Modelling the PSA1 indicator

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Modelling the PSA1 indicator

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An analysis of the under-reporting of major accidents and over-3-day injuries in RIDDOR reports was examined using various data sources, namely the RIDDOR database of reported accidents, the Labour Force Survey (LFS) and surveys carried out by the Risk Assessment (RA) section of HSL in the manufacturing and services sector. The key points emerging from the analysis were:

- The major accident rate for the manufacturing sector shows little change over the five-year period in both the RIDDOR and RA survey data.
- The reporting levels from the manufacturing sector analysis show a consistently higher reporting for major accidents against over-3-day injuries, with perhaps a trend towards convergence of the levels. This appears to contradict the basic assumption behind the original adjustment analysis, where the model was divergence of reporting levels for the two injury categories from an equal starting point.
- The comparison of overall accident rates from the RA survey and LFS datasets indicates that there is a significant amount of under-reporting within the RA survey itself.
- The trend of an increasing reportable accident rate, as seen in the RA services survey, is not observed in the RIDDOR or LFS data. This suggests that these data may not be useful in determining the relationship (ie reporting level) between the RIDDOR and LFS data.
- The most appropriate adjustment methodology is proposed. A global adjustment of the major accident rate is calculated by using the ratio of major accident to over-3-day injury reporting levels as obtained from the RA survey.
- This adjustment will shift the baseline of the PSA1 indicator down, reflecting the conclusion that the major injury reporting level is higher that the over-3-day reporting level, but leaves the trend in the PSA1 indicator unchanged.

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EXECUTIVE SUMMARY

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- The major accident rate for the manufacturing sector shows little change over the five-year period in both the RIDDOR and RA survey data.
- The reporting levels from the manufacturing sector analysis show a consistently higher reporting for major accidents against over-3-day injuries, with perhaps a trend towards convergence of the levels. This appears to contradict the basic assumption behind the original adjustment analysis, where the model was divergence of reporting levels for the two injury categories from an equal starting point.
- The comparison of overall accident rates from the RA survey and LFS datasets indicates that there is a significant amount of under-reporting within the RA survey itself.
- The trend of an increasing reportable accident rate, as seen in the RA services survey, is not observed in the RIDDOR or LFS data. This suggests that these data may not be useful in determining the relationship (i.e. reporting level) between the RIDDOR and LFS data.
- The most appropriate adjustment methodology is proposed. A global adjustment of the major accident rate is calculated by using the ratio of major accident to over-3-day injury reporting levels as obtained from the RA survey
- This adjustment will shift the baseline of the PSA1 indicator down, reflecting the conclusion that the major injury reporting level is higher that the over-3-day reporting level, but leaves the trend in the PSA1 indicator unchanged

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1 INTRODUCTION

PROJECT OBJECTIVES

Key objectives of the project were:

- To assess the method used to adjust the reported major accident rate
- To propose the most robust method for adjusting the major accident rate
- To obtain an understanding of the trends in major accidents and over-3-day injuries
- To obtain a robust adjusted PSA1 indicator
- To examine the trend in the PSA1 indicator, with a forecast to 2010
- To have the statistical methodology peer reviewed

As part of the Governments 'Revitalising Health and Safety Strategy', HSE have targets measured under the Public Service Agreement (PSA). The target in the PSA1 indicator is to reduce the rate of fatalities and major injuries by 10% of the value in the base year of 1999/2000 by 2010, with a 5% reduction achieved by 2004/05. To accurately assess the progress towards the target it is important to have a robust estimate of the injury rate, with confidence limits calculated with sound statistical methods.

The main data sources are the RIDDOR reported accidents and the Labour Force Survey (LFS). The RIDDOR is a record of all reported accidents but its quality is limited by significant under-reporting. The LFS is a large annual survey, with a small section on accidents, which is currently the main source for estimating the under-reporting in RIDDOR. Additional data sources will be examined to see if the they can be combined with the main sources to reduce the confidence limits around the estimates of accident rates, or to obtain more robust modelling of the trends in the PSA1 indicator.

The key assumptions in the estimation of RIDDOR under reporting utilising the LFS data are:

- There is no under-reporting of fatalities in RIDDOR.
- To estimate the under-reporting of other accidents in RIDDOR by comparison with the LFS, the following assumptions were made and will need to be re-examined for their current validity.
- The injury rates for employees and self-employed workers are not significantly different (from LFS).
- The distribution of injury types (major and over-3-day) in RIDDOR is the same as in the LFS.
- The most appropriate estimate of injury rates from the LFS is a three-year moving average.

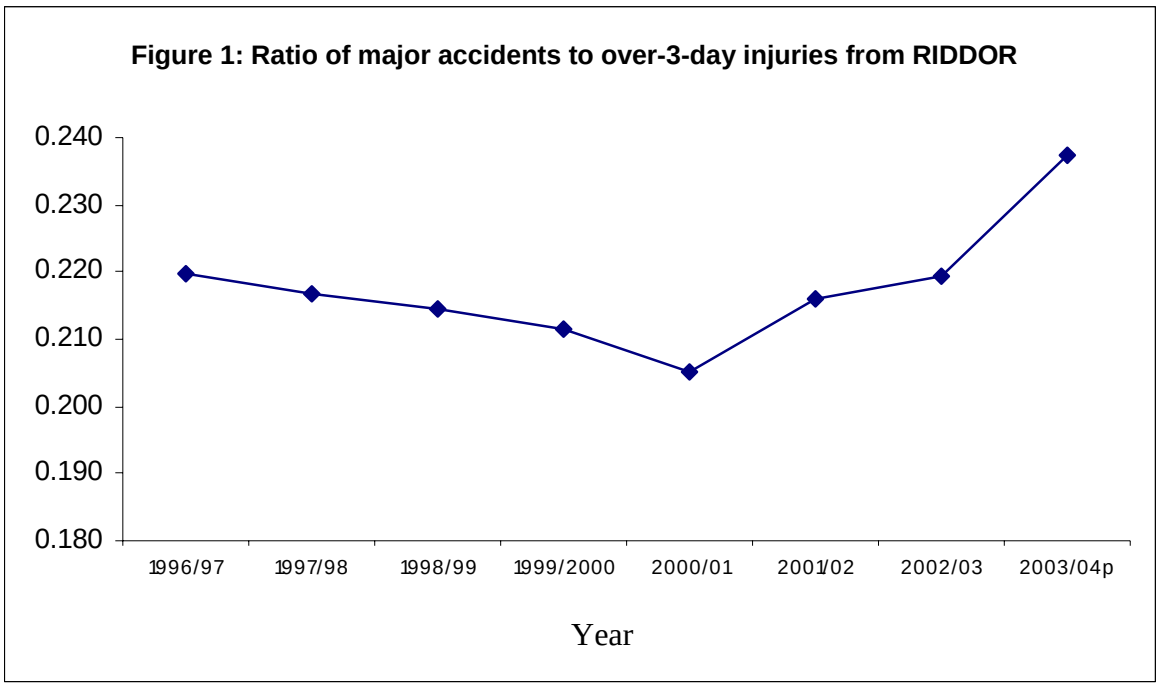
A key limitation in the use of the LFS to estimate the under-reporting of major injuries in RIDDOR is the detail of accident type within the survey. It is not possible to discriminate between major and over-3-day injuries, and it is not possible to have the LFS survey adjusted to enable this discrimination. If the assumption that the distribution of injury types in RIDDOR is the same as in the LFS holds, and can be shown to be a valid assumption, then the reporting level for the accident types will be equal and the calculations can progress straightforwardly to produce separate accident rates for the two types.

However the Safety and Enforcement Statistics Unit (SESU) in HSE has carried out an analysis of the relationship between major and over-3-day injuries and a change in the ratio between major accidents and over-3-day injuries, as reported in 'Health and Safety Statistical Highlights 2002/03.' It can be seen from table 1 that the relationship between major and over-3-day injuries is changing over the years, and it is especially noticeable that the ratio increases by 5.2% between 2000/01 and 2001/02, and then by a further 4.4% in 2002/03, giving an overall increase of 9.9% over the two years.

Table1. Ratio of major to over-3 day injuries (as reported in 'Health and Safety Statistical Highlights 2002/03')

Year	96/97	97/98	98/99	99/00	00/01	01/02	02/03
Ratio Major to Over-3-day injuries	0.220	0.217	0.215	0.212	0.205	0.216	0.226

More recent data are shown in figure 1.



It is important that such variations are incorporated into the methodology for estimating the under-reporting levels and hence calculating the accident rates. The initial adjustment to the methodology was to attribute the variations to differing under-reporting levels for major and over-3-day injuries. The adjustment was calculated on the basis that global (major and over-3-day) under-reporting level, as calculated from the analysis of RIDDOR and LFS, was the value assigned to over-3-day injuries, as this group has the greatest number of events. The under-reporting for the major accidents was then adjusted to produce the variations in the ratio as described above.

The major concern expressed by SESU is that there needs to be evidence for this assumption to be used to calculate the PSA1 indicator, and it is not possible to obtain the evidence to do this from the RIDDOR and LFS alone. Therefore, one of the main objectives of this project is to examine further data sources to obtain the evidence, or propose another methodology for estimating the reporting levels of major and over-3-day incidents if the evidence does not support the initial methodology.

The main source of extra data in addition to the RIDDOR and LFS is the survey carried out by the Risk Assessment Section (RA) of HSL, examining the number of accidents recorded internally by a sample of employers in the manufacturing industry and comparing the internal reporting with the RIDDOR data.

2 ADJUSTMENT METHODOLOGY

The background to the adjustment and the methodology are described in HSE's publication, 'Health and Safety Statistical Highlights – 2002/03', page 36.

In the next section the use of the RA survey in examining the variations in under-reporting will be explored.

First we give a brief examination of the adjustment methodology.

2.1 ADJUSTMENT CALCULATIONS

The basis for the adjustment is the ratio of the major injury rate to over-3-day injury rate from the RIDDOR data. The assumption is made that any changes in this ratio are due to differences in the reporting level for major accidents and over-3-day injuries developing. This assumption can be tested with further analysis of various data sources.

There are some aspects of the calculation commented on here:

- It would appear that the changes in the ratio are calculated from the base year of 2000/01 are expressed as a percentage of the value for 1999/2000

This is a minor point, which needs to be clarified.

- The base year, where it is assumed that the reporting levels are the same for both major accidents and over-3-day injuries, is chosen as 2000/01.

The choice of 2000/01 as the base year needs to be justified, especially since the choice of this year reduces the PSA1 indicator by the largest amount. Another choice could have been 1999/2000, the year when the Eurostat module was included in the LFS, and on which the initial assessment of the relationship of reporting levels between major accidents and over-3-day injuries was based.

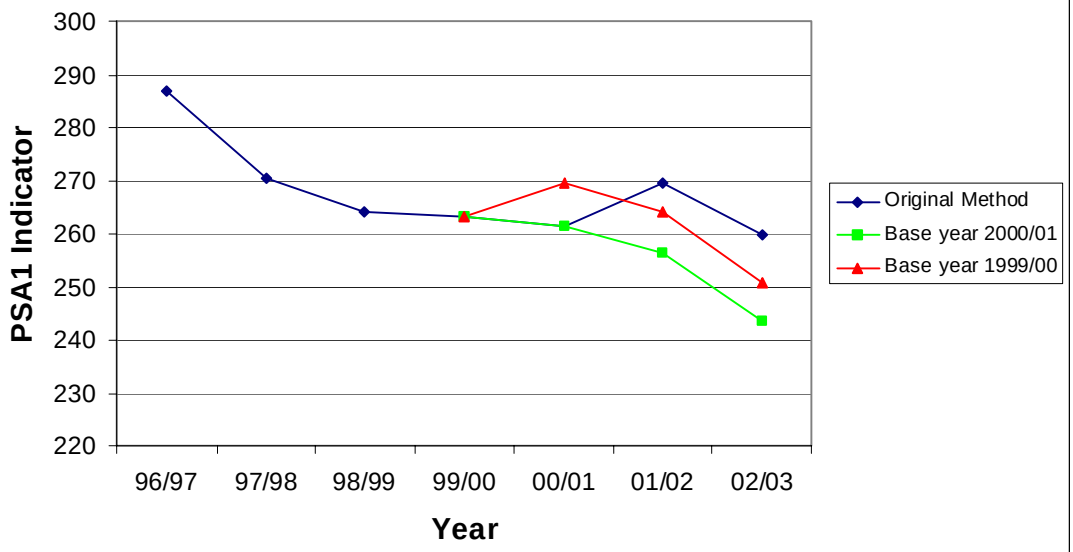
The effect of choosing differing base years is calculated in table 2.

Table 2: Effect of choosing a differing base years in the adjustment of the PSA1 indicator

	Unadjusted Value		Revised Value Base year 2000/01		Revised Value Base year 1999/2000	
Year	**Reporting Percentage**	**Indicator**	**Reporting Percentage**	**Indicator**	**Reporting Percentage**	**Indicator**
2001/02	41.3	269.8	43.4	256.4	42.1	264.0
2002/03	42.9	259.8	45.8	243.6	44.5	250.7

It can be seen that the choice of year significantly affects the value of the PSA1 indicator, and so it is important, if this methodology is to be used, that sufficient justification is given to the choice of base year. It is not possible to get sufficient evidence from the RIDDOR and LFS sources alone to say which year it would be best to use as a base, so this area will be explored when the RA data is analysed fully. What can be assessed from the RIDDOR and LFS data is a qualitative examination of how the choice of base year would affect the trends in PSA1 value.

Figure 2: **Trend in the PSA1 indicator with adjustments based on differing years**



It can be seen that the choice of 2000/01 as the base year produces a smoother trend in the indicator (figure 2), which may indicate that it is the most appropriate choice, but this will have to be investigated further.

3 ANALYSIS OF RA SURVEY

3.1 INITIAL ANALYSIS

The main source of data to discriminate between the under-reporting of major accidents and over-3-day injuries events is the RA survey.

The main survey concentrated on the basic details of the company (Number of Employees and Sector) and on the details of the accidents or injuries. There are no details on the individuals involved in the accidents or injuries.

The report gives a detailed analysis of the reporting level over four years by matching the responding companies with their RIDDOR entries. As with all survey work there were issues with missing data. The main thrust of the analysis was to produce separate under-reporting levels for major accidents and over-3-day injuries across the four-year period studied. The analysis showed a statistically significant increase in the under-reporting of major injuries over the four years but no significant change in the under-reporting level in over-3-day injuries.

This result seems to contradict the methodology used previously for the adjustment of the PSA1 indicator, where it was assumed that the under-reporting in the major accidents was becoming lower relative to the under-reporting in over-3-day injuries.

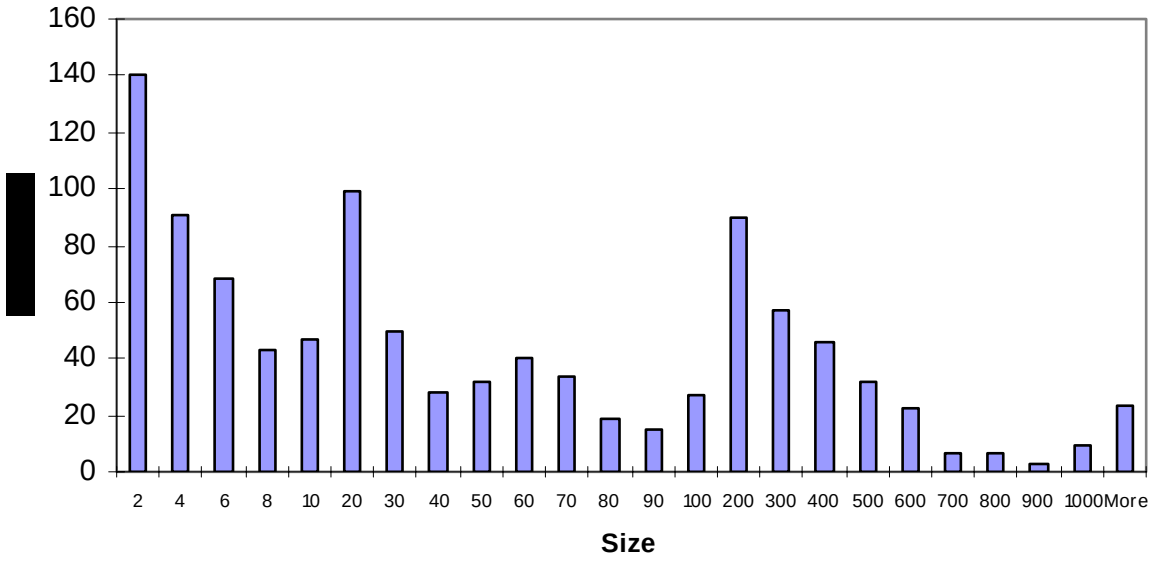
As this survey is the key source of data for investigating the relationship between under-reporting in major accidents and over-3-day injuries, it was important to gain as much information as possible from the analysis and to develop the calculations further.

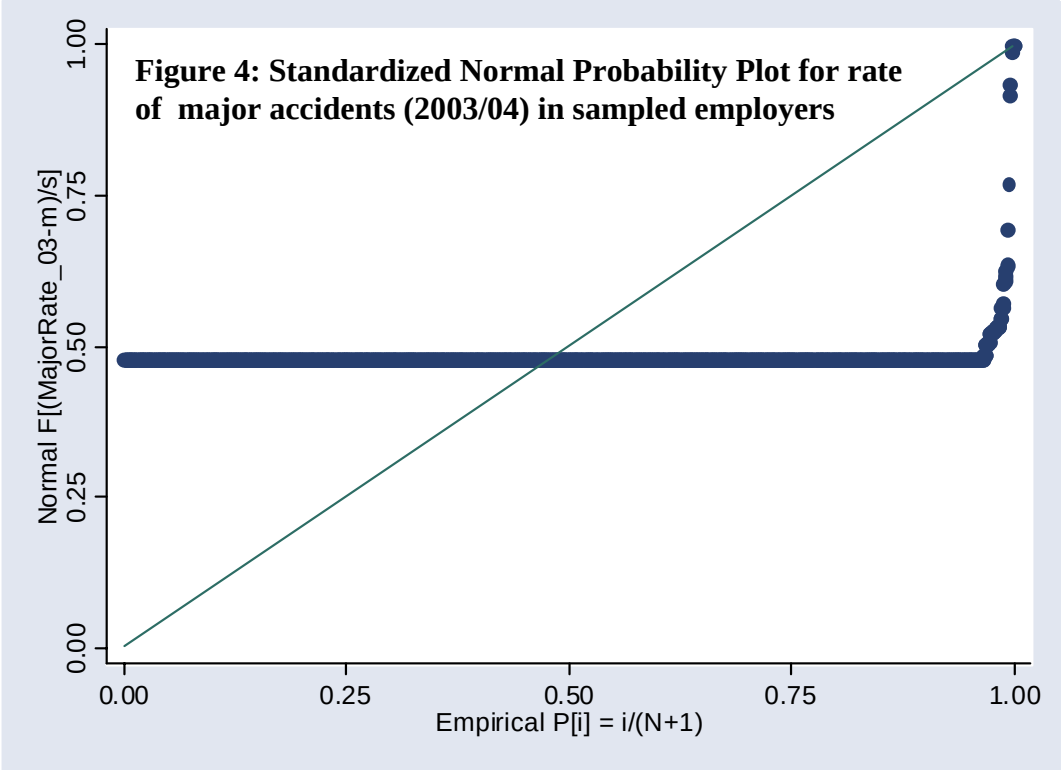
The initial analysis concentrated on testing the assumption that the data were drawn from a normally distributed population so that repeated measures ANOVAs were used to test for the differences in the yearly reporting levels. A check was performed on the normality on the Rate of Major Accidents across the sampling units (companies) to check if a normal assumption could be taken as a valid one. To develop the analysis further we shall test this assumption and explore alternative approaches.

Initially, there was no reason to assume that the number of employees per company follows a standard distribution as it is driven by the diversity and requirements of employers in the manufacturing sector. A plot of company number is given in figure 3 (note the changes in the abscissa scale).

A test was performed on the normality on the rate of major accidents across the sampling units (companies) to check if a normal assumption could be leading to distorted conclusions. The first test is simply to plot the cumulative distribution of calculated rate by company against the standard normal cumulative plot (figure 4).

Figure 3: Histogram of the size of companies in the RA survey





The plot in figure 4 clearly shows that the normal assumption should not be used for more detailed analysis of the accident rates. Furthermore, a Shapiro-Wilks normality test was undertaken using the same data and the low value of the statistic W indicates the non- normality of the data (Table 3).

Table 3. Results of the Shapiro-Wilks non-normality test

Variable	Obs	W	V	z	Prob>z
MajorRate_03	1029	0.12736	564.886	15.710	0.00000

Points to consider in this analysis are:

- There is no information at the individual worker level from the survey, the sampling unit is the employer, and the variables being measured for the unit are (for each year) number of employees, number of major accidents and number of over-3-day injuries.
- As such, if any regression modelling is performed, there is a limited number of explanatory variables available for the analysis (e.g. Number of employees or, as categorical, Small, Medium and Large companies)
- There is no expectation that the number of employees will be normally distributed, or indeed will follow any standard distribution, as it is not generated by an underlying stochastic process but by the diversity and requirements of employers in the manufacturing sector. As such it is not expected that the number of accidents or injuries at the employer level will be normally distributed.
- The rate of accidents or injuries is driven by a stochastic process at the individual worker level and as such can be analysed using statistical techniques if the data were recorded for individuals. At the worker level the process can be considered as a binomial process with probabilities that a worker has a major accident or over-3-day injuries in a given year (excluding multiple events for a single worker).
- When examining the data at the employers level, it is noted that a large number of employers have a few employees, and hence the number of incidents are 0 or 1. This is the basic factor that leads to a non-normal distribution of the rate when calculated at the employer's level, and will need to be handled correctly when the data is analysed with the binomial processes assumed.

The result of the analysis of the major accident and over-3-day injuries assuming the underlying binomial distribution injuries will be the Rates (by company size if appropriate) with calculated confidence limits. This will then be combined with the Rates of reported Accidents and Injuries from the overall RIDDOR data to produce under-reporting levels, with confidence limits, which can then be incorporated into an on-going methodology for calculating the PSA1 indicator.

An alternative approach would be to model the under-reporting level directly, utilizing the match between the RA survey data and the RIDDOR data. However, this approach may not be satisfactory, as there may not be a clear distribution in the level of reporting at the company level. It would need to be investigated whether there was a simple distribution of reporting level about the mean for the companies, or if they split into more discrete categories of, for example 100% reporters and low-level reporters, or somewhere in between. If the analysis was being carried out on the reporting at the company level in this manner, a careful consideration of these issues is needed.

3.2 FURTHER DATA ANALYSIS

3.2.1 Manufacturing Sector

Initially some simple missing data replacement techniques were used to try to gain full use of the available survey data. The number of workers in the company was simply rolled forward from a previous known value, taking care not to populate the worker count in years when a company had not started trading.

The first analysis was to look at the accident rates for major accidents and over-3-day accidents that were obtained from the RA survey and see how they compared to the RIDDOR and LFS values. First the major accident rate was analysed, and the result is shown in figures 5a and 5b.

Figure 5a:Trends in the rate of major accidents from the risk analysis manufacturing survey and RIDDOR (manufacturing)

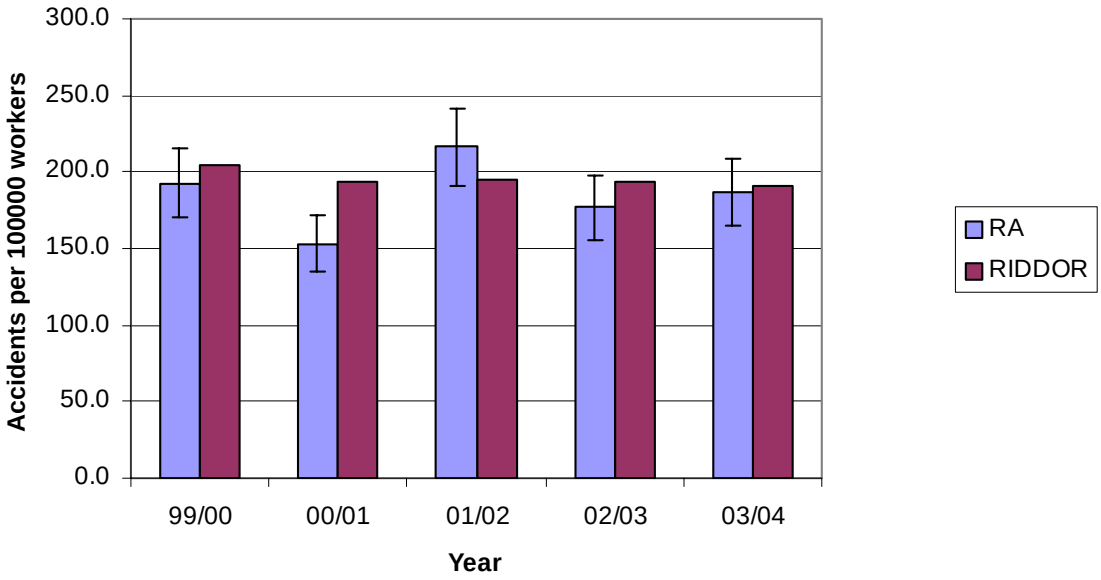
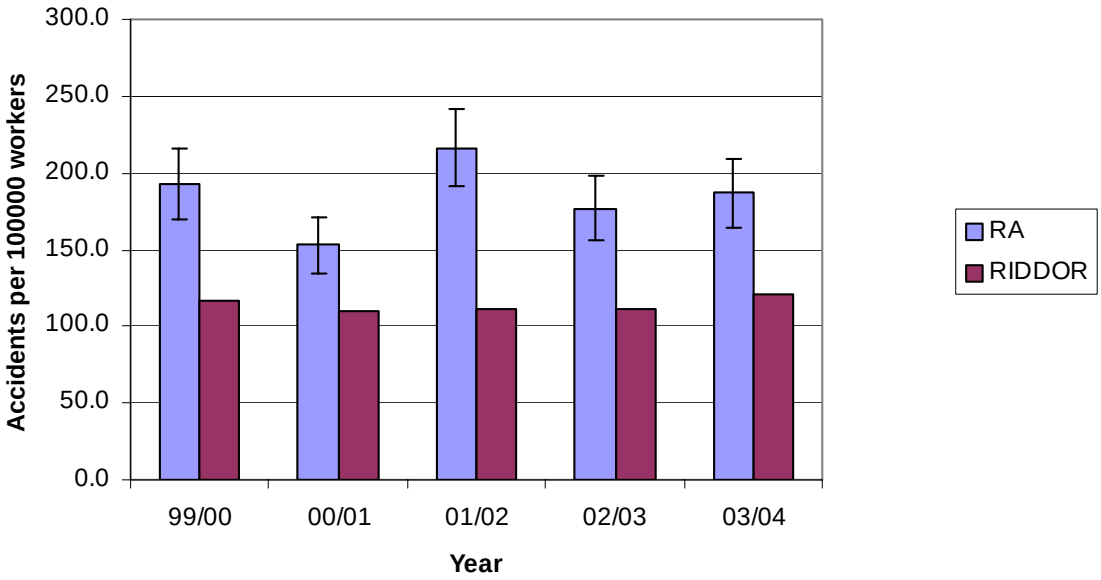


Figure 5b: Trends in the rate of major accidents from the risk analysis manufacturing survey and RIDDOR (all sectors)



The results show that the trend in major accidents as derived from the RA survey does not differ significantly from the trend in the reported major accidents. Both the RA survey and the RIDDOR data show marginal changes in the accident rate over the five-year period covered by the survey. The RIDDOR data for the manufacturing sector alone shows a small decrease in major accident rate across the five-year period whereas the trend for all sectors shows a marginal increase similar to the RA trend.

The consistency in the trends of the RA and RIDDOR data indicates that the reporting level is remaining constant over the five-year period. Thus,

- The RA survey shows no clear change in the major accident rate between 1999/2000 and 2003/04
- There is no clear change in the RIDDOR reported major accident rate in the manufacturing sector between 1999/2000 and 2003/04
- There is no clear change in the RIDDOR reported major accident rate across all sectors between 1999/2000 and 2003/04
- The comparison of major accident rates between the RA survey and RIDDOR reported manufacturing major accidents shows no clear under-reporting. This may be due to under-reporting also being present in the RA survey

Next, the over-3-day injuries rates were examined and the results are shown in figures 6a and 6b.

Figure 6a: Trends in the rate of over-3-day injuries from the risk analysis manufacturing survey and RIDDOR (manufacturing)

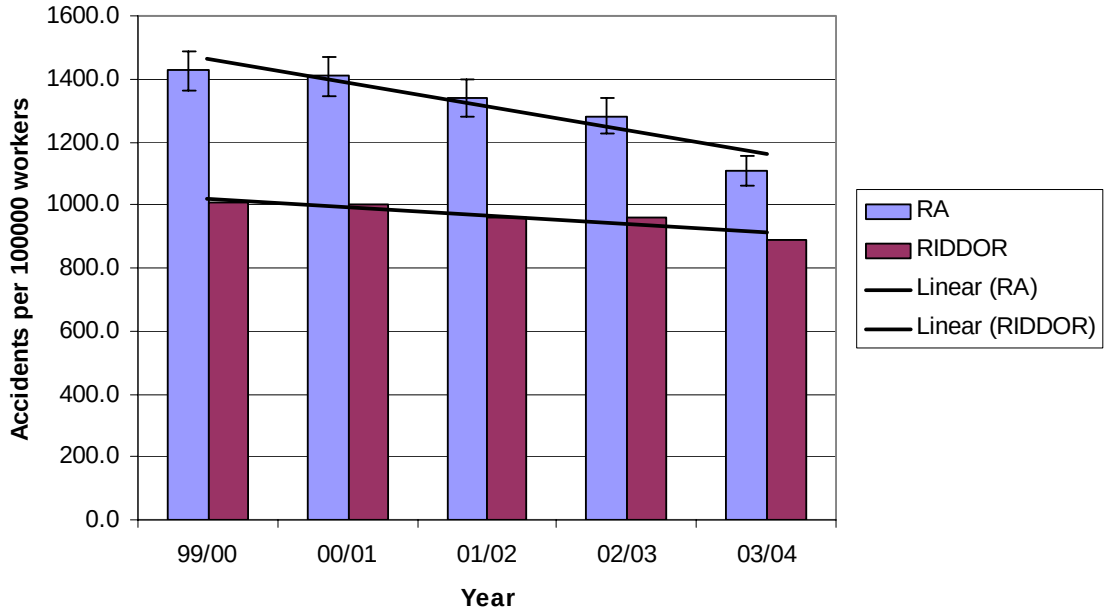
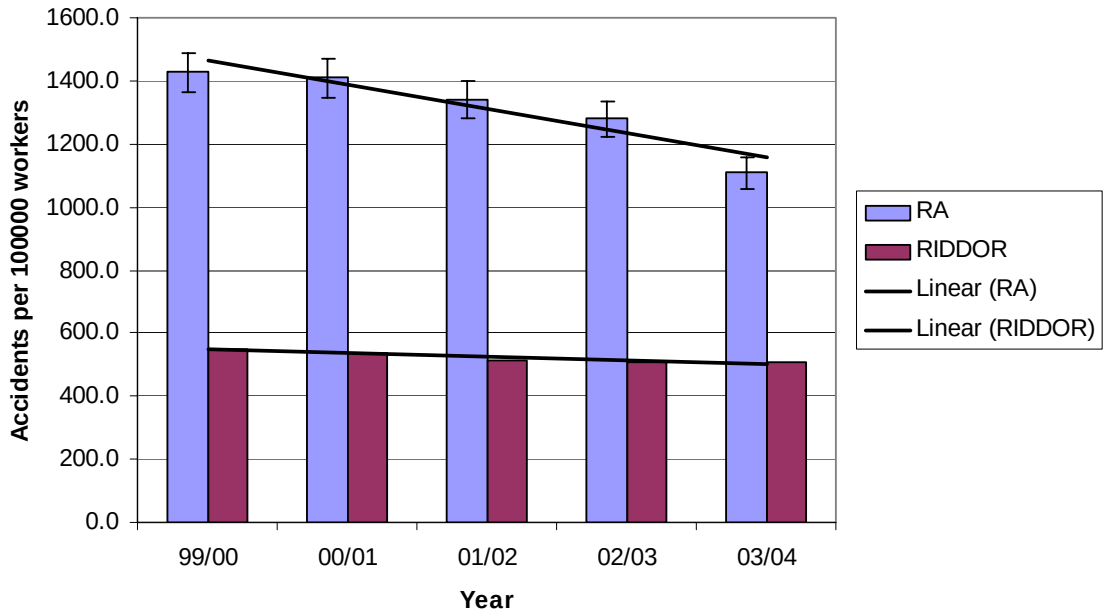


Figure 6b: Trends in the rate of over-3-day injuries from the risk analysis manufacturing survey and RIDDOR (all sectors)



With a larger number of over-3-day accidents, the variability in the calculated accident rate is lower, and the analysis of the RA data shows a clear downward trend in the rate over the five-year period. The RIDDOR data also show a downward trend but of a smaller magnitude.

Both the RIDDOR and RA data show that the over-3-day injury rate is decreasing over the five year period with the major accident rate not changing much at all. These variations are consistent between the two data sources, and would lead to the trend in the ratio of major accidents to over-3-day injuries that has been observed. Thus,

- The RA survey shows decrease in the over-3-day injury rate between 1999/2000 and 2003/04
- There is marginal decrease in the RIDDOR reported over-3-day injury rate in the manufacturing sector between 1999/2000 and 2003/04
- There is no clear change in the RIDDOR reported over-3-day injury rate across all sectors between 1999/2000 and 2003/04
- The comparison of major accident rates between the RA survey and RIDDOR reported manufacturing major accidents shows some under-reporting.

Also, looking at both the major accident results and the over-3-day injury results,

- The increase in the ratio of major accidents to over-3-day injuries between 1999/2000 and 2003/04 can be attributed to a decrease in over-3-day injury rates over that period
- The data does not support the view that the increase in the ratio of major accidents to over-3-day injuries is due primarily to an increase in the major accident reporting level

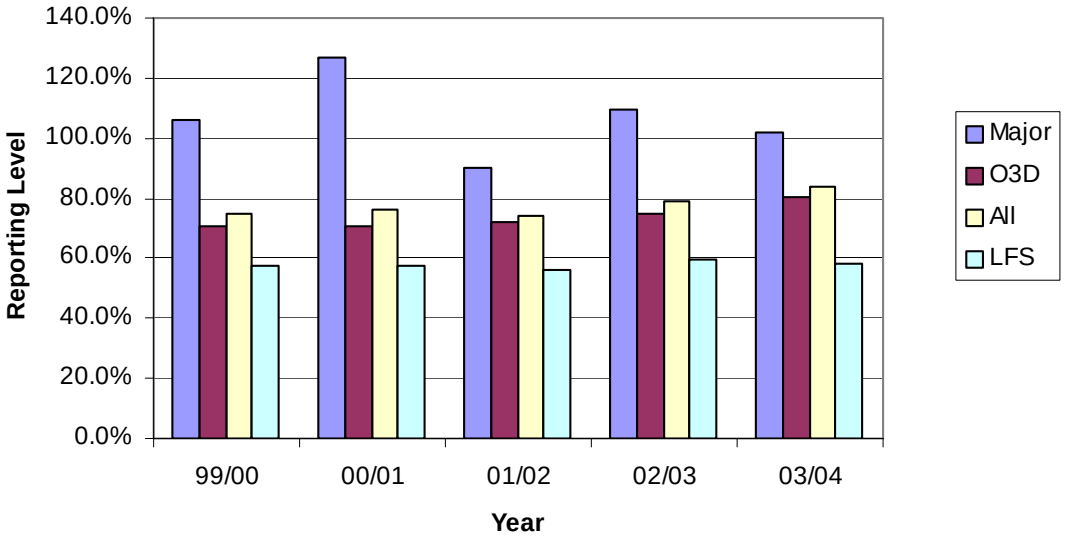
Finally, the combined major and over-3-day accident rate was analysed and the results are shown in figures 7a and 7b, including data from the LFS survey.

The accident rates from the RA and LFS surveys show trends in general agreement, which is a positive indicator that any conclusions drawn from the analysis of the RA survey should be a firm basis for building a model to use the LFS data to infer accident rate trends in the major and over-3-day categories separately.

However, the difference between the values of the accident rates from the RA manufacturing and the LFS survey for the manufacturing sector should be noted. One of the fundamental assumptions in the analysis is that there is under-reporting in the RIDDOR notifications, but that the survey results would reflect the true picture of accidents rates. Examining data for the manufacturing sector, the RA survey accident rates are lower than from the LFS survey. This suggests that there may also be an amount of under-reporting of accidents to employers; the LFS is a questionnaire aimed directly at the employees (or more exactly the head of the house where the employees reside) regarding any accidents that they have had in the proceeding three months, whereas the RA survey asks the employers to check their accident log book for recorded accidents over the last five years.

- The comparison of major and over-3-day events between the RA and the LFS survey for the manufacturing sector show a clearly lower rate in the RA survey.
- There is an indication that under-reporting is present in the RA survey

Figure 8a: **Reporting levels for major accidents, over-3-day injuries (RIDDOR and RA survey) and the combined data (RIDDOR, RA survey and LFS) - manufacturing**

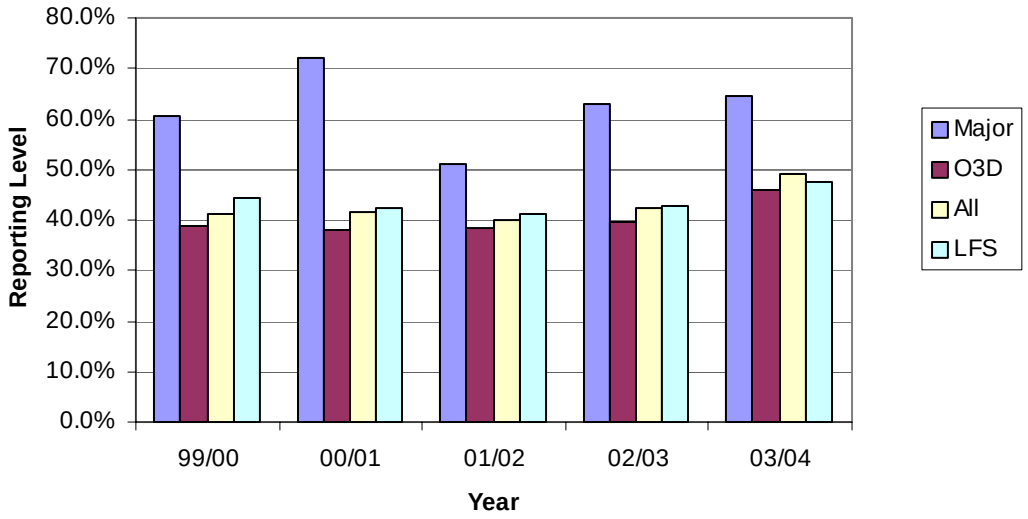


Following examination of the rates, the reporting levels were analysed to see how they varied between major accidents, over-3-day injuries and the combined data, as shown in figures 8a and 8b

The reporting levels for each of the categories above was defined as:

- **Major:** RIDDOR major accident rate / RA survey major accident rate
- **O3D:** RIDDOR over-3-day injury rate / RA survey over-3-day injury rate
- **All:** RIDDOR combined (major & over-3-day) accident rate / RA survey combined accident rate
- **LFS:** RIDDOR combined (major & over-3-day) accident rate / LFS survey combined accident rate

Figure 8b: **Reporting levels for major accidents, over-3-day injuries (RIDDOR and RA survey) and the combined data (RIDDOR, RA survey and LFS) - all sectors**



The first general point to note is that the data show that the major accidents have a higher reporting level than the over-3-day accidents, indicating that the initial assumption that the two reporting levels were the same may not be valid. If a correction were introduced to allow for this difference, it would have the effect of lowering the baseline value for major accidents. However, this would not have any bearing on the attainability of the PSA1 target, as it is the trend over the relevant period that is important.

There are two ways of interpreting these results to decide how to adjust the Major Accident rate and thus calculate the PSA1 indicator.

First, simply looking at the reporting level for major accidents, the data show only a marginal decrease over the five-year period. This could be used to justify not making any adjustment to the RIDDOR value above the simple up rating due to the overall reporting level calculated using the LFS survey. This would lead to the originally calculated PSA1 value.

The alternative interpretation is to note the increase in the over-3-day reporting level relative to that of major accidents. If this were to be reflected in the analysis of the LFS reporting level, it would result in an adjustment having the opposite effect to the original adjustment, which had the assumption that the reporting level for the major accidents increased relative to the over-3-day injuries. This is shown in figure 9a, with the original unadjusted PSA1 value, the first adjustment where the major accident reporting level is increasing relative to the over-3-day reporting level and the second adjustment where the major accident reporting level is decreasing relative to the over-3-day reporting level.

Figure 9a: **Trends in the PSA1 indicator with (Original) no adjustment, (1) trend in ratio of major to over-3-day accidents assumed to be due to reporting and (2) over-3-day reporting is increasing relative to major accident reporting, as indicated in the RA Survey**

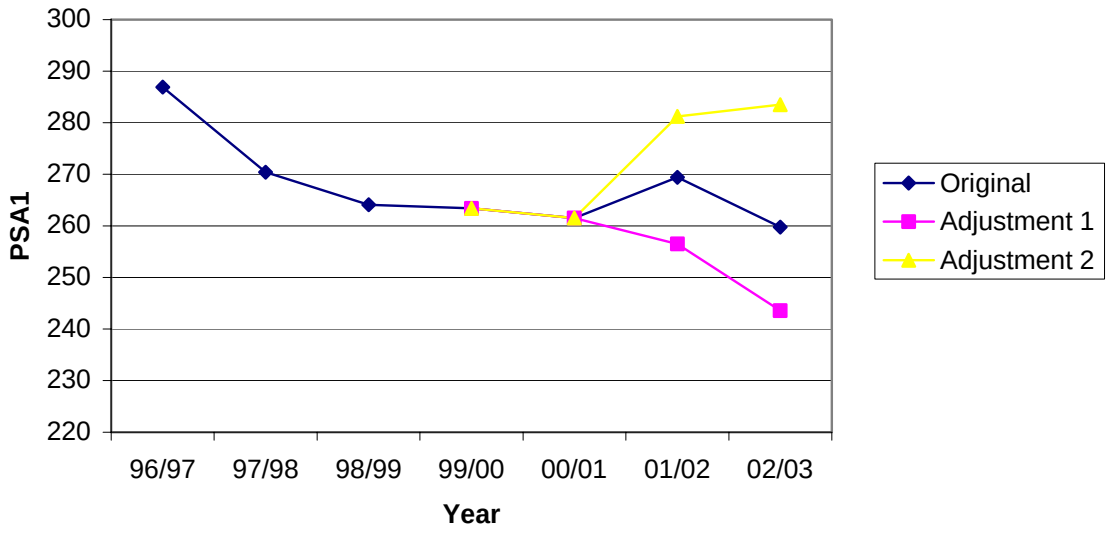
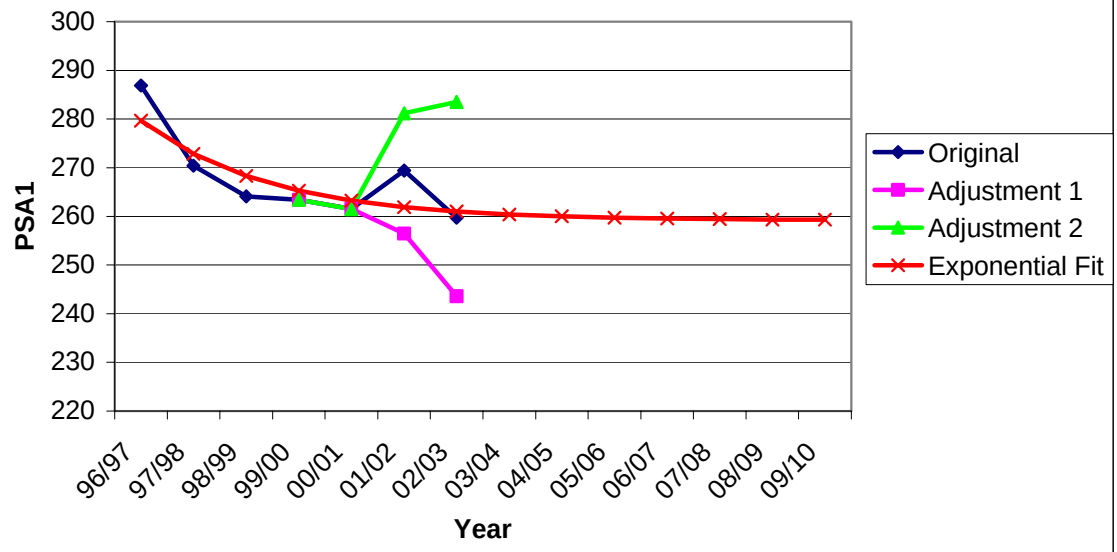


Figure 9b: **Trends in the PSA1 indicator with (Original) no adjustment, (1) trend in ratio of major to over-3-day accidents assumed to be due to reporting and (2) over-3-day reporting is increasing relative to major accident reporting, as indicated in the RA Survey**



The form of the unadjusted PSA1 value is suited to an exponential fit, with the results of this fit shown in figure 9b.

The predictive nature of this model is limited however, as by its nature the exponential model will have a flat tail, and the predicted values will be at a constant level. The form of the trend is

not suited to a linear model and the number of data points do not allow for more complex models to be of value.

In addition the data quality is not sufficient to justify any year-by-year detailed adjustment to the major accident rate, but a global adjustment across the time period would be justified. A ratio of major accident reporting level to over-3-day injury reporting level could be estimated from the data, which could be used for the adjustment. The adjustment formula would be (as described in Appendix B):

If α = major accident reporting level / over-3-day

R_m = RIDDOR major accident rate

R_o = RIDDOR over-3-day injury rate

R_{LFS} = LFS major accident and over-3-day injury rate

r_m = major accident reporting level

Then

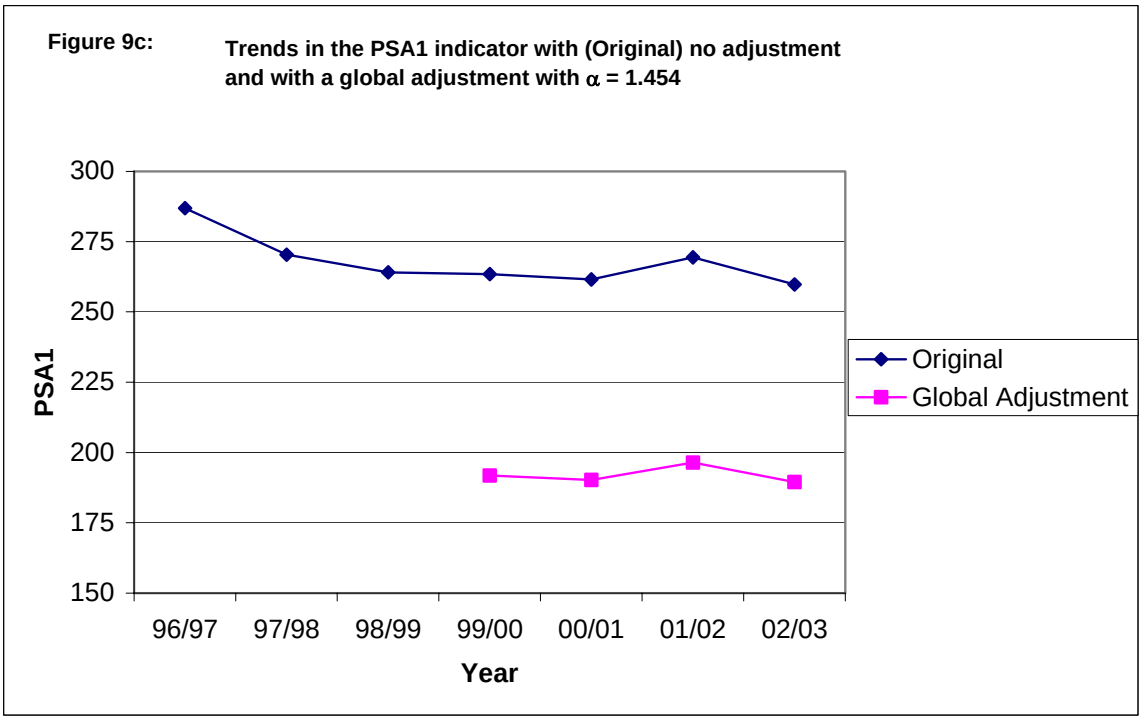
$$r_m = (R_m + \alpha R_o) / R_{LFS}$$

With the adjusted major accident rate now given by:

$$R_m^{adjusted} = R_m / r_m$$

From the RA data for the manufacturing sector, an estimate of α =1.454 was calculated. A recalculation of the PSA1 indicator with this value is shown in figure 9c.

Figure 9c: **Trends in the PSA1 indicator with (Original) no adjustment and with a global adjustment with α = 1.454**



Note that the data do not indicate a year for which the reporting levels for the major accidents and over-3-day injuries are equal to use a base year for an adjustment. It is not possible to clearly say what the reporting levels were before 1999/2000, but an indication from the trends is that the reporting levels are converging as the years progress, and it appears unlikely that the reporting levels were similar in the years immediately proceeding the start of the RA survey period.

The data here does not support any adjustment based on the assumption that the reporting of major and accidents and over-3-day injuries are similar at some time within the period being considered followed by some divergence, and it may not be fruitful spending time justifying using 1999/2000 as a base year for adjustments against 2000/01 or vice versa.

In summary

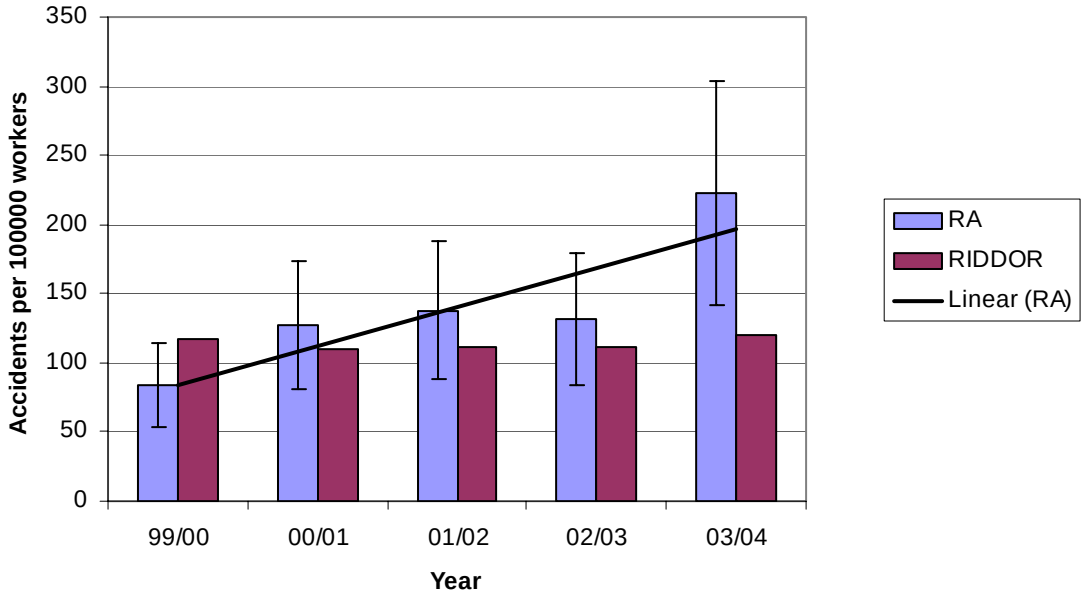
- Major accident reporting level is higher than the over-3-day injury reporting level
- Major accident reporting level can be larger than 100%, indicating that there is under-reporting in the RA survey
- The LFS survey is the only reliable indicator of the actual accident rate levels
- Reporting levels show no clear indication of a trend over the period 1999/2000 to 2003/04
- This indicates that the RIDDOR (and RA survey) data can be used to examine trends in the accident rates
- The data support a fixed adjustment of the major accident rate across all years but there is not enough confidence in the data to justify a detailed adjustment in individual years
- The global adjustment to the major accident rate can be calculated from the reported accident rates, the LFS survey and a value of α calculated from the RA survey using the formula given

3.2.2 Services Sector

A further survey carried out by the risk assessment section at HSL is also available for analysis for the services sector. The data available here are from a pilot study and have a smaller sample base and thus larger sampling errors. An analysis of these data is useful to see if conclusions drawn from the manufacturing sector data may be applicable across all sectors.

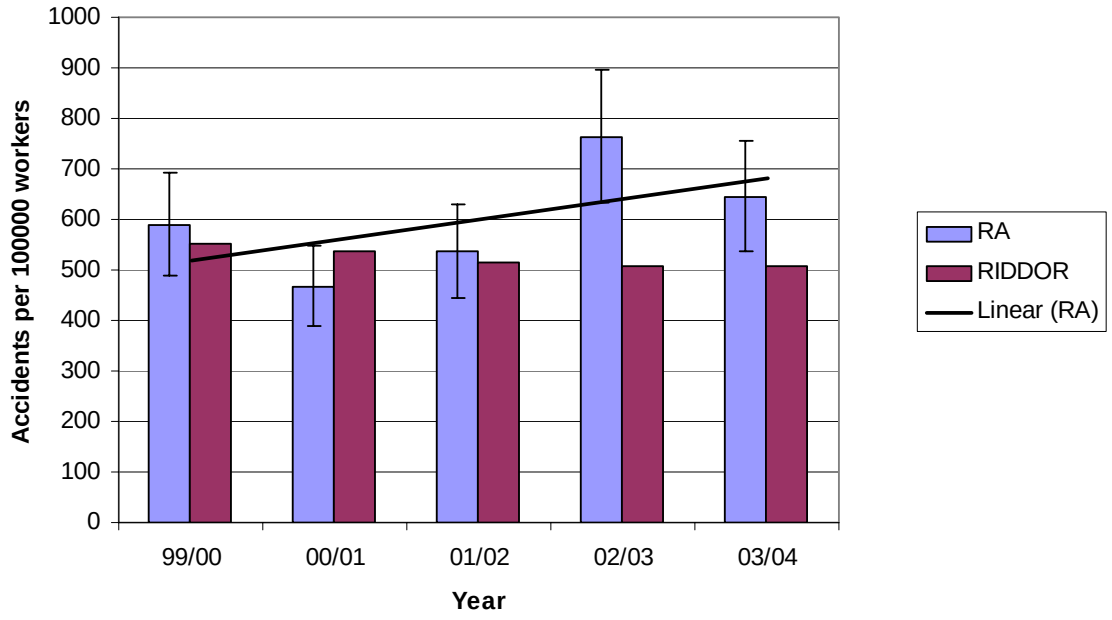
The first data to be examined were the accident rates for major accidents shown in figure 10.

Figure 10: **Trends in the rate of major accidents from the risk analysis services survey and RIDDOR (all sectors)**



The clear difference from the data for the manufacturing survey is the trend in the accident rate seen in the RA survey; in the services sector, the survey is showing a large increase in the major accident rate, not seen in the RIDDOR data. This trend is also seen in the over-3-day injury rates, as shown below in figure 11.

Figure 11: Trends in the rate of over-3-day injuries from the risk analysis services survey and RIDDOR (all sectors)



This trend follows on into the analysis of all reportable injuries where the LFS data can also be compared, as shown in figures 12a and 12b.

It can be seen that the increasing trend observed in the RA survey is not evident in either the LFS data or the RIDDOR data. This leads us to conclude that the RA services sector survey data would not be a sensible dataset to use to determine the relationship between the LFS and RIDDOR datasets. This factor, alongside the increased standard errors due to the smaller sample size, means that the analysis of the manufacturing sector will be the most useful, but that there is no supported argument for carrying any conclusions from the manufacturing sector over to all sectors.

Figure 12a: Trends in the rate of major accidents and over-3-day injuries from the risk analysis services survey, RIDDOR (services) and LFS (services)

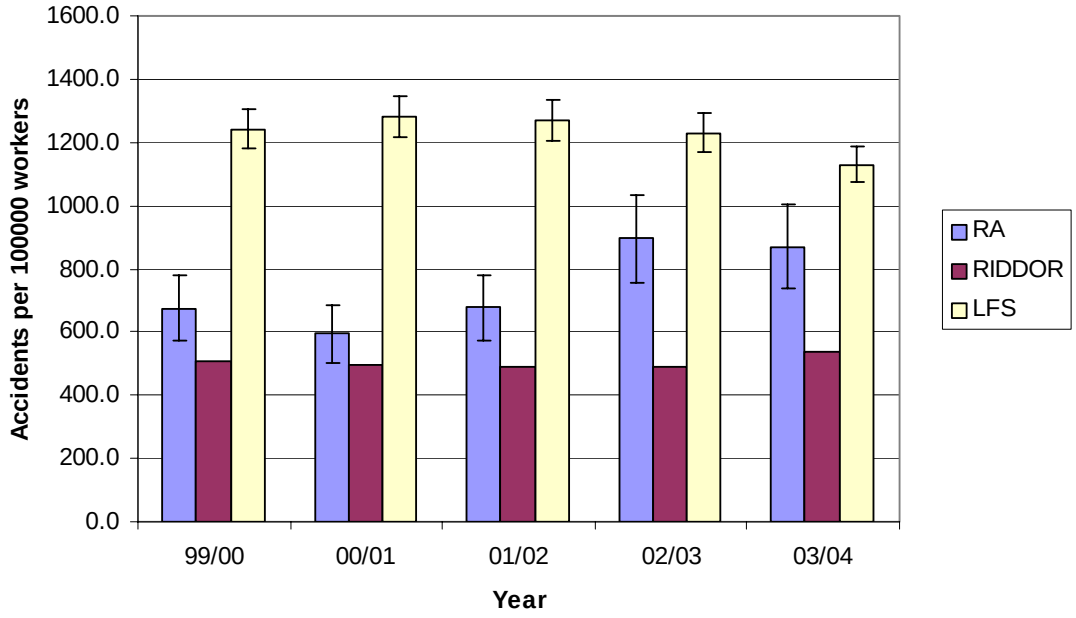
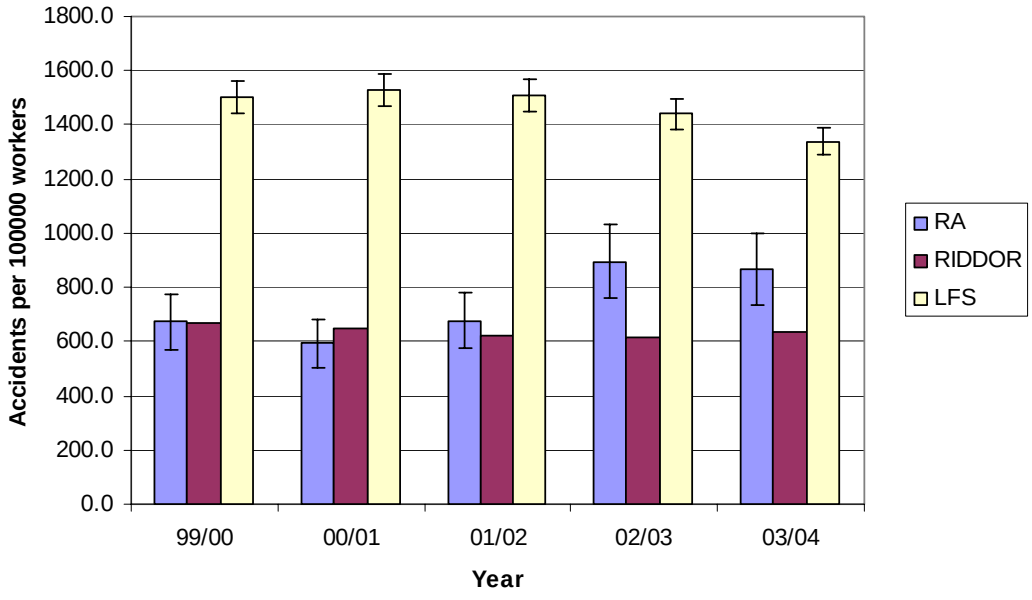


Figure 12b: Trends in the rate of major accidents and over-3-day injuries from the risk analysis services survey, RIDDOR (all sectors) and LFS (all sectors)



The reporting levels comparing the RIDDOR, LFS and the RA survey data for the Services sectors are shown in figure 13a. Also, the reporting levels comparing the RIDDOR and the LFS data for all sectors and the RA services survey are shown in figure 13b.

Figure 13a: **Reporting levels for major accidents, over-3-day injuries (RIDDOR and RA survey) and the combined data (RIDDOR, RA survey and LFS) - services**

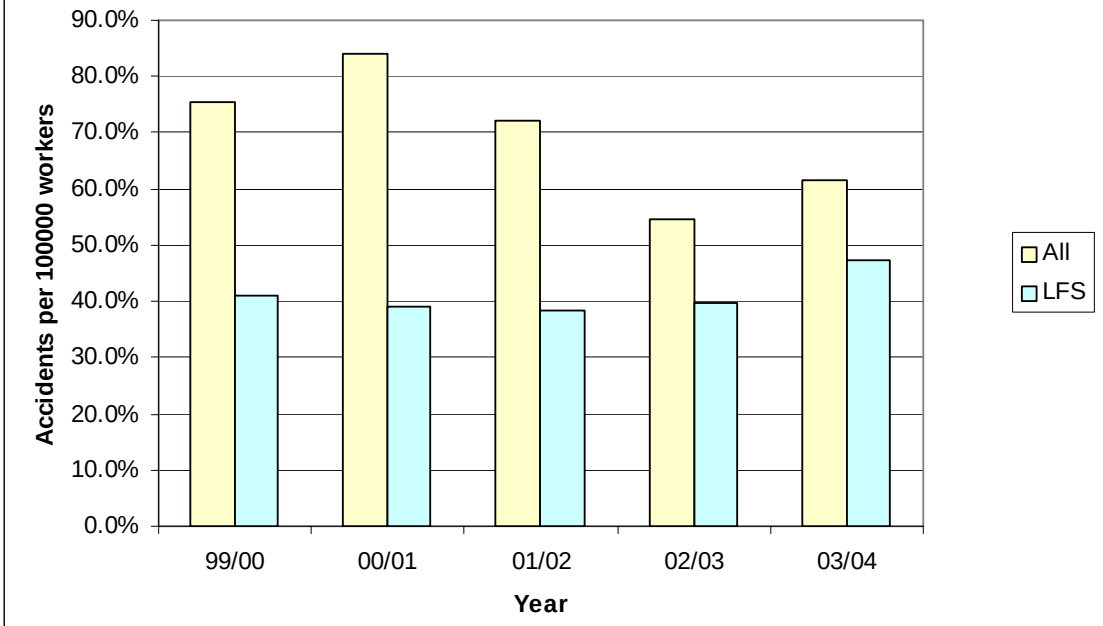
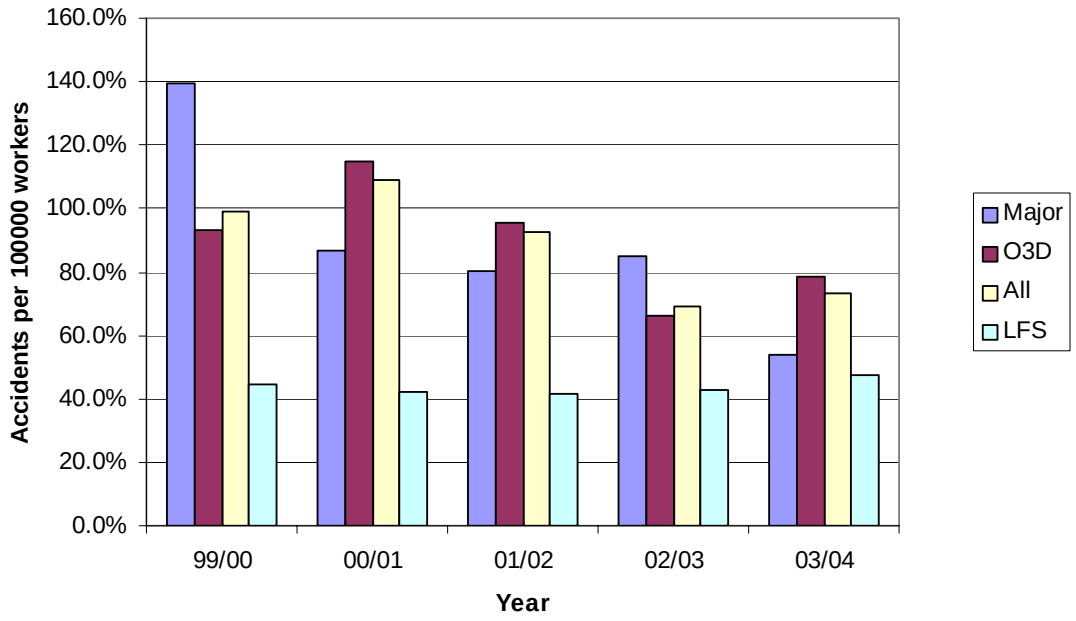


Figure 13b: **Reporting levels for major accidents, over-3-day injuries (RIDDOR and RA survey) and the combined data (RIDDOR, RA survey and LFS) - services**



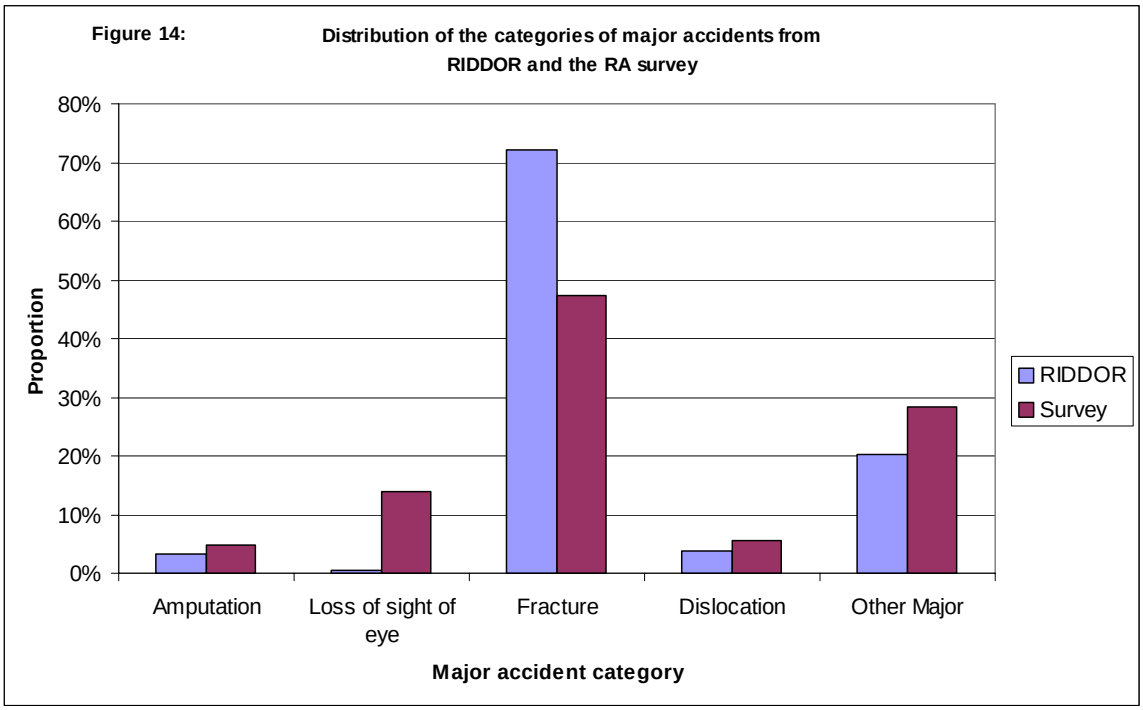
The reporting level calculated using the RA services survey shows different trends from the reporting levels calculated from the LFS survey, highlighting the difficulty in using the RA survey to make an adjustment based on this dataset.

3.2.3 Eye Injuries

As agreed with SESU, the RA manufacturing survey was further examined to see if any misclassification in the category of eye injuries could be shown to have an effect in the trend of the PSA1 indicator.

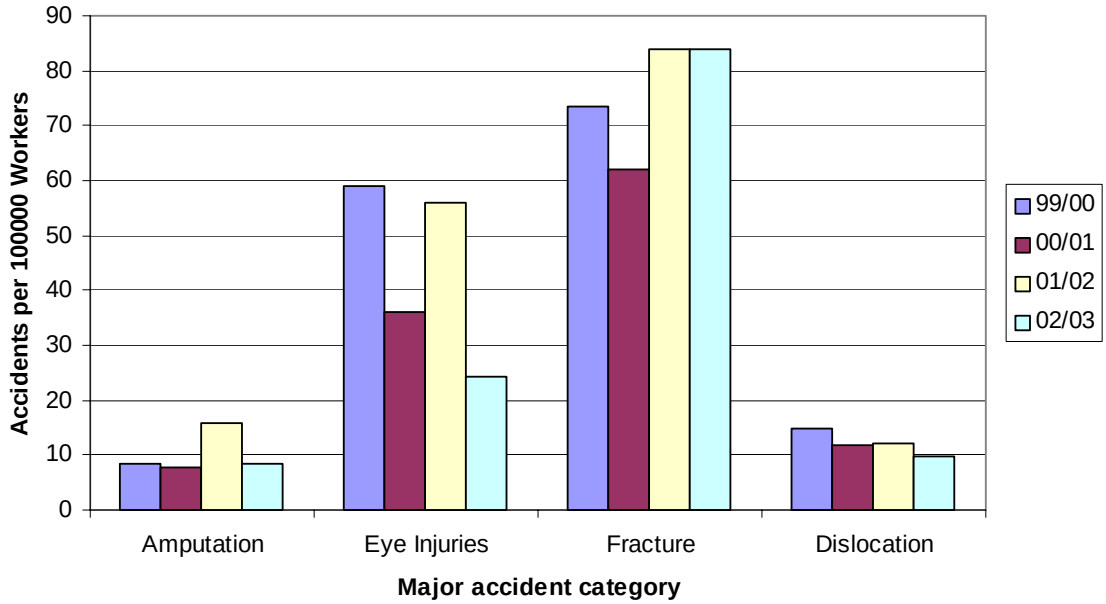
It is known that eye injuries are commonly misclassified as major accidents, where only a well-defined class of injuries are included. This is seen in the RIDDOR data, and is corrected for at the data quality assurance stage. As this correction is not carried out for the RA survey, there is a possibility that this may cause distortions in the PSA1 indicator trend.

The distribution of major accidents into the basic categories was examined and is shown in figure 14.



It can be seen that the eye injury category is over-represented in the RA survey. To see how this may affect the trend in the PSA1 indicator, the trend in the individual injuries was examined. If no clear trend were evident in the eye injuries, then any adjustment would shift the baseline of the PSA1 indicator, but would not have an overall effect in the trend of the indicator. The injury trends are shown in figure 15a.

Figure 15a: **Trends in major accident categories**
RA manufacturing survey

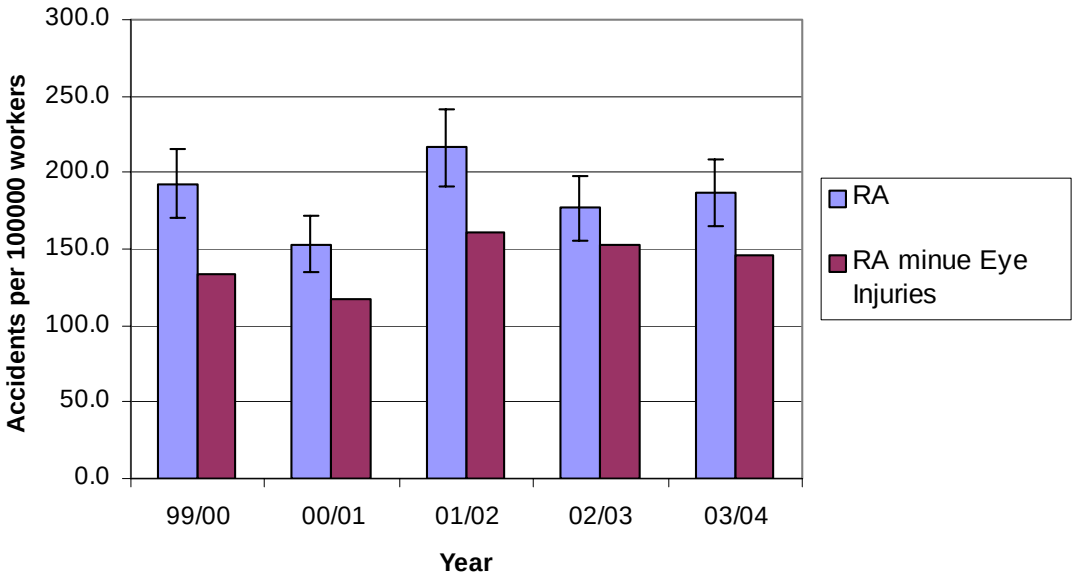


There may be a general downward trend in the eye injuries, which would result in an adjustment that would increase the PSA1 indicator over the period. However, the trend is not clear and it is not believed that an adjustment would be justified with the current data.

The effect of removing the eye injuries from the major accident category is seen in figure 15b below, where the major accident rate for the manufacturing sector is shown with the eye injuries included and excluded.

There is no clear difference in the trend in the accident rate with the eye injuries excluded.

Figure 15b: Trends in the rate of major accidents from the risk analysis manufacturing survey and RIDDOR (manufacturing)

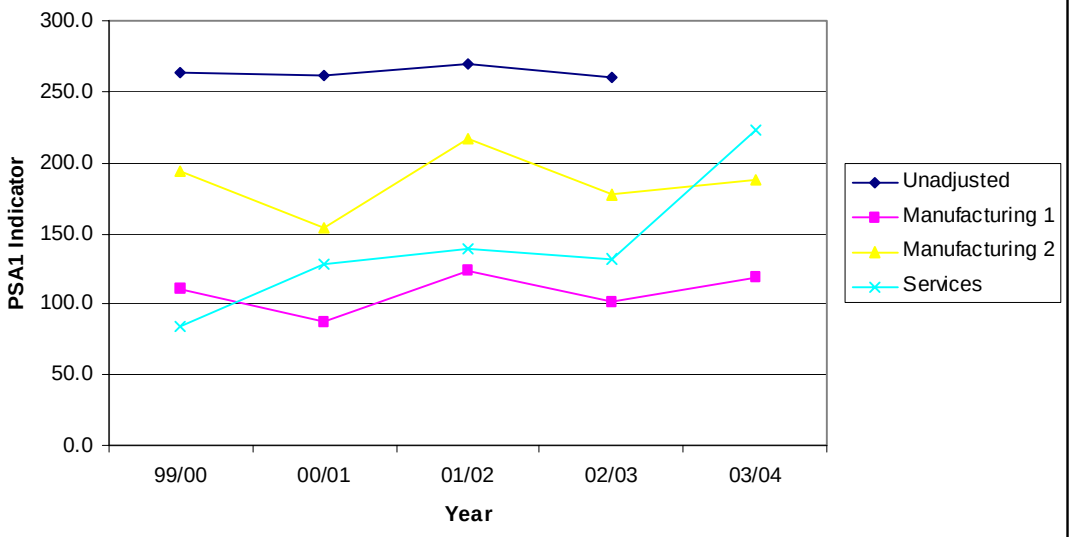


3.2.4 PSA1 Calculations

The reporting levels calculated from the manufacturing and services datasets are used to derive the PSA1 indicator.

In figure 16, the original PSA1 indicator, calculated from the LFS and RIDDOR datasets with the assumption that the reporting levels for major accidents and over-3-day injuries are the same is shown. Also shown is the calculation based on reporting levels from the RIDDOR manufacturing and RA manufacturing survey datasets (Manufacturing 1) and the reporting levels from the RIDDOR all sectors dataset and RA manufacturing dataset (Manufacturing 2). Finally the calculation from the RA services survey is shown.

Figure 16: **PSA1 Indicator using estimated reporting levels**



The PSA1 indicator calculated from the services survey shows a trend dissimilar from the other calculations, and should perhaps be discounted as suspect.

The other calculations show differing base levels; as noted previously, there may be some under-reporting in the RA survey, which would lead to the calculated PSA1 indicator values being too low.

As the RA survey reporting levels will not be generally available in future years, and due to the under-reporting believed to be present in the survey, it is preferable to use the adjustment methodology described in section 3.2.1, with the results shown in figure 9c. This methodology does not depend on the reporting levels, just the ratio of the major accident reporting level to the over-3-day injury reporting level, and is also averaged over the time period of the survey.

3.2.5 Theoretical Analysis

3.2.5.1 Introduction

The original project proposal included the provision for a theoretical analysis to examine the feasibility of using Generalized Linear Modelling (GLM) or Generalized Additive Modelling (GAM) to assist in predicting the trend in the PSA1 indicator. However, although the overall (major accident and over-3-day injury) reporting level is reliably obtained using the LFS survey alongside the RIDDOR data, the LFS survey does not break down the incidents into the major and over-3-day categories.

The only data available that reliably categorizes the incidents are the RIDDOR and RA survey data and any modelling of the reporting levels for the separate categories would have to use these datasets for model fitting and predicting. However, the RA survey is very limited in its scope, with the only variables collected other than the incident rates being the size of the company. Therefore, the lack of useful explanatory variables for a regression analysis makes any GLM or GAM modelling impossible.

An alternative method of obtaining more accurate estimates of incident rates is described here.

3.2.5.2 Modelling the Accident Reporting Rate

We denote the occurrence of a major accident as a reportable accident. The employer may or may not report the occurrence of the accident. If the accident is reported, then the RIDDOR database will contain the details about this accident/injury. We want to make inference about the proportion of accidents that are reported. We let π denote the reporting rate of major accidents. This is the number of reportable accidents divided by the number of reported accidents. We want to use the data we have on some manufacturing companies to estimate this proportion, and to provide upper and lower bounds.

3.2.5.3 Independent Events

Suppose that we can regard the reporting of each accident as an independent event. We further suppose each accident has the same probability, *p*, of being reported. We can regard the reportable accidents as a sequence of independent Bernoulli trials, with 0 representing the event that the accident is not reported and 1 it is reported. The number of reported accidents, therefore, has a binomial distribution.

We can use the information on manufacturing companies from the Risk Assessment (RA) survey in order to estimate the proportion, π. Suppose we have *n* reportable events and if we have *x* reported major accidents, then we can estimate π by

$$p = x / n$$

By the central limit theorem, we can approximate the distribution of proportion π by a normal distribution, with mean, *p* and variance of $n^{-1}p(1 - p)$. Using these two summaries we can calculate a confidence interval for the population proportion π.

Repeating this procedure for all years in which we have data, we can investigate the trend in the reporting rate for manufacturing companies through time.

3.2.5.4 Adjusting for Dependence

Analysis of the data from the Risk Assessment (RA) survey has shown that the probability of an accident being reported is not constant. Different companies have vastly different reporting rates. Any statistical analysis has to take this feature of the data into account. Resultantly, the model we develop is complicated somewhat by this. We have developed a hierarchical model in order to model the dependence structure within a company, and hence to model the overall reporting rate in the manufacturing sector. As a result of the increased complexity of the analysis, the reporting rate can only be investigated by simulation. After describing the model, the issue of simulation is addressed.

If for a given year, we take the rate at which accidents occur within a given company to be constant, with rate λ, then the accident rate is a Poisson Process. Resultantly, the number of accidents in a year has a Poisson distribution. This is of limited use in itself if we want to make inference about the manufacturing sector as a whole. However, it is reasonable to assume that companies of a similar size will have similar accident rates. By grouping companies of a similar size, such that companies of a given size make up a known proportion of all manufacturing companies, we can make inference about the overall reporting rate.

3.2.5.5 The model

- We have data from the RA survey for j = 1 … J years.
- We have i = 1 ... I company sizes. Company size is measured by number of employees rather than income/profit.

Let N_i denote the number of companies of size i and

$$\sum_{i=1}^{I} N_i = N ,$$

where N denotes the total number of manufacturing companies.

- Let λ_{ij} denote the rate of accidents for company size i in year j.
- Let Y_{ijk} denote the number of major accidents for company k of company size i in year j.

Y_{ijk} (for i = 1 … I, j = 1 … J, k = 1 …N_i) is a random variable and has a Poisson distribution with rate parameter λ_{ij}, which depends on year and company size. We can estimate λ_{ij} using the data from the RA survey. If we have data from the RA survey on n_i companies of size i in year j, then we estimate λ_{ij} as

$$\lambda_{ij} = \frac{\sum_{k=1}^{n_i} y_{ijk}}{n_i} .$$

The total number of accidents in the manufacturing sector in year j is given by the sum

$$\text{Total Major Accidents} = \sum_{i=1}^{I} \sum_{k=1}^{N_i} Y_{ijk} .$$

This quantity is a random variable, but for known N_i (for i = 1 … I), and resultantly known N, the Poisson assumption allows us to calculate the expectation and variance of this sum. The central limit theorem will be valid for a sum of this magnitude, so the normal approximation to the Poisson distribution will allow a confidence interval to be calculated. Exact values of N_i and hence N will not be known, however we only need to know the proportions N_i / N for the simulation method. These can be estimated from their sample equivalents n_i / n.

We now model the probability of an accident being reported for a company of size i in year j. We denote this reporting rate π_{ij}. We have identified two general patterns of reporting behaviour – a tendency to report accidents and a tendency to not report accidents. A proportion ρ_{1ij} of companies tend to report most of or all accidents and a proportion ρ_{2ij} report few or no accidents. Obviously $\rho_{1ij} + \rho_{2ij} = 1$. We can estimate these proportions from the RA survey data.

Within these two broad patterns of behaviour we have some variation; although companies have broadly similar reporting rates, all reporting rates are not identical. In order to take this variation

into account we model the proportion of accidents, reported by companies with a tendency to not report with a beta distribution that has probability mass located around zero. We can estimate the parameters of this distribution using the RA survey data and the method of moments (equate the sample expectation and variance to the first two central moments of the beta distribution). Similarly we model the proportion of accidents reported by companies with a tendency to report most accidents using a beta distribution with probability mass located around one. Therefore π_{ij} is modelled using a mixture of beta distributions, with weights ρ_{1ij} and ρ_{2ij} respectively.

The final stage of modelling is at a company level. The reporting rate of company k of size i in year j is π_{ijk}. We sample a value, $\pi_{ijk,}$ for the company reporting rate from the distribution of π_{ij}. Company k has Y_{ijk} accidents. We assume the probability of each accident being reported is π_{ijk}, and these events form a sequence of Bernoulli trials. If we let X_{ijk} denote the number of accidents reported, then X_{ijk} has a binomial distribution with Y_{ijk} `events' and probability $\pi_{ijk}$ of `success'.

3.2.5.6 Simulation Algorithm

For each iteration of our algorithm (m iterations in all)

- Sample a company size using proportions n_i / n for (i = 1 … I)
- For company size i in year j we have rate parameter λ_{ij}. Sample a value, $Y_{ijk,}$ from a Poisson distribution with rate parameter λ_{ij}.
- Sample a probability of reporting π_{ijk} from the distribution of π_{ij}.
- Sample a value, X_{ijk}, from a binomial distribution with Y_{ijk} observations and probability π_{ijk} of success.

The reporting rate for year j is given by

$$RR = \frac{\sum_{i=1}^{I} \sum_{k} X_{ijk}}{\sum_{i=1}^{I} \sum_{k} Y_{ijk}}.$$

We repeat the process and find the distribution of RR.

This theoretical analysis would involve simulation as stated above, which was not considered in the scope of the current project. The methodology presents an avenue to explore if it was considered that the extra information obtained was considered to be of sufficient value to justify the work.

4 PEER REVIEW

The project plan was presented to two independent researcher groups, Alistair Murray and Steven Fitzpatrick of the Central Science Laboratory (CSL) and Sara Hilditch of the Statistical Services Unit (SSU) at Sheffield University.

The comments from CSL are given below:

General points

This is a well thought-out and important piece of work. Some detailed comments follow where the text could be clarified to the benefit of the tender. In respect of the quality and impact of the work, perhaps the project might be strengthened by some wider reference to the national and European context? The work proposed is very much in the spirit of the Office of National Statistics Code of Practice and associated Protocols. A number of H&S statistics, including the number of fatalities and major injuries, are published on the ONS web site. This proposal encapsulates a number of aspects from the ONS code and protocols – this could perhaps be made explicit with the advantage of reference to a well considered external quality framework and greater transparency for HSL/HSE. The statistical reviewer(s) do not have knowledge of this subject area – but the question of wider European practice and European Union statistics came to mind. If relevant, the way in which the proposal draws on and/or contributes to development of methodology at the EU level might be mentioned.

Detailed comments on text

2.4 Aims and objectives

For the first objective, it may be important to identify determine and assess important covariates in the model. The term "robust model" is also used and it would be useful to define this explicitly.

The fourth bullet point reads: "how reporting practices affect the measurement of progress…". Might it not be better to assess/ quantify under-reporting as well?

The sixth bullet point mentions a peer review methodology for estimating reporting of major injuries by employers. Is it important to have this by sector as well?

2.5 Methodology

Use of existing data sources/databases will be identified and accessed. Will primary research survey work be required? How likely do existing sources reflect all the data? If under reporting is a problem, surveys may be necessary (scope would need to be defined).

3.1 Pertaining to second paragraph last line: what level will reporting be broken down between RIDDOR v LFS e.g. self-employed vs. permanent, less than 100 employees vs. 100+?

3.3 Beginning of third paragraph: mentions standard statistical techniques used to derive distributions of coefficients. It may be useful to have some further thoughts on these e.g. bootstrapping for production of confidence intervals.

3.4 Regarding the predictions from the model. Is it worthwhile incorporating some sort of sensitivity analysis?

The review was very constructive and useful. Some comments on specific points are:

- It terms of a 'Robust' model, the outcome of the project must be able to recommend a methodology for adjusting the RIDDOR/LFS analysis to obtain the PSA1 indicator that can take into account any differing behaviour in reporting levels between major accidents and over-3-day injuries to the level expected. If the variation were taking the methodology outside its validity range then some test would be needed to highlight this.
- With the RA survey limited to the Manufacturing and Service Sectors, an analysis of the under-reporting by sector (in terms of the differences between major accidents and over-3-day injuries) is not possible. However, some analysis of RIDDOR and LDS across sectors would help to establish how a methodology build on limited sectors would have validity across all sectors.
- In terms of breaking down the analysis by permanent, self-employed etc, the only variable available from the RA survey is company size.
- Some sort of sensitivity analysis is necessary to establish how the variations in Accident Rate and reporting level feed through into the PSA1 indicator. Hopefully some progress can be made analytically when the models are built up, but some simulation may be necessary.

The Statistical Services Unit, The University of Sheffield also reviewed the work. The team made many useful comments during the process, and the conclusion of their review was the following assessment.

"Following discussions with yourself and Graham Warren I am happy that the approach you are using to model the reporting levels is statistically sound. However, the proposed models (as do all statistical models) rely on a number of assumptions and therefore the final model cannot be validated until after it has been fitted and the assumptions validated."

Also, further responses were delivered after the draft of the final report was delivered. There comments are summarised here.

The further comments from The Statistical Services Unit, The University of Sheffield are:

"Review of reports on modelling the PSA1 indicator

With regard to the report on 'Modelling the PSA1 Indicator' produced by HSL (ESS group), provided to SSU on 1st July and the supplementary report on 'Modelling the accident Reporting Rate' provided on 19th July, we have read these reports and considered the statistical techniques applied and we are happy that the statistical methods have been employed correctly.

The reports rely on data from three sources: RIDDOR, LFS and a survey performed by the Risk Assessment group (RA). The work aims to model the under reporting in RIDDOR of major injuries and over-3-day injuries and so inform a correction of the PSA1 indicator. However, as is highlighted in the report, comparisons of LFS and RA data would over estimate the true reporting rate. In order for the modelling techniques to yield satisfactory results, a more reliable data source is needed."

This notes that the under reporting in the RA survey would make it difficult to make a detailed adjustment to the major accidents based on the survey. However, it is believed that using the ratio of major accident to over-3-day injury reporting levels derived from the RA survey to make a global adjustment would be reasonable.

The further comment from the Central Science Laboratory is:

"General points

The report is well presented and addresses the objectives of the tender Ref: T/6019 V2. In particular, it presents a full and clear account of how reporting practices affect targets to reduce major injuries as measured by the PSA indicator. Good use is made of the RA survey and LFS survey to assess the trends in RIDDOR under-reporting.

The report may benefit from a section detailing definitions used by each of the data sources and time periods for when the data was collected. This would allow a reader to easily establish the comparability of definitions across the RIDDOR, RA and LFS surveys.

The original tender stated that General Linear Models, Non-Linear Models and General Additive Models would all be investigated to identify the most appropriate approach in assessing the PSA 1 indicator. The report does not mention if these approaches were considered. A statement outlining why these methods were not pursued would be useful.

Additional data sources referred to in the tender document are not mentioned in the report: FOCUS/GAIN database, local Authority inspectors. These additional data sources might be important as it was noted in the report that under-reporting was also observed in the RA survey data"

5 CONCLUSIONS

Analysis of the trends in the rate of major accidents and over-3-day injuries used by SESU has highlighted that the assumption that the under-reporting of major accidents and over-3-day injuries in RIDDOR could be challenged. A methodology for including differing values of under-reporting was introduced and an independent review of the methodology reported.

A brief analysis was given of the adjustment methodology focusing on the choice of base year, and how this would affect the PSA1 indicator. As the choice significantly altered the PSA1 indicator, it is essential that the year employed be validated using alternative data.

On the more central issue of the analysis of the under-reporting level using the survey carried out by the Risk Assessment Section in HSL, the route for developing on the existing analysis, based on an assumption of normality, has been presented. A detailed examination indicated that it was not possible to assume that the data was normally distributed and if this was assumed than it could lead to distortions of the results. Instead an analysis based on an underlying binomial distribution was considered to be more appropriate.

With the data corresponding between the RA and the RIDDOR surveys, it was possible to model the under-reporting level directly, but it was seen that this would have to be done with care, with an examination of the distribution of reporting level based across the companies.

The main focus of the analysis was the examination of the trends and comparative values of accident rates from the various datasets, i.e. the reported RIDDOR incidents (major accidents and over-3-day incidents separate), the Labour Force Survey data (all reportable accidents combined) and the surveys carried out by the Risk Analysis section of HSL for both the manufacturing sector and services sector (major accidents and over-3-day incidents separate).

The key points emerging from the analysis were:

- The major accident rate for the manufacturing sector showed little change over the five-year period in both the RIDDOR and RA survey data.
- The reporting levels from the manufacturing sector analysis showed a consistently higher reporting for major accidents against over-3-day injuries, with perhaps a trend towards convergence of the levels. This appeared to contradict the basic assumption behind the original adjustment analysis, whereby the model was divergence of reporting levels for the two injury categories from an equal starting point.
- The comparison of overall accident rates from the RA survey and LFS datasets indicated that there was a significant amount of under-reporting within the RA survey.
- The trend of an increasing reportable accident rate, as seen in the RA services survey, was not observed in the RIDDOR or LFS data. This suggested that these data may not be useful in determining the relationship (i.e. reporting level) between the RIDDOR and LDS survey results.

To expand this point in more detail, with under-reporting in the RA surveys, it will be difficult to obtain a good estimate of the separate reporting levels for major accidents and over-3-day injuries. However, since the trend in the PSA1 indicator is the primary statistics of interest the larger survey from the manufacturing sector indicated that the trend in major accident rate is well reflected by the RIDDOR data. This would suggest that an uncorrected value of the PSA1 indicator would give a reasonable picture of the underlying trend, although the survey data

suggested that this approach would over-estimate the PSA1 due to the higher reporting level seen for major accidents against over-3-day injuries. An estimate of the disparity between the two reporting levels could be obtained from the survey data, but with under-reporting also seen in the RA survey data it may not be wise to use the datasets to fine tune the reporting levels across the time period. A broad shifting of the baseline value (i.e. a fixed estimate of the ratio of major accident reporting to over-3-day reporting) could be the most appropriate adjustment.

- The most appropriate adjustment methodology has been proposed. A global adjustment of the major accident rate was calculated using the ratio of major accident to over-3-day injury reporting levels as obtained from the RA survey
- The proposed adjustment would shift the baseline of the PSA1 indicator down, reflecting the conclusion that the major injury reporting level is higher than that of the over-3-day reporting level, but it would not affect the trend in the PSA1 indicator

6 RECOMMENDATION

The current methodology for adjusting the PSA1 indicator is not supported by the current analysis. Unfortunately the presence of under reporting in the RA survey makes it difficult to justify a detailed year-by-year adjustment of the PSA1 indicator. However, the ratio of major accident reporting level to over-3-day reporting level could be used to make a global (across all years) adjustment to the major accident reporting level.

Thus, it is recommended that the formula from section 3.2.1 is used to adjust the major accident rate. Hence, as detailed in appendix B,

If α = major accident reporting level / over-3-day

R_m = RIDDOR major accident rate

R_o = RIDDOR over-3-day injury rate

R_{LFS} = LFS major accident and over-3-day injury rate

r_m = major accident reporting level

Then

$$r_m = (R_m + \alpha R_o) / R_{LFS}$$

With the adjusted major accident rate now given by:

$$R_m^{adjusted} = R_m / r_m$$

Moreover, from the RA data for the manufacturing sector, an estimate of α =1.454 was calculated.

7 REFERENCES

Health and Safety Commission (2000). Revitalising Health and Safety: Strategy Statement, June 2000. Department of the Environment, Transport and the Regions (UK).

Health and Safety Commission/Health and Safety Executive (2003), Health and Safety Statistical Highlights 2002/03. National Statistics (UK), page 36

An Investigation of Trends in Under-reporting of Major and Over-3-Day Injuries in the Manufacturing Sector, C Daniels, P Marlow & R Cummings, HSL.

APPENDIX A

Accident rate data tables.

Table A1: RIDDOR accident rates, all sectors

	RIDDOR - All Services		
Year	Major	O3D	All
99/00	116.6	550.9	667.5
00/01	110.2	536.9	647.1
01/02	110.9	513.5	624.4
02/03	111.1	506.5	617.6
03/04	120.7	508.4	637.0

Table A2: LFS accident rates, all sectors

	LFS
Year	All
99/00	1500.0
00/01	1530.0
01/02	1510.0
02/03	1440.0
03/04	1340.0

Table A3: RIDDOR accident rates, manufacturing sectors

	RIDDOR - Manufacturing		
Year	Major	O3D	All
99/00	204.1	1007.9	1212.0
00/01	194.2	998.8	1193.0
01/02	194.9	962.6	1157.5
02/03	194.3	961.7	1156.0
03/04	190.6	891.4	1082.0

Table A4: Risk Assessment survey accident rates, manufacturing sector

	RA - Manufacturing		
Year	Major	O3D	All
99/00	192.7	1426.4	1619.1
00/01	153.1	1409.3	1562.4
01/02	216.3	1338.0	1554.3
02/03	177.0	1280.4	1457.4
03/04	186.9	1108.0	1294.8

Table A5: LFS accident rates, manufacturing sector

	LFS
Year	All
99/00	2110.0
00/01	2080.0
01/02	2070.0
02/03	1930.0
03/04	1860.0

Table A6: RIDDOR accident rates, services sector

RIDDOR – Services	
Year	All
99/00	509.5
00/01	498.8
01/02	487.5
02/03	488.8
03/04	535.0

Table A7: Risk Assessment survey accident rates, services sector

	RA - Services		
Year	Major	O3D	All
99/00	83.7	590.6	674.3
00/01	126.9	467	593.9
01/02	137.9	538.3	676.2
02/03	131	764.2	895.2
03/04	222.7	646	868.7

Table A8: LFS accident rates, services

	LFS
Year	All
99/00	1240.0
00/01	1280.0
01/02	1270.0
02/03	1230.0
03/04	1130.0

APPENDIX B

Calculating the Major Accident Reporting Level

Recorded accident rates:

RIDDOR Major accident rate	R_M	: From RIDDOR
RIDDOR over-3-day injury rate	R_O	: From RIDDOR
LFS overall accident rate	R_{LFS}	: From LFS

Reporting levels:

RIDDOR major accidents	r_m	
RIDDOR over-3-day injuries	r_o	
Overall (major + over-3-day) RIDDOR vs. LFS	r	
Ratio of major reporting level to over-3-day reporting level	α	: From HSL RA survey

Definitions:

$$r = (R_M + R_O) / R_{LFS}$$

$$\alpha = r_m / r_o$$

The value of r_m is required for calculating the PSA1 indicator value.

Overall accident rate (from LFS)	=	Major accident rate (from RIDDOR, adjusted for under-reporting)	+	Over-3-day injury rate (from RIDDOR, adjusted for under-reporting)

$$R_{LFS} = R_M / r_m + R_O / r_o$$

$$= R_M / r_m + R_O / (r_m/\alpha)$$

$$R_{LFS} = (R_M + \alpha R_O) / r_m$$

$$\Rightarrow \quad r_m = (R_M + \alpha R_O) / R_{LFS}$$

Calculation of α

The reporting level in the manufacturing sector over the five years is:

Reporting Level in Manufacturing			
Year	**Major**	**O3D**	**α**
99/00	105.9%	70.7%	1.499
00/01	126.8%	70.9%	1.790
01/02	90.1%	71.9%	1.252
02/03	109.8%	75.1%	1.462
03/04	102.0%	80.5%	1.268

which gives a mean value of α over the five years of 1.454, with a s.d. of 0.281

The value calculated from the pilot services data is;

Reporting Level in Services			
Year	**Major**	**O3D**	**α**
99/00	139.3%	93.3%	1.493
00/01	86.8%	115.0%	0.755
01/02	80.4%	95.4%	0.843
02/03	84.8%	66.3%	1.280
03/04	54.2%	78.7%	0.689

The mean value of α for services is 1.012, with a s.d. of 0.354

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