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Strategy for reliable identification of ischaemic stroke, thrombolytics and thrombectomy in large administrative databases

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ABSTRACT

Background Administrative data are frequently used in stroke research. Ensuring accurate identification of patients who had an ischaemic stroke, and those receiving thrombolysis and endovascular thrombectomy (EVT) is critical to ensure representativeness and generalisability. We examined differences in patient samples based on mode of identification, and propose a strategy for future patient and procedure identification in large administrative databases.

Methods We used non-public administrative data from the state of California to identify all patients who had an ischaemic stroke discharged from an emergency department (ED) or inpatient hospitalisation from 2010 to 2017 based on International Classification of Disease (ICD-9) (2010–2015), ICD-10 (2015–2017) and Medicare Severity-Diagnosis-related Group (MS-DRG) discharge codes. We identified patients with interhospital transfers, patients receiving thrombolytics and patients treated with EVT based on ICD, Current Procedural Terminology (CPT) and MS-DRG codes. We determined what proportion of these transfers and procedures would have been identified with ICD versus MS-DRG discharge codes.

Results Of 365 099 ischaemic stroke encounters, most (87.70%) had both a stroke-related ICD-9 or ICD-10 code and stroke-related MS-DRG code; 12.28% had only an ICD-9 or ICD-10 code and 0.02% had only an MS-DRG code. Nearly all transfers (99.99%) were identified using ICD codes. We identified 32 433 thrombolytic-treated patients (8.9% of total) using ICD, CPT and MS-DRG codes; the combination of ICD and CPT codes identified nearly all (98%). We identified 7691 patients treated with EVT (2.1% of total) using ICD and MS-DRG codes; both MS-DRG and ICD-9/ICD-10 codes were necessary because ICD codes alone missed 13.2% of EVTs. CPT codes only pertain to outpatient/ED patients and are not useful for EVT identification.

Conclusions ICD-9/ICD-10 diagnosis codes capture nearly all ischaemic stroke encounters and transfers, while the combination of ICD-9/ICD-10 and CPT codes are adequate for identifying thrombolytic treatment in administrative datasets. However, MS-DRG codes are necessary in addition to ICD codes for identifying EVT, likely due to favourable reimbursement for EVT-related MS-DRG codes incentivising accurate coding.

INTRODUCTION

Administrative database studies of ischaemic stroke often use discharge diagnosis codes (ie, International Classification of Disease, clinical modification, ninth revision, (ICD-9-CM) or tenth revision (ICD-10-CM)) and procedure codes (ICD-9-procedural coding system (ICD-9-PCS), ICD-10-PCS, Current Procedural Terminology (CPT)) to identify patients and the subset who receive thrombolytics or endovascular thrombectomy (EVT).[1–8] However, variation in patient-level and hospital-level coding exists,[9] and ICD-9 codes have been reported to underestimate thrombolytic treatment.[10] Medicare Severity-Diagnosis-related Group (MS-DRG) codes are more closely connected with patient billing and may be a more accurate means for identification of patients and treatments received. Prior work has demonstrated changes in ICD-9 coding with the introduction of the MS-DRG system[11]; however, there is limited information regarding the utility of using MS-DRG codes to identify patients who had a stroke and procedures.

We investigated different analytic strategies using the combination of diagnosis codes and procedure codes to identify the following patient groups in a large administrative database: patients who had an ischaemic stroke, transferred patients, patients receiving thrombolytics and patients receiving EVT. We sought to determine the optimal combination of codes for the identification of patients who had an ischaemic stroke and procedures using administrative data, and to determine whether there is additional value in the use of MS-DRG codes.

METHODS

Data sources

We used non-public data maintained by the California Office of Statewide Health Planning and Development[12] including all emergency department (ED) and hospital discharges from all non-federal, acute care

hospitals licensed in California. This study was approved by the local Institutional Review Board.

Patient and procedure identification

We identified all ED and hospital discharges from acute care hospitals for ischaemic stroke from 2010 to 2017 based on primary ICD-9-CM discharge codes (433.xx excluding 433.10, 434.xx and 436 for discharges from 2010 through the third quarter of 2015), or primary ICD-10-CM codes (I63 for discharges from the fourth quarter of 2015–2017), or MS-DRG codes (061, 062, 063).[1–4 8 11] Hospital discharges identified any inpatient hospital stay, whereas ED discharges were used to identify ED records of patients who were subsequently transferred to another hospital for inpatient stay. In addition, we also obtained data on MS-DRGs codes 064, 065 and 066 which may be used for patients who had an ischaemic or haemorrhagic stroke, and 023 and 024 codes which may be used for patients who had an ischaemic stroke who receive EVT, or for other procedures not related to ischaemic stroke. When any of these additional MS-DRGs (064, 065, 066, 023 and 024) were used, we required one of the specified ICD-9-CM or ICD-10-CM codes for ischaemic stroke to be present also to identify the subject as a case of interest.

We identified patients transferred between hospitals using an established strategy.[13 14] After identifying all ischaemic stroke hospitalisations, we used a unique patient identifier to look backward in ED and inpatient data to identify any earlier records. The earlier record could have any length of stay, provided that the discharge date was on the preceding or the same day as the index admission. If this earlier record had a discharge disposition consistent with transfer, and a discharge date that was the preceding or the same day as the index hospital admission date, then these records were linked to establish an ED-to-inpatient or an inpatient-to-inpatient transfer. We did not require any particular ICD or MS-DRG discharge code to be associated with the initial visit, recognising that, especially for patients transferred from an ED, a final diagnosis is often not yet established. The use of another code (eg, for weakness or headache) would not preclude a transfer for stroke as long as the final discharge diagnosis from the second hospital met our case definition of ischaemic stroke.

Using established methods and approaches,[6 15] we identified patients receiving thrombolytic based on the presence of any one of the following: ICD-9-PCS code (9910), a secondary ICD-9-CM code (V4588), ICD-10-PCS code (3E03317), a secondary ICD-10-CM code (Z9282), CPT codes (37195, 37201, 37202) or MS-DRG codes (061, 062, 063 alone; or 065 with a corresponding ICD-9 or ICD-10 code indicating alteplase receipt). These codes were not required to be in the primary position.

We identified patients treated with EVT based on the presence of any one of the following: ICD-9-PCS code (3974, 1753, 1754), ICD-10-PCS code (03CG3ZZ, 03CH3ZZ, 03CJ3ZZ, 03CK3ZZ, 03CL3ZZ, 03CM3ZZ, 03CN3ZZ, 03CP3ZZ, 03CQ3ZZ) or MS-DRG (023, 024).[6 7] MS-DRG codes 023 and 024 may also be used for craniotomy or device implantation procedures. Therefore, when 023 and 024 were present, we only identified EVT among observations with a primary ICD-9/ICD-10 diagnosis of ischaemic stroke, and who did not have any ICD-9-PCS/ICD-10-PCS codes for craniotomy, craniectomy or ventriculostomy (online supplemental table IV).[16–19] These codes were not required to be in the primary position. We did not use CPT codes for EVT because (consistent with national coding standards) our data only used CPT codes for ED patients, and all EVT-treated patients were treated as inpatient hospitalisations rather than ED patients.

We examined patient age, sex, race/ethnicity, expected payer and urban/rural location, overall and for each group of patients based on identification strategy. Urban versus rural location was based on county-level urban influence codes in 2013.[20]

We categorised each ischaemic stroke observation based on whether it was identifiable by ICD code only, by MS-DRG only or by both. Within each group, we determined the proportions of transfer, thrombolytic-treated and EVT-treated patients identified.

Among patients identified by ICD-9 or ICD-10 code only (ie, without one of our designated MS-DRG codes), we identified and reviewed the 10 most frequent MS-DRG codes used. Likewise, among patients identified by MS-DRG code (061, 062, 063) without a designated ICD-9 or ICD-10 code, we identified and reviewed the 10 most frequent ICD-9 or ICD-10 codes used.

RESULTS

Identification of patients who had an ischaemic stroke

We found 437851 encounters with either a primary ICD-9-CM, ICD-10-CM or MS-DRG code for ischaemic stroke between 2010 and 2017. We excluded 30890 for missing unique patient-identifier (ie, the visit link variable), 3627 records from non-acute hospitals and 38235 because they lacked an inpatient admission, giving a final sample of 365099 encounters (figure 1).

The vast majority of patients (87.70%, n=320187) had both a designated ICD-9-CM or ICD-10-CM code and a designated MS-DRG code, the remainder had only a designated ICD-9-CM or ICD-10-CM code (12.28%, n=44839); the most frequently appearing MS-DRG codes for these latter patients are presented in the online supplemental material. Very few patients were identified by MS-DRG code without a designated ICD-9-CM or ICD-10-CM code (0.02%, n=73); the most frequently appearing ICD-9-CM or ICD-10-CM codes for these patients are also presented in the online supplemental material. Observations in the MS-DRG only group tended to be younger, less often white and less often rural, than patients with ICD-9-CM or ICD-10-CM codes (table 1).

Identification of transferred patients

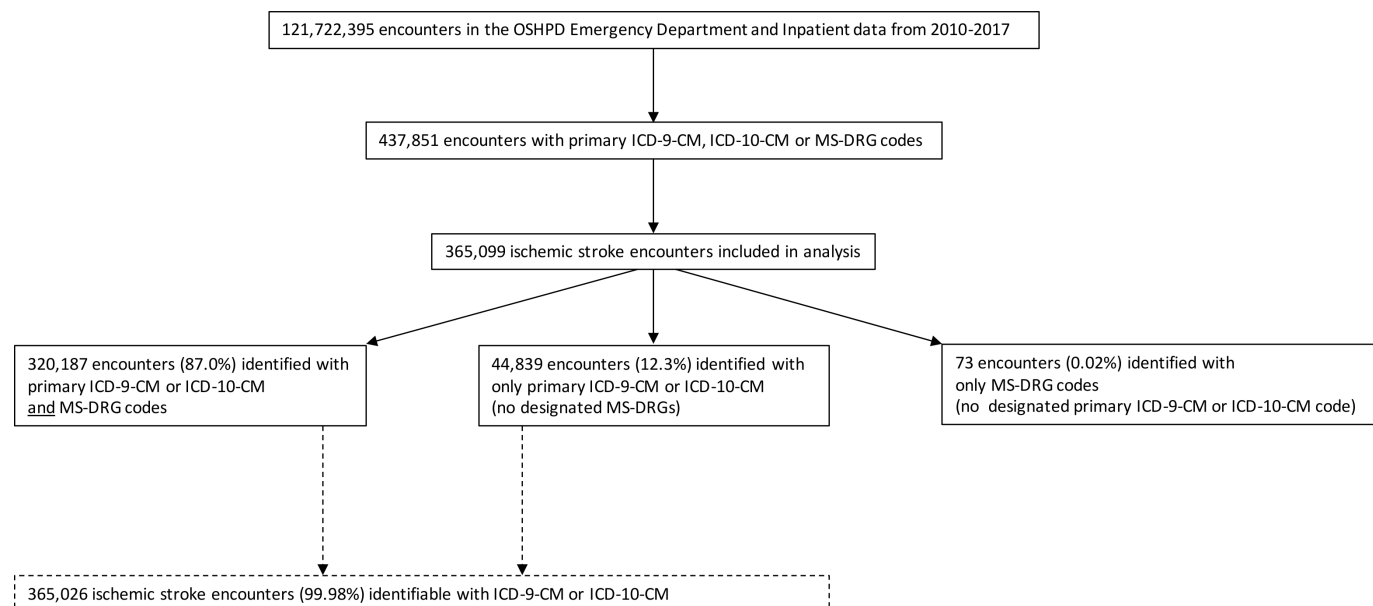Of the 365099 encounters in our sample, we identified 18859 (5.2%) transfers between hospitals using

Figure 1 Patient inclusion and identification flow diagram. ICD-CM: International Classification of Disease, clinical modification; MS-DRG: Medicare Severity-Diagnosis-related Group; OSHPD: Office of Statewide Health Planning and Development.

either ICD-9-CM, ICD-10-CM or MS-DRG codes at each encounter; 12 616 of the transfers (66.9%) originated in the ED and 6243 of the transfers (33.1%) were inpatient-to-inpatient. When requiring each encounter to have both a designated primary ICD-9-CM or ICD-10-CM diagnosis code and a designated MS-DRG code, the total sample size was 320 187 (figure 1) only 5442 transfers (1.7%) were identifiable if both the first and second encounter were also required to have both a designated primary ICD-9-CM or ICD-10-CM diagnosis code and a designated MS-DRG code.

Of the 44 839 encounters with only a designated primary ICD-9-CM or ICD-10-CM diagnosis code, 779 transfers (1.7%) were identified, and of the 73 encounters with only a designated MS-DRG, no transfers were identified. Finally, we combined the encounters with the designated ICD-9-CM and ICD-10-CM codes that did and did not also have the designated MS-DRG codes to examine the group of observations identifiable by ICD code regardless of DRG code agreement. Among these 365 026 encounters, 18 855 transfers were identifiable (5.2%). Thus, in a dataset with only ICD codes, 99.99% of interhospital transfers would be identifiable (table 2).

Identification of thrombolytic receipt
In our sample of 365 099 ischaemic stroke encounters from 2010 to 2017, we identified 32 506 patients treated with thrombolytic (8.9%) based on the combination of ICD, CPT and MS-DRG codes. Of the 365 026 stroke encounters identified by ICD-9-CM or ICD-10-CM code with or without a designated MS-DRG, 31 862 patients received thrombolytic (8.7%) based on ICD and CPT codes. Because of the rules used to identify these encounters, all 73 of the stroke encounters identified by MS-DRG

only received thrombolytic treatment. Thus, in a dataset with only ICD and CPT codes, only a very small proportion of thrombolytic treatments would be missed (1.8%).

Identification of EVT receipt
In the same sample of 365 099 ischaemic stroke encounters, we identified 7691 treated with EVT (2.1%) based on the combination of ICD-PCS and MS-DRG codes. Because the MS-DRGs used for EVT may also be used for patients who had other non-ischaemic stroke diagnoses, when MS-DRG codes were used to identify patients, we required the patient to also have a primary ICD-9-CM or ICD-10-CM consistent with ischaemic stroke. Therefore, none of the observations in our sample identified by MS-DRG alone had received EVT.

Given that ICD-9-CM and ICD-10-CM codes could identify ischaemic stroke hospitalisations, interhospital transfers and administration of thrombolytic with sufficient accuracy and completeness, we sought to determine whether MS-DRG had any added value for identification of EVT, or if, instead ICD-9 and ICD-10 codes were entirely sufficient. Limiting to the sample of 365 026 patients with ischaemic stroke identified by ICD-9-CM or ICD-10-CM codes (with or without an MS-DRG code), 273 EVT procedures (3.6%) were identified by ICD-9-PCS or ICD-10-PCS code only; 6401 (83.2%) had both ICD-PCS and MS-DRG codes for EVT, and 1017 (13.2%) were identified by MS-DRG code only. Thus, in a dataset with only ICD codes, 13.2% of EVT cases would be missed.

Proposed identification strategy
To summarise, the use of primary ICD-9-CM and ICD-10-CM diagnosis codes identifies 99.98% of all patients who had an ischaemic stroke in this large administrative

Table 1 Characteristics of patients based on identification strategy

| | Union | ICD-CM codes only | MS-DRG codes only | Overlap | |
	(ICD-CM or MS-DRG) n=365 099	n=44 839	n=73	(ICD-CM and MS-DRG) n=320 187	P value
Patient characteristics					
Median age (IQR)	73 (62–83)	71 (61–81)	67 (55–81)	73 (62–83)	<0.001
Female, n (%)	182 588 (50.0)	20 249 (45.2)	36 (49.3)	162 303 (50.7)	<0.001
Race/ethnicity, n (%)					
White	201 704 (55.2)	25 514 (56.9)	36 (49.3)	176 154 (55.0)	<0.001
Black	37 780 (10.4)	4571 (10.2)	7 (9.6)	33 202 (10.4)	
Asian/Pacific Islander	38 589 (10.6)	3788 (8.4)	4 (5.5)	34 797 (10.9)	
Hispanic	72 226 (19.8)	8767 (19.6)	23 (31.5)	63 436 (19.8)	
Other	12 137 (3.3)	1636 (3.6)	2 (2.7)	10 499 (3.3)	
Missing	2663 (0.7)	563 (1.3)	1 (1.4)	2099 (0.6)	
Expected payer, n (%)					
Medicare	232 145 (63,6)	19 162 (42.7)	37 (50.7)	212 946 (66.5)	<0.001
Medicaid	43 287 (11.9)	4804 (10.7)	13 (17.8)	38 470 (12.0)	
Private insurance	71 343 (19.5)	18 436 (41.1)	22 (30.1)	52 885 (16.5)	
Self-pay	9050 (2.5)	1461 (3.3)	0 (0.0)	7589 (2.4)	
Other	9274 (2.5)	976 (2.2)	1 (1.4)	8297 (2.6)	
Rural residence, n (%)	10 487 (2.9)	2298 (5.1)	1 (1.4)	8188 (2.6)	<0.001
Hospital characteristics*					
Rural location, n (%)	7807 (2.1)	2150 (4.8)	0 (0.0)	5657 (1.8)	<0.001
Academic, n (%)	52 617 (14.4)	5604 (12.5)	12 (16.4)	47 001 (14.7)	<0.001
Stroke centre status, n (%)					
None	60 459 (16.5)	9441 (21.0)	3 (4.1)	51 015 (15.9)	<0.001
Acute Stroke Ready Hospital	975 (0.3)	261 (0.6)	0 (0.0)	714 (0.2)	
Primary Stroke Center	239 603 (65.6)	28 504 (63.6)	58 (79.5)	211 041 (65.9)	
Thrombectomy-capable or Comprehensive Stroke Center	64 062 (17.6)	6633 (14.8)	12 (16.4)	57 417 (18.0)	

*Hospital characteristics are presented at the visit level.
ICD-CM, International Classification of Disease, clinical modification; MS-DRG, Medicare Severity-Diagnosis-related Group.

database, regardless of MS-DRG. Identification of transferred patients also can be achieved with ICD codes only, with almost full capture. For identification of thrombolytic and EVT treatments, MS-DRGs should be considered in combination with ICD-9 or ICD-10 procedure codes or secondary ICD-9-CM or ICD-10-CM codes or CPT codes when available. However, if MS-DRGs are unavailable, the use of ICD and CPT codes only minimally underestimates thrombolytic receipt. With respect to EVT, both ICD-PCS codes and MS-DRG codes are required to fully capture all procedures (box 1).

DISCUSSION
In a large administrative database, with ICD diagnosis and procedure codes, CPT codes and MS-DRG codes available, we investigated the identification of patients who had an ischaemic stroke, interhospital transfers and

receipt of thrombolytic or EVT treatments. After identification of patients who had an ischaemic stroke, we identified nearly all patient transfers using ICD-9-CM and ICD-10-CM coding alone and nearly all patients treated with thrombolytic were identifiable using ICD-9-PCS and ICD-9-CM, ICD-10-PCS and ICD-10-CM, and CPT coding. By contrast, we found that use of MS-DRG codes enabled identification of a substantial group of EVT procedures that would have otherwise been missed.

Previous studies have evaluated the accuracy of ICD codes for identification of patients who had a stroke.[8 21–25] These studies have found varying concordance between ICD codes and clinical diagnoses, with some reporting higher concordance[21–23] while two international studies demonstrated lower sensitivity.[24 25] It is likely that there are differences in coding practices and quality by region. We now extend this literature by reporting all-payer

Table 2 Identification of transfers, thrombolysis and EVT treatments, by patient identification strategy

	Interhospital transfer, n (%)	Thrombolysis, n (%)	EVT, n (%)
Ischaemic stroke observations with ICD-9-CM, ICD-10-CM or MS-DRG (ie, Union) n=365 099	18 859 (5.2) ICD-9-CM/ICD-10-CM MS-DRG	32 506 (8.9) ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG CPT	7691 (2.1) ICD-9-PCS/ICD-10-PCS MS-DRG
Ischaemic stroke observations with ICD-9-CM, ICD-10-CM or MS-DRG (ie, Union) n=365 099	18 855 (5.2) ICD-9-CM/ICD-10-CM	31 932 (8.7) ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS CPT	6674 (1.8) ICD-9-PCS/ICD-10-PCS
Ischaemic stroke observations with ICD-9-CM, ICD-10-CM (with or without MS-DRG) n=365 026	18 855 (5.2) ICD-9-CM/ICD-10-CM MS-DRG	32 433 (8.9) ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG CPT	7691 (2.1) ICD-9-PCS/ICD-10-PCS MS-DRG
Ischaemic stroke observations with ICD-9-CM, ICD-10-CM (with or without MS-DRG) n=365 026	18 855 (5.2) ICD-9-CM/ICD-10-CM	31 862 (8.7) ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS CPT	6674 (1.8) ICD-9-PCS/ICD-10-PCS
Ischaemic stroke observations with both ICD-9-CM or ICD-10-CM and MS-DRG (ie, overlap) n=320 187	5442 (1.7) ICD-9-CM/ICD-10-CM MS-DRG	27 874 (8.7) ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG	7418 (2.3) ICD-9-PCS/ICD-10-PCS MS-DRG
Ischaemic stroke observations with ICD-9-CM or ICD-10-CM only* n=44 839	779 (1.7) ICD-9-CM/ICD-10-CM	2172 (4.8) ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS CPT	273 (0.6) ICD-9-PCS/ICD-10-PCS
Ischaemic stroke observations with MS-DRG only† n=73	0 (0) MS-DRG	73 (100) MS-DRG	0 (0) MS-DRG

*MS-DRGs for these patients are presented in the online supplemental material.
†Primary ICD-9-CM/ICD-10-CM codes for these patients are presented in the online supplemental material.
CPT, Current Procedural Terminology; EVT, endovascular thrombectomy; ICD-CM, International Classification of Disease, clinical modification; ICD-PCS, International Classification of Disease, procedural coding system; MS-DRG, Medicare Severity-Diagnosis-related Group.

administrative data from California, and considering whether MS-DRG codes should also be included in the identification of stroke admissions, transfers and procedures used in patients who had an ischaemic stroke. Because many of the potential MS-DRGs for patients who had an ischaemic stroke are broad enough to include other non-ischaemic stroke observations, our strategy required a designated ICD-9-CM or ICD-10-CM code in combination with MS-DRG codes that are most commonly used for ischaemic stroke. As a result, the only MS-DRG codes that could identify an ischaemic stroke observation independently were those used for patients who had an ischaemic stroke that had received thrombolysis. This likely explains why the group of observations identified by MS-DRG alone was so small.

With increasing rates of EVT in the population,[26] in the future we may find the MS-DRGs for EVT may be even more frequently used. In our data, we found increasing frequency of EVT over time, and particularly after 2014. In each year of data, the addition of MS-DRG codes identified more EVT procedures than would have been

identified with ICD procedure codes alone. However, given that the MS-DRGs used for EVT may also be used for patients with procedures not related to ischaemic stroke, these MS-DRGs in isolation will still not be adequate for identifying ischaemic stroke observations, and so ICD-10-CM codes will be required to verify an ischaemic stroke diagnosis. It is important to note that CPT codes, used for outpatient or ED visits, have no additional value for EVT identification given that EVT-receiving patients are inpatients at the time of the procedure.

In prior studies, methods for identification and subsequent population-level estimates of thrombolytic and EVT use have varied.[6 7 10 11 27] In order to adequately understand changes in stroke care delivery, disparities in care delivery between population and the effects on patient outcomes, it is critical to have a consensus standard for classification and identification of cases going forward. While administrative data files do not capture the same degree of nuance and diagnostic accuracy as clinical registry data, nevertheless they are commonly used by investigators and federal officials to conduct

> **Box 1   Proposed strategy for identification of patients who had an ischaemic stroke in administrative data**
>
> **Identification of ischaemic stroke hospitalisations**
> Primary International Classification of Disease, clinical modification, ninth revision (ICD-9-CM) codes (433.xx.xx excluding 433.10, 434. xx.xx and 436), primary ICD-10-CM codes (I63) are sufficient for identification of ischaemic stroke hospitalisations.
>
> **Identification of interhospital transfers**
> After identifying all ischaemic stroke hospitalisations, look backward in ED and inpatient data to identify any earlier records with discharge date on the same or preceding day of the index admission. If this record had a discharge disposition consistent with transfer, these records are linked to establish an ED-to-inpatient or an inpatient-to-inpatient transfer. No restrictions are necessary for the initial hospital diagnosis, recognising that the final diagnosis may not always be apparent at the time of an acute hospital transfer.
>
> **Identification of patients treated with thrombolytic**
> ICD-9 procedural coding system (PCS) code (9910), a secondary ICD-9-CM code (V4588), ICD-10-PCS code (3E03317), a secondary ICD-10-CM code (Z9282) or Current Procedural Terminology (CPT) code (37195, 37201, 37202). If available, use of MS-DRG codes will enable identification of a small additional group (061, 062, 063, alone or 065 with a corresponding ICD-9 or ICD-10 code indicating alteplase receipt).
>
> **Identification of patients receiving EVT**
> ICD-9-PCS code (3974, 1753, 1754), ICD-10-PCS code (03CG3ZZ, 03CH3ZZ, 03CJ3ZZ, 03CK3ZZ, 03CL3ZZ, 03CM3ZZ, 03CN3ZZ, 03CP3ZZ, 03CQ3ZZ) or MS-DRG (023, 024). When MS-DRG 023 or 024 is used in the absence of an ICD-9-PCS/ICD-10-PCS code indicating EVT, we exclude those patients with an ICD-9-PCS/ICD-10-PCS code indicating craniectomy/craniotomy/ventriculostomy. An approach without MS-DRG codes will substantially underestimate thrombectomy procedures.
>
> ED, emergency department; EVT, endovascular thrombectomy; MS-DRG, Medicare Severity-Diagnosis-related Group.

analyses on stroke prevalence, incidence, payment policy and outcomes. Given this reality, we feel it is important to present what we believe to be a more accurate method for optimal case ascertainment by leveraging ICD and DRG codes together. Furthermore, there must be vigilance to any changes in reimbursement or coding so that the strategy remains accurate. Our findings highlight the importance of this issue, by demonstrating the inadequacy of prior strategies using ICD-9 and ICD-10 codes alone for accurately capturing EVT rates in this large administrative dataset. It is important to note that our study period did include 2015, which coincided with the publication of benefit for EVT and the transition from ICD-9 to ICD-10.

In our proposed strategy for identification of patients who had an ischaemic stroke in administrative databases, we suggest that ICD codes are sufficient for patient identification, as well as interhospital transfers and administration of thrombolytic therapy. For accurate identification of EVT procedures, however, MS-DRGs were also required to ensure complete capture. Failing to also use MS-DRG

codes could lead to EVT underestimates and potentially bias results.

The study does have potential limitations. We used a single-state database and these results may not be generalisable to other states or other administrative data. However, California is a large state with a diversity of patients and hospital settings and is more broadly representative than many other states. In addition, we did not have clinical data to use as a criterion standard, so our comparisons were based in ICD versus DRG identification without knowing whether there is another group of patients who had a stroke that both types of administrative coding had missed altogether. However, previous research in US data suggests that ICD codes are accurate for patient with stroke identification,[28] therefore, we believe the primary contribution of our research is in determining the potential additional value added by MS-DRG codes. We also do not have a criterion standard for verification of transfers and procedures, and we are unable to determine whether our process led to inaccurate identification of some transfers or procedures (ie, false positives). Further validation studies are required to confirm the accuracy of using the MS-DRGs for EVT identification. Finally, previous work has found that pharmacy data (eg, the Premier database) may further augment identification of thrombolysis administration in administrative data.[10 27] While we did not analyse pharmacy data in this analysis, we identified thrombolytic administration in over 8% of patients overall, which is higher than the rates in previous studies, suggesting differences in data sources or that changes in coding practices may have occurred since that time.

CONCLUSION

Administrative data are frequently used for the study of stroke care delivery and outcomes. ICD-9, ICD-10 and CPT codes are appropriate for identification of patients who had an ischaemic stroke, interhospital transfers and delivery of thrombolytics. However, MS-DRG codes are also required to identify EVT procedures. Based on these findings, we provide a strategy for the identification of patients who had an ischaemic stroke and relevant-related treatments using administrative data.

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Correction notice The article has been corrected since it has been published online first. The value "27202" has been corrected to "37202" in Box 1.

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