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RESEARCH REPORTS

ASSOCIATION BETWEEN STROKE CENTER AND COUNTY-LEVEL EMERGENCY MEDICAL SERVICES BYPASS POLICIES AND PROPORTION OF STROKE PATIENTS RECEIVING THROMBOLYTIC THERAPY

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ABSTRACT

Objective: Over the past two decades, numerous policy efforts have been made to improve management in acute stroke, including stroke center policy and EMS bypass policy. The effect of these policies on clinical outcomes such as thrombolysis are yet not understood on a national scale. Our objective is to identify the association between thrombolysis and stroke center policy, and furthermore, the synergistic effect of stroke center policy and EMS bypass policy on thrombolysis rates.

Methods: We conducted a retrospective observational study using a 20% national sample of Medicare beneficiaries diagnosed with ischemic stroke from 2007 to 2014. We estimated the difference-in-differences (DID) to determine the stroke center policy effect on thrombolysis rates, and to determine the stroke center and EMS bypass policy effect together on thrombolysis rates.

Results: Overall, counties that implemented a stroke center policy had a significant increase in thrombolysis compared to counties who did not have a stroke center policy (RR = 1.42, 95% CI [1.12, 1.80], p = 0.004) in the pre-policy period. There was no significant association in stroke policy counties with increasing thrombolysis rate in only the post-policy period compared to no stroke center policy counties. There was an increase in thrombolysis rate overall and in the post policy period among counties that implemented both an EMS bypass and stroke center policy compared to counties that did not implement any policy (RR = 1.48, 95% CI [1.19, 1.84], p < 0.001).

Conclusions: Counties with both stroke center policy and EMS bypass policy had significantly higher thrombolysis rates after policy implementation. This is likely the first analysis of the effect of stroke policies on thrombolysis using the largest ever national stroke database.

INTRODUCTION

Background

In recent decades, improvements in the management of acute stroke have led to numerous policy implementations. In 2000, the Brain Attack Coalition recommendations led to the establishment of comprehensive stroke centers that deliver specialized care including appropriate personnel, advanced neuroimaging capabilities, and appropriate intensive care infrastructure (Alberts et al., 2000). Subsequently, the Joint Commission began certifying primary stroke centers (PSCs) in 2003 (Uchino et al., 2015), and by 2022, 44% of United States emergency departments (EDs) were associated with stroke centers (Boggs et al., 2022). However, the clinical effect of these policies on the care of stroke patients is not yet fully understood on a national scale.

Importance

Some existing literature suggests that PSCs are associated with high thrombolysis utilization. For example, Mullen et al. (2013) identified high rates of intravenous thrombolysis at PSCs as compared to non-PSCs. Similarly, Meng et al. (2022) noted higher probabilities of intravenous thrombolysis use among patients treated at stroke centers. Man et al. (2017) found hospitals certified as PSCs between 2009 and 2013 had improved mortality rates compared to existing PSCs. Furthermore, new and existing PSCs have demonstrated improved mortality when compared to non-PSC hospitals (Man et al., 2017).

Multiple studies indicate pre-hospital factors greatly contribute to delays in the administration of intravenous tissue plasminogen activator (Amalia, 2023; Sharobeam et al., 2021) (a well-established yet highly time-sensitive treatment therapy (National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group, 1995)). Given that “time is brain” in acute stroke management, dedicated efforts enhance stroke care (in addition to stroke center policy) such as pre-hospital bypass policies in which emergency medical service (EMS) providers bypass the nearest hospital to instead go directly to the nearest certified stroke center were established. As such, the American Heart Association and American Stroke Association suggested establishing interactions within stroke systems of care, such as pre-hospital providers triaging patients to the highest level of care stroke center when multiple are available (Higashida et al., 2013). In addition to clinical outcomes of stroke center policy, the impact of interactions with EMS bypass policy and stroke center policy on clinical outcomes of stroke patients on a national scale is nascent.

Goals of This Investigation

In this study, we examine the independent effect of stroke center policy on thrombolysis (specifically tPA) utilization in stroke patients on a national scale. Furthermore, we describe the synergistic effect of EMS bypass policy and stroke center policy on proportion of thrombolysis utilization. We hypothesize that the presence of a stroke center policy and county-level pre-hospital bypass policy are independently associated with an increase in county-level thrombolysis usage, in addition to the synergistic effect of the two.

METHODS

Study Design and Setting

We conducted a retrospective observational study using a 20% national random sample of Medicare beneficiaries diagnosed with ischemic stroke using Medicare fee-for-service claims from 2007 to 2014. We accessed the following Medicare files for patient-level data: 1) Outpatient files for ED, 2) Carrier files for EMS claims, 3) Medicare Provider Analysis and Review (MedPAR) files for aggregated inpatient claims, and 4) Master Beneficiary Summary File (MBSF) files for demographic data.

To construct hospital-level data and characteristics, we accessed the Provider of Services (POS) Current File. This quarterly updated database contains geographic and resource information for Centers for Medicare and Medicaid Services (CMS)-certified hospitals, including hospital characteristics. We added stroke center certification data from the certifying organizations (Joint Commission, Det Norske Veritas [DNV], Healthcare Facilities Accreditation Program [HFAP], and independent state-level organizations). These organizations would not provide historical data; therefore, we obtained the information using a non-profit resource (Internet Archive's Wayback Machine, web.archive.org) as well as direct contact with individuals at the American Heart Association and state-level certifying bodies.

To obtain and verify effective policy, we distributed a questionnaire to the EMS officials to obtain the effective policy dates, reviewed online protocols published on the state websites, and the dates mentioned in previous publications, and analyzed state law and compilations by the Centers for Disease Control and Prevention. Stroke center policy and EMS bypass policy were defined by the Westlaw Database definitions (Dunkley et al., 2024). Stroke center policy was defined as policy that expressly required or authorized hospitals or other health care facilities to hold themselves out as providing stroke care at a specified level. With regards to EMS bypass policy, this was defined broadly as any policy that authorizes or requires EMS providers to bypass the nearest local hospital and instead transport to the closest certified stroke facility. Most states had state-level policy, but a few had county-level policies and, therefore, the analysis was done at the county level. If policy was at the state level, it was assumed that the policy applied at the county level. An example of a state policy included in the supplemental materials, the Commonwealth of Massachusetts Circular Letter from June 2005, describes regulations regarding primary stroke services.

Selection of Participants

Our study population includes patients aged 66 years or older who received their initial care in the ED and were subsequently admitted through the ED with a primary diagnosis of acute ischemic stroke (International Classification of Diseases, Ninth Revision, Clinical Modification, ICD-9-CM: 433.x1, 434.x1, 436). We focused on the patient's first hospitalization for stroke observed in the study dataset. We restricted the cohort to patients with at least 12 months of continuous Medicare Part A or Part B enrollment before inpatient admission, to allow sufficient time to identify pre-existing medical comorbidities. Patients with Medicare Advantage plans were excluded to ensure we observed complete claims. The CMS, the Research Data Assistance Center (ResDAC), and the University Institutional Review Board approved the study (IRB 48353).

To evaluate the impact of stroke center and single-tier EMS bypass policies, which allow EMS providers to bypass the nearest hospital and go directly to a PSC, we restricted the population to those who used EMS to arrive at the hospital. Participants were identified using the Healthcare Common Procedure Coding System (HCPCS) codes in inpatient and carrier claims (HCPSC codes A0426-A0434). We excluded private transportation to the hospital and inter-hospital transfers. In Medicare databases, ED visits and subsequent hospitalizations are not linked by construct. Therefore, we linked inpatient records and prior ED visit(s) leading up to admission. Associated ED visits were captured if: 1) the MedPAR ED charge amount (variable ER_AMT was > $0 or 2) emergency services (Revenue Center Codes 045x) were reported in outpatient claims two days before the MedPAR inpatient admission date.

Measurements

Our team defined the pre-policy period as two years before the policy went into effect. This was deemed an adequate timeframe to capture a pre-policy period and pilot implementation with the gradual infrastructure and logistical changes that need to occur before an official policy implementation date. The post-policy period was defined as the year of policy going into effect and onward. An actual washout period was not excluded during policy implementation to assess the real world, continuous impact of implementation efforts. We identified policy counties (cases) with the policy in effect at any time from 2007-2014 and no policy counties (controls) without any policy in effect during 2007-2014. We also categorized counties with policies taking effect after 2016 as control counties and excluded counties that enacted policies before 2007. Finally, Rhode Island counties were excluded because it was the only state to implement a stroke policy in the year 2009, and there was no thrombolysis data available during the pre-policy period.

The county-level stroke center policy and the single-tier EMS bypass policy were both measured as ever vs. never. Time-based policy effect status was measured each year between 2007 and 2014. The primary independent variables in the analysis are: 1) stroke center policy, a binary variable indicating whether the patient resides in a county with a stroke center policy; 2) post-policy, a binary variable indicating whether the observation is from the pre- or post-policy period; and 3) the interaction term stroke center policy * post-policy. The secondary independent variables in the analysis are: 1) EMS bypass policy and stroke center policy, which includes a 4-level category that denotes whether counties had neither policy, one of the policies, or both; and 2) the interaction term EMS bypass policy * stroke center policy.

The Charlson Comorbidity Index (CCI) was used to assess patient comorbidity from one year before stroke hospitalization. We obtained patient-level demographic and clinical characteristics and categorized age, sex, and race/ethnicity variables. Patients were categorized into groups by age (66-75 years, 76-85 years, or   86 years), sex (female or male), and race/ethnicity (Asian, Black, Hispanic, Native American, White, Other, or Unknown). Race and ethnicity information was obtained from the Social Security Administration records and further refined by algorithms generated through the Research Triangle Institute (RTI). We constructed urban and rural classifications using residence zip codes from the MBSF files and census data. Using 2010 Census classifications, we defined zip codes with more than 50% of the population living in a rural area as "rural" and others as "urban."

We conducted descriptive analyses of all variables using summary statistics, counts, and percentages for categorical variables and mean and standard deviation for continuous variables (see Table 1).

	Total (N = 189,345) % (N)	Stroke Center Policy (n = 32,719) % (n)	No Stroke Center Policy (n = 156,626) % (n)
Age (N = 169,276)			
66 to 75	31.86 (53930)	34.28 (9946)	31.36 (43984)
76 to 85	40.39 (68367)	39.87 (11568)	40.49 (56799)
> 85	27.75 (46979)	25.85 (7500)	28.15 (39479)
Gender			
Female	57.32 (108537)	57.61 (18850)	57.26 (89687)
Male	42.68 (80808)	42.39 (13869)	42.74 (66939)
Race/Ethnicity			
Asian	1.24 (2355)	0.99 (325)	1.30 (2030)
Black	12.07 (22852)	12.56 (4108)	11.97 (18744)
Hispanic	2.45 (4641)	1.08 (355)	2.74 (4286)
Native American	0.50 (944)	1.51 (493)	0.29 (451)
White	82.31 (155844)	82.84 (27104)	82.20 (128740)
Other	1.20 (2278)	0.85 (278)	1.28 (2000)
Unknown	0.23 (431)	0.17 (56)	0.24 (375)
Charlson Comorbidity Index (CCI)			
1	10.56 (20004)	10.95 (3583)	10.48 (16421)
2+	89.44 (169341)	89.05 (29136)	89.52 (140205)
Inhabitance			
Urban	82.40 (156013)	77.74 (25437)	83.37 (130576)
Rural	15.98 (30256)	20.53 (6716)	15.03 (23540)
Unknown	1.62 (3076)	1.73 (566)	1.60 (2510)
Thrombolysis Usage	5.24 (9921)	5.24 (1713)	5.24 (8208)

Table 1. Patient demographics and clinical characteristics by stroke center policy status.

Outcomes and Analysis

We estimated the difference-in-differences (DID) to determine the stroke center policy effect on proportion of thrombolysis utilization. We calculated Zou's relative risk regression using Poisson GLM with a log link and generalized estimating equations with independent working correlation and robust standard errors (Zou & Donner, 2013). The outcome was proportion of IV tPA a county-level variable, where the numerator represented the number of patients receiving thrombolysis. The offset/denominator was all stroke patients. Independent variables included county-level policy and the post-policy indicator. The difference-in-difference term of interest is the interaction coefficient (stroke center policy * post).

In the DID model, the policy group (cases) was defined as those with an effective stroke policy (and no EMS policy) enacted during our study period, while the no policy group (controls) were those without an effective policy in place. We then conducted a per year pairing of policy and no policy counties by assigning a pseudo-policy year to the no policy counties that was the same as the policy counties (Zou & Donner, 2013). We repeated this process for each implementation year pairing policy counties with all no policy counties. For example, suppose that counties A and B implemented a policy in 2012, counties E and F implemented a policy in 2013, and counties C and D did not implement a policy during the observation period. In this example, counties C and D would serve as controls for all the counties who implemented a policy in 2012 and for all the counties who implemented a policy in 2013. To assess the effect of both EMS bypass policy and stroke center policy on thrombolysis, we conducted a DID analysis that included counties that had both policies implemented to counties that did not have any policy between 2007 and 2014.

To ensure internal validity for the DID models and prevent biased estimation of the causal effect, we confirmed the parallel trends assumption using linear regression models by comparing pre-policy outcome trends between policy and no policy counties. We evaluated estimates at a significance level of $p < 0.05$. The analytic models were conducted in R 4.1.1 while all other analyses used SAS 9.4.

RESULTS

Our study included 284,452 hospitalized ischemic stroke patients from within the ED, which represented 4,745 hospitals from 3,142 counties in 50 states (including District of Columbia). There were 561 counties who implemented a stroke center policy and 432 counties that implemented an EMS bypass policy during the study period; there were 393 counties that implemented both (Figure 1).

There were 32,719 (17.28%) patients residing in a stroke center policy county and 156,626 (82.72%) in a no policy stroke center county (Table 1). There were 1,713 (5.24%) patients that received thrombolysis in a policy county and 8,208 (5.24%) that received thrombolysis in a no stroke center policy county. In our study, most patients were female (57.32%),

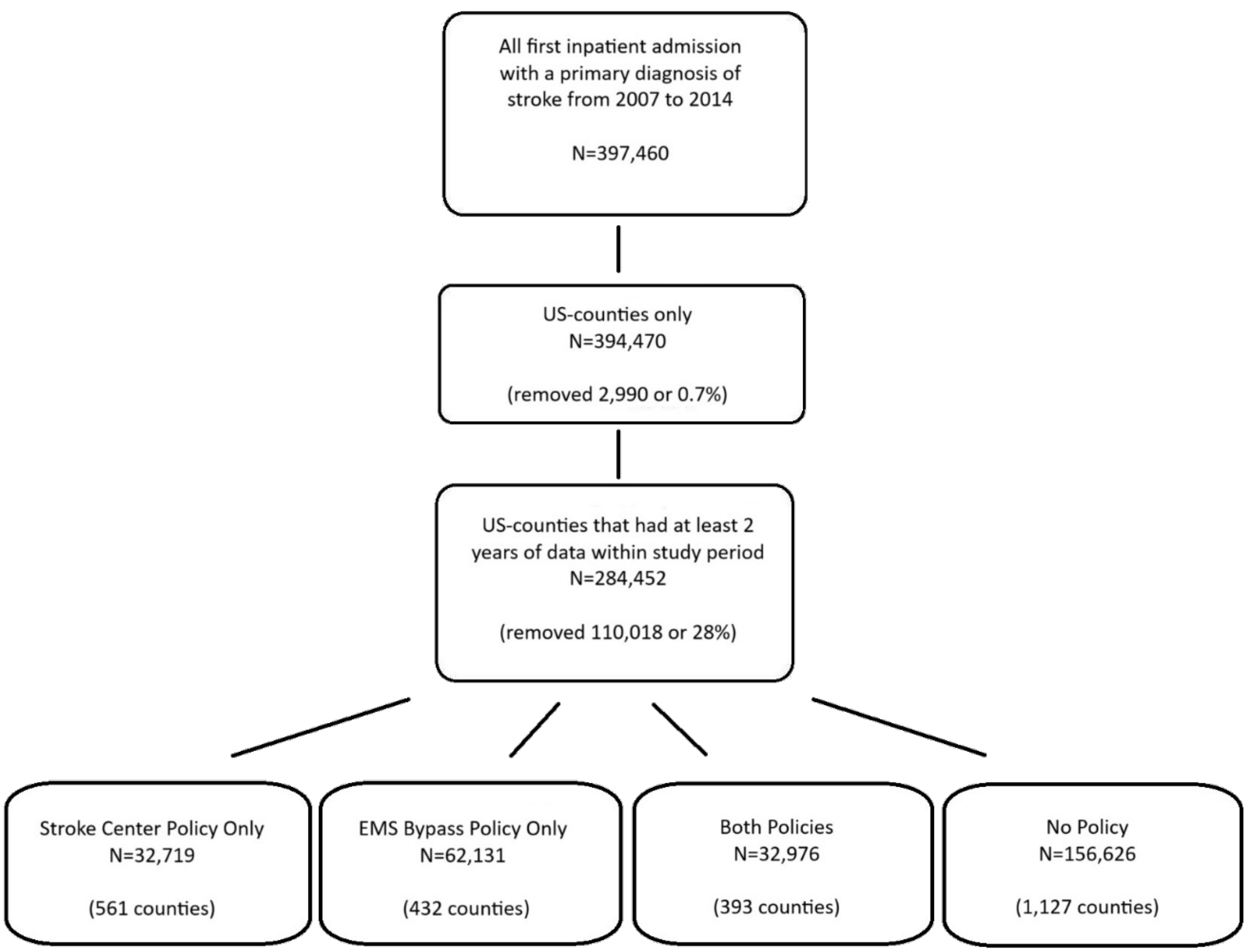

Figure 1. Study cohort.

White (82.31%), and between the ages of 76 and 85 (40.39%). Most patients also lived in an urban environment (82.40%) and had a Charlson Comorbidity Index (CCI) score of 2 or more (89.44%). When comparing policy and no policy counties, many patient demographics and clinical characteristics were similar. However, policy counties had less patients living in an urban setting compared to no policy counties (77.74% vs 83.37%, respectively).

Using inferential testing, we confirmed that the parallel trends assumption was met during the two-year pre-policy period ($p = 0.27$). In the primary difference-in-differences (DiD) analysis, counties that implemented a stroke center policy experienced a significant increase in thrombolysis during the two years preceding policy implementation ($RR = 1.42$, 95% CI [1.12, 1.80], $p = 0.004$). Thrombolysis utilization continued to rise across all counties during the post-implementation period ($RR = 1.17$, 95% CI [1.09, 1.25], $p < 0.001$). However, there was no significant difference in the rate of increase in thrombolysis use between stroke policy and non-policy counties during the post-policy period ($RR = 1.04$, 95% CI [0.76, 1.41], $p = 0.83$) (Table 2).

For clarity, the post-policy period interaction term estimates whether counties that adopted stroke center policy experienced greater change in thrombolysis rates after policy implementation compared to counties without a policy–to assess the added effect of the policy itself beyond pre-existing trends.

	Relative Risk of Thrombolysis Use (95% CI)	*p*-value
Stroke-Policy (ref=No Stroke Policy)	1.42 [1.12, 1.80]	0.004
Post-Policy (ref=Pre Policy)	1.17 [1.09, 1.25]	< 0.001
Stroke-Policy*Post-Policy	1.04 [0.76, 1.41]	0.826

Table 2. Modified poisson regression by stroke policy status and policy pre/post implementation.

For our secondary analysis, we observed trends between counties that had a stroke center and EMS bypass policy and compared them to those with no policy. There were 94,850 (37.72%) patients residing in a stroke center and EMS bypass policy county, while 156,626 (62.28%) patients resided in a no stroke center and EMS bypass policy county (Table 3). There were 4,918 (5.19%) patients that received thrombolysis in a policy county and 8,208 (5.24%) that received thrombolysis in a no policy stroke center county. Most patients were female (57.15%), White (80.46%), and between the ages of 76 and 85 (40.25%). Most patients also lived in an urban environment (83.00%) and had a Charlson Comorbidity Index (CCI) score of 2 or more (89.26%). When comparing policy and no policy counties, patient demographics and clinical characteristics were similar.

We observed an increase in thrombolysis utilization during the post-implementation period in counties that implemented both an EMS bypass policy and a stroke center policy, compared to counties without any policy implementation ($RR = 1.35$, 95% CI [1.00, 1.81], $p = 0.040$). Thrombolysis use also increased in the two years prior to policy implementation in these counties relative to those with no policy ($RR = 1.48$, 95% CI [1.19, 1.84], $p < 0.001$), and continued to rise in the post-policy period across all counties ($RR = 1.33$, 95% CI [1.23, 1.44], $p < 0.001$) (Table 4; Figure 2).

LIMITATIONS

Our data has several limitations. First, many of the counties in our database had zero proportion of thrombolysis, suggesting potential gaps in the dataset. Given thrombol-

	Total (N = 251,476) % (N)	Stroke Center + EMS Bypass Policy (n = 94,850) % (n)	No Policy (n = 156,626) % (n)
Age (N = 224,640)			
66 to 75	32.05 (72004)	33.21 (28020)	31.36 (43984)
76 to 85	40.25 (90423)	39.85 (33624)	40.49 (56799)
> 85	27.69 (62213)	26.94 (22734)	28.15 (39479)
Gender			
Female	57.15 (143725)	56.97 (54038)	57.26 (86987)
Male	42.85 (107751)	43.03 (40812)	42.74 (66939)
Race/Ethnicity			
Asian	1.98 (4979)	3.11 (2949)	1.30 (2030)
Black	12.63 (31766)	13.73 (13022)	11.97 (18744)
Hispanic	2.74 (6894)	2.75 (2608)	2.74 (4286)
Native American	0.48 (1205)	0.79 (754)	0.29 (451)
White	80.46 (202331)	77.59 (73591)	82.20 (128740)
Other	1.50 (3775)	1.87 (1775)	1.28 (2000)
Unknown	0.21 (526)	0.16 (151)	0.24 (375)
Charlson Comorbidity Index (CCI)			
1	10.74 (26997)	11.15 (10576)	10.48 (16421)
2+	89.26 (224479)	88.85 (84274)	89.52 (140205)
Inhabitance			
Urban	83.00 (208731)	82.40 (78155)	83.37 (130576)
Rural	15.20 (38233)	15.49 (14693)	15.03 (23540)
Unknown	1.79 (4512)	2.11 (2002)	1.60 (2510)
Thrombolysis Usage	5.22 (13126)	5.19 (4918)	5.24 (8208)

Table 3. Patient demographics and clinical characteristics by stroke center and EMS bypass policy status.

	Relative Risk of Thrombolysis Use (95% CI)	*p*-value
Stroke/EMS-Policy (ref=No Stroke OR EMS Policy)	1.48 [1.19, 1.84]	< 0.001
Post-Policy (ref=Pre Policy)	1.33 [1.23, 1.44]	< 0.001
Stroke/EMS-Policy*Post-Policy	1.35 [1.00, 1.81]	0.04

Table 4. Modified poisson regression by stroke/EMS policy status and pre/post policy implementation.

ysis in general is quite low, small changes may exaggerate the effect of intervention. Furthermore, the quality of policy data is highly variable, and collected from multimodal sources. Survey data relies on response rate and is also subject to response bias. Bypass policy data in general differs in nature, execution, and enforcement nationally. Some counties had state-level policies dictating care, while others were county-level only. Additionally, our stroke data are limited. We were unable to adjust for many patient-level factors relevant to the administration of thrombolytic including stroke severity, comorbidities, and meeting of exclusion criteria, as the analysis was done on a county level. We also acknowledge the significant multifactorial approach to administration of thrombolytic that we cannot account for, including physician and staff resources, financial resources, drug availability, etc. Finally, the data set spans from 2007 to 2014, which may be less applicable to today's systems given the dynamic nature of stroke care over time. The data set is only a 20% random sampling, which, despite a resultant cohort of nearly 250,000 patients, still limits our relative sample size on a national level, and is only of Medicare patients, which limits the generalizability. Nonetheless, the breadth of data

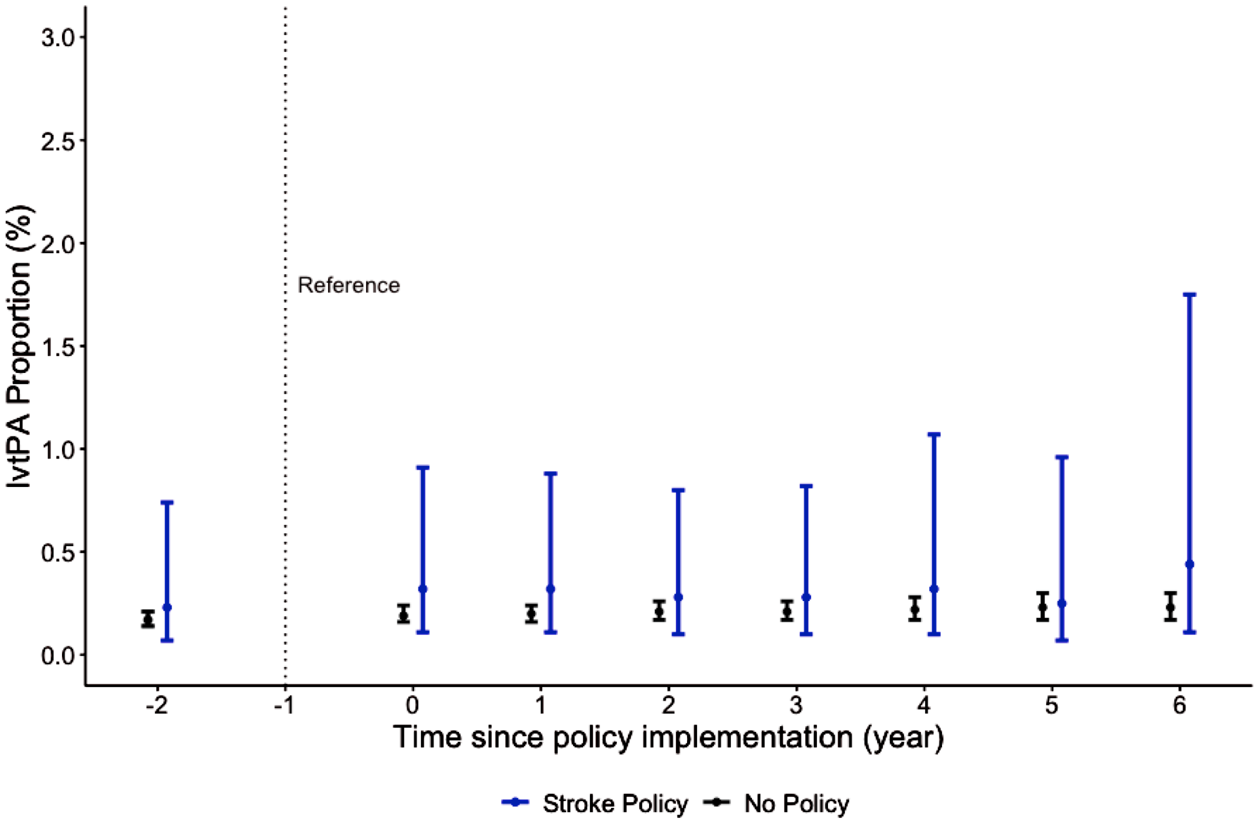

Figure 2. Proportion of IV tPA utilization by time since policy implementation (pre and post policy) by stroke policy status. Time 0 refers to the year that policy was implemented.

provides valuable insight into the possible synergistic effect of policies and subsequent clinical outcomes.

DISCUSSION

Our dataset, derived from the largest national stroke database of Medicare enrollees, is the first to assess the effects of stroke policy across the nation. Our findings suggest a significant increase in thrombolysis utilization in counties with stroke center policy. Specifically in the post-policy era, there were no independent associations with stroke center policy and increase in thrombolysis usage. Counties with both stroke center policy and EMS bypass policy had a significant increase in thrombolysis use, which was maintained in post-policy era.

Although the administration of thrombolytic is incredibly multifactorial, our data suggest that targeted policies encouraging EMS transport to designated stroke centers rather than local EDs increase the likelihood of a patient receiving thrombolysis. Furthermore, stroke centers, in general, have higher rates of thrombolytic use when compared to non-stroke centers, deriving directly from the certification process (Shkirkova et al., 2020), thus, targeted transfer of patients to these centers also likely improves thrombolysis utilization.

We identified that the post-policy era had an independent association with increase in proportion of thrombolysis use, irrespective of policy status (meaning both counties with and without stroke center policies had increases in thrombolysis utilization over time).

Our hypothesis is that even despite formal stroke center policy, there may have been a spill-over effect of the general national stroke center policy conversation and national emphasis on thrombolysis as a desired outcome in non-policy counties. This is in-line with existing literature suggesting an overall increase in thrombolytic administration over time, likely due to additional data regarding efficacy of thrombolytic, clinician comfort, and increasing hospital resources.

Although stroke center policy independently was not associated with an increase in thrombolysis in the post-policy era, when combined with EMS bypass policy, we identified a significant association, which suggests a synergistic effect when stroke center policy is combined with EMS bypass policy. A system-wide approach involving not only stroke center resources but also a focus on pre-hospital policy, education, and resources can clearly have a significant impact on patient-centered stroke outcomes.

We also found an increase in proportion of thrombolysis usage in policy counties prior to policy implementation. As policy making is not an immediate intervention (it requires extensive education, lobbying, and training before implementation), we are likely to see the effects of gradual onboarding prior to the exact policy date. Furthermore, many of our policy dates are estimates given lack of official data.

In general, our study period thrombolysis utilization was quite low. A variety of factors limit the use of thrombolytic, including poor public awareness of stroke systems, insufficient facility funding, and physician fear of legal liability (Bambauer et al., 2006), and the overall national thrombolytic administration rate remains extremely low (Kleindorfer et al., 2008). However, by precisely determining the most effective bypass policies at the appropriate level with systems of care, we can continue to optimize care for stroke patients.

Numerous strategies to improve thrombolysis utilization, including multilevel stroke education, pre-hospital acute stroke triage protocols, mobile stroke units, increased pre-hospital priority level for stroke, telestroke, and even less restrictive exclusion thrombolytic treatment criteria, have been met with varying improvements in thrombolysis rates (McDermott et al., 2019). Put into this context, our work suggests stroke center policy combined with county-level EMS bypass policy has the greatest potential to improve regional stroke care. Identification of county needs and barriers to thrombolytic administration may yield to a precision approach in improving stroke care. In stroke systems in which hospital resources vary widely, or pre-hospital care variations or delays are predominant, a stroke center and EMS bypass policy may be appropriate, whereas other stroke systems may have barriers in which this may not be effective.

This is the first analysis of the effect of stroke policy on thrombolysis using the largest ever national stroke database. Although national stroke policies have existed for decades and have widely been understood to improve access to stroke care, direct investigations on clinical outcomes of these policies such as thrombolysis have not been extensively studied, necessitating our work and driving its importance. Our findings highlight important trends and opportunities for further investigation, laying the groundwork for future studies that can include larger as well as more localized databases to continue to assess and monitor improvements in stroke care. Finally, we used data in the pre-thrombectomy period, allowing us to investigate a foundational association between initial stroke care and fundamental clinical outcomes of thrombolysis, which would not be as feasible with contemporary data. Assessing this initial impact may be crucial to guide further policy implementation in the dynamic field of stroke care. Future studies will need to investigate the association of policy with thrombectomy rates, novel thrombolytics, and new advances in stroke management.

CONCLUSION

Stroke center policy alone was not independently associated with increased thrombolysis in the post-policy period. However, stroke center policy combined with single-tier EMS county bypass policies is associated with increased usage of thrombolysis when compared to non-policy counties, which is a pattern that is sustained over time. Continued work is needed at various levels to continue to monitor the effect of stroke policy and novel stroke management therapies.

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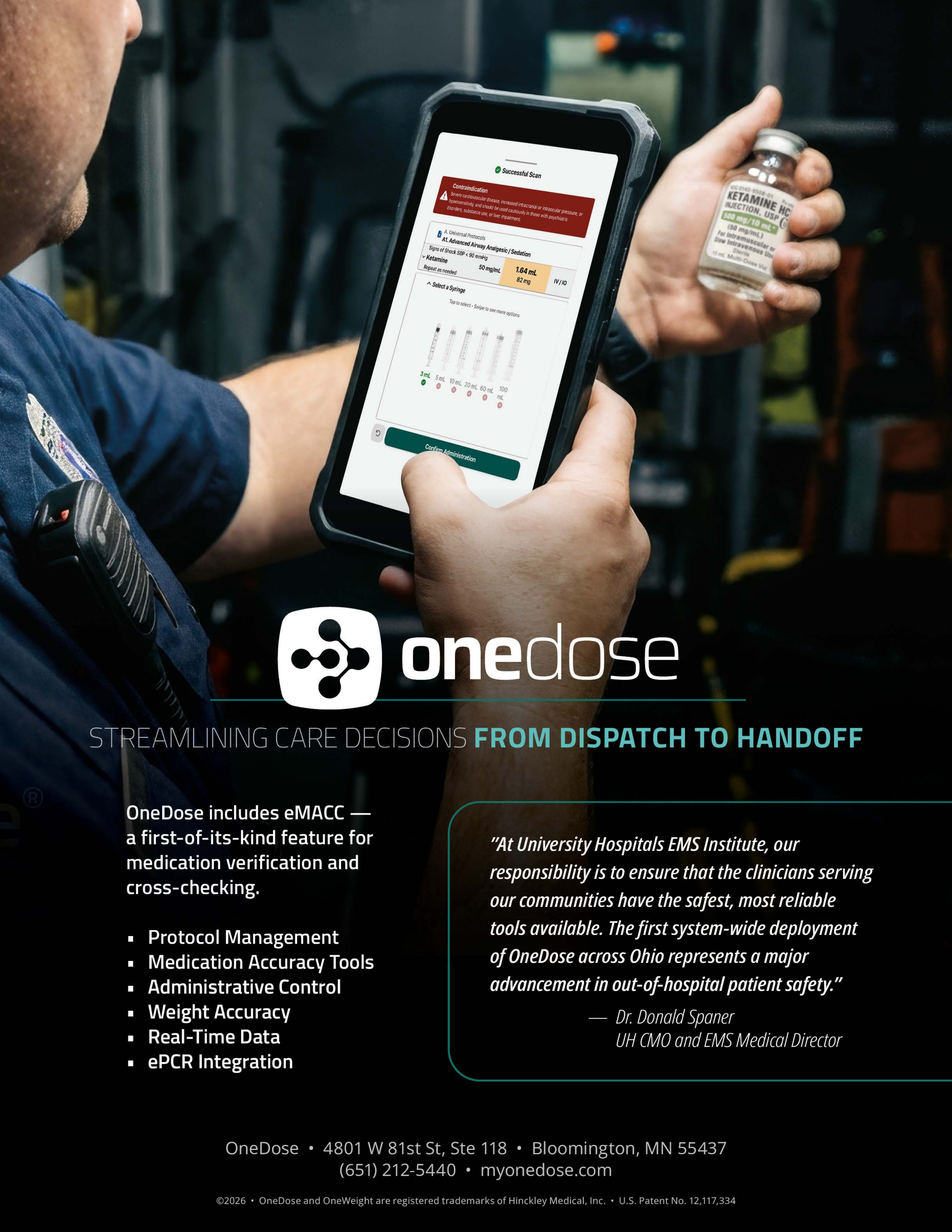
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