**S1 Table. Characteristics of studies validating ICD codes from hospital and death certificate data for stroke and its pathological types.\***

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Study | | Country | | Age (range) | ICD code group | | ICD version | | Code  source | Coded events assessed (n)†  (a) | | Diagnostic position | Reference standard‡ | Coded events confirmed (n)  (b) | | PPV  (% & 95% CI)  (b/a) | Score§  (14) |
| **Studies validating codes for stroke** | | | | | | | | | | | | | | | | |  |
| Mayo  1993 | | Canada | | - | 430-434, 436, 437 | | | 9 | H | | 96 | P | Medical Record | 72 | 76 (67 to 83) | | 8 |
| Liu  1999 | | Canada | | - | 430-438 | | | 9 | H | | 862 | P/S | Medical Record¶ | 487 | 56 (53 to 60) | | 8 |
| 430-438 | | |  | | 621 | P | 417 | 67 (63 to 71) | |  |
| 430-438 | | |  | | 327 | P/S | 151 | 46 (41 to 52) | |  |
| 430-438 | | |  | | 213 | P | 129 | 61 (54 to 67) | |  |
| Leibson  1994 | | US | | - | 430-438 | | | 9 | H | | 377 | P | Population Register | 225 | 60(55 to 65) | | 11 |
| 430-438 | | |  | | 462 | P/S | 249 | 54(49 to 58) | |  |
| 430-438 | | |  | | - | P | Hospital Register | 239 | - | |  |
| 430-438 | | |  | | - | P/S | 290 | - | |  |
| Rosamond  1999 | | US | | 45-64 | 430-438 | | | 9-CM | H | | 1058 | - | Medical Record\*\* | 326 | 31 (28 to 34) | | 12 |
| 430-434 | | |  | | 526 |  |  | 234 | 44 (40 to 49) | |  |
| Reker  2001 | | US | | - | 430-438 | | | 9-CM | H | | 671 | - | Medical Record\*\* | 279 | 42 (38 to 45) | | 6 |
| 430, 431, 433, 434, 436 | | |  | | 334 | - |  | 198 | 59 (54 to 64) | |  |
| 430, 431, 432, 434, 436 OR  430-438†† | | |  | | 491 | P/S | Inpatient register | 254 | 52 (47 to 56) | |  |
| 431.x, 433.x1, 434.x1 | | |  | | 200 | P/S |  | 150 | 75 (69 to 80) | |  |
| Klatsky  2005 | | US | | - | 430-438 | | | 9 | H | | 3239 | P | Medical Record\*\* | 2494 | 77 (76 to 78) | | 10 |
| Leone  2004 | | Italy | | - | 430-438 | | | 9 | H | | 1017 | P/S | Inpatient Register | 609 | 60 (57 to 63) | | 11 |
| 430-438 | | |  |  | | 833 | P | 550 | 66 (63 to 69) | |  |
| 430, 431, 434, 436 | | |  |  | | 411 | P/S | 371 | 90 (87 to 93) | |  |
| 430, 431, 434, 436 | | |  |  | | 375 | P | 353 | 94 (91 to 96) | |  |
| Sporalore  2005 | | Italy | | - | 430-434, 436-438 | | | 9 | H | | 3619 | P/S | Medical Record | 1296 | 36 (34 to 37) | | 9 |
| 430-434, 436-438 | | |  | | 2174 | P | 1021 | 47‡‡ (45 to 49) | |  |
| Palmieri  2007 | | Italy | |  | 342, 430-438 | | | 9 | H+D | | 2793 | P/S | Population register | 1173 | 42 (40 to 44) | | 8 |
| Stegmayr  1992 | | Sweden | | 25-74 | 430-438 | | | 9 | D | | 899 | P/S | Population Register | 812 | 90(88 to 92) | | 12 |
| 430-438 | | | H | | 5101 | P/S |  | 3492 | 69(67 to 70) | |  |
| Ellekjaer  1999 | | Norway | | ≥ 15 | 430-438 | | | 9 | H | | 759 | P/S | Population Register | 369 | 49 (45 to 52) | | 9 |
| 430,431,434, 436 | | |  | | 508 | P/S | 347 | 68 (64 to 72) | |  |
| Panayiotou  1993 | | UK | | 25-100 | 430-438 | | | 9 | H | | 117 | P | Inpatient Register | 94 | 80 (72 to 87) | | 8 |
| Hasan  1996 | | UK | | 60-94 | 430-438 | | | 9 | H | | 166 | P | Medical Record | 113 | 68 (61 to 75) | | 9 |
| Harriss  2010 | | Australia | | 40-69 | 430-438, I60-I69 | | | 9 +10 | D | | 119 | P | Medical Record | 72 | 61 (52 to 69) | | 12 |
| 430-431, 433-434, I60, I61, I63, I690, I691, I693 | | |  | | 61 | P | 54 | 89 (78 to 94) | |  |
| 430-438, I60-I69 | | |  | | - | P/S | - | - | |  |
| Johnsen  2002 | | Denmark | | 50-64 | I60-I69 and G45 | | | 10 | H | | 565 | P/S | Medical Record | 325 | 58 | | 10 |
| I60, I61, I63, I64 | | |  | | 378 | P/S | 299 | 79 (75 to 83) | |  |
| Krarup  2007 | | Denmark | | - | I60-I69, G45 | | | 10 | H | | 236 | - | Medical Record | 153‡‡ | 65‡‡ (59 to 71) | | 9 |
| I60, I61, I63, I64 | | |  | | 164 | - | 136‡‡ | 83‡‡ (76 to 88) | |  |
| Sinha  2008 | | UK | | 40-79 | I60-I69 | | | 10 | H + D | | 250 | P/S | Medical Record | 191 | 76 (71 to 81) | | 11 |
| Roumie  2008 | | US | | 50-84 | 430, 431, 433.x1, 434.x1, 436§§ | | | 9-CM | H | | 231 | P/S | Medical Record\*\* | 205 | 89 (84 to 92) | | 9 |
| 430, 431, 433.x1, 434.x1, 436 | | | 9-CM |  | | 203 | P | Medical Record\*\* | 196 | 97 (93 to 98) | |  |
| *\*Derby*  *2000* | | *US* | | *35-74* | *431, 432, 434, 435, 436, 437* | | | *9* | *H* | | *3811* | *P/S* | *Medical Record*\*\*\* | *2269* | *60 (58 to 61)* | | *11* |
| *\*Derby*  *2001* | | *US* | | *35-74* | *431, 432, 434, 436, 437* | | | *9* | *H* | | *2124* | *P* | *Medical Record*\*\*\* | *1699* | *80 (78 to 82)* | | *11* |
| *\*Lakshminarayan*  *2009* | | *US* | | *30-74* | *431, 432, 434, 436, 437* | | | *9* | *H* | | *6032* | *P/S* | *Medical Record* | *3773* | *63(61 to 64)* | | *9* |
| *431, 432, 434, 436, 437* | | |  | | *4445* | *P* |  |  | *85(84 to 86)* | |  |
| *\*Davenport*  *1996* | | *UK* | | *≥ 18* | *431, 433-438* | | | *9* | *H* | | *557* | *P* | *Inpatient Register* | *529* | *95 (93 to 96)* | | *11* |
| *\*Barer*  *1996* | | *UK* | | *-* | *431, 433, 434, 436* | | | *9* | *H* | | *340* | *-* | *Hospital Register* | *278* | *82 (77 to 86)* | | *8* |
| *\*Mant*  *1998* | | *UK* | | *-* | *431, 432.9, 434, 436, 437.0, 437.1, 437.9* | | | *9* | *H* | | *318* | *P/S* | *Inpatient Register* | *230* | *72 (67 to 77)* | | *11* |
| *\*Ives*  *1995* | | *US* | | *≥ 65* | *430, 431, 432.9, 434, 436* | | | *9-CM* | *H* | | *79* | *-* | *Medical Record* | *71* | *90 (81 to 95)* | | *8* |
| *\*Appelros*  *2011* | | *Sweden* | | *-* | *I61, I63, I64* | | | *10* | *D* | | *98* | *-* | *Population Register* | *78* | *80 (71 to 86)* | | *11* |
| *I61, I63, I64* | | | *H* | | *328* | *-* | *318* | *97 (94 to 98)* | |  |
| *I61, I63, I64* | | | *H + D* | | *363* | *-* | *333* | *92 (88 to 94)* | |  |
| *\*Koster*  *2013* | | *Sweden* | | *≥ 20* | *I61, I63, I64* | | | *10* | *D* | | *102* | *P/S* | *Population Register* | *40* | *39 (30 to 49)* | | *12* |
| *H* | | *1426* | *P/S* |  | *1224* | *86 (84 to 88)* | |  |
| *H + D* | | *1526* | *P/S* |  | *1264* | *83 (81 to 85)* | |  |
| *\*Aboa-Eboule*  *2013* | | *France* | | *-* | *I61, I63, I64, G46* | | | *10* | *H* | | *903* | *P* | *Hospital Register* | *625* | *69 (66 to 72)* | | *11* |
| **Studies validating codes for ischemic stroke** | | | | | | | | | | | | | | | | |  |
| Benesch  1997 | US | | - | | 433, 434, 436 | | 9-CM | | H | | 550 | P/S | Medical Record | 234 | 43 (38 to 47) | | 4 |
| 433, 434, 436 | |  | | 379 | P | 199 | 53 (47 to 57) | |  |
| 434, 436 | |  | | 250 | P/S | 216 | 86 (82 to 90) | |  |
| 434, 436 | |  | | 203 | P | 183 | 90 (85 to 94) | |  |
| 433, 434 | |  | | 521 | P/S | 210 | 40 (36 to 45) | |  |
| 433, 434 | |  | | 361 | P | 183 | 51 (46 to 56) | |  |
| 433 | |  | | 295 | P/S | 18 | 6 (4 to 9) | |  |
| 433 | |  | | 176 | P | 16 | 9 (6 to 14) | |  |
| 434 | |  | | 226 | P/S | 192 | 85 (80 to 89) | |  |
| 434 | |  | | 185 | P | 167 | 91 (85 to 94) | |  |
| Goldstein  1998 | US | | - | | 434 | | 9-CM | | H | | 108 | P | Discharge summary\*\*\* | 88 | 82 (73 to 88) | | 7 |
| 434.x1 | |  | | 106 | P | 86 | 82 (73 to 87) | |  |
| 433, 434, 436 | |  | | 175 | P | 106 | 61 (53 to 68) | |  |
| 434, 436 | | 127 | P | 104 | 82 (74 to 88) | |  |
| Rosamond  1999 | US | | 45-64 | | 433, 434, 436 | | 9-CM | | H | | 560 | - | Medical Record | 252 | 45 (41 to 49) | | 12 |
| 434, 436 | |  | | 294 | 216 | 73 (68 to 78) | |  |
| 433 | |  | | 266 | 36 | 14 (10 to 18) | |  |
| 434 | |  | | 186 | 143 | 77 (70 to 82) | |  |
| 436 | |  | | 108 | 73 | 70 (58 to 76) | |  |
| Rinaldi  2003 | Italy | | - | | 434, 436 |  | 9 | | H | | 180 | P/S | Inpatient register | 128 | 71 (64 to 77) | | 9 |
| 434, 436 |  | | 157 | P | 119 | 76 (69 to 82) | |  |
| 436 |  | | 177 | P/S | 125 | 71 (64 to 77) | |  |
| 436 |  | | 154 | P | 116 | 75 (68 to 81) | |  |
| Leone  2004 | Italy | | - | | 433 |  | 9 | | H | | 134 | P/S | Inpatient register | 8 | 6 (3 to 11) | | 11 |
| 433 |  | |  | | 89 | P | 7 | 8 (4 to 15) | |  |
| 434 |  | |  | | 202 | P/S | 176 | 87 (82 to 91) | |  |
| 434 |  | |  | | 188 | P | 169 | 90 (85 to 93) | |  |
| 436 |  | |  | | 57 | P/S | 40 | 70 (57 to 80) | |  |
| 434, 436 |  | |  | | 259 | P/S | 216 | 83 (78 to 87) | |  |
| 434, 436 |  | |  | | 236 | P | 205 | 87 (82 to 91) | |  |
| 433, 434, 436 |  | |  | | 393 | P/S | 224 | 57 (52 to 62) | |  |
| 433, 434, 436 |  | |  | | 325 | P | 212 | 65 (60 to 70) | |  |
| Ellekjaer  1999 | Norway | | ≥ 15 | | 436 | | 9 | | H | | 313 | P/S | Stroke register | 206 | 66 (61 to 71) | | 9 |
| 434, 436 | | 402 | 261 | 65 (60 to 69) | |  |
| 436 | | 89 | 55 | 62 (51 to 71) | |  |
| Roumie  2008 | US | | 50-84 | | 433.x1, 434.x1, 436 | | 9-CM | | H | | 150 | P | Medical Record | 127 | 85 (78 to 90) | | 9 |
| Johnsen  2002 | Denmark | | 50-64 | | I63 | | 10 | | H | | 113 | P/S | Medical record | 99 | 88 (80 to 92) | | 10 |
| I63, I64 | | 313 | 238 | 76 (71 to 80) | |  |
|  | | I64 | | 200 | 139 | 70 (63 to 75) | |  |
| Krarup  2007 | Denmark | | - | | I63, I64 | | 10 | | H | | 138 | - | Medical record | 96g | 70 (61 to 77) | | 9 |
| I64 | |  | | 105 | - | 64g | 61 (51 to 70) | |  |
| Wright  2012 | UK | | - | | I63 | | 10 | | H | | 190 | P/S | GP record¶ | 164 | 86 (81 to 90) | | 10 |
| I63, I64 | | 309 | 242 | 78 (73 to 83) | |  |
| I64 | | 119 | 78 | 66 (57 to 73) | |  |
| Tirschwell  2002 | US | | ≥ 20 | | 433.X1, 434.X1, 436§§ | | 9-CM | | H+D | | i) 50¶¶ | P/S | Medical Record | 45 | 90(79 to 96) | | 9 |
| 433.X1, 434.X1, 436§§ | |  | | Ii) 50¶¶ | P/S | 46 | 91 (81 to 98) | |  |
| 433.X1, 434.X1, 436 | |  | | iii) 50¶¶ | P | 44 | 88 (76 to 94) | |  |
| Wahl  2010 | US | | - | | 433.x1, 434.x1, 436, 437.1, 437.9 | | 9-CM | | H | | 200 | - | Medical record | 175 | 87 (82 to 91) | | 9 |
| Haesbert  2013 | France | | >18 | | I63 | | 10 | | H | | 329 | P | Hospital register and medical record | 313 | 95 (92 to 97) | | 11 |
| *\*Tonolen*  *2007* | *Finland* | | *25-74* | | *433, 434, I63* | | *9 +10* | | *H+D* | | *2711* | *P/S* | *Hospital register* | *2223* | *82 (81 to 83)* | | *5* |
| *433, 434, 436, I63, I64* | |  | |  | | *2900* | *2407* | *83 (82 to 84)* | |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Studies validating codes for haemorrhagic stroke (SAH or ICH)** | | | | | | | | | | | |  |
| Rosamund33  1999 | US | 45-64 | 430, 431 | | 9-CM | H | 63 | P/S | Medical Record | 46 | 73 (61 to 82) | 12 |
| Leone  2004 | Italy | - | 430, 431 | | 9 | H | 152 | P/S | Inpatient Register | 131 | 86 (80 to 91) | 11 |
| Ellekjaer  1999 | Norway | ≥ 15 | 430, 431 | | 9 | H | 69 | P/S | Stroke Register | 51 | 74 (62 to 83) | 9 |
| Tonolen  2007 | Finland | 25-74 | 430, 431, I60, I61 | | 9+10 | H+D | 729 | P/S | Hospital Register | 646 | 89 (86 to 91) | 5 |
| Johnsen  2002 | Denmark | 50-64 | I60, I61 | | 10 | H | 65 | P/S | Medical Record | 42 | 65 (52 to 75) | 10 |
| **Studies validating codes for subarachnoid Haemorrhage (SAH)** | | | | | | | | | | | |  |
| Tirschwell  2002 | US | ≥ 20 | 430§§ | 9-CM | | H+D | i) 51¶¶ | P/S | Medical Record | 43 | 86 (72 to 92) | 9 |
| 430§§ | ii) 51¶¶ | P/S | 46 | 89 (79 to 97) |  |
| 430 | iii)51¶¶ | P | 48 | 94 (84 to 98) |  |
| Tonolen  2007 | Finland | 25-74 | 430, I60 | 9 + 10 | | H+D | 253 | P/S | Stroke Register | 220 | 87 (82 to 91) | 5 |
| Kirkmann  2009 | UK | - | I60 | 10 | | H | 1169 | P | Discharge summary | 1123 | 96(95 to 97) | 8 |
| Wright  2012 | UK | - | I60 | 10 | | H | 78 | P/S | GP record¶ | 75 | 96 (89 to 99) | 10 |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Studies validating codes for intracerebral haemorrhage (ICH)** | | | | | | | | | | |  |
| Leone49  2004 | Italy | - | 431 | 9 | H | 110 | P/S | Inpatient register | 82 | 75 (66 to 82) | 11 |
|  | 102 | P | 78 | 76 (67 to 84) |  |
| Ellekjaer  1999 | Norway | ≥ 15 | 431 | 9 | H | 56 | P/S | Stroke Register | 40 | 71 (59 to 82) | 9 |
| Tonolen  2007 | Finland | 25-74 | 431, I61 | 9 + 10 | H + D | 476 | P/S | Stroke Register | 413 | 87 (83 to 90) | 5 |
| Kirkmann  2009 | UK | - | I61 | 10 | H | 978 | P | Discharge summary | 938 | 96 (94 to 97) | 8 |

PPV: Positive Predictive Value; H: Hospital data; D: Death certificates; H+D: both; P: Primary position code; P/S: Primary or Secondary position code.

\**Italics* indicate studies using miscellaneous groups of codes or excluding SAH, not included in Fig. 3.

†Number of ICD coded events compared against the reference standard.

‡Population register: population based stroke register, Hospital register: inpatient and outpatient stroke register, Inpatient register: inpatient stroke register. Medical Record: definite or probable stroke diagnoses confirmed by review of medical records (excludes ‘possible’ stroke). Medical records were reviewed by stroke physicians or neurologists, unless otherwise specified.

§Quality score (total 14). See S1\_Appendix for questions and scoring methods.

¶Medical record reviewed by ‘cardiovascular researchers’.

\*\*Medical record reviewed by ‘trained data abstractors’.

††431, 432, 434, 436 primary position, or rehabilitation code primary position AND 430-438 secondary position, OR 433, 434 primary position AND 430-438 secondary position.

‡‡Mean value calculated from published data.

§§If > 1 code per discharge they were chosen in the following hierarchy: SAH>ICH>IS>TIA

¶¶One code for each discharge chosen from: i) First 9 discharge diagnoses ii) First 2 discharge diagnoses iii) Primary discharge code chosen

\*\*\*Abstracts of the medical record reviewed by ‘study physician’.