Crude Rates, Age-Specific Rates And Percentages

Calculating Rates

The basic measure of the frequency of disease or mortality is the number of events observed. This count is essential information for planning the health services needed to treat and care for the individuals affected. However, to properly investigate the distribution of disease and to make comparisons between different populations, the denominator population-years at risk in which the observed events occurred must also be taken into account. The simplest method to do this is the Crude Rate, where the number of observed events is divided by the population-years at risk. For presentation purposes this rate is usually multiplied by a scaling factor, e.g. 100,000.

For example, a rate, \( r \), expressed per 100,000 population is given by:

\[
r = \frac{O}{n} \times 100,000
\]

where:

- \( O \) is the number of observed events;
- \( n \) is the population-years at risk.

If the rate is for a one year time period, \( n \) is simply the mid-year population estimate for that year. If the rate is for two or more years then \( n \) is the sum of the mid-year population estimate for each of the years in the period.

Age-specific rates are simply crude rates for specified age groups:
\[ r_i = \frac{O_i}{n_i} \times 100,000 \]

where:
\( i \) represents the age group.

Percentages, like crude rates, are a form of ratio and are calculated in a similar way. By definition they are expressed per 100:

\[ r = \frac{O}{n} \times 100 \]

**Confidence Intervals For Crude Rates, Age-Specific Rates and Percentages**

Within the *Compendium* the 95% confidence intervals for crude rates and percentages are calculated using the likelihood-based method described by Aitken et al, which is a good approximation of the exact method.¹

For example lower and upper limits for a rate expressed per 100,000 are given by:

\[
\begin{align*}
    r_{LI} &= \frac{\exp \left( \ln \left( \frac{r}{1-r} \right) - \frac{1.96}{\sqrt{nr(1-r)}} \right)}{1 + \exp \left( \ln \left( \frac{r}{1-r} \right) - \frac{1.96}{\sqrt{nr(1-r)}} \right)} \times 100,000 \\
    r_{UL} &= \frac{\exp \left( \ln \left( \frac{r}{1-r} \right) + \frac{1.96}{\sqrt{nr(1-r)}} \right)}{1 + \exp \left( \ln \left( \frac{r}{1-r} \right) + \frac{1.96}{\sqrt{nr(1-r)}} \right)} \times 100,000
\end{align*}
\]
Age Standardisation

Introduction

Disease and mortality rates may vary widely by age. Such variation complicates any comparisons made between two populations that have different age structures. For example, consider two areas A and B with equally sized populations and identical crude all-age death rates. At first glance they appear to have a similar mortality experience. Suppose, however, that area A has a younger age structure than area B. Given that mortality rates increase with age, one would expect the older population in area B to experience more deaths. The fact that the two have identical rates means that the younger population in area A must have a relatively worse mortality experience.

The most comprehensive way of comparing the disease experience of two populations is to present and compare their age specific rates. However, when the number of populations being compared increases, the volume of data that needs to be considered quickly becomes unmanageable. What is needed is a single, easily interpreted, summary figure for each population that is adjusted to take into account its age structure. Such summary figures are calculated using age standardisation methods. It may also be desirable to standardise for other variables, such as sex or level of deprivation, that may also potentially confound any comparisons.

Two different methods of age standardisation are used in the Compendium, direct and indirect.

- **Direct Method:** The rate of events that would occur in a chosen standard population is found by applying the age-specific rates of the subject population to the age structure of the standard population.

- **Indirect Method:** The age-specific rates of a chosen standard population (usually the relevant national or regional population) are applied to the age structure of the subject population. This gives an expected number of events against which the observed number of events may be compared.

These are the two most commonly used methods for adjusting rates for comparisons between different populations, and both have advantages and disadvantages.

The preferred method for comparing a number of different populations against each other using the same standard population is the direct method. This is because it preserves consistency between the populations, i.e. if each age-specific rate in area A is greater than each of the corresponding age-specific rates in area B, then the directly standardised rate for area A will always be higher than that of area B irrespective of the standard population used.\(^2,3\)

Indirect standardisation does not necessarily preserve this consistency, and in extreme situations may give misleading results. Indirectly standardised ratios for areas A and B may be compared to the standard but should only be directly compared to each other if the age structures of areas A and B are similar, or the ratio of their age-specific mortality rates is homogenous across the age groups.\(^4\)

Where the ratio between the age-specific rates of areas A and B varies by age group the choice of standard population becomes crucially important for both direct and indirect methods.

One of the disadvantages of the direct method is that it requires that the observed events in the subject population are available broken down by age. If this information is not available the directly standardised rate cannot be calculated. A further problem is that for small subject populations the age-specific rates of the subject population are based on small numbers and consequently are unstable. Small changes in the number of deaths in a particular age band may result in large changes in the directly standardised rate.

The indirect method requires only the total number of observed events in the subject population and may therefore be used in some situations where the direct method cannot. Indirect standardisation is also more stable as it minimises the variance, giving a smaller standard error and narrower confidence intervals. It is therefore more appropriate when dealing with the statistical significance of small populations.

In practice, the two methods generally give comparable results. Moreover, it has been demonstrated by Breslow & Day that when the two do differ it is not necessarily true that the direct method is the more “correct”.\(^5\) It has also been shown that the choice of standard population is often as, or more, important than the choice of method.\(^6,7\)

**Direct Standardisation**

The directly age-standardised rate is the rate of events that would occur in a standard population if that population were to experience the age-specific rates of the subject population. Explicitly:

\[
DSR = \sum_i w_i r_i \times 100,000 \quad \text{(expressed per 100,000 population)}
\]
where:

- \( w_i \) is the number, or proportion, of individuals in the standard population in age group \( i \).
- \( r_i \) is the crude age-specific rate in the subject population in age group \( i \), given by:

\[
r_i = \frac{O_i}{n_i}
\]

where:

- \( O_i \) is the observed number of events in the subject population in age group \( i \).
- \( n_i \) is the number of individuals in the subject population in age group \( i \).

Within the *Compendium* the standard population generally used for the direct method is the European Standard Population (see Annex 5). The age groups used are: Under 1, 1-4, 5-9, ..., 80-84, 85-89, 90+. However, there are exceptions, such as the age-standardised relative survival rates for cancers where the appropriate England & Wales cancer patient population is used as the standard.

The same standard population is used for males, females and persons. This means that rates can be compared across gender but also that rates for persons are standardised for age only, and not for sex.

**A Worked Example Of The Calculation Of A Directly Age-Standardised Rate**

NB: Note that this calculation and the calculation for Confidence Limits have been revised for 2011 data onwards

**Mortality From All Circulatory Diseases (ICD10 I00-I99, ICD9 390-459), 1999 -2001 Pooled, Ages Under 75 Years**

**Stage 1: Calculate the age-specific rates in area A**

1a – Observed events (deaths) in area A by age group

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>65-69</th>
<th>70-74</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2001</td>
<td>M</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>...</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>100</td>
</tr>
</tbody>
</table>

1b – Population in area A by age group

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>65-69</th>
<th>70-74</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2001</td>
<td>M</td>
<td>2,400</td>
<td>9,500</td>
<td>12,200</td>
<td>...</td>
<td>5,800</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2,300</td>
<td>9,000</td>
<td>11,400</td>
<td>...</td>
<td>6,500</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>4,700</td>
<td>18,500</td>
<td>23,600</td>
<td>...</td>
<td>12,200</td>
</tr>
</tbody>
</table>

1c – Age-specific rates in area A

Divide each age-, sex- and year-specific observed events by the corresponding age-, sex- and year-specific population (1a/1b). Person rate is the person events divided by the person population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>65-69</th>
<th>70-74</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2001</td>
<td>M</td>
<td>0.00000</td>
<td>0.00010</td>
<td>0.00000</td>
<td>...</td>
<td>0.01121</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.00000</td>
<td>0.00000</td>
<td>0.00000</td>
<td>...</td>
<td>0.00543</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.00000</td>
<td>0.00005</td>
<td>0.00000</td>
<td>...</td>
<td>0.00816</td>
</tr>
</tbody>
</table>
Stage 2: Calculate the expected number of events (deaths) in the standard population, given the age-specific rate in area A

### 2a – Standard population (European Standard Population) by age group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>00-01</th>
<th>05-09</th>
<th>...</th>
<th>65-69</th>
<th>70-74</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,600</td>
<td>6,400</td>
<td>7,000</td>
<td>...</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,000</td>
</tr>
</tbody>
</table>

### 2b – Expected number of events (deaths) in the standard population

Multiply each age-, sex- and year-specific rate in area A by the corresponding age-specific standard population (1c x 2a)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>0</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>65-69</th>
<th>70-74</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2001</td>
<td>M</td>
<td>0.00</td>
<td>0.67</td>
<td>0.00</td>
<td>...</td>
<td>44.85</td>
<td>59.06</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>...</td>
<td>21.70</td>
<td>26.49</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.00</td>
<td>0.35</td>
<td>0.00</td>
<td>...</td>
<td>32.66</td>
<td>41.15</td>
</tr>
</tbody>
</table>

Stage 3: - Calculate the age-standardised annual rates

Sum the expected events across all appropriate age groups to give a total number of expected events for each year and sex. Sum the standard population across all appropriate age groups. Divide the total expected events by the total standard population and multiply by 100,000 to give the age-standardised rate.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>Total Expected 0-74Yrs</th>
<th>Total Standard Population 0-74Yrs</th>
<th>Standardised Rate 0-74 Yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2001</td>
<td>M</td>
<td>166</td>
<td>96,000</td>
<td>173.03</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>73</td>
<td>96,000</td>
<td>75.77</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>117</td>
<td>96,000</td>
<td>121.53</td>
</tr>
</tbody>
</table>

For mortality data for the years 1993-98 and 2000, the observed number of deaths may need to be adjusted as a result of the change from using ICD-9 to ICD-10 to code the cause of death (see Annex 2). The adjusted counts are then used in the rate calculation in the normal way.

For data pre-2011, the overall rate was an average of the three individual yearly rates.

**Confidence Intervals For Directly Standardised Rates**

The 100(1–a)% confidence limits for the directly standardised rate DSR are given by:

\[
DSR_{lower} = DSR + \sqrt{\frac{Var(DSR)}{Var(O)}} \times (O_{lower} - O)
\]

\[
DSR_{upper} = DSR + \sqrt{\frac{Var(DSR)}{Var(O)}} \times (O_{upper} - O)
\]

where:
- \(O\) is the total observed count of events in the local or subject population;
- \(O_{lower}\) and \(O_{upper}\) are the lower and upper confidence limits for the observed count of events;
- \(Var(O)\) is the variance of the total observed count \(O\);
- \(Var(DSR)\) is the variance of the directly standardised rate.

Using Byar’s method1, the 100(1–a)% confidence limits for the observed number of events are given by:

\[
O_{lower} = O \times \left(1 - \frac{1}{9O+1} \left[\frac{z}{\sqrt{3O}}\right]^3\right)
\]

\[
O_{upper} = (O+1) \times \left(1 - \frac{1}{9(O+1)} \left[\frac{z}{\sqrt{3(O+1)}}\right]^3\right)
\]
where:

z is the 100(1−a/2)th percentile value from the Standard Normal distribution.
For example, for a 95% confidence interval, a = 0.05 and z = 1.96 (i.e. the 97.5th percentile value from the Standard Normal distribution).

The variances of the observed count $O$ and the DSR are estimated by:

$$Var(O) = \sum_i O_i$$

$$Var(DSR) = \frac{1}{\left(\sum_i w_i\right)^2} \times \sum_i \frac{w_i^2 O_i}{n_i^2}$$

Confidence intervals are not presented for annual trend data.

Indirect Standardisation

Indirect standardisation uses an opposite approach to direct standardisation. Rather than applying the age-specific rates of the subject population to the standard age structure, the age-specific rates of the standard population are applied to the age structure of the subject population. This gives an expected number of events against which the observed number of events may be compared.

The statistic most commonly presented for the indirect method is the standardised ratio - the ratio of the observed to expected events. For presentation purpose, the ratio is usually multiplied by 100. By definition, the standard population used will have a ratio of 100. Ratios above 100 indicate that the number of events observed was greater than expected given the standard rates and ratios below 100 that it was lower.

Examples of standardised ratios used in the Compendium include the Standardised Mortality Ratio (SMR) for mortality data and the Standardised Registration Ratio (SRR) for cancer incidence data.

$$SMR = O \times 100 = \frac{\sum_i O_i}{\sum_i E_i} \times 100 = \frac{\sum_i O_i}{\sum_i n_i \lambda_i} \times 100$$

where:

$O_i$ is the observed number of events in the subject population in age group $i$.

$E_i$ is the expected number of events in the subject population in age group $i$.

$n_i$ is the number of individuals in the subject population in age group $i$.

$\lambda_i$ is the crude age-specific rate in the standard population in age group $i$.

Up to and including the 2003 Compendium, the standard rates used for mortality and cancer registration ratios were the appropriate rates for England and Wales. However, the Compendium is designed as a resource for the NHS in England and does not include data for Welsh Health Boards. The national average used for comparisons of English organisations is that of England, not England and Wales. It is therefore more appropriate to use England rates as the standard and for Compendium releases dating from April 2005 onwards the England rates are used.

The age groups used are: Under 1, 1-4, 5-9, ..., 80-84, 85-89,90+. Neonatal deaths are excluded for cause-specific mortality indicators (see Annex 2).

For other indicators, other standards and age groupings may be used.

Male and female ratios are calculated using separate male and female standard rates, and cannot be compared. Person ratios are found by summing the separately calculated male and female expected events, rather than by using the standard rates for persons. This means that the person ratios are standardised for both age and sex.

Where ratios are presented for pooled time periods of two years or more, the individual annual standard rates are used to give annual expecteds which are then summed. This means the ratios are standardised for the yearly differences in the standard rates.

A Worked Example Of The Calculation Of An Indirectly Age-Standardised Ratio
Mortality From All Circulatory Diseases (ICD10 I00-I99, ICD9 390-459), 1999 & 2001 Pooled, All Ages

Stage 1: Calculate the standard age-specific rates

1a – Observed events (deaths) in the standard population (E&W) by age group

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>0</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>M</td>
<td>28</td>
<td>28</td>
<td>11</td>
<td>...</td>
<td>18,220</td>
<td>22,023</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>25</td>
<td>12</td>
<td>6</td>
<td>...</td>
<td>23,145</td>
<td>51,728</td>
</tr>
<tr>
<td>2001</td>
<td>M</td>
<td>23</td>
<td>11</td>
<td>7</td>
<td>...</td>
<td>18,808</td>
<td>22,342</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>15</td>
<td>18</td>
<td>10</td>
<td>...</td>
<td>22,562</td>
<td>50,758</td>
</tr>
</tbody>
</table>

1b – Standard population (E&W) by age group (rounded to the nearest 100 for presentation only)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>0</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>M</td>
<td>320,100</td>
<td>1,315,200</td>
<td>1,745,600</td>
<td>...</td>
<td>376,200</td>
<td>268,900</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>304,600</td>
<td>1,250,300</td>
<td>1,664,100</td>
<td>...</td>
<td>674,400</td>
<td>720,200</td>
</tr>
<tr>
<td>2001</td>
<td>M</td>
<td>300,900</td>
<td>1,279,200</td>
<td>1,691,200</td>
<td>...</td>
<td>440,500</td>
<td>282,600</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>287,900</td>
<td>1,218,200</td>
<td>1,609,400</td>
<td>...</td>
<td>749,500</td>
<td>733,400</td>
</tr>
</tbody>
</table>

1c – Standard age-specific rates

Divide each age-, sex- and year-specific standard observed events by the corresponding age-, sex- and year-specific standard population (1a/1b)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>0</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>M</td>
<td>0.00009</td>
<td>0.00002</td>
<td>0.00001</td>
<td>...</td>
<td>0.04843</td>
<td>0.08190</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.00008</td>
<td>0.00001</td>
<td>0.00000</td>
<td>...</td>
<td>0.03432</td>
<td>0.07182</td>
</tr>
<tr>
<td>2001</td>
<td>M</td>
<td>0.00008</td>
<td>0.00001</td>
<td>0.00000</td>
<td>...</td>
<td>0.04270</td>
<td>0.07906</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.00005</td>
<td>0.00001</td>
<td>0.00001</td>
<td>...</td>
<td>0.03010</td>
<td>0.06921</td>
</tr>
</tbody>
</table>

Stage 2: Calculate the expected number of events (deaths) in the subject area A

2a – Population of area A by age group (rounded to the nearest 100 for presentation only)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>0</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>M</td>
<td>2,400</td>
<td>9,500</td>
<td>12,200</td>
<td>...</td>
<td>2,000</td>
<td>1,500</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2,300</td>
<td>9,000</td>
<td>11,400</td>
<td>...</td>
<td>3,400</td>
<td>3,800</td>
</tr>
<tr>
<td>2001</td>
<td>M</td>
<td>2,200</td>
<td>9,300</td>
<td>11,900</td>
<td>...</td>
<td>2,400</td>
<td>1,600</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2,100</td>
<td>9,000</td>
<td>11,100</td>
<td>...</td>
<td>3,600</td>
<td>3,800</td>
</tr>
</tbody>
</table>

2b – Expected events (deaths) in area A by age group

Multiply each age-, sex- and year-specific population of area A by the corresponding age-, sex- and year-specific standard rate (2a x 1c)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>0</th>
<th>01-04</th>
<th>05-09</th>
<th>...</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>M</td>
<td>0.21</td>
<td>0.20</td>
<td>0.08</td>
<td>...</td>
<td>96.86</td>
<td>122.85</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.19</td>
<td>0.09</td>
<td>0.04</td>
<td>...</td>
<td>116.69</td>
<td>272.93</td>
</tr>
<tr>
<td>2001</td>
<td>M</td>
<td>0.17</td>
<td>0.08</td>
<td>0.05</td>
<td>...</td>
<td>102.47</td>
<td>126.49</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>0.11</td>
<td>0.13</td>
<td>0.07</td>
<td>...</td>
<td>108.37</td>
<td>262.99</td>
</tr>
</tbody>
</table>
Stage 3: Calculate the standardised ratio

Sum the sex-specific expected events across all appropriate age groups and across all the years in the time period to give a total number of expected events for each sex. The person total expected is the sum of the male and female expecteds. Divide the total observed events in area A by the total expected events and multiply by 100 to give the standardised ratio.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sex</th>
<th>Total Observed</th>
<th>Total Expected</th>
<th>Ratio (O/E) x 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999 &amp; 2001</td>
<td>M</td>
<td>1,015</td>
<td>1,119</td>
<td>90.7</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>1,148</td>
<td>1,180</td>
<td>97.3</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>2,163</td>
<td>2,299</td>
<td>94.1</td>
</tr>
</tbody>
</table>

Standardised ratios for annual trend data are calculated in a similar way, with the exception that the standard rates are calculated for one standard year only, usually the latest year in the trend. The standard rates for this single standard year are used to calculate the expecteds for all years in step 2b. At stage 3 the observed and expecteds are summed for each individual year. For mortality data for the years 1993-98 and 2000 the observed number of deaths may need to be adjusted as a result of the change from using ICD-9 to ICD-10 to code the cause of death (see Annex 2). The adjusted counts are then used in the ratio calculation as outlined above.

Confidence Intervals Of Indirectly Standardised Ratios

When calculating 95% confidence intervals for indirectly standardised ratios, it is assumed that the standard rates come from a population sufficiently large as to assume their sampling variance is negligible, and that the observed number of events _O_ follows a Poisson distribution. Where the number of observed events is less than 500, the exact upper and lower limits for _O_ are found from a look-up table and used to calculate the respective limits of the ratio. Where the number of observed events is 500 or more, confidence intervals are calculated using the method described by Goldblatt and Jones. The lower and upper confidence limits for the SMRs and SRRs are denoted by SMR_{LL}/SMR_{UL} and SRR_{LL}/SRR_{UL} respectively.

For _O_ < 500:

\[
SMR_{LL} = \frac{O_{LL}}{E} \times 100 \\
SMR_{UL} = \frac{O_{UL}}{E} \times 100
\]

where:

_\text{O}_{LL/UL}_ are the exact lower and upper 95% confidence limits from a standard Poisson distribution table for the total number of observed events _O_ in the subject population. 
_E_ is the total expected number of events in the subject population.

For _O_ >= 500:

\[
SMR_{LL} = \frac{0.96 + O - 1.96\sqrt{(O + 0.11)}}{E} \times 100 \quad \text{for } O < 900 \\
SMR_{UL} = \frac{0.962 + O - 1.9602\sqrt{O}}{E} \times 100 \quad \text{for } O \geq 900 \\
SMR_{UL} = \frac{1.94 + O + 1.96\sqrt{O + 0.96}}{E} \times 100
\]

Confidence intervals are not presented for annual trend data.
Years Of Life Lost

Years of life lost (YLL) is a measure of premature mortality. Its primary purpose is to compare the relative importance of different causes of premature death within a particular population and it can therefore be used by health planners to define priorities for the prevention of such deaths. It can also be used to compare the premature mortality experience of different populations for a particular cause of death. The concept of YLL is to estimate the length of time a person would have lived had they not died prematurely. By inherently including the age at which the death occurs, rather than just the fact of its occurrence, the calculation is an attempt to better quantify the burden, or impact, on society from the specified cause of mortality. Infant deaths are omitted, as they are mostly a result of causes specific to this age period and have different aetiologies to deaths later in life. The YLL are calculated using the methods described by Romeder and McWhinnie.

Number Of Years Of Life Lost

The number of YLL is calculated by summing over ages 1 to 74 years the number of deaths at each age multiplied by the number of years of life remaining up to age 75 years.

\[ \text{YLL} = \sum_{i=1}^{74} a_i d_i \]

where:
- \( i \) is the age (by single year).
- \( d_i \) is the number of observed deaths in the subject population between ages \( i \) and \( i + 1 \).
- \( a_i \) is number of years of life remaining to age 75 when death occurs between ages \( i \) and \( i + 1 \).

Assuming a uniform distribution of deaths within age groups, \( a_i = 75 - (i + 0.5) \) and therefore:

\[ \text{YLL} = \sum_{i=1}^{74} (74.5 - i) d_i \]

Crude Years Of Life Lost Rate

The crude YLL rate is simply the number of years of life lost divided by the resident population aged under 75 years. Within the Compendium this is expressed by 10,000 resident population:

\[ \text{YLL Rate} = \frac{\text{YLL}}{n} \times 10,000 \]

where:
- \( n \) is the number of individuals in the subject population aged under 75 years.

The variance of the YLL is related to the variance of the age specific numbers of deaths \( d_i \). If it is assumed that each \( d_i \) follows a Poisson distribution then it can be shown that the standard error of the crude YLL rate is given by:

\[ \text{SE(YLL Rate)} = \sqrt{\frac{\sum_{i=1}^{74} (74.5 - i)^2 \cdot d_i}{n^2}} \times 10,000 \]

The 95% confidence intervals may then be calculated using the Normal approximation:

\[ \text{YLL Rate}_{LL/UL} = \text{YLL Rate} \pm 1.96 \times \text{SE(YLL Rate)} \]

Age-Standardised Years Of Life Lost Rate (SYLL)

Like conventional mortality rates, YLL can be age-standardised to eliminate the effects of differences in population age structures between areas, allowing geographical comparisons of premature mortality. The age-standardised years of life lost rate (SYLL Rate) is calculated by the direct standardisation methods described above, using the European Standard Population (see Annex 5). It is expressed per 10,000 resident population aged under 75.
Compendium of Population Health Indicators
Health and Social Care Information Centre
December 2015

SYLL Rate = \frac{\sum_i \left( w_i \cdot \frac{a_i d_i}{n_i} \right)}{\sum_i w_i} \times 10,000

where:

i is the age group (1-4, 5-9, 10-14… 70-74).

\(d_i\) is the observed number of deaths in the subject population age group \(i\).

\(a_i\) is the average number of years of life remaining up to age 75 when death occurs in age group \(i\) (found by subtracting the midpoint of the age group from 75), i.e. 72, 67.5, 62.5,… , 7.5, 2.5 .

\(n_i\) is number of individuals in the subject population age group \(i\).

\(w_i\) is the number, or proportion, of individuals in the standard population in age group \(i\).

The SYLL rate for the pooled time period is the average of the individually calculated annual SYLL rates.

Using the same Poisson assumptions made for the YLL rate it can be shown that:

\[ SE(SYLL\ Rate) = \pm \frac{1}{\sqrt{\sum_i w_i}} \times \sum_i \frac{w_i^2 \cdot a_i^2 \cdot d_i}{n_i^2} \times 10,000 \]

The 95% confidence intervals may then be calculated using the Normal approximation:

\[ SYLLRate_{LL/UL} = SYLLRate \pm 1.96 \times SE(SYLLRate) \]
Cancer Survival

The survival time for an individual cancer patient is measured as the number of days between the date of diagnosis and the date of death (or loss to follow-up) and is the basic element of survival analysis. When analysing the survival times of a number of cancer patients, the object is to estimate the probability of survival at a given time since diagnosis, e.g. one or five years. There are three main approaches to estimating cancer survival: crude survival, net survival and relative survival.

Crude Cancer Survival

The observed, or crude, survival of a group of cancer patients is simply the estimated probability of survival at the end of some specified period of time. Crude survival takes no account of the cause of death, or of the background risk of death in the general population, to which cancer patients are also subject. A crude survival rate can be interpreted as the probability of survival from cancer and all other causes of death combined.

Net Cancer Survival

An alternative approach is to use net (or corrected) survival rates, in which we allow the overall risk of death among cancer patients to be separated into two components: a background risk of death applicable to everyone, and an extra risk of death due to cancer, which will form the basis of our cancer survival estimate. The risks are assumed to act independently of one another. Patients certified as dying of cancer then provide the endpoints for analysis, while those certified as dying of other causes are treated as censored observations, in effect, lost to follow-up at the time of death. However, this approach requires agreement on which deaths should be considered attributable to the cancer, as well as suitably accurate information on the cause of death of all cancer patients. Such information is not usually available for population-based survival estimates.

Relative Cancer Survival

The third approach is relative survival. It also assumes additivity between the risk of death due to the cancer and the background (or competing) risk of death from other causes but, crucially, it does not require information about the cause of death in the cancer patients. If we assume that the two risks of death may be considered to act independently, the impact of other causes of death can be estimated from routine vital statistics, i.e. the mortality rates in the general population from which the cancer patients are drawn.

Relative survival is defined as the ratio of the survival probability observed in a given group of cancer patients to the survival probability that would be expected if they had been subject only to the same overall mortality rates by sex, age, and calendar period as the general population. It is usually expressed as a percentage (e.g. 0.4/0.8=50%), and it can be interpreted as the probability of surviving the cancer in the absence of other causes of death.

\[
S_e(t) = \frac{S_o(t)}{S_e(t)} \times 100 \quad \text{(expressed as a percentage)}
\]

where:
- \(r\) is the time since diagnosis at which survival is measured.
- \(S_e(t)\) is the probability of surviving the cancer.
- \(S_o(t)\) is the observed survival probability of the cancer patients.
- \(S_e(t)\) is the expected survival probability of the cancer patients given the mortality rates of the general population.

Overall mortality has a component due to the cancer, but it is not necessary to subtract this component from the calculation. The basis of relative survival is a comparison of mortality in the cancer patients with that of the general population regardless of cause.

Relative survival has become the most widely used technique for exploring the survival of cancer patients in population studies. It is important in analysing survival over long periods, because the extra risk of death related to the cancer tends to decay with time, while the background risk from other causes of death rises inexorably as the surviving cancer patients become older.

Use of Life Tables In Calculating the Relative Survival Rate

The expected survival probability \(S_e(t)\) is found using life tables. These tables of the mortality rates of the general population (by sex, single year of age at death, and geographic region) are used to calculate the probability of survival between various ages. The overall expected survival probability is found by applying the age-specific survival probabilities from the life table to the age-specific numbers of cancer patients and summing over all the age groups. This is in effect a form of indirect standardisation.11
Following exploratory work on the choice of life table, the Department of Health concluded that regional life tables should be used to reflect background mortality, instead of national life tables used previously, even though the numerical effect is small. There are two main reasons for this choice:

- in a country like England with large regional variation in background mortality, relative survival rates derived from regional life tables are intrinsically more defensible, since they approximate the background mortality of the local population more closely;

- the range of cancer survival rates for NHS Regions based on regional life tables is smaller than the range based on national life tables, and this almost certainly reflects the true range of regional variation in cancer survival more accurately.

### Age-Standardised Relative Survival Rate

The calculation of the expected survival probability $S_e(t)$ uses a form of indirect standardisation, but this adjusts only for the age-specific mortality from other causes. The excess hazard from the cancer itself is usually age-dependent, i.e. the relative survival rate itself varies with age. If an overall (all-ages) estimate of relative survival for cancer patients is used to compare survival rates for two populations with very different age structures, the results may be misleading. It is therefore desirable to age-standardise the relative survival rates.

Age-adjustment is also important for the analysis of time trends in relative survival. This is because if survival varies markedly with age, a change in the age distribution of cancer patients over time can produce spurious survival trends (or obscure real trends).

Age standardisation of the relative survival rate is performed using the direct method described previously. A full description of the methods used is given by Coleman MP et al.¹²

$$DSR = \frac{\sum w_i S_i}{\sum w_i} \times 100$$

(expressed as a percentage)

where:

- $w_i$ is the number, or proportion, of individuals in the standard population in age group $i$.
- $S_i$ is the cumulative relative survival rate of the subject cancer patient population in age group $i$.

The standard population used is the number of persons who were diagnosed with the particular cancer under consideration in England and Wales during the period 1986-90. These were broken down into the following age (at diagnosis) groups:

- 15-69, 70-79, and 80-99 years for bladder and stomach cancers;
- 15-59, 60-69, 70-79, and 80-99 years for colon and prostate cancers;

Male, female, and person relative survival rates are age-standardised using the same person standard population and may therefore be compared against each other. Rates for different cancers, however, are standardised using different standard populations, and in some instances different age groupings, and should therefore not be compared.

### Confidence Intervals Of Age-Standardised Relative Survival Rate

The 95% confidence intervals are calculated using the same normal approximation approach described above for direct standardisation:

$$DSR_{LL/UL} = DSR \pm 1.96 \times 100 \times \sqrt{\frac{1}{\left(\sum w_i\right)^2} \times \sum w_i^2 \cdot Var(S_i)}$$

(expressed as a percentage)

where:

- $w_i$ is the number, or proportion, of individuals in the standard population in age group $i$.
- $Var(S_i)$ is the variance of the cumulative relative survival rate of the subject cancer patient population in age group $i$. 
Clinical Indicators

The Compendium has previously included the following 8 indicators from the larger set of historical NHS Performance Indicators. Some of these indicators have also formed part of the NHS Star Ratings published by the Healthcare Commission.

- CI1A: Deaths in hospital and after discharge within 30 days of surgery (non-elective admissions).
- CI1B: Deaths in hospital and after discharge within 30 days of surgery (elective admissions).
- CI1C: Deaths in hospital and after discharge within 30 days of CABG surgery (all admissions).
- CI2: Deaths in hospital and after discharge within 30 days of emergency admission with fractured proximal femur.
- CI3: Deaths in hospital and after discharge within 30 days of emergency admission with a heart attack (myocardial infarction).
- CI3B: Deaths in hospital and after discharge within 30 days of emergency admission with stroke.
- CI5: Discharge to usual place of residence within 56 days of emergency admission from there with a stroke.
- CI6: Discharge to usual place of residence within 28 days of emergency admission from there with a hip fracture (neck of femur).

Changes In Method Used For Clinical Indicators

In the June 1999 Clinical Indicator (CI) publications, the indicators listed above were directly standardised for age using the European Standard Population. The indicators were not standardised for sex.

In the July 2000 publication, and in all successive publications, three changes to the previous standardisation method have been made:

- Indirect standardisation is used instead of direct standardisation, and the ratios (and their confidence intervals) are then converted into absolute rates;
- The indicators are standardised for age and sex, not just age (Some indicators are also standardised for other factors such as method of admission and/or case type);
- For each indicator, the reference population used for standardisation is the appropriate national number of hospital admissions for that indicator, as opposed to the European Standard Population.

These changes bring the method of standardisation in line with that used for the Scottish and Welsh clinical indicators.

The main reasons behind the change in standardisation method were:

- Indirect standardisation is more robust with small numbers and avoids the distortions caused by direct standardisation based on unstable age-specific rates;
- Indirect standardisation is more flexible to future refinements, such as standardising for other factors, e.g. deprivation or co-morbidity;
- As there are gender variations in health outcomes, person rates need to be standardised for age and sex;
- The age distribution of a hospital patient population is different to that of a general population such as the European Standard Population. Hence the former is a more appropriate basis for standardisation within the Clinical Indicators.

Comparison of Standardisation Methods For Clinical Indicators

The effects of the different methods of standardisation were investigated for each of the Clinical Indicators. Table A3.1. below illustrates an example using indicator CI6 (discharge to usual place of residence within 28 days of emergency admission from there with a hip fracture) for the financial year 2000/01. At this time there were 390 Trusts in England. Of these, 170 Trusts with zero denominators and 25 Trusts with zero numerators (and therefore zero rates) have been dropped from the illustrative analysis. Results are therefore presented for 195 Trusts, of which 24 have denominators
The inspection of the results for methods 2 and 3 highlighted the following observations:

- The indirect method gives a better distribution of significantly low and significantly high trust rates.
- The results are more plausible with indirect standardisation.

Where observed numbers are low, both direct and indirect methods (not surprisingly) give unreliable results. But the results are more plausible with indirect standardisation.

Method 1 clearly gives unsatisfactory results, with 127 trusts having significantly low rates and none having significantly high. Indeed, all 195 trust rates were lower than the average rate for England as a whole. There are two reasons for these apparently nonsensical results. Firstly, the European Standard Population is a reflection of the age structure of the general population, and not the age structure of patients being admitted to hospital with a hip fracture. The European Standard Population has a much younger age structure than the patient population, and therefore disproportionately weights the rates that occur in the younger age groups. The rates in these younger age groups are based on smaller numbers and are therefore less stable than those of the older age groups. The second problem is a failure of the direct method to handle the small denominator populations at the trust level. If for a particular age group a trust has a denominator of zero admissions it is effectively missing information on its rate for that age group. When the age specific rates are applied to the standard population the missing rates are treated as zeros, resulting in an artificially low estimate of the overall age-standardised rate. This problem is further compounded by the use of the European Standard Population, as it disproportionately weights those younger age groups that are most likely to have missing age-specific rates.

Calculations for CI6 were repeated using only age groups above 65 years. These age groups contained over 95% of cases for this indicator. This compromise reduced the distorting effects of the differently weighted standard population and the effects of missing age-specific rates at Trust level, but did not eliminate them completely. The resulting England rate was more representative of the Trust rates, but of the 42 Trusts that showed a statistically significant difference from the England rate, all were lower. No Trust had a significantly higher rate.

Using the England hip fracture admissions as the standard population, as in method 2, gives much improved results. The resulting weights given to the age-specific rates are better proportioned, and also reduce the effect of any missing age-specific rates. This is because the age groups that are most likely to have missing rates at Trust level also have relatively small numbers in the standard national admissions population and are therefore given a lower weighting. The results are still not ideal though, with nearly twice as many trusts with significantly low rates than significantly high (30 and 17 respectively).

For method 3, indirect standardisation was used. This eliminates the problem of missing age-specific rates, since when the England age-specific discharge rate is applied to a Trust that has no admissions in that age group, the expected discharges for that age group will be zero - matching the zero observed discharges. The age group therefore contributes nothing to either the total observed or total expected discharges, and does not distort the ratio of the two. The results show that the indirect method gives a better distribution of significantly low and significantly high trust rates. Closer inspection of the results for methods 2 and 3 highlighted the following observations:

- Many of the significantly lower rates from direct standardisation were based on very small numbers. For example, we found three Trusts with 4/5, 2/2, and 3/3 cases being discharged within 28 days, resulting in discharge rates significantly below that of England. In contrast, only results based on large numbers show up as statistically significant with the indirect method. In the case of those three particular Trusts, the corresponding results by the indirect method showed higher (though not statistically significant) discharge rates than the England average, which is what one would have expected.

- Where observed numbers are low, both direct and indirect methods (not surprisingly) give unreliable results.
lowest admission figures (i.e. with 1/1 cases being discharged), the directly standardised rates are low, whereas
the indirectly standardised rates are high.

- The direct method gives improbably low rates for some Trusts with low observed numbers, which are often also
  statistically significant. The indirect method results in more stable rates and wide confidence intervals for these
  Trusts.
- This also demonstrates that there is a case for excluding from the analysis Trusts with denominators below a
  threshold value. A threshold of 50 is used.

In summary the indirectly standardised rates showed less volatility, less bias towards low rates, and fewer “false”
differences (especially lower rates) than the directly standardised rates. The indirect method also allows for the
possibility of standardising for other possible confounding factors such as sex, deprivation, or case-mix. It would be
hazardous to attempt to do this using the direct method, since the problem of low cell numbers and missing specific rates
would be compounded further.

Indirectly Standardised Rates For Clinical Indicators

The Clinical Indicators are calculated using the indirect methods already described above. However, instead of
expressing the ratio of observed to expected events as a percentage, it is converted to a rate by multiplying it by the
overall crude rate of the standard population. This indirectly age-standardised rate (ISR) is then expressed per 100,000
denominator population or as a percentage depending on the indicator, e.g.:

\[
\text{ISR} = \frac{O}{E} \times \lambda \times 100,000 = \sum \frac{O_i}{E_i} \times \lambda \times 100,000 = \sum \frac{O_i}{n_i \lambda_i} \times \lambda \times 100,000
\]

(expressed per 100,000 denominator population)

where:
\(O_i\) is the observed number of events in the subject population in age group \(i\).
\(E_i\) is the expected number of events in the subject population in age group \(i\).
\(n_i\) is the number of individuals in the subject population in age group \(i\).
\(\lambda_i\) is the crude age-specific rate in the standard population in age group \(i\).
\(\lambda\) is the overall crude rate in the standard population.

This crude rate multiplication is used in both the Scottish and Welsh clinical indicators and is done in order to produce a
more useable and interpretable final value.

Confidence Intervals Of Indirectly Standardised Rates For Clinical Indicators

The lower and upper limits of the 95% confidence interval for the indirectly standardised rate are calculated by finding the
lower and upper limits of the standardised ratio and multiplying by the overall crude rate of the standard population. The
methods used for determining the lower and upper limits of the standardised ratio are different to those used elsewhere
in the Compendium and described previously. Rather than using the exact Poisson limits for observed counts of less
than 500 and the Goldblatt and Jones approximation for greater counts, Byar’s approximation is used in all instances. It
is a sufficiently accurate approximation to the Poisson probabilities. The 95% limits are given by:

\[
\text{ISR}_{LL} = \frac{O}{E} \times \left(1 - \frac{1}{9O} - \frac{1.96}{3\sqrt{O}}\right) \times \lambda \times 100,000
\]

\[
\text{ISR}_{UL} = \frac{(O+1)}{E} \times \left(1 - \frac{1}{9(O+1)} + \frac{1.96}{3\sqrt{(O+1)}}\right) \times \lambda \times 100,000
\]

(expressed per 100,000 denominator population)

where:
\(O\) is the total observed number of events in the subject population.
\(E\) is the total expected number of events in the subject population.
\(\lambda\) is the overall crude rate in the standard population.
For indicators such as cancer deaths at home, where the observed event is not rare, the binomial distribution may be more appropriate for use in determining the confidence interval. In such instances, the 95% limits may be estimated by:

\[ ISR_{LL} = \frac{r_{LL}}{E} \times \lambda \times 100 \]

\[ ISR_{UL} = \frac{r_{UL}}{E} \times \lambda \times 100 \]

(expressed per 100 denominator population)

where:

- \( r_{LL/UL} \) is the lower/upper limit of the crude rate in the subject population as given in section “Confidence Intervals For Crude Rates, Age-Specific Rates and Percentages” above.
- \( n \) is the denominator at risk in the subject population.
- \( E \) is the total expected number of events in the subject population.
- \( \lambda \) is the overall crude rate in the standard population.

A Worked Example Of The Calculation Of An Indirectly Age-Standardised Rate For Clinical Indicators

CI2: Deaths In Hospital And After Discharge Within 30 Days Of Emergency Admission With Fractured Proximal Femur, Ages Over 65 Years.

Stage 1: Calculate the standard age-specific rates

1a - Observed events (deaths) in the standard population (England admissions) by age group

<table>
<thead>
<tr>
<th>Sex</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>24</td>
<td>66</td>
<td>197</td>
<td>270</td>
<td>635</td>
</tr>
<tr>
<td>F</td>
<td>45</td>
<td>133</td>
<td>330</td>
<td>531</td>
<td>1,861</td>
</tr>
</tbody>
</table>

1b - Standard population (England admissions) by age group

<table>
<thead>
<tr>
<th>Sex</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>695</td>
<td>1,098</td>
<td>1,778</td>
<td>1,877</td>
<td>2,949</td>
</tr>
<tr>
<td>F</td>
<td>1,657</td>
<td>3,315</td>
<td>6,514</td>
<td>8,451</td>
<td>16,782</td>
</tr>
</tbody>
</table>

1c - Standard age-specific rates

Divide each age- and sex-specific standard observed events by the corresponding age- and sex-specific standard population (1a/1b)

<table>
<thead>
<tr>
<th>Sex</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>0.03453</td>
<td>0.06011</td>
<td>0.11080</td>
<td>0.14385</td>
<td>0.21533</td>
</tr>
<tr>
<td>F</td>
<td>0.02716</td>
<td>0.04012</td>
<td>0.05066</td>
<td>0.06283</td>
<td>0.11089</td>
</tr>
</tbody>
</table>

Stage 2: Calculate the expected number of events (deaths) in the subject PCO/Trust A

2a - Denominator population (admissions) of PCO/Trust A by age group

<table>
<thead>
<tr>
<th>Sex</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>9</td>
<td>10</td>
<td>20</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>F</td>
<td>33</td>
<td>35</td>
<td>76</td>
<td>93</td>
<td>172</td>
</tr>
</tbody>
</table>
**2b - Expected events (deaths) in PCO/Trust A by age group**

Multiply each age-and sex-specific denominator population for PCO/Trust A by the corresponding age- and sex-specific standard rate (2a x 1c)

<table>
<thead>
<tr>
<th>Sex</th>
<th>65-69</th>
<th>70-74</th>
<th>75-79</th>
<th>85-89</th>
<th>90+</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>0.31</td>
<td>0.60</td>
<td>2.22</td>
<td>3.16</td>
<td>7.32</td>
</tr>
<tr>
<td>F</td>
<td>0.90</td>
<td>1.40</td>
<td>3.85</td>
<td>5.84</td>
<td>19.07</td>
</tr>
</tbody>
</table>

**Stage 3: Calculate the indirectly standardised ratio**

Sum the sex-specific expected events across all appropriate age groups to give a total number of expected events for each sex. The person total expected is the sum of the male and female expecteds. Divide the total observed events by the total expected events to give the standardised ratio. Use Byar's approximation to calculate the upper and lower limits of the 95% confidence interval.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Total Observed</th>
<th>Total Expected</th>
<th>Ratio</th>
<th>Ratio LL</th>
<th>Ratio UL</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>14</td>
<td>13.61</td>
<td>1.0284</td>
<td>0.5617</td>
<td>1.7256</td>
</tr>
<tr>
<td>F</td>
<td>40</td>
<td>31.07</td>
<td>1.2875</td>
<td>0.9197</td>
<td>1.7533</td>
</tr>
<tr>
<td>P</td>
<td>54</td>
<td>44.68</td>
<td>1.2086</td>
<td>0.9078</td>
<td>1.5769</td>
</tr>
</tbody>
</table>

**Stage 4: Calculate the crude rate for the standard population (England admissions)**

Sum the standard observed events and standard denominator population across both sexes and all the age groups. Divide the total observed events by the total denominator population to give the standard crude rate.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Total Observed</th>
<th>Total Denominator</th>
<th>Crude Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>4,092</td>
<td>45,116</td>
<td>0.0907</td>
</tr>
</tbody>
</table>

**Stage 5: Calculate the indirectly standardised rate**

Multiply the person standardised ratio and its lower and upper limits by the standard crude rate (4 x 5)

<table>
<thead>
<tr>
<th>Sex</th>
<th>ISR</th>
<th>ISR LL</th>
<th>ISR UL</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>10,961.6</td>
<td>8,234.1</td>
<td>14,302.9</td>
</tr>
</tbody>
</table>

The following indicator has been standardised for the operative procedure (OPCS4 chapter / selective sub-chapters) in additional to age and sex:

- CI1A: Deaths in hospital and after discharge within 30 days of surgery (non-elective admissions).

This has been undertaken to remove differences in these indicators caused by the differences in the case-mix of the patients treated by each trust. The indirect method of standardisation described above was used and the calculation follows closely that of the specific example for hip fractures, but with expected numbers of events being derived for each combination of age group/sex/OPCS4 Chapter. The introduction of the additional factor makes the tables very much larger.

**Note:** Where data are presented individually for more than one year, one year will be used to provide the national standard rates against which data for all the years are standardised. This is necessary to facilitate comparisons between the years. This base year not only provides the standard rates used to calculate the expected numbers of events, but also the overall crude rate by which the standardised ratios are multiplied to produce the standardised rates.

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References
