Stroke as a Public Policy Problem

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Contents

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Too Many Virginians Suffer Long Term Disability From Stroke

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STROKE IN VIRGINIA – DISPARITIES IN GEOGRAPHY AND AGE

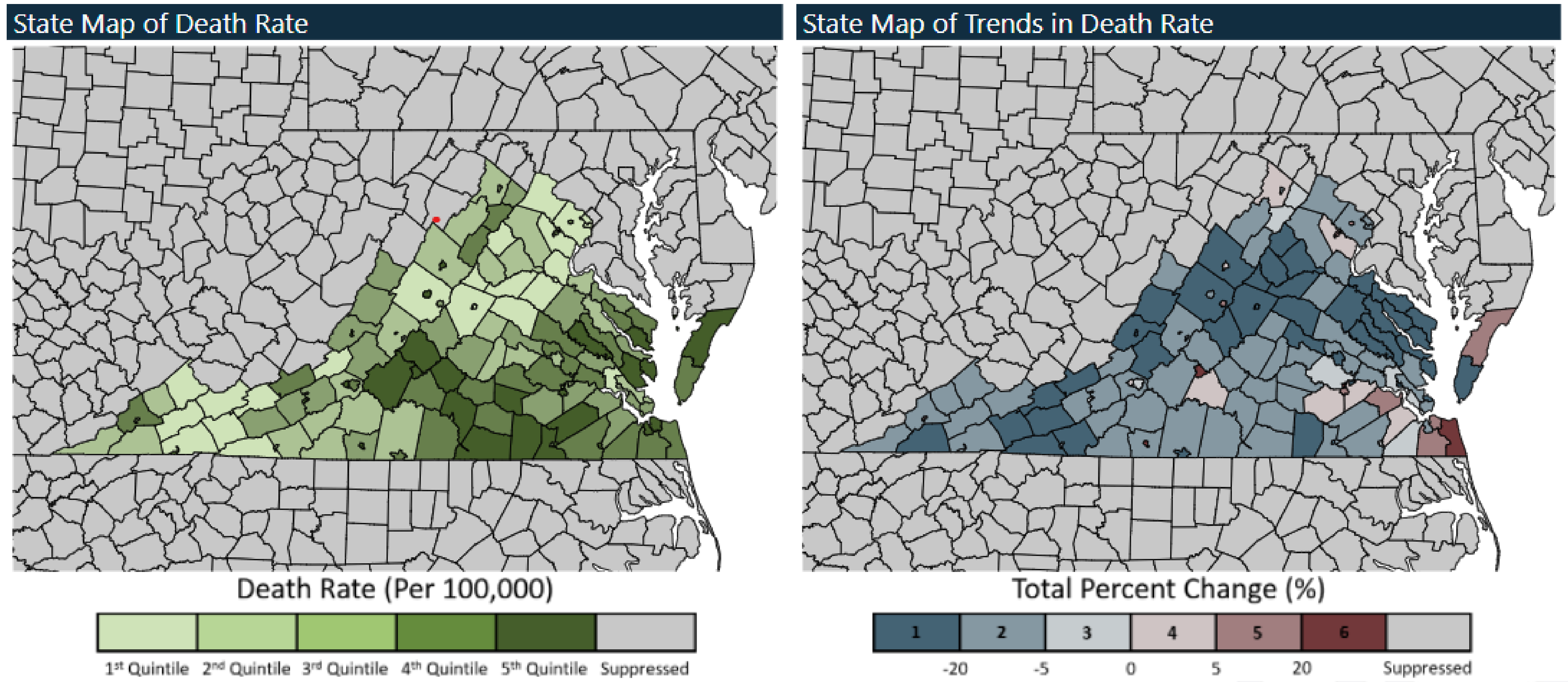

FIGURE 1. STROKE DEATH RATE IN VIRGINIA BY COUNTY FOR INDIVIDUALS AGED 65 AND OLDER. DATA FROM 2019 NATIONAL CENTER FOR CHRONIC DISEASE PREVENTION AND HEALTH PROMOTION , DIVISION FOR HEART DISEASE AND STROKE PREVENTION

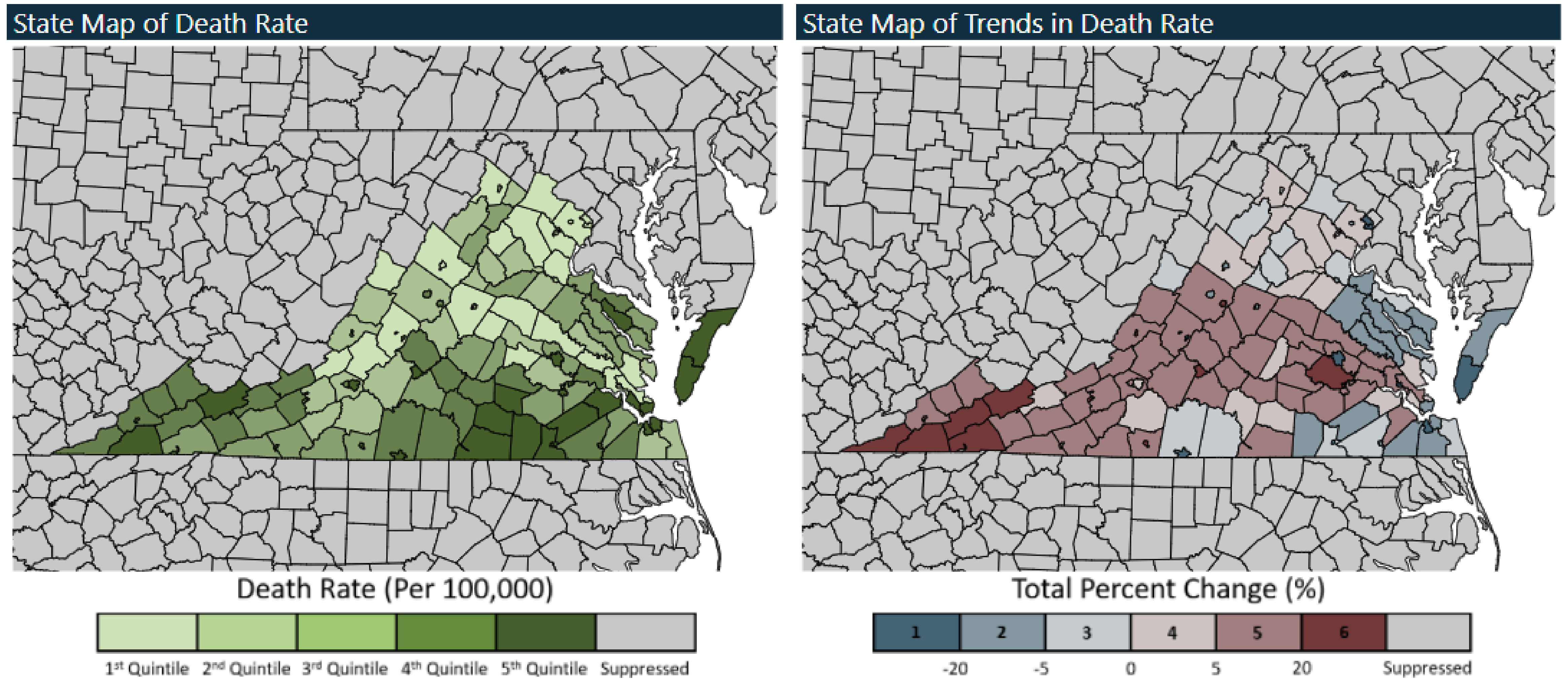

FIGURE 2. STROKE DEATH RATE IN VIRGINIA BY COUNTY FOR INDIVIDUALS AGED 35 - 64. DATA FROM 2019 NATIONAL CENTER FOR CHRONIC DISEASE PREVENTION AND HEALTH PROMOTION , DIVISION FOR HEART DISEASE AND STROKE PREVENTION

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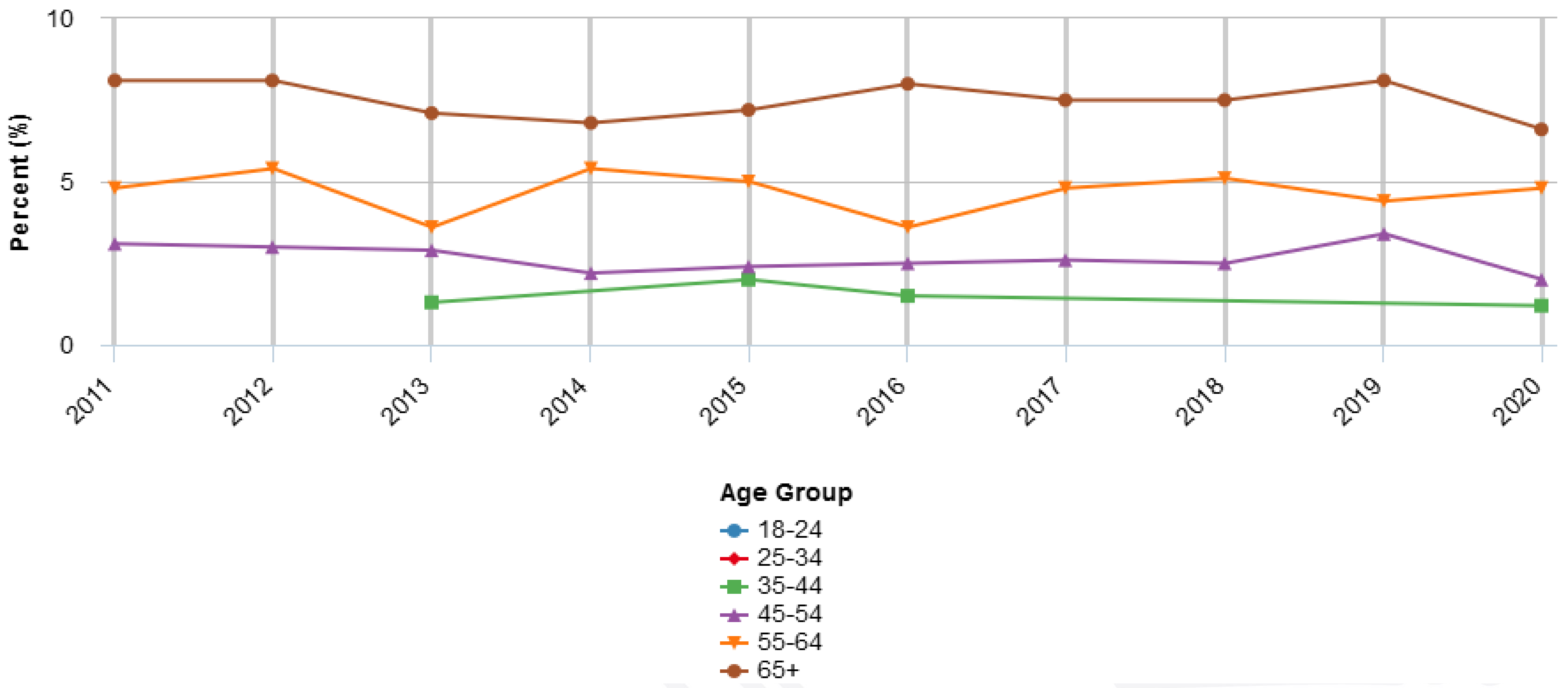
STROKE IN VIRGINIA – "HAVE YOU EVER BEEN TOLD THAT YOU HAVE HAD A STROKE?"

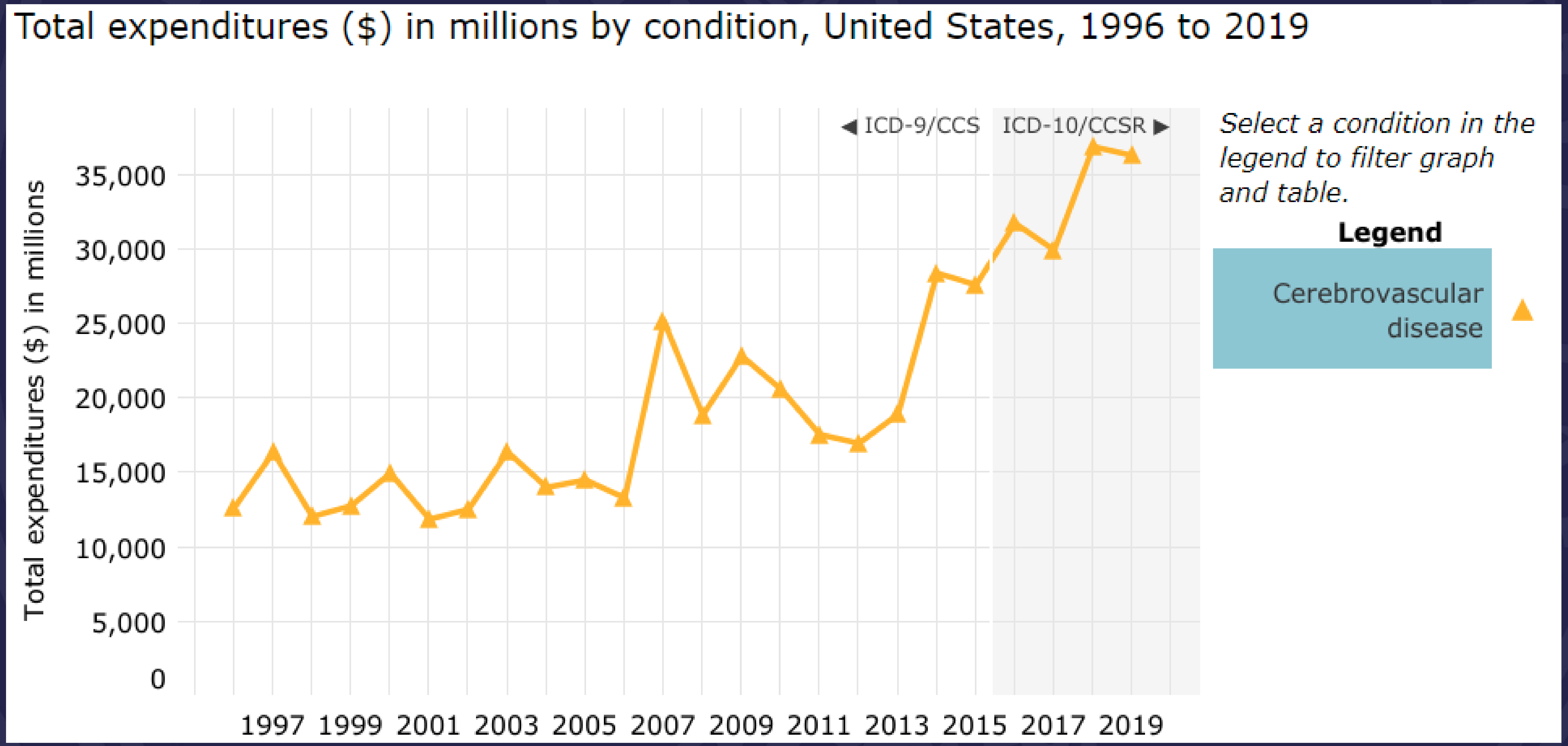


Costs to Society: Direct Medical

Stroke accounts for an estimated $33.9 billion per year in direct and indirect costs nationally.

- Systematic review by Rochmah et al estimates that the economic burden of stroke ranges from $1809.51 to $325,108.84 per patient.

- Total economic costs are correlated with level of disability, with patients suffering from hemiparesis costing about 150% more than non-paralyzed patients.



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Costs to Society: Virginia

Reference	2018 Average Costs	2018 Virginia Incidence and Cost	2019 Costs Adjusted for Inflation	2019 Population Incidence	2020 Costs Adjusted for Inflation	2020 Population Incidence
Emergency Department Care	$ 1,938.00		$ 2,013.98		$ 2,100.57	
Home Health Visits	$ 11,462.00		$ 11,911.40		$ 12,423.50	
Inpatient Stays	$ 25,722.00		$ 26,730.51		$ 27,879.72	
Office-Based Events	$ 1,063.00		$ 1,104.68		$ 1,152.17	
Prescription Medication Costs	$ 578.00		$ 600.66		$ 626.49	
Ambulance Costs*	$ 516.00		$ 536.23		$ 559.29	
Estimated Population Incidence		43691		43782		44046
Estimated Total Direct Costs		*$ 98,199,652*		*$ 102,263,521*		*$ 107,302,988*

- As of 2015, about 26,000 Virginians suffered a stroke that had a previous stroke while 17,000 had a first-time stroke.
- Stroke prevalence remained stable in Virginia from 2015 through 2018.
- Using population projections from the Weldon Cooper Center, and inflations projections from the federal reserve, estimated direct medical costs for stroke in 2020 amounted to ~$107,302,988.

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Costs to Society: Opportunity Costs

Costs borne by patients and families in the form of lost wages and economic opportunity is substantial.

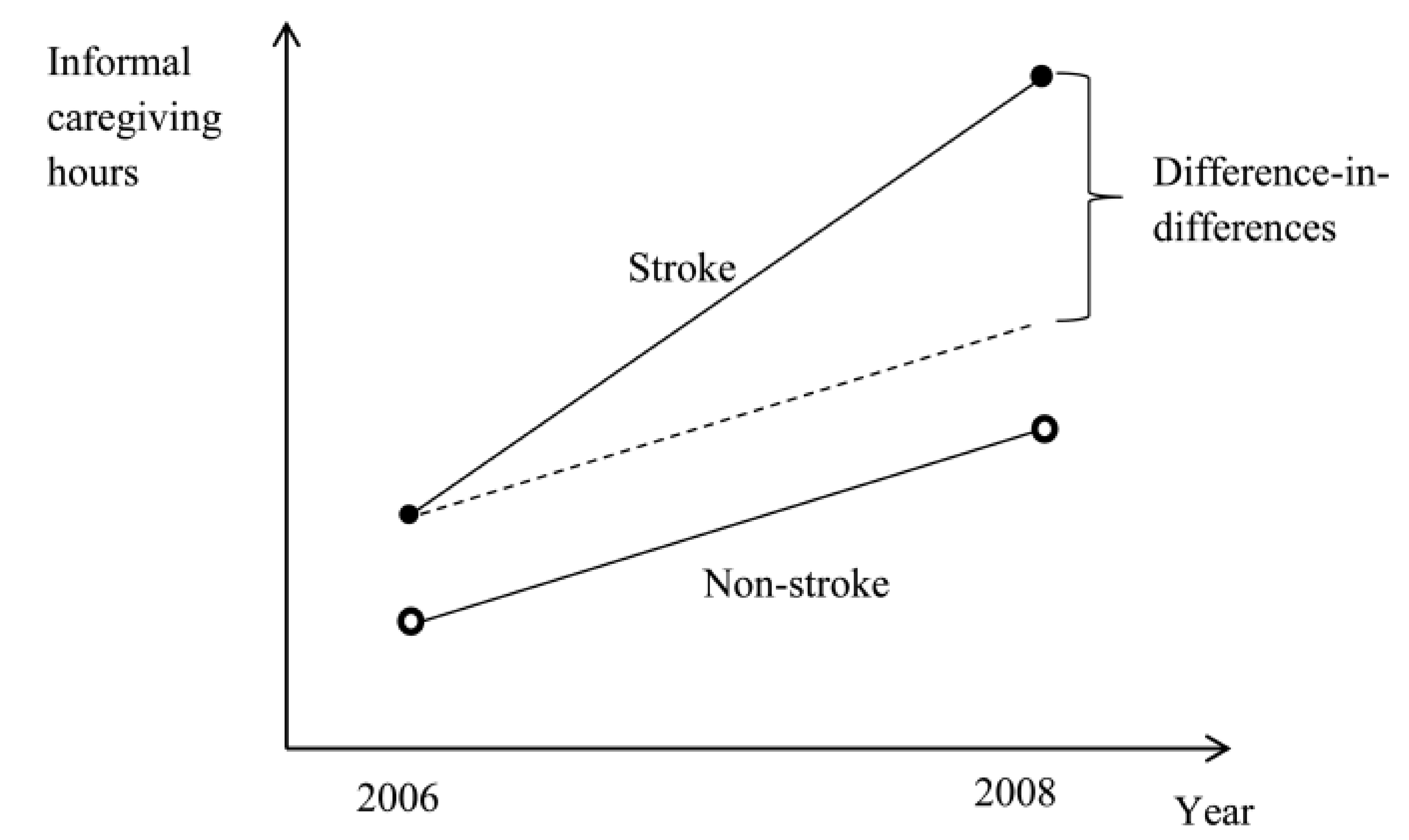

Figure 2.
Difference-in-Differences approach
Stroke: Patients with first-ever stroke between year 2006 and 2008 based on self-report Non-Stroke: Those who reported never has been diagnosed as stroke before Difference-in-differences: Additional informal caregiving hours associated with stroke

- Adjusting for age, annual wages for individuals that have suffered a stroke is $19,663 compared to $37,268 for that have not (Giotra et al., 2020).
- The AHA estimates that stroke mortality accounts for $19.1 billion annually in opportunity costs nationally (Khan et al., 2021; Virani et al., 2020).
- Health and Retirement Study (2006-2008) estimated that families spend an incremental 8.5 hours per week taking care of them. This amounts to $4,356 in lost economic value per stroke survivor and amounts to $14.2 billion annually (Joo et al., 2014).

Costs to Society: Opportunity Costs - Virginia

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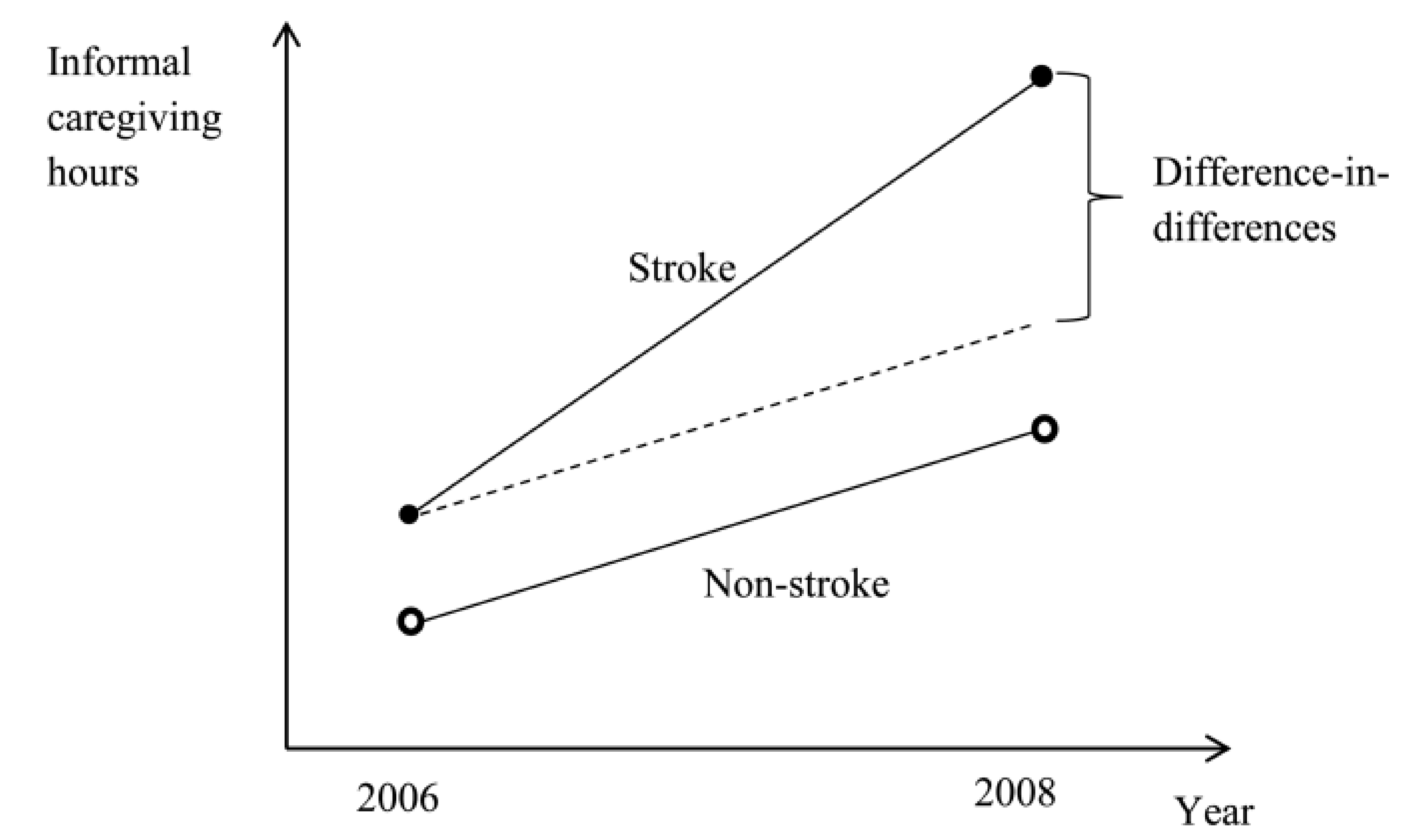

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- Giotra et al,. estimated average productivity loss per survivor as ~$27,400 in 2020 $.
- Applying these figures to estimated Virginia prevalence amounts to $1,206,867,823.
- Applying Joo et al’s estimates on informal care giving costs amounts to $191,865,556.
- *Total Opportunity and Indirect Costs = $1,206,867,823 + $191,865,556 = $ 1,398,733,380.10*

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Total Estimated Cost to Society = $1,206,867,823

+ $191,865,556 = $1,398,733,740

*2020 $

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Role of Government - Federal

The federal government covers most stroke related care, funds research, and exerts regulatory influence.

- Medicare covers approximately 72% of all patients with stroke and approximately 75% of the total stroke cost in the United States (Trogdon et al., 2007).
- The federal government exerts additional influence on stroke care through the regulatory environment, meaningfully in telemedicine.
- Federal funding for stroke research is done through the Department of Health and Human Services' National Institute of Neurological Disorders and Stroke (NINDS).
- The 2021-2026 NINDS Strategic Plan identifies several priority areas for stroke research, but mostly focus on clinical interventions, advanced biomarker tracking and promoting a diverse neurological sciences workforce.

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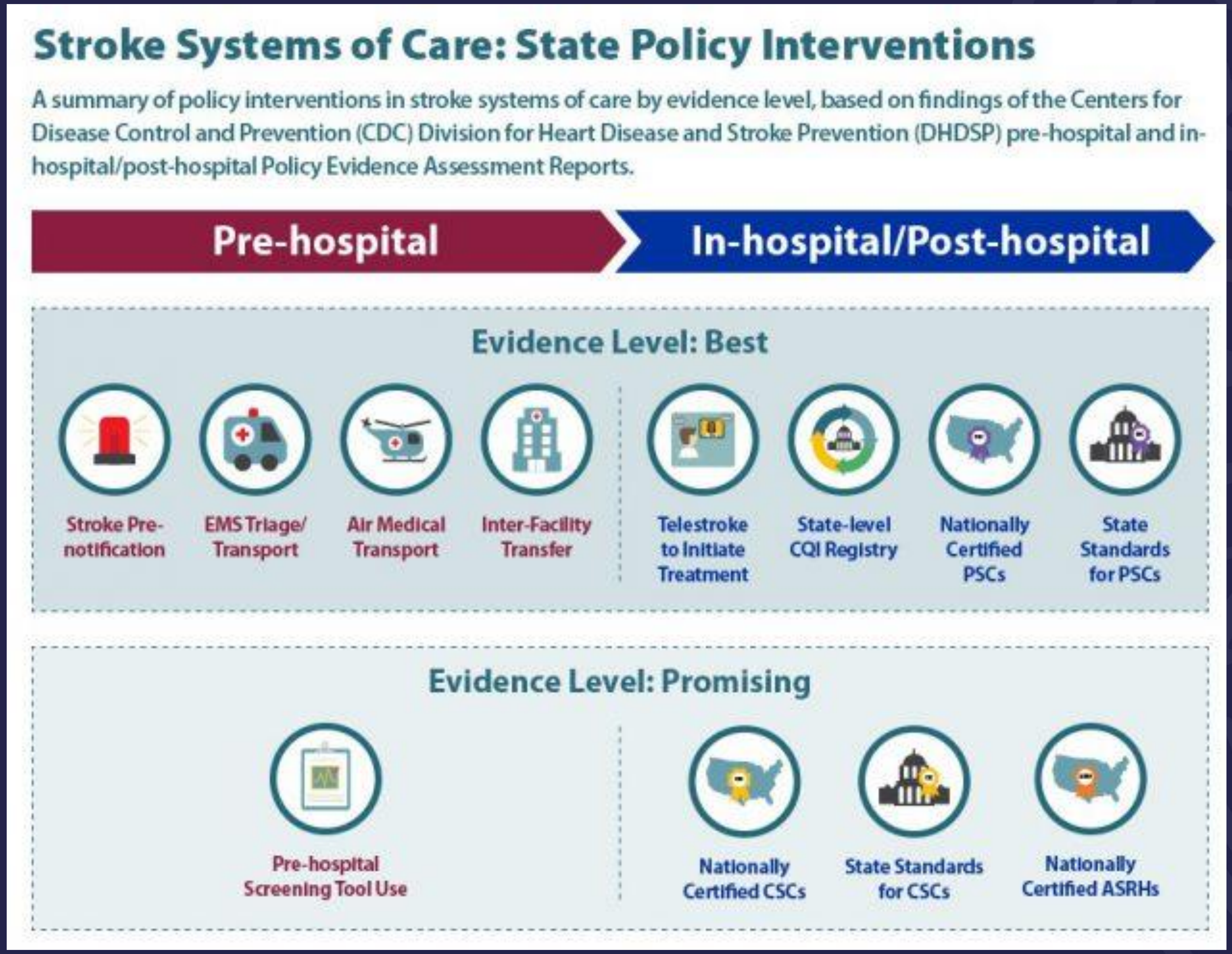
Role of Government - Local

Local governments operate and administer emergency and social services that touch each element of the stroke continuum of care.



HTTPS://WWW.CDC.GOV/DHDSP/POLICY_RESOURCES/STROKE_SYSTEMS_OF_CARE/EVIDENCE_INTERVENTIONS.HTM

- Community centers designed for aging populations are frequent venues for community education and primary prevention efforts. These centers also provide the opportunity to partner with local health systems to provide primary medical prevention services like blood pressure management (Siegler et al., 2015).
- Local governments are the primary administrators of emergency medical services. Emergency medical services in the United States are known internationally as disparate and heterogenous in both staffing model and quality of services provided (M. N. Shah, 2006).

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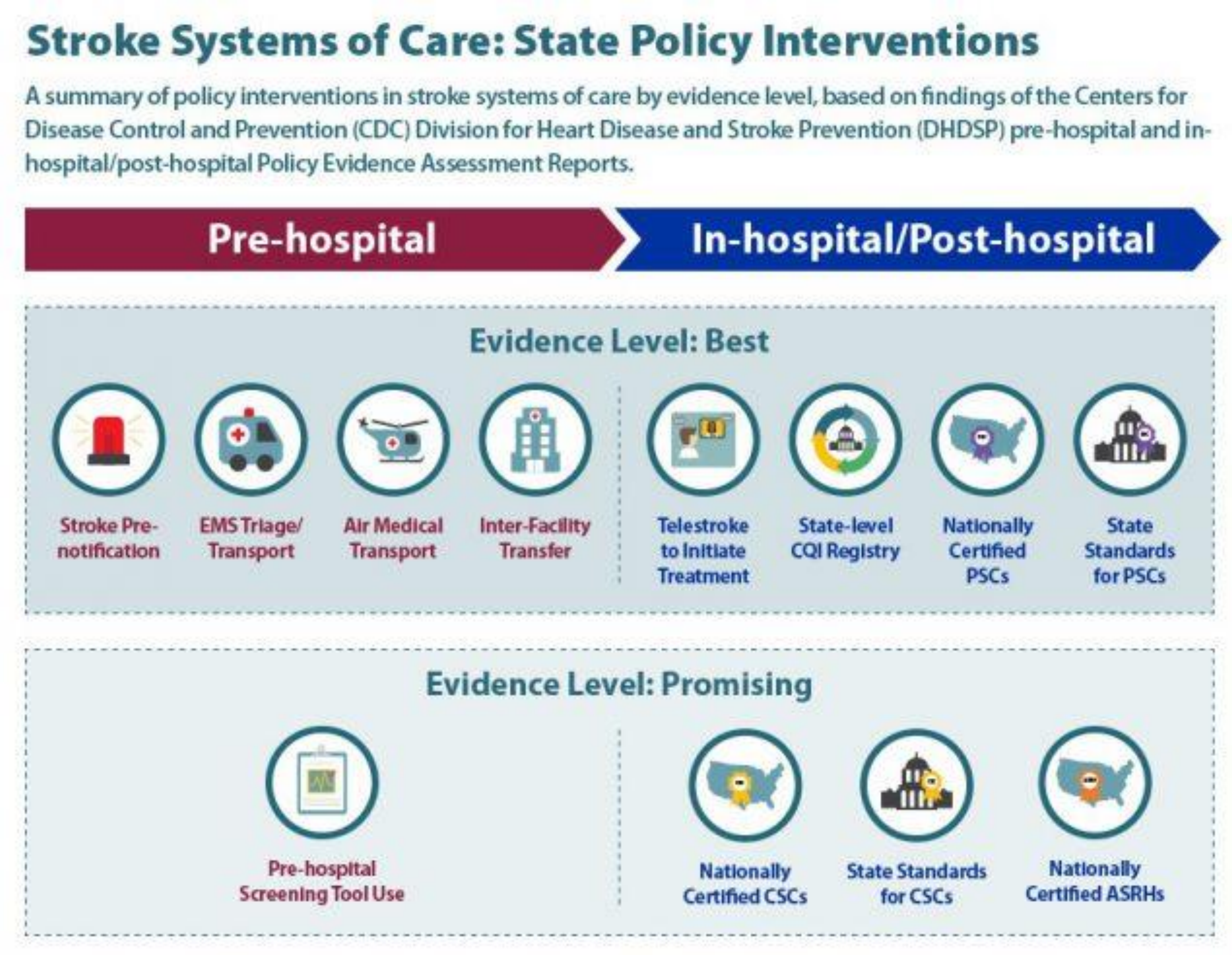
Role of Government - State

States maintain regulatory oversight of clinician scope of practice and licensing, and administer Medicaid and "Stroke Systems of Care"



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- States are the primary authority for clinical and operational protocols regarding stroke identification and triage for emergency medical services.
- The combination of regulatory oversight levers and the logistical nature of emergent stroke care, states are in a unique position to facilitate stakeholder and decisionmaker coordination.

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Role of Government - Virginia

Stroke care in Virginia is governed under both legislative and executive branch policy.

- The Virginia Stroke Systems Task Force (VSSTF) was established after a 2008 study by the Joint Commission on Healthcare (JCHC) recommended creating a permanent task force on improving stroke systems of care in the Commonwealth.
- Hospitals are required under VA code § 32.1-111.15:1 are required to share stroke patient data with the VSSTF for the purposes of establishing continuous quality improvement for the delivery of stroke care (Department Responsible for Stroke Care Quality Improvement; Sharing of Data and Information, 2020).
- Prehospital care in Virginia is governed by regional "councils" regulated under Virginia Administrative code 12VAC5-31-2330. EMS councils provide a clearinghouse for training, quality improvement and state accountability. EMS councils publish regional treatment protocols that to encourage departmental interoperability.

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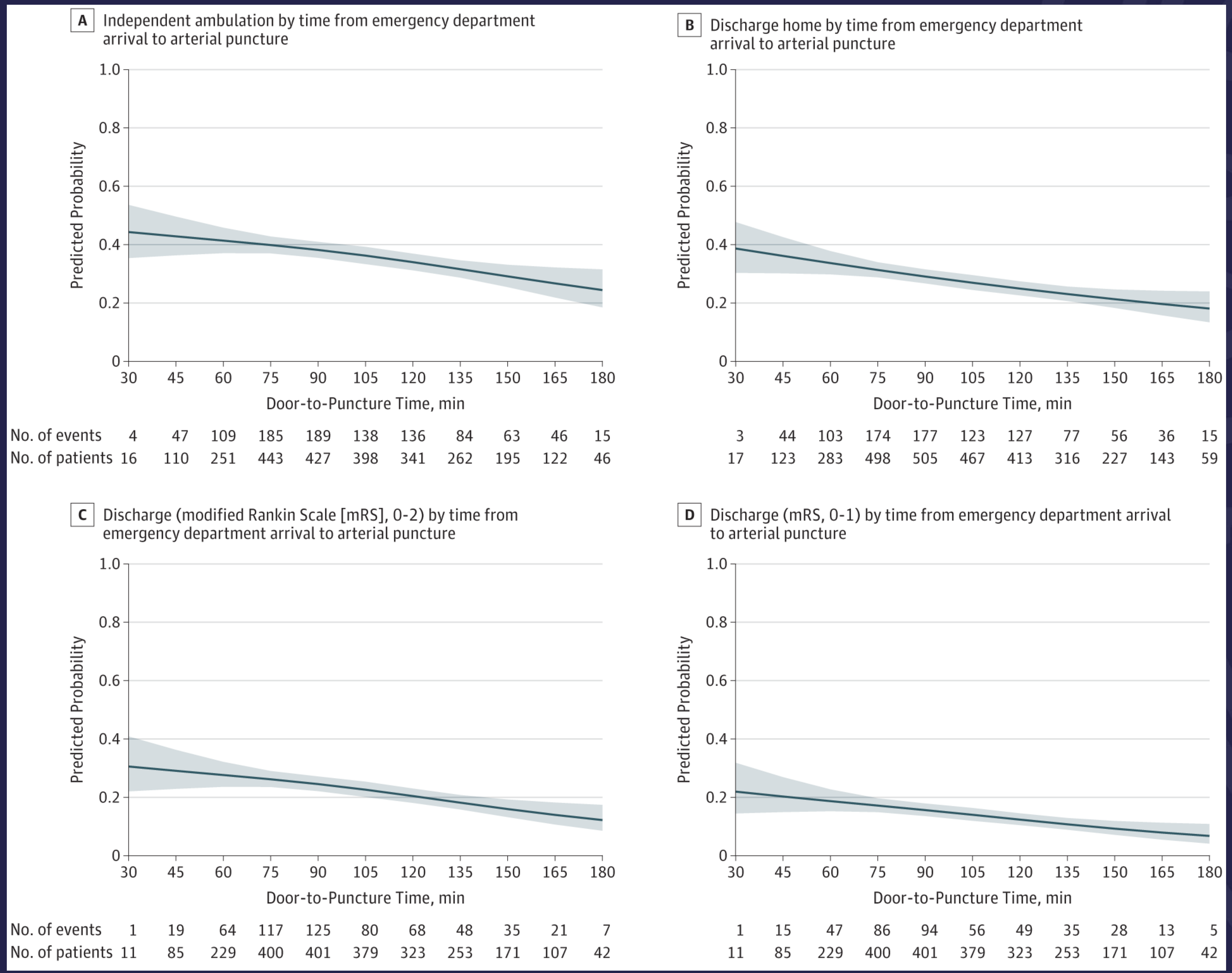
Existing Evidence: Time is Brain

The majority of patients that are eligible for reperfusion therapy do not receive it due to delay in presentation to hospitals (Herpich & Rincon, 2020).



- Rai et al., found a possible two-to-five-fold increase in reperfusion eligible patients that do not receive therapy because of prehospital and interhospital systems of care (Rai et al., 2016).
- Major factors affecting treatment delays include emergency medical pathways, stroke symptomatology, patient and bystander behavior, patient health characteristics and stroke treatment awareness (Pulvers & Watson, 2017).
- For every fifteen-minute decrease in time to endovascular therapy a patient's odds of discharge home increase by 2.13% and their odds of in-hospital mortality or hospice discharge decreases by 1.48% (Jahan et al., 2019).

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Existing Evidence: Time is Brain

Patient factors contribute to delays in seeking treatment.

Factor	Effect on Delay in Acute Ischemic Stroke
Sociodemographic characteristics	
Older age	No difference
Female sex	No difference
Lower educational level	No difference
Black or Latino race	Increase
Low socioeconomic status	Increase or no difference
Clinical characteristics	
Prior myocardial infarction	No difference
Diabetes	No difference
Hypertension	No difference
Heart failure	No difference
History of atrial fibrillation	No difference
Smoking	No difference
Hyperlipidemia	No difference
Prior stroke or transient ischemic attack	Decrease
Social	
Living alone or being alone at symptom onset	Increase
Consultation with physician	Increase
Consultation with a family member versus a nonrelative	Increase
Consultation with a nonrelative	Increase
Cognitive and emotional	
Knowledge of symptoms or risk factors	No difference
Appraisal of symptoms as not being serious or urgent	Increase
Self-treatment	Increase

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Existing Evidence: Prevention

Primary prevention programs focus on provider and patient education on modifiable and non-modifiable risk factors.

TABLE 2 Summary of the Effectiveness of Intervention for the Primary Prevention of First-Ever Stroke

Intervention	Risk Ratio	Stroke Risk per Year (%): Control	Stroke Risk per Year (%): Intervention	Relative Risk Reduction (95% CI) (%)	Absolute Risk Reduction (%)
Nil		0.14			
Blood pressure–lowering (by 10-mm Hg systolic)	1.54	0.22	0.13	41 (33-48)	0.09
LDL cholesterol–lowering (by 1.0 mmol/l)	1.27	0.18	0.14	21 (6-13)	0.04
Anticoagulation (for atrial fibrillation)	5.00	0.70	0.25	64 (49-74)	0.45
Cigarette smoking–cessation	1.45	0.20	0.14	31 (25-36)	0.06

CI = confidence interval; LDL = low-density lipoprotein.

- 75% of stroke patients have hypertension. Diener and Hankey found in 2020 that for every 10mmHg increase in systolic blood pressure reduces the relative risk of stroke by 41% (95% CI: 33% to 48%) compared to normotensive patients and an absolute risk reduction of 0.09% (Diener & Hankey, 2020).
- Patient education programs targeting populations that benefit from an antithrombotic or anticoagulant agent have been successful (Man-Son-Hing et al., 1999). However, these programs are targeted toward patients with risk factors that are likely to cause concern among the *patients themselves* such as an irregular heartbeat or previous history of stroke.

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Existing Evidence: Stroke Systems of Care

Stroke systems of care aim to reduce barriers to effective and efficient care through stakeholder cooperation and engagement.

- The stroke system of care paradigm attempts to integrate eight different domains of stroke care, underpinned by continuous quality improvement (Adeoye et al., 2019).
- Ganesh et al performed a retrospective analysis of integrated systems of stroke care in Canada, finding a reduction in crude 30-day mortality from 15.8% in fiscal year 2003/2004 to 12.7% in FY 2013/2014 for provinces with integrated systems of stroke care compared to a steady rate of 14.5% for those that did not with an adjusted incidence rate ratio (aIRR) of 0.86 (CI:0.79-0.92) (Ganesh et al., 2016).
- Stroke systems of care are not created equally, however. While most states have codified stroke systems of care through regulation or legislation, performance is inequitable (Hammond-Heaton & Lucian, 2016).

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Existing Evidence: Stroke Systems of Care

Stroke systems of care aim to reduce barriers to effective and efficient care through stakeholder cooperation and engagement.

- The benefit of stroke systems of care stems from the critical appraisal of each component of stroke care. Inefficiencies in stroke systems of care stem from everything from the availability of resources, geography and weather (Herpich & Rincon, 2020; Pulvers & Watson, 2017; Rai et al., 2016; Sheth et al., 2015).

- State health departments hire on average 2.5 full time equivalent employees when developing a state stroke system of care, with variation based on the number and resources of partner agencies. PCNASP funded expenditures during the funding period ranged from $790,123 to $1,298,160 (Yarnoff et al., 2019).

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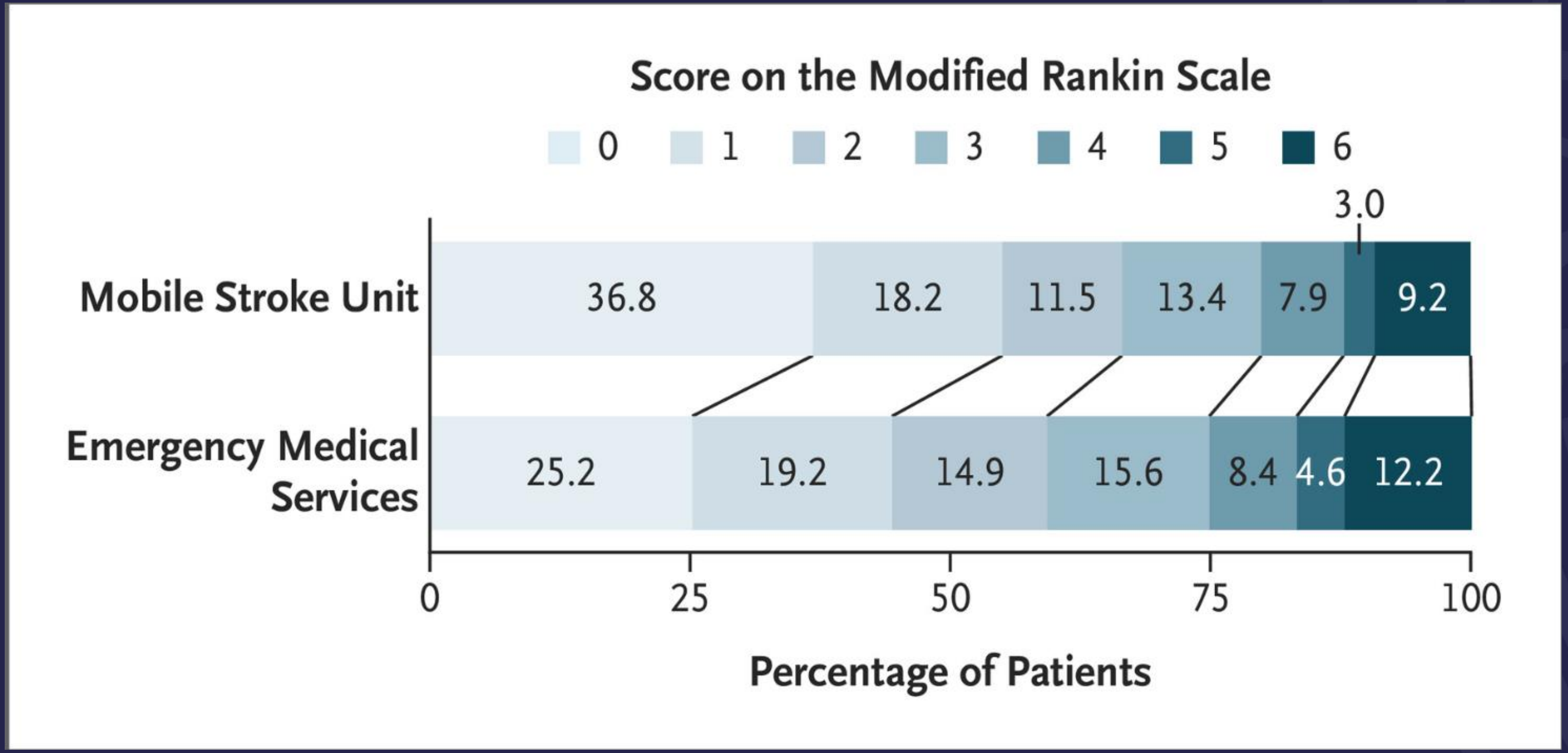
Existing Evidence: Mobile Stroke Units

Mobile stroke units attempt to "bring the hospital to the patient" using ambulances outfitted with advanced imaging and treatment capabilities.



- Mobile stroke units seem to reliably reduce the time to treatment for stroke patients, but their cost-effectiveness remains questionable (Southerland & Brandler, 2017).
- A modeling study by Reimer et al found mobile stroke units are cost-preferable to standard of care when they treat >391 patients a year, basing this assessment on the estimated number of interhospital transfers (by air and ground) and emergency department encounters avoided (Reimer et al., 2020).
- The BEST-MSU study found meaningful improvements in mRS from MSU treated patients.

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Policy Alternatives

Primary Hypertension Reduction Program

Modeled off Los Angeles Barbershop hypertension reduction program.

Central Stroke Registry Collaborative Through VSSTF

Modeled off Florida Stroke Collaborative

Mobile Stroke Unit

Modeled BEST-MSU, various cost-effectiveness estimates

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Policy Alternatives – Hypertension Reduction Program

Outcome	Intervention Group (N=132)	Control Group (N=171)	Intervention Effect	P Value†
Blood pressure				
Systolic blood pressure — mm Hg‡				
At baseline	152.8±10.3	154.6±12.0		
At 6 mo	125.8±11.0	145.4±15.2		
Change	−27.0±13.7	−9.3±16.0	−21.6 (−28.4 to −14.7)§	<0.001
Diastolic blood pressure — mm Hg				
At baseline	92.2±11.5	89.8±11.2		
At 6 mo	74.7±8.3	85.5±12.0		
Change	−17.5±11.0	−4.3±11.8	−14.9 (−19.6 to −10.3)§	<0.001
Hypertension control at 6 mo — no. (%)				
Blood pressure <140/90 mm Hg	118 (89.4)	55 (32.2)	3.4 (2.5 to 4.6)¶	<0.001
Blood pressure <135/85 mm Hg	109 (82.6)	32 (18.7)	5.5 (2.6 to 11.7)¶	<0.001
Blood pressure <130/80 mm Hg	84 (63.6)	20 (11.7)	5.7 (2.5 to 12.8)¶	<0.001

* Plus–minus values are means ±SD.
† For systolic blood pressure and diastolic blood pressure, P values were calculated from linear mixed-effects models with random intercepts for clusters. The estimated intervention effect was controlled for baseline systolic or diastolic blood pressure, routine doctor, and high cholesterol level. For hypertension control at 6 months, P values were calculated from generalized estimating equations with a compound symmetry working correlation to account for cluster effects. The estimated intervention effect was controlled for baseline systolic blood pressure, routine doctor, and high cholesterol level.
‡ The prespecified primary outcome was the change in systolic blood pressure from baseline to 6 months. The intraclass correlation coefficient from the linear mixed-effects model for change in systolic blood pressure was 0.05. Degrees of freedom for the estimated intervention effect=276.
§ Shown is the difference in mean change in blood pressure and 95% confidence interval.
¶ Shown is the relative risk and 95% confidence interval.

- Public intervention campaigns require that you meet people where they are. Victor et al. used a model where pharmacists performed blood pressure management in Black barbershops in Los Angeles.
- This program shows that conventionally marginalized populations are reachable with public outreach efforts, using informed, culturally sensitive approaches.
- The barbershop portion is not the key factor here, it is *the knowledge of the community and population you are trying to reach.*

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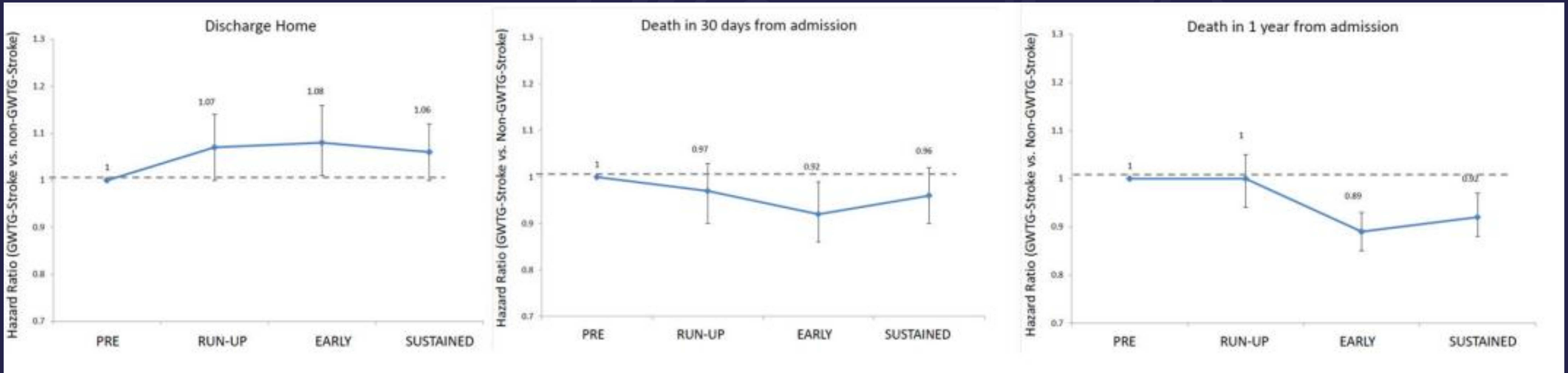
Policy Alternatives - Central Stroke Registry Collaborative Through VSSTF



- In 2016 Song et al. found that implementation of a registry and data sharing program improves disability outcomes by a sustained 1% during the run-up, early, and sustained portion of implementation

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Policy Alternatives - Central Stroke Registry Collaborative Through VSSTF 2

Acute Stroke Treatment Among FSR participating hospitals in Florida	2010	*2020
Use of thrombolytics (clot busting medication) in stroke	7%	**14%**
Use of clot busting medication amongst stroke patients arriving in 3.5 hrs. and treated within 4.5 hrs. of stroke onset	69%	**90%**
Treatment within 60 min. of hospital arrival	19%	**92%**
Treatment within 45 min. of hospital arrival	6%	**75%**
Catheter based stroke treatment (clot removal or thrombectomy)	2%	**15%**
Defect Free Care (overall quality of care)	74%	**92%**

- The Florida Stroke Registry began at the University of Miami in 2017 and serves as Florida's central coordinating hub for stroke related care.
- The Registry provides QA/QI services, as well as continuing education and outreach efforts.
- Importantly, the Registry creates regular data reports, allowing individuals not affiliated with hospital systems to see aggregate data.
- Registry is funded by GAA Line # 476 and received $750,000 in Fy20-21 and requested $1,000,000 in nonrecurring funds in FY21-2022.

Policy Alternatives – Mobile Stroke Units

Author	Sources	Location	Duration	Study design	Year	Cost of study intervention $	Net cost of intervention $	Cost of study control $	Incremental cost $	Outcomes	Cost-saving $
Dietrich et al. (27)	Current wage agreements of the German public service	Germany	1 year	Trial-based	2014	1,207,753	NA	NA	236,568	Benefit-cost ratio: 1.96	463,124
Gyrd-Hansen et al. (28)	Berlin fire department and Charité hospital Official human resources tables	Germany	10.5 months	Trial-based	2015	1,410,708[a]	947,767	NA	NA	Cost-effectiveness ratio: 31,911 per QALY	481,482
Kim et al. (29)	MSU financial and patient tracking reports and related databases.	Australia	1 year	Model-based	2019	1,881,331[a]	1,736,617	NA	NA	Cost-effectiveness ratio: 38,731 per DALY	295,033
Reimer et al. (30)	Bureau of Labor and Statistics Peer-reviewed published literature.	USA	15 months	Model-based	2020	783,463[a]	NA	785,869	70,613	NA	NA

$, US Dollar; benefit-cost ratio, cost saving/incremental cost; cost-effectiveness ratio, net cost/outcomes.
[a]Adjusted by US Consumer Price Inflation Rate (based on 2014).

- A review published in March 2022 by Chen et al. found favorable cost effectiveness compared to standard care for Mobile Stroke Units.

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Cost-Effectiveness

What is a Cost-Effectiveness Analysis?

- Cost-effectiveness relates the costs of a program to its key outcome and benefits but differs from cost-benefit in that it does not compare the costs of *all* a program's benefits.

Why Cost-Effectiveness?

- This form of analysis allows for the standardized comparison of programs and focuses analysis on the outcome of interest.

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Cost-Effectiveness 2

What is the outcome measure?

- Ordinal modified Rankin Scale, projected over the 2022-2023 time period. Data taken from incidence of stroke in Virginia as a proportion of population, then distributed by mRS using estimates from a large registry study by Olavarria et al.
- Cost estimates derived from the average of three studies assessing the first year costs of stroke survivors by mRS.
- Costs then projected over a ten year period from 2022 – 2032 using inflation rates estimated by the Federal Reserve.

Average Cost by mRS	mRS 0	mRS 1	mRS 2	mRS 3	mRS 4	mRS 5
Fattore 2012	$ 2,146.00	$ 2,146.00	$ 2,146.00	$ 5,722.00	$ 14,615.00	$ 14,615.00
Baeten, 2010	$ 2,014.00	$ 2,014.00	$ 4,798.00	$ 4,798.00	$ 20,380.00	$ 25,744.00
Hayes 2008	$ 16,034.00	$ 13,598.00	$ 13,720.00	$ 24,983.00	$ 33,326.00	$ 30,805.00
Average and Conversion	$ 8,172.92	$ 7,187.02	$ 8,363.13	$ 14,368.77	$ 27,650.88	$ 28,801.49
Convert to 2022 $	$ 8,388.21	$ 7,376.34	$ 8,583.44	$ 14,747.29	$ 28,379.28	$ 29,560.21

*Meta analysis reported costs adjusted for 2015 Euro PPI, average of costs were converted to 2015 USD. Using Oanda.com historical currency converter web tool. Studies used reported 12 month total direct costs for patients by mRS.

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Cost-Effectiveness 3

What is the outcome measure?

Distribution of mRS Scores	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	9022	9107	9193	9272	9306	9441	9527	9613	9621	9708	9796
1	12747	12868	12990	13101	13148	13340	13461	13583	13594	13717	13842
2	5296	5346	5397	5443	5463	5543	5593	5643	5648	5699	5751
3	4758	4803	4848	4890	4907	4979	5024	5070	5074	5120	5166
4	4803	4848	4894	4936	4954	5026	5071	5117	5122	5168	5215
5	7900	7974	8050	8119	8148	8267	8342	8417	8424	8501	8578
Total	**44525**	**44946**	**45372**	**45762**	**45926**	**46595**	**47017**	**47444**	**47483**	**47914**	**48348**

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Cost-Effectiveness 4

What is the projected base case costs?

First Year Direct Medical Costs by mRS Adjusted for Inflation Base Case	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
0	$ 75,675,828.06	$ 77,996,330.66	$ 80,387,988.52	$ 82,781,500.98	$ 84,822,778.65	$ 87,952,300.48	$ 90,879,471.83	$ 93,904,063.39	$ 96,238,266.34	$ 99,441,205.82	$ 102,750,743.46
1	$ 94,026,693.49	$ 96,001,254.05	$ 99,881,520.31	$ 102,855,443.00	$ 105,391,716.40	$ 109,280,125.65	$ 112,917,115.83	$ 116,675,149.95	$ 119,575,380.98	$ 123,555,011.16	$ 127,667,088.81
2	$ 45,460,601.00	$ 46,415,273.62	$ 48,291,328.49	$ 49,729,178.83	$ 50,955,431.80	$ 52,835,423.70	$ 54,593,857.96	$ 56,410,815.29	$ 57,813,036.73	$ 59,737,132.67	$ 61,725,265.13
3	$ 70,163,248.80	$ 71,636,677.02	$ 74,532,153.58	$ 76,751,311.46	$ 78,643,892.97	$ 81,545,445.87	$ 84,259,388.45	$ 87,063,654.70	$ 89,227,823.45	$ 92,197,445.92	$ 95,265,901.45
4	$ 136,294,008.47	$ 139,156,182.64	$ 144,780,724.17	$ 149,091,498.38	$ 152,767,889.14	$ 158,404,234.14	$ 163,676,140.99	$ 169,123,504.03	$ 173,327,460.36	$ 179,096,032.34	$ 185,056,590.18
5	$ 233,513,391.37	$ 238,417,172.59	$ 248,053,735.35	$ 255,439,412.21	$ 261,738,195.88	$ 271,394,981.60	$ 280,427,373.14	$ 289,760,374.87	$ 296,963,039.98	$ 306,846,371.03	$ 317,058,632.69
Total	**$ 655,133,771.17**	**$ 669,622,890.58**	**$ 695,927,450.41**	**$ 716,648,344.86**	**$ 734,319,904.83**	**$ 761,412,511.43**	**$ 786,753,348.19**	**$ 812,937,562.22**	**$ 833,145,007.83**	**$ 860,873,198.96**	**$ 889,524,221.73**

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Cost-Effectiveness

Alternative 1: Hypertension Reduction Program

Year	Staff Costs	Direct Medical Costs W Hypertension Reduction	Full Cost of Program	Status Quo Costs	Annual Difference	NPV
2022	$ 253,563.24	$ 655,133,771.17	$ 655,387,334.41	$ 655,133,771.17	$ 253,563.24	
2023	$ 258,888.06	$ 666,918,350.20	$ 667,177,238.27	$ 669,622,890.58	$ (2,445,652.32)	
2024	$ 264,324.71	$ 676,906,186.11	$ 677,170,510.82	$ 695,927,450.41	$ (18,756,939.59)	
2025	$ 269,875.53	$ 687,043,600.84	$ 687,313,476.37	$ 716,648,344.86	$ (29,334,868.48)	
2026	$ 275,542.92	$ 697,332,834.51	$ 697,608,377.43	$ 734,319,904.83	$ (36,711,527.40)	
2027	$ 281,604.86	$ 708,469,379.35	$ 708,750,984.21	$ 761,412,511.43	$ (52,661,527.22)	
2028	$ 288,363.38	$ 721,192,355.85	$ 721,480,719.23	$ 786,753,348.19	$ (65,272,628.96)	
2029	$ 295,284.10	$ 734,143,816.65	$ 734,439,100.75	$ 812,937,562.22	$ (78,498,461.47)	
2030	$ 302,370.92	$ 747,327,864.97	$ 747,630,235.89	$ 833,145,007.83	$ (85,514,771.95)	
2031	$ 309,627.82	$ 760,748,677.70	$ 761,058,305.52	$ 860,873,198.96	$ (99,814,893.44)	
2032	$ 317,058.89	$ 774,410,506.75	$ 774,727,565.64	$ 889,524,221.73	$ (114,796,656.09)	
Total	**$ 3,116,504.43**	**$ 7,829,627,344.11**	**$ 7,832,743,848.53**	**$ 8,416,298,212.21**	**$ (583,554,363.68)**	**$219,724,316.42**

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Cost-Effectiveness

Alternative 2: Stroke Registry Program

Year	Operating Expenses (Annual)	Non-Recurring Startup Costs	Direct Medical Costs Stroke Reg	Full Cost of Registry	Status Quo Costs	Annual Difference	NPV
2022	$ 65,426.40	$ 750,000.00	$ 651,960,236.96	$ 652,775,663.36	$ 655,133,771.17	$ (2,358,107.81)	
2023	$ 66,800.35	$ 1,000,000.00	$ 671,040,405.05	$ 672,107,205.40	$ 669,622,890.58	$ 2,484,314.82	
2024	$ 68,203.16		$ 690,689,276.72	$ 690,757,479.89	$ 695,927,450.41	$ (5,169,970.52)	
2025	$ 69,635.43		$ 710,394,158.12	$ 710,463,793.54	$ 716,648,344.86	$ (6,184,551.31)	
2026	$ 71,097.77		$ 727,545,361.29	$ 727,616,459.07	$ 734,319,904.83	$ (6,703,445.76)	
2027	$ 72,661.92		$ 752,866,116.98	$ 752,938,778.90	$ 761,412,511.43	$ (8,473,732.53)	
2028	$ 74,405.81		$ 776,953,316.39	$ 777,027,722.20	$ 786,753,348.19	$ (9,725,625.99)	
2029	$ 76,191.55		$ 801,818,909.48	$ 801,895,101.03	$ 812,937,562.22	$ (11,042,461.19)	
2030	$ 78,020.15		$ 821,656,101.58	$ 821,734,121.73	$ 833,145,007.83	$ (11,410,886.11)	
2031	$ 79,892.63		$ 847,961,253.88	$ 848,041,146.51	$ 860,873,198.96	$ (12,832,052.45)	
2032	$ 81,810.05		$ 875,116,901.04	$ 875,198,711.09	$ 889,524,221.73	$ (14,325,510.64)	
Total	**$ 804,145.23**			**$ 8,330,556,182.71**	**$ 8,416,298,212.21**		**$219,727,150.93**

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Cost-Effectiveness

Alternative 3: Mobile Stroke Unit

Year	Operating Expenses (Annual)	Initial Vehicle Purchase, Outfitting**	Direct Medical Costs W MSU	Full Cost of MSU	Status Quo Costs	Annual Difference	NPV
2022	$ 500,000.00	$ 1,200,000.00	$ 655,133,771.17	$ 656,833,771.17	$ 655,133,771.17	$ 1,700,000.00	
2023	$ 510,500.00		$ 675,228,096.59	$ 675,738,596.59	$ 669,622,890.58	$ 6,115,706.01	
2024	$ 521,220.50		$ 695,933,103.72	$ 696,454,324.22	$ 695,927,450.41	$ 526,873.81	
2025	$ 532,166.13		$ 716,654,166.49	$ 717,186,332.62	$ 716,648,344.86	$ 537,987.76	
2026	$ 543,341.62		$ 734,325,870.02	$ 734,869,211.64	$ 734,319,904.83	$ 549,306.81	
2027	$ 555,295.13		$ 761,418,696.70	$ 761,973,991.84	$ 761,412,511.43	$ 561,480.41	
2028	$ 568,622.22		$ 786,759,739.32	$ 787,328,361.53	$ 786,753,348.19	$ 575,013.34	
2029	$ 582,269.15		$ 812,944,166.05	$ 813,526,435.21	$ 812,937,562.22	$ 588,872.98	
2030	$ 596,243.61		$ 833,151,775.82	$ 833,748,019.43	$ 833,145,007.83	$ 603,011.60	
2031	$ 610,553.46		$ 860,880,192.19	$ 861,490,745.65	$ 860,873,198.96	$ 617,546.69	
2032	$ 625,206.74		$ 889,531,447.71	$ 890,156,654.45	$ 889,524,221.73	$ 632,432.72	
					$ 8,416,298,212.21	**$ 13,008,232.13**	**$221,094,069.97**

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Cost-Effectiveness – Results Table

Year	Status Quo Costs	Mobile Stroke Unit	Targeted Hypertension Reduction Program	Stroke Registry
2022	$ 655,133,771.17	$ 656,833,771.17	$ 655,387,334.41	$ 652,775,663.36
2023	$ 669,622,890.58	$ 675,738,596.59	$ 667,177,238.27	$ 672,107,205.40
2024	$ 695,927,450.41	$ 696,454,324.22	$ 677,170,510.82	$ 690,757,479.89
2025	$ 716,648,344.86	$ 717,186,332.62	$ 687,313,476.37	$ 710,463,793.54
2026	$ 734,319,904.83	$ 734,869,211.64	$ 697,608,377.43	$ 727,616,459.07
2027	$ 761,412,511.43	$ 761,973,991.84	$ 708,750,984.21	$ 752,938,778.90
2028	$ 786,753,348.19	$ 787,328,361.53	$ 721,480,719.23	$ 777,027,722.20
2029	$ 812,937,562.22	$ 813,526,435.21	$ 734,439,100.75	$ 801,895,101.03
2030	$ 833,145,007.83	$ 833,748,019.43	$ 747,630,235.89	$ 821,734,121.73
2031	$ 860,873,198.96	$ 861,490,745.65	$ 761,058,305.52	$ 848,041,146.51
2032	$ 889,524,221.73	$ 890,156,654.45	$ 774,727,565.64	$ 875,198,711.09

NPV	*$220,275,783.80*	*$221,094,069.97*	*$219,724,316.42*	*$219,727,150.93*
Summed Projected mRS Scores	105482	104069	91058	102839
Result	*2088*	*2124*	*2413*	*2137*

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Other Considerations - Hypertension Reduction Program

- Implementing an effective primary or secondary prevention campaign in Virginia requires cooperation between several stakeholders, meaningfully Virginia's Chronic Disease Prevention and Health Promotion Collaborative.
- Effective programs must do more than simply provide information by including resource access in program design.
- The political feasibility of this program is region specific and comes down to buy-in from health systems, community members, and local leaders. The data I used in my projections assumed that any such program in Virginia would not be one sized fits all, but rather tailored to meet local needs.

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Other Considerations - Central Stroke Registry Collaborative Through VSSTF 2

- This option requires the most government intervention and advocacy, the political feasibility of which is likely to be low in the short term. Implementation requires identification of friendly state representatives to support increased statutory funding for VSSTF, VDH.

- Provision of these data collection and dissemination services does not equal end user utilization. Program evaluation should use a design to make use of the Local Average Treatment Effect theorem to assess equity of utilization across Virginia regions.

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Other Considerations - – Mobile Stroke Units

- A mobile stroke unit pilot project is necessarily inequitable because of the limited geographic nature of a ground ambulance unit and the variability of call volume.

- MSU’s are likely more effective in areas without rapid access to comprehensive stroke centers as their cost-effectiveness requires that they prevent a certain proportion of interfacility transfers.

- This option would likely require the most of health systems, who are the primary suppliers of ground based critical care transport services in Virginia.

- Health systems are monopsony employers for stroke clinicians, making any MSU program dependent on the staffing levels of supporting institutions.

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Takeaways

Stroke poses uniquely high costs to society in the form of lost economic opportunity and direct medical costs.

- Advancements in treatment and prevention have reduced mortality from stroke, but those gains have since leveled off.
- Cost-effectiveness of stroke related programs is dependent on the level of analysis.
- Several policy options exist that may improve stroke outcomes, but these effects are secondary.

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Takeaways 2

Preventing stroke is more cost-effective than high intensity intervention or treatments.

- Mobile stroke units likely improve stroke outcomes, but require a high call volume to reach cost-effectiveness, and even then, are limited by geography.
- A stroke registry program similarly improves stroke outcomes at a system level, but when accounting for ongoing costs and the need to obtain recurrent funding, the labor investment is substantial.
- Well-funded, evidence-based primary prevention programs are especially cost-effective, but require significant personnel buy-in and community engagement to be effective.

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End of Presentation