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

Kori S Zachrison, Sijia Li, Mathew J Reeves, Opeolu Adeoye, Carlos A Camargo, Lee H Schwamm, Renee Y Hsia

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 thrombolitics 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 7,691 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 pertained 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 thrombolitics or endovascular thrombectomy (EVT). However, variation in patient-level and hospital-level coding exists, and ICD-9 codes have been reported to underestimate thrombolytic treatment.

METHODS

Data sources

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

Using established methods and approaches, 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, we identified and reviewed the 10 most frequent MS-DRG codes. 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...
either ICD-9-CM, ICD-10-CM or MS-DRG codes at each encounter; 12616 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 320187 (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 44839 encounters with only a designated primary ICD-9-CM or ICD-10-CM diagnosis code, 779 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 73 encounters with only a designated MS-DRG code, no transfers 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.

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 365026 encounters, 18855 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 365099 ischaemic stroke encounters from 2010 to 2017, we identified 32506 patients treated with thrombolytic (8.9%) based on the combination of ICD, CPT and MS-DRG codes. Of the 365026 stroke encounters identified by ICD-9-CM or ICD-10-CM code with or without a designated MS-DRG, 31862 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 365099 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 365026 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
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. Previous studies have found varying concordance between ICD codes and clinical diagnoses, with some reporting higher concordance while two international studies demonstrated lower sensitivity. It is likely that there are differences in coding practices and quality by region. We now extend this literature by reporting all-payer

**Table 1** Characteristics of patients based on identification strategy

| Patient characteristics | Union (ICD-CM or MS-DRG) n=365099 | ICD-CM codes only n=44839 | MS-DRG codes only n=73 | Overlap (ICD-CM and MS-DRG) n=320187 | P value |
|-------------------------|----------------------------------|--------------------------|------------------------|--------------------------------------|---------|
| Median age (IQR)        | 73 (62–83)                       | 71 (61–81)               | 67 (55–81)             | 73 (62–83)                          | <0.001  |
| Female, n (%)           | 182588 (50.0)                    | 20249 (45.2)             | 36 (49.3)              | 162303 (50.7)                       | <0.001  |
| Race/ethnicity, n (%)   |                                  |                          |                        |                                      |         |
| White                   | 201704 (55.2)                    | 25514 (56.9)             | 36 (49.3)              | 176154 (55.0)                       | <0.001  |
| Black                   | 37780 (10.4)                     | 4571 (10.2)              | 7 (9.6)                | 33202 (10.4)                        |         |
| Asian/Pacific Islander  | 38589 (10.6)                     | 3788 (8.4)               | 4 (5.5)                | 34797 (10.9)                        |         |
| Hispanic                | 72226 (19.8)                     | 8767 (19.6)              | 23 (31.5)              | 63436 (19.8)                        |         |
| Other                   | 12137 (3.3)                      | 1636 (3.6)               | 2 (2.7)                | 10499 (3.3)                         |         |
| Missing                 | 2663 (0.7)                       | 563 (1.3)                | 1 (1.4)                | 2099 (0.6)                          |         |
| Expected payer, n (%)   |                                  |                          |                        |                                      |         |
| Medicare                | 232145 (63.6)                    | 19162 (42.7)             | 37 (50.7)              | 212946 (66.5)                       | <0.001  |
| Medicaid                | 43287 (11.9)                     | 4804 (10.7)              | 13 (17.8)              | 38470 (12.0)                        |         |
| Private insurance       | 71343 (19.5)                     | 18436 (41.1)             | 22 (30.1)              | 52885 (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 (%)  | 10487 (2.9)                      | 2298 (5.1)               | 1 (1.4)                | 8188 (2.6)                          | <0.001  |
| Expected payer, n (%)   |                                  |                          |                        |                                      |         |
| Medicare                | 232145 (63.6)                    | 19162 (42.7)             | 37 (50.7)              | 212946 (66.5)                       | <0.001  |
| Medicaid                | 43287 (11.9)                     | 4804 (10.7)              | 13 (17.8)              | 38470 (12.0)                        |         |
| Private insurance       | 71343 (19.5)                     | 18436 (41.1)             | 22 (30.1)              | 52885 (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 (%)  | 10487 (2.9)                      | 2298 (5.1)               | 1 (1.4)                | 8188 (2.6)                          | <0.001  |
| Expected payer, n (%)   |                                  |                          |                        |                                      |         |
| Medicare                | 232145 (63.6)                    | 19162 (42.7)             | 37 (50.7)              | 212946 (66.5)                       | <0.001  |
| Medicaid                | 43287 (11.9)                     | 4804 (10.7)              | 13 (17.8)              | 38470 (12.0)                        |         |
| Private insurance       | 71343 (19.5)                     | 18436 (41.1)             | 22 (30.1)              | 52885 (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 (%)  | 10487 (2.9)                      | 2298 (5.1)               | 1 (1.4)                | 8188 (2.6)                          | <0.001  |

*Hospital characteristics are presented at the visit level.
ICD-CM, International Classification of Disease, clinical modification; MS-DRG, Medicare Severity-Diagnosis-related Group.*
Table 2  Identification of transfers, thrombolysis and EVT treatments, by patient identification strategy

| Table 2 | Identification of transfers, thrombolysis and EVT treatments, by patient identification strategy |
|---------|-------------------------------------------------------------------------------------------------|
| **Ischaemic stroke observations with ICD-9-CM, ICD-10-CM or MS-DRG (ie, Union)** n=365099 | **Interhospital transfer, n (%)** | **Thrombolysis, n (%)** | **EVT, n (%)** |
| | 18859 (5.2) | 32506 (8.9) | 7691 (2.1) |
| | ICD-9-CM/ICD-10-CM MS-DRG | ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG | ICD-9-PCS/ICD-10-PCS MS-DRG |
| **Ischaemic stroke observations with ICD-9-CM, ICD-10-CM or MS-DRG (ie, Union)** n=365099 | 18855 (5.2) | 31932 (8.7) | 6674 (1.8) |
| | ICD-9-CM/ICD-10-CM MS-DRG | ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG | ICD-9-PCS/ICD-10-PCS MS-DRG |
| **Ischaemic stroke observations with ICD-9-CM, ICD-10-CM (with or without MS-DRG) n=365026** | 18855 (5.2) | 32433 (8.9) | 7691 (2.1) |
| | ICD-9-CM/ICD-10-CM MS-DRG | ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG | ICD-9-PCS/ICD-10-PCS MS-DRG |
| **Ischaemic stroke observations with ICD-9-CM, ICD-10-CM (with or without MS-DRG) n=365026** | 18855 (5.2) | 31862 (8.7) | 6674 (1.8) |
| | ICD-9-CM/ICD-10-CM MS-DRG | ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG | ICD-9-PCS/ICD-10-PCS MS-DRG |
| **Ischaemic stroke observations with both ICD-9-CM or ICD-10-CM and MS-DRG (ie, overlap) n=320187** | 5442 (1.7) | 27874 (8.7) | 7418 (2.3) |
| | ICD-9-CM/ICD-10-CM MS-DRG | ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG | ICD-9-PCS/ICD-10-PCS MS-DRG |
| **Ischaemic stroke observations with ICD-9-CM or ICD-10-CM only** n=44839 | 779 (1.7) | 2172 (4.8) | 273 (0.6) |
| | ICD-9-CM/ICD-10-CM MS-DRG | ICD-9-CM/ICD-10-CM ICD-9-PCS/ICD-10-PCS MS-DRG | ICD-9-PCS/ICD-10-PCS MS-DRG |
| **Ischaemic stroke observations with MS-DRG only† n=73** | 0 (0) | 73 (100) | 0 (0) |
| | MS-DRG | MS-DRG | 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, 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. 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 thrombolysis
ICD-9 procedural coding system (PCS) code (9910), a secondary ICD-9-CM code (V4588), ICD-10-PCS code (SE0317), a secondary ICD-10-CM code (23282) 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 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 thrombolytic administration in administrative data.10 However, 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.

Author affiliations
1Department of Emergency Medicine, Massachusetts General Hospital, Boston, Massachusetts, USA
2Department of Emergency Medicine, Harvard Medical School, Boston, Massachusetts, USA
3Department of Epidemiology and Biostatistics, Michigan State University, East Lansing, Michigan, USA
4University of Cincinnati, Cincinnati, Ohio, USA
5Massachusetts General Hospital, Boston, Massachusetts, USA
6Department of Emergency Medicine, University of California San Francisco, San Francisco, California, USA

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

Twitter Kori S Zachrison @k_sauser
Contributors KZS and RYH conceived the study; KZS, SL, LHS and RYH designed the analysis; SL and KSZ performed the analysis. All authors contributed to interpretation and presentation of the results, and critical revisions of the manuscript.

Funding Agency for Healthcare Research and Quality (PI Zachrison, K08HS024561); National Institutes of Health (PI Hsia R01HL134182, R01HL114822).

Competing interests OA reports Founder and Equity Holder, Sense Diagnostics. LHS reports the following relationships relevant to research grants or companies that manufacture products for thrombolyis or thrombectomy even if interactions involve non-thrombolyis products: scientific consultant regarding trial design and conduct to Genentech (late window thrombolysis) and Member of steering committee (TIMELESS NCT03785678); user interface design and usability to Lifeline (privately held company); stroke systems of care consultant to the Massachusetts Dept of Public Health; member of a Data Safety Monitoring Board (DSMB) for Penumbra (MIND NCT03342664); Diffusion Pharma PHAST-TSC NCT01763929); National PI or member of National Steering Committee for Medtronic (Stroke AF NCT02700945; CURRENT); PI, Late window thrombolysis trial, NINDS (PS05015343, MR WITNESS NCT01282242); PI, StrokeNet Network NINDS (New England Regional Coordinating Center U24NS107243).

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. This study used non-public data maintained by the California Office of Statewide Health Planning and Development. All data requests should be made directly to this organisation.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non-Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iD Kori S Zachrison http://orcid.org/0000-0001-8160-3257

REFERENCES
1 Andrade SE, Harrold LR, Tija J, et al. A systematic review of validated methods for identifying cerebrovascular accident or transient ischemic attack using administrative data. Pharmacoepidemiol Drug Saf 2012;21 Suppl 1:100–28.
2 Kokotailo RA, Hill MD. Coding of Stroke and Stroke Risk Factors Using International Classification of Diseases, Revisions 9 and 10. Stroke 2005;36:1776–81.
3 Panozzo CA, Woodworth TS, Welch EC, et al. Early impact of the ICD-10-CM transition on selected health outcomes in 13 electronic health care databases in the United States. Pharmacoepidemiol Drug Saf 2018;27:839–47.
4 Dantas LF, Marchesi JF, Peres IT, et al. Public hospitalizations for stroke in Brazil from 2009 to 2016. PLoS One 2019;14:e0213837.
5 Adami F, Figureiredo FWDS, Paiva LdaS, et al. Mortality and incidence of hospital admissions for stroke among Brazilians aged 15 to 49 years between 2008 and 2012. PLoS One 2016;11:e0152739.
6 Siddiqui FM, Weber MW, Dandapat S, et al. Endovascular thrombolyis or thrombectomy for cerebral venous thrombosis: study of nationwide inpatient sample 2004–2014. J Stroke Cerebrovasc Dis 2019;28:1440–7.
7 Brinjikji W, Rabinstein AA, Clift HJ. Socioeconomic disparities in the utilization of mechanical thrombectomy for acute ischemic stroke. J Stroke Cerebrovasc Dis 2014;23:979–84.
8 McCormick N, Bhole V, Lacaillde D, et al. Validity of diagnostic codes for acute stroke in administrative databases: a systematic review. PLoS One 2015;10:e0135834.
9 Chang TE, Lichtman JH, Goldstein LB, et al. Accuracy of ICD-9-CM codes by hospital characteristics and stroke severity: Paul Covernell National acute stroke program. J Am Heart Assoc 2016;5. doi:10.1161/JAHA.115.003056. [Epub ahead of print: 31 May 2016].
10 Kleindorfer D, Lindsey CJ, Braas L, et al. National us estimates of recombinant tissue plasminogen activator use: ICD-9 codes substantially underestimate. Stroke 2008;39:924–8.
11 Derby CA, Lapane KL, Feldman HA, et al. Possible effect of DRGs on the classification of stroke: implications for epidemiological surveillance. Stroke 2001;32:1487–91.
12 Data and Reports - OSHPD. Available: https://osphpd.ca.gov/data-and-reports/ [Accessed 7 May 2020].
13 Zachrison KS, Boggs KM, Hayden EM, et al. Understanding barriers to telemedicine implementation in rural emergency departments. Ann Emerg Med 2020;75:392–9.
14 Zachrison KS, Omneia J-R, Reeves MJ, et al. Hospital factors associated with interhospital transfer destination for stroke in the Northeast United States. J Am Heart Assoc 2020;9:e011575.
15 Moradiya Y, Crystal H, Valsamis H, et al. Thrombolytic utilization for ischemic stroke in US hospitals with neurology residency program. Neurology 2013;81:1986–95.
16 Hoffman H, Furst T, Jalaal MS, et al. Costs and predictors of 30-day readmissions after craniotomy for traumatic brain injury: a nationwide analysis. J Neurosurg 2019;85:83–9.
17 Dassenbrock HH, Coté DJ, Pompeu Y, et al. Validation of an international classification of disease, ninth revision coding algorithm to identify decompressive craniectomy for stroke. BMC Neurol 2017;17:121.
18 Rumalla K, Ottenhausen M, Kan P, et al. Recent nationwide impact of mechanical thrombectomy on decompressive hemicraniectomy for acute ischemic stroke. Stroke 2019;50:2133–9.
19 Murthy SB, Moradiya Y, Shah J, et al. Incidence, predictors, and outcomes of Ventriculostomy-Associated infections in spontaneous intracerebral hemorrhage. Neurocrit Care 2016;24:389–96.
20 USDA ERS - Urban Influence Codes. Available: https://www.ers.usda.gov/data-products/urban-influence-codes.aspx
21 Kumamaru H, Judd SE, Curtis JR, et al. Validity of claims-based stroke algorithms in contemporary Medicare data: reasons for geographic and racial differences in stroke (regards) study linked with Medicare claims. Circ Cardiovasc Qual Outcomes 2014;7:611–9.
22 Jones SA, Gottesman RF, Shahar E, et al. Validity of hospital discharge diagnosis codes for stroke: The atherosclerosis risk in communities study. In: Stroke; 2014: 3219–29.
23 Chang TE, Tong X, George MG, et al. Trends and Factors Associated With Concordance Between International Classification of Diseases, Ninth and Tenth Revision, Clinical Modification Codes and Stroke Clinical Diagnoses. Stroke 2019;50:1959–67.
24 Li L, Binney LE, Carter S, et al. Sensitivity of administrative coding in identifying inpatient acute strokes complicating procedures or other diseases in UK hospitals. J Am Heart Assoc 2019;8:e012995.
25 Hall R, Mondor L, Porter J, et al. Accuracy of administrative data for the coding of acute stroke and TIA.s. Can J Neurol Sci 2016;43:765–73.
26 Shah S, Xian Y, Sheng S, et al. Use, temporal trends, and outcomes of endovascular therapy after interhospital transfer in the United States. Circulation 2019;139:1568–77.
27 Adeoye O, Hornung R, Khatri P, et al. Recombinant tissue-type plasminogen activator use for ischemic stroke in the United States. Stroke 2011;42:1986–9.
28 Chang TE, Tong X, George MG, et al. Trends and factors associated with concordance between International classification of diseases, ninth and tenth revision, clinical modification codes and stroke clinical diagnoses. Stroke 2019;50:1959–67.

Stoke Vasc Neurol: first published as 10.1136/svn-2020-000533 on 11 November 2020. Downloaded from http://svn.bmj.com/Stroke Vasc Neurol on 14 November 2023 by guest. Protected by copyright.