**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**  |  |
| Mayo1993 | Canada | - | 430-434, 436, 437 | 9 | H | 96 | P | Medical Record | 72 | 76 (67 to 83) | 8 |
| Liu1999 | 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) |  |
| Leibson1994 | 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 | - |  |
| Rosamond1999 | 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) |  |
| Reker2001 | 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 OR430-438†† |  | 491 | P/S | Inpatient register | 254 | 52 (47 to 56) |  |
| 431.x, 433.x1, 434.x1 |  | 200 | P/S |  | 150 | 75 (69 to 80) |  |
| Klatsky2005 | US | - | 430-438 | 9 | H | 3239 | P | Medical Record\*\* | 2494 | 77 (76 to 78)  | 10 |
| Leone2004 | 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)  |  |
| Sporalore2005 | 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) |  |
| Palmieri2007 | Italy |  | 342, 430-438 | 9 | H+D | 2793 | P/S | Population register | 1173 | 42 (40 to 44) | 8 |
| Stegmayr1992 | 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) |  |
| Ellekjaer1999 | 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 |
| Hasan1996 | 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) |  |
| Sinha2008 | UK | 40-79 | I60-I69 | 10 | H + D | 250 | P/S | Medical Record | 191 | 76 (71 to 81) | 11 |
| Roumie2008 | 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** |  |
| Benesch1997 | 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) |  |
| Goldstein1998 | 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) |  |
| Rosamond1999 | 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) |  |
| Rinaldi2003 | 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) |  |
| Leone2004 | 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) |  |
| Roumie2008 | 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) |  |
| Wright2012 | 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) |  |
| Tirschwell2002  | 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) |  |
| Wahl2010 | US | - | 433.x1, 434.x1, 436, 437.1, 437.9 | 9-CM | H | 200 | - | Medical record | 175 | 87 (82 to 91) | 9 |
| Haesbert2013 | 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 |
| Leone2004 | Italy | - | 430, 431 | 9 | H | 152  | P/S | Inpatient Register | 131 | 86 (80 to 91) | 11 |
| Ellekjaer1999 | Norway | ≥ 15 | 430, 431 | 9 | H | 69 | P/S | Stroke Register | 51 | 74 (62 to 83) | 9 |
| Tonolen2007 | Finland | 25-74 | 430, 431, I60, I61 | 9+10 | H+D | 729  | P/S | Hospital Register | 646 | 89 (86 to 91) | 5 |
| Johnsen2002  | 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) |  |
| Tonolen2007 | Finland | 25-74 | 430, I60  | 9 + 10 | H+D | 253  | P/S | Stroke Register | 220 | 87 (82 to 91) | 5 |
| Kirkmann2009 | UK | - | I60 | 10 | H | 1169 | P | Discharge summary | 1123 | 96(95 to 97) | 8 |
| Wright2012 | 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) |  |
| Ellekjaer1999 | Norway | ≥ 15 | 431 | 9 | H | 56 | P/S | Stroke Register | 40 | 71 (59 to 82) | 9 |
| Tonolen2007 | Finland | 25-74 | 431, I61 |  9 + 10 | H + D | 476  | P/S | Stroke Register | 413 | 87 (83 to 90) | 5 |
| Kirkmann2009 | 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’.