Communicating uncertainty and change

Guidance for official statistics producers

November 2014
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Communicating uncertainty and change: Guidance for official statistics producers

Introduction

Uncertainty is completely normal in statistics, but for many of the users of official statistics, the word “uncertainty” also means “unreliable”. As a result, there is understandable concern that making information about uncertainty easily accessible might reduce users’ confidence in the numbers that we publish. But this shouldn’t be the case. Being upfront about uncertainty helps to protect integrity and ensures that users do not draw conclusions that are not supported by the statistics. The challenge for the GSS when communicating uncertainty and change is to provide information and explanation in a way that provides assurance and supports understanding. Official statistics inform and underpin important decisions and it is essential that statistical uncertainty is clearly communicated so that we help users get the clearest picture of what the statistics show. The Code of Practice for Official Statistics strongly emphasises the need for clear, frank communication of these issues.

Statistics based on surveys have uncertainty caused by both sampling and non-sampling errors. Those which are produced from administrative sources and which may appear to provide definitive counts also have uncertainty from the data collection (including issues about definitions, coverage and timeliness), the effects of imputation or editing, or the impact of manipulating the data. The uncertainty in data from mixed sources (such as rates calculated from both administrative data and population estimates) also needs proper explanation.

The way we communicate uncertainty and change for these different types of statistics needs to be tailored to suit the audience. We should offer users the opportunity to “zoom in” according to their needs and be able to find detailed information when they require it. However, information about uncertainty that is critical to allow users to assess and use statistics sensibly should be easy to find and not hidden in background appendices or footnotes. The guidance aims to provide practical advice on how to achieve this.

Who is this guidance for?

The guidance is aimed at all staff involved in communicating official statistics, irrespective of the format used for dissemination. It provides practical advice about describing uncertainty and change in statistics to enable the audience to make better use of the numbers that are being presented.
What does this guidance cover?

The guidance covers two topics - uncertainty and change. Both are fundamental for official statistics, and are closely related:

- Uncertainty describes the sum total of possible errors that affect the accuracy of a statistic. It includes the impact of sampling error (related to sample surveys) and all other sources of error that exist in a data source.

- Change is the difference between measures of the same phenomenon at two different time points. In this guidance, we exclude the issue of reporting on revisions (i.e. the difference between estimates of different vintages that refer to the same time point).  

The guidance provides a common approach to aid the clear communication of uncertainty and change. It can be applied to all sources of information, including surveys, censuses, administrative data and other sources, as well as estimates derived from a combination of these. It includes examples of good practice, as well as standard wording to be used when appropriate.

The guidance does not cover how to measure uncertainty and change, as this is very much dependent on the specifics of particular data collection scenarios. Links to information which may be helpful on this topic are provided at the end of this guidance.

How should this guidance be used?

The guidance is a tool to support statistics producers when writing about statistics. It is not meant to be overly prescriptive. When implementing the guidance, you will need to use your knowledge and judgement to decide the best way to communicate uncertainty and change to your specific audience. The level of detail you need to provide should take account of the importance of the information and the user need for this, without overwhelming the user with detail. Engaging with your users and getting their feedback will help to achieve this.

The guidance outlines the high level principles that we should aim for when communicating uncertainty and change. This is followed up with practical advice on how to apply these principles.

This guidance will continue to evolve as we learn more about the successful ways to communicate uncertainty and change. It should be used alongside other more detailed guidance on reporting quality, which can be found on the GSS website.

---

1 The Code of Practice for Official Statistics and accompanying National Statistician’s guidance contains information on reporting revisions to statistics.
Principles for communicating uncertainty and change

The principles for communicating uncertainty and change apply regardless of the source of the statistics.

Overall, you should provide sufficient and appropriate information to:
- allow users to judge whether the estimates are fit for their purpose
- maintain and build users’ confidence in the estimates

You should provide sufficient and appropriate information to indicate:
- the quality of the statistics
- the level of uncertainty in the statistics
- the direction, actual and/or relative size of any change
- the level of uncertainty in the estimate of change
- a longer term view of change (e.g. trend)

The following pages give practical advice on how to apply these principles. They use the idea of “progressive disclosure” – starting with simple, high-level information on uncertainty and change, and building on this to provide more detailed technical information.

How to apply the principles

This section provides practical guidance on how to apply the principles. The guidance is split into things that you should do and things that you could do. It can be applied to statistics from all sources, but where there are points relevant to particular source types this is mentioned in the text.

The guidance contains a range of examples which demonstrate how the principles have been applied in practice. These are signposted throughout this section.
Early on in the publication

You should...

✓ Use the word *estimates* to describe the numbers, where appropriate.
✓ Include a high-level, plain English description of the likely sources of uncertainty. Sources might include sampling variations; non-sampling variations; definitions, processes and systems used by data suppliers; any checks or adjustments made to the data.
✓ Provide information on the size and direction of the uncertainty and its potential impact on the statistics.
  • Where possible, quantify the impact of uncertainty on the statistics precisely.
  • Where it is not possible to quantify the impact, make reasoned judgements about the likely size and direction of the uncertainty and the potential impact on the statistics.
✓ Include high-level information on any adjustments made to the data before publication (for example, imputation, seasonal adjustment).
✓ Describe the direction of change, its absolute size and its relative size over time.
✓ Describe the long term trend and how the current change fits with this pattern.

You could...

✓ Provide information on change across a range of appropriate time periods. For example:
  • For monthly publications, provide the month on month change, month on last year change, plus a longer time series (e.g. five years).\(^2\)
  • For quarterly publications, provide the quarter on quarter change, quarter on last year change, plus a longer time series (e.g. five years).
  • For annual publications, provide the year on year change, plus a longer time series (e.g. ten years).
✓ Provide a longer time series beyond five or ten years if this adds useful additional context and a link to the entire time series if the data are available.
✓ For survey data, explain whether a change is statistically significant. Provide a plain English description of statistical significance.

\(^2\) For volatile data, it might be more appropriate to use rolling averages rather than data for individual months.
In narrative sections of the publication

You should...

- Clearly indicate any changes in definitions, methods of collection, editing, imputation or other issues that affect the data and how they impact on the use of the statistics.

You could

- Provide information on change across a range of appropriate time periods, with appropriate supporting commentary. For example:
  - For monthly publications, provide the month on month change, month on last year change, plus a longer time series.
  - For quarterly publications, provide the quarter on quarter change, quarter on last year change, plus a longer time series.
  - For annual publications, provide the year on year change, plus a longer time series.

- For survey data, explain whether a change is statistically significant. Provide a plain English description of statistical significance.

In tables

You should...

- Clearly indicate in each table any changes in definitions, methods of collection, editing, imputation or other issues that affect the data.

- Publish quantitative measures of uncertainty, where they are available. For example:
  - For survey data - confidence intervals, standard errors, relative standard errors, coefficients of variation.
  - For administrative data - measures of coverage and completeness, editing rates, imputation rates.

You could...

- Use colour coding or asterisks to highlight relative levels of uncertainty in the data. (Colour coding usually works best with coefficients of variation)
In background or quality notes

You should...

✓ Provide a description of the data collection and quality assurance processes.
✓ Include a detailed description of the likely sources of uncertainty. Sources might include sampling variations; non-sampling variations; definitions, processes and systems used by data suppliers; any checks or adjustments made to the data.
✓ Provide more detailed information on the size and direction of the uncertainty and its potential impact on the statistics.
  • Where possible, quantify the impact on the statistics.
  • Where it is not possible to quantify the impact, make reasoned judgements about the likely size and direction of the uncertainty and the potential impact on the statistics.
✓ Include quantitative measures of uncertainty, where they are available (see the section on tables above for examples for both survey and administrative data).
✓ For survey data, include relevant information on the sample size and response rates.
✓ Include detailed information on any adjustment made to the data before publication (for example, imputation, seasonal adjustment).

You could...

✓ Include information on any comparisons made with other sources.
✓ For survey data, include definitions of concepts like coefficient of variation, confidence interval and statistical significance, where appropriate.
✓ Consider how you can visualise the uncertainty in the data using charts, diagrams or infographics.

Chart 2. % of drivers self-reporting drink (left hand only) and drug (right hand only) driving at least once in the last year: 2010/11 onwards. Error bars show 95% confidence intervals.

Error bars are used here by the Department of Transport to show confidence intervals.
Examples of communicating uncertainty and change

This section contains some examples from across the GSS and beyond of communicating uncertainty and change. These examples are not intended to serve as templates and you may be able to think of ways the examples could be improved. The aim is to share good practice and help develop an understanding of the different ways of approaching this topic.

1. Communicating uncertainty and change early on in a publication

This example from UK Labour Market shows the first bullet point from the set of key points. It uses the word “estimates” to describe the figures and puts the latest change in the longer term context.

Comparing the estimates for March to May 2014 with those for December 2013 to February 2014, employment continued to rise and unemployment continued to fall. These changes continue the general direction of movement over the past two years.

The UK Labour Market report also contains information early on about the accuracy and reliability of the statistics in clear, simple language. This information is part of the section Understanding and working with labour market statistics, which comes immediately after the key points and a summary table.

Accuracy and reliability of survey estimates

Most of the figures in this Statistical Bulletin come from surveys of households or businesses. Surveys gather information from a sample rather than from the whole population. The sample is designed carefully to allow for this, and to be as accurate as possible given practical limitations such as time and cost constraints, but results from sample surveys are always estimates, not precise figures. This means that they are subject to a margin of error which can have an impact on how changes in the numbers should be interpreted, especially in the short-term.

Changes in the numbers reported in this Statistical Bulletin (and especially the rates) between three month periods are usually not greater than the margin of error. In practice, this means that small, short-term movements in reported rates (for example within +/- 0.3 percentage points) should be treated as indicative, and considered alongside medium and long-term patterns in the series and corresponding movements in administrative sources, where available, to give a fuller picture.

Further information is available in the Accuracy of the Statistics: Estimating and Reporting Uncertainty section of this Statistical Bulletin.
2. Communicating statistical significance

This example from *Crime in England and Wales* describes change over the short and medium term, using statistical significance.

The CSEW showed no statistically significant change in the levels of violence based on interviews in the year ending March 2013 compared with the previous year (the apparent 6% decrease was not statistically significant). Figure 4 shows that this continues a general trend seen over the last decade where the CSEW has seen a sustained period of modest annual decreases (though often not large enough to be statistically significant year on year). However, the cumulative effect of these changes is statistically significant over the medium-term with the estimated number of violent incidents having decreased 13% between the 2007/08 survey and the 2012/13 survey (Table 5b).

Significance is also discussed in the commentary for statistics on *drink driving and drug driving*.
3. Communicating changes in definitions or methods

When the method for calculating statistics on cancer registrations changed, some high level information on this was included in the statistical report, which highlighted the impact the changes had. This information was included on the front page, after the key points.

New European Standard Population 2013
The age-standardised cancer incidence rates produced in this report and in the associated reference tables have been calculated using the new 2013 European Standard Population (ESP). Eurostat updated the ESP for the first time since it was introduced in 1976, to make it more representative of the current population in Europe (Eurostat, 2013). For almost all cancers, the age-standardised cancer incidence rates for registrations are higher when calculated using the 2013 ESP, and for some cancers, this change is large. This is because the age distributions of diagnoses differ depending on the type of cancer. More information about the impact of this change can be found on the ONS website.

This was supplemented by separate methodological documents which explained the changes in more detail for expert users of the statistics.

These two examples from Crime in England and Wales highlight how changes in recording practices may have had an impact on the statistics. These were included in the relevant narrative sections of the publication, alongside the figures themselves.

The remaining 6% of recorded crimes were fraud offences. There were 211,344 fraud offences recorded by Action Fraud and the police in the year ending March 2014 (an increase of 17% on the previous year). However, trends in fraud should be interpreted with caution. It is unclear to what extent there has been a genuine increase in such crimes or whether the move to the centralised recording of such offences has led to improved counting of fraud offences; see the “Total fraud offences recorded by the police (including via Action Fraud)” section for further details.
Police recorded crime figures showed an increase of 20% in all sexual offences for the year ending March 2014 compared with the previous year (up from 53,620 to 64,200; Table 9a). This is the highest level recorded since the introduction of the Crime Recording Standard (NCRS) in April 2002.

There are several possible factors feeding into this increase which are discussed below:

- The effect of Operation Yewtree linked to the Jimmy Savile inquiry;
- Review of the sexual offences guidance within the Home Office Counting Rules (HOCR) to provide further clarity for recording sexual offences; and
- Investigation by Her Majesty’s Inspectorate of Constabulary (HMIC) and HM Crown Prosecution Service Inspectorate (HMCPSI) into the recording and prosecution of sexual offences.

4. Communicating uncertainty and change in reference tables

The Welsh Government’s National Survey for Wales uses colour coding in reference tables to visually convey the relative levels of uncertainty in the statistics.

<table>
<thead>
<tr>
<th>Estimate is precise</th>
<th>Estimate is reasonably precise</th>
<th>Estimate is considered acceptable</th>
<th>Estimate is not reliable</th>
<th>Value is suppressed due to small cell size (fewer than 30 responses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ≤ CV &lt; 5</td>
<td>5 ≤ CV &lt; 10</td>
<td>10 ≤ CV &lt; 20</td>
<td>CV ≥ 20</td>
<td></td>
</tr>
</tbody>
</table>

As with any survey, the National Survey is also subject to a range of other sources of error: for example, due to non-response; because respondents may not interpret the questions as intended or answer accurately; and because errors may be introduced as the survey data is processed. These kinds of error are known as non-sampling error, and are discussed further in the Quality Report for the survey.

Table 13: Parents’ satisfaction with their child’s school (a)

<table>
<thead>
<tr>
<th>Primary School</th>
<th>Secondary School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lower</td>
</tr>
<tr>
<td>Very satisfied</td>
<td>68</td>
</tr>
<tr>
<td>Fairly satisfied</td>
<td>24</td>
</tr>
<tr>
<td>Neither satisfied nor dissatisfied</td>
<td>3</td>
</tr>
<tr>
<td>Fairly dissatisfied</td>
<td>4</td>
</tr>
<tr>
<td>Very dissatisfied</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: National Survey for Wales, April 2013 - March 2014
Sample size: Primary school 1,900; Secondary School 1,400
(a) This question was only asked of parents of children who attended a local authority funded primary or secondary school
The Annual Survey of Hours and Earnings uses a similar approach in its reference tables.

Colour coding is a potentially useful, visual way to communicate this information, although you might have different ideas which CV bands to use (or the words to describe the bands) which might better suit your statistics.

When using colour coding, consider how the colours will appear when printed in black and white, as well as how they will appear to people with colour-blindness.

The example below illustrates a different approach to highlighting uncertainty in tables. Instead of colour coding, it uses asterisks to demonstrate the relative levels of uncertainty.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Managers, directors and senior officials</td>
<td>1</td>
<td>239.5</td>
<td>69.2</td>
<td>13</td>
<td>795.0</td>
<td>11</td>
<td>390.0</td>
<td>240.2</td>
<td>459.3</td>
<td>969.2</td>
<td>989.0</td>
<td>117.9</td>
<td>989.0</td>
<td>1007.3</td>
<td>1222.4</td>
<td>1001.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subofficers</td>
<td>2</td>
<td>190.9</td>
<td>213.3</td>
<td>40</td>
<td>127.0</td>
<td>422.0</td>
<td>103.0</td>
<td>409.1</td>
<td>167.9</td>
<td>150.3</td>
<td>150.3</td>
<td>20.0</td>
<td>150.3</td>
<td>150.3</td>
<td>20.0</td>
<td>150.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chief executives and senior officials</td>
<td>1</td>
<td>170.3</td>
<td>22.4</td>
<td>15</td>
<td>1352.4</td>
<td>0.2</td>
<td>470.0</td>
<td>294.0</td>
<td>329.4</td>
<td>640.5</td>
<td>190.0</td>
<td>1079.0</td>
<td>150.0</td>
<td>2010.0</td>
<td>2010.0</td>
<td>2010.0</td>
<td></td>
<td></td>
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<tr>
<td>Directors and senior officials</td>
<td>1</td>
<td>110.3</td>
<td>18.4</td>
<td>3.4</td>
<td>1352.0</td>
<td>-0.2</td>
<td>576.0</td>
<td>820.0</td>
<td>926.0</td>
<td>1247.0</td>
<td>1247.0</td>
<td>190.0</td>
<td>1247.0</td>
<td>1247.0</td>
<td>1247.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Supervisors and senior officials</td>
<td>1</td>
<td>5.4</td>
<td>6.9</td>
<td>2.8</td>
<td>28.4</td>
<td>29.5</td>
<td>29.0</td>
<td>29.6</td>
<td>29.7</td>
<td>29.8</td>
<td>29.9</td>
<td>30.0</td>
<td>30.1</td>
<td>30.2</td>
<td>30.3</td>
<td>30.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production managers and officials</td>
<td>1</td>
<td>59.8</td>
<td>26.9</td>
<td>2.1</td>
<td>898.0</td>
<td>0.3</td>
<td>326.7</td>
<td>678.1</td>
<td>538.2</td>
<td>787.2</td>
<td>678.0</td>
<td>826.4</td>
<td>1097.6</td>
<td>1097.6</td>
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<td></td>
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<td>Production managers and officials in manufacturing</td>
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<td>49.9</td>
<td>77.1</td>
<td>0.1</td>
<td>195.0</td>
<td>0.0</td>
<td>418.2</td>
<td>678.1</td>
<td>538.2</td>
<td>787.2</td>
<td>678.0</td>
<td>826.4</td>
<td>1097.6</td>
<td>1097.6</td>
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<td></td>
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<tr>
<td>Production managers and officials in mining, quarrying and energy industries</td>
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<td>96.4</td>
<td>22.7</td>
<td>0.3</td>
<td>386.3</td>
<td>0.1</td>
<td>396.9</td>
<td>698.9</td>
<td>5275.6</td>
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<td>297.9</td>
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<td>881.9</td>
<td>1279.0</td>
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<tr>
<td>Production managers and officials in transport, storage and communication</td>
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<td>3.4</td>
<td>3.4</td>
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<td>3.4</td>
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<tr>
<td>Others</td>
<td>1</td>
<td>81.2</td>
<td>111.2</td>
<td>0.2</td>
<td>155.2</td>
<td>0.0</td>
<td>398.6</td>
<td>574.9</td>
<td>495.2</td>
<td>786.9</td>
<td>393.4</td>
<td>133.0</td>
<td>133.0</td>
<td>444.8</td>
<td>669.4</td>
<td>243.0</td>
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<tr>
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<td>97.0</td>
<td>91.0</td>
<td>-0.4</td>
<td>193.6</td>
<td>-2.9</td>
<td>322.7</td>
<td>599.6</td>
<td>6205.9</td>
<td>699.9</td>
<td>699.9</td>
<td>1549.9</td>
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<td>Employment and earnings, excluding the public sector</td>
<td>102</td>
<td>34.6</td>
<td>34.6</td>
<td>34.6</td>
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<td>34.6</td>
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<tr>
<td>Other employees</td>
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<td>881.1</td>
<td>597.4</td>
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<td>-0.1</td>
<td>5.2</td>
<td>-0.1</td>
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<tr>
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<td>6.0</td>
<td>-0.1</td>
<td>8.8</td>
<td>-0.1</td>
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<td>-0.1</td>
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<td>-0.1</td>
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<td>3.1</td>
<td></td>
</tr>
</tbody>
</table>

Colour coding is a potentially useful, visual way to communicate this information, although you might have different ideas which CV bands to use (or the words to describe the bands) which might better suit your statistics.

When using colour coding, consider how the colours will appear when printed in black and white, as well as how they will appear to people with colour-blindness.

The example below illustrates a different approach to highlighting uncertainty in tables. Instead of colour coding, it uses asterisks to demonstrate the relative levels of uncertainty.
5. Communicating uncertainty and change in quality notes

The *Households Below Average Income* report contains a chapter towards the end of the publication which is dedicated to communicating uncertainty. This provides more detail which builds on the high-level information provided earlier in the report. This chapter contains detailed information on the types of uncertainty in the data (for example, sampling error and non-sampling error) and explains statistical significance and confidence intervals. The 95% confidence limits for a number of statistics are given in this chapter.

Statistics on road casualties (which are based on administrative data) are clearly presented as estimates. Information is included on the coverage of the statistics and advice is provided to avoid inappropriate use.

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3. Strengths and weaknesses of the data

- The quarterly figures are based on estimates. It should be noted that no single quarter’s figures should be taken in isolation, especially if they appear to show a change in trend, as there are seasonal fluctuations particularly in the smaller categories of road user. The 2013 Q2 results are based on complete (April to June 2013) figures provided by 47 police authorities with partial data for two authorities and no data for one authority. Adjustments are made to take account of police authorities with missing data. Table RAS45011 provides a list of which police authorities are included in these figures.

- Comparisons of road accident reports with death registrations show that very few, if any, road accident fatalities are not reported to the police. However, it has long been known that a considerable proportion of non-fatal casualties are not known to the police, as hospital, survey and compensation claims data all indicate a higher number of casualties than police accident data would suggest.

- Our current best estimate, derived primarily from National Travel Survey (NTS) data and produced in 2012, is that the total number of road casualties in Great Britain each year, including those not reported to police, is within the range 630 thousand to 790 thousand with a central estimate of 710 thousand. A methodology note containing guidance as to how this estimate has been derived and its limitations, together with information on complementary sources of data on road accidents and casualties, can be found at:

- The data used as the basis for these statistics are therefore not a complete record of all personal injury road accidents, and this should be borne in mind when using and analysing the figures. However, police data on road accidents (STATS19), whilst not perfect, remain the most detailed, complete and reliable single source of information on road casualties covering the whole of Great Britain, in particular for monitoring trends over time.
6. Visualising change and uncertainty

The example on drink driving and drug driving statistics in section two shows how error bars can be used to communicate confidence intervals. The *Understanding Uncertainty* website also provides a collection of examples of visualising uncertainty.

The Health and Safety Executive’s annual statistics report uses a range of techniques for visualising change and uncertainty.

Errors bar can be used to show confidence intervals, like in this example on drink driving and drug driving.
An infographic was used to help communicate how low income is measured in the Households Below Average Income report. This included a section explaining the concept of uncertainty in the statistics.
Other relevant guidance and information

The following documents provide information on measuring uncertainty, which complement this guidance. They provide suggestions and guidance on a range of measures of quality and uncertainty, which can be used to help communicate uncertainty to users of the statistics.

- **Guidelines for measuring statistical quality**: Government Statistical Service
  This provides good practice guidance and a checklist of measures for reporting quality in statistical outputs. It includes suggested measures for statistics from surveys, administrative data and mixed sources.

- **Quality assurance and audit arrangements for administrative data**: UK Statistics Authority
  This provides conceptual and practical guidance on auditing administrative data and communicating the findings of the audit to users of the statistics.