Original Paper

European Neurology

Eur Neurol 2015;74:92–99
DOI: 10.1159/000438859

Received: April 30, 2015
Accepted: July 12, 2015
Published online: August 22, 2015

Positive Predictive Value of French Hospitalization Discharge Codes for Stroke and Transient Ischemic Attack

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Key Words
Stroke · ICD-10 · Hospital discharge records · Positive predictive value

Abstract
Background: We aimed at measuring the positive predictive value (PPV) of data in the French Hospital Medical Information Database (FHD). ***Summary:*** This retrospective multicenter study included 31 hospitals from where 56 hospital stays were randomly selected among all hospitalizations for the years 2009 and 2010 with at least 1 principal diagnosis of stroke or transient ischemic attack (TIA). Three algorithms were evaluated. Algorithm 1 selected discharge abstracts with at least 1 principal diagnosis identified by one of the relevant International Classification of Diseases, 10th revision codes. Algorithm 2 selected stays with 1 principal diagnosis of the whole stay, but without the dates of the stay. Algorithm 3 took into account the kind of medical wards. The PPV of each algorithm was calculated using medical records as the reference. We found 1,669 discharge abstracts with a diagnosis of stroke among the 1,680 that were randomly selected. The neurologist's review revealed 196 false-positive cases providing a global PPV of 88.26% for algorithm 1, 89.96% for algorithm 2 and 92.74% for algorithm 3. ***Key Messages:*** It was possible to build an algorithm to optimize the FHD for stroke and TIA reporting, with a PPV at 90%. The FHD could be a good tool to measure the burden of stroke in France.

Introduction

As of 2015, stroke remains a life-threatening condition; it has not only become a very common phenomenon but also one that involves expensive treatment methods [1]. Given the case-fatality rates at 1 month between 10 and 25% [1] and the rising incidence in people younger than 55 years [1, 2], dedicated care networks are necessary to limit the adverse consequences of stroke [3]. Reliable estimates of the stroke burden at the national level are required to establish efficient health policies [4, 5].

Population-based registries are still the gold standard to assess the epidemiological indices of stroke. They ensure the exhaustiveness, the sensitivity and the specificity of case ascertainment but in a restricted geographical area [6, 7]; this however, cannot reflect disparities across a country [2, 8].

The French Hospital Discharge Database (FHD) was developed to collect administrative data as a matter of routine in acute care hospitals for the purpose of allocating financial resources [9].

KARGER 125

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0014–3022/15/0742–0092$39.50/0

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Even though, the FHD was originally created to determine the financial requirements of hospitals throughout France, it could be a useful tool to evaluate the nationwide burden of stroke, since a similar approach has been used in other countries but with divergent results [10–15].

We have already used the FHD to evaluate time trends in hospital-referred stroke and transient ischemic attack (TIA), but we were unable to evaluate incidence rates and the positive predictive value (PPV) [16].

However, data about the validation of the FHD in France are limited to the results of 2 studies conducted in small cohorts from geographically limited areas with divergent conclusions on PPV [17, 18].

The main objective of this multicenter study was to assess the quality of stroke identification by measuring the PPV for all stroke subtypes and TIA using FHD data, and to build an algorithm to optimize these data.

Material and Methods

The FHD

The FHD was adapted from the American diagnosis-related group [19] and implemented in 1998 [9, 20]. It is used to evaluate the activity of public hospitals so as to establish their financial requirements.

Each department has to fill in a discharge abstract, which includes a principal diagnosis and associated diagnoses, coded using the International Classification of Diseases, 10th revision (ICD-10), and procedures using the French Common Classification of Medical procedures. At the end of hospitalization, the discharge abstracts of all departments are gathered and a principal diagnosis for the whole stay is defined.

Study Populations

To meet the study objectives, we described the project during the Congress of the French Society of Stroke of November 2009, in order to include, on a voluntary basis, neurologists working in hospitals with or without a stroke unit. In each hospital, the first stage consisted in randomly selecting 56 hospital stays in 2009–2010 of patients aged 18 years or more with at least 1 principal diagnosis of a first or recurrent stroke sub-type defined based on the codes of the ICD-10: I60, I61, I629, I63, I64, G45 (excluding G45.4), G46 and G81. In each hospital, each case of stroke was recorded in the FHD by the practitioner, whether or not a neurologist managed the case. The second stage consisted in ascertaining the diagnosis code recorded by the head of the neurological team of each hospital. This person was considered the investigating neurologist whose review was based on clinical and cerebral imaging. When the investigating neurologist disagreed with the hospital discharge diagnosis, his point of view was considered correct.

Study Variables

The following variables were considered: age, gender, cerebral imaging and the principal diagnosis codes used for the random selection of the 56 hospital stays. We also considered aphasia (R47.00 or R47.01) and hemiplegia (G81.00 or G81.01) when coded either as the principal or secondary diagnosis. It must be noted that hemiplegia and aphasia were not criteria used for the random selection of the 56 hospital stays but an additional variable.

Quality Assessment of the Diagnostic Codes

To assess the inter-observer concordance for the diagnosis of stroke, a randomized sample of 280 medical records was assessed twice. The first assessment was done by the investigating neurologist who filled out the e-CRF. The second assessment was done by one of the experts in stroke during a monitoring visit. The expert neurologist was independent from the center and blinded to e-CRF and FHD data, and the second assessment was done with the complete medical record. The kappa statistic was computed.

Estimation of PPV for the Different Variables and for the 3 Algorithms

The PPV was defined as the proportion of stays confirmed as stroke among those identified as stroke in the FHD. The true-positive cases were the hospitalizations for which stroke was identified both in the administrative abstracts and in the corresponding medical records. False-positive cases were hospitalizations with a diagnosis code of stroke recorded in the administrative abstracts that were not identified as such in the patients' medical records after review. PPV is the ratio between the true-positive cases and the true-positive cases plus the false-positive cases.

Univariate analyses were performed to identify determinants associated with the probability of a false-positive based on the following items: age, sex, stroke subtypes, types of hospital department, type of cerebral imaging.

For each of these variables, the PPV was estimated and compared based on the different modalities (chi-square test). A p value <0.05 was considered significant.

Algorithms for Identifying a Stroke

Algorithm 1 selected discharge abstracts with at least 1 principal diagnosis identified by one of the relevant ICD-10 codes, and corresponds to the data in table 1. Algorithm 2 selected stays with 1 principal diagnosis of the whole stay from the same list of codes but without the dates of the stay. This algorithm limited the number of false-positive cases. Algorithm 3 took into account the kind of department and made it possible to evaluate the impact of the type of hospital department on the accuracy of the coding procedure.

Ethics

The validation study involved consulting medical records and was approved by the National Data Protection Authority (Commission Nationale de l'Informatique et des Libertés). The study was approved by the IRB CECIC n° 5891 on December 30, 2012, and was declared at ClinicalTrials.gov Identifier: NCT01573221.

Results

Characteristics of the Study Population

Thirty-one hospitals including 15 university hospitals and 16 general hospitals all with a stroke unit were in-

Table 1. PPV of the different variables using the medical record as the gold standard

Patients	n (%)
Age, years	
≤65	613 (36.73)
≥65	1,056 (63.27)
Gender	
Female	786 (47.09)
Male	883 (52.91)
Hemiplegia as symptom	
No	1,338 (80.17)
Yes	331 (19.83)
Aphasia as symptom	
No	1,464 (87.72)
Yes	205 (12.28)
MRI	
No	974 (58.36)
Yes	695 (41.64)
CT-scan	
No	521 (31.22)
Yes	1,148 (68.78)
Diagnosis code	
G45 (transient cerebralischemic attacks and related syndromes)	258 (15.46)
G46 (vascular syndromes of brain in cerebrovascular diseases)	13 (0.78)
G81 (hemiplegia)	28 (1.68)
I60 (subarachnoid hemorrhage)	72 (4.31)
I61 (intracerebral hemorrhage)	188 (11.26)
I629 (non-traumaticintracranial hemorrhage or infarction	14 (0.84)
I63 (cerebral infarction)	914 (54.76)
I64 (unspecified hemorrhagic or ischemic stroke)	47 (2.82)
Other (associated with comorbidities)	135 (8.09)

Table 2. PPV according to different hospitals wards

	Stroke/TIA						
	yes	no	total	PPV, %	95% CI	min	max
Medicine wards	585	103	688	85.03	82.30–87.70	41.18	100
Stroke units	171	12	183	93.44	89.85–97.02	50.00	100
Intensive stroke units	671	34	705	95.18	93.60–96.76	82.35	100
Total	1,473	196	1,669	88.26	86.72–89.80		

Table 3. Description of the false-positive cases

Non-ruptured aneurysm	12
History of stroke	22
Other (hyperglycemia, multiple sclerosis, alcohol abuse, psychiatric disorder, post-partum, transient global amnesia)	46
Headache	8
Dementia and delirium	7
Epilepsy	14
Sub-dural hematoma	10
Post-traumatic intracranial hemorrhage	16
Post-traumatic sub-arachnoid hemorrhage	34
Vertigo	18
Traumatic brain injury trauma	3
Brain tumor	6
Total	196

volved. However, all the patients were not hospitalized in stroke units.

We analyzed 1,669 records for neurovascular events among the 1,736 randomly selected hospitalizations, because the whole medical record was not retrieved in 67 cases (3.85%).

Clinical features extracted from the FHD are described in table 1. Of the 1,669 patients, 613 (36.73%) were below 65-years-old and 883 (52.91%) were male.

There were 914 cerebral infarctions (I63; 54.76%), 188 cerebral hemorrhages (I61; 11.26%), 72 subarachnoid hemorrhages (I60; 4.31%), 258 TIA (G45; 15.46%), 13 cases of vascular syndromes (G46; 0.78%), 14 non-traumatic intracranial hemorrhages (I629; 0.84%), 47 cases of unspecified hemorrhagic or ischemic stroke (I64; 2.82%), 135 cases of other stroke associated with co-morbidities (8.09%) and 28 cases of hemiplegia from stroke (G81; 1.68%).

Cerebral imaging was performed in all of the patients with a CT-scan in 1,148 patients and an MRI in 695 patients.

Finally, 705 patients were managed in intensive stroke units, 183 in stroke units, 688 in medical wards and 93 in surgical wards (table 2).

Among the 1,669 stays, we identified 1,473 true-positive cases and 196 false-positive cases (table 3).

Estimation of the PPV for the Different Variables

Table 4 shows that the global PPV was 88.26%. The PPV was better after 65 years (90.53%), and was improved if variable aphasia (98.05%) or hemiplegia (96.98%) was associated, and after MRI (90.79%) or CT-scan (90.33%). No differences were observed based on gender.

Table 4. PPV of the different variables

	True-positives n (%)	False-positives n (%)	Total n (%)	PPV, %
Age, years				p = 0.0002
≤65	517 (35.10)	96 (48.98)	613 (36.73)	84.34
≥65	956 (64.90)	100 (51.02)	1,056 (63.27)	90.53
Gender				p = 0.80
Female	692 (46.98)	94 (47.96)	786 (47.09)	88.04
Male	781 (53.02)	102 (52.04)	883 (52.91)	88.45
Hemiplegia as symptom				p < 0.0001
No	1,152 (78.21)	186 (94.90)	1,338 (80.17)	86.10
Yes	321 (21.79)	10 (5.10)	331 (19.83)	96.98
Aphasia as symptom				p < 0.0001
No	1,272 (86.35)	192 (97.96)	1,464 (87.72)	86.89
Yes	201 (13.65)	4 (2.04)	205 (12.28)	98.05
MRI				p = 0.006
No	842 (57.16)	132 (67.35)	974 (58.36)	86.45
Yes	631 (42.84)	64 (32.65)	695 (41.64)	90.79
CT-scan				p = 0.0001
No	436 (29.60)	85 (43.37)	521 (31.22)	83.69
Yes	1,037 (70.40)	111 (56.63)	1,148 (68.78)	90.33
Diagnosis code				
G45 (transient cerebral ischemic attacks and related syndromes)	231 (15.68)	27 (13.78)	258 (15.46)	89.53
G46 (vascular syndromes of brain in cerebrovascular diseases)	7 (0.48)	6 (3.06)	13 (0.78)	53.85
G81 (hemiplegia)	11 (0.75)	17 (8.67)	28 (1.68)	39.29
I60 (subarachnoid hemorrhage)	33 (2.24)	39 (19.90)	72 (4.31)	45.83
I61 (intracerebral hemorrhage)	168 (11.41)	20 (10.20)	188 (11.26)	89.36
I629 (non-traumatic intracranial hemorrhage or infarction)	9 (0.61)	5 (2.55)	14 (0.84)	64.29
I63 (cerebral infarction I64	880 (59.74)	34 (17.35)	914 (54.76)	96.28
I64 (unspecified hemorrhagic or ischemic stroke)	41 (2.78)	6 (3.06)	47 (2.82)	87.23
Other (associated with comorbidities)	93 (6.31)	42 (21.43)	135 (8.09)	68.89

The codes for the principal diagnosis provided very different results: cerebral infarction was associated with a high PPV (96.28%) as were TIA and related syndromes (PPV = 89.53%) and non-traumatic intracranial hemorrhage (89.36%), while neither subarachnoid hemorrhage (45.83%) nor hemiplegia (39.29%) was a good criterion. The number of patients with the codes G46 and I629 was small.

Table 2 shows that intensive stroke units provided a better PPV (95.18%) than did stroke units (93.44%) and medical and surgical departments (85.03 and 49.46%, respectively).

Estimation of the PPV for the Different Algorithms

As the confidence intervals overlapped, the PPV for algorithm 2 was not significantly higher than that for algorithm 1. The same applied to algorithms 2 and 3. However, the PPV for algorithm 3 was significantly higher than that for algorithm 1, as the corresponding confidence intervals did not overlap (table 5).

Table 5. PPV of the 3 algorithms

Algorithms	Number of stays	True-positives	False-positives	PPV, %	95% CI
Algorithm 1	1,669	1,473	196	88.26	86.72–89.80
Algorithm 2	1,534	1,380	154	89.96	88.46–91.46
Algorithm 3	1,377	1,277	100	92.74	91.37–94.11

Table 6 shows that whatever the algorithm, the PPV in general hospitals was always better than that in university hospitals.

Table 6. PPV in general hospitals vs. university hospitals according to the 3 algorithms

		Stroke/TIA						
		yes	no	total	PPV, %	95% CI	min	max
Algorithm 1	General hospitals	835	73	908	91.96	90.19–93.73	75	100
	University hospitals	638	123	761	83.84	81.22–86.45	63.64	100
	Total	1,473	196	1,669	88.26	86.72–89.80		
Algorithm 2	General hospitals	787	54	841	93.58	91.92–95.24	75	100
	University hospitals	593	100	693	85.57	82.95–88.19	75	100
	Total	1,380	154	1,534	89.96	88.46–91.46		
Algorithm 3	General hospitals	728	38	766	95.04	93.50–96.58	85.71	100
	University hospitals	549	62	611	89.85	87.45–92.24	80	100
	Total	1,277	100	1,377	92.74	91.36–94.11		

Inter-Observer Variability

Inter-observer (investigation vs. monitoring) agreement based on 280 cases was 95.36% and the kappa was 0.83 ± 0.06.

Discussion

This study is the first French evaluation of the PPV of FHD for stroke based on input from 31 hospitals. It included university hospitals as well as medium-sized and small non-university hospitals. All patients in France are recorded in the FHD, whatever the size of the hospital. If a stroke patient is admitted to a private hospital, he is then transferred to a public hospital with 24-hour-a-day cerebral imaging and management on site or via a tele-stroke procedure.

The study design allowed us to evaluate the reliability of data from specialized and non-specialized hospital wards, and to monitor the burden of stroke at the national level. Therefore, the 31 hospitals may be considered representative of the organization of acute stroke management in France [16]. The demographic patterns of the study population extracted from our nationwide survey are concordant with international [1], national [16] and local [18] data with 12% of intracerebral hemorrhage, 5% of subarachnoid hemorrhage, 55% of cerebral infarctions and 15% of TIA. Only 3% of cases were unspecified hemorrhagic or ischemic strokes. It is important to underline that all our patients had cerebral imaging and more than half of the cohort had cerebral MRI.

From this reliable and representative French cohort, we report a PPV of up to 90%, thus demonstrating that both the identification and coding of stroke were excellent.

At the same time, the results demonstrate the disparity in the quality of coding, depending on clinical criteria, stroke subtypes, cerebral imaging and care wards (table 2).

On the basis of clinical criteria, stroke subtypes and cerebral imaging, the best PPV were provided by aphasia (PPV = 98.05%) and hemiplegia (PPV = 96.98%), the use of MRI (PPV = 90.79%), age >65 years (PPV = 90.53%) and CT-scan (PPV = 90.33%), whereas subarachnoid hemorrhage provided a far lower PPV (45.83%). However, the choice of the principal diagnosis may also induce a low PPV. For example, when hemiplegia was the principal diagnosis and the only symptom, stroke was the cause of hospitalization only in 39.29% of cases, thus underlining the multiple causes of acute hemiplegia. The small number of patients in diagnosis codes G46 and I629 indicates that coders are becoming more and more precise in the diagnosis code.

With regard to the types of hospital department, the best PPV was obtained for intensive stroke units (95.18%) and the worst for surgical departments (table 2), thus reflecting the role of medical experience in coding rather than possible case-mix differences. Patients in surgical departments were managed medically before being transferred to the surgical ward because of lack of beds in medical wards. The PPV in surgical wards was low but was related only to 93 cases. Only 5% of the coding in surgical wards had to be reviewed to identify erroneous stays and to correct them.

Comparison of the 3 algorithms allowed us to confirm that the results obtained using FHD data depended on the choice of items corresponding to the diagnosis codes and could be improved by adding 2 symptoms with a high degree of sensitivity for stroke as well as hemiplegia and aphasia. For all 3 algorithms, a higher PPV was observed in general hospitals than in university hospitals (table 6). This can be explained by the fact that in university hospitals, young residents with little experience generally fill in the FHD files, while in general hospitals, senior doctors do this task. First, the aim of the study was not to compare the quality of data recording in university hospitals and general hospitals. It was actually designed to evaluate the global quality of the French database by measuring its PPV in real life, to build an algorithm in order to optimize the value of these data.

The results showing an unexpected difference between university and general hospitals allowed us to identify a problem of data recording, and solutions will need to be found in the near future. Coding in surgical wards and university hospitals must be improved.

The high PPV provided by this nationwide study, close to 90%, was similar to that in other recent studies which reported a PPV between 85 and 90% [5, 15, 18, 21–28] or 95% [17]. In contrast to the first French study, which involved a single area [17], we included hemorrhagic stroke and TIA managed in a regional stroke network as well as ischemic stroke. Since all of these require the same care givers and the same logistics and financial resources, it was important to compare their PPV. The study of all stroke subtypes revealed that the PPV was lower for hemorrhagic stroke (89.36%) than for ischemic stroke, but nonetheless higher than that in other studies (74%) [24]. The risk of a lower PPV for hemorrhagic stroke is related to the possibility that it may overestimate global stroke incidence [17, 21, 23, 25].

The fact that we included TIA may have decreased coding error because TIA is included in ischemic cerebrovascular syndromes, and recent changes in the definition of TIA according to the duration of the event and the results of the cerebral imaging may lead to changes in the diagnosis [26]. For this study, TIA was selected based on the WHO definition with a duration of less than 24 h.

The strength of the study is that the results were provided by 31 hospitals representative of French public hospital practices for stroke, with varying degrees of coding quality depending on whether cases were managed in university hospitals or non-university hospitals, in multiple medical or surgical departments, or in stroke units. Only 705 and 183 patients were managed in intensive stroke units and in stroke units, respectively, while 781 were managed outside specialized stroke units. In France, more than 80% of acute stroke patients are hospitalized in these types of hospitals [16]. Selecting records from all of the departments that manage stroke in France reflected another real-life situation.

We collected all stroke subtypes and TIA, which allowed us to report the PPV for overall stroke, which would be useful for public health deciders. We used several approaches with 3 algorithms to refine the data. The fact that the 3 algorithms selected stroke identified by cerebral imaging probably decreased the number of false-positive cases. The medical record was incomplete only in 3.85% of the hospitalizations, which could therefore not be studied. The statistical methods were straightforward. Finally, the excellent kappa scores show the reliability of our results.

The weakness of our study was that we did not include small local hospitals or private hospitals, which have no emergency wards for stroke. Nevertheless, they are able to manage stroke especially in old patients before transferring them to a hospital with the necessary facilities. We have included both first and recurrent stroke to analyze the quality of the identification of the stroke itself. It is not possible to extrapolate mortality rates to the whole territory because we did not include stroke patients who died at home, even though the proportion is very small at less than 2% [29] and this was not the objective of the study.

Second, the study could not determine the sensitivity of FHD or the negative predictive value. The previous assessment based on the Dijon Stroke Registry allowed us to estimate a sensitivity of 82.9% [18].

Conclusion

It was possible to build an algorithm to optimize FHD data for stroke and TIA reporting, with a PPV at 90% and above. The FHD is a good tool to measure not only the burden of stroke but also the quality of hospital organization around stroke and the resources necessary to meet the needs of the population.

Support Grants

This work was supported by a grant from the Programme Hospitalier de Recherche Clinique 2010 of the French Ministry of Health, the Regional Council and the University of Burgundy and the University Hospital of Dijon.

Acknowledgments

To the Fresco Study the FRESCO study (French Stroke Cohort) was conducted by a Steering Committee: Prof. Maurice Giroud (Dijon Stroke Registry, Dijon, France); Prof. Catherine Quantin (Service d'Informatique Médicale, Dijon, France); Prof. Yannick Béjot (Dijon Stroke Registry, Dijon, France); Prof. Marc Hommel (Clinical Investigation Center, Grenoble, France); Dr. Jérôme Fauconnier (Service d'Information Médicale, Grenoble, France); Dr. France Woimant (Neurological Service, Lariboisière Paris, France); Prof. Serge Timsit (Stroke Registry of Brest, France); G. Oger (Stroke Registry of Brest, France); Prof. Thierry Moulin (Service of Neurology, Besançon, France); Jean Dalongeville (MONICA, Lille, France); Serge Bruandet (Biostatisticien, Lille, France); Eric Jougla (Inserm, CépiDC, France); Olivier Grimaud (Public Health School, Rennes, France).

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We are grateful to all of the doctors of the Medical Information Departments of the participant hospitals for their help in this project, and we thank Philip Bastable for assistance with language.

Disclosure Statement

The authors declare no conflict of interest.

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