The implementation of ICD-10 for cause of death coding – some preliminary results from the bridge coding study

**Introduction**

From January 2001 information on cause of death in England and Wales has been coded to the Tenth Revision of the International Classification of Diseases (ICD-10). The Tenth Revision has been introduced on the recommendation of the World Health Organization (WHO) and replaces the Ninth Revision (ICD-9) which has been in use since 1979. Provisional quarterly registration figures for selected causes of deaths have already been published in ICD-10. Annual death registrations coded to ICD-10 will be first published in May 2002.

A previous article described the major changes between the two revisions and the changes to be expected in mortality statistics. That article also introduced a bridge coding study which is being carried out to measure the effect of the change of classification on mortality statistics by cause. This article describes the study, reports results for some major causes of death, and provides the timetable for reporting more detailed results.

**What is different in ICD-10?**

ICD-10 represents the largest change in the ICD in over 50 years. The first character is now a letter rather than a number. This has enabled an expansion of the number of codes to provide for recently recognised conditions and to provide more detail about common diseases. Some diseases and groups of conditions have moved between Chapters to reflect current ideas about aetiology and pathology. Some Chapters have been split, some others reordered or renamed. All these changes will affect the numbers and proportion of deaths attributed to particular causes in ICD-10. However, the change that will affect mortality statistics most is in the rules which are used to select underlying cause of death from the diseases and injuries listed on the death certificate.

---

This article follows on from that published in Health Statistics Quarterly 08, which explained the potential impact on mortality statistics in England and Wales as a result of the move to coding cause of death to the Tenth Revision of the International Classification of Diseases (ICD-10) from 2001. It describes the main differences in mortality coding in ICD-10 compared with ICD-9 and preliminary results from our bridge coding study. The rationale behind the study was described in the previous article. The article presents results for selected causes of death. These show a variety of effects on underlying cause assignment by age and sex. In addition, the article demonstrates the use of comparability ratios to adjust recent ICD-9-coded mortality data for comparison with current ICD-10-coded numbers and rates.
Routine death statistics are usually based on a single cause for each death. This is the underlying cause of death, defined by WHO as:

a) the disease which initiated the train of events directly leading to death; or
b) the circumstances of the accident or violence which produced the fatal injury.

The death certificate used in England and Wales, how it should be completed and how the underlying cause of death is usually assigned have been described in detail in earlier articles. This article focuses on the aspects that have changed in ICD-10.

### Changes in classification

These include changes to the number and structure of Chapters, movement of the codes for a condition or group of conditions from one place in the classification to another, new codes for conditions not previously identifiable, changes in the code assigned to a given term in the index, and changes in inclusion and exclusion notes in the tabular list. Some categories have been expanded for more detailed classification of conditions of increasing importance. Conversely, some have been collapsed where distinctions are no longer relevant.

The order of Chapters III and IV has been reversed, so that ‘Diseases of the blood forming organs’ is now Chapter III. However, it has gained ‘certain disorders of the immune mechanism’ from Chapter IV which is now just ‘Endocrine, nutritional and metabolic diseases’. AIDS and HIV infection had already been moved to Chapter I (042-044) in ICD-9 in 1993 in England and Wales. This section is expanded to B20-B24. Chapter VI has been split into three, expanding the range of codes for neurological diseases, and giving disorders of the eye and ear their own Chapters.

New codes include those for mesothelioma and Kaposi’s sarcoma, and a range of chromosomal disorders. There are no equivalent codes in ICD-9. Deaths coded to these causes in ICD-10 would have been coded to a variety of non-specific codes in ICD-9. For example, mesothelioma deaths were coded to malignant neoplasm of the site (pleura, peritoneum or lung) if it was stated or to unspecified site, if not. Deaths due to Kaposi’s sarcoma were always coded to 173, ‘other malignant neoplasm of skin’, whatever the site.

Table 1 shows some examples of conditions which have been moved from one Chapter to another. In each of these three cases, the number of categories has been expanded to provide more detail as well.

The number of deaths assigned to a disease such as sarcoidosis is not affected by this change, but the total coded to the two Chapters is. Equivalence is straightforward at the 3-character code (in this case, disease) level but not the Chapter level. Greater detail is provided in ICD-10, with breakdown by the main body site affected at the 4th character level. This is one of many examples where mapping forward to ICD-10 at a detailed level from ICD-9 coded data is not possible. The extra information required in the new Revision is not available from the codes in the earlier Revision. How the deaths will be subdivided in the new Revision can only be quantified by coding from the text statements.

The code assigned to some diagnostic terms has been altered through new or different index entries, or through exclusion and inclusion notes in the tabular list. The term ‘autoimmune disease’ was indexed in ICD-9 to 279.4 in Chapter III, whereas the terms ‘connective tissue disease’ and ‘collagen disease’ went to 710.9 in Chapter XIII. These terms are used almost synonymously. In ICD-10, all are indexed to M35.9 in Chapter XIII (Diseases of the musculo-skeletal system and connective tissue).

It is not always possible to isolate the different kinds of change. Indeed, the same purpose may be achieved through more than one change. In ICD-9, if dementia (unspecified, or specified as senile/presenile) and Alzheimer’s disease were both mentioned on the certificate, whether in a due to sequence or not, the code for the dementia was given precedence through rule 7, linkage. This was also reflected in the index assignments under ‘dementia’ in ICD-9. The ICD-10 index directs the coder to G30 - Alzheimer’s disease, and there are no linkages specified in Volume II.

### Changes in the underlying cause selection and modification rules

A table summarising the changes to all of the mortality rules is given in the report of the US comparability study. The rule that is likely to change cause of death statistics most is rule 3, which is shown in Box 1, with the instructions for its application (as updated, see below). In the past, interpretation of which conditions could be assumed to be due to which other diseases or conditions was left up to users of the ICD. In effect, this meant that vital statistics offices drew up their own lists of codes and combinations to which rule 3 applied. The new notes on rule 3 in Volume II of ICD-10 were also initially interpreted differently by different national vital statistics offices, with widely differing effects on mortality rates. The Mortality Reference Group reached consensus on how rule 3 should be applied, and this was endorsed through the official mechanism for updating ICD-10. For the first time, there is an agreed list of combinations of conditions, identified by their ICD-10 codes, to which rule 3 applies. This is the interpretation used in the automated coding software produced by the National Centre for Health Statistics (NCHS) and used in England and Wales, in Scotland and an increasing number of other countries.

The use of rule 3 to reassign deaths which would have been assigned to one of the less specific types of pneumonia (J18.0 bronchopneumonia, etc.) is now just...
Box one

ICD-10 Rule 3

‘If the condition selected by the General Principle or by Rule 1 or Rule 2 is obviously a direct consequence of another reported condition, whether in Part I or Part II, select this primary condition.’

Assumed direct consequences of another condition

Kaposi’s sarcoma, Burkitt’s tumour and any other malignant neoplasm of lymphoid, haematopoietic and related tissue, classifiable to C46.- or C81-C96, should be considered to be a direct consequence of HIV Disease, where this is reported. No such assumption should be made for other types of malignant neoplasm.

Any infectious disease classifiable to A00-B19, B2S-B49, B58-B64, B99 or J12-J18 should be considered to be a direct consequence of reported HIV disease.

Certain postoperative complications (pneumonia (any type), haemorrhage, thrombophlebitis, embolism, thrombosis, septicemia, cardiac arrest, renal failure (acute), aspiration, atelectasis, and infarction) can be considered direct consequences of an operation, unless surgery was carried out four weeks or more before death.

“Any pneumonia in J12-J18 should be considered an obvious consequence of conditions that impair the immune system. Pneumonia in J18.0 and J18.2-J18.9 should be considered an obvious consequence of wasting diseases (such as malignant neoplasm and malnutrition) and diseases causing paralysis (such as cerebral haemorrhage or thrombosis), as well as serious respiratory conditions, communicable diseases, and serious injuries. Pneumonia in J18.0 and J18.2-J18.9, J69.0, and J69.8 should also be considered an obvious consequence of conditions that affect the process of swallowing. Note: A list of conditions is available from the World Health Organization.”*

Any disease described or qualified as ‘embolic’ may be assumed to be a direct consequence of venous thrombosis, phlebitis or thrombophlebitis, valvular heart disease, atrial fibrillation, childbirth or any operation.

Any disease described as secondary should be assumed to be a direct consequence of the most probable primary cause entered on the certificate.

Secondary or unspecified anemia, malnutrition, marasmus, or cachexia may be assumed to be a consequence of any malignant neoplasm.

Any pyelonephritis may be assumed to be a consequence of urinary obstruction from conditions such as hyperplasia of the prostate or ureteral stenosis.

Nephritic syndrome may be assumed to be a consequence of any streptococcal infection (scarlet fever, streptococcal sore throat etc).

Dehydration may be assumed to be a consequence of any intestinal infectious disease.

Any operation on a given organ should be considered a direct consequence of any surgical condition (such as malignant tumour or injury) of the same organ reported anywhere on the certificate.


* This paragraph replaces the corresponding third paragraph of these notes as originally published.

J18.2 hypostatic pneumonia unspecified, J18.8–9 other and unspecified pneumonia, organism unspecified) was expected to have a large impact on mortality statistics in England and Wales. About 20 per cent (112,615) of all deaths registered in 1999 in England and Wales had bronchopneumonia or unspecified pneumonia mentioned on the death certificate. Since the introduction of automatic cause coding in 1993, a large proportion of these were selected as the underlying cause of death, as shown for 1999 in Table 2. This proportion is high in deaths at ages 0 to 4, decreases in the 5 to 9 age group and then increases with age to a high of about 60 per cent. Overall about half of all bronchopneumonia and unspecified pneumonia mentions were selected as the underlying cause of death in 1999 using ICD-9. More explanation of this can be found in Health Statistics Quarterly 08 and in ICD-10 Volume II.

Bridge coding study

In order to understand the impact of the introduction of ICD-10 on mortality statistics we have carried out a bridge coding study in which we have compared the cause of death allocated in ICD-10 with the cause allocated in ICD-9. This allows us to quantify the discontinuities arising from the change in classification.

<table>
<thead>
<tr>
<th>Age</th>
<th>480-484</th>
<th>485-486</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>48.4</td>
<td>41.8</td>
</tr>
<tr>
<td>5-9</td>
<td>37.5</td>
<td>23.1</td>
</tr>
<tr>
<td>10-14</td>
<td>58.3</td>
<td>20.4</td>
</tr>
<tr>
<td>15-19</td>
<td>40.0</td>
<td>24.0</td>
</tr>
<tr>
<td>20-24</td>
<td>57.1</td>
<td>23.0</td>
</tr>
<tr>
<td>25-29</td>
<td>63.2</td>
<td>36.4</td>
</tr>
<tr>
<td>30-34</td>
<td>80.0</td>
<td>33.8</td>
</tr>
<tr>
<td>35-39</td>
<td>68.1</td>
<td>38.9</td>
</tr>
<tr>
<td>40-44</td>
<td>55.3</td>
<td>35.3</td>
</tr>
<tr>
<td>45-49</td>
<td>72.3</td>
<td>33.8</td>
</tr>
<tr>
<td>50-54</td>
<td>60.0</td>
<td>29.7</td>
</tr>
<tr>
<td>55-59</td>
<td>68.2</td>
<td>31.3</td>
</tr>
<tr>
<td>60-64</td>
<td>59.8</td>
<td>33.4</td>
</tr>
<tr>
<td>65-69</td>
<td>53.5</td>
<td>32.5</td>
</tr>
<tr>
<td>70-74</td>
<td>48.6</td>
<td>36.3</td>
</tr>
<tr>
<td>75-79</td>
<td>58.2</td>
<td>41.5</td>
</tr>
<tr>
<td>80-84</td>
<td>60.1</td>
<td>50.0</td>
</tr>
<tr>
<td>85-89</td>
<td>64.0</td>
<td>55.9</td>
</tr>
<tr>
<td>90 and over</td>
<td>68.3</td>
<td>66.5</td>
</tr>
<tr>
<td>All ages</td>
<td>60.2</td>
<td>50.1</td>
</tr>
</tbody>
</table>

Table 2 Proportion of pneumonia mentions that were selected as underlying cause of death, 1999. Pneumonias affected by rule 3 (485,486); Pneumonias not affected by rule 3 (480-484).
Many other countries, including Australia,15 Mexico,16 Scotland,17 Sweden,18 and the United States,19 have carried out similar studies following the introduction of ICD-10. The results of those studies are largely similar to ours, though some differences are apparent. These will be due in part to real differences in the distribution of causes of deaths between countries. However, they will also reflect differences in the way certificates are completed, the numbers and types of conditions mentioned, and the exact terminology used. In addition, most of these other countries either already had or added a fourth line in part I for the sequence of conditions leading to death, as recommended by WHO in ICD-10. This has not been done in England and Wales. Previous studies in the USA19 and France20 have shown that the addition of lines in part I will be due in part to real differences in the distribution of causes of debilitating diseases, through the ability to record longer sequences directly leading to death.

Data

All deaths registered in 1999 were included so that we could assess the impact of ICD-10 on all causes that contribute significant numbers of deaths in one year. We chose to use a data set based on date of registration because, unlike that based on date of occurrence, no further deaths could later be added to it. In addition, the earliest annual mortality statistics, published in May of the following year, are based on registrations. There is no reason to imagine that the effect of the change in Revisions would be any different for an occurrence-based annual data set around the same time. 1999 was chosen because it was the most recent complete, checked data set available. This allowed us to start coding as soon as coders had been trained in ICD-10 in late 2000, and to complete it in autumn 2001.

Coding

The deaths had already been coded to ICD-9 following ONS routine procedures and mortality statistics published.21 The majority of the records were coded automatically to both Revisions using the Automated Cause Coding System (ACCS). The ICD-9 version of ACCS used in England and Wales has been described in previous articles.7,22 Coding to ICD-10 was done independently, from the stored electronic cause of death text, using a new version of the NCHS software.13 Intervention by trained coders was needed for less than 20 per cent of deaths. This was largely to deal with rare medical terms not in the electronic dictionary, certificates with operations or drugs mentioned, spelling mistakes, and poorly completed certificates.

Two kinds of death are not coded by the US software: neonatal deaths and deaths certified after a coroner’s inquest. England and Wales adopted the WHO recommended perinatal certificate for stillbirths and neonatal deaths in 1986. This means that these deaths cannot be coded by the US software. The text for each of the conditions mentioned is coded to ICD-10 using a modified version of the NCHS software.13 Intervention by trained coders was needed for less than 20 per cent of deaths. This was largely to deal with rare medical terms not in the electronic dictionary, certificates with operations or drugs mentioned, spelling mistakes, and poorly completed certificates.

The largest shift in numbers of deaths is from ICD-9 Chapter VIII (Diseases of the respiratory system) reflecting the application of rule 3 in relation to pneumonia. In 1999, 97 per cent of all pneumonia deaths were in the codes affected by rule 3. Fifty-eight per cent of these deaths remained as pneumonia in ICD-10, compared to 96 per cent of pneumonias in codes unaffected by rule 3. Fifty-seven per cent of the rule-3-affected deaths that remained as pneumonia had no other cause mentioned. 8,200 respiratory disease deaths have been reclassified to Chapter IX (Diseases of the circulatory system), including stroke, heart failure, and chronic ischaemic heart disease. 4,500 deaths have been moved to any dementia in Chapter V (Mental and behavioural disorders). A further 3,700 deaths have been assigned to ICD-10 Chapter VI (Diseases of the nervous system). These include almost 1,500 deaths now classified as Alzheimer’s and just over 1,200 deaths now classified as Parkinson’s disease. In addition a further 3,300 deaths have been classified as neoplasms. Overall, neoplasms increased by 3 per cent, but malignant neoplasms by only 1 per cent.

Comparability Ratios

The examination of the Chapter shifts is useful to understand how the change in classification has affected some broad groups of conditions. To interpret time trends, we need to be able to quantify the overall change in deaths assigned to specific causes. Table 4 shows the percentage of deaths in five causes (pneumonia, ischaemic heart disease, cerebrovascular disease including stroke, malignant neoplasms, and diabetes) in ICD-9 which were assigned to the same group in ICD-10. For ischaemic heart disease and malignant neoplasms, over 99 per cent of deaths in ICD-9 were also coded to the same causes in ICD-10. The concordance is slightly lower for cerebrovascular disease and diabetes, at around 96 to 98 per cent. In contrast, only just over half of pneumonia deaths from ICD-9 were still coded to pneumonia in ICD-10.

This table does not take into account movements into these cause groups in ICD-10 compared to ICD-9. To measure the full extent to
### Table 3
Underlying cause of death by Chapter in ICD-10 and ICD-9

<table>
<thead>
<tr>
<th>ICD-9 Chapter</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>XII</th>
<th>XIII</th>
<th>X</th>
<th>XV</th>
<th>XVI</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Certain infectious and parasitic diseases</td>
<td>3,051</td>
<td>27</td>
<td>5</td>
<td>15</td>
<td>5</td>
<td>17</td>
<td>70</td>
<td>402</td>
<td>177</td>
<td>37</td>
<td>15</td>
<td>52</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>Neoplasms</td>
<td>67</td>
<td>135,443</td>
<td>1,002</td>
<td>108</td>
<td>26</td>
<td>9</td>
<td>153</td>
<td>3,295</td>
<td>95</td>
<td>-</td>
<td>8</td>
<td>33</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>III</td>
<td>Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism</td>
<td>113</td>
<td>13</td>
<td>786</td>
<td>64</td>
<td>7</td>
<td>-</td>
<td>15</td>
<td>49</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>IV</td>
<td>Endocrine, nutritional and metabolic diseases</td>
<td>10</td>
<td>14</td>
<td>6</td>
<td>7,074</td>
<td>48</td>
<td>52</td>
<td>258</td>
<td>286</td>
<td>22</td>
<td>2</td>
<td>16</td>
<td>1</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>V</td>
<td>Mental and behavioural disorders</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>18</td>
<td>8,449</td>
<td>19</td>
<td>135</td>
<td>4,675</td>
<td>34</td>
<td>-</td>
<td>1</td>
<td>9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VI-VIII</td>
<td>Diseases of the nervous system, the eye and adnexa, and of the ear and mastoid process</td>
<td>11</td>
<td>20</td>
<td>5</td>
<td>8</td>
<td>919</td>
<td>9,769</td>
<td>259</td>
<td>3,658</td>
<td>11</td>
<td>2</td>
<td>50</td>
<td>11</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>IX</td>
<td>Diseases of the circulatory system</td>
<td>47</td>
<td>73</td>
<td>22</td>
<td>92</td>
<td>1,338</td>
<td>91</td>
<td>215,886</td>
<td>8,217</td>
<td>165</td>
<td>47</td>
<td>43</td>
<td>95</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>X</td>
<td>Diseases of the respiratory system</td>
<td>61</td>
<td>70</td>
<td>10</td>
<td>45</td>
<td>111</td>
<td>103</td>
<td>349</td>
<td>73,775</td>
<td>70</td>
<td>15</td>
<td>22</td>
<td>41</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>XI</td>
<td>Diseases of the digestive system</td>
<td>100</td>
<td>57</td>
<td>2</td>
<td>25</td>
<td>109</td>
<td>7</td>
<td>171</td>
<td>528</td>
<td>20,881</td>
<td>3</td>
<td>5</td>
<td>30</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>XII</td>
<td>Diseases of the skin and subcutaneous tissue</td>
<td>22</td>
<td>2</td>
<td>-</td>
<td>8</td>
<td>4</td>
<td>7</td>
<td>37</td>
<td>21</td>
<td>6</td>
<td>1,011</td>
<td>15</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XIII</td>
<td>Diseases of the musculo-skeletal system and connective tissue</td>
<td>46</td>
<td>14</td>
<td>5</td>
<td>21</td>
<td>14</td>
<td>19</td>
<td>270</td>
<td>1,102</td>
<td>25</td>
<td>8</td>
<td>3,365</td>
<td>14</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XIV</td>
<td>Diseases of the genitourinary system</td>
<td>19</td>
<td>28</td>
<td>1</td>
<td>24</td>
<td>18</td>
<td>12</td>
<td>80</td>
<td>79</td>
<td>29</td>
<td>8</td>
<td>7</td>
<td>6,919</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XV</td>
<td>Pregnancy, childbirth and the puerperium</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XVI</td>
<td>Certain conditions originating in the perinatal period</td>
<td>21</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>5</td>
<td>4</td>
<td>13</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>84</td>
</tr>
<tr>
<td>XVII</td>
<td>Congenital malformations, deformations and chromosomal abnormalities</td>
<td>3</td>
<td>12</td>
<td>2</td>
<td>7</td>
<td>-</td>
<td>19</td>
<td>42</td>
<td>152</td>
<td>9</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>XVIII</td>
<td>Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>14</td>
<td>17</td>
<td>3</td>
<td>111</td>
<td>12</td>
<td>-</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XX</td>
<td>External causes of injury and poisoning</td>
<td>36</td>
<td>14</td>
<td>9</td>
<td>13</td>
<td>80</td>
<td>32</td>
<td>220</td>
<td>188</td>
<td>75</td>
<td>10</td>
<td>23</td>
<td>38</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>3,611</td>
<td>135,791</td>
<td>1,855</td>
<td>7,537</td>
<td>11,145</td>
<td>10,164</td>
<td>218,062</td>
<td>96,453</td>
<td>21,606</td>
<td>1,146</td>
<td>3,567</td>
<td>7,279</td>
<td>31</td>
<td>115</td>
<td>1,175</td>
</tr>
</tbody>
</table>
which deaths attributed to given cause groups are increased or decreased by the change in classification, we calculated comparability ratios. These are simply the ratio of the number of deaths coded to a cause in ICD-10 to the number coded to the equivalent cause in ICD-9. The first step in this process is to identify equivalent codes or code groups in the two Revisions which represent the same causes. In most cases this is not contentious, and the same groupings have been used by various authors and national statistics offices.10,15,17,18

The comparability ratio reflects the net effect of the change. Thus if the ratio is 1 the number of deaths coded to that cause is the same in both Revisions. If the comparability ratio is 0.5 it means that half as many deaths have been coded to that cause in ICD-10 as in ICD-9. A ratio of exactly 1 does not necessarily mean that assignment of deaths to that category is unchanged. It may mean that the same numbers of deaths have moved into and out of the category. We have calculated overall crude comparability ratios and ratios specific to each age-sex group and have compared the effect of applying these to mortality data from earlier years coded in ICD-9.

![Box two](image)

**Box two**

**Formula for the standard error of the comparability ratio**

\[
s.e.(\log \text{Ratio}) = \sqrt{\text{var}(\log \text{T}) + \text{var}(\log \text{B}) - 2\text{cov}(\log \text{T}, \log \text{B})}
\]

Where:

\[
\text{var}(\log \text{T}) = \frac{\text{var}(\text{T})}{\text{T}^2}
\]

\[
\text{var}(\log \text{B}) = \frac{\text{var}(\text{B})}{\text{B}^2}
\]

\[
\text{cov}(\log \text{T}, \log \text{B}) = \frac{\text{Cov}(\text{T}, \text{B})}{\text{T}\text{B}}
\]

\[
\text{Ratio} = \text{comparability ratio}
\]

\[
\text{T} = \text{number of deaths in ICD-10}
\]

\[
\text{B} = \text{number of deaths in ICD-9}
\]

\[
\text{var}(\text{T}) = n(p_1(1-p_1))
\]

\[
\text{var}(\text{B}) = n(p_2(1-p_2))
\]

\[
\text{cov}(\text{T}, \text{B}) = -n(p_2p_3)
\]

where:

\[
n = \text{total number of deaths coded to cause in ICD-9 or ICD-10}
\]

\[
p_1 = \text{proportion of deaths coded to cause in both ICD-10 and ICD-9}
\]

\[
p_2 = \text{proportion of deaths coded to cause in ICD-10 but not ICD-9}
\]

\[
p_3 = \text{proportion of deaths coded to cause in ICD-9 but not ICD-10}
\]

We calculated 95 per cent confidence intervals for the comparability ratios, to measure their precision and see if they were significantly different from unity. We based these on multinomial sampling theory. This method takes into account the fact that a proportion of the deaths coded to a particular cause in ICD-10 and ICD-9 are the same deaths, i.e. the numerator and denominator in the ratio are not independent. The formula for the standard error is given in Box 2.

We found that the causes we present here showed very different patterns, which are described below. For some causes the likelihood of the particular condition being selected as the underlying cause varied both by sex and by age; for other causes the same underlying cause was likely to be selected regardless of sex or age.

### 1. No change in mortality rates

For many important causes of death there is no appreciable change in the numbers or rates when deaths are coded to ICD-10 as opposed to ICD-9. Ischaemic heart disease (IHD) illustrates this clearly. Virtually the same number of deaths are assigned to this cause (Table 4). Only a very small number move into and out of this group. This reflects the fact that in both Revisions, if one or more codes are on the certificate, then IHD is nearly always the underlying cause.21 Doctors generally consider it to be directly lethal, and so certify it unambiguously as the underlying cause. The overall comparability ratios are 1.005 for males and 1.007 for females (Table 5). The comparability ratios in the USA and Scotland for IHD were also very close to unity. This means that mortality from IHD can be compared across the Revisions without any need for adjustment.

### 2. Mortality rates lower in ICD-10 than ICD-9

The most obvious cause group that is reduced in ICD-10 is the pneumonias, because of the change in rule 3. The ratio for the overall category J12-J18 is 0.583 (95 per cent confidence interval 0.577, 0.590) for males and 0.644 (0.639, 0.649) for females. The greatest effect is seen in bronchopneumonia, hypostatic, and unspecified pneumonia. The effect on pneumonias specified as lobar, pneumococcal, or due to pneumonia, because of the change in rule 3. The ratio for the overall category J12-J18 is 0.583 (95 per cent confidence interval 0.577, 0.590) for males and 0.644 (0.639, 0.649) for females. The greatest effect is seen in bronchopneumonia, hypostatic, and unspecified pneumonia. The effect on pneumonias specified as lobar, pneumococcal, or due to other bacteria or viruses is much smaller (Table 6).
The comparability ratio for pneumonia varies markedly with age. The numbers of deaths in age groups under 60 are small, and the confidence intervals for the ratios correspondingly wide (Figure 1). In older age groups, the ratios are lowest (i.e. the smallest proportion of ICD-9 pneumonia deaths are assigned to pneumonia in ICD-10) in people in their 70s. Above 80, an increasing proportion of deaths remain as pneumonia. However, even in deaths at ages over 90, about a quarter of deaths are re-assigned to conditions other than pneumonia.

Similar patterns may be expected for other terminal conditions included in the ICD-10 rule 3 instructions. These include thrombotic and embolic conditions (such as pulmonary embolism) which often complicate a wide range of diseases, injuries and operations.

3. Mortality rates higher in ICD-10 than in ICD-9

Many debilitating chronic diseases are selected more often as the underlying cause of death in ICD-10.
Below age 75 there are only very small changes

3.2 Malignant Neoplasms

In men the highest ratio is in 85-89 year olds, at 1.183 (1.167, 1.200), and in women 1.104 (1.096, 1.112). However, the number of deaths in each age group is small. The confidence intervals for the ratios are wide, overlapping and include unity.

Over age 60, the ratios appear to rise with age. The ratios are higher in men than women in each age group, and the rise with age is steeper in men. In men the highest ratio is in 85-89 year olds, at 1.183 (1.167, 1.200), and in women 1.104 (1.096, 1.112).

3.3 Diabetes

There are small numbers of deaths from diabetes compared with the other causes we have examined in this article. Consequently, for the majority of ages, the comparability ratios have wide confidence intervals that include 1. For men, the ratios are significantly raised in ages 65 to 89, at around 1.04 or 1.05. For women, the ratios are only statistically significant over the age of 85. Overall, there is about a 4 per cent increase in deaths coded to diabetes in ICD-10 compared to ICD-9 (Table 5). This is similar to changes seen in Scotland and the USA. It is a much smaller increase than was caused by the OPCS version of rule 3, in use in England and Wales from 1984 to 1992. That change increased mortality attributed to diabetes by 20–25 per cent compared to the preceding and succeeding years.

**Effect of using comparability ratios to adjust rates**

Figures 4-6 show age-specific mortality rates in ICD-9 and ICD-10 for IHD, cerebrovascular disease, and pneumonia. The rates for IHD show what we would expect from examining the comparability ratios: there is very little change in the rates between ICD-9 and ICD-10 and therefore data can be used unadjusted. The rates for cerebrovascular disease vary between ICD-9 and ICD-10 by age. At younger ages there is very little difference, but at older ages, rates are markedly higher under ICD-10. This means that adjustment of ICD-9 data is required in order to be able to interpret trends over time. The same is true for pneumonia, except that rates are lower in ICD-10 than ICD-9. These figures are for males, but the picture for females is very similar.

Figures 7 and 8 show the effect on age-specific rates of applying comparability ratios to cerebrovascular disease and pneumonia data. This is done by multiplying the number of deaths in ICD-9 by the comparability ratio to estimate the number of deaths that would have been coded to that cause under ICD-10. The figures show the difference in rates obtained by applying age-specific versus overall ratios, for males only (the picture for females is very similar). The choice of age-specific or crude ratios only affects the estimated rates at older ages for these causes of death. ONS will explore how far age-sex specific ratios are needed for different causes in a future report.

Figures 9 and 10 show the effect on age-standardised rates from 1993 onwards, again applying overall and age-specific ratios to the data. These figures are for males, but the pattern is the same for females. Again we can see that the choice of ratio appears to make little difference to the rates, although differences are more marked for pneumonia.
Figure 4  Age-specific mortality rates in ICD-9 and ICD-10, ischaemic heart disease (120-125, 410-414), males, England and Wales, 1999

Figure 5  Age-specific mortality rates in ICD-9 and ICD-10, cerebrovascular disease (160-169, 430-438), males, England and Wales, 1999

Figure 6  Age-specific mortality rates in ICD-9 and ICD-10, pneumonia (J12-J18, 480-486), males, England and Wales, 1999

Figure 7  Comparison of age-specific death rates calculated applying comparability ratios, males, cerebrovascular disease (160-169, 430-438), England and Wales, 1999
In this paper we have provided preliminary results from our bridge coding study. These show a variety of effects of the change from ICD-9 to ICD-10 on how underlying cause of death is assigned. In addition, the article demonstrates the use of comparability ratios to adjust recent ICD-9-coded mortality data for comparison with numbers and rates in ICD-10. More detailed work is being carried out on a wider range of causes, for example more thorough analysis is needed on accidents and injuries, and on cancers by site. ONS will publish detailed comparability ratios for a comprehensive range of causes including the majority of those on the European Union shortlist and the ONS standard cause list, where appropriate. More detailed analyses will be published on the National Statistics website. Where comparability ratios are referred to in ONS electronic publications, we envisage there will be direct links to downloadable tables of ratios.

Comparability ratios for 1999 help us to interpret the artefacts in time trends which will be seen between mortality data coded in ICD-9 and ICD-10. However, 1999 may not be a representative sample of recent years. Medical terminology changes over time. The terms used to describe a given condition may change, as may the number of conditions, the length of the direct sequence, and the propensity to consign some conditions to part II. These are likely to happen gradually over time in a given country, so will tend to make the comparability ratios less valid the further the data year is from the study year.

Comparability ratios measure the net effect of all the differences between ICD-9 and ICD-10 on the assignment of deaths to a given underlying cause. However, it may sometimes be necessary to understand the individual contribution made by some of the changes described above. For example, the effect of applying rule 3 will depend on the number (and proportion) of deaths in a given year certified as being due to one of the unspecified pneumonias (or other less common
terminal conditions to which it applies). England and Wales has a comparatively high proportion of deaths certified as pneumonia. The number of pneumonia deaths has varied from a low of 48,917 (1994) to a high of 59,273 (1999) over the last eight years. Much of this variation is related to the number of ‘excess winter deaths’ (EWD). These in turn have been shown to be largely a function, at the national level, of how cold the winter is and levels of flu in the population. Those most likely to die of pneumonia in the winter are the old and chronically ill. In a year with high EWD, such as 1999, the proportional increase in deaths assigned to cerebrovascular and other debilitating diseases instead of pneumonia may be larger than in milder years. ONS plan to study these effects further.

Key points

- Cause of death in England and Wales has been coded to the Tenth Revision of the International Classification of Diseases (ICD-10) from January 2001.
- This is the most substantial Revision of the ICD in 50 years, and more closely reflects current medical knowledge.
- Changes in the rules for selecting underlying cause of death will make more difference to mortality data than changes to disease codes.
- Mortality statistics in ICD-10 are not directly comparable to those coded in ICD-9 in earlier years.
- Comparability ratios can be used to quantify the net effect of the change in classification on particular causes of death.
- These ratios can be applied to recent earlier years’ data to allow for the examination of trends over time using ICD-10.
- In a future report, ONS will publish comparability ratios for a comprehensive list of causes and give advice on when and how they should be used.

Acknowledgements

The authors wish to thank the following for their help and advice: Michael Hills, and Susan Cole and Graham Jackson from the General Register Office for Scotland.

The study could only have been done with the management provided by Sue Smith, Lin Shane and Rosemary Coward, and the skill and hard work of the cause coding and ICD-10 project teams in ONS Titchfield Office.

References

11. Cumulative official updates to ICD-10, the Update Reference Committee. WHO/GPE/CAS/C/01.30
12. Roberts R, Innes K and Bramley M. Annual report of the Update Reference Committee, WHO/GPE/ICD/C/00.20
15. McKenzie K, Casey R, Walker S, Burke P, Tong S. Examining the impact on mortality data resulting from the change from ICD-9 manual coding to ICD-10 automated coding, National Centre for Classificats in Health and Australian Bureau of Statistics, Australian Centre. WHO/GPE/CAS/C/01.38
16. Motor vehicle traffic accidents in Mexico. Changes resulting from implementation of ICD-10. Mexican Centre for the Classification of Diseases, WHO/GPE/CAS/C/01.86
20. Effects of Changes in the General Death Certificate Form in France, Preliminary Results, Paris Collaborating Centre for the ICD. WHO/GPE/ICD/C/00.42