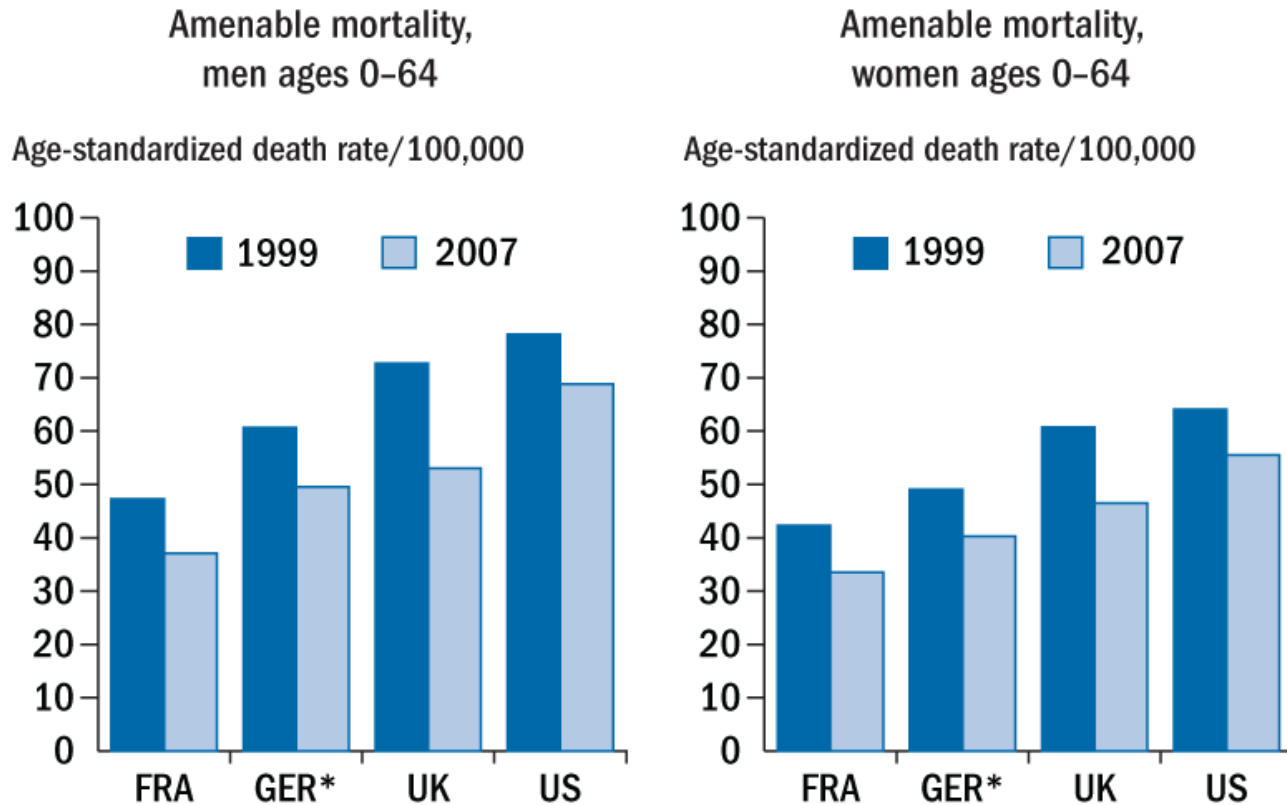
- What are public health activities and what roles do they play in the larger U.S. health system?
- How and how well are they delivered in the U.S.?
- What are the health and economic effects attributable to public health delivery?
- What strategies may work to improve public health delivery?

Fundamental health system performance



Preventable mortality in the U.S. & peers

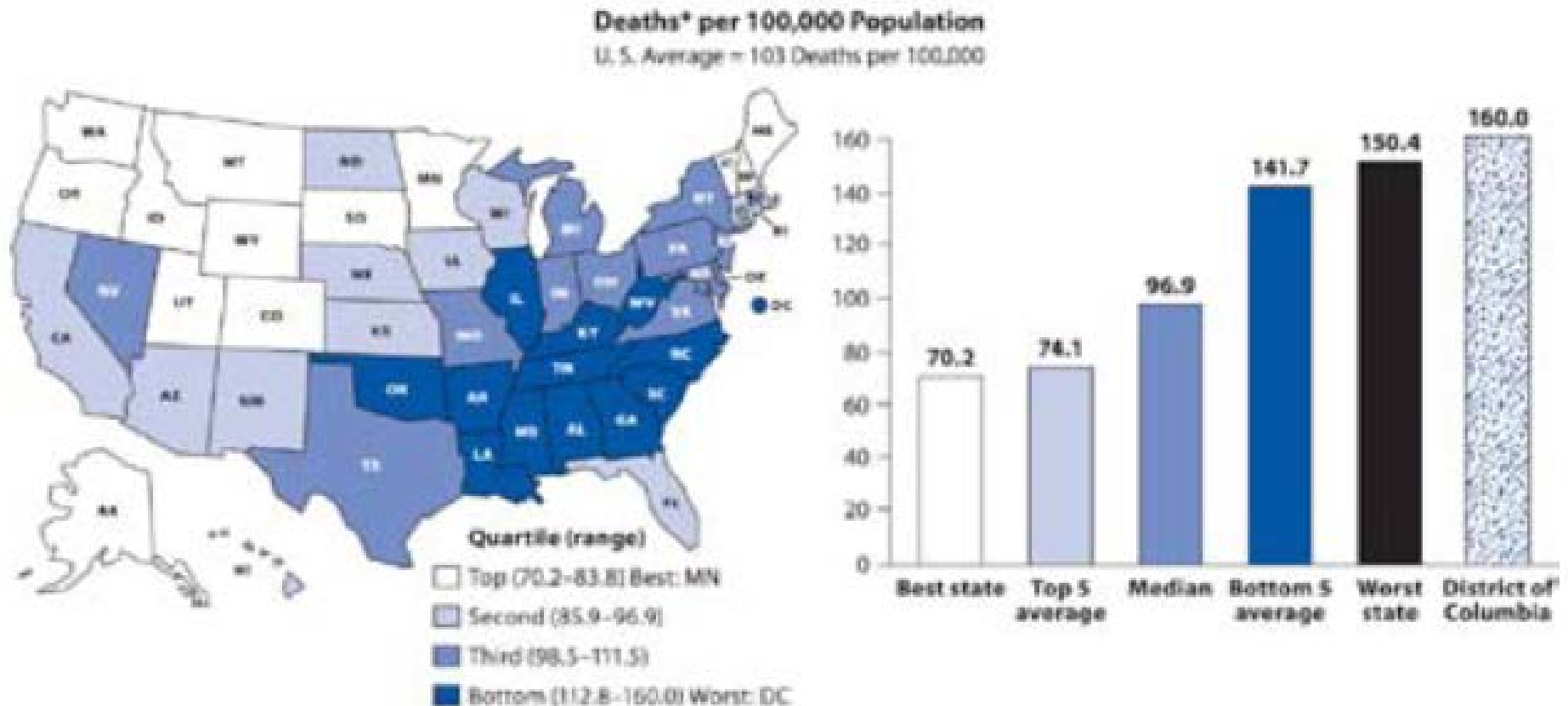
U.S. Men and Women Under Age 65 Have Higher Rates of Potentially Preventable Deaths Slowest Rate of Improvement, 1999–2007



* Data for Germany are 1999 and 2006.

Source: Adapted from E. Nolte and C. M. McKee, "In Amenable Mortality—Deaths Avoidable Through Health Care—Progress in the US Lags That of Three European Countries," *Health Affairs*, published online Aug. 29, 2012.

Geographic variation in population health



Preventable disease burden and national health spending

>75% of national health spending is attributable to conditions that are largely preventable

- Cardiovascular disease
- Diabetes
- Lung diseases
- Cancer
- Injuries
- Vaccine-preventable diseases and sexually transmitted infections

<5% of national health spending is allocated to public health and prevention

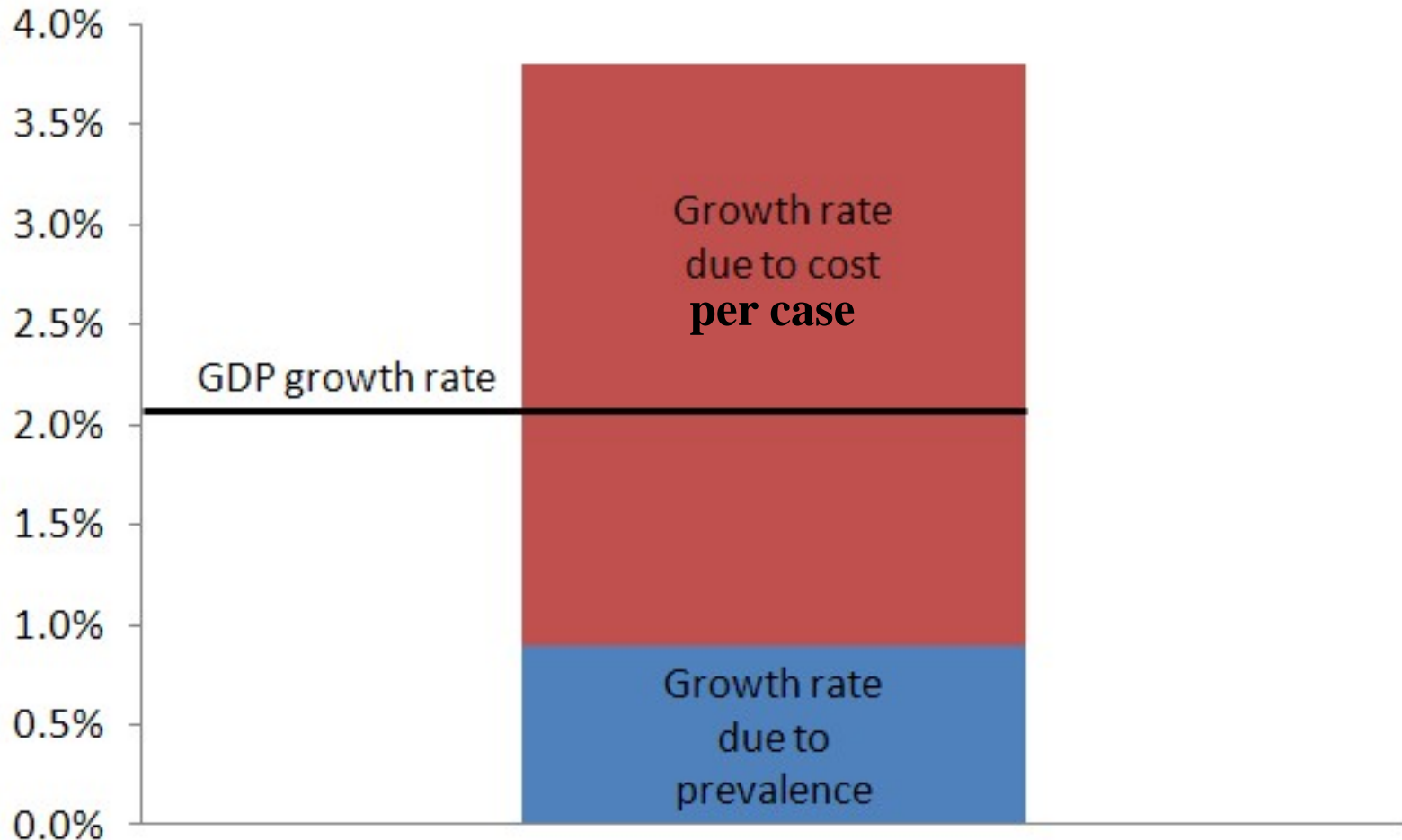
Public health activities

Organized programs, policies, and laws to prevent disease and injury and promote health on a population-wide basis

- Epidemiologic surveillance & investigation
- Community health assessment & planning
- Communicable disease control
- Chronic disease and injury prevention interventions
- Health education and communication
- Environmental health monitoring and assessment
- Enforcement of health laws and regulations
- Inspection and licensing: food, facilities, services
- Inform, advise, and assist school-based, worksite-based, and community-based health programming
- ...and roles in assuring access to medical care

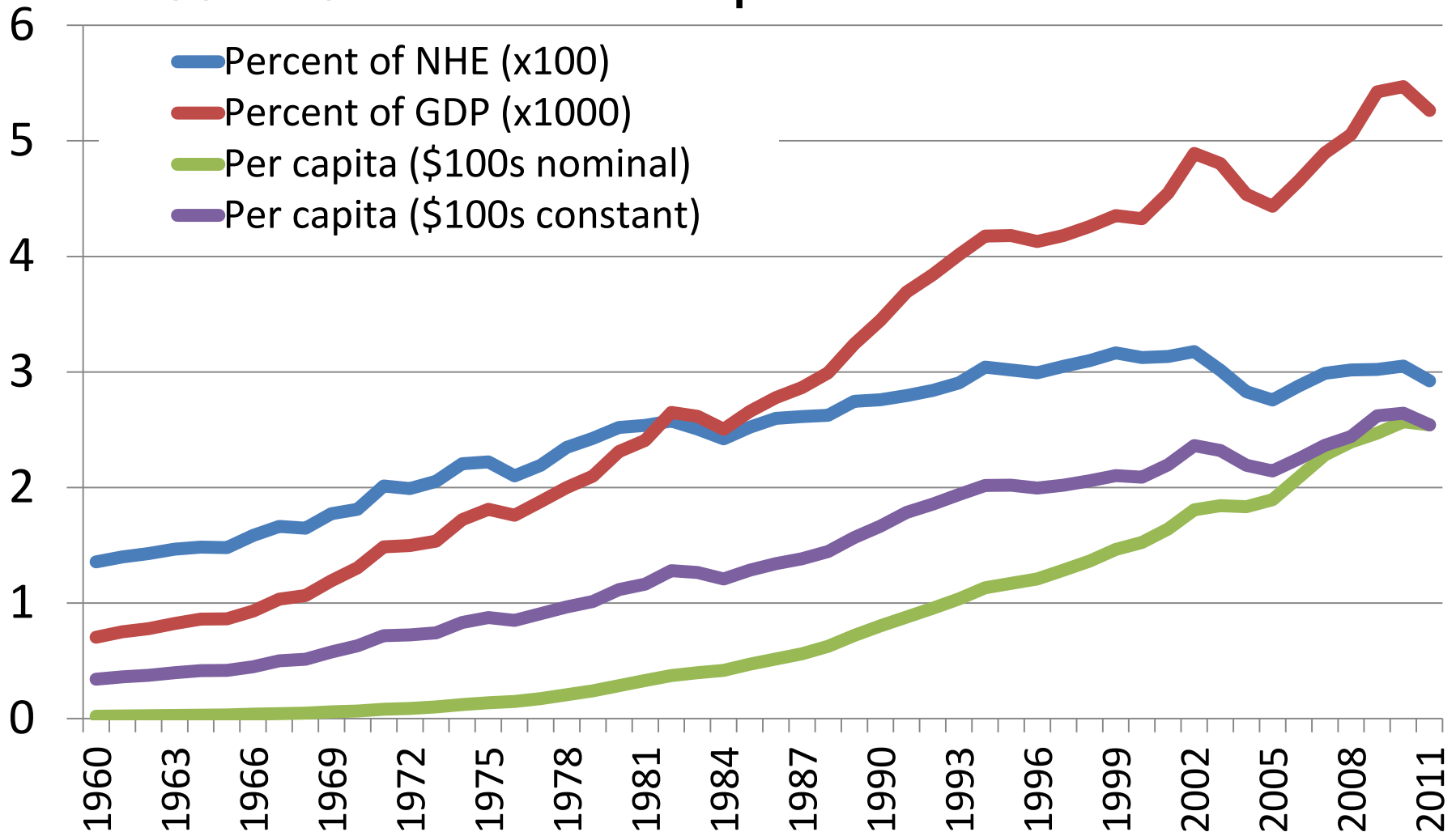
Factors driving growth in medical spending

Health spending growth rate 1996-2006



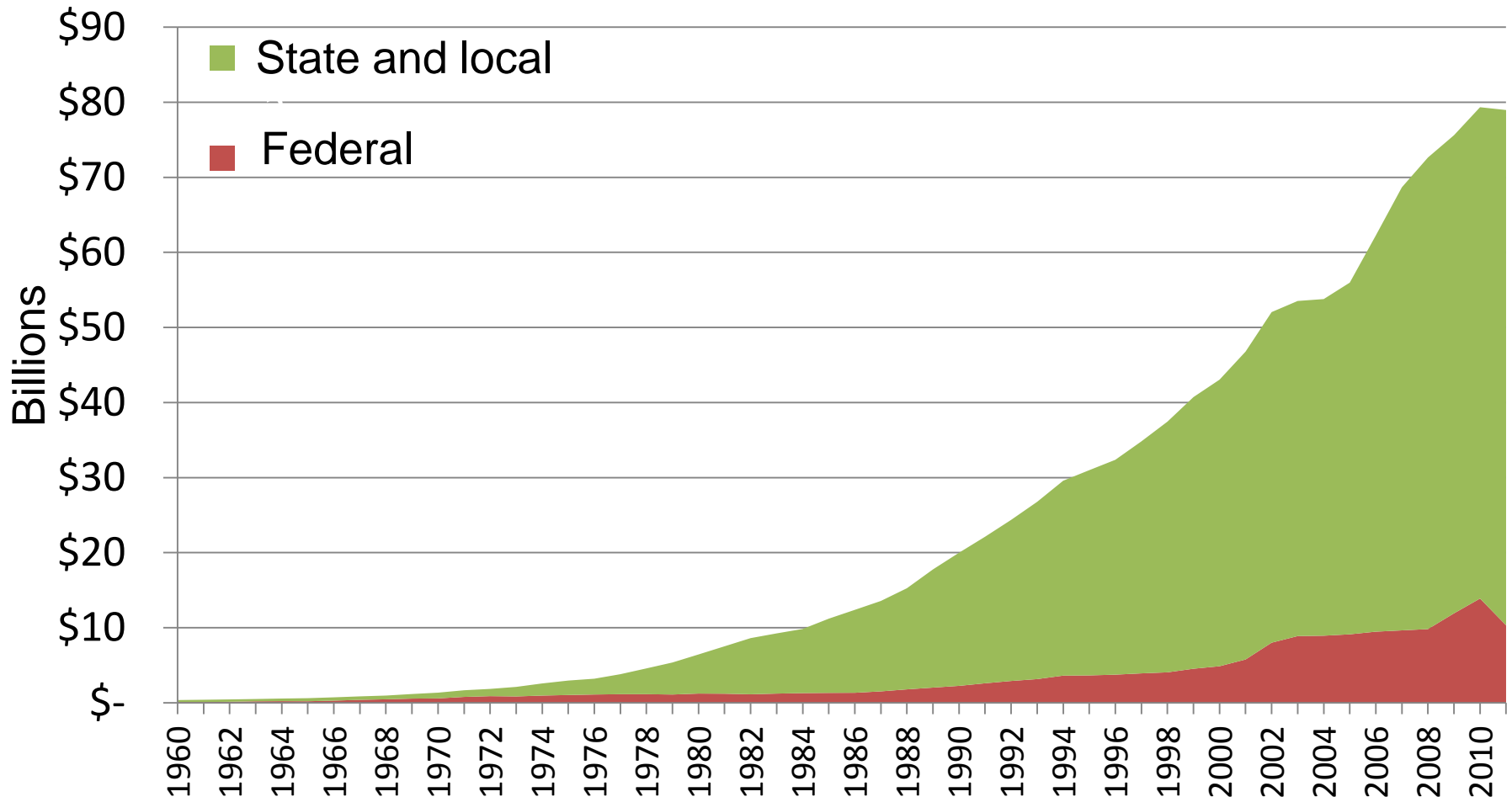
Public health spending in the U.S.

Governmental Expenditures for Public Health Activity, USDHHS National Health Expenditure Accounts



Who pays for public health?

Governmental Expenditures for Public Health Activity, USDHHS National Health Expenditure Accounts



Challenges in public health delivery

- Lack of clear, coherent mission and expectations
- Complex, fragmented, variable financing and delivery systems
- Resources \neq preventable disease burden
- Large inequities in resources & capacity
- Variable productivity and efficiency
- Gaps in evidence base for public health delivery
- Inability to demonstrate value/return on investment

Public Health in the Affordable Care Act

- ◆ \$15 billion in new federal public health spending over 10 years (cut by \$5B in 2012)
- ◆ Public Health and Prevention Trust Fund
- ◆ Incentives for hospitals, health insurers to invest in public health and prevention

Public Health in the Affordable Care Act

Subtitle D—Support for Prevention and Public Health Innovation

Patient Protection and Affordable Care Act of 2010

SEC. 4301. RESEARCH ON OPTIMIZING THE DELIVERY OF PUBLIC HEALTH SERVICES.

(a) IN GENERAL.—The Secretary of Health and Human Services (referred to in this section as the “Secretary”), acting through the Director of the Centers for Disease Control and Prevention, shall provide funding for research in the area of public health services and systems.

(b) REQUIREMENTS OF RESEARCH.—Research supported under this section shall include—

(1) examining evidence-based practices relating to prevention, with a particular focus on high priority areas as identified by the Secretary in the National Prevention Strategy or Healthy People 2020, and including comparing community-based public health interventions in terms of effectiveness and cost;

(2) analyzing the translation of interventions from academic settings to real world settings; and

(3) identifying effective strategies for organizing, financing, or delivering public health services in real world community settings, including comparing State and local health department structures and systems in terms of effectiveness and cost.

2012 Institute of Medicine Recommendations

- ◆ Double current federal spending on public health
- ◆ Identify components and costs of a “minimum package” of public health activities
- ◆ Allow greater flexibility in how states and localities use federal public health funds
- ◆ Implement national chart of accounts for tracking spending levels and flow of funds
- ◆ Expand research on costs and effects of public health delivery

Institute of Medicine. For the Public's Health: Investing in a Healthier Future. Washington, DC: National Academies Press; 2012.



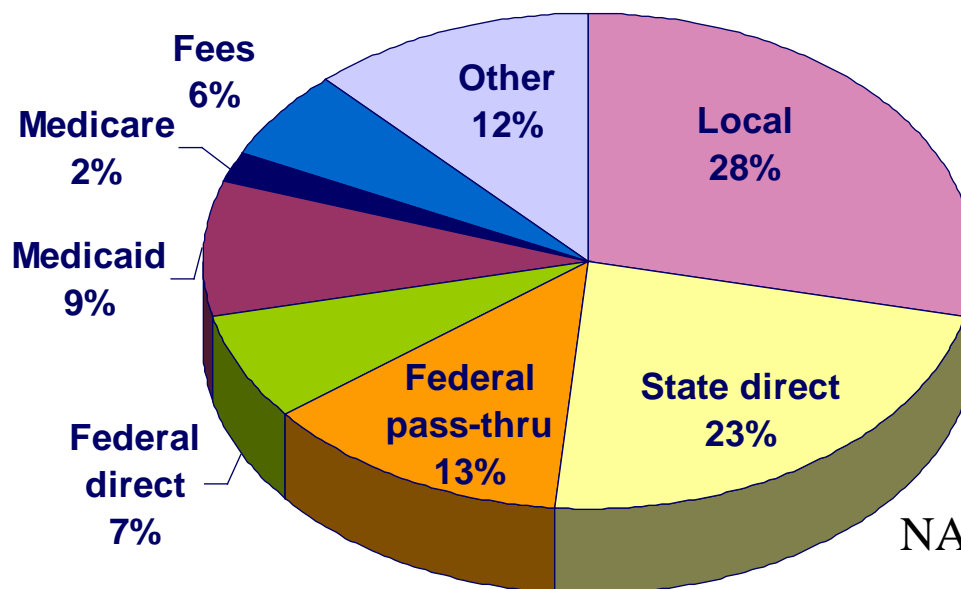
Some research questions of interest...

- ◆ How does *public health* spending vary across communities and change over time?
- ◆ What are the health effects attributable to changes in public health spending?
- ◆ What are the medical cost effects attributable to changes in public health spending?

The problem with public health financing

- ◆ Federal & state funding sources often targeted to communities based in part on disease burden, risk, need
- ◆ Local funding sources often dependent on local economic conditions that may also influence health
- ◆ Public health spending may be correlated with other resources that influence health

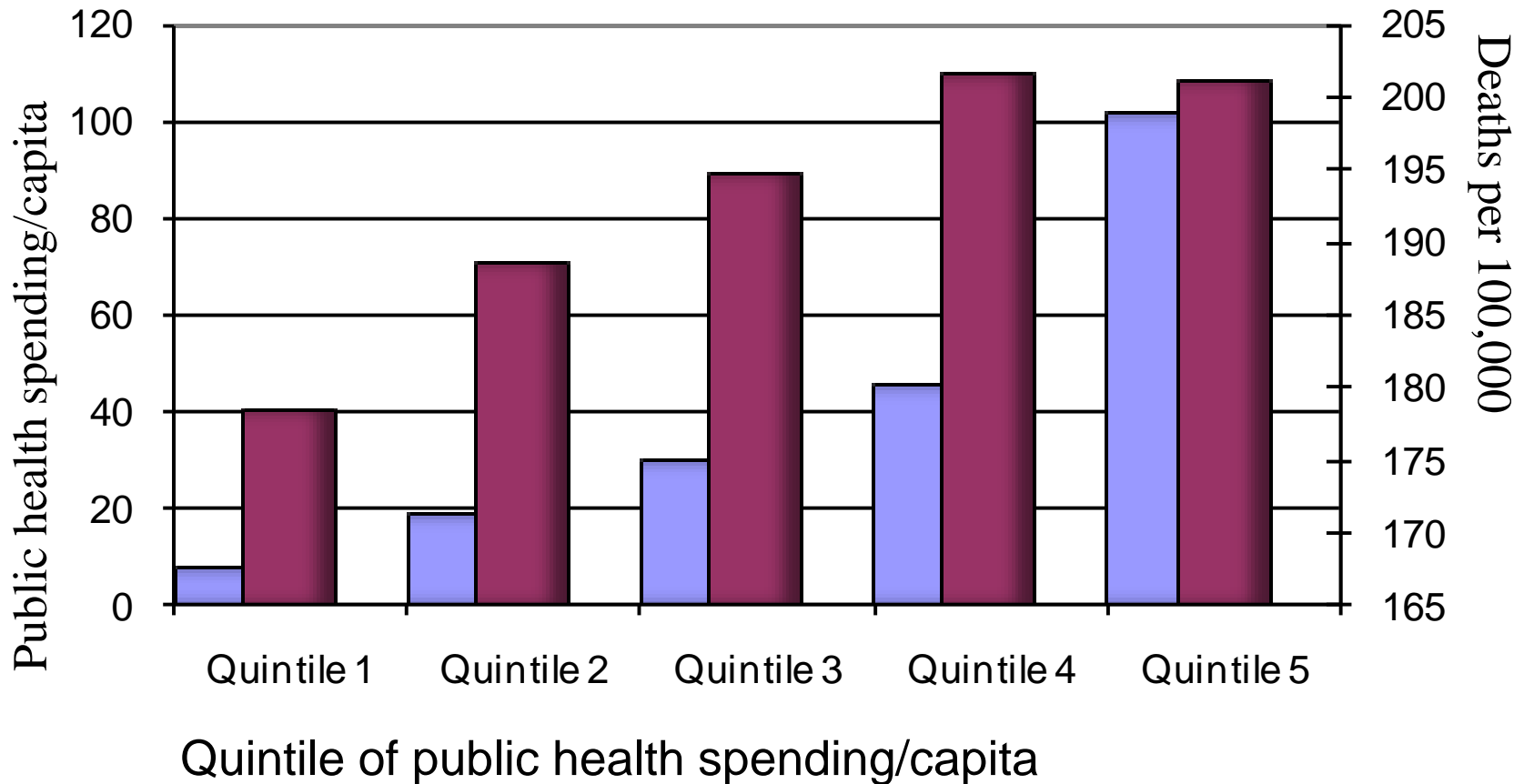
Sources of Local Public Health Agency Revenue, 2005



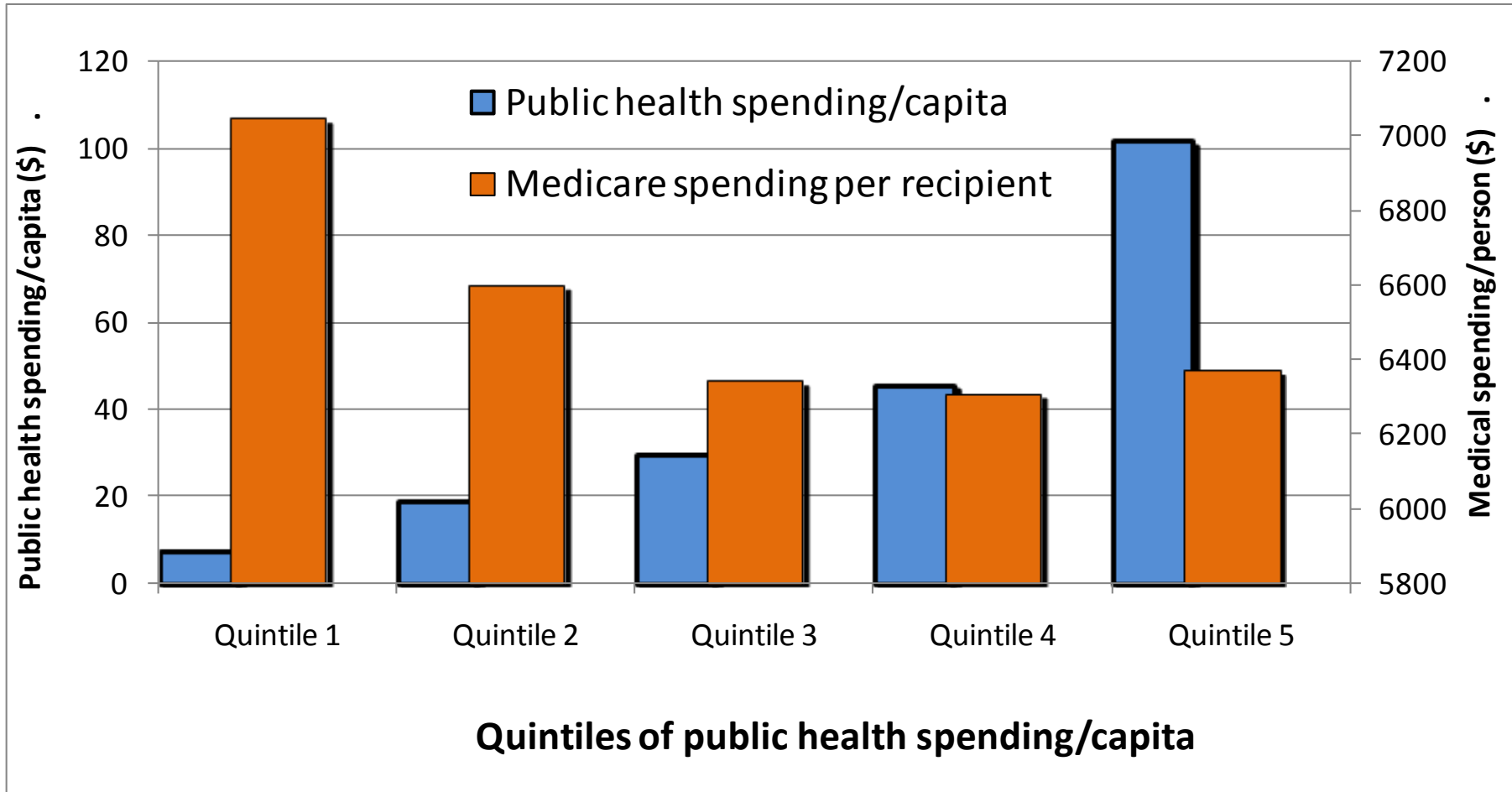
NACCHO 2005

Example: cross-sectional association between PH spending and mortality

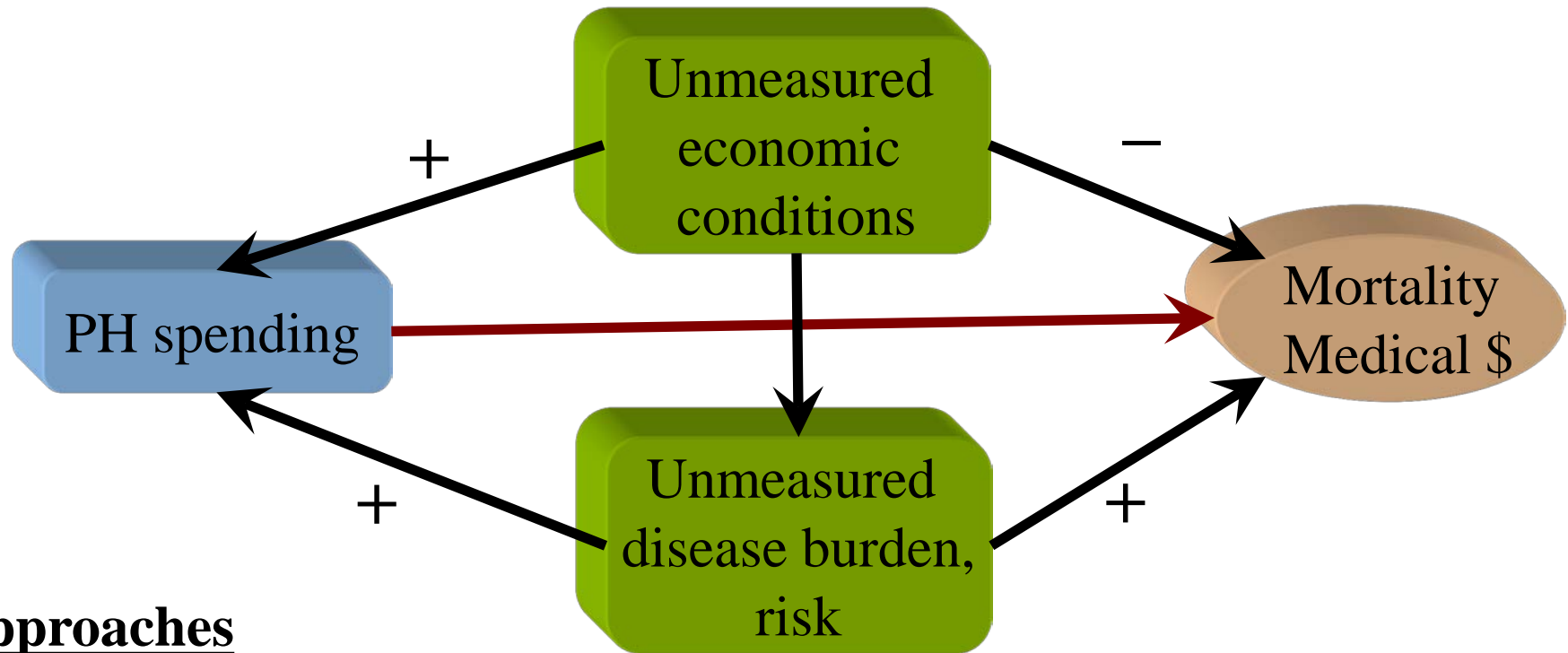
Public health spending/capita
Heart disease mortality



Example: cross-sectional association between PH spending and Medical spending



Estimating public health spending effects



Approaches

1. Cross-sectional regression: control for **observable** confounders
2. Fixed effects: also control for **time-invariant**, **unmeasured** differences between communities
3. IV: use exogenous sources of variation in spending
4. Discriminate between causes of death amenable vs. non-amenable to PH intervention

Data used in empirical work

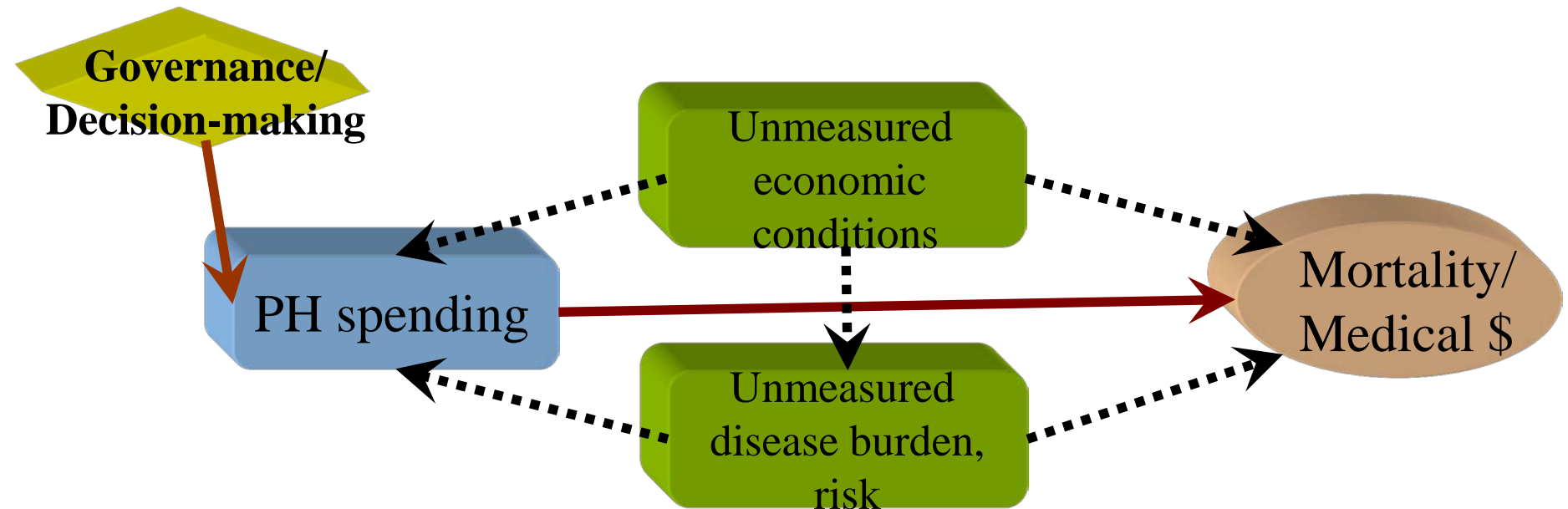
- ◆ NACCHO Profile: financial and institutional data collected on the national population of **local public health agencies** (N≈2800) in 1993, 1997, 2005, 2008, 2010
- ◆ Residual state and federal spending estimates from US Census of Governments and Consolidated Federal Funding Report
- ◆ Community characteristics obtained from Census and Area Resource File (ARF)
- ◆ Community mortality data obtained from CDC's Compressed Mortality File
- ◆ **HSA-level** medical care spending data from CMS and Dartmouth Atlas (Medicare claims data)

Analytical approach

- ◆ Dependent variables
 - Age-adjusted mortality rates, conditions sensitive to public health interventions
 - Medical care spending per recipient (Medicare as proxy)
- ◆ Independent variables of interest
 - Local PH spending per capita, all sources
 - Residual state spending per capita (funds not passed thru to local agencies)
 - Residual federal spending per capita
- ◆ Analytic strategy for panel data: 1993-2008
 - Fixed effects estimation
 - Random effects with instrumental variables (IV)

Analytical approach: IV estimation

- ◆ Identify exogenous sources of variation in spending that are unrelated to outcomes
 - Governance structures: local boards of health
 - Decision-making authority: agency, board, local, state
- ◆ Controls for unmeasured factors that jointly influence spending and outcomes



Analytical approach

- ◆ Semi-logarithmic multivariate regression models used to test associations between spending, service delivery, and outcomes while controlling for other factors

$$\text{Ln}(\text{PH\$}_{ijt}) = \beta \text{Agency}_{ijt} + \delta \text{Community}_{ijt} + \lambda \text{State}_{jt} + \mu_j + \varphi_t + \varepsilon_{ijt}$$

$$\text{Ln}(\text{Mortality}_{ijt}) = \alpha \text{Ln}(\text{PH\$}_{ijt-1}) + \beta \text{Agency}_{ijt} + \delta \text{Community}_{ijt} + \lambda \text{State}_{jt-1} + \mu_j + \varphi_t + \varepsilon_{ijt}$$

$$\text{Ln}(\text{Medical\$}_{ijt}) = \alpha \text{Ln}(\text{PH\$}_{ijt-1}) + \beta \text{Agency}_{ijt} + \delta \text{Community}_{ijt} + \lambda \text{State}_{jt-1} + \mu_j + \varphi_t + \varepsilon_{ijt}$$

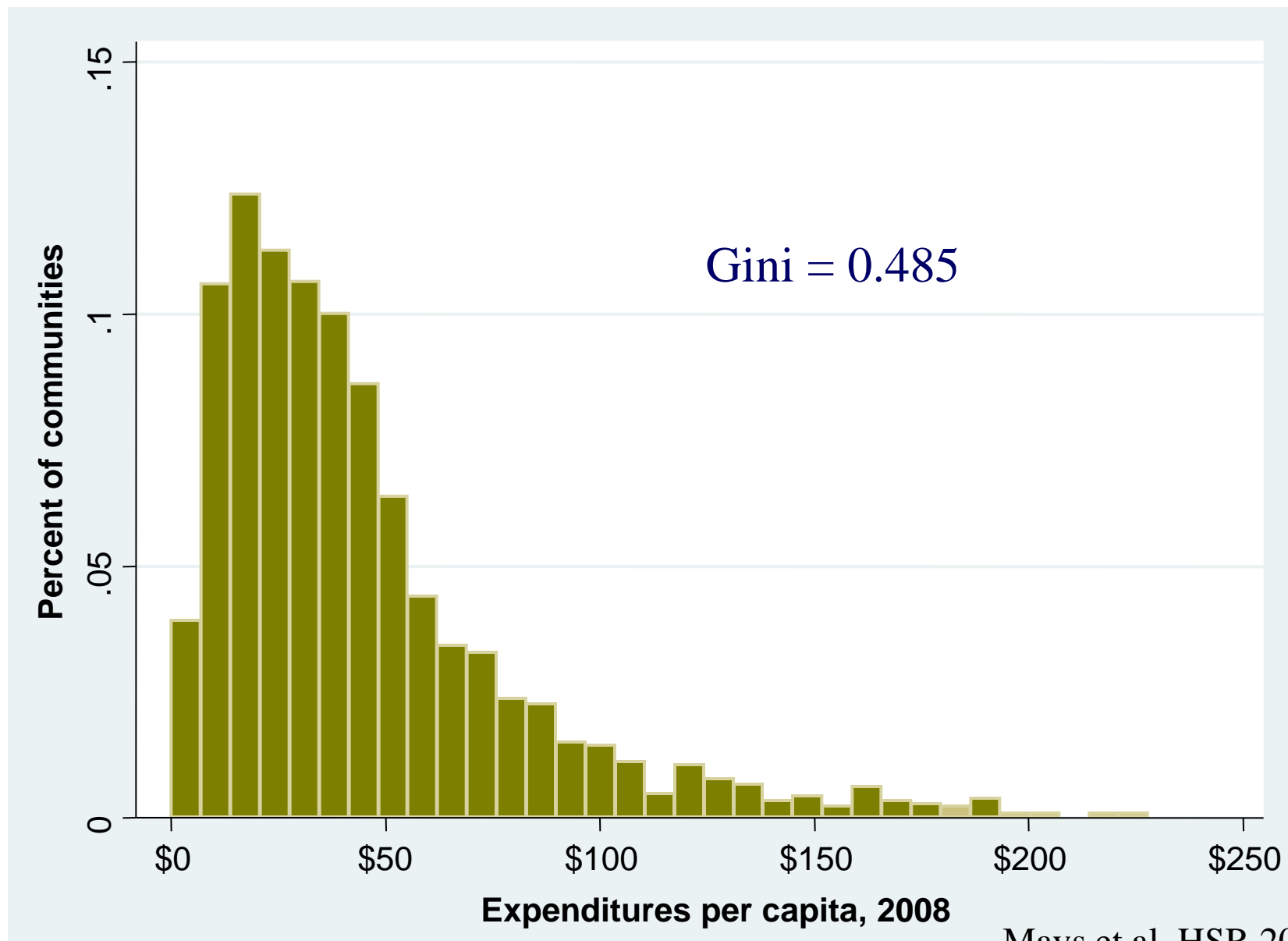
Sensitivity analyses using 1, 5, and 10 year lag structures

Analytical approach

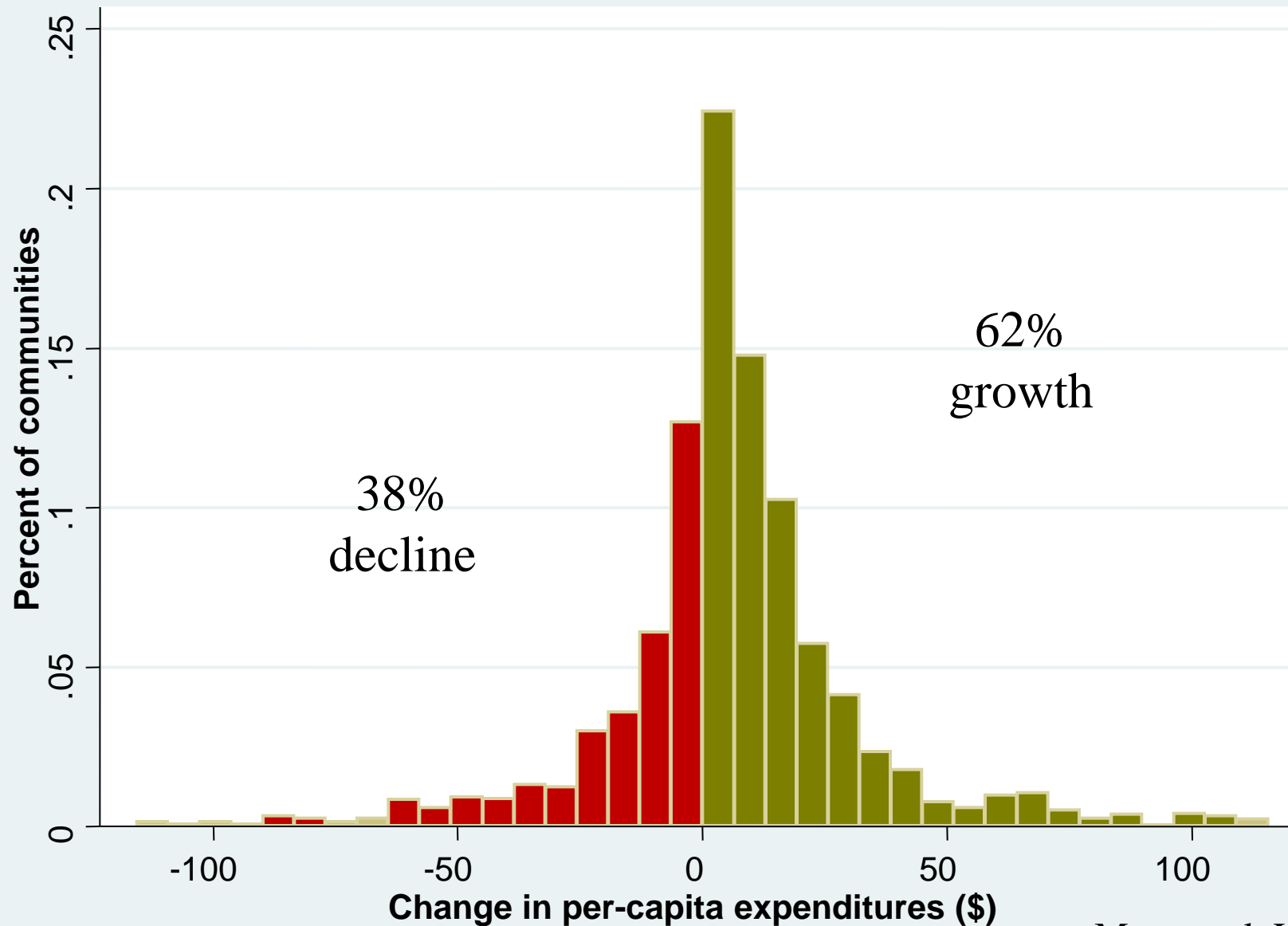
Other Variables Used in the Models

- ◆ ***Agency characteristics***: type of government jurisdiction, scope of services offered, ***local governance and decision-making structures***
- ◆ ***Community characteristics***: population size, rural-urban, poverty, income per capita, education attainment, unemployment, age distributions, physicians per capita, CHC funding per low income, health insurance coverage, local health care wage index
- ◆ ***State characteristics***: Private insurance coverage, Medicaid coverage, state fixed effects

Variation in Local Public Health Spending



Changes in Local Public Health Spending 1993-2008



Determinants of Local Public Health Spending Levels: IVs

<u>Governance/Decision Authority</u>	<u>Elasticity Coefficient</u>	<u>95% CI</u>
Governed by local board of health	0.131**	(0.061, 0.201)
State hires local PH agency head†	-0.151*	(-0.318, 0.018)
Local govt approves local PH budget†	-0.388***	(-0.576, -0.200)
State approves local PH budget†	-0.308**	(-0.162, -0.454)
Local govt sets local PH fees	0.217**	(0.101, 0.334)
Local govt imposes local PH taxes	0.190**	(0.044, 0.337)
Local board can request local PH levy	0.120**	(0.246, 0.007)

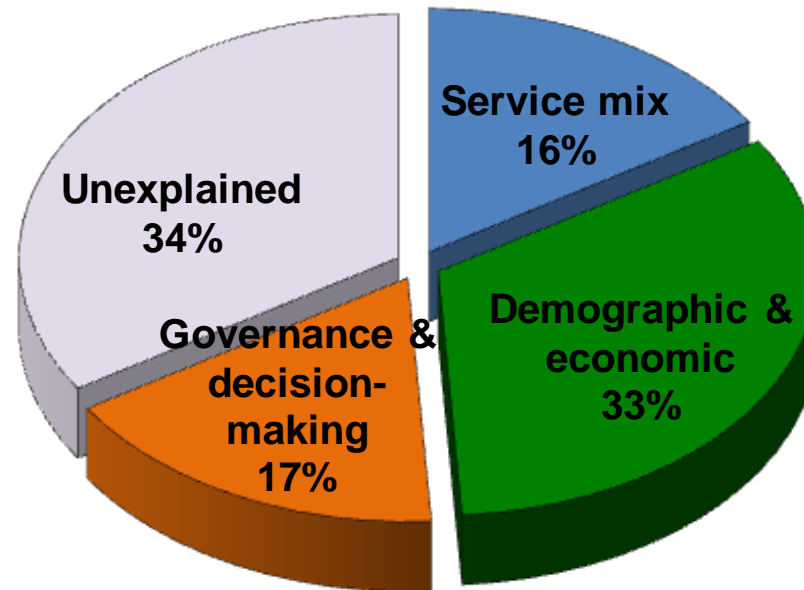
F=13.4 p<0.001

log regression estimates controlling for community-level and state-level characteristics. *p<0.10 **p<0.05 ***p<0.01

†As compared to the local board of health having the authority.

Mays et al. HSR 2009

Determinants of Local Public Health Spending Levels



- Delivery system size & structure
- Service mix
- Population needs and risks
- Efficiency & uncertainty

Multivariate estimates of public health spending effects on mortality 1993-2008

	<u>Cross-sectional model</u>		<u>Fixed-effects model</u>		<u>IV model</u>	
<u>Outcome</u>	<u>Elasticity</u>	<u>St. Err.</u>	<u>Elasticity</u>	<u>St. Err.</u>	<u>Elasticity</u>	<u>St. Err.</u>
Infant mortality	0.0516	0.0181 **	0.0234	0.0192	-0.1437	0.0589 ***
Heart disease	-0.0003	0.0051	-0.0103	0.0040 **	-0.1881	0.0292 **
Diabetes	0.0323	0.0187	-0.0487	0.0174 ***	-0.3015	0.0633 **
Cancer	0.0048	0.0029 *	-0.0075	0.0240	-0.0532	0.0166 **
Influenza	-0.0400	0.0200 **	-0.0275	0.0107 **	-0.4320	0.0624 **
Alzheimer's	0.0024	0.0075	0.0032	0.0047	0.0028	0.0311
Residual	0.0007	0.0083	0.0004	0.0031	0.0013	0.0086

log regression estimates controlling for community-level and state-level characteristics

*p<0.10 **p<0.05 ***p<0.01

Mays et al. Health Affairs 2011

Effects of public health spending on medical care spending 1993-2008

Change in Medical Care Spending Per Capita Attributable to
1% Increase in Public Health Spending Per Capita

<u>Model</u>	<u>Elasticity</u>	<u>Std. Error</u>
Fixed effects	-0.010	0.002 **
Instrumental variables	-0.088	0.013 **

log regression estimates controlling for community-level and state-level characteristics

*p<0.10 **p<0.05 ***p<0.01

Mays et al. forthcoming 2013

Effects of public health spending on medical care spending 1993-2008

Change in Medical Care Spending Per Capita Attributable to 1% Increase in Public Health Spending Per Capita

<u>Model</u>	<u>N</u>	<u>Elasticity</u>	<u>S.E.</u>	
One year lag	8532	-0.088	0.013	***
Five year lag	6492	-0.112	0.053	**
Ten year lag	4387	-0.179	0.112	

log regression estimates controlling for community-level and state-level characteristics

*p<0.10 **p<0.05 ***p<0.01

Mays et al. forthcoming 2013

Projected effects of ACA public health spending

- ◆ 10% increase in public health spending in average community:

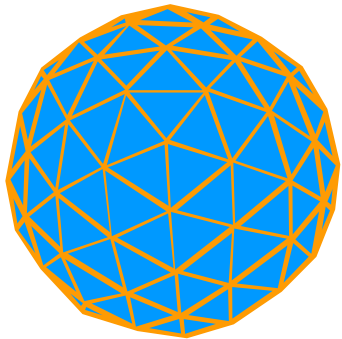
Public health cost	\$594,291	
Medical cost offset	-\$515,114	(Medicare only)
LY gained	148	
Net cost/LY	\$534	

More questions of interest

- Who contributes to public health delivery?
- How are roles and responsibilities divided?
- How and why do delivery systems vary and change over time?
- How do system structures affect public health delivery and outcomes?

Defining public health delivery systems

The collection of governmental and private actors that contribute to the delivery of public health services for a defined population.



- Intergovernmental and public-private relationships
- Vertical and horizontal relationships
- Division of responsibility

Why is organizational structure important?

Other organizations may:

- ◆ Complement or substitute for PH agency work
- ◆ Extend the reach of PH agencies
- ◆ Bring new resources and expertise

Improve quality

Enhance efficiency

Reduce disparities



Why is organizational structure important?

Also some potential problems:

- ◆ Lack of clarity/accountability about responsibilities
- ◆ Duplication, competition, or rivalry
- ◆ Gaps in service due to incomplete coordination
- ◆ Instability in contributions over time

Diminished quality

Inconsistent service

Inefficiency/waste



Critical dimensions of delivery system structure

- ◆ Scope of activities performed
(Diversification)
- ◆ Breadth of organizations involved
(Integration)
- ◆ Governmental agency's role
(Centralization)

-Bazzoli, Shortell et al. 1999; 2004

Data used in empirical work

- ◆ National Longitudinal Survey of Public Health Systems
- ◆ Cohort of 360 communities with at least 100,000 residents
- ◆ Followed over time: 1998, 2006, 2012
- ◆ Measures:
 - **Scope**: availability of 20 recommended PH activities
 - **Centralization**: effort contributed by the local PH agency
 - **Integration**: other organizations contributing to activities
 - **“Quality”**: perceived effectiveness of each activity
- ◆ Linked with secondary data on agency and community characteristics
 - **Scale**: population size served
 - **Cost**: Local public health agency expenditures
 - Agency and area characteristics

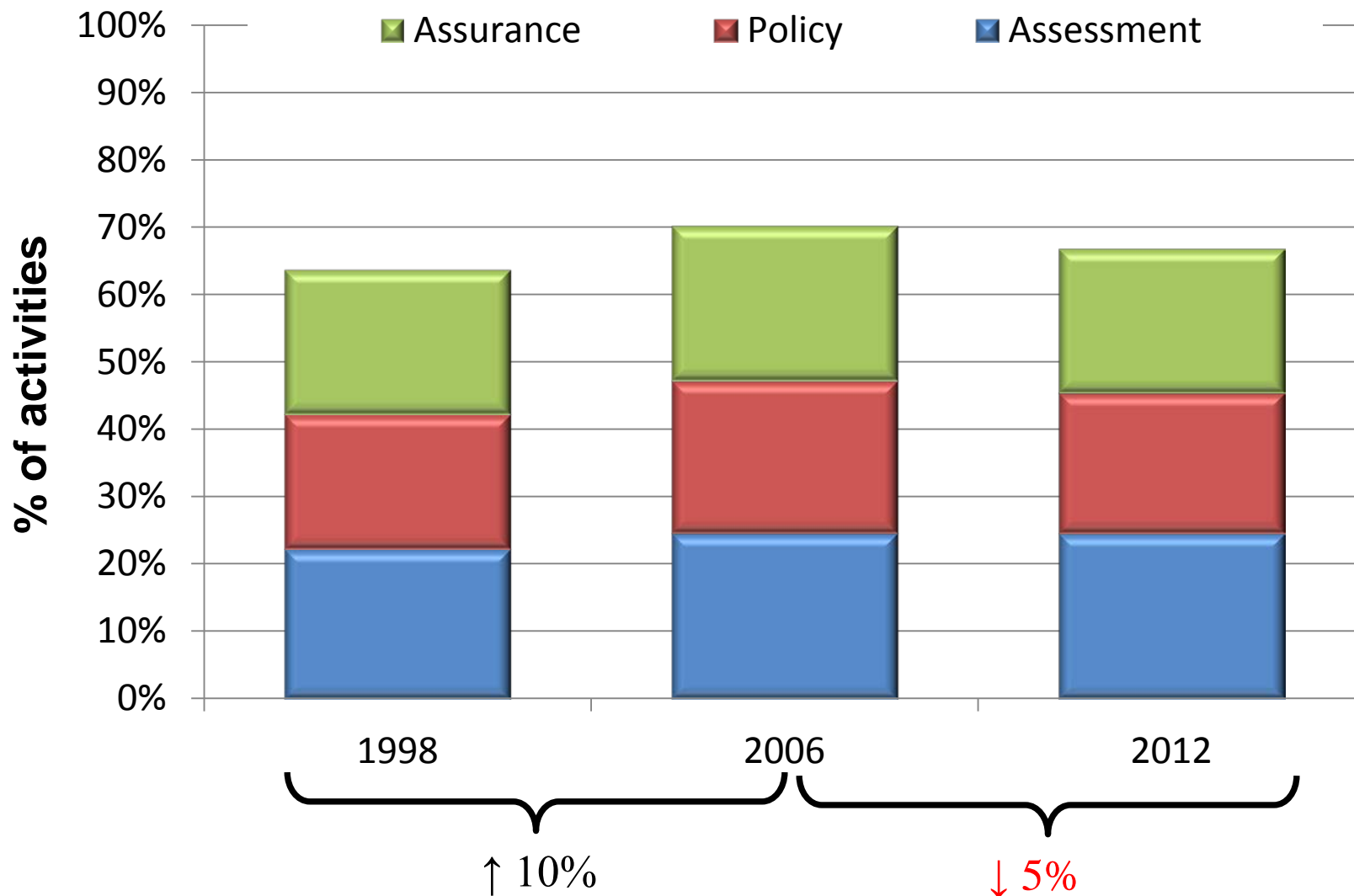
Data and Methods

- ◆ Hierarchical cluster analysis to classify systems based on structural attributes
- ◆ Network analysis to characterize systems and organizations based on patterns of interaction
 - Network centralization
 - Organizational degree centrality
 - Organizational betweenness centrality
- ◆ Multinomial logit estimation to examine institutional & economic factors associated with structural change
- ◆ Fixed-effects regression models to estimate the effects of structural change on measures of service delivery and population health

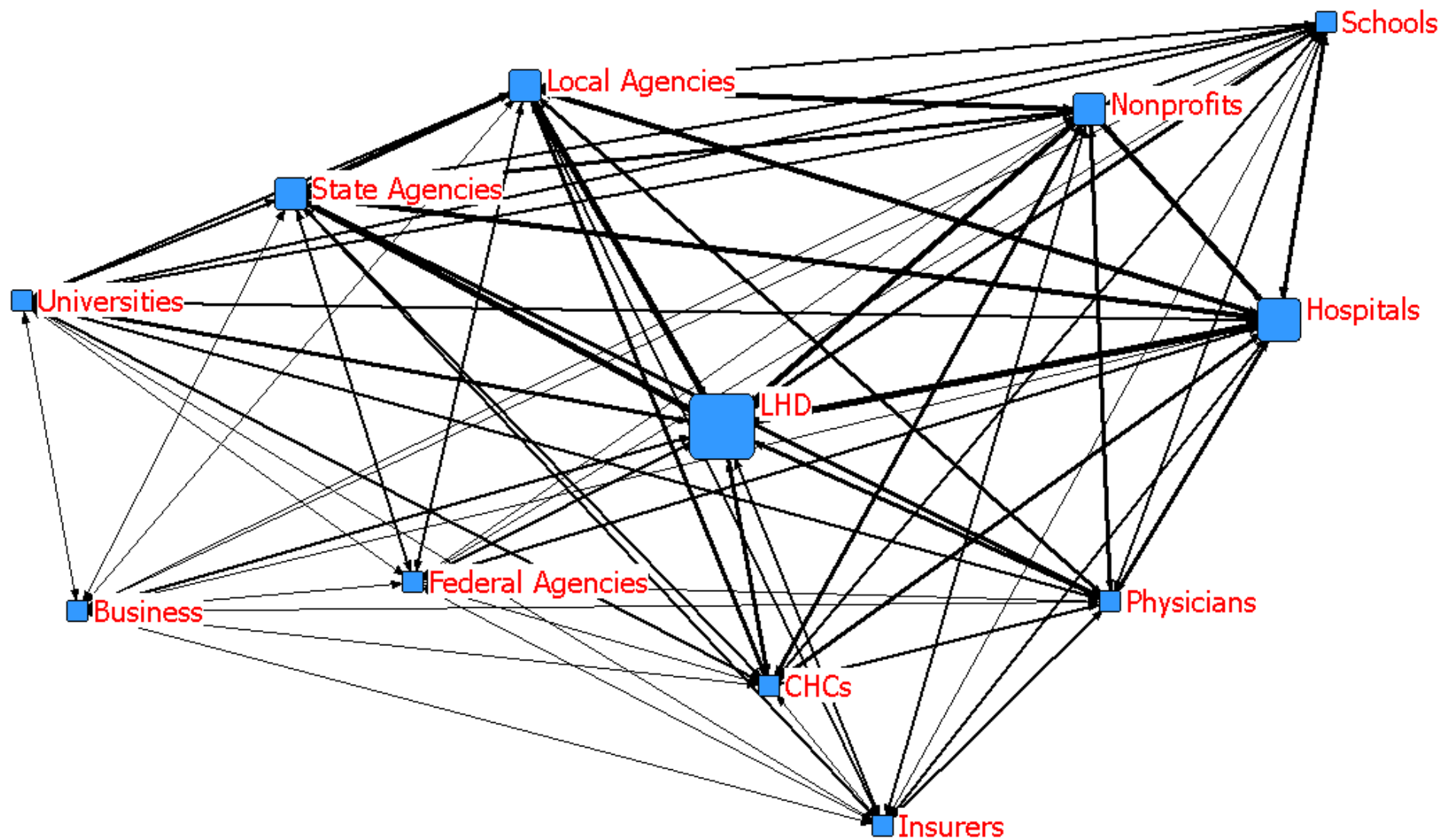


National Longitudinal Survey of Public Health Systems

Delivery of recommended public health activities

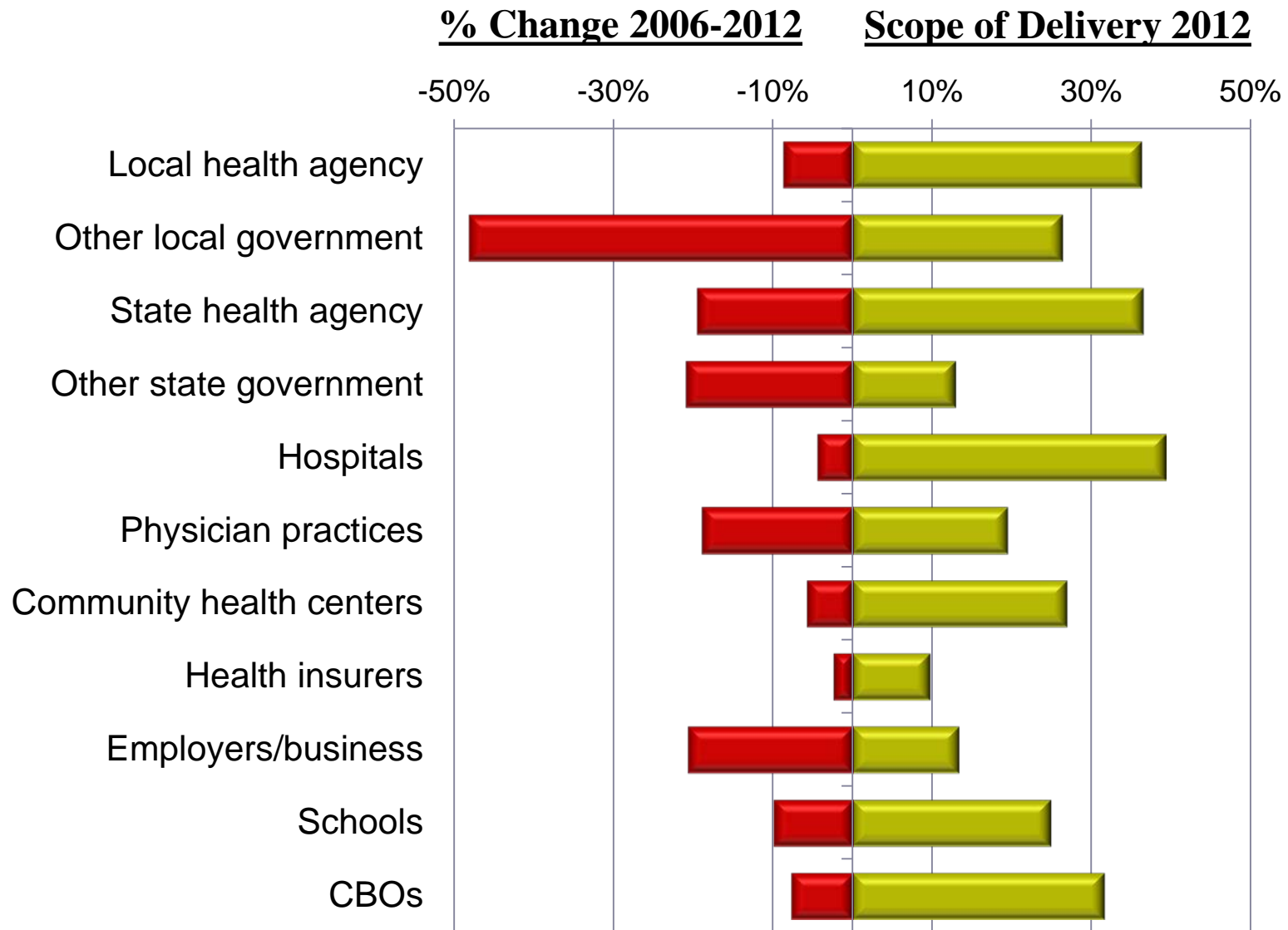


Public health delivery systems



National Longitudinal Survey of Public Health Systems, 2012

Organizations engaged in local public health delivery



Effects of organizational contributions on total supply of public health activities

Variable	Coeff.	S.E.
Local public health agency	0.46154	0.01601 ***
State government	0.04894	0.00698 ***
Other local govt	0.00778	0.00428 *
Federal govt	-0.00461	0.00255 *
Hospitals	0.04816	0.00724 ***
Physician practices	-0.00696	0.00388 *
CHCs	0.00190	0.00159
Insurers	0.00190	0.00059 **
Business/employers	0.00372	0.00192 **
Schools	-0.00341	0.00388
Other nonprofits/CBOs	0.04003	0.00546 ***

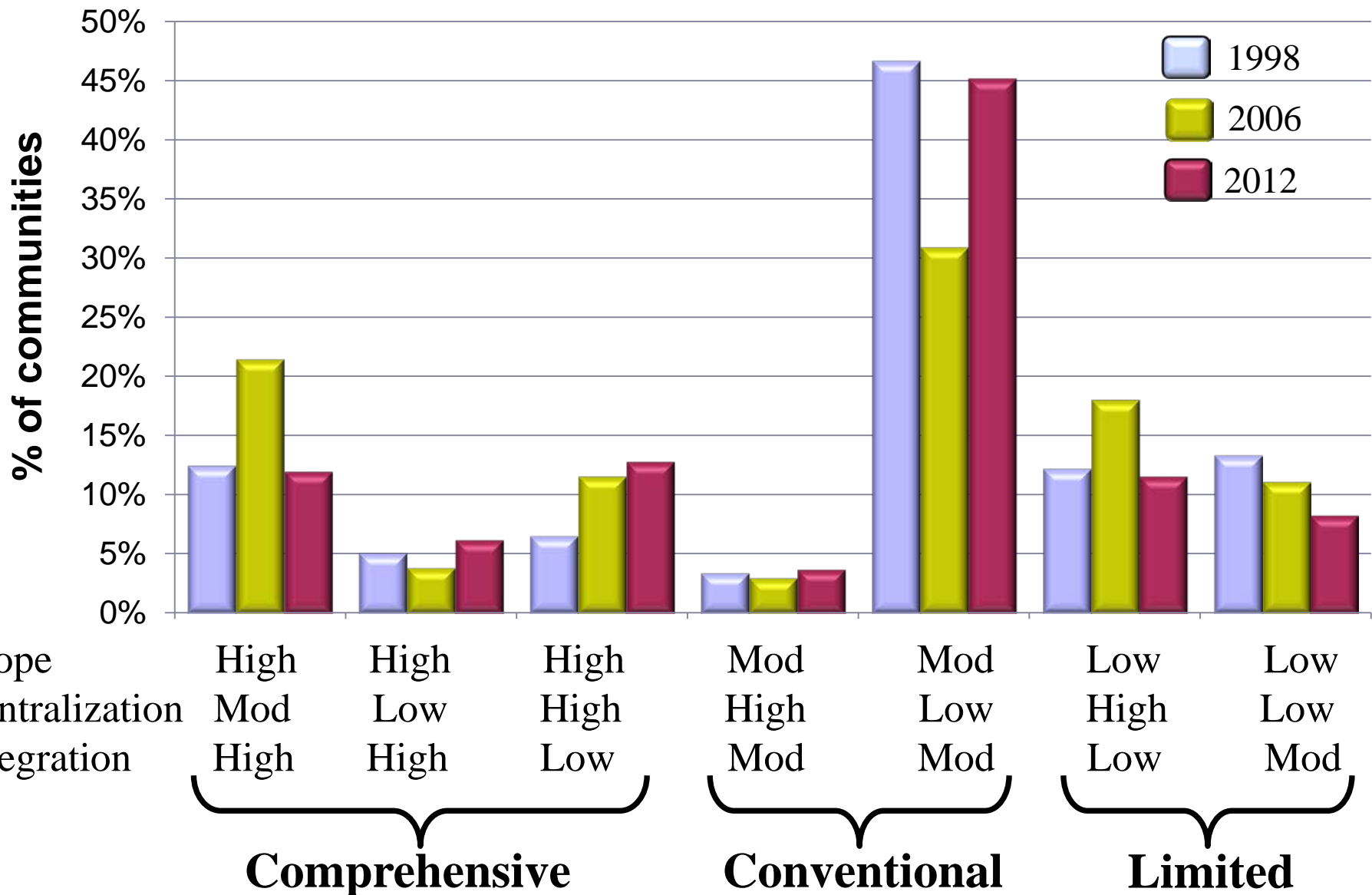
Fixed-effects models control for population size, density, age composition, poverty status, racial composition, and physician supply. Reference System = Cluster 3 ***p<0.01 **p<0.05 *p<0.10

Substitution and Complementarity Effects on Public Health Agency Activities

Variable	Coeff.	S.E.
State government	0.06166	0.01034 ***
Other local govt	0.02713	0.00627 ***
Federal govt	-0.00121	0.00378
Hospitals	0.07712	0.01061 ***
Physician practices	-0.00615	0.00275 **
CHCs	-0.00251	0.00084 **
Insurers	0.00607	0.00303 **
Business/employers	0.00479	0.00434
Schools	0.01150	0.00571 **
Other nonprofits/CBOs	0.05918	0.00805 ***

Fixed-effects models control for population size, density, age composition, poverty status, racial composition, and physician supply. Reference System = Cluster 3 ***p<0.01 **p<0.05 *p<0.10

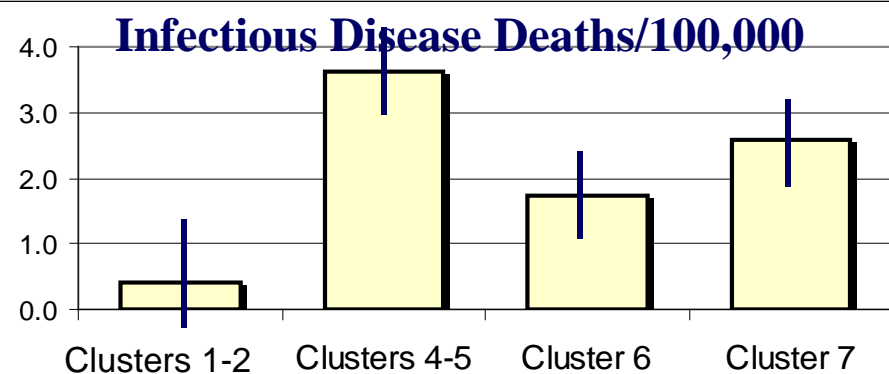
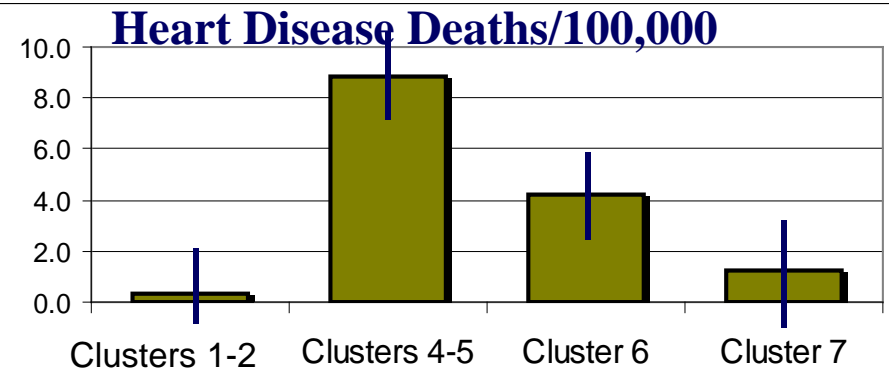
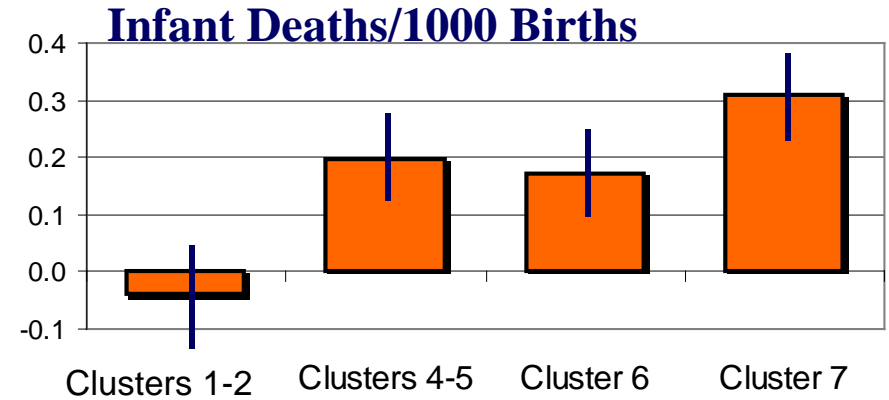
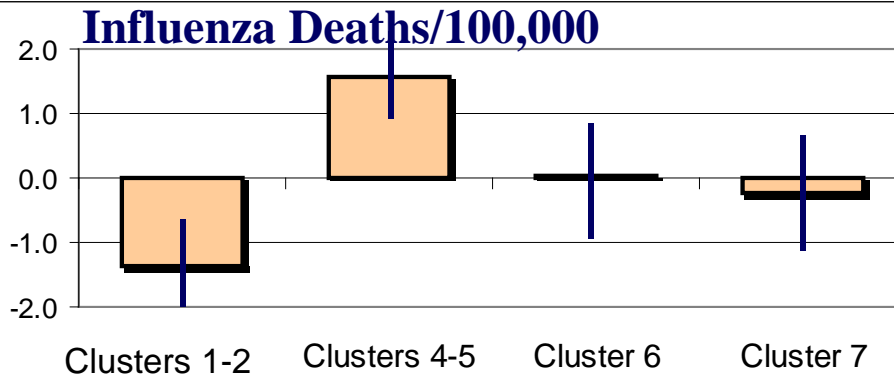
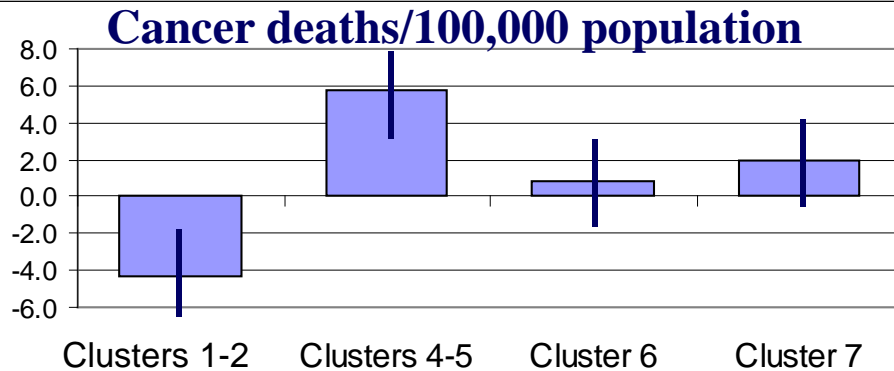
A typology of public health delivery systems



Source: Mays et al. 2010; 2012

Changes in health associated with delivery system

Percent Changes in Preventable Mortality Rates by System Typology (cluster)

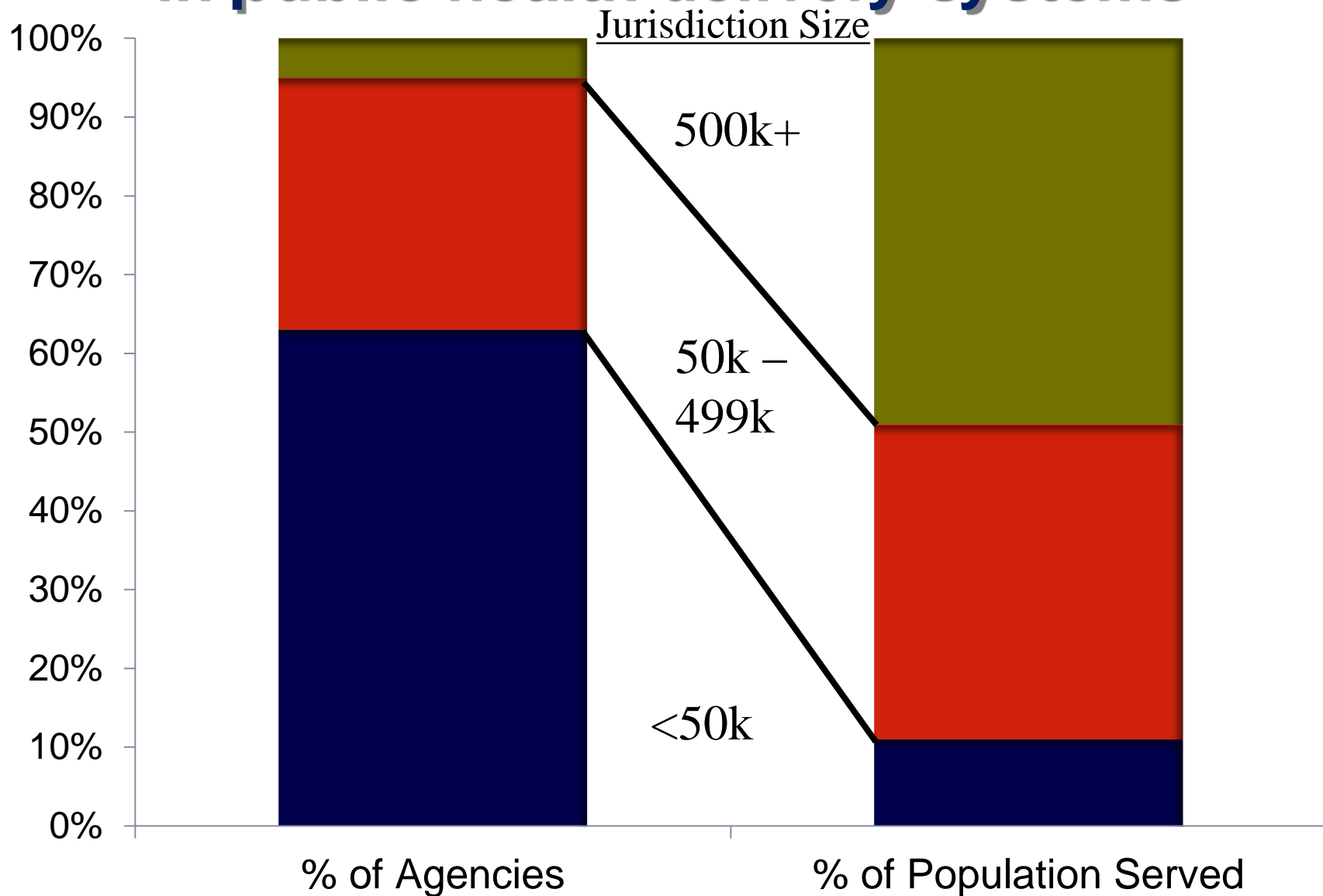


Fixed-effects models control for population size, density, age composition, poverty status, racial composition, and physician supply. Reference System = Cluster 3

More questions of interest...

- ◆ How can we derive greater value from existing public health delivery systems & resources?
- ◆ Are there economies of scale and scope in the delivery of public health services?
- ◆ Can regionalization improve availability, efficiency & effectiveness of public health services?

Economies of scale and scope in public health delivery systems



Source: 2010 NACCHO National Profile of Local Health Departments Survey

Sources of Scale and Scope Effects

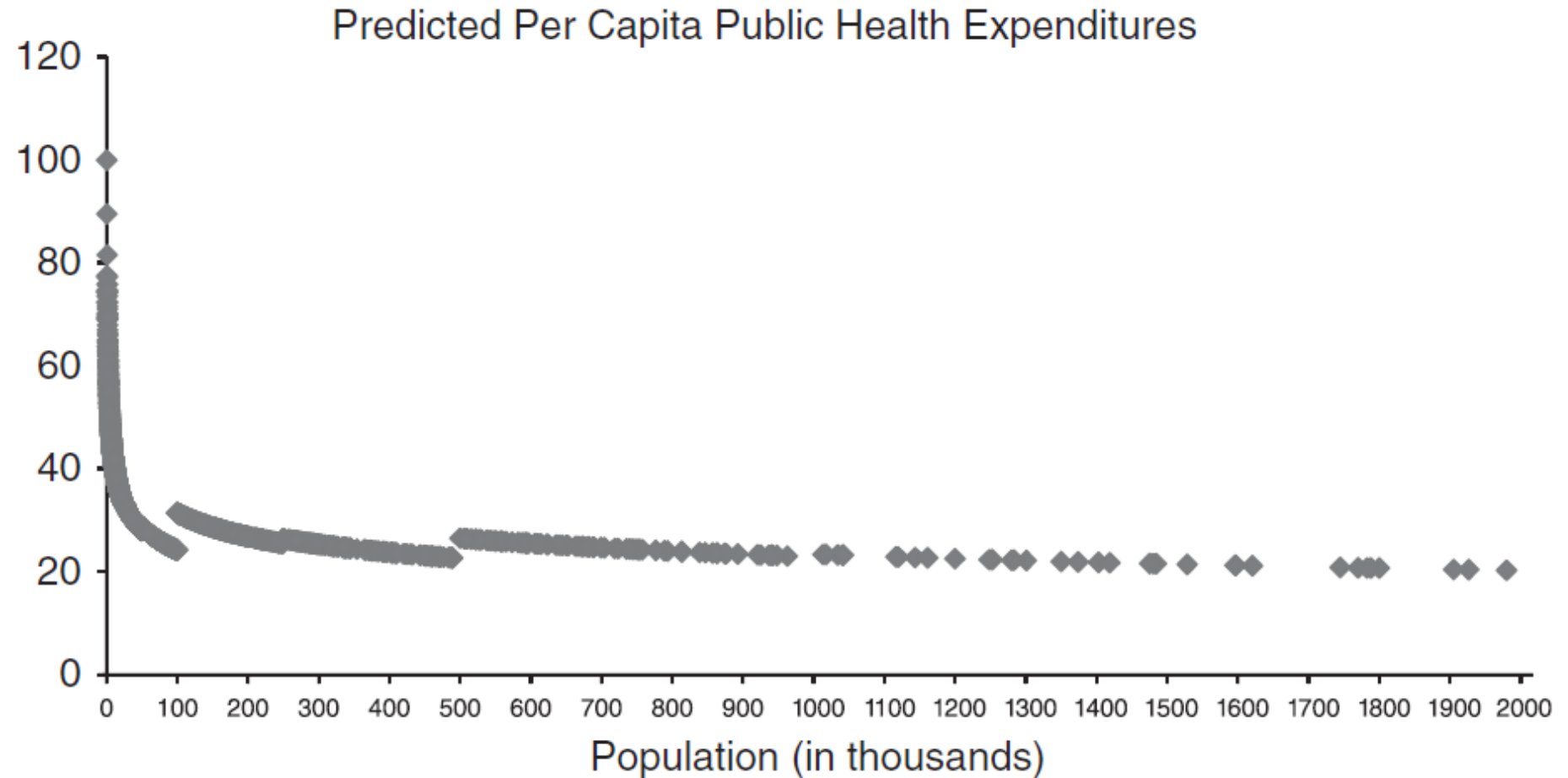
Economies of Scale

- ◆ Spread fixed costs of public health activities
- ◆ Allow specialization of labor and capital
- ◆ Enhance predictability of infrequent events
- ◆ Pool surge capacity
- ◆ Learn by doing
- ◆ Internalize spill-over effects
- ◆ Network effects

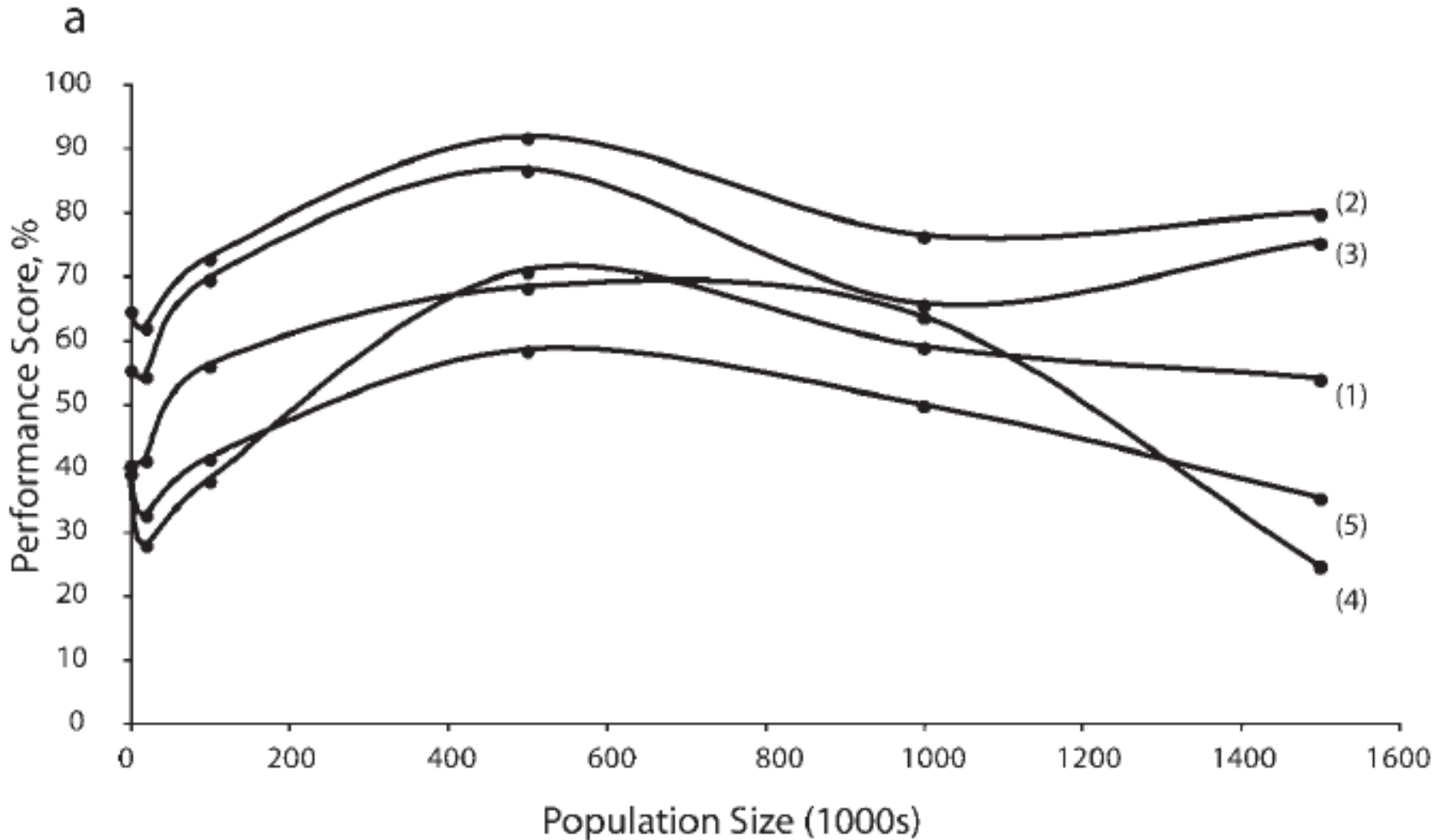
Economies of Scope

- ◆ Use common infrastructure for multiple activities
- ◆ Cross-train workforce
- ◆ Realize synergies across activities
- ◆ Network effects

Sources of Scale and Scope Effects



Sources of Scale and Scope Effects



Source: Mays GP et al; 2006

Analytic Approach

- ◆ Estimate the effects of **scale** (population served) and **scope** (array of activities delivered) on:
 - public health expenditures
 - health outcomes (preventable mortality)
- ◆ Address the potential endogeneity of scope, quality
- ◆ Simulate the effects of regionalizing jurisdictions that fall below selected population thresholds
 - <25,000
 - <50,000
 - <100,000
 - <150,000

Data used in empirical work

- ◆ National Longitudinal Survey of Public Health Systems
- ◆ Cohort of 360 communities with at least 100,000 residents
- ◆ Followed over time: 1998, 2006, 2012
- ◆ Measures:
 - **Scope**: availability of 20 public health activities
 - **Effort**: contributed by the local public health agency
 - **“Quality”**: perceived effectiveness of each activity
 - **Network**: organizations contributing to each activity
- ◆ Linked with data from NACCHO Profile
 - **Scale**: population size served
 - **Cost**: Local public health agency expenditures
 - Agency characteristics

Data used in empirical work

- ◆ Survey data linked with secondary sources of area characteristics (Census, ARF)
- ◆ Small sample of jurisdictions under 100,000 (n=36) used to evaluate prediction accuracy

Analytical approach

Cost Function Model (semi trans-log)

$$\ln(\text{Cost}_{ijt}) = \alpha_1 \text{Scale}_{ijt} + \alpha_2 \text{Scale}_{ijt}^2 + \beta_1 \text{Scope}_{ijt} + \beta_2 \text{Scope}_{ijt}^2 + \varphi_1 \text{Quality}_{ijt} + \varphi_2 \text{Quality}_{ijt}^2 + \lambda X_{ijt} + \mu_j + \varphi_t + \varepsilon_{ijt}$$

Instrumental Variables Model

$$\text{Scope}_{ijt} = \theta \text{Network}_{ijt} + \lambda \text{Agency}_{ijt} + \delta \text{Community}_{ijt} + \mu_j + \varphi_t + \varepsilon_{ijt}$$

$$\text{Quality}_{ijt} = \theta \text{Network}_{ijt} + \lambda \text{Agency}_{ijt} + \delta \text{Community}_{ijt} + \mu_j + \varphi_t + \varepsilon_{ijt}$$

IVs: Network: degree centrality, average path length

All models control for type of jurisdiction, governance structure, centralization, population density, metropolitan area designation, income per capita, unemployment, racial composition, age distribution, educational attainment, physician and hospital availability

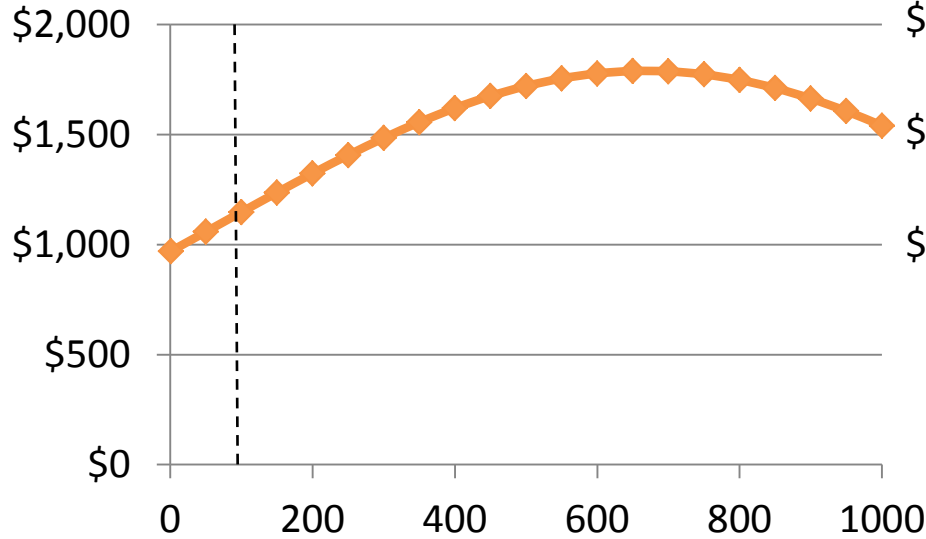
Results: Scale and Scope Estimates

Variable	Partial Elasticity	
	Coeff.	S.E.
Population size	0.0184	0.0029***
Population size squared	-0.0014	0.0002***
Scope	3.89	1.41***
Scope squared	-2.58	0.99***
Quality	-2.98	1.39**
Quality squared	2.72	1.23**

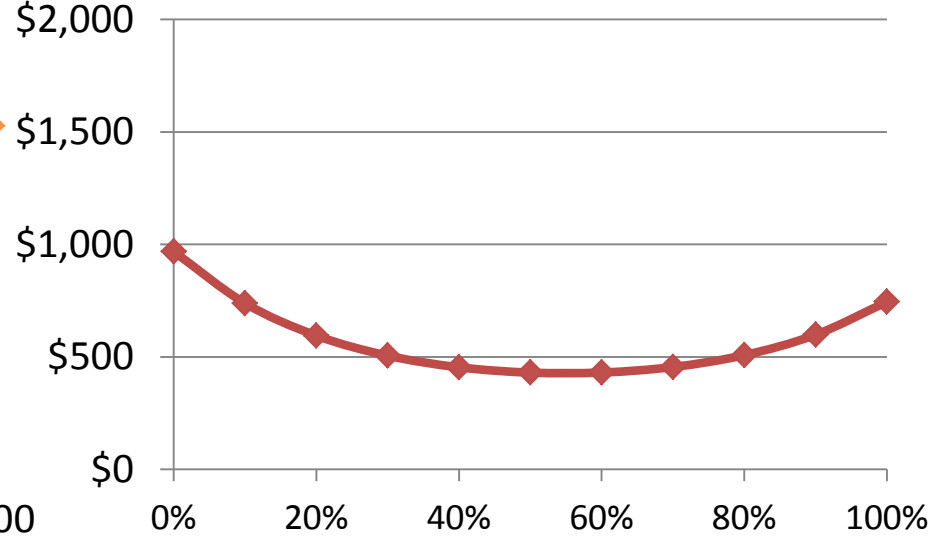
p<0.05 *p<0.01

Empirical estimates of scale and scope economies

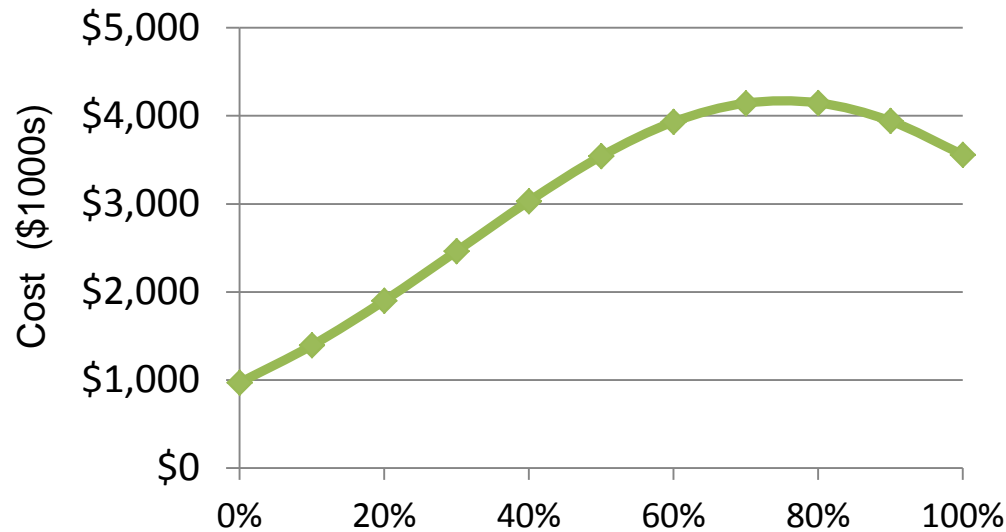
Scale (Population in 1000s)



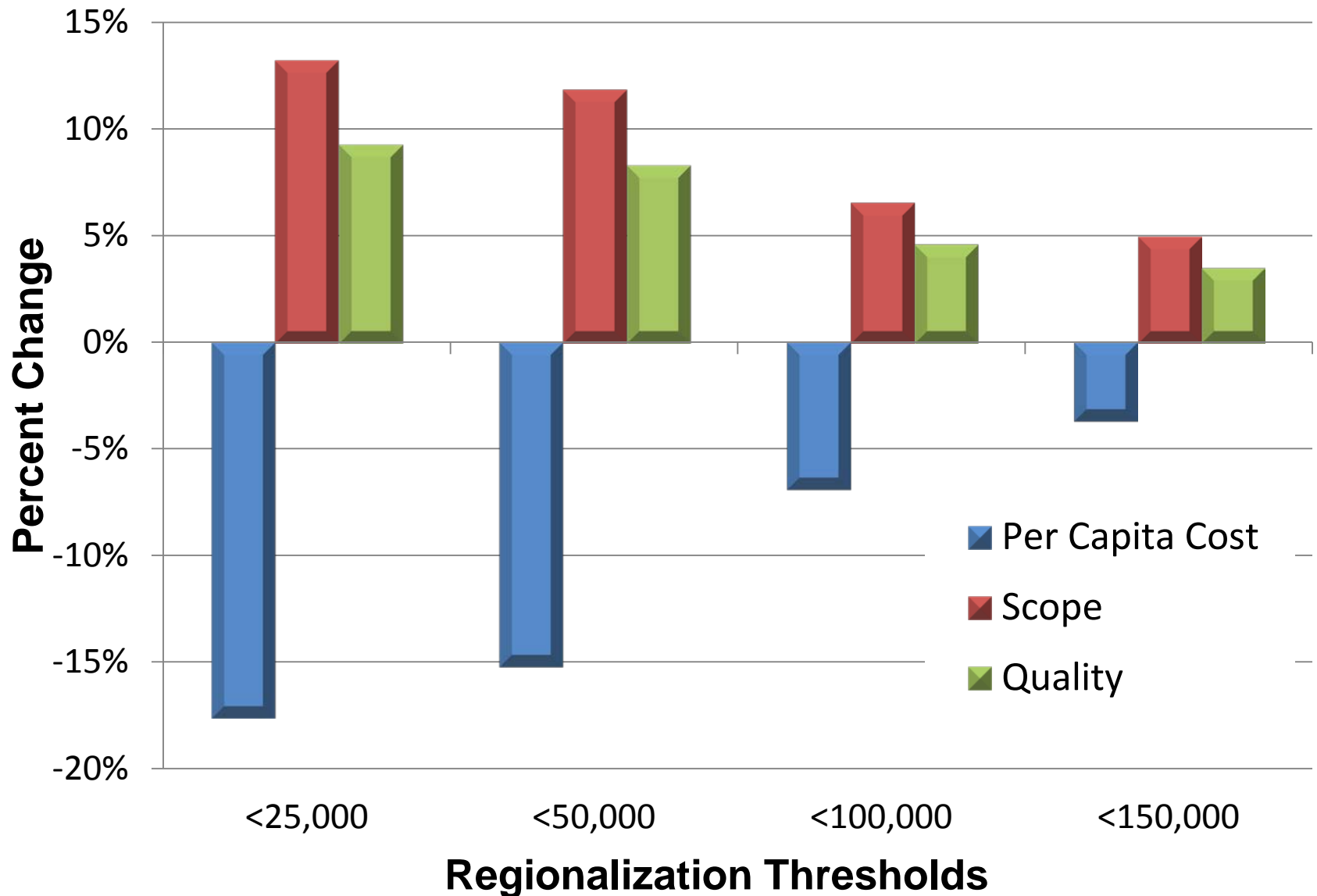
Quality (Perceived Effectiveness)



Scope (% of Activities)



Simulated Effects of Regionalization



Some Conclusions & Implications: Spending

- ◆ Local public health spending varies widely across communities
- ◆ Communities with higher spending experience lower mortality from leading preventable causes of death
- ◆ Growth in local public health spending appears to offset growth in medical care spending

Some Conclusions & Implications: Spending

- ◆ Mortality reductions achievable through increases in public health spending may equal or exceed the reductions produced by similar expansions in local medical care resources
- ◆ Increased federal investments may help to reduce geographic disparities in population health and bend the medical cost curve.
- ◆ Gains from federal investments may be offset by reductions in state and local spending

Limitations and next steps: Spending

- ◆ Aggregate spending measures
 - Average effects
 - Role of allocation decisions?
- ◆ Mortality – distal measures with long incubation periods
- ◆ Medical care spending relies on Medicare as a proxy measure (20% of total medical \$)
- ◆ Ongoing exploration of lag structures

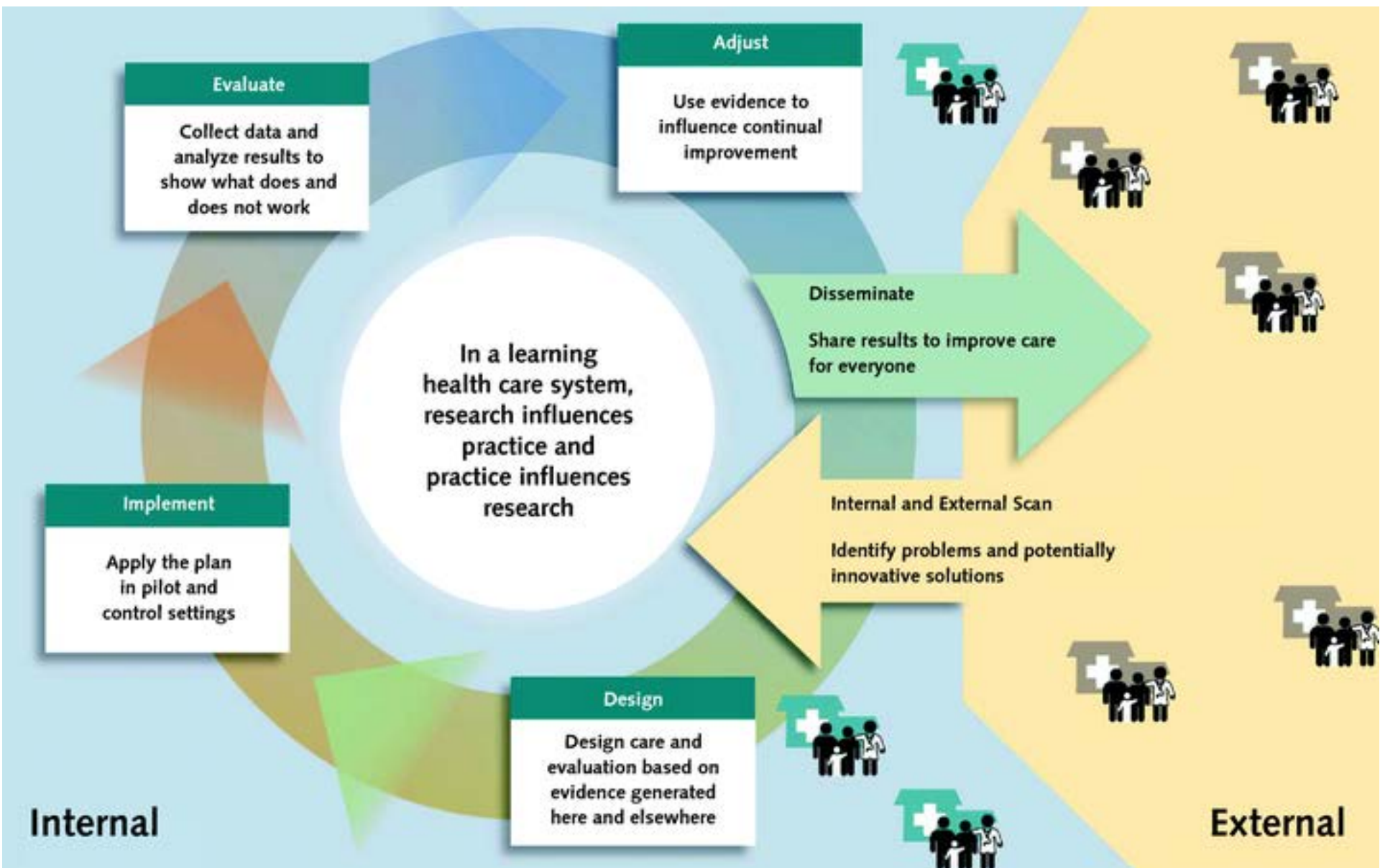
Some Conclusions & Implications: Delivery System Structure

- ◆ Hospital and health insurer contributions may accentuate the impact of government agency reductions in public health delivery due to complementarities
- ◆ Physician practices and CHCs attenuate government reductions due to substitution effects
- ◆ Health system stakeholders respond differently to policy incentives and economic constraints that shape public health delivery.
- ◆ Private-sector contributions to public health appear to offset governmental reductions under certain organizational and community conditions.

Some Conclusions & Implications: Delivery System Structure

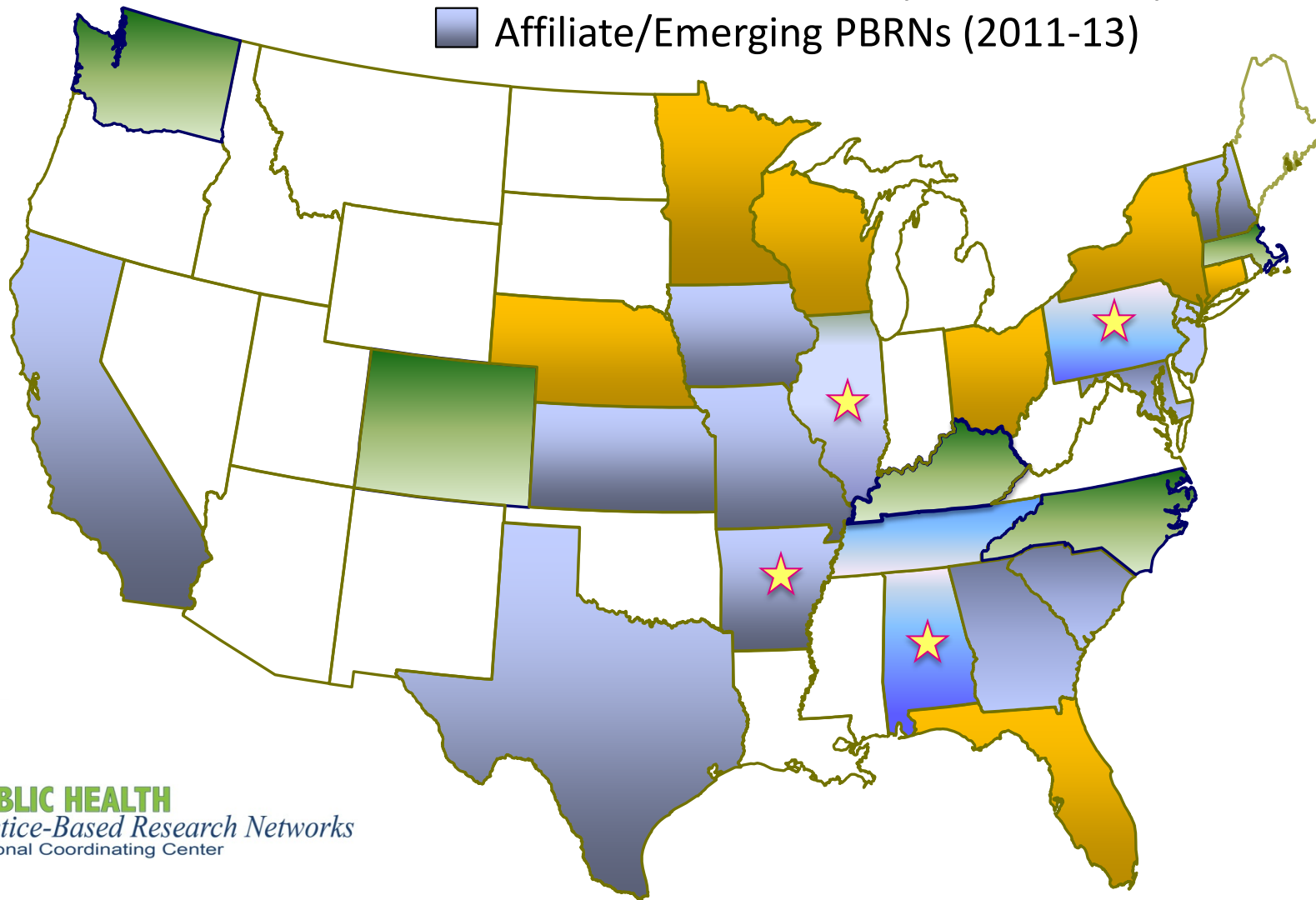
- ◆ Significant scale and scope effects are apparent in local public health production
- ◆ Gains from regionalization may accrue through efficiency, scope, and quality
- ◆ Largest regionalization gains accrue to smallest jurisdictions
- ◆ If savings are re-invested in public health production, possibility of important health gains

Toward a “rapid-learning system” in public health



Public Health Practice-Based Research Networks (PBRNs)

- First cohort (December 2008 start-up)
- Second cohort (January 2010 start-up)
- Affiliate/Emerging PBRNs (2011-13)



For More Information



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