

# Supplementary materials

Temporal trends in the accuracy of hospital diagnostic coding for identifying acute stroke: a population-based study

**Web appendix 1** Distribution of management mode stratified by study period for all ascertained stroke cases and incident stroke cases

**Web appendix 2** Reasons for “false negative” cases in hospitalised stroke cases stratified by study period and initial reasons for admission

**Web appendix 3** Reasons and temporal trends for wrong subtyping among otherwise correctly identified hospitalised incident strokes

**Web appendix 4** Temporal trends and impact of using hospital discharge codes in identifying incident stroke ascertained in OXVASC with stratification by study period and patient age groups

**Web appendix 5** Reasons for “false positive” cases stratified by time period and searching strategy

**Web appendix 6** Age-specific time trends of the accuracy of hospital discharge codes in identifying true acute stroke cases (positive predictive value) stratified by searching strategies

**Web appendix 1 Distribution of management mode stratified by study period for all ascertained stroke cases and incident stroke cases**

	<b>2002-2005</b>	<b>2005-2008</b>	<b>2008-2011</b>	<b>2011-2014</b>	<b>2014-2017</b>	<b>P<sub>heterogeneity</sub></b>	<b>Total</b>
<b>All ascertained stroke cases</b>	<b>(n=612)</b>	<b>(n=577)</b>	<b>(n=614)</b>	<b>(n=603)</b>	<b>(n=605)</b>	<b>0.10</b>	<b>(n=3011)</b>
Patients seen in outpatient clinic or managed in community	240 (39.2)	207 (35.9)	196 (31.9)	198 (32.8)	204 (33.7)		1044 (34.7)
Strokes that happened out of the area or abroad	13 (2.1)	12 (2.1)	16 (2.6)	25 (4.1)	17 (2.8)		84 (2.8)
Strokes that happened during hospital admission for other disease	56 (9.2)	43 (7.5)	53 (8.6)	42 (7.0)	42 (6.9)		236 (7.8)
Patients admitted to hospital for acute stroke	303 (49.5)	315 (54.6)	349 (56.8)	338 (56.1)	342 (56.5)		1647 (54.7)
<b>Incident stroke cases</b>	<b>(n=430)</b>	<b>(n=428)</b>	<b>(n=463)</b>	<b>(n=471)</b>	<b>(n=462)</b>	<b>0.46</b>	<b>(n=2254)</b>
Patients seen in outpatient clinic or managed in community	166 (38.6)	141 (32.9)	152 (32.8)	151 (32.1)	149 (32.3)		759 (33.7)
Strokes that happened out of the area or abroad	11 (2.6)	11 (2.6)	13 (2.8)	23 (4.9)	16 (3.5)		74 (3.3)
Strokes that happened during hospital admission for other disease	30 (7.0)	32 (7.5)	30 (6.5)	29 (6.2)	32 (6.9)		153 (6.8)
Patients admitted to hospital for the acute stroke	223 (51.9)	244 (57.0)	268 (57.9)	268 (56.9)	265 (57.4)		1268 (56.3)

Numbers are presented as n (%).

**Web appendix 2 Reasons for “false negative” cases in hospitalised stroke cases stratified by study period and initial reasons for admission**

	2002-2005	2005-2008	2008-2011	2011-2014	2014-2017	P <sub>heterogeneity</sub>	Total
<b>All hospitalised stroke cases:</b>							
<b>Initial reason as “suspected acute stroke”</b>	<b>(n=72)</b>	<b>(n=98)</b>	<b>(n=96)</b>	<b>(n=72)</b>	<b>(n=62)</b>	<b>&lt;0.0001</b>	<b>(n=400)</b>
Complete omission*	45 (62.5)	62 (63.3)	60 (62.5)	45 (62.5)	23 (37.1)		235 (58.8)
Identified by coding but not from primary diagnosis	3 (4.2)	2 (2.0)	4 (4.2)	4 (5.6)	13 (21.0)		26 (6.5)
Inaccurately coded as transient ischaemic attack	16 (22.2)	13 (13.3)	22 (22.9)	14 (19.4)	8 (12.9)		73 (18.3)
Inaccurately coded with other relevant diagnosis‡	8 (11.1)	21 (21.4)	10 (10.4)	9 (12.5)	18 (29.0)		66 (16.5)
<b>Initial reason as other non-stroke diagnosis‡</b>	<b>(n=31)</b>	<b>(n=28)</b>	<b>(n=28)</b>	<b>(n=30)</b>	<b>(n=25)</b>	<b>0.0003</b>	<b>(n=142)</b>
Complete omission*	15 (48.4)	15 (53.6)	14 (50.0)	2 (6.7)	6 (24.0)		52 (36.6)
Identified by coding but not from primary diagnosis	15 (48.4)	8 (28.6)	5 (17.9)	16 (53.3)	10 (40.0)		54 (38.0)
Inaccurately coded as transient ischaemic attack	0 (0)	2 (7.1)	2 (7.1)	0 (0)	1 (4.0)		5 (3.5)
Inaccurately coded with other diagnosis‡	1 (3.2)	3 (10.7)	7 (25.0)	12 (40.0)	8 (32.0)		31 (21.8)
<b>Hospitalised incident stroke cases:</b>							
<b>Initial reason as “suspected acute stroke”</b>	<b>(n=54)</b>	<b>(n=81)</b>	<b>(n=74)</b>	<b>(n=53)</b>	<b>(n=49)</b>	<b>0.0004</b>	<b>(n=311)</b>
Complete omission*	32 (59.3)	49 (60.5)	42 (56.6)	27 (50.9)	15 (30.6)		165 (53.1)
Identified by coding but not from primary diagnosis	2 (3.7)	2 (2.5)	4 (5.4)	3 (5.7)	10 (20.4)		21 (6.8)
Inaccurately coded as transient ischaemic attack	12 (22.2)	10 (12.3)	18 (24.3)	13 (24.5)	7 (14.3)		60 (19.3)
Inaccurately coded with other relevant diagnosis‡	8 (14.8)	20 (24.7)	10 (13.5)	10 (18.9)	17 (34.7)		65 (20.9)
<b>Initial reason as other non-stroke diagnosis‡</b>	<b>(n=20)</b>	<b>(n=21)</b>	<b>(n=20)</b>	<b>(n=21)</b>	<b>(n=17)</b>	<b>0.002</b>	<b>(n=99)</b>
Complete omission*	9 (45.0)	9 (42.9)	9 (45.0)	0 (0)	3 (17.6)		30 (30.3)
Identified by coding but not from primary diagnosis	11 (55.0)	8 (38.1)	3 (15.0)	13 (61.9)	8 (47.1)		43 (43.4)
Inaccurately coded as transient ischaemic attack	0 (0)	2 (9.5)	2 (10.0)	0 (0)	1 (5.9)		5 (5.1)
Inaccurately coded with other diagnosis‡	0 (0)	2 (9.5)	6 (30.0)	8 (38.1)	5 (29.4)		21 (21.2)

Numbers are presented as n(%).

\*true acute stroke admissions to the hospitals that were not matched to any administrative data records obtained from the same hospitals or were only matched to non-relevant diagnosis.

‡ acute stroke that happened during admission for other diseases.

†e.g. subdural haemorrhage, occlusion of cerebral artery, cerebral aneurysm without rupture, headache, dementia, collapse, brain injury, dysphagia.

**Web appendix 3 Reasons and temporal trends for wrong subtyping among otherwise correctly identified hospitalised incident strokes**

	<b>2002-2005</b>	<b>2005-2008</b>	<b>2008-2011</b>	<b>2011-2014</b>	<b>2014-2017</b>	<b>Total</b>
IS coded as ICH or SAH	6	3	3	1	1	14
ICH coded as I63	0	1	0	0	1	2
ICH coded as I64	9	6	1	0	0	16
ICH coded as SAH	1	2	2	2	4	11
SAH coded as ICH	0	2	0	1	0	3
<b>Total</b>	<b>16</b>	<b>14</b>	<b>6</b>	<b>4</b>	<b>6</b>	<b>46</b>

IS=ischaemic stroke; ICH=intracerebral haemorrhage; SAH=subarachnoid haemorrhage.

**Web appendix 4 Temporal trends and impact of using hospital discharge codes in identifying incident stroke ascertained in OXVASC with stratification by study period and patient age groups**

	2002-2005	2005-2008	2008-2011	2011-2014	2014-2017	p <sub>trend</sub>	Total	p*
<b>All incident stroke cases</b>								
<65y	38/87 (43.7)	25/86 (29.1)	46/114 (40.2)	58/119 (48.7)	47/121 (38.8)	0.52	214/527 (40.6)	0.001
65-74y	37/117 (31.6)	37/85 (43.5)	41/88 (46.6)	60/114 (52.6)	34/80 (42.5)	0.02	209/484 (43.2)	
≥75y	107/226 (47.3)	114/257 (44.4)	120/261 (46.0)	113/238 (47.5)	152/261 (58.5)	0.009	606/1243 (48.8)	
<b>Incident stroke cases that were hospitalised†</b>								
<65y	37/49 (75.5)	25/44 (56.8)	44/65 (67.7)	55/71 (77.5)	46/60 (76.7)	0.22	207/289 (71.6)	0.98
65-74y	36/56 (64.3)	37/55 (67.3)	41/56 (73.2)	58/74 (78.4)	34/53 (64.2)	0.47	206/294 (70.1)	
≥75y	106/148 (71.6)	112/177 (63.3)	119/177 (67.2)	110/152 (72.4)	151/184 (82.1)	0.003	598/838 (71.4)	

Numbers are presented as n (%).

\*p values indicate the trend of sensitivity with increasing age.

†including cases that were admitted for suspected stroke or cases where stroke happened during admission for other diseases.

Web appendix 5 Reasons for “false positive” cases stratified by time period and searching strategy

	Total	2002-2005	2005-2008	2008-2011	2011-2014	2014-2017	P <sub>het</sub>
<b>Full codes and all admissions</b>	<b>(n=608)</b>	<b>(n=139)*</b>	<b>(n=135)</b>	<b>(n=112)</b>	<b>(n=112)</b>	<b>(n=110)</b>	<b>&lt;0.0001</b>
Cancelled or duplicated admission	19 (3.1)	7 (5.0)	1 (0.7)	2 (1.8)	8 (7.1)	1 (0.9)	
Elective admission for investigation/procedure after stroke	228 (37.5)	27 (19.4)	53 (39.3)	60 (53.6)	46 (41.1)	42 (38.2)	
Admission for rehabilitation after stroke	59 (9.7)	39 (28.1)	11 (8.1)	1 (0.9)	2 (1.8)	6 (5.5)	
Admission for medical complication after stroke	30 (4.9)	11 (7.9)	7 (5.2)	1 (0.9)	5 (4.5)	6 (5.5)	
Non-stroke diagnosis	249 (41.0)	49 (35.3)	60 (44.0)	45 (40.2)	46 (41.1)	49 (44.0)	
TIA	56 (9.2)	7 (5.0)	12 (8.9)	16 (14.3)	13 (11.6)	8 (7.3)	
Old stroke or small vessel disease on imaging	24 (3.8)	3 (2.2)	11 (8.1)	0 (0)	3 (2.7)	7 (6.4)	
Seizure	16 (2.6)	5 (3.6)	2 (1.5)	4 (3.6)	3 (2.7)	2 (1.8)	
MS, vasculitis or other CNS inflammatory disease	6 (1.0)	2 (1.4)	0 (0)	1 (0.9)	1 (0.9)	2 (1.8)	
CNS tumour or metastatic disease	12 (2.0)	2 (1.4)	5 (3.7)	1 (0.9)	3 (2.7)	1 (0.9)	
Dementia or other neurodegenerative disease	6 (1.0)	4 (2.9)	1 (0.7)	0 (0)	1 (0.9)	0 (0)	
Trauma, SDH, EDH or unruptured aneurysm	82 (13.5)	13 (9.4)	16 (11.9)	17 (15.2)	17 (15.2)	19 (17.3)	
Other†	47 (7.7)	13 (9.4)	13 (9.6)	6 (5.4)	5 (4.5)	10 (9.1)	
Wrong GP	23 (3.8)	6 (4.3)	3 (2.2)	3 (2.7)	5 (4.5)	6 (5.5)	
<b>Stroke-specific codes and first admission only</b>	<b>(n=152)</b>	<b>(n=37)*</b>	<b>(n=41)</b>	<b>(n=23)</b>	<b>(n=23)</b>	<b>(n=28)</b>	<b>0.24</b>
Cancelled or duplicated admission	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Elective admission for investigation/procedure after stroke	9 (5.9)	1 (2.7)	6 (14.6)	1 (4.3)	1 (4.3)	0 (0)	
Admission for rehabilitation after stroke	3 (2.0)	1 (2.7)	1 (2.4)	1 (4.3)	0 (0)	0 (0)	
Admission for medical complication after stroke	6 (3.9)	2 (5.4)	4 (9.8)	0 (0)	0 (0)	0 (0)	
Non-stroke diagnosis	113 (74.3)	28 (75.7)	27 (65.9)	18 (78.3)	17 (73.9)	23 (82.1)	
TIA	36 (23.7)	6 (16.2)	8 (19.5)	8 (34.8)	8 (34.8)	6 (21.4)	
Old stroke or small vessel disease on imaging	12 (7.9)	2 (5.4)	9 (22.0)	0 (0)	0 (0)	1 (3.6)	
Seizure	13 (8.6)	5 (13.5)	2 (4.9)	3 (13.0)	2 (8.7)	1 (3.6)	
MS, vasculitis or other CNS inflammatory disease	3 (2.0)	2 (5.4)	0 (0)	0 (0)	0 (0)	1 (3.6)	
CNS tumour or metastatic disease	9 (5.9)	2 (5.4)	2 (4.9)	1 (4.3)	3 (13.0)	1 (3.6)	
Dementia or other neurodegenerative disease	3 (2.0)	2 (5.4)	1 (2.4)	0 (0)	0 (0)	0 (0)	
Trauma, SDH, EDH or unruptured aneurysm	10 (6.6)	0 (0)	1 (2.4)	3 (13.0)	2 (8.7)	4 (14.3)	
Other†	27 (17.8)	9 (24.3)	4 (9.8)	3 (13.0)	2 (8.7)	9 (32.1)	
Wrong GP	21 (13.8)	5 (13.5)	3 (7.3)	3 (13.0)	5 (21.7)	5 (17.9)	

Numbers are presented as n (%).

\*n=6 cases with unknown reasons excluded. †including headache, sepsis, acute peripheral vascular disease and myocardial infarction.

**Web appendix 6 Age-specific time trends of the accuracy of hospital discharge codes in identifying true acute stroke cases (positive predictive value) stratified by searching strategies**

	2002-2005	2005-2008	2008-2011	2011-2014	2014-2017	P <sub>trend</sub>
<b>Full non-specific codes (I60-I68):</b>						
<b>All admissions</b>						
<65y	63.5 (52.0-73.7)	50.0 (39.6-60.4)	59.4 (49.6-68.5)	62.7 (53.0-71.6)	57.0 (47.1-66.3)	0.93
65-74y	57.1 (46.8-66.9)	59.5 (47.9-70.0)	65.8 (54.7-75.4)	73.5 (63.8-81.3)	60.5 (49.2-70.9)	0.16
≥75y	64.9 (58.4-70.9)	71.8 (65.5-77.4)	79.4 (73.5-84.3)	78.0 (72.0-83.0)	84.4 (79.2-88.5)	<0.0001
<b>Excluding re-admission ≤ 28 days</b>						
<65y	73.4 (61.3-82.8)	52.5 (41.6-63.2)	62.8 (52.6-71.9)	65.3 (55.4-74.1)	62.6 (52.3-72.0)	0.80
65-74y	76.5 (64.9-85.1)	65.2 (52.9-75.7)	67.1 (55.8-76.7)	74.5 (64.7-82.2)	69.7 (57.6-79.6)	0.87
≥75y	76.3 (69.7-81.8)	76.1 (69.8-81.4)	79.6 (73.6-84.5)	79.0 (73.0-84.0)	85.0 (79.8-89.1)	0.02
<b>First admission only</b>						
<65y	78.3 (66.1-87.0)	57.4 (45.4-68.5)	70.5 (59.5-79.6)	71.9 (61.7-80.3)	69.2 (58.1-78.5)	0.96
65-74y	76.9 (65.1-85.6)	67.2 (54.8-77.6)	68.7 (56.6-78.6)	79.7 (69.4-87.2)	75.0 (62.0-84.6)	0.57
≥75y	76.0 (69.2-81.6)	76.8 (70.3-82.2)	79.4 (73.8-85.2)	80.1 (73.8-85.2)	86.2 (80.7-90.3)	0.01
<b>Stroke-specific codes (I60, I61, I63, I64):</b>						
<b>All admissions</b>						
<65y	67.6 (55.7-77.7)	64.2 (50.5-75.9)	86.4 (75.8-92.8)	87.3 (77.4-93.3)	72.6 (61.3-81.6)	0.06
65-74y	65.4 (54.2-75.1)	75.0 (61.5-84.9)	90.9 (79.9-96.2)	93.3 (84.9-97.2)	80.0 (67.3-88.6)	0.0005
≥75y	71.9 (65.2-77.7)	83.2 (77.0-87.9)	93.7 (88.9-96.5)	91.0 (85.7-94.4)	94.2 (90.1-96.7)	<0.0001
<b>Excluding re-admission ≤ 28 days</b>						
<65y	78.0 (65.6-86.8)	68.0 (53.9-79.4)	87.5 (76.9-93.6)	88.6 (78.7-94.2)	76.8 (65.4-85.3)	0.32
65-74y	87.9 (76.7-94.2)	79.2 (65.4-88.4)	90.7 (79.5-96.1)	93.2 (84.7-97.2)	88.0 (75.7-94.5)	0.28
≥75y	83.5 (77.2-88.4)	87.9 (82.1-92.0)	94.2 (89.5-96.8)	92.4 (87.3-95.5)	95.0 (90.9-97.3)	<0.0001
<b>First admission only</b>						
<65y	83.6 (71.4-91.3)	73.8 (58.5-84.9)	86.9 (75.8-93.3)	88.6 (78.7-94.2)	78.1 (66.3-86.6)	0.92
65-74y	89.1 (77.7-95.0)	80.9 (67.0-89.8)	89.8 (77.7-95.7)	95.4 (86.6-98.5)	88.9 (75.9-95.3)	0.27
≥75y	83.0 (76.5-88.0)	87.3 (81.4-91.6)	93.7 (88.6-96.6)	92.4 (87.0-95.6)	95.0 (90.7-97.4)	<0.0001

Numbers are presented as n (%).