Government Statistical Service

Communicating uncertainty and change

Guidance for official statistics producers

November 2014

Version 1

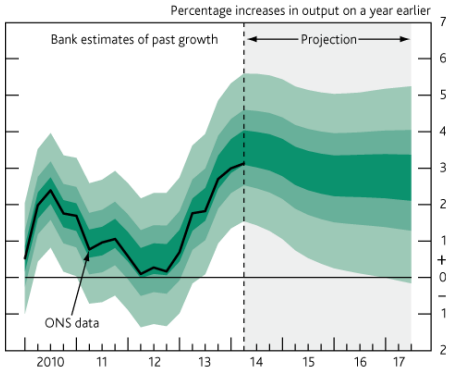
Contents

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 gets the clearest picture if 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.



Bank of England fan charts, illustrating uncertainty around GDP estimates

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)[1].

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

See example 1

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.

See example 2

[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

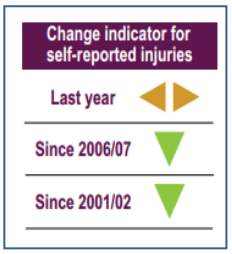
See example 3

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

See example 4

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

See example 5

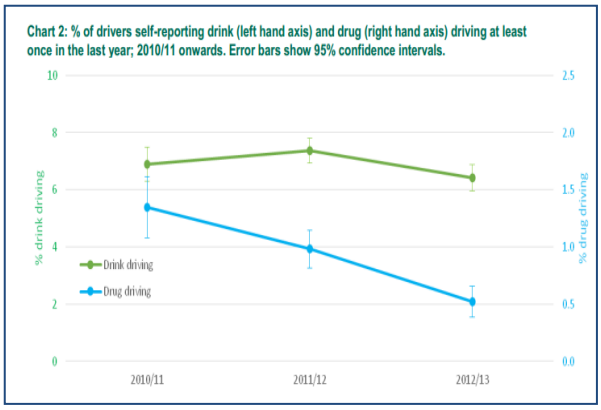
You should...

- ✓ 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

See example 6



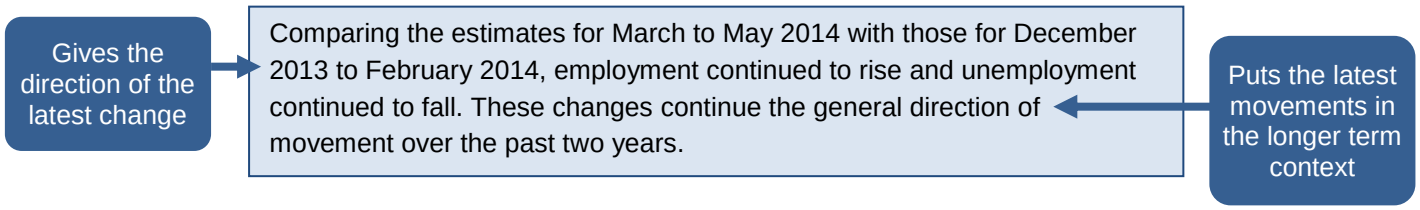
Error bars are used here by the Department of Transport to show confidence intervals

Examples of communicating uncertainty and change

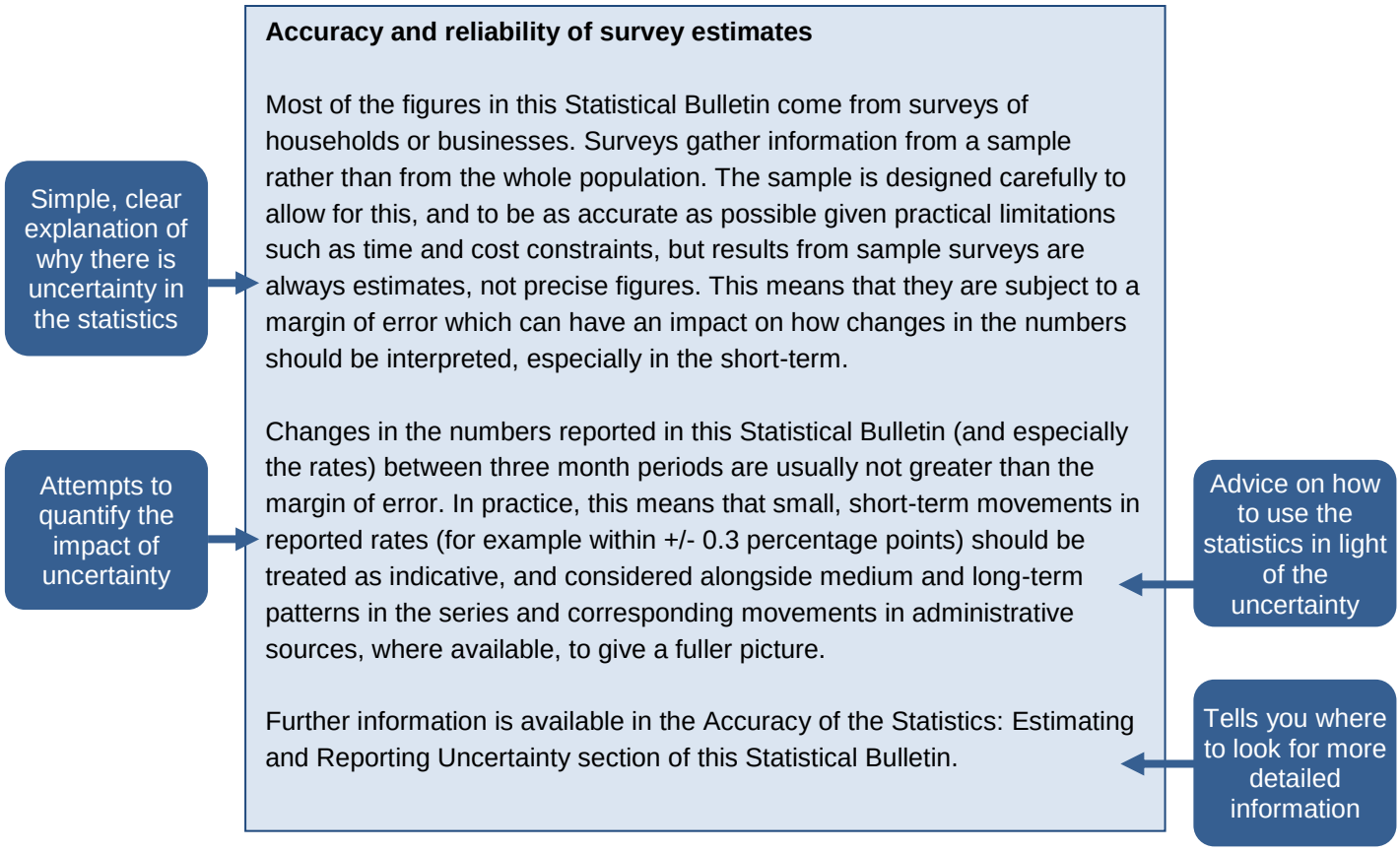
This section contains some examples from across the GSS and beyond of communicating uncertainty and change. These examples are not intended to serve as templates and you may be able to think of ways the examples could be improved. The aim is to share good practice and help develop an understanding of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



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.



2. Communicating statistical significance

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

Gives the latest change and states this is not significant

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).

Puts the latest change in the longer term context

Gives the significance of the longer term change

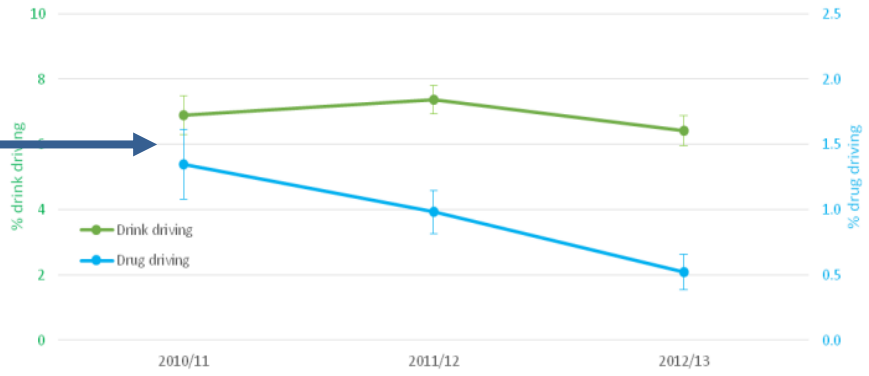
Significance is also discussed in the commentary for statistics on drink driving and drug driving.

Confidence intervals shown on the chart

Trends over time

- Chart 2 below compares the prevalence of self-reported drink and drug driving each year from 2010/11 onwards.

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



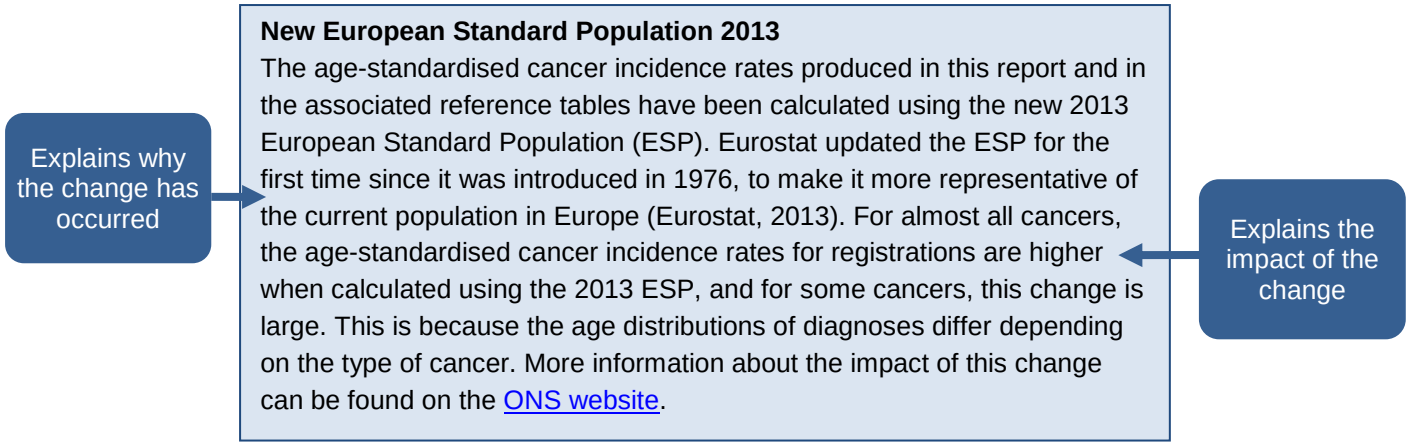
- Although the proportion who reported drink driving within the last year (green line) has been relatively stable, the proportion for drug driving (blue line) has seen a statistically significant decrease, from 1.3 per cent in 2010/11 to just 0.5 per cent in 2012/13.
- A decrease in drug driving could simply be due to a reduction in general drug use amongst the drivers. However, if we consider only the sub-set of drivers who stated that they had used drugs (in any context) within the last year, we still see a reduction in the proportion reporting drug driving: in 2010/11, 20 per cent of drivers who had taken an illegal drug in the past 12 months reported that they had driven under the influence of an illegal drug; by 2012/13, this had fallen to 9 per cent. This suggests that the apparent reduction in self-reported drug driving is not simply due to a reduction in general drug use, but a reduction in drug driving, even amongst those drivers who do take drugs.
- Care is needed when comparing year-on-year trends from sample surveys and even changes that appear to be statistically significant can still be the result of random fluctuations. As more data is added to the time series each year, it will be possible to monitor the longer term trends and put individual changes in context.

Gives significance of the change over two years

Provides advice on interpreting the statistics

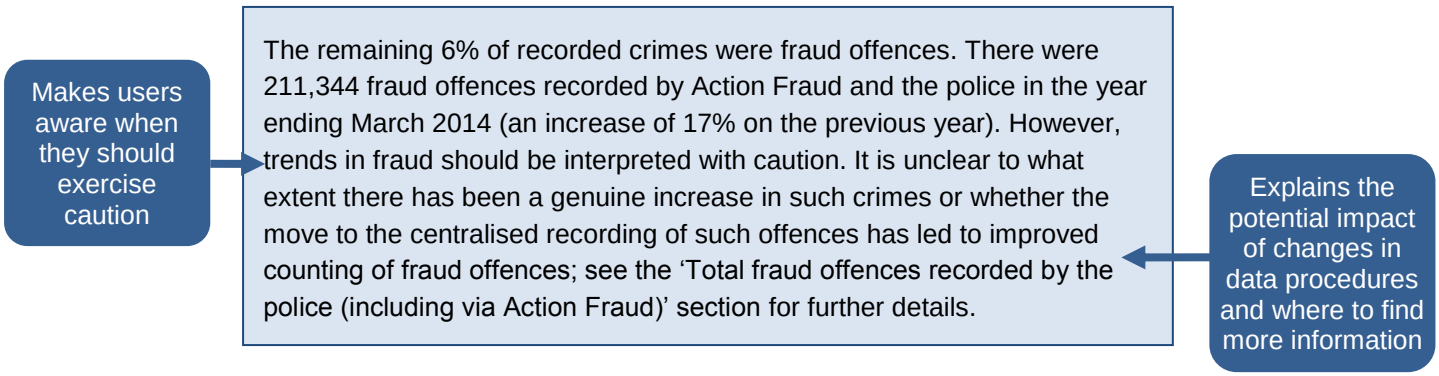
3. Communicating changes in definitions or methods

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.



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.



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.

Clearly indicates changes that may have affected the statistics

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.

The results presented in the Annex have been colour coded according to the CV for each result as follows.

Estimate is precise	0 ≤ CV < 5
Estimate is reasonably precise	5 ≤ CV < 10
Estimate is considered acceptable	10 ≤ CV < 20
Estimate is not reliable	CV ≥ 20
- Value is suppressed due to small cell size	(fewer than 30 responses)

Colour coding based on coefficient of variation

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)

	Primary School			Secondary School		
	%	lower CI	upper CI	%	lower CI	upper CI
Very satisfied	68	65	70	49	46	52
Fairly satisfied	24	22	26	36	33	39
Neither satisfied nor dissatisfied	3	2	4	6	4	8
Fairly dissatisfied	4	3	5	6	4	7
Very dissatisfied	1	1	2	3	2	5

Confidence intervals provided

Source: National Survey for Wales, April 2013 - March 2014

Sample size: Primary school 1,900, Secondary School 1,400

Sample size for these statistics is given

(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.

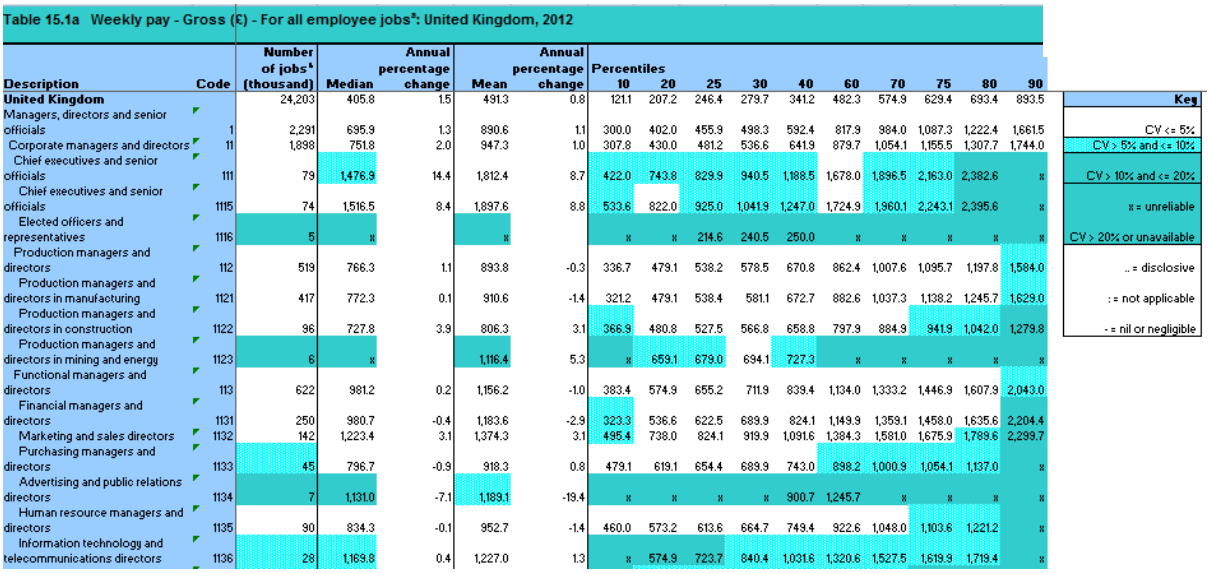


Table 15.1a Weekly pay - Gross (£) - For all employee jobs[a]: United Kingdom, 2012

Description	Code	Number of jobs[k] (thousand)	Median	Annual percentage change	Mean	Annual percentage change	Percentiles 10	20	25	30	40	60	70	75	80	90
United Kingdom		24,203	405.8	1.5	491.3	0.8	121.1	207.2	246.4	279.7	341.2	482.3	574.9	629.4	693.4	893.5
Managers, directors and senior officials	1	2,291	695.9	1.3	890.6	1.1	300.0	402.0	455.9	498.3	592.4	817.9	984.0	1,087.3	1,222.4	1,661.5
Corporate managers and directors	11	1,898	751.8	2.0	947.3	1.0	307.8	430.0	481.2	536.6	641.9	879.7	1,054.1	1,155.5	1,307.7	1,744.0
Chief executives and senior officials	111	79	1,476.9	14.4	1,812.4	8.7	422.0	743.8	829.9	940.5	1,188.5	1,678.0	1,896.5	2,163.0	2,382.6	x
Chief executives and senior officials	1115	74	1,516.5	8.4	1,897.6	8.8	533.6	822.0	925.0	1,041.9	1,247.0	1,724.9	1,960.1	2,243.1	2,395.6	x
Elected officers and representatives	1116	5	x		x		x	x	214.6	240.5	250.0	x	x	x	x	x
Production managers and directors	112	519	766.3	1.1	893.8	-0.3	336.7	479.1	538.2	578.5	670.8	862.4	1,007.6	1,095.7	1,197.8	1,584.0
Production managers and directors in manufacturing	1121	417	772.3	0.1	910.6	-1.4	321.2	479.1	538.4	581.1	672.7	882.6	1,037.3	1,138.2	1,245.7	1,629.0
Production managers and directors in construction	1122	96	727.8	3.9	806.3	3.1	366.9	480.8	527.5	566.8	658.8	797.9	884.9	941.9	1,042.0	1,279.8
Production managers and directors in mining and energy	1123	6	x		1,116.4	5.3	x	659.1	679.0	694.1	727.3	x	x	x	x	x
Functional managers and directors	113	622	981.2	0.2	1,156.2	-1.0	383.4	574.9	655.2	711.9	839.4	1,134.0	1,333.2	1,446.9	1,607.9	2,043.0
Financial managers and directors	1131	250	980.7	-0.4	1,183.6	-2.9	323.3	536.6	622.5	689.9	824.1	1,149.9	1,359.1	1,458.0	1,635.6	2,204.4
Marketing and sales directors	1132	142	1,223.4	3.1	1,374.3	3.1	495.4	738.0	824.1	919.9	1,091.6	1,384.3	1,581.0	1,675.9	1,789.6	2,299.7
Purchasing managers and directors	1133	45	796.7	-0.9	918.3	0.8	479.1	619.1	654.4	689.9	743.0	898.2	1,000.9	1,054.1	1,137.0	x
Advertising and public relations directors	1134	7	1,131.0	-7.1	1,189.1	-19.4	x	x	x	x	900.7	1,245.7	x	x	x	x
Human resource managers and directors	1135	90	834.3	-0.1	952.7	-1.4	460.0	573.2	613.6	664.7	749.4	922.6	1,048.0	1,103.6	1,221.2	x
Information technology and telecommunications directors	1136	28	1,169.8	0.4	1,227.0	1.3	x	574.9	723.7	840.4	1,031.6	1,320.6	1,527.5	1,619.9	1,719.4	x

Key
CV <= 5%
CV > 5% and <= 10%
CV > 10% and <= 20%
x = unreliable
CV > 20% or unavailable
.. = disclosive
: = not applicable
- = nil or negligible

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.

Median gross weekly earnings for employees in the York travel to work area, York Unitary Authority and York Central Constituency in current and constant prices, between April 1997 and April 2013

Full-time employees

	Current prices (£) Men		Women		All	
1997	357	*	236	*	297	*
1998	363	*	252	*	319	
1999	367	*	265	*	335	*
2000	401		284	*	369	
2001	386		300	*	356	
2002	429		305	*	385	
2003	432		333	*	394	
2004[b]	456		351	*	418	*
2004[c]	439		355	*	413	
2005	435	*	356	*	407	
2006[d]	472		381	*	441	
2006[e]	469		380	*	438	
2007	494	*	371	*	447	*
2008	488	*	405	*	458	
2009	513		399	*	476	
2010	518		437	*	482	
2011[f,h]	517		412	*	481	
2011[g,h]	511		408	*	477	
2012	535		416	*	489	
2013	553		393	*	499	

Part-time employees

	Current prices (£) Men		Women		All	
1997	x		88	*	87	*
1998	83	**	89	*	89	*
1999	x		100	*	100	*
2000	x		116	*	110	*
2001	x		116	**	112	**
2002	x		124	*	118	*
2003	114	**	125	*	124	*
2004[b]	x		130	*	128	*
2004[c]	x		125	*	122	*
2005	x		127	*	124	*
2006[d]	x		141	*	134	*
2006[e]	x		142	*	136	*
2007	x		148	*	144	*
2008	x		150	*	146	*
2009	x		149	*	147	*
2010	121	**	157	*	151	*
2011[f,h]	139	**	150	*	148	*
2011[g,h]	139	**	148	*	147	*
2012	118	**	152	*	144	*
2013	134	**	170	*	158	*

Guide to quality: The coefficient of variation (CV) indicates the quality of a figure; the smaller the CV value, the higher the quality. The true value is likely to lie within +/- twice the CV. For example, for an average of 200 with a CV of 5%, we would expect the population average to be within the range 180 to 220.

Key

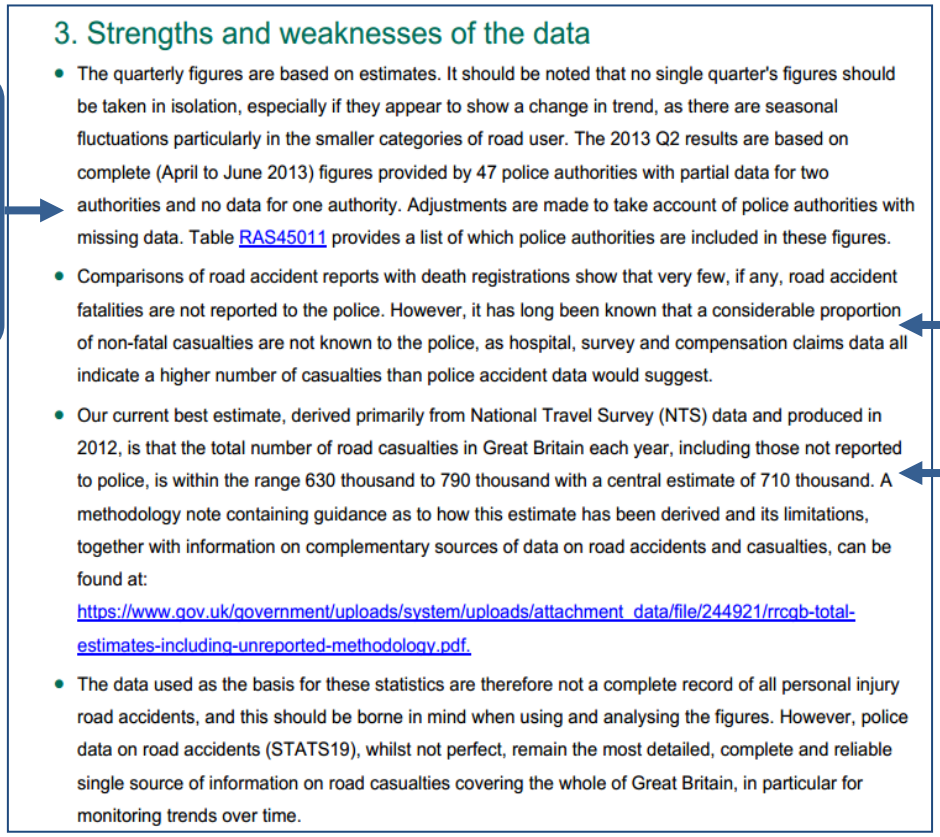
	CV <= 5%
*	CV > 5% and <=10%
**	CV > 10% and <=20%
x	Unreliable

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.

Provides advice on interpreting the statistics and the adjustments that have been made to the statistics



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: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244921/rrcgb-total-estimates-including-unreported-methodology.pdf.
- 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.

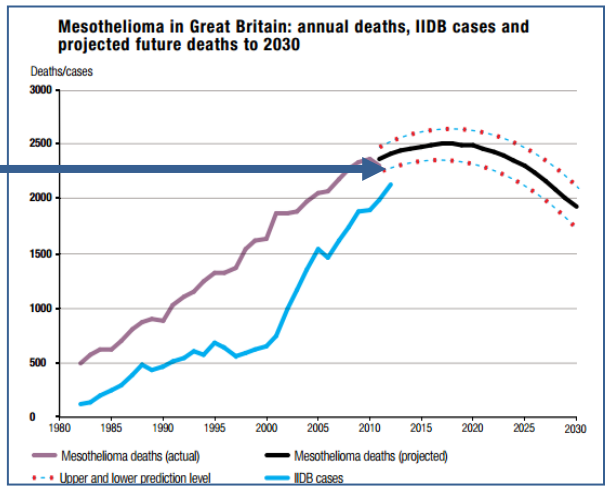
Provides information on coverage, including comparisons with other sources

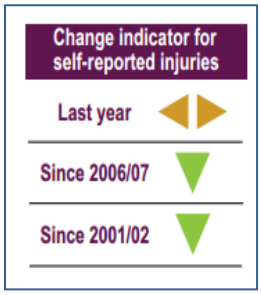
6. Visualising change and uncertainty

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.

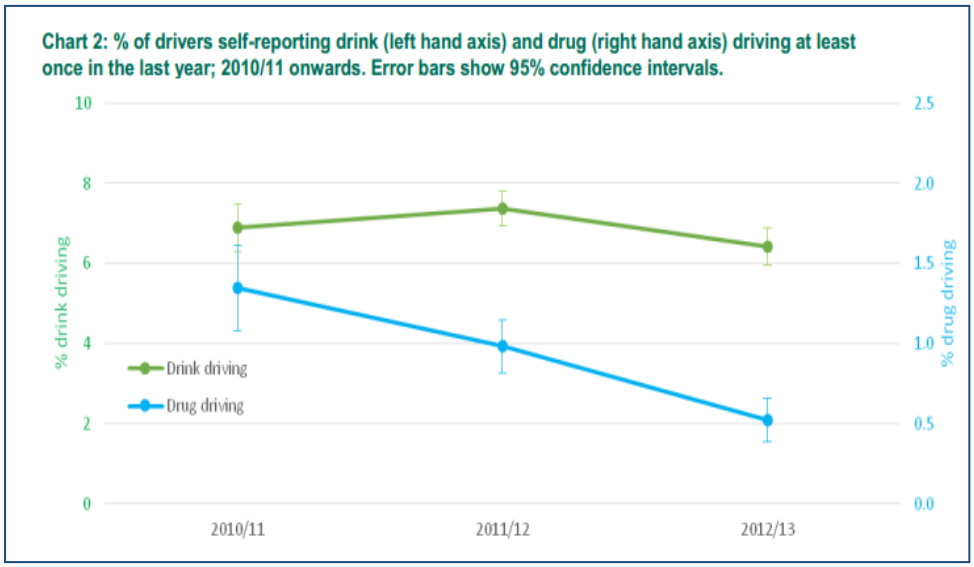
The upper and lower bounds of the prediction are illustrated on the chart



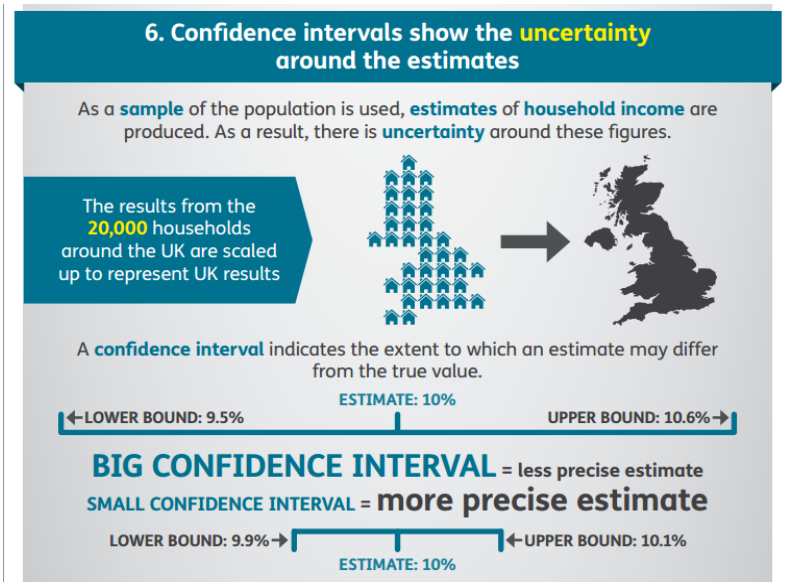


Colour coded arrows illustrate change over a range of time periods

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.