Time trends in the incidence of work-related ill-health in the UK, 1996-2015: estimation from THOR surveillance data

Report to the UK Health and Safety Executive

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31st August 2016

KEY MESSAGES

- Work-related contact dermatitis (CD) incidence as reported by dermatologists to EPIDERM decreased during 1996-2006, after which it remained relatively flat until 2012, with a suggested further decrease between 2012 and 2015. The annual average change in CD incidence (1996-2015) was -3.8% (95% CIs: -4.3, -3.3). Analyses of shorter-term trends (2006 to 2015) suggested a similar annual average decrease of -3.9% (95% CIs: -5.3, -2.4) per year.
- For neoplasia, observed trends were markedly different depending on whether analyses were based on reports from 'core' or 'sample' dermatologists; the former suggested a decrease in incidence and the latter an increase. Of the two, it is possible that 'sample' data are more representative for this particular condition. However, for both groups the confidence intervals on the annual plots were wide and overlapping. It is therefore difficult to draw any firm conclusions about neoplasia trends from these data.
- The incidence of work-related respiratory disease as reported by chest physicians to SWORD fell between 1999 and 2007, after which it remained relatively flat. The average decrease in asthma incidence (1999-2015) was -7.0% (95% CIs: -8.2, -5.8) per year. Analyses of shorter-term trends (2007 to 2015) showed an average change of -3.3% (95% CIs: -6.6, 0.1) per year.
- Overall, the annual pattern of change for non-malignant pleural disease (NMPD) and mesothelioma incidence was relatively flat. However, for mesothelioma there was evidence of a decrease in incidence between 2013 and 2015. For NMPD the average change in incidence was -1.4% (95% CIs: -2.4, -0.3) per year whilst for mesothelioma it was -3.2% (95% CIs: -4.5, -1.9). However (especially when considering information from other sources) the results for mesothelioma in particular should be viewed very cautiously as they may reflect a shift in clinical practice rather than a 'true' trend (resulting in cases previously seen by SWORD reporters being increasingly seen by chest physicians specialising in lung cancer, who may not participate in SWORD).
- Reports from chest physicians continue to suggest that the incidence of pneumoconiosis has been increasing since (approximately) 2007 with an average increase of +4.0% (95% CIs: +2.0, +6.0) per year (1999-2015). For the period 2007-2015, the equivalent estimate was +10.6% (95% CIs: +5.7, +15.7). The observed increase appears largely attributable to asbestos rather than other agents (e.g. silica or coal).
- Due to methodological changes, analyses based on cases reported by general practitioners to THOR-GP for the period 2011 onwards (i.e. since the change to 100% 'sample' reporting) are the most informative for current and future trends for this group. These data suggest an average annual decrease in the incidence of total work-related illness of -13.9% (95% CIs: -18.9, -8.6). Equivalent figures for skin were -18.9% (95% CIs: -33.2, -1.4), for musculoskeletal -9.3% (95% CIs: -16.4, -1.5) and for mental ill-health -16.1% (95% CIs: -23.4, -8).
- The estimates provided in this report were not adjusted for the potential impact of reporter 'fatigue'. However, a summary of previous analyses investigating this phenomenon has been provided. Based on these, the likely impact on the average, annual change in incidence for total skin disease (EPIDERM) and total respiratory disease (SWORD) would be to attenuate the estimate from -3.9% to -3.5% and from -3.1% to -2.6%, respectively. There was no evidence of fatigue in THOR-GP sample reporters.

EXECUTIVE SUMMARY

The Health and Safety Executive (HSE) funded data collection for three constituent schemes of THOR during 2015. These were EPIDERM (dermatologists), SWORD (chest physicians) and THOR-GP (GPs). This report describes temporal trends in incidence of work-related illness (WRI) in the UK as reported to these three schemes and updates previously submitted reports by the incorporation of a further year (2015) of data. Data were analysed in a manner (using a 'multi-level' statistical model) in which the number of reported cases over time could be investigated whilst taking into account other factors that might influence the trend, (for example, change in the number of physicians reporting or in the number of people employed in the UK.) Change in incidence has been presented either as the average, annual percentage change in incidence rate over a defined period or as graphs showing the risk for each year relative to a reference year (2015).

Analyses were carried out separately (for each scheme), for the total reported cases and then for each of the conditions of interest (for example, asthma). THOR physicians participate either on a monthly basis (termed 'core' reporters) or for one randomly allocated month per year (termed 'sample' reporters) and separate analyses were carried out for each of these groups as well as (where appropriate) both types together. Both EPIDERM and SWORD comprise (and have done throughout the study period) a smaller 'core' group (approximately 10% of reporters) and a larger 'sample' group with most physicians remaining as either 'core' or 'sample' throughout their time in the scheme. THOR-GP differs in that all physicians initially participated as 'core' but over time the proportion of 'sample' reporters increased and from 2011 onwards all physicians have been 'sample'. Thus, some physicians changed their reporting frequency from 'core' to 'sample' during their time in the scheme. This is important because evidence (from THOR-GP and the occupational physician reporting scheme, OPRA) has shown that physicians behave differently depending on whether they are participating as 'core' or 'sample', with the former reporting less cases (in any given month) compared to the latter. Because of these extensive changes, GP analyses based on 'sample' reporters only for the period 2011 onwards are probably the most informative of current and future trends for this physician group.

It is also important to consider the issue of 'reporter fatigue' i.e. the longer a physician participates in a voluntary scheme such as THOR they might start to lose interest but still retain membership. How such 'fatigue' may manifest, implications for the trend estimates and whether/how it can be adjusted for has been an important

methodological challenge for this project and an overview of previous analyses investigating this phenomenon is provided. The results of these analyses suggest that, for EPIDERM and SWORD, some of the observed decrease in disease incidence over time is in fact due to reporter 'fatigue' rather than a 'true trend'. Evidence of fatigue was also observed for THOR-GP 'core' reporters but not 'sample' reporters who are asked to report much less frequently. For EPIDERM, adjusting for 'fatigue' would likely mean (on average) a decrease in (total skin disease) incidence of -3.5% per year (compared to -3.9% per year if not adjusted for). For SWORD (total respiratory disease) the equivalent change would be from -3.1% to -2.6%.

WORK-RELATED SKIN DISEASE: The main diagnostic breakdown of the 18917 cases of work-related skin disease reported to EPIDERM (1996-2015) was 82% contact dermatitis (CD), 12% neoplasia, and 5% urticaria. The annual average decrease in CD incidence (1996-2015) was -3.9% (95% CIs: -4.3, -3.4). The graphs showing relative risk by year (compared to 2015) suggest an initial decrease in incidence (1996-2006) followed by a relatively flat trend (2006-2012) and then a further decrease between 2012 and 2015. The average annual, estimated change in CD incidence for the shorter period (2006-2015) was -3.9% (95% CIs: -5.3, -2.4).

Neoplasia trends continue to differ depending on reporter type ('core' and 'sample'). Reports from 'core' reporters suggested an annual average decrease in incidence of -4.9% (95% CIs: -6.5, -3.3) whilst 'sample' reporters suggested an *increase* in incidence of +2.2% (95% CIs: -0.7, +5.3). Of the two, it is likely that 'sample' data are more representative for this diagnosis (EPIDERM 'core' reporters are a self-selected group of 'motivated specialists' whose main area of expertise is likely to be CD and therefore other cases, such as neoplasia, may be triaged to other e.g. 'sample' reporters). However, for both groups of reporters, the confidence intervals on the annual plots are wide and overlapping suggesting that dermatologists in general (or those reporting to EPIDERM) are seeing relatively few neoplasia cases and it may be that other physicians, for example oncologists, would be a better source of information about trends in incidence for this disease.

General Practitioners reporting to THOR-GP also report skin diagnoses (10% of the total GP cases). The average, annual change in (total skin disease) incidence based on sample reports only (2011-2015) was -18.9% (95% CIs: -33.2, -1.4).

WORK-RELATED RESPIRATORY DISEASE: Case reports of work-related

respiratory disease reported by chest physicians to SWORD (12686 in total, 1999-2015) were asthma (19%) with the remainder being the (primarily) asbestos related diseases; benign pleural plaques (43%), and mesothelioma (19%), as well as pneumoconiosis (9%). The average annual decrease in asthma incidence (1999-2015) was -7.0% (95% CIs: -8.2, -5.8). The graphs showing relative risk by year suggested an initial decrease in incidence (1999-2007) followed by a relatively flat trend. The average annual, estimated change in asthma incidence since 2007 was -3.3% (95% CIs: -6.6, 0.1).

Reports by chest physicians suggested an average annual decrease in mesothelioma incidence of -3.2% (95% CIs: -4.5, -1.9) per year. The annual plots show a relatively flat trend overall but with a suggested fall in incidence between 2013 and 2015. An average, annual decrease in incidence was also observed for non-malignant pleural disease at -1.4% (95% CIs: -2.4, -0.3) with some slight variation when analyses were restricted to 'core' data or 'sample' data only. However (especially when considering information from other sources) the results for mesothelioma in particular should be viewed very cautiously as they may reflect changes in clinical practice rather than a 'true' trend (such cases previously seen by SWORD reporters, may be increasingly seen by physicians specialising in lung cancer, who may not participate in SWORD).

Data from SWORD continue to suggest a possible increase in pneumoconiosis incidence since approximately 2007. The average, annual change (1999-2015) in incidence was +4.0% (95% CIs: +2.0, +6.0) and for 2007-2015 it was +10.6% (95% CIs: +5.7, +15.7). The observed increase appears largely attributable to asbestos rather than other agents (e.g. silica or coal).

Analyses based on cases of work-related respiratory disease reported to THOR-GP data were not carried out (only 2% of case reports to THOR-GP are in this category).

WORK-RELATED MUSCULOSKELETAL DISEASE: GPs reported 3371 diagnoses of musculoskeletal disorders during 2006-2015 (52% of the total reports to THOR-GP). Of these, 47% were upper limb (hand/wrist/arm/elbow/shoulder), 38% spine/back (neck/thoracic spine/lumbar spine/trunk) and 14% lower limb (hip/knee/ankle/foot). Data from 'sample' reporters (2011-2015) suggested an average, annual decrease in incidence (total musculoskeletal disorders) of -9.3% (95% CIs: -16.4, -1.5). For upper limb disorders the equivalent estimate was -4.8%

(95% CIs: -15.3, +7.1), for spine/back it was -11.8% (95% CIs: -22.3, +0.1) and for lower limb it was -4.5% (95% CIs: -21, +15.5). It is difficult to draw any firm conclusions of the year on year trend (from the annual plots) at this stage because the confidence intervals for the individual year estimates are wide and overlapping.

WORK-RELATED MENTAL ILL-HEALTH: A total of 2102 mental ill-health diagnoses were reported to THOR-GP (2006-2015) comprising 32% of the total cases. Diagnoses were predominantly other work stress (66%) and anxiety and depression (43%). For 'sample' reporters an (average) annual change in incidence (2011-2015) of total mental ill-health of -16.1% (95% CIs: -23.4, -8.0) was observed. As observed for musculoskeletal disorders, it is difficult to draw any firm conclusions (from the annual plots) regarding the year on year change as the confidence intervals for the individual year estimates are wide and overlapping. A decrease in incidence was also suggested for anxiety and depression at -18.3% (95% CIs: -30.4, -4.0) per year and for other work stress at -12.4% (95% CIs: -21.3, -2.5).

EXECUTIVE SUMMARY

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1. BACKGROUND

The ability to accurately measure trend in work-related illness (WRI) incidence is an important objective of occupational disease surveillance. This report describes the trend in incidence of WRI based on data from three occupational disease surveillance systems supported by the Health and Safety Executive (HSE) for data collection during 2015: case reports of work-related skin disease reported to EPIDERM by dermatologists (1996-2015), case reports of work-related respiratory disease reported to SWORD by chest physicians (1999-2015), and case reports of (any) WRI reported to THOR-GP by general practitioners (2006-2015). These three schemes are part of The Health and Occupation Research (THOR) network, hosted by the Centre for Occupational and Environmental Health at the University of Manchester[1]. The report builds on previous reports submitted to the HSE on an annual basis[2-11].

To measure WRI trends, one approach is to simply look at case counts over time but this method does not take into account other factors that might influence the trend (for example, changes in the numbers of reporters). Thus, in 2005, McNamee *et al* proposed a methodology (in a report submitted to HSE) to assess change in incidence of WRI over time using surveillance data collected by THOR[12]. This method proposed using a multi-level model (MLM) which enables change over time in the number of reporters and in other reporter characteristics which could independently impact on case density to be taken into account. This method was subsequently employed to determine trends in incidence for the period 1996 to 2004[2], and in agreement with HSE, on an annual basis thereafter, thus incorporating each additional year of available data[3-11].

A range of methodological issues have been successfully addressed since the inception of this programme of work. Most recently, the focus has been on the issue of 'reporter fatigue' and how best to address this. Extensive analyses have been undertaken (and reported upon) to determine whether physicians participating in THOR are exhibiting 'reporter fatigue', and if so, how it impacts on the estimate of trend and whether it can be adjusted for[2, 5, 13-16]. The culmination of this body of work (to date) has recently been submitted for peer review[17] and it has been agreed with HSE that the annual trends estimates would not be formally adjusted (if appropriate) for fatigue until after the publication of this article. However, the importance of the implications of this body of work regarding the interpretation of the annual trends estimates is also recognised. To this end, the present report includes a summary of the work in this area, including guidance on interpreting the annual trends results if the existing evidence for fatigue from this work was accepted.

2. METHOD

A full description of the methodology employed in this study is provided hereunder.

2.1 DATA PERIOD

The data period used for the trends analysis is shown in Table 1.

Table 1 Data period for trends analyses

	Scheme start date	Data period for trends study		
		All reporters	**Core reporters**	**Sample reporters**
EPIDERM	**1993**	1996-2015	1996-2015	1996-2015
SWORD	**1989**	1999-2015	1999-2015	1999-2015
THOR-GP	**June 2005**	N/A	2006-2009	2011-2015

2.2 REPORTER GROUPS

Physicians reporting to THOR report either as core reporters (reporting every month) or as sample reporters (reporters who report one randomly allocated month a year). The composition of each of the schemes is as follows:

EPIDERM: Consultant dermatologists began reporting to EPIDERM in 1993 and initially all reporters reported at 3-month intervals[18]. In January 1996 the scheme was redesigned to consist of a 'core' group with a special interest in occupational skin disease who reported to the scheme on a monthly basis (24 dermatologists originally) with the remaining specialists (220 originally) assigned to report on a 'sample' basis. This mix of 'core' and 'sample' reporters i.e. a smaller 'core' group consisting generally of 'keen specialists' and a larger 'sample' group, continued for the period covered by the current report (1996-2015). For this scheme, analyses based on all reporters combined and separately for 'core' and 'sample' groups were carried out.

SWORD: UK wide SWORD reporting began in 1989[19] and originally physicians could report either monthly (78% of physicians originally), quarterly (19%), bi-annually (<1%) or annually (2%). This original system of reporting was modified in January 1992 (to combat potential reporter fatigue) with those physicians who had reported the most cases forming a 'core' group (approximately 10% of physicians at that time) with the remainder assigned to report on a 'sample' (monthly) basis. As for EPIDERM, this structure of a smaller group of keen specialists and a larger 'sample' group continued throughout the time period covered by these analyses (1999-2015

for SWORD). For this scheme, analyses based on all reporters combined and separately for 'core' and 'sample' groups were carried out.

THOR-GP: Initially all reporters to THOR-GP reported on a 'core' basis. This permitted the scheme to 'come up to speed' rapidly, and to provide the HSE with early data on the distribution of GP reported WRI from THOR-GP. 'Sample' reporting was introduced to THOR-GP in April 2007 to counteract possible reporter fatigue with a small number of 'sample' reporters (33 (7%) reporters during the period April 2007 to December 2009). In 2010, the proportion of 'sample' reporters increased to 78% to give a core:sample ratio of 1:4. Since the introduction of 'sample' reporting in 2007, all new reporters that were recruited to the scheme were randomly allocated to participate as either 'core' or 'sample'. Additionally, in 2010 all reporters not previously assigned 'core' or 'sample' status were randomly allocated to one of these two different reporting groups. From 2011 onwards, (especially because HSE could no longer fund remuneration for GP participation) all reporters became 'sample' reporters. Because of these extensive changes (there is evidence that 'sample' GPs might report more cases during any one month compared to 'core' reporters)[20], it was not felt appropriate to consider THOR-GP trends for the period as a whole, for all reporters combined ('core' and 'sample') or to directly compare pre and post 2010/2011 trends. Therefore GP analyses were carried out for 'sample' reporters only for the period 2011 onwards, and for 'core' reporting only for the period 2006-2009. Given that 'core' reporting has now ceased, it is the former that will be most informative of future trends for this group.

Definition of an active reporter: For the purpose of the analyses it was deemed important to include only those reporters with evidence of active participation. For the THOR specialist schemes an active reporter was defined as a reporter who either returned cases or declared 'I have nothing to report' (a zero return) during the study period. For THOR-GP, reporters can submit a sickness absence (SA) return only in any given month (i.e. information about additional sickness absence that has been issued to a previously reported case). Approximately 5 reporters a month submit a SA return with no other information about cases (case or zero return): ideally they should also have submitted a zero return if there are no new cases. While these reporters are, in the general sense of the word, active, in terms of contributing information about incidence they are not. On the other hand, it might be assumed that, if they had seen new cases they would have contributed them and therefore this corresponds to a zero return in terms of incidence. However, as it is difficult to be sure of this and this activity accounts for a very small proportion of the monthly returns, we considered them to be inactive. Therefore for the purpose of this trends analysis also, a THOR-GP reporter has to have submitted a case or zero return to be considered active for the purpose of studying trends in incidence.

2.3 CATEGORIES OF ILLNESS

Initial power calculations undertaken for the THOR specialist schemes suggested that a specific disease category should only be investigated (separately) if the number of actual cases reported during the study period exceeded 250[2]. For THOR-GP it was decided that, although over a shorter time period, the minimum number of cases required for any disease category to be included in the analysis would remain at 250. The resulting disease groups to be included in the analysis are shown in Table 2.

Table 2 Categories of illness included in the analyses

	Clinical specialist	THOR-GP
All work-related illness	-	Yes
Total skin	Yes	Yes
Contact dermatitis (CD)	Yes	-
• Allergic CD	Yes	-
• Irritant CD	Yes	-
• Mixed CD	Yes	-
Neoplasia	Yes	-
Contact urticaria	Yes	-
Other skin (other than contact dermatitis)	Yes	-
Total respiratory	Yes	-
Asthma	Yes	-
Mesothelioma	Yes	-
Benign pleural disease	Yes	-
• Predominantly plaques	Yes	
• Predominantly diffuse	Yes	
Pneumoconiosis	Yes	-
Other respiratory disease (other than those specified above)	Yes	-
Total musculoskeletal	-	Yes
Upper limb disorders (hand/wrist/arm/shoulder/elbow)	-	Yes
Spine/back disorders (neck/thoracic spine/lumbar spine/trunk)	-	Yes
Lower limb disorders (hip/knee/ankle/foot)	-	Yes
Total mental ill-health	-	Yes
Anxiety and depression	-	Yes
Other work stress	-	Yes

2.4 THE MULTI-LEVEL MODEL AND ITS ASSUMPTIONS

The STATA software command **xtnbreg** was used to fit longitudinal, negative binomial (i.e. over-dispersed) Poisson models with random effects.

In these models, the dependent variable was the number of actual cases, including zeros, per reporter per month; the main 'covariate' is calendar time. The aim of the analysis is to estimate the relationship between annual UK incidence rate and time, after adjusting for potential confounders. Numbers of cases might vary from year to year solely because of changes in the size of the UK working population, even though the rate is constant. Therefore estimated population sizes for each year (see below) were included in the model as an 'offset'; this feature means that the model estimates change in rates, not changes in case counts.

Apart from 'calendar time', the other variables included in the regression models as covariates were 'season', 'reporter type' ('core' or 'sample'), 'first month/s as a new reporter'. These are factors that can influence the reported incidence levels. Further details of covariates/offsets in the model are given later in this section.

It is important to allow for the possible impact of having different reporting centres at different periods of time: some centres may have a larger, or more 'at risk' catchment patient population than others. In a statistical model, we can take account of such differences by allowing the incidence level to vary between centres; the analysis can then trace the pattern over time 'within centres'. In a 'fixed effects' approach to this, the incidence level is estimated for each centre; in a 'random effects' model, the incidence levels are assumed to vary randomly between centres in each subgroup (e.g. subgroups of core reporters and sample reporters) but not estimated directly. In previous reports, two sets of results were presented corresponding to each of these options but, after consultation with HSE, it was decided that from 2010 onwards only results based on models with random effects would be presented. (One reason was because the fixed effects model omits all reporters who had reported only zero cases throughout the study period).

Every statistical model has to make an assumption about the form of the variability which remains after taking into account all covariates in the model. The Poisson distribution is the usual distribution assumed for count data; the Negative Binomial distribution is a more general version of a Poisson distribution which is less rigid; in the Poisson the variance and mean are constrained to be equal, but not in the Negative Binomial.

Calendar time – For the main analyses, changes in incidence were estimated in two different ways: 1) '*non-parametric' approach*: the model contained separate indicator variables for different years. In the current analyses, 2015 was taken as the reference year (2009 for THOR-GP core only analyses) and the percentage increase

or decrease in incidence compared to 2015 (or 2009) was estimated. These analyses had no in-built assumptions about the pattern of change over time. 2) *'parametric' approach* with a continuous time variable measured on a scale of years. The statistical models for these analyses assumed a systematic trend throughout the period being studied. Specifically, it was assumed that the percentage change from one year to the next is a constant throughout the relevant period. Where the assumption is valid, this parametric approach offers a more precise way of estimating change than approach 1.

Season – Seasonal variation refers to variation within a year whose pattern tends to be repeated from year to year. This short-term variation could be due to seasonal variation in illness or seasonality in reporting behaviour; the latter could occur because of holidays, for example. To address this, indicator variables for months (with June as the reference category) were included in the models. Seasonal variation should not bias the assessment of long-term changes in this study. However it could affect precision in the estimate of trend if not controlled.

Reporter type – Reporter type ('core' or 'sample') had been shown to cause variation in incidence between reporters. Thus, a variable which took the value '1' if a 'core' reporter and '0' if a 'sample' reporter was included in the models. Furthermore, for the purpose of the analysis, if a reporter changed from the 'core' reporting group to 'sample' reporting or vice versa, he or she was treated as a new reporter for the period after the change. We have previously shown[20] that there are differences in behaviour for the same reporter depending on whether they are reporting as 'core' or as 'sample'.

First month/s as a new reporter – It is conceivable that, in the first month/s of reporting, a new entrant to a surveillance scheme might include cases seen over a period longer than the assigned single month. If there was a sufficiently large 'harvest' of old cases, it could produce a false, decreasing 'trend' over time. For the THOR specialist schemes, initial investigations suggested that 'new recruit' harvesting might be occurring during the first month that a reporter actively reported to a scheme. Thus, to control for harvesting, a variable which took the value '1' if it was the first month the reporter had reported and '0' for all other months was included in the models. Initial investigations suggested that the period of 'harvesting' maybe longer for THOR-GP compared to the specialist schemes (5 months compared to 1). This might occur because, compared to specialists, there is more opportunity for 'old' cases to present themselves again to a GP, thus prompting a report. Thus, variables representing the first 5 months of active reporting were included in the THOR-GP regression models. Moreover, for these main analyses, the first 7 months of THOR-GP were excluded (June to December 2005). Since approximately 28% of the GPs (reporting between 2006 and 2013) joined the scheme in 2005, it was felt that the 2005 data may have been particularly prone to the effect of harvesting. Of note, for those reporters joining THOR-GP as 'sample'

reporters (19% of the total ever reporters), the period of harvesting was taken as 1 month rather than 5 ('sample' reporters only report for one randomly selected month per year, therefore the first 5 months of reporting would in effect span 5 years).

Population change - Analysis of data from the UK Labour Force Survey (LFS) had shown a fairly regular increase in the size of the working population of the order of 1% a year up to 2006[21], although decreases may have occurred since then. One might perhaps expect to see an increase in cases over time because of this even if true incidence *rates* remained constant. Therefore we have accounted for this change in population base by including in the ML model an offset variable representing the UK working population, obtained from the LFS, for each year.

Table 3 Summary of model features

Feature	Description
Centre variation	Variation in incidence between centres is assumed; analysis attempts to measure change within centres
Centre number	If a reporter changed from 'core' to 'sample' (or vice versa) they were assigned a new centre number and thus treated as a new reporter in the model
Denominators/population sizes	The catchment population for each centre is assumed to increase/decrease in line with changes in the size of UK working population
Unexplained variation	Assumed to follow a Negative Binomial distribution
Active reporter	Only 'active' reporters were included in the analysis. This was defined as a reporter who either returned cases or declared 'I have nothing to report' (a zero return) at least once during the study period.
New recruit 'harvesting' of old cases	For SWORD and EPIDERM, the model assumes that this effect only occurs during the first month of reporting or the first month a reporter returned as a core reporter. For THOR-GP, it allows it to occur for the first 5 months of reporting for those joining as 'core' and 1 month for those joining as 'sample' reporters.
Calendar time treatment: non-parametric approach	Rate Ratio for each year compared to 2015 is estimated
Calendar time treatment: parametric approach	A linear trend over time is assumed: Rate Ratio for each year compared to the previous one is estimated

2.5 SUMMARY OF 'REPORTER FATIGUE' INVESTIGATIONS

A major methodological concern of this project has been the issue of reporter 'fatigue' (i.e. as membership time increases a reporter might become less committed to active participation but still retain membership), how it manifests and whether this can cause bias in time trend estimation. Previous investigations reported to HSE have focussed on two different manifestations of fatigue; an increase in non-response over time and an increase in zero (blank) returns over time[2, 5, 13-16]. We have argued previously that an increase in non-response over time would not necessarily cause bias in trends estimation; therefore results of these analyses have not been reproduced here. In contrast, an increase in zero returns over time, some of which may be 'false zeroes' and which do not truly equate to 'zero cases', would mean that the trend over time would be biased downwards compared to the situation if there were no reporting fatigue.

Steps taken to investigate this particular manifestation of fatigue are summarised in Appendix 1. The most recent (and we believe improved) approach has been the application of a zero-inflated negative binomial (ZINB) model. These analyses have recently been written up and submitted for peer review[17] with an overview provided below.

Analysis of zero-inflated count data using a zero-inflated negative binomial model (ZINB)

To account for the presence of excess zero cases within the reported data, the reported monthly number of cases was fitted using a Zero-Inflated Negative Binomial Model (ZINB) with multi-level random effects.

This model has two parts; the first supposes that, on occasion, a reporter might send back a zero report regardless of the actual number of cases seen i.e. an excess zero. This part of the model supposes a binary decision: send back an excess zero regardless or send back the true count zero or otherwise. The second part is the usual negative binomial model for true cases, including true zero cases, each month. The model allows for two sets of predictors in the two portions of the model. These were mean centred membership year (first part of model) and calendar time (second part of model). Thus the complete model allows for the possibility of excess zeros in the data; it can estimate their frequency and can estimate the true trend after allowing for this phenomenon.

The covariate thought to influence zero case reports and therefore included in the first part of the model was peak holiday season. Covariates thought to influence the incidence of work-related illness, and therefore included in the second part of the model, were first month as a reporter and months of the year containing a bank

holiday. All modelling was repeated for 'core' reporters only, 'sample' reporters only, and both 'core' and 'sample' reporters.

Using this approach, data for EPIDERM (1996-2012), SWORD (1999-2012) and THOR-GP (2006-2012) were analysed[15-17]. The impact of adjusting for excess zeros on the annual average percentage change in incidence of total work-related skin disease (EPIDERM), total work-related respiratory disease (SWORD) and total WRI (THOR-GP) is shown in Table 4.

Results:

EPIDERM

The results suggest that both core and sample dermatologists reporting to EPIDERM are exhibiting reporter fatigue. Overall core reporters were less likely to report an excess zero than sample, yet both experienced an increase in excess zero returns with increasing membership time. Thus, adjusting for 'excess zeros' would have a greater impact on the trend estimates for sample reporters compared to core. However, because sample reporters contribute less data, the impact on the overall estimate (core and sample) is less pronounced.

SWORD There is little evidence that SWORD core reporters are exhibiting reporter fatigue as would be shown by an increase in excess zero returns with increasing membership time. The evidence of reporting fatigue for SWORD sample reporters appears to be less strong than for EPIDERM sample reporters but there does appear to be fatigue manifesting in this way for this group. For SWORD, sample reporters contribute more data than core reporters and therefore fatigue in this group may have more impact on the overall estimate (compared to core).

THOR-GP There was some evidence of reporter fatigue (as shown by an increase in excess zero returns with increasing membership time) for THOR-GP. Contrary to SWORD and EPIDERM, excess zeros were more likely to be reported by core compared to sample reporters. Since core reporting has now ceased, it is the impact of fatigue on sample reporting that is of greater interest. It should be noted that sample reporting is a relatively new phenomenon in THOR-GP (only 100% since 2011) and therefore it is important to continue to monitor the potential impact of reporter fatigue on this group.

Table 4 Influence of excess zeros on the average annual percentage change in reported incidence in work-related illness

		Core	Sample	Core + sample
EPIDERM	Member year[a]	1.14 (1.06, 1.22)*	1.09 (1.05, 1.12)*	1.08 (1.05, 1.12)*
(Total skin disease)	Negative binomial[b]	-2.8	-1.8	-2.6
	ZINB[c]	-2.4	0.0	-2.3
	% change[d]	14%	100%	12%
	Vuong p-value[e]	<0.001	0.003	<0.001
SWORD	Member year	1.04 (0.94, 1.14)	1.05 (1.02, 1.08)*	1.04 (1.02, 1.07)*
(Total respiratory disease)	Negative binomial	-2.7	-2.4	-2.5
	ZINB	-2.8	-0.5	-2.1
	% change	4%	79%	16%
	Vuong p-value	0.406	0.053	0.012
THOR-GP	Member year	1.26 (1.11, 1.44)*	1.10 (0.92, 1.32)	1.17 (1.05, 1.29)*
(Total work-related illness)	Negative binomial	-13.8%	-23.7%	-14.4%
	ZINB	-9.2%	-20.9%	-10.98%
	% change	34%	12%	25%
	Vuong p-value	0.010	0.263	0.006

*****Statistically significant at the 5% level or below

[a]Excess zero odds ratio: This denotes whether the proportion of excess zeros is (significantly) increasing with membership time. For example, for EPIDERM core reporters, excess zeros increase by 14% per year of membership and this increase is statistically significant

[b]Annual average percentage change in incidence from negative binomial model (i.e. not adjusted for excess zeros)

[c]Annual average percentage change in incidence from zero-inflated negative binomial model (i.e. adjusted for excess zeros)

[d]Percentage difference between negative binomial model and zero-inflated negative binomial model

[e]Vuong test comparing whether the zero-inflated negative binomial model is a statistically better fit to the data than the negative binomial model

3 RESULTS

3.1 OVERVIEW OF SCHEMES

An overview of the reporting activity of the physicians participating in EPIDERM, SWORD and THOR-GP is provided in Appendix B and briefly described below.

3.1.1 EPIDERM

A total of 453 dermatologists have been enrolled in EPIDERM during the study period with 93% actively participating at least once (i.e. either returning cases or declaring 'I have nothing to report this month'). On average, 190 dermatologists participated in EPIDERM each year and 2015 saw a small drop in the overall number of physicians in EPIDERM (from 153 in 2014 to 148 in 2015). Response rates (cards returned/cards sent out) per year showed an initial increase between 1996 and 2001, after which they exhibited an overall decline until 2012 after which they appeared to increase slightly again, stabilising at around 65-70%. The number of active reporters per month has shown a similar pattern with an average of 21 per month in 2015 (compared to 22 per month in 2014). The average cases per active reporter remained the same between 2014 and 2015 at 2. Reporters to EPIDERM are predominantly 'sample' (86% in 2015) but 'core' reporters report more cases per active reporter per month (3.5) compared to 'sample' (1). Case reports to EPIDERM continue to be predominantly contact dermatitis (82% of total cases) with smaller proportions of neoplasia (12%) and other skin diagnoses.

3.1.2 SWORD

Active participation in SWORD during the study period was similar to EPIDERM with 93% of the 871 chest physicians enrolled during this period actively reporting at least once. On average, 468 chest physicians participated in SWORD each year and the total number of reporters in SWORD decreased slightly between 2014 and 2015 (433 to 422). Response rates (cards returned/cards sent out) have declined over time and were approximately 55% (for both 'core' and 'sample') for 2015. The average number of active reporters per month decreased slightly between 2014 and 2015 (29 and 27, respectively) whilst the average number of cases per active reporter increased slightly (1.1 in 2014, 1.2 in 2015). Similar to EPIDERM, the smaller group of chest physicians reporting as 'core' reported more cases per active reporter per month (3.1) than chest physicians reporting as 'sample' (0.5). The majority of the diagnoses (43%) reported to SWORD during the study period were benign pleural plaques. Of the remaining cases 19% were mesothelioma, 19% asthma, 9% pneumoconiosis, and 14% 'other' respiratory disease.

3.1.3 THOR-GP

THOR-GP differs from EPIDERM and SWORD in that at the start of the study period (2006) all GPs reported to THOR-GP on a ‘core’ basis whilst since 2011, reporting has been exclusively ‘sample’, with the majority of the switch from ‘core’ to ‘sample’ occurring in 2010. On average, 259 GPs were enrolled in THOR-GP each year. Active participation during this period was lower than observed for SWORD and EPIDERM (77% of the 555 GPs ever enrolled). In contrast to the clinical specialists, GPs participating as ‘sample’ physicians reported on average more cases per active reporter per month than GPs participating as ‘core’ reporters (sample: 1.5, core: 0.6). The average number of active reporters per month has decreased slightly since the introduction of 100% ‘sample’ reporting (15 in both 2011 and 2012, 14 in 2013, 13 in 2014 and 11 in 2015), as has the average number of cases per active reporter month (1.4 for 2011 and 2012, 1.3 for 2013, 1.1 in 2014 and 2015). Musculoskeletal and mental ill-health case reports comprised the majority (52% and 32%, respectively) of the cases reported to THOR-GP with smaller proportions of skin (10%), respiratory (3%) and other diagnoses (5%).

3.2 TIME TRENDS BY DISEASE CATEGORY

This report continues with the approach first adopted in the trends report submitted to HSE in September 2010[7], in that the statistical uncertainty (confidence intervals) in the graphs illustrating time trends are presented in such a way as to allow the reader to assess the significance of the difference between any two years. This useful approach suggested by the then HSE liaison officer (John Hodgson) when steering the research follows the method described by Firth and de Menezes[22] which assigns a confidence (or comparison) interval to the reference category (2015 in the present analyses) and reduces the width of the confidence (comparison) intervals of non-reference categories in such a way that all pairwise comparisons between years can validly be made using these adjusted confidence intervals.

Interpreting the results in light of reporter fatigue

The results presented here have not been formally adjusted for reporter fatigue. However, for SWORD and EPIDERM the likely impact of adjusting for 'excess zeros' (i.e. if a zero inflated binomial model was applied to the data) has been *estimated* by applying the results of the analyses described under Section 2.5 (Table 4) to the present data. These analyses suggested that adjusting for excess zeros would reduce the annual average estimated decrease from -2.6% to -2.3% for EPIDERM and from -2.5% to -2.1% for SWORD.

Thus, for example if an annual average decrease in incidence of -3.9% was observed in the present study for total skin disease reported to EPIDERM, adjusting this for the likely impact of fatigue based on the above would reduce the decrease to approximately -3.5%. These adjustments have been carried out for total skin (EPIDERM), total respiratory (SWORD) and total WRI (THOR-GP) only (it cannot be assumed at this stage that the observed effect would be the same across the different diagnoses).

Note: it must be stressed that these are estimates, provided for guidance purposes only.

3.2.1 TOTAL WORK-RELATED ILLNESS

The average annual percentage change in risk of total WRI, as reported to THOR-GP is shown in Table 5 whilst the relative rates by year are shown in Tables 6 and Figure 1. Based on reports from 'core' reporters only, the average annual decrease in incidence for the period 2006-2009 was -13.5% (95% CIs: -16.2, -10.8). This compares to an annual average decrease of -13.9% (95% CIs: -18.9, -8.6) for analyses based on 'sample' reporters only for the period 2011-2015. The graph showing relative risk by year (Figure 1) for THOR-GP suggest a year on year decline for both 'core' (2006-2009) and 'sample' reporters (2011-2015). For 'sample'

reporters, the data suggest a possible drop in incidence between 2013 and 2015 (however, confidence intervals are wide and overlapping).

For estimates based on 'core' reports (2006-2009), extrapolating the results of the previously described analyses using a zero-inflated binomial model (Section 2.5), the impact of adjusting for 'excess zeros' in the present analyses *might be* expected to change the average annual percentage change in incidence of total WRI in the order of from -13.5% to -8.9%. There was no evidence of fatigue manifesting in this way for 'sample' reporters, and as previously stated, THOR-GP is now exclusively reliant on 'sample' reporters (since HSE stopped funding honoraria for participation).

Table 5 Average annual percentage change in reported incidence in total work-related illness

	ESTIMATED % CHANGE (95% CONFIDENCE INTERVAL)	
	THOR-GP	
	Core reporters	**Sample reporters**
Year (continuous)		
2006-2009	-13.5 (-16.2, -10.8)	/
2011-2015	/	-13.9 (-18.9, -8.6)

Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

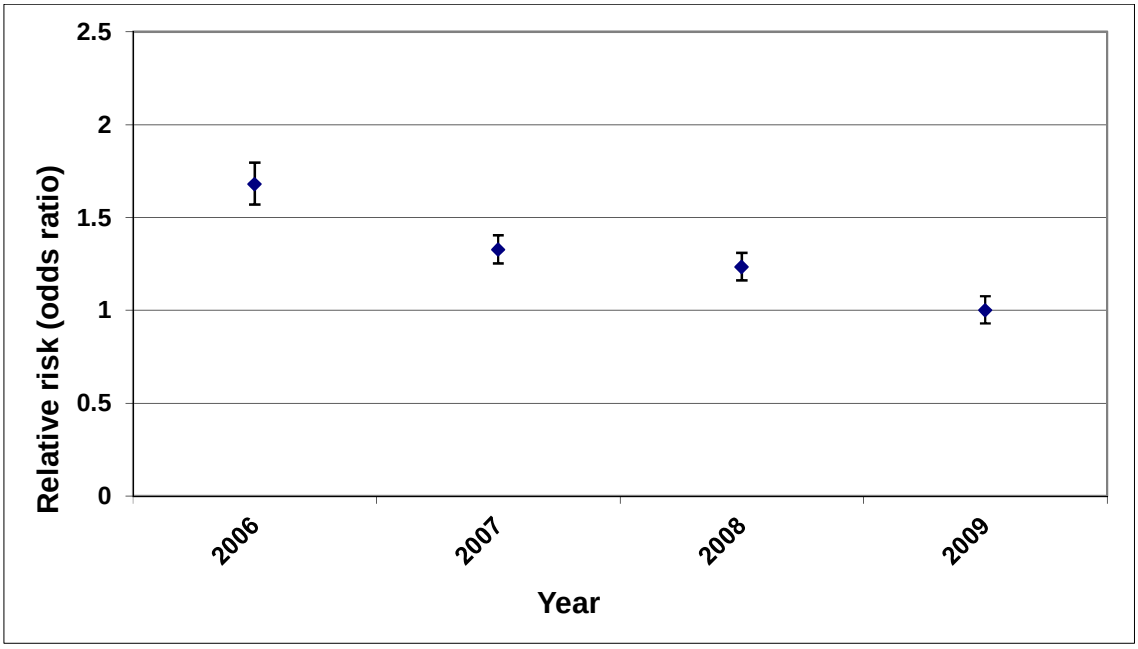
Table 6 Relative risk by year, with 95% comparison intervals, total work-related illness (core analyses 2009 estimate =1, sample analyses 2015 estimate = 1)

	Relative rates (95% comparison interval)	
	THOR-GP	
	Core reporters	**Sample reporters**
YEAR		
2006	1.68 (1.57,1.79)	/
2007	1.33 (1.25,1.4)	/
2008	1.23 (1.16,1.31)	/
2009	1 (0.93,1.08)	/
2010	/	/
2011	/	1.69 (1.47,1.95)
2012	/	1.54 (1.34,1.78)
2013	/	1.4 (1.21,1.63)
2014	/	1.11 (0.94,1.31)
2015	/	1 (0.83,1.21)

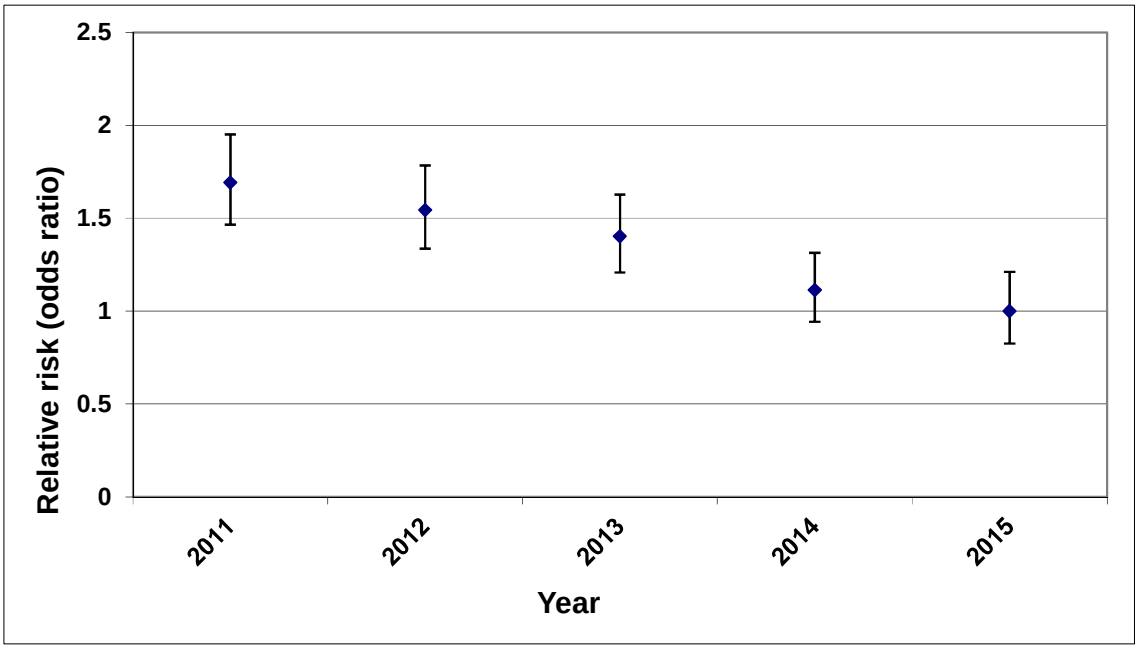
Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 1 **Relative risk by year (core analyses 2009 estimate = 1, sample analyses 2015 estimate = 1), with 95% comparison intervals, total work-related illness**

a) Core reporters



b) Sample reporters



3.2.2 WORK-RELATED SKIN DISEASE

The average annual percentage change in risk of work-related skin disease, as reported by dermatologists and GPs is shown in Table 7 whilst the relative rates by year are shown in Tables 8 to 15 and Figures 2 to 9.

Dermatologists reporting to EPIDERM: The annual average change in incidence of dermatologist reported work-related skin disease (1996-2015) was -3.9% (95% CIs: -4.3, -3.4). This compares to the previous estimate of -3.8% (95% CIs: -4.3, -3.3) reported in 2015 (based on data for the period 1996-2014). The graphs (Figure 2) showing relative risk by year suggest an initial decrease in incidence in the earlier part of the study period (1996-2005) followed by a relatively flat trend (2006-2012) and a further decrease between 2012 and 2015. The estimated annual change (Figure 3) in incidence of contact dermatitis (CD) was similar at -3.8% (95% CIs: -4.3, -3.3) with a similar annual pattern. Analyses of shorter-term trends (2006-2015) for CD suggested an annual average decrease in CD incidence of -3.9% (95% CIs: -5.3, -2.4) per year. Analysis by type of CD indicated a steeper decrease in the incidence of allergic CD (-5.3% (95% CIs: -6.0, -4.5)) compared to irritant CD (-2.7% (95% CIs: -3.4, -2.0)) or mixed CD (-2.4% (95% CIs: -3.5, -1.3)) and these estimates remain relatively unchanged by the addition of the 2015 data. The graphs (Figure 4) showing relative risk by year continue to suggest an overall downward trend for allergic CD between 1996 and 2006 followed by a relatively flat trend. For irritant CD (Figure 5), after an initial decrease between 1999 and 2000, the trend is flat until about 2012, after which it appears to decrease to 2015. The annual average change in incidence of dermatologist reported urticaria remained largely unchanged with the addition of the 2015 data at -7.2% (95% CIs: -8.8, -5.5) compared to the previously reported -7.1% (95% CIs: -8.8, -5.4) (based on data for 1996-2014). Similarly, the trend in incidence for neoplasia suggested a decrease, of -3.2% (95% CIs: -4.7, -1.8) compared to -3.0% (95% CIs: -4.5, -1.6) reported in 2015.

There was some variation by reporter type ('core' versus 'sample'). This was still most pronounced for neoplasia with data from 'core' reporters suggesting an annual average decrease of -4.9% (95% CIs: -6.5, -3.3) whilst data from 'sample' reporters suggested an increase of 2.2% (95% CIs: -0.7, 5.3) and for urticaria there was evidence of a decrease in incidence but only from 'core' reporters (core: -7.6% (95% CIs: -9.3, -6.0); 'sample': -1.3% (95% CIs: -7.2, 4.9)).

Extrapolating the results of the previously described analyses using a zero-inflated binomial model (Section 2.5), the impact of adjusting for 'excess zeros' in the present analyses *might be* expected to change the average annual percentage change in incidence of total work-related skin disease in the order of from -3.9% to -3.5%.

GPs reporting to THOR-GP: As reported previously, for GPs the estimated annual decrease in incidence of total work-related skin disease based on reports from 'core' reporters only (2006-2009) was -6.4% (95% CIs: -14.8, -3). For 'sample' reporters only (2011-2015), the estimated annual decrease was -18.9% (95% CIs: -33.2, -1.4) compared to -19.2% (95% CIs: -37.8, 4.9) reported for the period 2011-2014. The graph (Figure 2) showing relative rates by year might suggest a general decrease over time for 'core' reporters (although confidence intervals overlap for all years). For 'sample' reporters, there is an initial decrease between 2011 and 2012 followed by a relatively flat trend, although confidence intervals are again very wide and overlapping for all years, since the overall numbers reported by monthly 'sample' reporting only are considerably less than those which were collected through 'core' reporting at the inception of THOR-GP.

Table 7 Average annual percentage change in reported incidence in work-related skin disease

		ESTIMATED % CHANGE (95% CONFIDENCE INTERVAL)				
		All reporters	Core reporters		Sample reporters	
		EPIDERM	EPIDERM	THOR-GP	EPIDERM	THOR-GP
	Year (continuous)					
Total skin	1996-2015	-3.9 (-4.3, -3.4)	-4.0 (-4.5, -3.5)	/	-2.5 (-3.9, -1.1)	/
	2006-2009	/	1.3 (-2.6, 5.4)	-6.4 (-14.8, -3)	/	/
	2011-2015	/	/	/	-4.9 (-13.7, 4.9)	-18.9 (-33.2, -1.4)
Contact dermatitis (CD)	1996-2015	-3.8 (-4.3, -3.3)	-3.8 (-4.3, -3.3)	/	-3.6 (-5.1, -2.0)	/
	2006-2015	-3.9 (-5.3, -2.4)	/	/	/	/
• **Allergic CD**	1996-2015	-5.3 (-6.0, -4.5)	-5.6 (-6.4, -4.8)	/	-3.1 (-5.2, -0.9)	/
• **Irritant CD**	1996-2015	-2.7 (-3.4, -2.0)	-2.7 (-3.4, -1.9)	/	-2.7 (-5.0, -0.4)	/
• **Mixed CD**	1996-2015	-2.4 (-3.5, -1.3)	-2.7 (-3.9, -1.9)	/	-0.2 (-3.6, 3.4)	/
Urticaria	1996-2015	-7.2 (-8.8, -5.5)	-7.6 (-9.3, -6.0)	/	-1.3 (-7.2, 4.9)	/
Neoplasia	1996-2015	-3.2 (-4.7, -1.8)	-4.9 (-6.5, -3.3)	/	2.2 (-0.7, 5.3)	/
Other* skin	1996-2015	-5.7 (-6.7, -4.7)	-6.8 (-7.8, -5.7)	/	-0.5 (-2.8, 1.9)	/

*Other than contact dermatitis
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

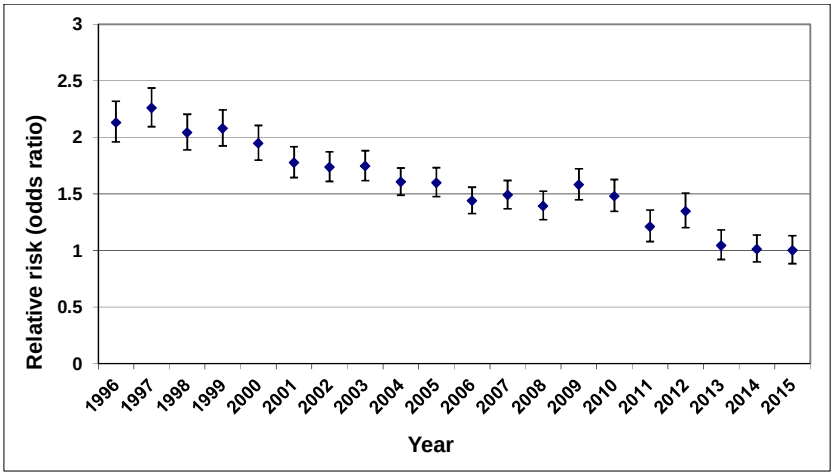
Table 8 **Relative risk by year, with 95% comparison intervals, total skin disease (EPIDERM 2015 estimate = 1, THOR-GP core 2009 estimate = 1, THOR-GP sample 2015 estimate = 1)**

	Relative risk (95% comparison interval)				
	All reporters	Core reporters		Sample reporters	
	EPIDERM	EPIDERM	THOR-GP	EPIDERM	THOR-GP
YEAR					
1996	2.13 (1.96,2.32)	2.32 (2.13,2.54)	/	1.14 (0.84,1.55)	/
1997	2.26 (2.09,2.44)	2.43 (2.24,2.62)	/	1.68 (1.3,2.17)	/
1998	2.04 (1.89,2.2)	2.2 (2.03,2.38)	/	1.46 (1.15,1.85)	/
1999	2.08 (1.92,2.24)	2.22 (2.04,2.41)	/	1.61 (1.31,1.97)	/
2000	1.95 (1.8,2.11)	2.13 (1.96,2.32)	/	1.27 (1.02,1.59)	/
2001	1.78 (1.64,1.92)	1.9 (1.75,2.06)	/	1.42 (1.14,1.75)	/
2002	1.74 (1.61,1.87)	1.85 (1.71,2.01)	/	1.4 (1.11,1.75)	/
2003	1.75 (1.62,1.88)	1.92 (1.77,2.08)	/	1.03 (0.8,1.34)	/
2004	1.6 (1.49,1.73)	1.72 (1.59,1.86)	/	1.19 (0.95,1.51)	/
2005	1.6 (1.48,1.73)	1.73 (1.59,1.88)	/	1.11 (0.87,1.4)	/
2006	1.44 (1.33,1.56)	1.5 (1.38,1.64)	1.32 (1.07,1.62)	1.33 (1.07,1.64)	/
2007	1.49 (1.37,1.62)	1.63 (1.49,1.78)	1.21 (1.01,1.45)	0.99 (0.77,1.27)	/
2008	1.39 (1.27,1.53)	1.53 (1.39,1.69)	1.22 (1.02,1.45)	0.86 (0.64,1.14)	/
2009	1.58 (1.45,1.72)	1.7 (1.55,1.86)	1 (0.8,1.24)	1.17 (0.89,1.53)	/
2010	1.48 (1.35,1.63)	1.59 (1.44,1.76)	/	1.1 (0.83,1.46)	/
2011	1.21 (1.08,1.36)	1.27 (1.12,1.43)	/	1.04 (0.77,1.4)	2.46 (1.64,3.69)
2012	1.35 (1.2,1.51)	1.42 (1.25,1.6)	/	1.15 (0.87,1.51)	1.47 (0.86,2.5)
2013	1.04 (0.92,1.18)	1.06 (0.92,1.22)	/	1 (0.75,1.34)	1.14 (0.63,2.07)
2014	1.01 (0.9,1.14)	1.04 (0.92,1.19)	/	0.87 (0.64,1.18)	1.48 (0.87,2.53)
2015	1 (0.88,1.13)	1 (0.87,1.15)	/	1 (0.74,1.35)	1 (0.5,2)

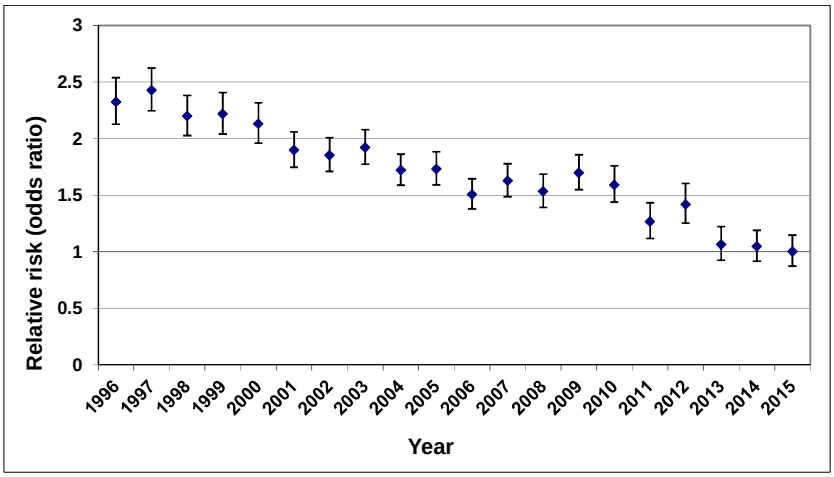
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 2 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, total skin**

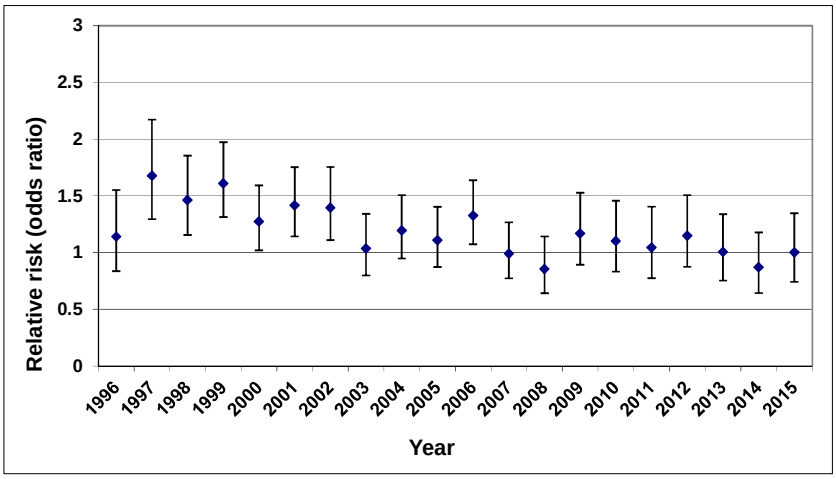
a) EPIDERM, all reporters



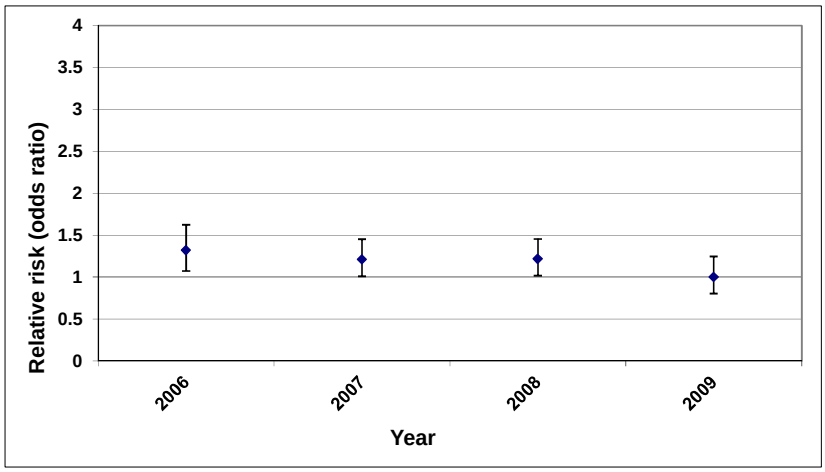
b) EPIDERM, core reporters



c) EPIDERM, sample reporters



d) THOR-GP, core reporters (note scale change)



e) THOR-GP, sample reporters

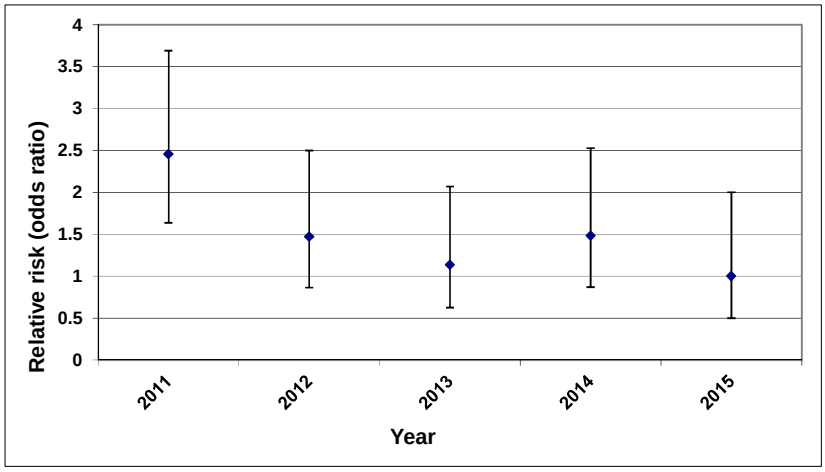


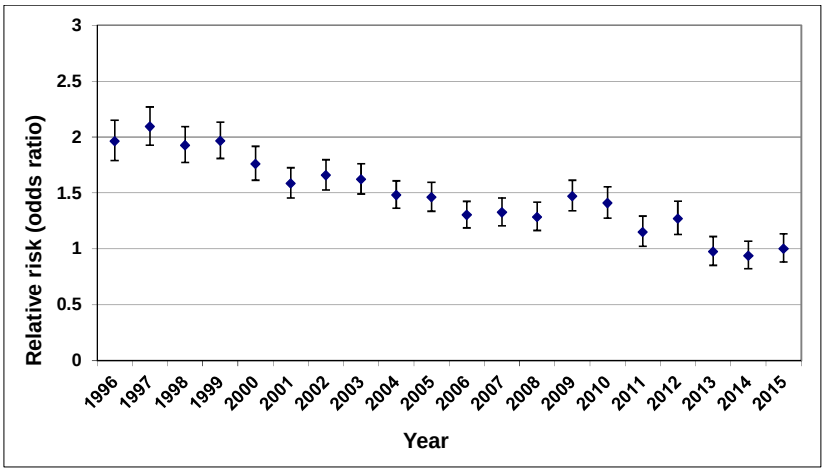
Table 9 Relative risk by year, with 95% comparison intervals, all contact dermatitis (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	All reporters	Core reporters	Sample reporters
	EPIDERM	EPIDERM	EPIDERM
YEAR			
1996	1.96 (1.79,2.15)	2.07 (1.88,2.28)	1.31 (0.94,1.82)
1997	2.09 (1.93,2.27)	2.2 (2.02,2.39)	1.77 (1.34,2.35)
1998	1.93 (1.77,2.09)	2.03 (1.86,2.21)	1.63 (1.27,2.09)
1999	1.96 (1.81,2.13)	2.02 (1.85,2.21)	1.94 (1.57,2.4)
2000	1.76 (1.61,1.92)	1.86 (1.7,2.04)	1.41 (1.11,1.79)
2001	1.58 (1.45,1.73)	1.68 (1.54,1.84)	1.26 (0.98,1.61)
2002	1.66 (1.53,1.8)	1.74 (1.59,1.9)	1.46 (1.14,1.87)
2003	1.62 (1.49,1.76)	1.75 (1.61,1.91)	1.05 (0.79,1.39)
2004	1.48 (1.36,1.61)	1.58 (1.45,1.73)	1.05 (0.79,1.39)
2005	1.46 (1.34,1.59)	1.54 (1.4,1.7)	1.15 (0.89,1.49)
2006	1.3 (1.19,1.43)	1.37 (1.25,1.51)	1.11 (0.86,1.44)
2007	1.33 (1.21,1.46)	1.44 (1.31,1.59)	0.8 (0.6,1.08)
2008	1.28 (1.16,1.42)	1.4 (1.26,1.55)	0.77 (0.55,1.06)
2009	1.47 (1.34,1.61)	1.57 (1.43,1.74)	1 (0.73,1.36)
2010	1.41 (1.27,1.56)	1.5 (1.35,1.67)	0.99 (0.72,1.36)
2011	1.15 (1.02,1.29)	1.19 (1.05,1.35)	1.03 (0.74,1.42)
2012	1.27 (1.13,1.43)	1.33 (1.17,1.51)	1.07 (0.79,1.45)
2013	0.97 (0.85,1.11)	0.99 (0.85,1.14)	0.96 (0.7,1.32)
2014	0.94 (0.82,1.07)	0.96 (0.84,1.1)	0.86 (0.62,1.19)
2015	1 (0.88,1.13)	1 (0.87,1.15)	1 (0.73,1.37)

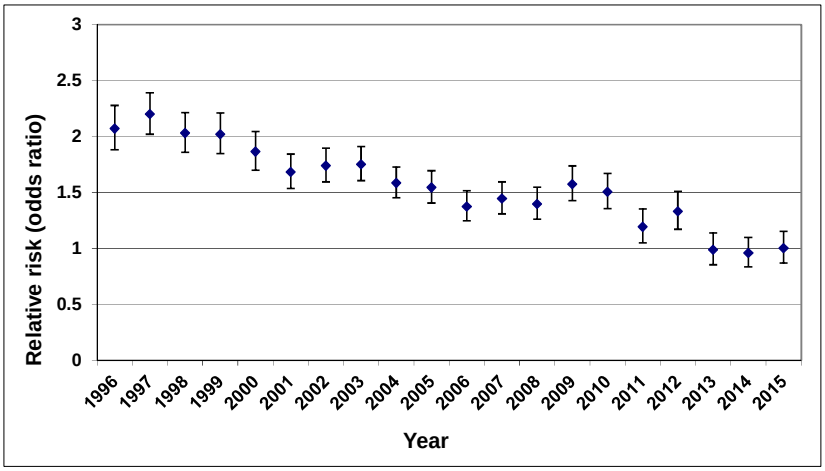
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 3 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, all contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

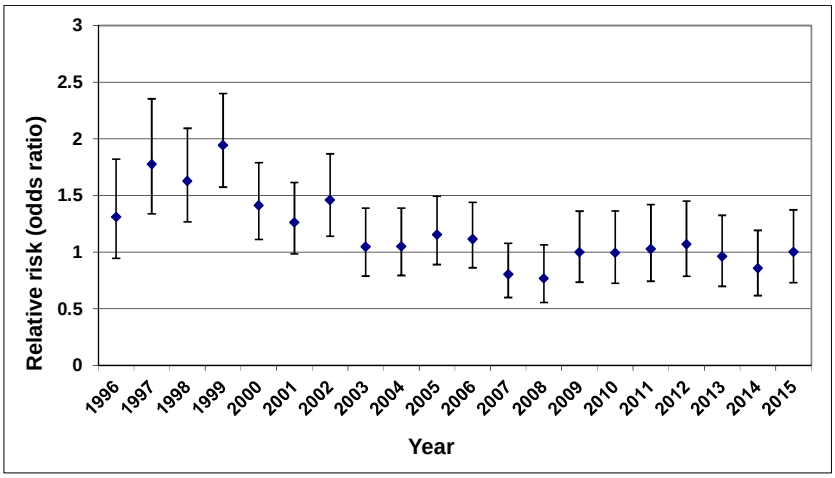


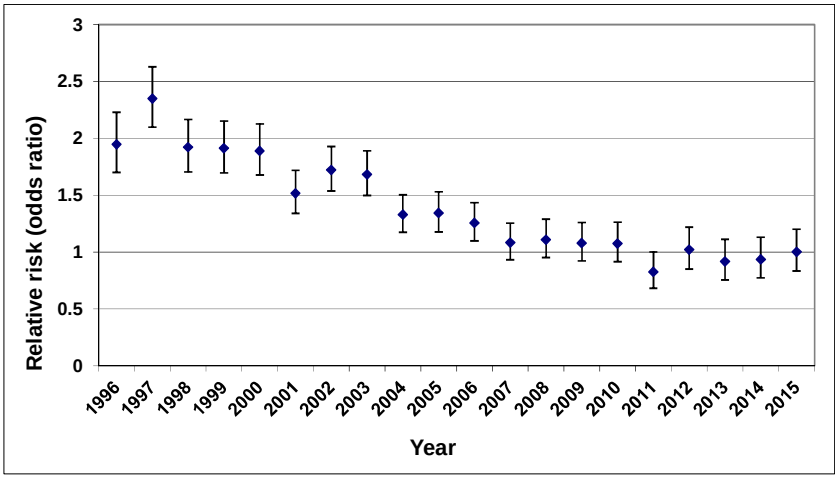
Table 10 Relative risk by year, with 95% comparison intervals, allergic contact dermatitis (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	EPIDERM		
	All reporters	Core reporters	Sample reporters
YEAR			
1996	1.95 (1.7,2.23)	2.12 (1.84,2.44)	1.24 (0.79,1.94)
1997	2.35 (2.1,2.63)	2.5 (2.22,2.82)	1.86 (1.28,2.69)
1998	1.92 (1.71,2.17)	2.1 (1.85,2.38)	1.18 (0.79,1.75)
1999	1.91 (1.7,2.15)	2.03 (1.79,2.3)	1.54 (1.1,2.17)
2000	1.89 (1.68,2.13)	2.05 (1.81,2.32)	1.32 (0.94,1.86)
2001	1.52 (1.34,1.72)	1.69 (1.48,1.92)	0.82 (0.54,1.24)
2002	1.72 (1.54,1.93)	1.8 (1.6,2.03)	1.56 (1.12,2.18)
2003	1.68 (1.5,1.89)	1.82 (1.61,2.05)	1.18 (0.81,1.72)
2004	1.33 (1.17,1.5)	1.44 (1.26,1.64)	0.9 (0.59,1.37)
2005	1.34 (1.18,1.53)	1.39 (1.21,1.61)	1.22 (0.86,1.73)
2006	1.26 (1.1,1.43)	1.31 (1.13,1.51)	1.15 (0.8,1.65)
2007	1.08 (0.93,1.25)	1.14 (0.97,1.33)	0.94 (0.63,1.4)
2008	1.11 (0.95,1.29)	1.18 (1,1.39)	0.86 (0.55,1.34)
2009	1.08 (0.92,1.26)	1.15 (0.98,1.36)	0.74 (0.44,1.24)
2010	1.07 (0.92,1.26)	1.11 (0.93,1.32)	1.01 (0.64,1.59)
2011	0.83 (0.68,1)	0.81 (0.66,1)	1.08 (0.68,1.72)
2012	1.02 (0.85,1.22)	1.09 (0.9,1.32)	0.77 (0.46,1.27)
2013	0.92 (0.75,1.11)	0.93 (0.75,1.15)	0.88 (0.55,1.39)
2014	0.94 (0.77,1.13)	0.96 (0.79,1.17)	0.84 (0.52,1.36)
2015	1 (0.83,1.2)	1 (0.82,1.22)	1 (0.64,1.57)

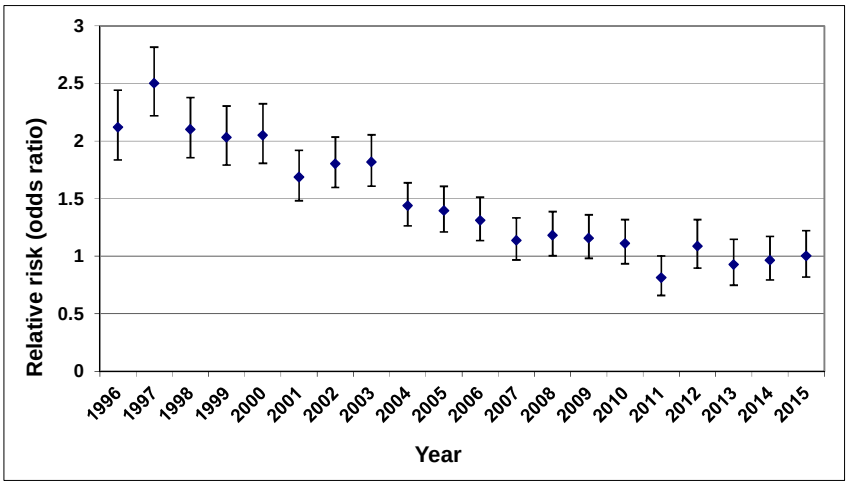
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 4 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, allergic contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

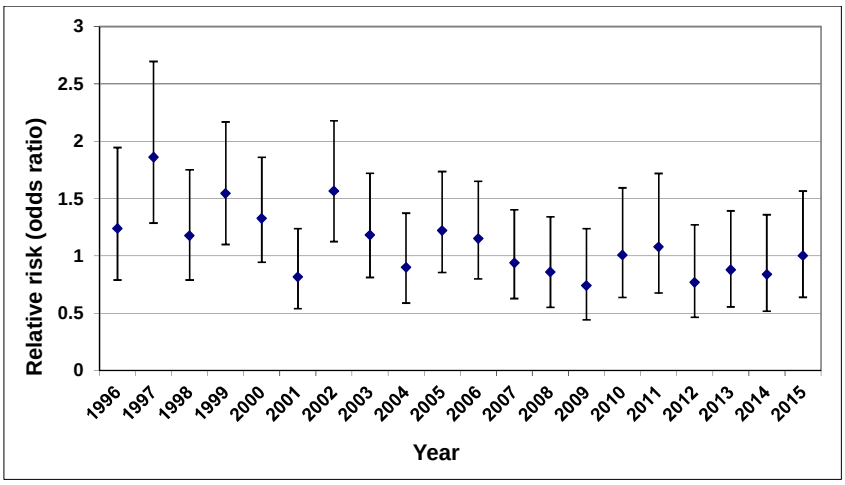


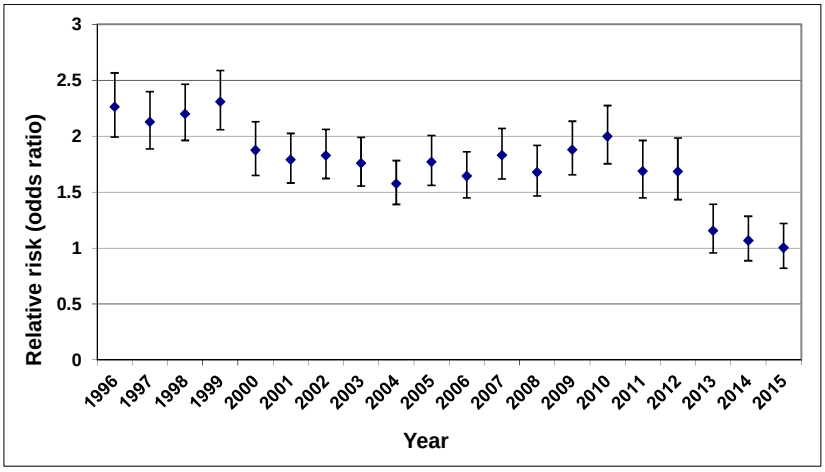
Table 11 Relative risk by year, with 95% comparison intervals, irritant contact dermatitis (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	EPIDERM		
	All reporters	Core reporters	Sample reporters
YEAR			
1996	2.26 (1.99,2.57)	2.48 (2.17,2.84)	0.85 (0.47,1.54)
1997	2.13 (1.89,2.4)	2.34 (2.06,2.65)	1.23 (0.76,2.01)
1998	2.2 (1.96,2.46)	2.35 (2.08,2.66)	1.75 (1.22,2.51)
1999	2.31 (2.06,2.59)	2.49 (2.2,2.82)	1.7 (1.21,2.39)
2000	1.87 (1.65,2.13)	2.05 (1.79,2.35)	1.25 (0.85,1.83)
2001	1.79 (1.58,2.02)	1.89 (1.66,2.16)	1.6 (1.14,2.23)
2002	1.83 (1.62,2.06)	1.98 (1.75,2.25)	1.32 (0.89,1.96)
2003	1.76 (1.55,1.99)	1.94 (1.71,2.21)	1.04 (0.67,1.61)
2004	1.57 (1.39,1.78)	1.73 (1.52,1.97)	0.99 (0.64,1.53)
2005	1.77 (1.56,2.01)	1.94 (1.7,2.21)	1.16 (0.77,1.73)
2006	1.64 (1.45,1.86)	1.82 (1.59,2.08)	1.09 (0.73,1.62)
2007	1.83 (1.62,2.07)	2.09 (1.84,2.37)	0.7 (0.43,1.14)
2008	1.68 (1.47,1.92)	1.89 (1.64,2.17)	0.77 (0.45,1.3)
2009	1.88 (1.65,2.13)	2.12 (1.86,2.42)	0.75 (0.43,1.29)
2010	2 (1.75,2.27)	2.27 (1.98,2.59)	0.77 (0.45,1.33)
2011	1.69 (1.45,1.96)	1.85 (1.58,2.17)	0.98 (0.59,1.63)
2012	1.68 (1.43,1.98)	1.8 (1.51,2.14)	1.36 (0.88,2.1)
2013	1.15 (0.96,1.39)	1.2 (0.98,1.48)	1.04 (0.64,1.7)
2014	1.07 (0.89,1.28)	1.09 (0.89,1.33)	0.94 (0.59,1.51)
2015	1 (0.82,1.22)	1 (0.81,1.24)	1 (0.62,1.62)

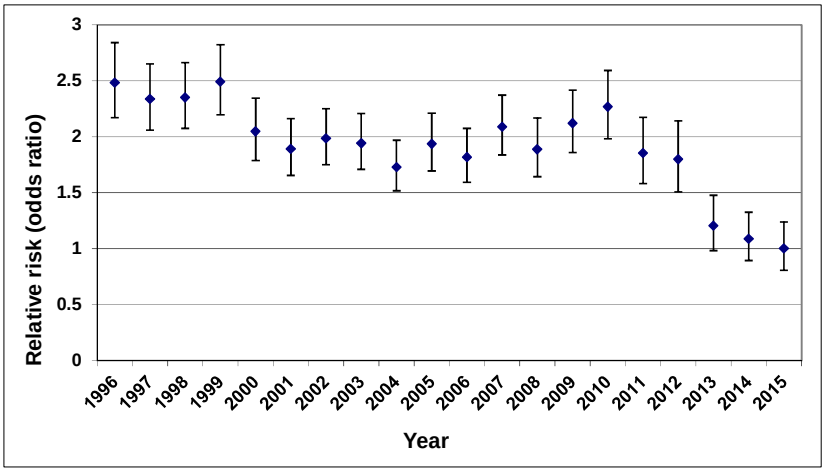
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 5 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, irritant contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

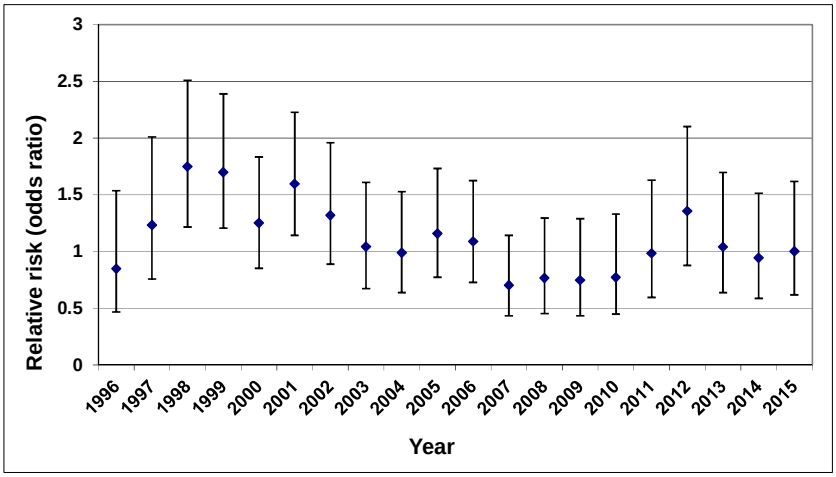


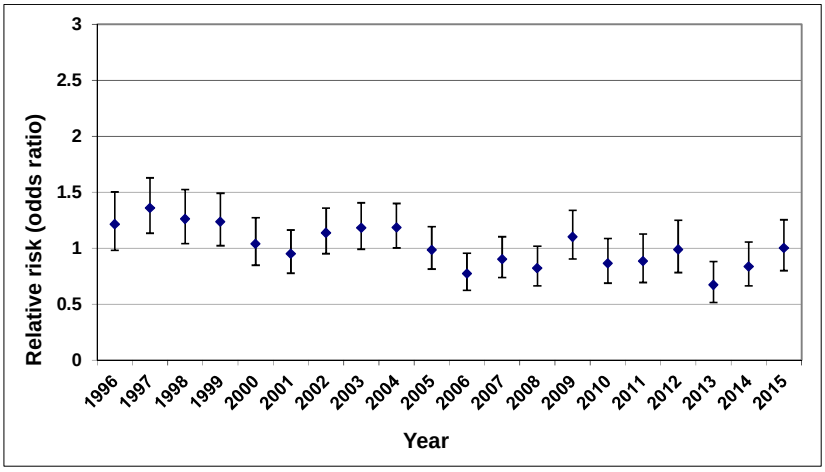
Table 12 Relative risk by year, with 95% comparison intervals, mixed contact dermatitis (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	EPIDERM		
	All reporters	Core reporters	Sample reporters
YEAR			
1996	1.21 (0.98,1.5)	1.36 (1.08,1.7)	0.74 (0.34,1.64)
1997	1.36 (1.13,1.63)	1.48 (1.22,1.8)	1.2 (0.64,2.27)
1998	1.26 (1.04,1.52)	1.39 (1.13,1.69)	1.04 (0.59,1.85)
1999	1.23 (1.02,1.49)	1.35 (1.1,1.65)	1.09 (0.66,1.82)
2000	1.04 (0.85,1.27)	1.18 (0.95,1.47)	0.64 (0.34,1.18)
2001	0.95 (0.78,1.16)	1.12 (0.91,1.38)	0.42 (0.18,0.96)
2002	1.14 (0.95,1.36)	1.29 (1.07,1.56)	0.69 (0.35,1.34)
2003	1.18 (0.99,1.4)	1.39 (1.16,1.66)	0.34 (0.14,0.83)
2004	1.18 (1,1.4)	1.33 (1.12,1.58)	0.8 (0.44,1.45)
2005	0.98 (0.81,1.19)	1.12 (0.92,1.37)	0.59 (0.31,1.13)
2006	0.77 (0.62,0.95)	0.85 (0.68,1.07)	0.67 (0.37,1.22)
2007	0.9 (0.74,1.1)	1.07 (0.87,1.31)	0.26 (0.1,0.67)
2008	0.82 (0.66,1.02)	0.94 (0.75,1.18)	0.37 (0.16,0.84)
2009	1.1 (0.9,1.34)	1.3 (1.06,1.59)	0.23 (0.07,0.73)
2010	0.86 (0.69,1.09)	0.91 (0.71,1.16)	0.94 (0.52,1.72)
2011	0.88 (0.69,1.13)	0.93 (0.71,1.21)	0.83 (0.45,1.53)
2012	0.99 (0.78,1.25)	1.05 (0.81,1.35)	0.85 (0.46,1.58)
2013	0.67 (0.51,0.88)	0.68 (0.51,0.92)	0.69 (0.35,1.35)
2014	0.83 (0.66,1.05)	0.85 (0.66,1.09)	0.94 (0.52,1.68)
2015	1 (0.8,1.25)	1 (0.78,1.28)	1 (0.57,1.76)

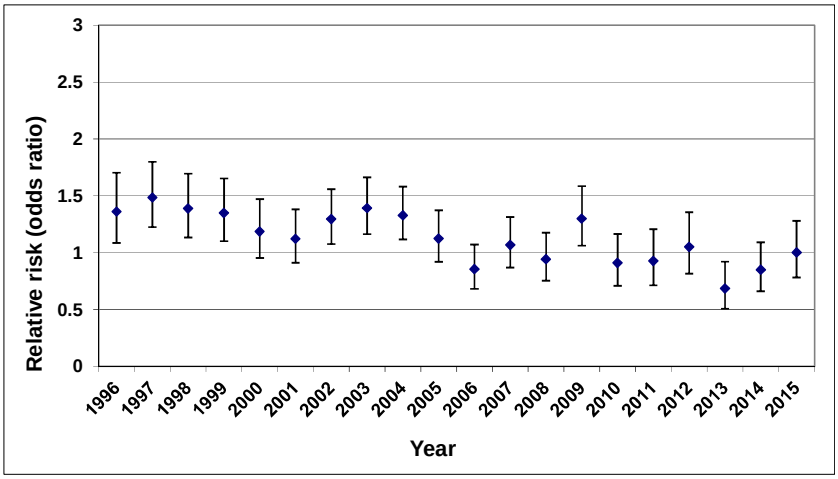
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 6 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, mixed contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

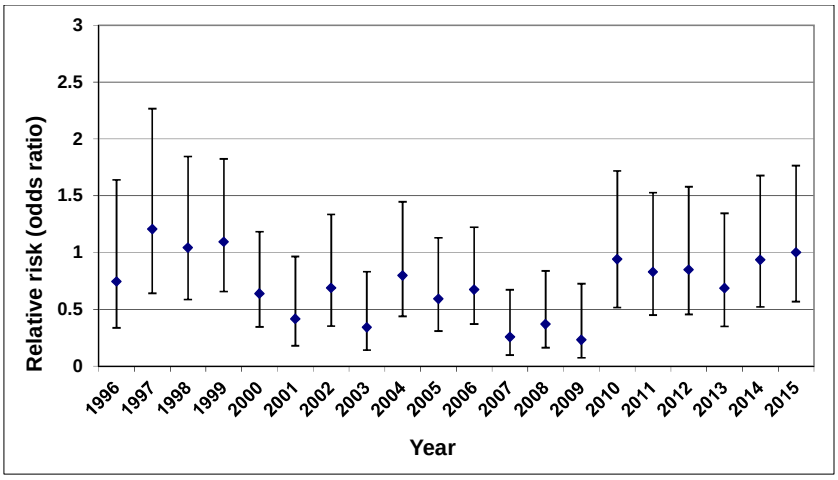


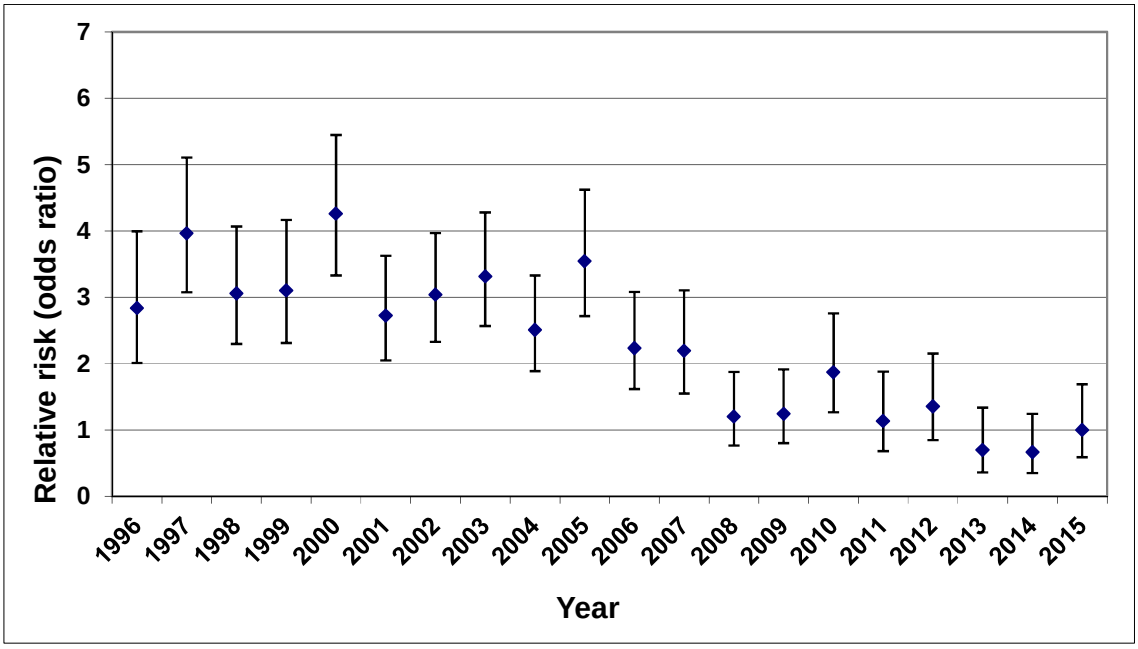
Table 13 Relative risk by year, with 95% comparison intervals, contact urticaria (2015 estimate = 1)

	Relative risk (95% comparison interval)	
	EPIDERM	
	All reporters	Core reporters
YEAR		
1996	2.83 (2.01,4)	3.06 (2.16,4.34)
1997	3.96 (3.07,5.11)	4.25 (3.32,5.45)
1998	3.05 (2.3,4.07)	3.31 (2.48,4.43)
1999	3.1 (2.31,4.17)	3.15 (2.31,4.31)
2000	4.26 (3.33,5.44)	4.68 (3.64,6.02)
2001	2.72 (2.05,3.62)	2.87 (2.13,3.85)
2002	3.04 (2.33,3.97)	3.32 (2.54,4.35)
2003	3.31 (2.57,4.28)	3.62 (2.8,4.69)
2004	2.51 (1.89,3.33)	2.62 (1.96,3.51)
2005	3.54 (2.71,4.62)	3.83 (2.92,5.02)
2006	2.23 (1.62,3.08)	2.11 (1.48,3)
2007	2.19 (1.55,3.1)	2.29 (1.59,3.28)
2008	1.2 (0.77,1.87)	1.18 (0.73,1.89)
2009	1.24 (0.8,1.92)	1.22 (0.77,1.93)
2010	1.87 (1.26,2.76)	1.89 (1.26,2.84)
2011	1.13 (0.68,1.88)	1.07 (0.62,1.84)
2012	1.35 (0.85,2.15)	1.38 (0.85,2.24)
2013	0.7 (0.36,1.34)	0.75 (0.39,1.45)
2014	0.66 (0.35,1.24)	0.57 (0.28,1.15)
2015	1 (0.59,1.69)	1 (0.58,1.73)

Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 7 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, contact urticaria**

a) EPIDERM, all reporters



b) EPIDERM, core reporters

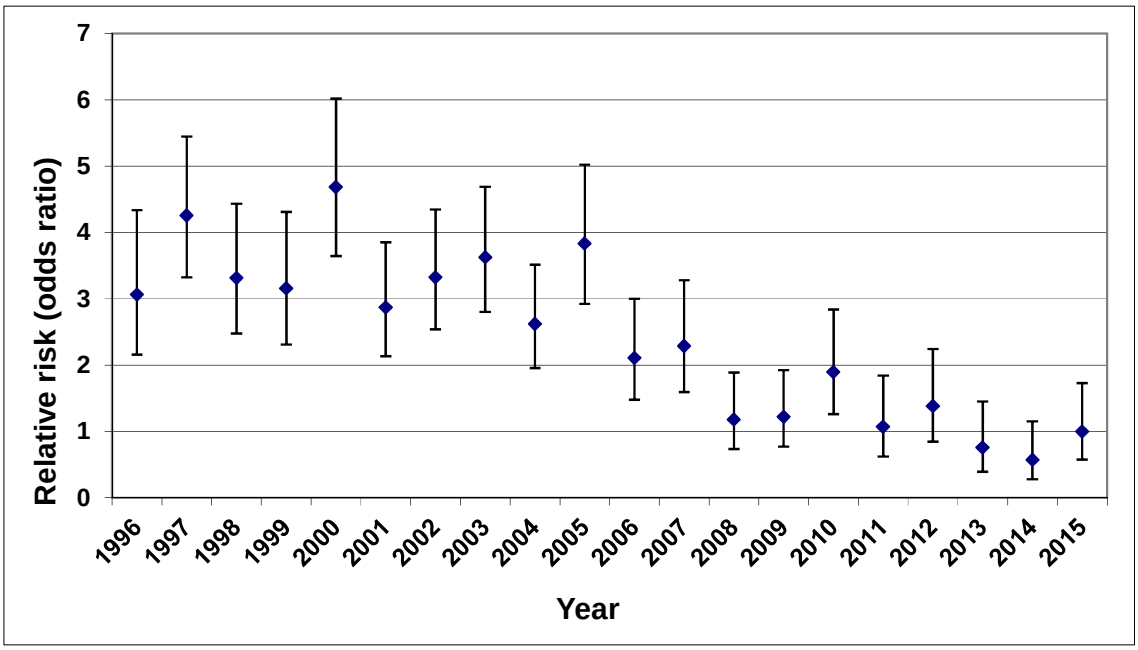


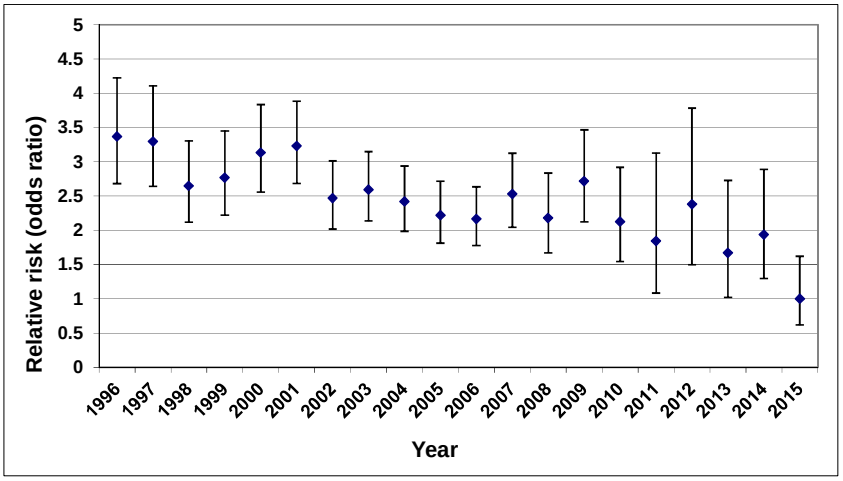
Table 14 Relative risk by year, with 95% comparison intervals, neoplasia (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	EPIDERM		
	All reporters	Core reporters	Sample reporters
YEAR			
1996	3.36 (2.68,4.22)	12.63 (9.68,16.46)	0.44 (0.18,1.1)
1997	3.29 (2.64,4.11)	11.51 (8.85,14.97)	1.28 (0.71,2.31)
1998	2.65 (2.12,3.3)	9.09 (6.99,11.82)	0.81 (0.44,1.49)
1999	2.77 (2.22,3.45)	10.31 (7.95,13.38)	0.64 (0.35,1.2)
2000	3.13 (2.56,3.83)	11.05 (8.63,14.13)	0.94 (0.56,1.58)
2001	3.23 (2.68,3.88)	10.58 (8.36,13.39)	1.56 (1,2.41)
2002	2.47 (2.02,3.01)	8.23 (6.46,10.5)	1.05 (0.6,1.83)
2003	2.59 (2.14,3.15)	8.81 (6.95,11.17)	0.99 (0.58,1.7)
2004	2.42 (1.99,2.94)	7.76 (6.08,9.91)	1.25 (0.78,2)
2005	2.22 (1.81,2.71)	7.84 (6.13,10.01)	0.73 (0.41,1.32)
2006	2.16 (1.78,2.64)	6.39 (4.95,8.25)	1.59 (1.08,2.35)
2007	2.53 (2.04,3.12)	8.05 (6.14,10.54)	1.53 (1,2.36)
2008	2.18 (1.67,2.83)	7.43 (5.44,10.16)	0.96 (0.54,1.72)
2009	2.71 (2.12,3.47)	7.8 (5.79,10.52)	1.72 (1.04,2.83)
2010	2.12 (1.55,2.92)	5.87 (3.89,8.84)	1.35 (0.8,2.27)
2011	1.84 (1.08,3.13)	3.39 (1.05,10.97)	1.09 (0.6,1.97)
2012	2.38 (1.5,3.78)	2.66 (0.64,11.08)	1.55 (0.95,2.5)
2013	1.67 (1.02,2.73)	2.11 (0.73,6.06)	1.02 (0.57,1.82)
2014	1.93 (1.3,2.89)	2.64 (1.31,5.33)	0.97 (0.54,1.74)
2015	1 (0.62,1.62)	1 (0.47,2.14)	1 (0.51,1.95)

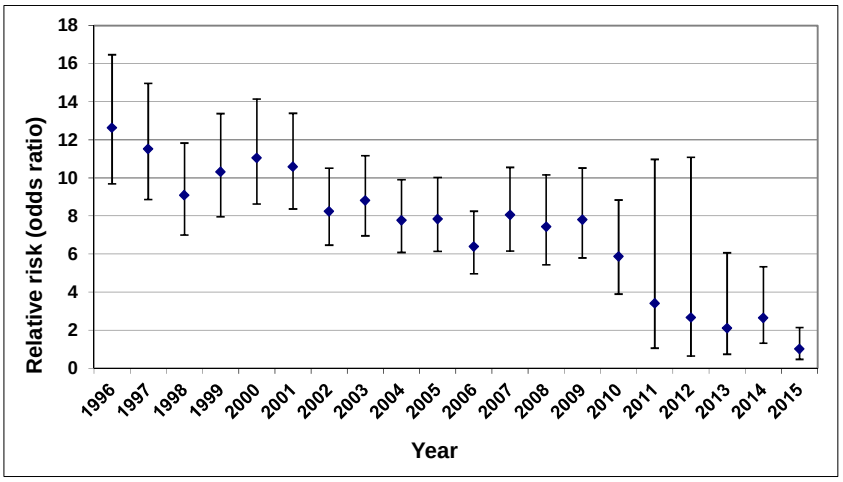
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 8 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, neoplasia**

a) EPIDERM, all reporters



b) EPIDERM, core reporters (Note: scale change)



c) EPIDERM, sample reporters

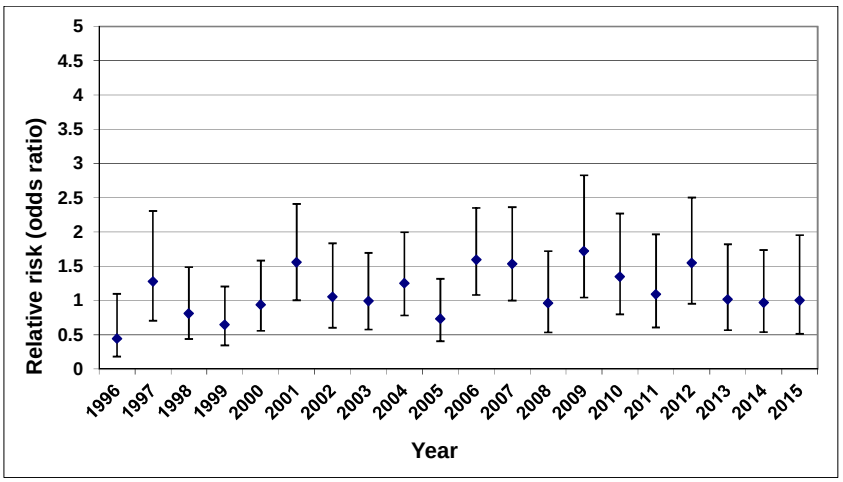


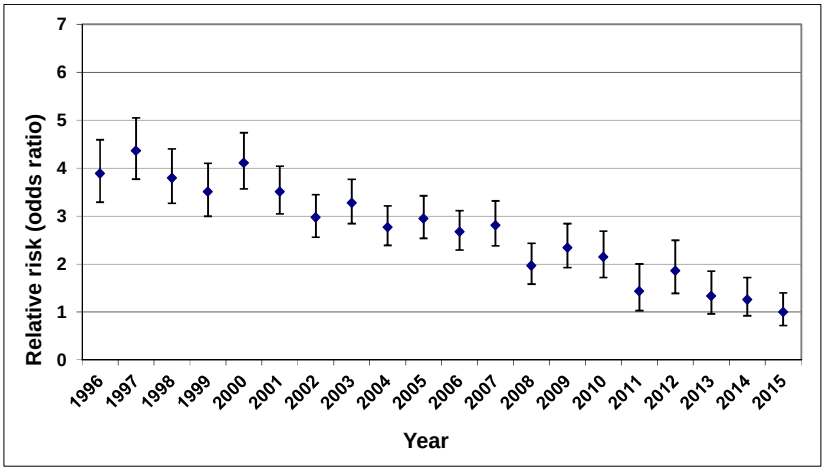
Table 15 Relative risk by year, with 95% comparison intervals, other (than contact dermatitis) skin (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	EPIDERM		
	All reporters	Core reporters	Sample reporters
YEAR			
1996	3.88 (3.29,4.59)	6.08 (5.12,7.21)	0.81 (0.43,1.51)
1997	4.36 (3.77,5.05)	6.43 (5.52,7.48)	1.66 (1.04,2.64)
1998	3.79 (3.27,4.4)	5.52 (4.71,6.46)	1.45 (0.98,2.17)
1999	3.51 (3,4.1)	5.32 (4.5,6.27)	1.19 (0.79,1.78)
2000	4.11 (3.57,4.74)	6.42 (5.54,7.45)	1.06 (0.69,1.62)
2001	3.51 (3.04,4.04)	5 (4.3,5.81)	1.63 (1.12,2.37)
2002	2.97 (2.56,3.44)	4.3 (3.68,5.02)	1.21 (0.77,1.89)
2003	3.27 (2.84,3.77)	4.87 (4.21,5.64)	1.03 (0.65,1.63)
2004	2.77 (2.39,3.21)	3.84 (3.27,4.51)	1.48 (1.02,2.16)
2005	2.95 (2.54,3.42)	4.47 (3.83,5.23)	0.92 (0.58,1.46)
2006	2.67 (2.29,3.11)	3.42 (2.88,4.07)	1.95 (1.42,2.68)
2007	2.81 (2.38,3.32)	3.96 (3.31,4.75)	1.53 (1.04,2.25)
2008	1.96 (1.58,2.43)	2.75 (2.17,3.47)	1.05 (0.64,1.73)
2009	2.34 (1.92,2.84)	3.02 (2.46,3.7)	1.77 (1.15,2.71)
2010	2.15 (1.72,2.69)	2.82 (2.23,3.57)	1.37 (0.85,2.19)
2011	1.43 (1.03,2)	1.46 (0.94,2.28)	1.27 (0.77,2.08)
2012	1.86 (1.39,2.49)	2.22 (1.53,3.22)	1.3 (0.81,2.08)
2013	1.33 (0.96,1.85)	1.5 (0.99,2.28)	1 (0.6,1.68)
2014	1.26 (0.92,1.72)	1.39 (0.94,2.06)	0.89 (0.51,1.53)
2015	1 (0.72,1.39)	1 (0.66,1.51)	1 (0.56,1.78)

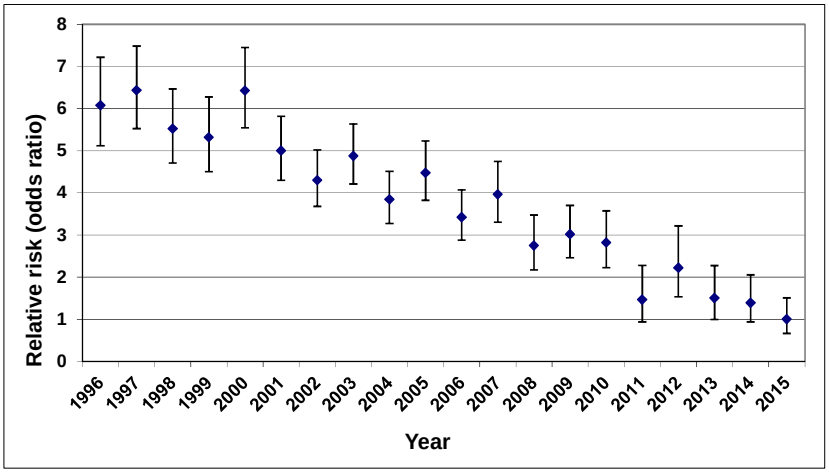
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 102

Figure 9 **Relative risk by year (2015 estimate = 1), with 95% comparison intervals, other (than contact dermatitis) skin**

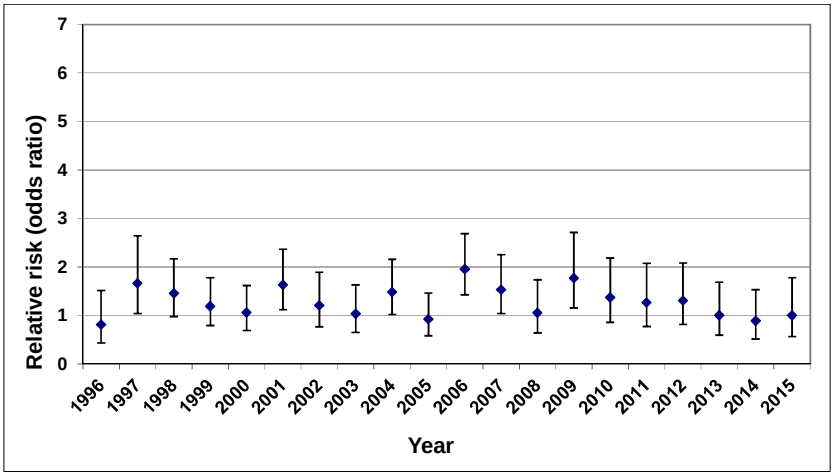
a) EPIDERM, all reporters



b) EPIDERM, core reporters (note scale change)



c) EPIDERM, sample reporters



3.2.3 WORK-RELATED RESPIRATORY DISEASE

The average annual percentage change in risk of work-related respiratory disease, as reported by chest physicians to SWORD is shown in Table 16 whilst the relative rates by year are shown in Tables 17 to 24 and Figures 10 to 17.

The addition of a further year of data (2015) resulted in little change to the annual decrease in incidence of total respiratory disease from -3.2% (95% CIs: -3.9, -2.4) for the period 1999-2014 to -3.1% (95% CIs: -3.8, -2.4). Similar to the pattern observed for total skin disease, the graphs (Figure 10) showing relative rates by year suggest that much of the decrease occurred in the earlier part of the study period (1996-2007 in this instance) with a relatively flat trend thereafter.

The annual average decrease in the incidence of asthma also remained relatively unchanged from -7.2% (95% CIs: -8.4, -6.0) (for the period 1999-2014) to -7.0% (95% CIs: -8.2, -5.8) with a relatively flat trend since 2007 (Figure 11). Analyses of shorter-term trends (2007-2015) showed an average change of -3.3% (95% CIs: -6.6, 0.1) per year. An overall decrease in incidence was also observed for all other groups of respiratory disease except pneumoconiosis, for which an annual average increase of 4.0% (95% CIs: 2.0, 6.0) was observed. The graph showing relative rates by year (Figure 16) for pneumoconiosis suggests a relatively flat trend in the earlier part of the study period (1999 to 2007) followed by an increasing trend thereafter. Analysis of shorter term trends (2007 to 2015) for pneumoconiosis suggested an annual average increase of 10.6% (95% CIs: 5.7, 15.7). For mesothelioma, the data suggest an average annual decrease of -3.2% (95% CIs: -4.5, -1.9) per year, with the annual plots (Figure 12) showing a fall in incidence between 2013 and 2014 but little change between 2014 and 2015. A smaller annual average decrease was observed for non-malignant pleural disease at -1.4% (95% CIs: -2.4, -0.3) with the annual plots (Figure 13) showing a relatively flat trend throughout the study period, with no suggestion of a change in incidence between 2014 and 2015. Overall there was little variation by reporter type ('core' and 'sample').

Extrapolating the results of the previously described analyses using a zero-inflated binomial model (Section 2.5), the impact of adjusting for 'excess zeros' in the present analyses *might be* expected to change the average annual percentage change in incidence of total work-related respiratory disease in the order of from -3.1% to -2.6%.

Table 16 Average annual percentage change in reported incidence in work-related respiratory disease

		ESTIMATED % CHANGE (95% CONFIDENCE INTERVAL)		
		SWORD		
		All reporters	Core reporters	Sample reporters
	Year (continuous)			
Total respiratory	**1999-2015**	-3.1 (-3.8, -2.4)	-3.4 (-4.2, -2.6)	-2.4 (-3.6, -1.2)
Asthma	**1999-2015**	-7.0 (-8.2, -5.8)	-6.7 (-8.0, -5.4)	-8.6 (-11.4, -5.6)
	2007-2015	-3.3 (-6.6, 0.1)	/	/
Mesothelioma	**1999-2015**	-3.2 (-4.5, -1.9)	-3.6 (-5.4, -1.7)	-2.9 (-4.8, -1.1)
Non-malignant pleural disease	**1999-2015**	-1.4 (-2.4, -0.3)	-2.1 (-3.3, -0.9)	0.4 (-1.6, 2.4)
• **Predominantly plaques**	**1999-2015**	-1.2 (-2.4, 0)	-2.2 (-3.6, -0.8)	1.2 (-1.0, 3.5)
• **Predominantly diffuse**	**1999-2015**	-1.4 (-3.2, 0.5)	-2.3 (-4.4, -0.2)	2.6 (-1.7, 7.1)
Pneumoconiosis	**1999-2015**	4.0 (2.0, 6.0)	4.6 (2.2, 7.0)	2.4 (-1.0, 6.0)
	2007-2015	10.6 (5.7, 15.7)	/	/
Other* respiratory disease	**1999-2015**	-1.4 (-2.9, 0.1)	-1.3 (-3.0, 0.5)	-1.2 (-4.0, 1.6)

*Other than those specified above
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

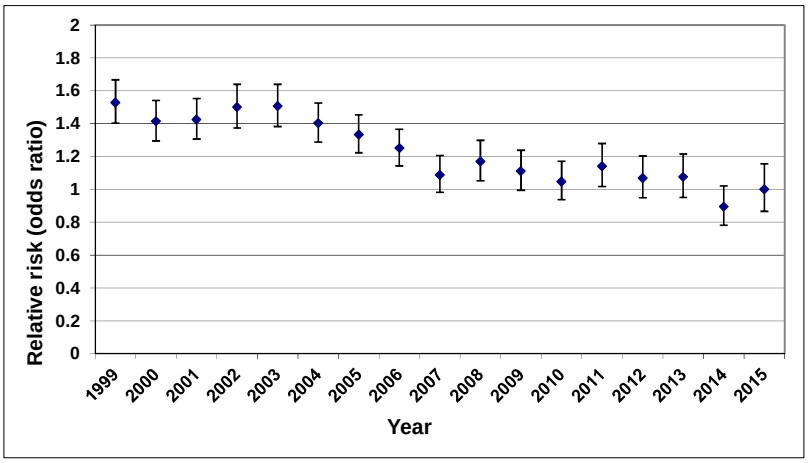
Table 17 Relative risk by year, with 95% comparison intervals, total respiratory disease (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.53 (1.4,1.67)	1.53 (1.38,1.68)	1.65 (1.4,1.94)
2000	1.41 (1.29,1.54)	1.46 (1.32,1.61)	1.41 (1.18,1.67)
2001	1.42 (1.31,1.55)	1.52 (1.38,1.68)	1.27 (1.05,1.52)
2002	1.5 (1.37,1.64)	1.65 (1.5,1.82)	1.21 (1,1.47)
2003	1.51 (1.38,1.64)	1.71 (1.56,1.87)	1.04 (0.85,1.27)
2004	1.4 (1.29,1.53)	1.57 (1.43,1.72)	1.03 (0.85,1.25)
2005	1.33 (1.22,1.45)	1.41 (1.28,1.55)	1.24 (1.04,1.48)
2006	1.25 (1.14,1.37)	1.29 (1.16,1.42)	1.25 (1.04,1.5)
2007	1.09 (0.98,1.21)	1.07 (0.95,1.21)	1.18 (0.98,1.42)
2008	1.17 (1.05,1.3)	1.17 (1.02,1.33)	1.2 (1,1.44)
2009	1.11 (0.99,1.24)	1.13 (0.99,1.29)	1.08 (0.88,1.31)
2010	1.05 (0.94,1.17)	1.1 (0.96,1.25)	0.95 (0.76,1.18)
2011	1.14 (1.02,1.28)	1.16 (1.01,1.33)	1.13 (0.92,1.39)
2012	1.07 (0.95,1.2)	1.11 (0.96,1.28)	1 (0.8,1.26)
2013	1.07 (0.95,1.21)	1.06 (0.91,1.24)	1.13 (0.92,1.4)
2014	0.89 (0.78,1.02)	0.86 (0.73,1.01)	0.98 (0.78,1.24)
2015	1 (0.87,1.16)	1 (0.84,1.2)	1 (0.78,1.28)

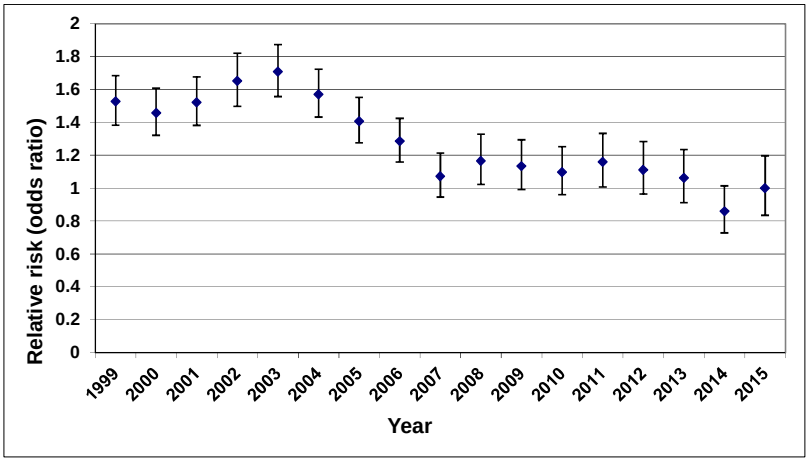
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 10 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, total respiratory disease

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters

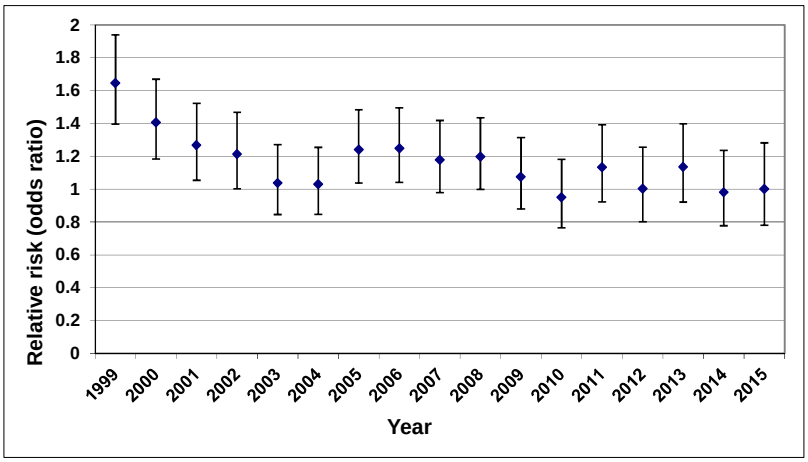


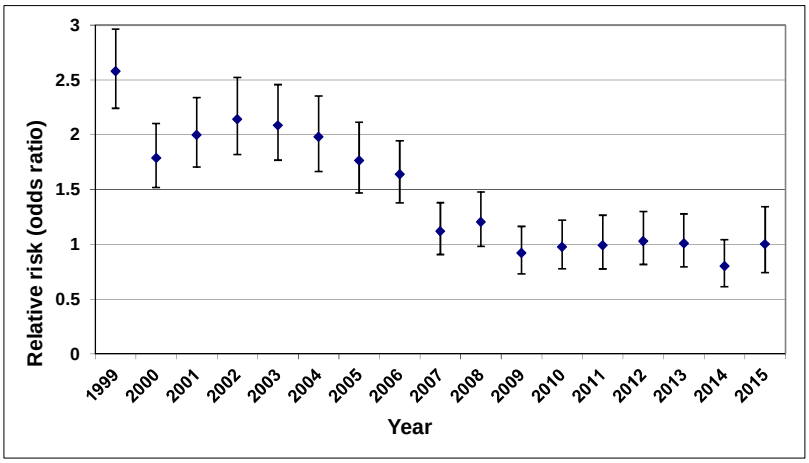
Table 18 Relative risk by year, with 95% comparison intervals, asthma (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	2.58 (2.24,2.96)	2.28 (1.94,2.68)	6.88 (4.95,9.56)
2000	1.79 (1.52,2.1)	1.57 (1.3,1.89)	4.67 (3.18,6.84)
2001	2 (1.7,2.34)	1.91 (1.62,2.26)	3.21 (1.98,5.18)
2002	2.14 (1.82,2.52)	2.06 (1.73,2.46)	3.38 (2.09,5.45)
2003	2.08 (1.77,2.46)	2.05 (1.72,2.45)	2.71 (1.62,4.52)
2004	1.98 (1.66,2.35)	1.97 (1.64,2.37)	2.33 (1.35,4.03)
2005	1.76 (1.47,2.11)	1.67 (1.37,2.04)	3.09 (1.94,4.92)
2006	1.64 (1.38,1.95)	1.49 (1.23,1.79)	4.06 (2.61,6.32)
2007	1.12 (0.91,1.38)	1.03 (0.82,1.3)	2.37 (1.37,4.11)
2008	1.2 (0.98,1.48)	1.09 (0.87,1.37)	2.89 (1.74,4.82)
2009	0.92 (0.73,1.16)	0.86 (0.67,1.1)	1.8 (0.93,3.49)
2010	0.97 (0.78,1.22)	0.9 (0.7,1.15)	2.12 (1.13,3.97)
2011	0.99 (0.78,1.27)	0.96 (0.74,1.24)	1.5 (0.71,3.17)
2012	1.03 (0.82,1.3)	0.96 (0.75,1.23)	2.07 (1.04,4.1)
2013	1.01 (0.8,1.28)	0.95 (0.74,1.23)	1.72 (0.86,3.48)
2014	0.8 (0.61,1.04)	0.74 (0.55,0.98)	1.66 (0.78,3.52)
2015	1 (0.74,1.34)	1 (0.73,1.37)	1 (0.37,2.69)

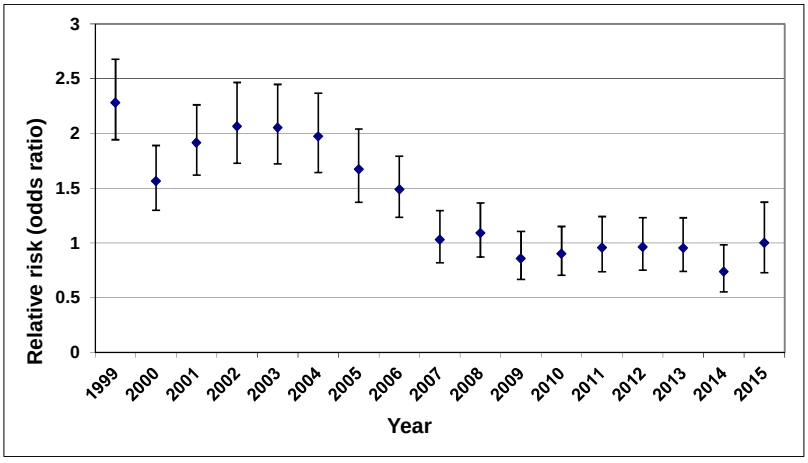
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 11 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, asthma

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters (note scale change)

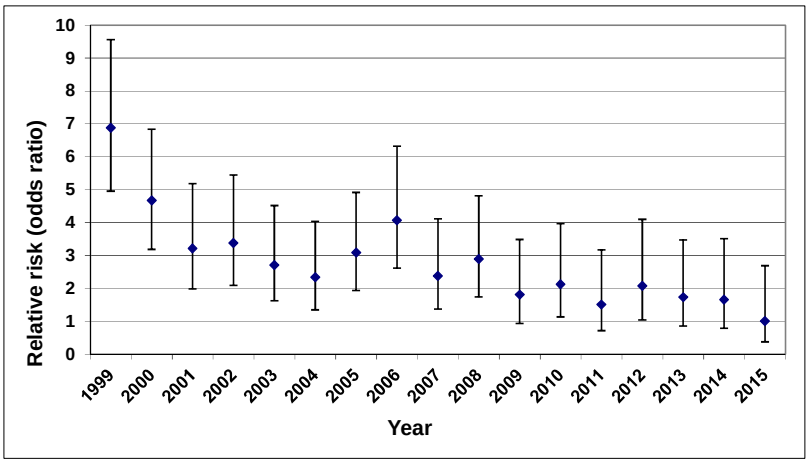


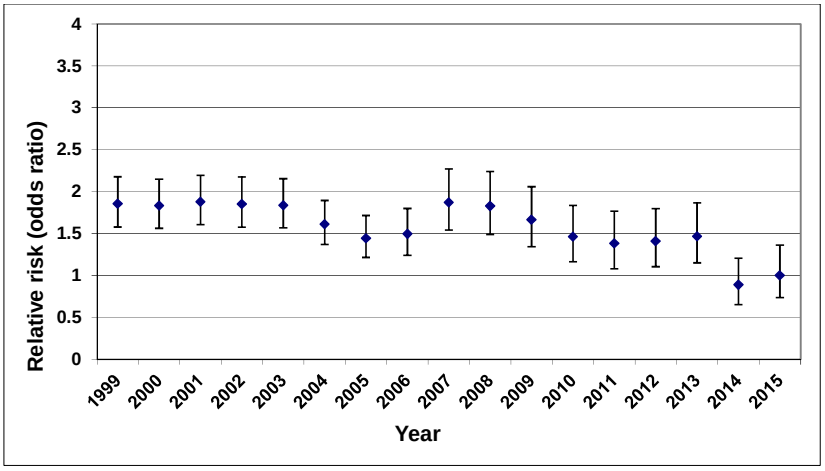
Table 19 Relative risk by year, with 95% comparison intervals, mesothelioma (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.85 (1.58,2.18)	2.34 (1.89,2.9)	1.7 (1.32,2.19)
2000	1.83 (1.56,2.15)	2.57 (2.11,3.13)	1.44 (1.1,1.89)
2001	1.88 (1.61,2.19)	2.54 (2.08,3.1)	1.58 (1.22,2.04)
2002	1.85 (1.58,2.17)	2.6 (2.12,3.18)	1.46 (1.1,1.93)
2003	1.84 (1.57,2.15)	2.68 (2.2,3.26)	1.31 (0.99,1.74)
2004	1.61 (1.37,1.89)	2.4 (1.98,2.91)	1.11 (0.82,1.5)
2005	1.44 (1.21,1.71)	2.03 (1.63,2.52)	1.12 (0.83,1.5)
2006	1.49 (1.24,1.8)	2.25 (1.78,2.84)	1.06 (0.77,1.44)
2007	1.87 (1.54,2.27)	2.47 (1.87,3.26)	1.55 (1.19,2.02)
2008	1.83 (1.49,2.24)	3.19 (2.43,4.19)	1.12 (0.82,1.51)
2009	1.66 (1.34,2.06)	2.7 (2.04,3.57)	1.09 (0.78,1.51)
2010	1.46 (1.16,1.83)	2.09 (1.54,2.86)	1.13 (0.81,1.57)
2011	1.38 (1.08,1.76)	2.14 (1.54,2.98)	0.96 (0.67,1.39)
2012	1.41 (1.1,1.8)	1.68 (1.17,2.43)	1.3 (0.94,1.8)
2013	1.46 (1.15,1.86)	1.76 (1.21,2.55)	1.33 (0.97,1.82)
2014	0.89 (0.65,1.21)	0.98 (0.62,1.56)	0.82 (0.54,1.25)
2015	1 (0.74,1.36)	1 (0.62,1.62)	1 (0.67,1.5)

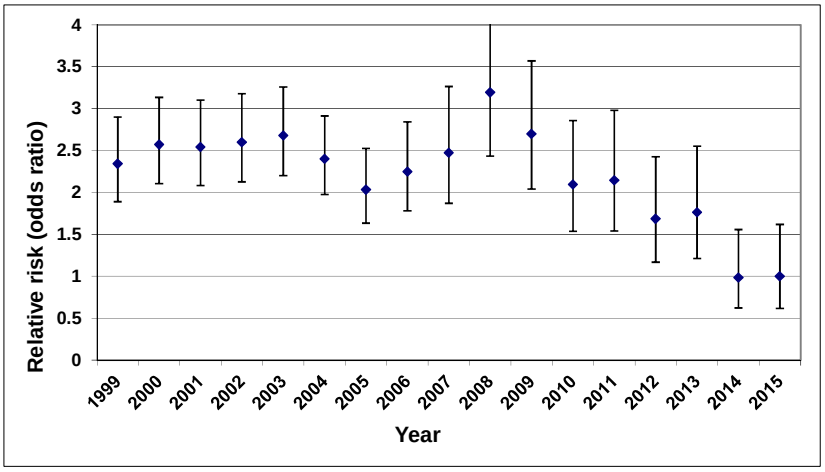
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 12 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, mesothelioma

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters

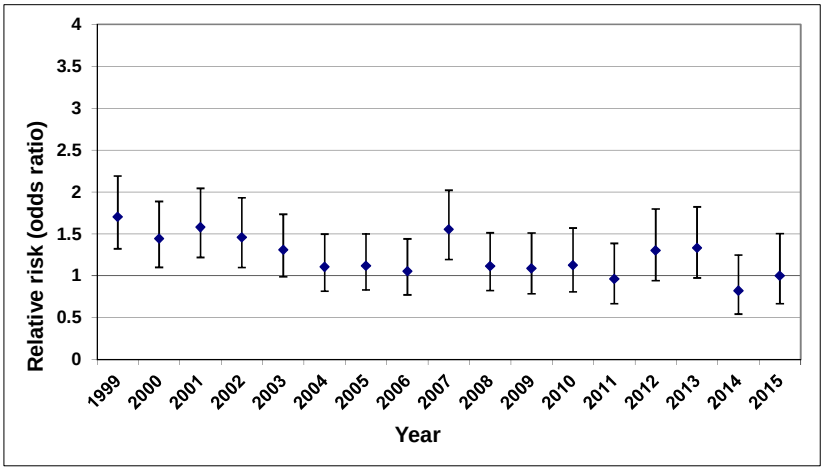


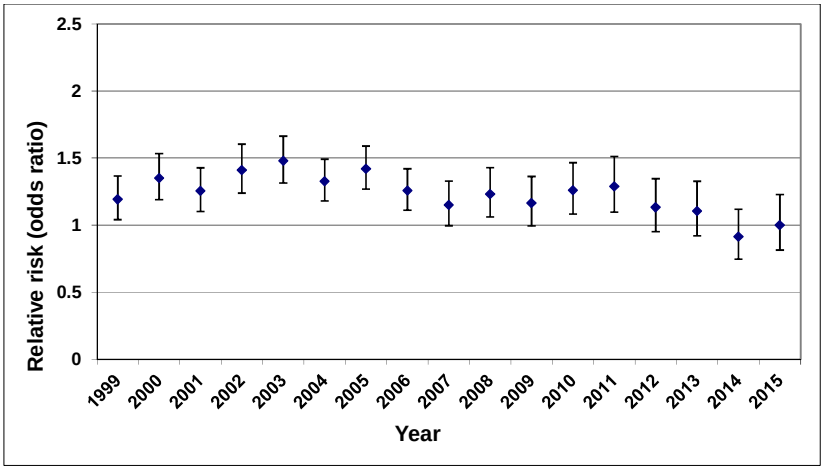
Table 20 Relative risk by year, with 95% comparison intervals, benign pleural plaques (2015 estimate = 1)

	Relative rates (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.19 (1.04,1.37)	1.36 (1.16,1.58)	1.06 (0.79,1.43)
2000	1.35 (1.19,1.53)	1.61 (1.4,1.85)	0.98 (0.73,1.31)
2001	1.25 (1.1,1.43)	1.58 (1.38,1.81)	0.68 (0.48,0.97)
2002	1.41 (1.24,1.6)	1.76 (1.54,2.02)	0.8 (0.56,1.12)
2003	1.48 (1.31,1.66)	1.85 (1.63,2.1)	0.79 (0.57,1.1)
2004	1.33 (1.18,1.49)	1.61 (1.42,1.83)	0.84 (0.62,1.14)
2005	1.42 (1.27,1.59)	1.62 (1.43,1.84)	1.27 (0.99,1.63)
2006	1.26 (1.11,1.42)	1.33 (1.16,1.54)	1.31 (1.02,1.68)
2007	1.15 (1,1.33)	1.28 (1.08,1.51)	0.97 (0.73,1.29)
2008	1.23 (1.06,1.43)	1.28 (1.07,1.54)	1.17 (0.9,1.52)
2009	1.16 (0.99,1.36)	1.27 (1.06,1.53)	0.98 (0.73,1.32)
2010	1.26 (1.08,1.47)	1.45 (1.22,1.73)	0.91 (0.66,1.24)
2011	1.29 (1.1,1.51)	1.42 (1.18,1.72)	1.05 (0.78,1.42)
2012	1.13 (0.95,1.35)	1.26 (1.03,1.54)	0.93 (0.67,1.29)
2013	1.1 (0.92,1.33)	1.21 (0.98,1.51)	0.91 (0.65,1.27)
2014	0.91 (0.75,1.12)	0.97 (0.76,1.24)	0.81 (0.56,1.16)
2015	1 (0.81,1.23)	1 (0.78,1.29)	1 (0.7,1.44)

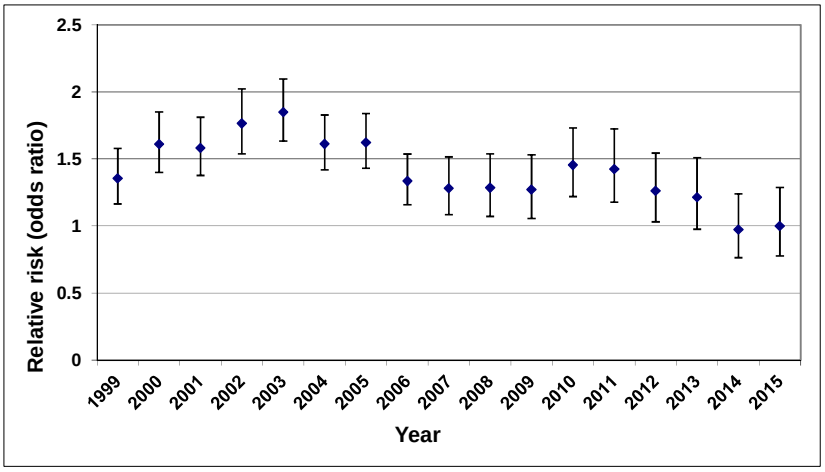
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 13 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, benign pleural plaques

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters

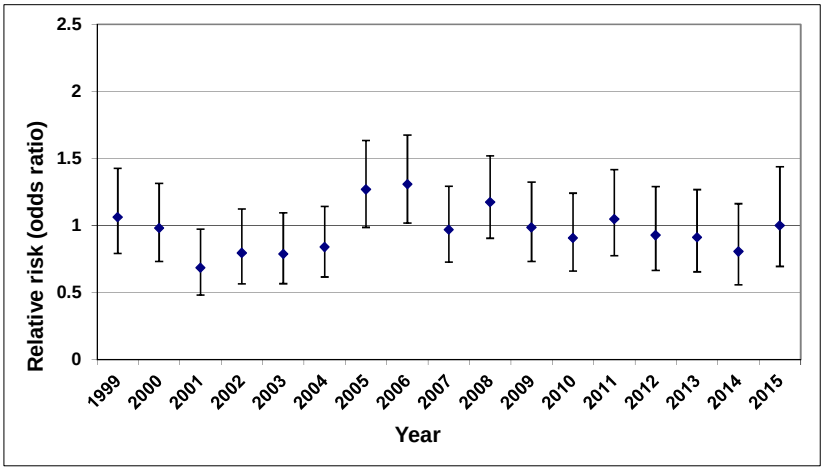


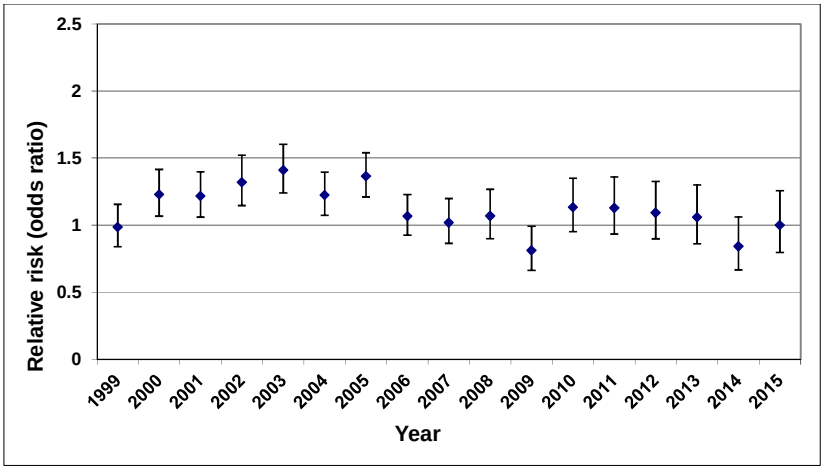
Table 21 Relative risk by year, with 95% comparison intervals, benign pleural plaques – predominantly plaques (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	0.99 (0.84,1.16)	1.31 (1.1,1.55)	0.48 (0.31,0.75)
2000	1.23 (1.07,1.42)	1.51 (1.29,1.77)	0.91 (0.66,1.25)
2001	1.22 (1.06,1.4)	1.57 (1.35,1.82)	0.72 (0.5,1.03)
2002	1.32 (1.15,1.52)	1.71 (1.47,1.99)	0.75 (0.52,1.08)
2003	1.41 (1.24,1.6)	1.81 (1.58,2.08)	0.8 (0.57,1.13)
2004	1.22 (1.07,1.39)	1.6 (1.4,1.84)	0.58 (0.4,0.85)
2005	1.36 (1.21,1.54)	1.63 (1.42,1.87)	1.17 (0.89,1.53)
2006	1.07 (0.92,1.23)	1.19 (1.01,1.41)	1.01 (0.75,1.35)
2007	1.02 (0.86,1.2)	1.21 (1,1.47)	0.75 (0.53,1.05)
2008	1.07 (0.9,1.27)	1.25 (1.02,1.53)	0.8 (0.57,1.11)
2009	0.81 (0.66,0.99)	1.08 (0.86,1.35)	0.36 (0.22,0.6)
2010	1.13 (0.95,1.35)	1.33 (1.08,1.63)	0.84 (0.59,1.2)
2011	1.13 (0.93,1.36)	1.34 (1.08,1.67)	0.78 (0.54,1.12)
2012	1.09 (0.9,1.33)	1.25 (0.99,1.57)	0.89 (0.62,1.27)
2013	1.06 (0.86,1.3)	1.18 (0.92,1.52)	0.87 (0.61,1.25)
2014	0.84 (0.67,1.06)	0.87 (0.65,1.17)	0.81 (0.54,1.19)
2015	1 (0.8,1.26)	1 (0.75,1.33)	1 (0.68,1.47)

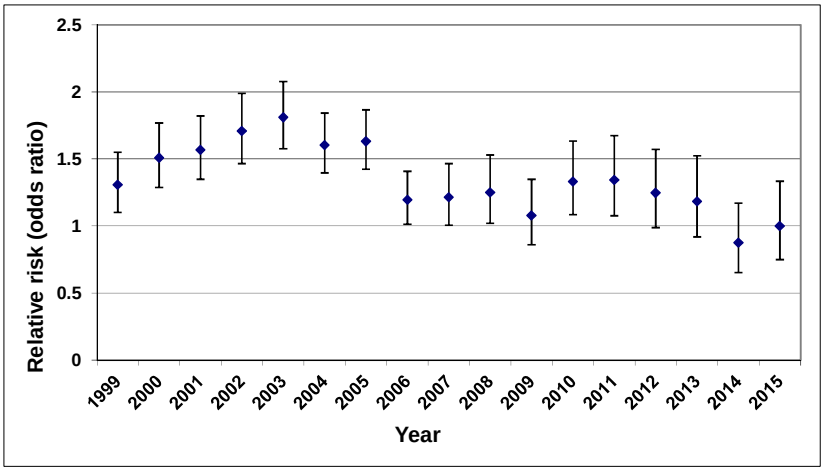
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 14 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, benign pleural plaques – predominantly plaques

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters

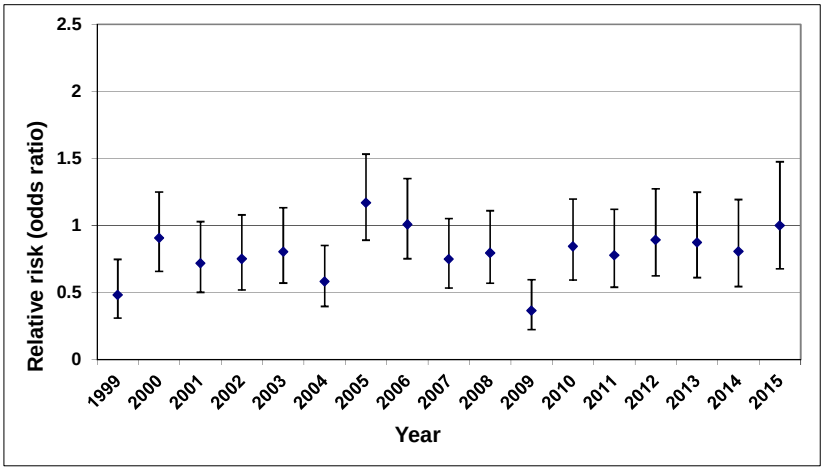


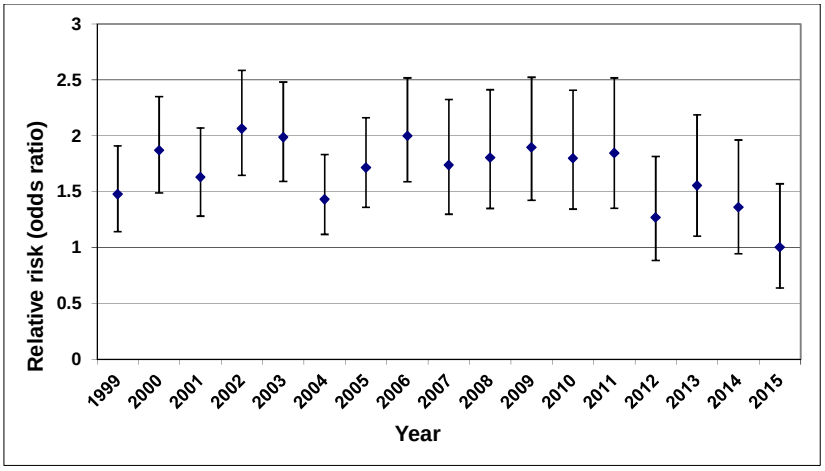
Table 22 Relative risk by year, with 95% comparison intervals, benign pleural plaques – predominantly diffuse (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.48 (1.14,1.91)	1.58 (1.21,2.06)	1.24 (0.51,3)
2000	1.87 (1.49,2.35)	2.08 (1.65,2.63)	1.13 (0.47,2.74)
2001	1.63 (1.28,2.07)	1.82 (1.42,2.32)	0.92 (0.34,2.48)
2002	2.06 (1.65,2.58)	2.22 (1.76,2.8)	1.88 (0.89,3.95)
2003	1.99 (1.59,2.48)	2.18 (1.73,2.74)	1.41 (0.63,3.14)
2004	1.43 (1.12,1.83)	1.61 (1.25,2.07)	0.65 (0.21,2.02)
2005	1.71 (1.36,2.16)	1.7 (1.33,2.19)	2.94 (1.65,5.24)
2006	2 (1.59,2.52)	1.82 (1.4,2.36)	3.93 (2.42,6.38)
2007	1.74 (1.3,2.32)	1.5 (1.07,2.11)	3.09 (1.79,5.36)
2008	1.8 (1.35,2.41)	1.55 (1.1,2.18)	3.2 (1.88,5.44)
2009	1.89 (1.42,2.52)	1.6 (1.14,2.24)	3.7 (2.18,6.27)
2010	1.8 (1.34,2.41)	1.97 (1.45,2.67)	0.74 (0.24,2.31)
2011	1.84 (1.35,2.52)	1.69 (1.19,2.41)	2.75 (1.43,5.29)
2012	1.27 (0.88,1.82)	1.31 (0.89,1.91)	1.01 (0.33,3.12)
2013	1.55 (1.1,2.19)	1.43 (0.97,2.1)	2.19 (1.07,4.47)
2014	1.36 (0.94,1.96)	1.31 (0.88,1.97)	1.51 (0.63,3.63)
2015	1 (0.64,1.57)	1 (0.61,1.63)	1 (0.32,3.15)

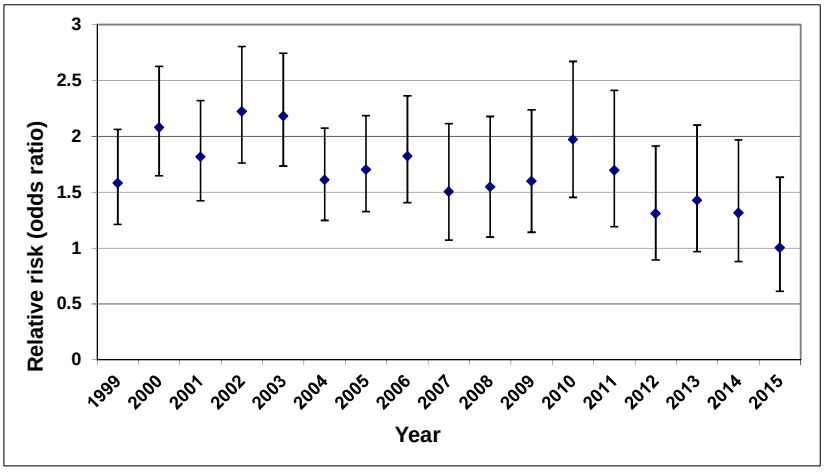
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 15 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, benign pleural plaques – predominantly diffuse

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters (note scale change)

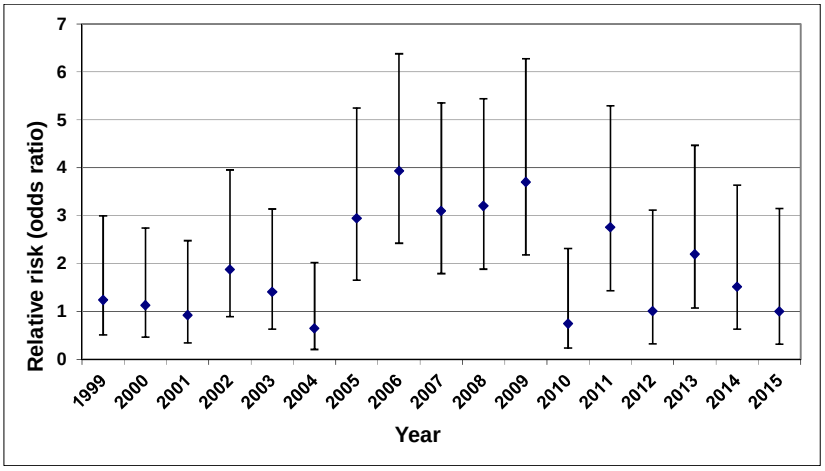


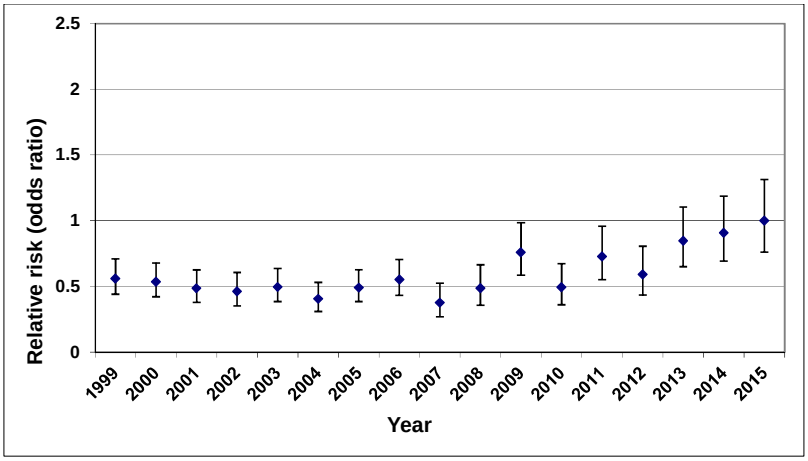
Table 23 Relative risk by year, with 95% comparison intervals, pneumoconiosis (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	0.56 (0.44,0.71)	0.45 (0.34,0.6)	1.12 (0.71,1.75)
2000	0.53 (0.42,0.68)	0.49 (0.38,0.64)	0.7 (0.4,1.22)
2001	0.49 (0.38,0.63)	0.41 (0.31,0.55)	0.88 (0.52,1.46)
2002	0.46 (0.35,0.61)	0.46 (0.34,0.62)	0.36 (0.16,0.81)
2003	0.5 (0.38,0.64)	0.49 (0.37,0.64)	0.42 (0.2,0.88)
2004	0.41 (0.31,0.53)	0.43 (0.32,0.57)	0.21 (0.08,0.55)
2005	0.49 (0.38,0.63)	0.46 (0.35,0.61)	0.61 (0.34,1.09)
2006	0.55 (0.43,0.7)	0.54 (0.41,0.71)	0.59 (0.32,1.07)
2007	0.38 (0.27,0.52)	0.31 (0.21,0.47)	0.62 (0.35,1.1)
2008	0.49 (0.36,0.66)	0.45 (0.31,0.65)	0.65 (0.36,1.18)
2009	0.76 (0.59,0.98)	0.78 (0.58,1.04)	0.64 (0.34,1.18)
2010	0.49 (0.36,0.67)	0.52 (0.37,0.73)	0.39 (0.18,0.87)
2011	0.73 (0.55,0.96)	0.69 (0.5,0.95)	0.9 (0.52,1.55)
2012	0.59 (0.43,0.81)	0.57 (0.4,0.81)	0.68 (0.35,1.32)
2013	0.85 (0.65,1.1)	0.79 (0.58,1.09)	1.09 (0.66,1.78)
2014	0.91 (0.69,1.19)	0.8 (0.58,1.11)	1.32 (0.82,2.12)
2015	1 (0.76,1.31)	1 (0.73,1.37)	1 (0.56,1.79)

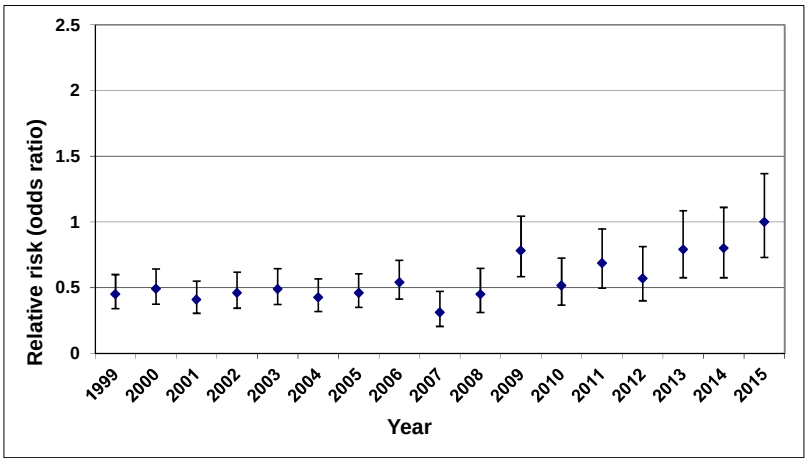
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 16 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, pneumoconiosis

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters

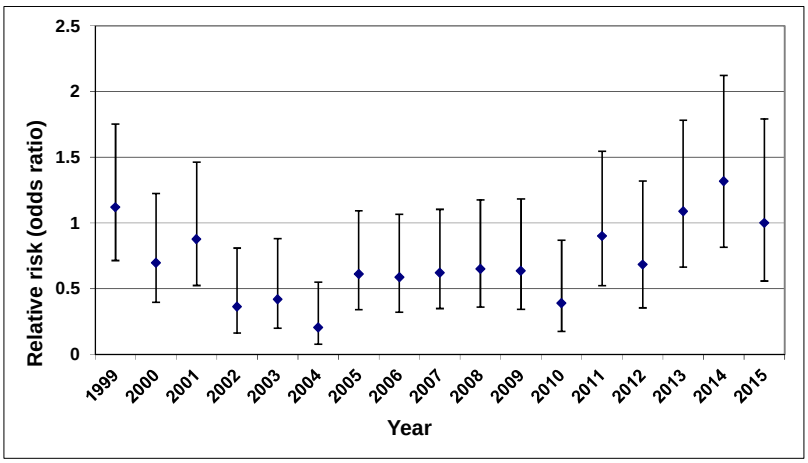


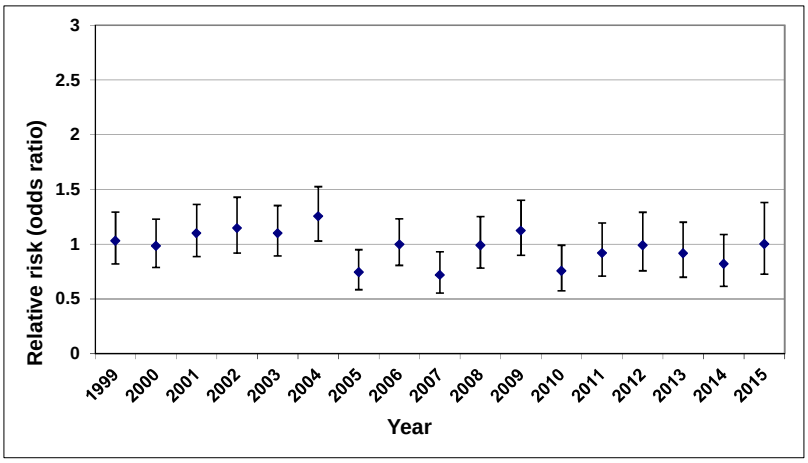
Table 24 Relative risk by year, with 95% comparison intervals, other (than those investigated separately) respiratory disease (2015 estimate = 1)

	Relative risk (95% comparison interval)		
	SWORD		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.03 (0.82,1.29)	0.91 (0.7,1.18)	1.21 (0.75,1.95)
2000	0.98 (0.79,1.23)	0.78 (0.59,1.02)	1.69 (1.12,2.54)
2001	1.1 (0.89,1.36)	0.9 (0.7,1.16)	1.72 (1.14,2.6)
2002	1.14 (0.92,1.43)	1.04 (0.8,1.33)	1.27 (0.79,2.02)
2003	1.1 (0.89,1.35)	0.99 (0.78,1.24)	1.34 (0.84,2.14)
2004	1.25 (1.03,1.52)	1.16 (0.93,1.44)	1.4 (0.9,2.18)
2005	0.74 (0.58,0.95)	0.64 (0.49,0.85)	1.1 (0.66,1.82)
2006	1 (0.81,1.23)	0.93 (0.74,1.17)	1.05 (0.63,1.75)
2007	0.72 (0.55,0.93)	0.62 (0.46,0.84)	0.99 (0.59,1.66)
2008	0.99 (0.78,1.25)	0.9 (0.69,1.18)	1.22 (0.75,1.99)
2009	1.12 (0.9,1.4)	0.94 (0.72,1.23)	1.66 (1.09,2.52)
2010	0.75 (0.57,0.99)	0.74 (0.55,0.99)	0.64 (0.32,1.29)
2011	0.92 (0.71,1.19)	0.65 (0.46,0.91)	2.05 (1.34,3.13)
2012	0.99 (0.76,1.29)	0.99 (0.74,1.32)	0.8 (0.41,1.56)
2013	0.92 (0.7,1.2)	0.68 (0.48,0.98)	1.67 (1.07,2.59)
2014	0.82 (0.62,1.09)	0.71 (0.51,1)	1.17 (0.66,2.08)
2015	1 (0.73,1.38)	1 (0.69,1.46)	1 (0.52,1.93)

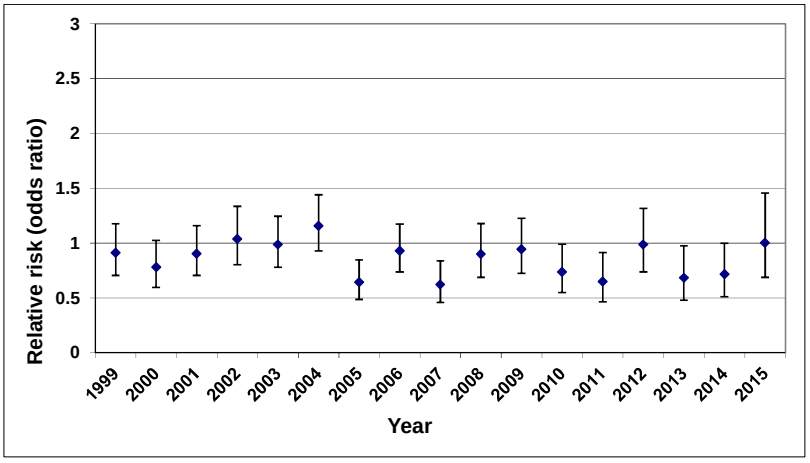
Models adjusted for reporter type (where appropriate), season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 110

Figure 17 Relative risk by year (2015 estimate = 1), with 95% comparison intervals, other (than those investigated separately) respiratory disease

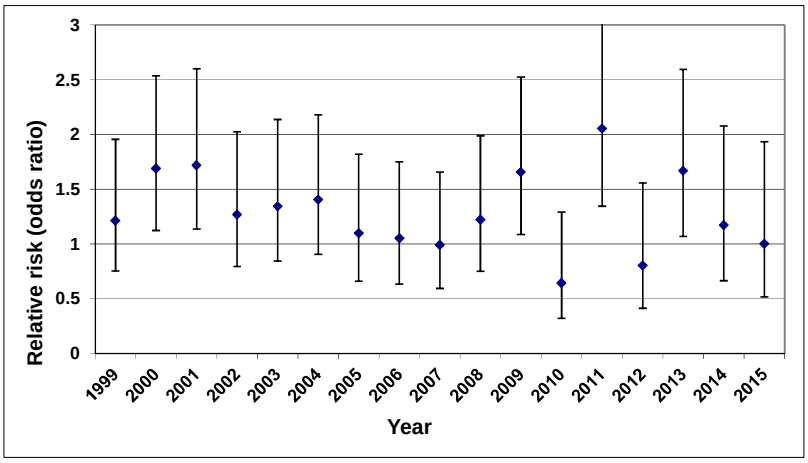
a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters



3.2.4 WORK-RELATED MUSCULOSKELETAL DISORDERS

The average annual percentage change in reported incidence of work-related musculoskeletal disorders (MSDs), as reported by GPs (THOR-GP) is shown in Table 25 whilst the relative rates by year are shown in Tables 26 to 29 and Figures 18 to 21. As reported previously, data from GPs reporting as 'core' reporters suggested a downward trend in the incidence of total work-related MSDs in the order of -15.8% (95% CIs: -18.9, -12.1) per year (2006-2009) with the graph (Figure 18) suggesting the largest decrease being between 2006 and 2007. Similar annual patterns were seen for the subset of upper limb disorders, with an average annual decrease of -14.7% (95% CIs: -19.6, -9.5) and spine/back disorders at -19.7% (95% CIs: -24.9, -14.1) with the annual plots (Figures 19 and 20) suggesting a continual decrease throughout the study period. For lower limb disorders an initial decrease between 2006 and 2007 (Figure 21) was followed by a relatively flat trend: average annual decrease for this group of -10% (95% CIs: -19.5, +0.6).

For 'sample' reporters, the annual average decrease in incidence for total musculoskeletal disorders (2011-2015) was -9.3% (95% CIs: -16.4, -1.5). This compared to -12.1% (95% CIs: -21.3, -1.7) reported previously (based on data for 2011 to 2014). The graph (Figure 18) showing relative rates by year suggest a gradual decline in incidence with the largest drop between 2013 and 2014 (although confidence intervals were wide and overlapping). Some variation was observed between the different MSD sub-groups but confidence intervals were very wide. For upper limb disorders a non-significant average annual decrease of -4.8% (95% CIs: -15.3, 7.1) was observed whilst for spine/back the equivalent figure was -11.8% (95% CIs: -22.3, 0.1) and for lower limb it was -4.5% (95% CIs: -21, 15.5).

Table 25 Average annual percentage change in reported incidence in total work-related musculoskeletal disorders

		ESTIMATED % CHANGE (95% CONFIDENCE INTERVAL)	
		THOR-GP	
		Core reporters	Sample reporters
	Year (continuous)		
Total musculoskeletal	**2006-2009**	-15.8 (-19.4, -12.1)	/
	2011-2015	/	-9.3 (-16.4, -1.5)
Upper limb	**2006-2009**	-14.7 (-19.6, -9.5)	/
	2011-2015	/	-4.8 (-15.3, 7.1)
Spine/back	**2006-2009**	-19.7 (-24.9, -14.1)	/
	2011-2015	/	-11.8 (-22.3, 0.1)
Lower limb	**2006-2009**	-10 (-19.5, 0.6)	/
	2011-2015	/	-4.5 (-21, 15.5)

Models adjusted for, season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

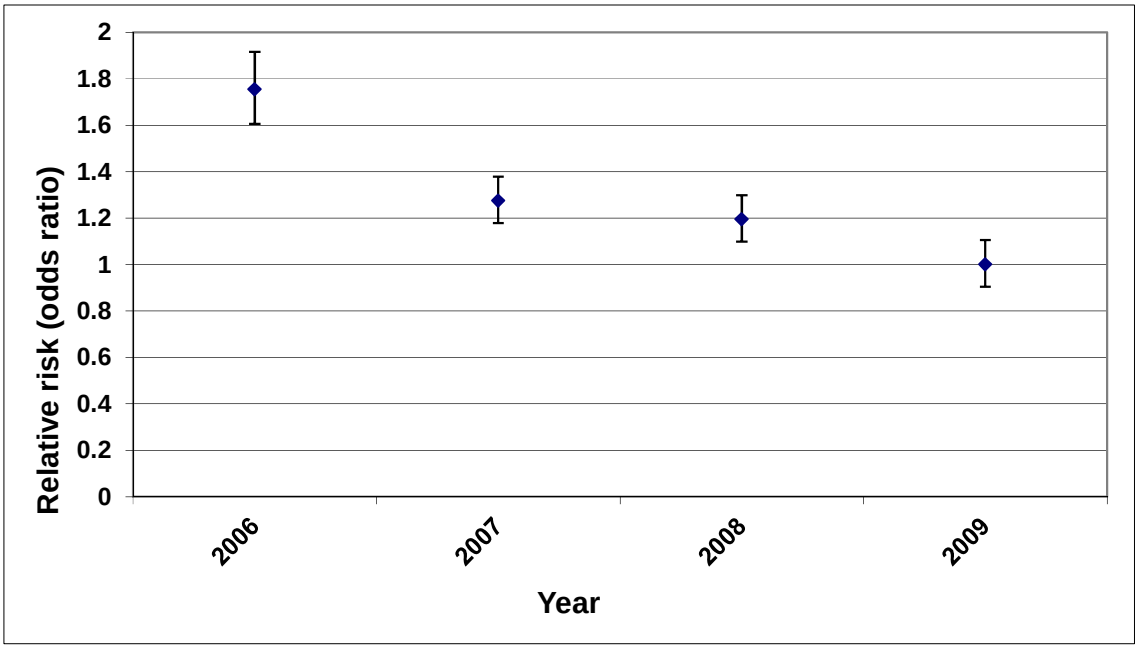
Table 26 Relative risk by year, with 95% comparison intervals, total work-related musculoskeletal disorders (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1)

	Relative risk (95% comparison interval)	
	THOR-GP	
	Core reporters	Sample reporters
YEAR		
2006	1.75 (1.61,1.92)	/
2007	1.27 (1.18,1.38)	/
2008	1.19 (1.1,1.3)	/
2009	1 (0.9,1.11)	/
2010	/	/
2011	/	1.32 (1.08,1.62)
2012	/	1.27 (1.04,1.55)
2013	/	1.21 (0.98,1.48)
2014	/	0.93 (0.74,1.17)
2015	/	1 (0.78,1.28)

Models adjusted for, season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 18 **Relative risk by year (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1), with 95% comparison intervals, total musculoskeletal disorders**

a) THOR-GP, core reporters



b) THOR-GP, sample reporters

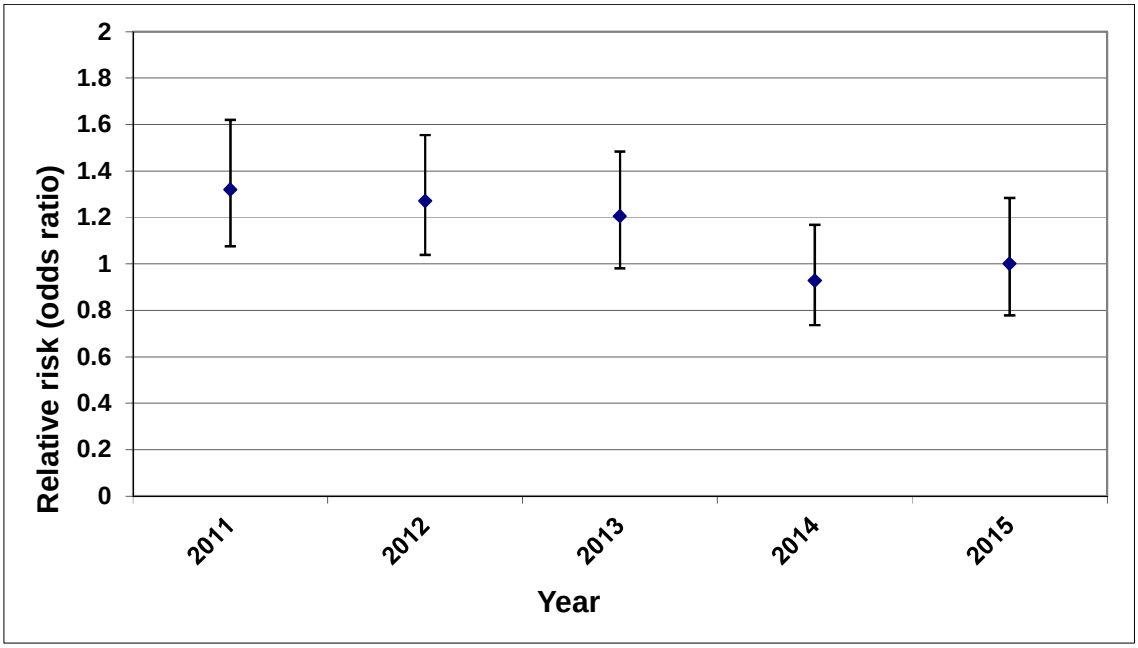


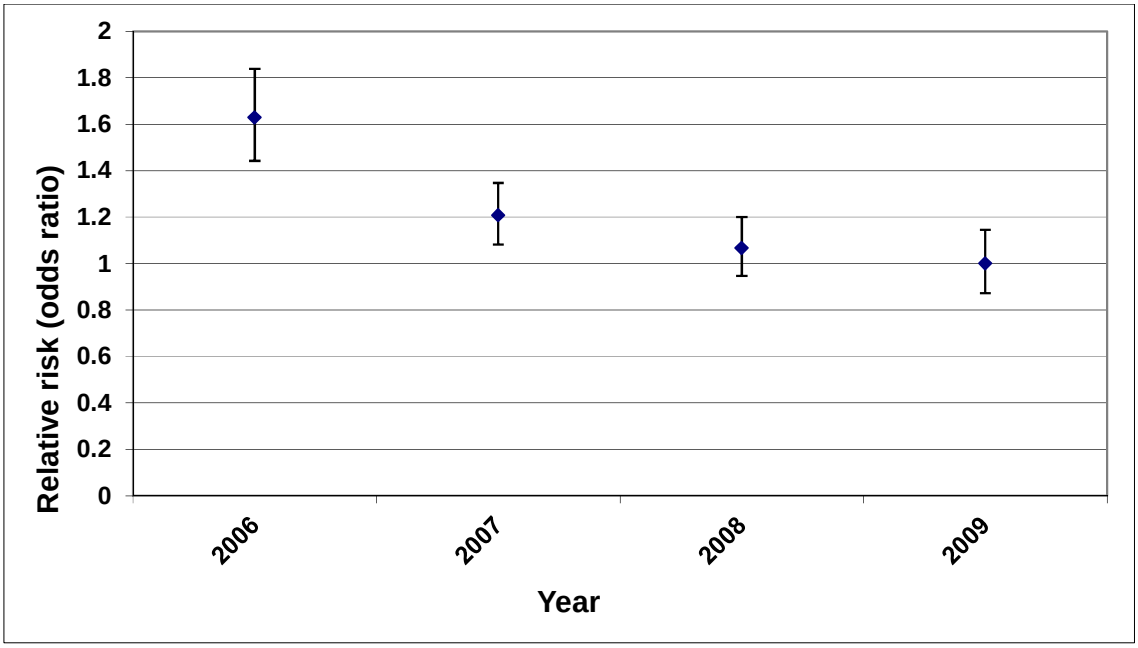
Table 27 Relative risk by year, with 95% comparison intervals, upper limb disorders (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1)

	Relative risk (95% comparison interval)	
	THOR-GP	
	Core reporters	Sample reporters
YEAR		
2006	1.63 (1.44,1.84)	/
2007	1.21 (1.08,1.35)	/
2008	1.07 (0.95,1.2)	/
2009	1 (0.87,1.15)	/
2010	/	/
2011	/	1.24 (0.91,1.69)
2012	/	1.17 (0.86,1.6)
2013	/	1.39 (1.05,1.84)
2014	/	1.07 (0.76,1.49)
2015	/	1 (0.68,1.46)

Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 19 **Relative risk by year (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1), with 95% comparison intervals, upper limb disorders**

a) THOR-GP, core reporters



b) THOR-GP, sample reporters

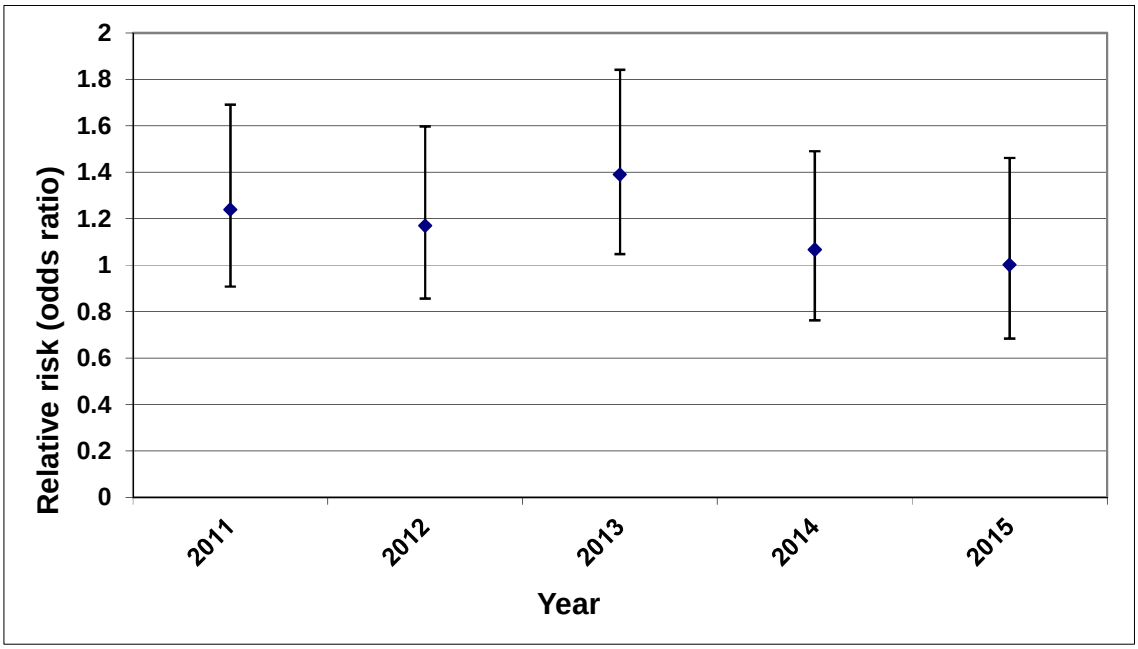


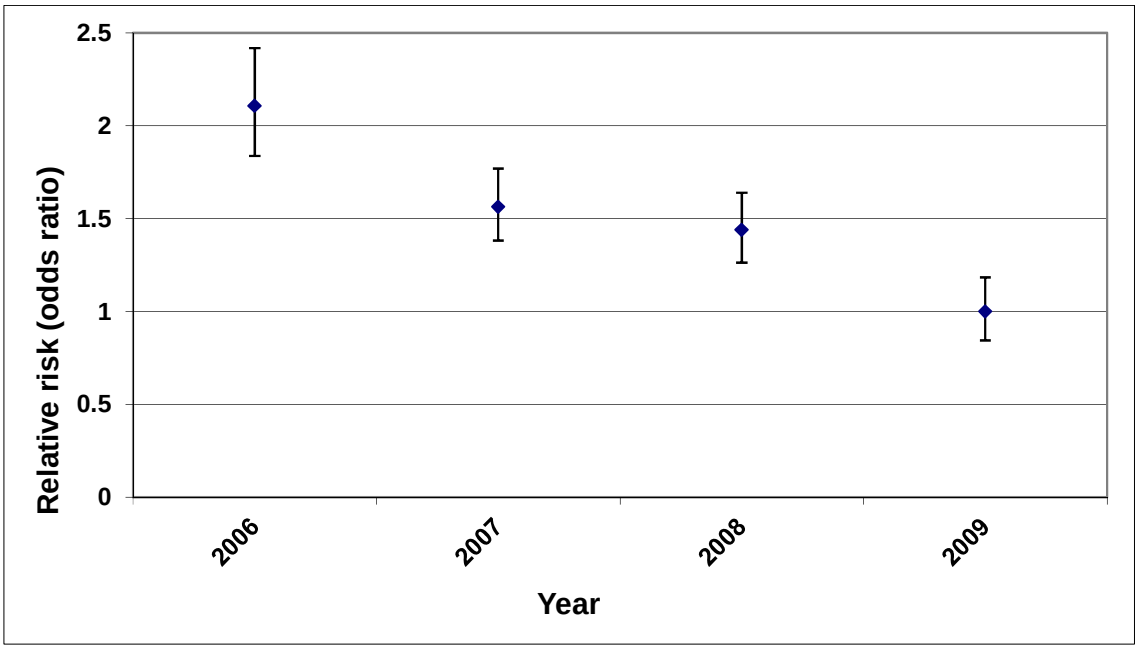
Table 28 Relative risk by year, with 95% comparison intervals, spine/back disorders (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1)

	Relative risk (95% comparison interval)	
	THOR-GP	
	Core reporters	Sample reporters
YEAR		
2006	2.11 (1.84,2.42)	/
2007	1.56 (1.38,1.77)	/
2008	1.44 (1.26,1.64)	/
2009	1 (0.85,1.18)	/
2010	/	/
2011	/	1.28 (0.94,1.73)
2012	/	1.3 (0.97,1.75)
2013	/	1.14 (0.83,1.56)
2014	/	0.74 (0.51,1.09)
2015	/	1 (0.68,1.47)

Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 20 **Relative risk by year (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1), with 95% comparison intervals, spine/back disorders**

a) THOR-GP, core reporters



b) THOR-GP, sample reporters

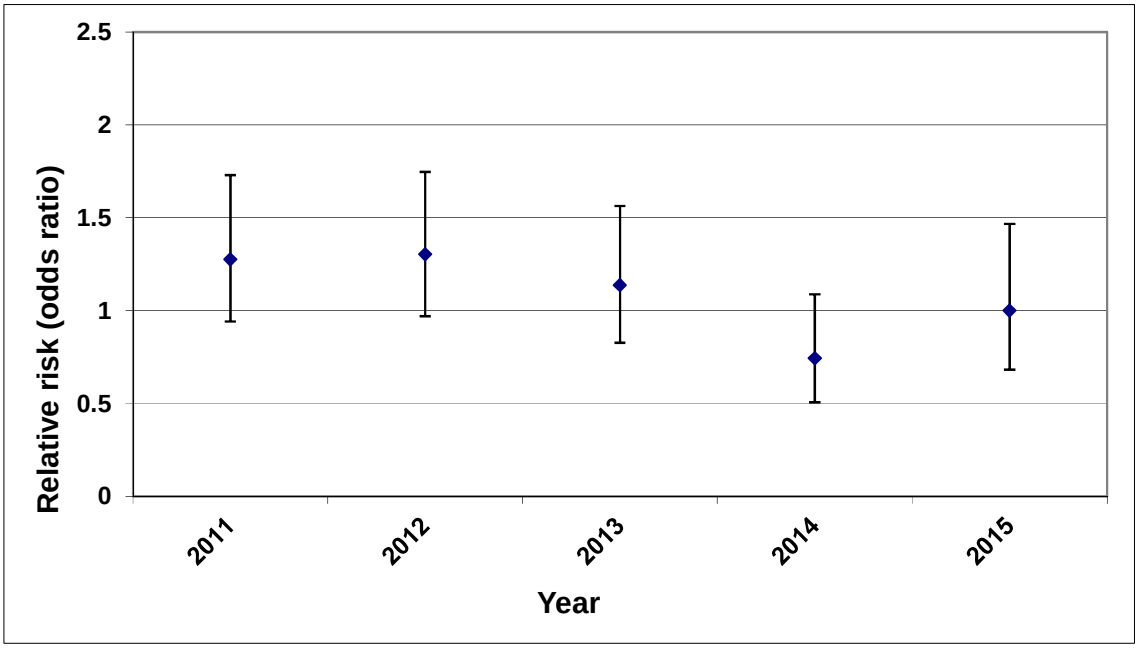


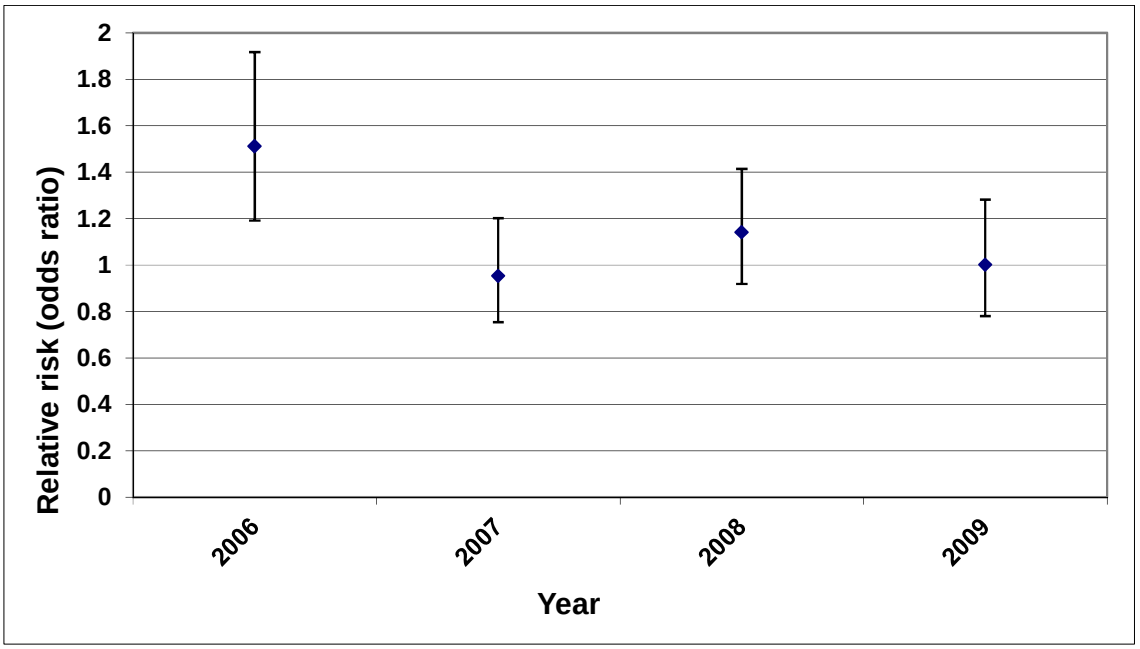
Table 29 Relative risk by year, with 95% comparison intervals, lower limb disorders (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1)

	Relative risk (95% comparison interval)	
	THOR-GP	
	Core reporters	Sample reporters
YEAR		
2006	1.51 (1.19,1.92)	/
2007	0.95 (0.75,1.2)	/
2008	1.14 (0.92,1.41)	/
2009	1 (0.78,1.28)	/
2010	/	/
2011	/	1.21 (0.75,1.94)
2012	/	1 (0.6,1.67)
2013	/	0.73 (0.41,1.3)
2014	/	1.12 (0.67,1.9)
2015	/	1 (0.56,1.77)

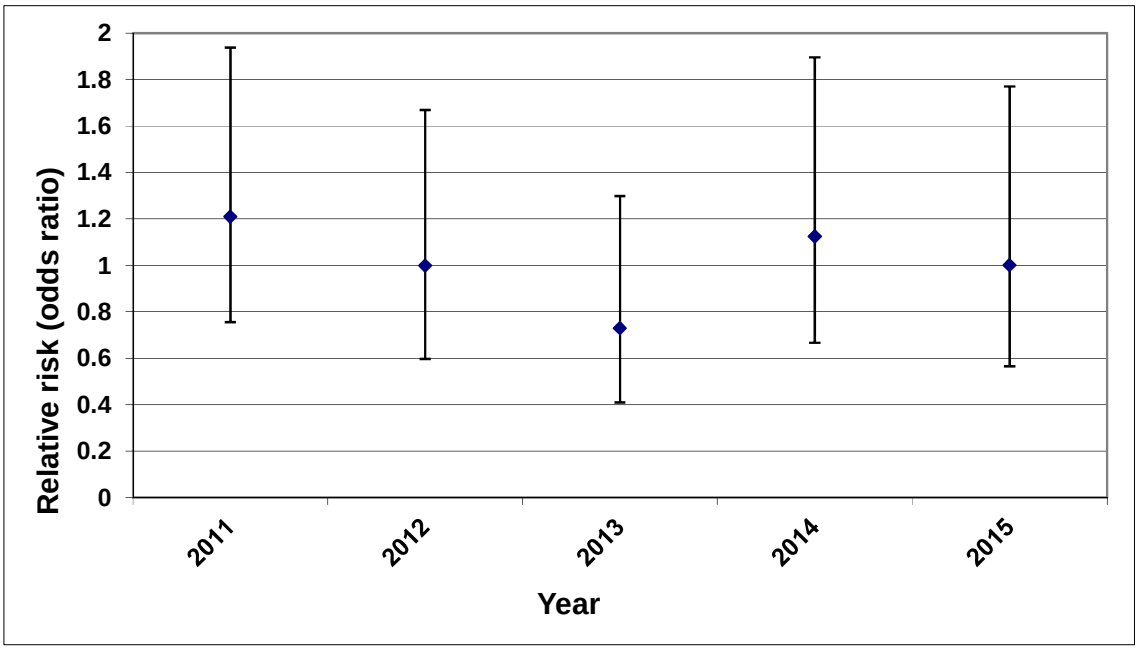
Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 21 **Relative risk by year (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1), with 95% comparison intervals, lower limb disorders**

a) THOR-GP, core reporters



b) THOR-GP sample reporters



3.2.5 WORK-RELATED MENTAL ILL-HEALTH

The average annual percentage change in reported incidence of work-related mental ill-health, as reported by GPs (THOR-GP) is shown in Table 30 whilst the relative rates by year are shown in Tables 31 to 33 and Figures 22 to 24.

Based on data from core reporters, an average annual decrease in the incidence of total mental ill-health of -12.4% (95% CIs: -17.1, -7.4) was observed (2006-2009). This compared to an average annual decrease of -11.4% (95% CIs: -18.6, -3.7) for anxiety and depression and -13.3% (95% CIs: -19, -7.1) for other work stress. Overall, the graphs showing relative rates by year suggest a general decrease in incidence over the study period.

For sample reporters, the annual average decrease in incidence for total mental ill-health (2011-2015) was -16.1% (95% CIs: -23.4, -8.0). This compared to -15.0% (95% CIs: -25.1, -3.5) reported previously (based on data for 2011 to 2014). The annual plot suggests a flat trend between 2011 and 2012, which decreases thereafter (although confidence intervals were wide and overlapping). The equivalent changes in incidence for anxiety and depression and other work stress were -18.3% (95% CIs: -30.4, -4.0) and -12.4% (95% CIs: -21.3, -2.5), respectively.

Table 30 Average annual percentage change in reported incidence in total work-related mental ill-health

		ESTIMATED % CHANGE (95% CONFIDENCE INTERVAL)	
		THOR-GP	
		Core reporters	**Sample reporters**
	Year (continuous)		
Total mental ill-health	**2006-2009**	-12.4 (-17.1, -7.4)	/
	2011-2015	/	-16.1 (-23.4, -8.0)
Anxiety and depression	**2006-2009**	-11.4 (-18.6, -3.7)	/
	2011-2015	/	-18.3 (-30.4, -4.0)
Other work stress	**2006-2009**	-13.3 (-19, -7.1)	/
	2011-2015	/	-12.4 (-21.3, -2.5)

Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

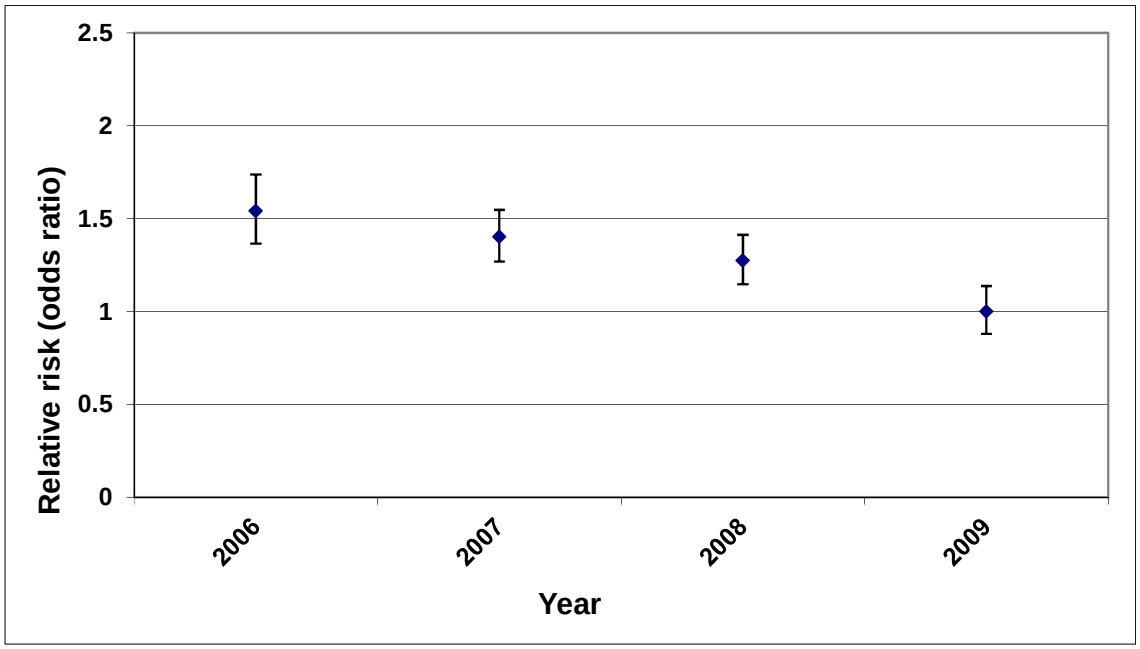
Table 31 Relative risk by year, with 95% comparison intervals, total mental ill-health (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1)

	Relative risk (95% comparison interval)	
	THOR-GP	
	Core reporters	Sample reporters
YEAR		
2006	1.54 (1.37,1.74)	/
2007	1.4 (1.27,1.55)	/
2008	1.27 (1.15,1.41)	/
2009	1 (0.88,1.14)	/
2010	/	/
2011	/	1.84 (1.48,2.3)
2012	/	1.8 (1.45,2.24)
2013	/	1.59 (1.28,1.99)
2014	/	1.18 (0.91,1.54)
2015	/	1 (0.74,1.36)

Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 22 **Relative risk by year (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1), with 95% comparison intervals, total mental ill-health**

a) THOR-GP, core reporters



b) THOR-GP, sample reporters

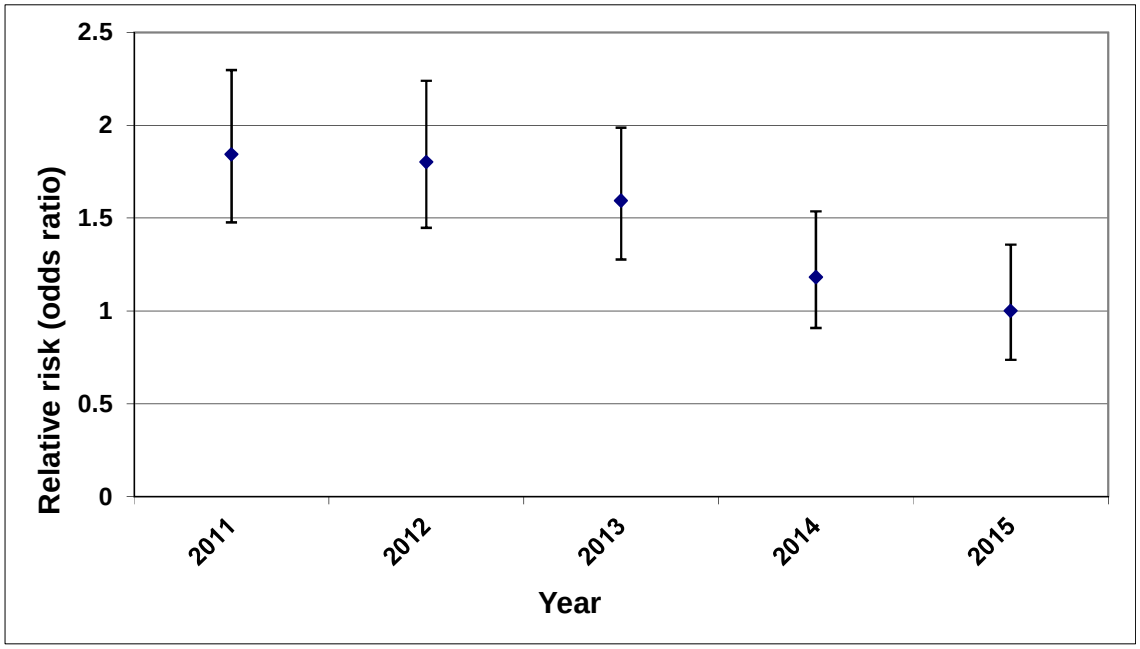


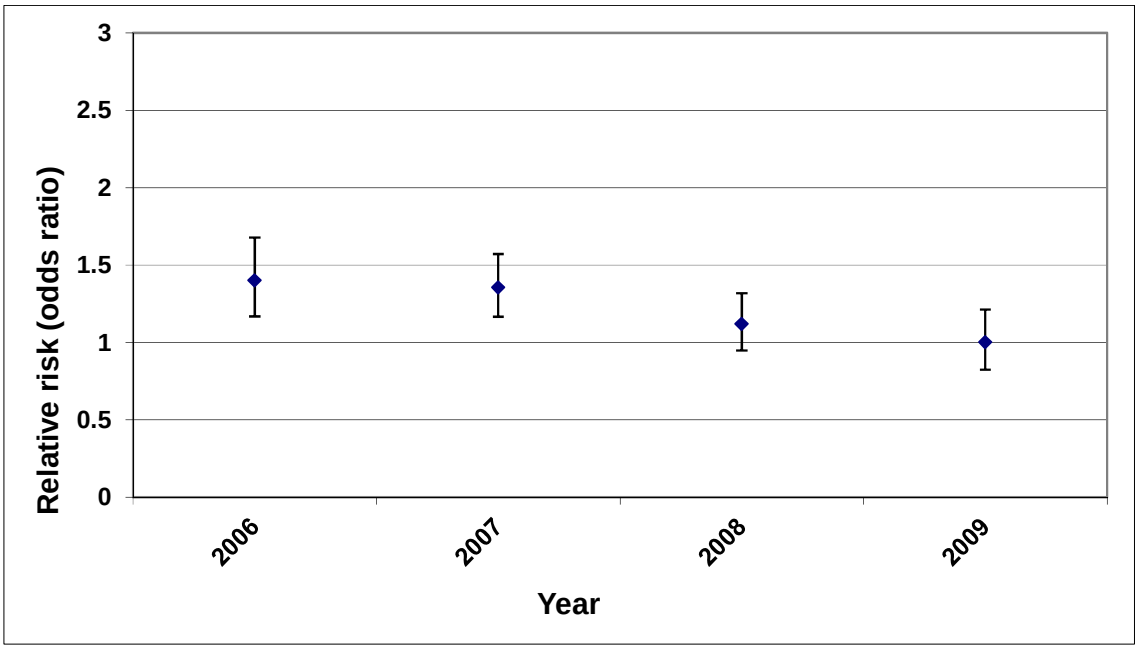
Table 32 Relative risk by year, with 95% comparison intervals, anxiety and depression (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1)

	Relative risk (95% comparison interval)	
	THOR-GP	
	Core reporters	Sample reporters
YEAR		
2006	1.4 (1.17,1.68)	/
2007	1.35 (1.17,1.57)	/
2008	1.12 (0.95,1.32)	/
2009	1 (0.82,1.21)	/
2010	/	/
2011	/	1.86 (1.27,2.73)
2012	/	1.79 (1.24,2.58)
2013	/	1.29 (0.85,1.96)
2014	/	1.03 (0.64,1.66)
2015	/	1 (0.59,1.69)

Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 23 **Relative risk by year (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1), with 95% comparison intervals, anxiety and depression**

a) THOR-GP, core reporters



b) THOR-GP, sample reporters

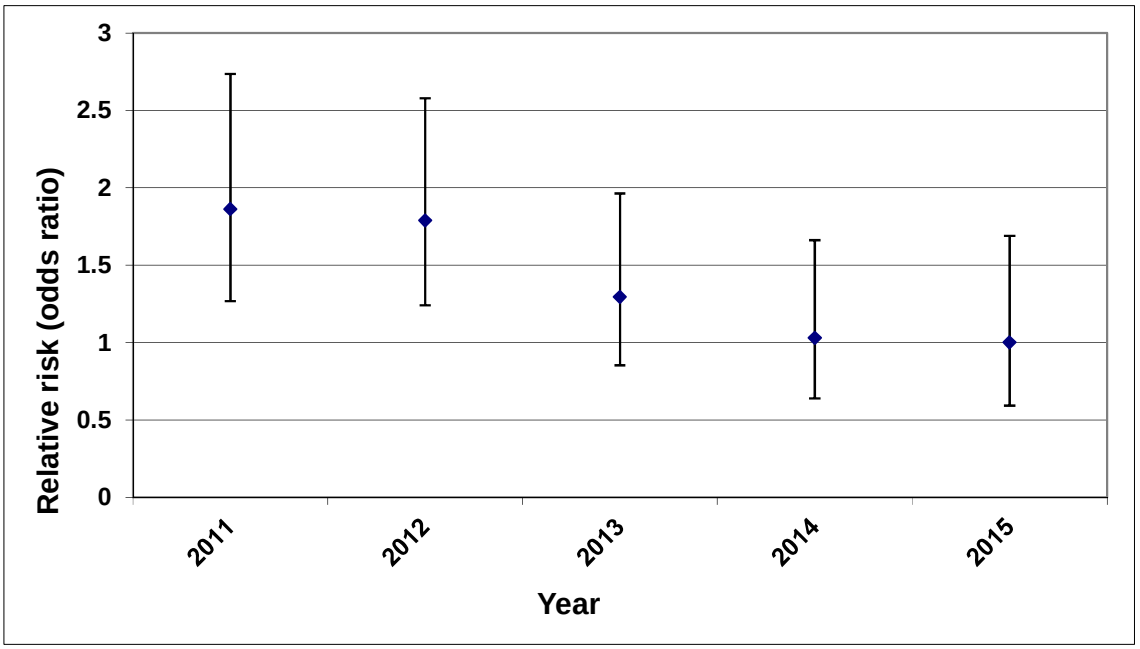


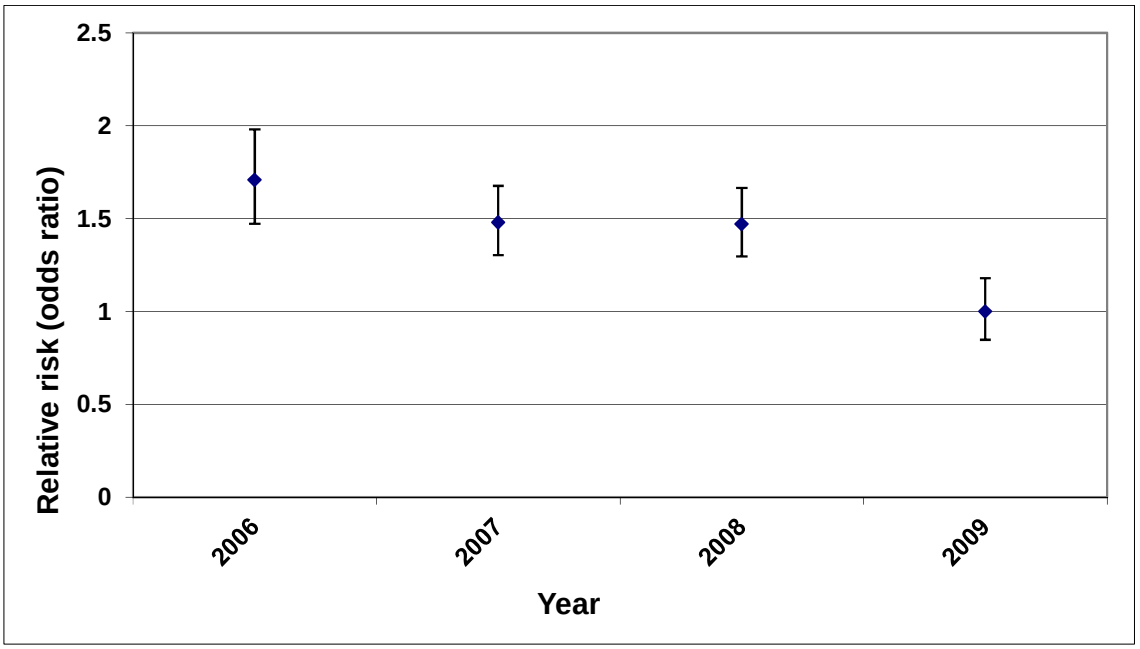
Table 33 Relative rates by year, with 95% comparison intervals, other work stress (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1)

	Relative rates (95% comparison interval)	
	THOR-GP	
	Core reporters	Sample reporters
YEAR		
2006	1.71 (1.47,1.98)	/
2007	1.48 (1.3,1.68)	/
2008	1.47 (1.3,1.67)	/
2009	1 (0.85,1.18)	/
2010	/	/
2011	/	1.76 (1.36,2.27)
2012	/	1.49 (1.13,1.98)
2013	/	1.59 (1.23,2.07)
2014	/	1.23 (0.91,1.67)
2015	/	1 (0.7,1.43)

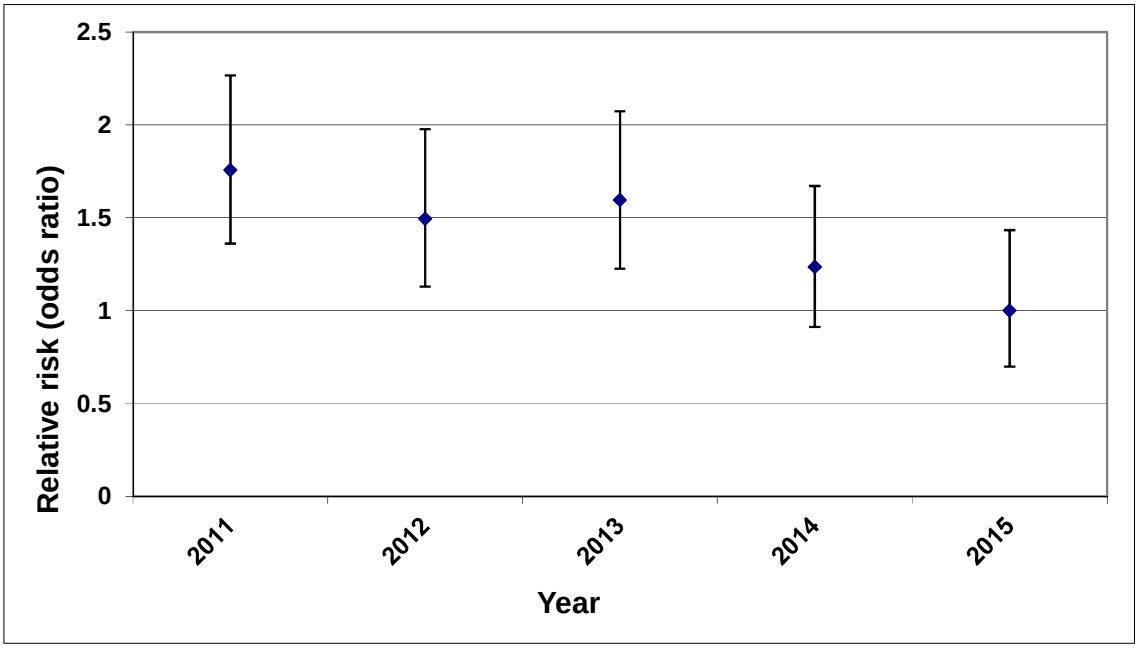
Models adjusted for season and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B6 on page 120

Figure 24 **Relative risk by year (analyses based on core reporters 2009 estimate = 1, analyses based on sample reporters 2015 estimate = 1), with 95% comparison intervals, other work related stress**

a) THOR-GP, core reporters



b) THOR-GP, sample reporters



4 DISCUSSION

This is the latest report to describe temporal trends in incidence of WRI in the UK, updating on previous reports[2-11] by the incorporation of a further year (2015) of data. It describes trends in WRI as reported to the three constituent schemes of the occupational surveillance system THOR which were funded by HSE for data collection during 2015. These were EPIDERM (dermatologists), SWORD (chest physicians) and THOR-GP (GPs). The method employed has been described in full in both the current and preceding reports. Essentially, a longitudinal, negative binomial (i.e. over-dispersed) Poisson model with random effects was fit to the data. This enabled change over time in the number of reporters and in other reporter characteristics which could independently impact on case density to be taken into account.

The main residual methodological issue with this body of work has been the impact of reporter 'fatigue' (i.e. a reporter may lose interest in reporting over time but still retain membership), how this manifests and whether it can be adjusted for. An extensive body of work has been undertaken to investigate this issue, details of which are provided in both the current and previous reports[2, 5, 13-16]. Most recently these analyses have focused on whether fatigue may be manifesting as an excess of zero reports in the data, and whether the proportion of 'excess zeros' has increased the longer a reporter has participated in the scheme[17]. The results of these investigations have suggested that for both EPIDERM and SWORD, there is some evidence of fatigue manifesting in this way but that the magnitude is different for the two schemes and tended to be greater for sample compared to core reporters. There was also some evidence of fatigue amongst GPs reporting to THOR-GP. Here though, the effect appeared to be greater for core reporters, with little evidence of a significant increase in excess zeros over time for sample reporters who comprise the currently reporting participants.

As previously agreed with HSE, the trend estimates presented in the annual reports will not be formally adjusted for fatigue until after the methodology has been through the peer review process (as of August 2016, the article is under review with the Journal of Clinical Epidemiology[17]). However, as in the report submitted in 2014 and 2015, we have endeavoured to provide an estimate as to the *possible* impact of adjusting for fatigue on the current trend results. It is important to stress though that these are estimates, provided for guidance purposes only. Differences between the current datasets and those used in the zero-inflated binomial models (which only included data up to 2012) and differences in the modelling procedure means that applying the zero-inflated binomial model to the current data would likely yield different results to the estimates provided here.

An abridged commentary by category of illness is provided in the following sections.

SKIN (EPIDERM and THOR-GP): Reports from dermatologists to EPIDERM comprise the main THOR source on work-related skin disease with approximately 19000 case reports during the study period (1996-2015). Reports from dermatologists suggest an average, annual decrease in incidence of total work-related skin disease of -3.9%. This estimate has remained fairly constant (3-4%) since trends were first reported (for the period 1996-2004). The annual plots suggest some variation from year to year with an initial decrease in incidence (1996-2007) followed by a levelling out (2007-2012) and then a further drop between 2012 and 2015. Whilst there is evidence of fatigue (exhibiting as an increase in zeros over membership time) in both EPIDERM 'core' and 'sample' reporters, it appears to be more extensive in the latter, perhaps because they are less committed to the scheme or have less sophisticated systems than the 'core' reporters who tend to have a strong interest in the area and who tend to work in larger referral centres. Since 'sample' reporters contribute less data overall compared to 'core' reporters (12%), the *likely* impact of adjusting the estimate for fatigue may be relatively small (remaining at a 3-4% decrease in incidence per year).

Two other THOR schemes currently collect reports of work-related skin disease: THOR-GP (GPs) and OPRA (occupational physicians). Trends based on OPRA data are not currently reported but have been documented previously[2-7]. For THOR-GP, the extensive change in the reporter type mix (from predominantly 'core' to 100% 'sample', and the stages in between) meant that, in agreement with HSE, trends are restricted to 'core' reports only (2006-2009) or 'sample' reports only (2011-2015). The former have been presented previously (and are again included here for completeness) and suggest a bigger annual decrease (compared EPIDERM trends based on 'core' data for the same period) of 6%. The addition of a further year of data (2015) has had little impact on the trend estimate based on 'sample' data only (2011-2015) remaining at approximately 19%. However, it should be noted that the confidence intervals for this estimate, and the individual year estimates on the annual plot were very wide.

As reported previously, the impact of reporter fatigue on GP reported skin disease trends cannot be directly estimated. There is evidence that 'core' reporters (who reported during 2006 and 2010) experienced fatigue, and if so, the trend estimates for this group would be attenuated. However, the fatigue analyses were based on total cases and cannot be directly extrapolated to specific disease (e.g. skin) groups. There was no evidence that the proportion of excess zeros increased over time for THOR-GP 'sample' reporters.

The observed trend for dermatologist reported CD was very similar to that observed for total skin disease (unsurprising as CD comprise 82% of the case reports to EPIDERM). Analysis of shorter-term trends (2006-2015) also suggested a very similar average, annual decrease in incidence of -3.9%. However, the annual plots

suggest a relatively flat trend since 2013 so it will be of interest to continue to monitor trends for this group.

As reported upon previously, in addition to investigating CD trends overall, the MLM methodology (or an adaptation of) has also been applied to investigate change in incidence of CD related to specific agents or economic sectors[23-27]. In doing so we have shown that whilst the incidence of dermatologist reported CD may be falling overall, the extent to which it is falling may vary between workers and for certain groups with specific exposures, it may even be increasing. For example, we have shown a reduction in incidence of CD in cement workers attributed to chromate, and in healthcare workers attributed to latex (in response to specific Government interventions aimed at reducing exposure to these agents)[23, 24] but also an increase in incidence of CD in nail technicians attributed to acrylates, and in healthcare workers attributed to methylchoroisothiazolinone/methylisothiazolinone (MCI/MI)[25-26]. Importantly, we have also shown an increase in irritant CD amongst healthcare workers attributed to increased handwashing as a result of interventions aimed at reducing healthcare associated infections[27]. Most recently this methodology has been applied to investigate trends in CD incidence attributed to fragrances in different groups of potentially exposed workers (for example, healthcare, beauty, food and cleaners). Initial results (not yet published) suggest there is no significant difference between CD trends attributed to fragrances and CD trends overall. Work is also ongoing to investigate the impact of the HSE's 'bad hand day campaign' on CD incidence amongst hairdressers.

Dermatologist reported trends by CD type continue to suggest an overall larger decrease for allergic CD (compared to irritant and mixed allergic/irritant). As suggested previously, this disparity may reflect the aforementioned Government interventions (UK/EU) aimed at reducing allergic CD attributed to specific agents (latex, chromate). However, the graph showing annual change for irritant CD suggests that after a relatively flat trend between approximately 2000 and 2012 (during which an overall downward trend was observed for allergic CD) the incidence of irritant CD appears to have been declining since 2012 (whereas for allergic CD, incidence has remained relatively unchanged since 2012). If taken at face value these findings may suggest that (besides the beneficial trends in allergic CD caused by specific agents as mentioned above) there are now favourable reductions in trends of irritant CD. However these findings warrant cautious interpretation as various biases could be at play. For instance if there is pressure on NHS referrals to our EPIDERM reporters and these are differentially restricted in favour of cases needing specialist patch testing. These and other possible explanations are being considered further.

A statistically significant annual average decrease in incidence was also observed for dermatologist reported neoplasia and contact urticaria. For neoplasia this was of a similar order to that observed for CD (approximately 3% per year) whilst for

urticaria it was larger at approximately 7% per year. For both diagnoses, markedly different trends were observed for 'core' and 'sample' reporters, with 'core' data suggesting a decrease in incidence and 'sample' data suggesting a much smaller decrease (urticaria) or an increase (neoplasia) in incidence. Furthermore, if EPIDERM 'sample' reporters are experiencing greater fatigue than 'core' reporters (shown for total skin disease) then the disparity between the 'core' and 'sample' trend estimates may become even larger. However, for neoplasia, the confidence intervals for the annual plots are wide and overlapping for both 'core' and 'sample' reporters, suggesting that EPIDERM in general may not be particularly capturing these cases.

The effectiveness of EPIDERM as a data source for neoplasia was discussed at the 2016 EPIDERM Academic Advisory Committee Meeting, in particular whether the data is already captured elsewhere (and thus whether there is a need to improve the ability of EPIDERM to capture this diagnosis). Representatives of the HSE informed the meeting that although the work carried out by Lesley Rushton (based on the attributable fraction) was the HSE's main source of information on work-related neoplasia[28], this work addressed (in relation to skin) only non-melanoma skin cancer i.e. not melanoma. Therefore EPIDERM is a potentially useful data source for this latter particular sub-type. Further discussions are to be held by HSE as to whether a recruitment drive to EPIDERM of skin cancer specialists (which may include, for example, surgeons) is desirable and if so, how this would be accomplished/supported.

In addition to internal comparisons of trends derived from different THOR sources (for example, dermatologist and GP reported skin disease) it is also useful to compare THOR trends with trends suggested by other, external data sources, such as the Self-reported Work-related Illness (SWI) survey, conducted annually as part of the Labour Force Survey (LFS)[29]. The latest 3-year estimates (numbers are typically too small to provide reliable annual estimates) from the SWI suggest a fairly flat trend over the last three reporting periods (i.e. similar to EPIDERM) at 22 per 100,000 employed for the current reporting period (2011/12, 2013/14, 2014/15), 17 for the period 2010/11, 2011/12, 2013/14 and 22 for the period 2009/10-2011/12[30]. THOR derived CD trends have also been compared with trends for other European countries as part of the work undertaken by the Modernet group (an EU wide network for development of new techniques for discovering trends in WRI and tracing new and emerging risks)[31]. The results showed a similarity in CD trends across the different countries, with data for most countries suggesting a decline in incidence.

RESPIRATORY (SWORD): The primary THOR source of respiratory data is reports from chest physicians to SWORD with both OPs and GPs reporting relatively few respiratory diagnoses (<5% of total cases reported by these two groups). Unlike

dermatologists the addition of each successive year of data appears to have had more of an impact on the trend estimate (from an initial 1% annual decrease in the first report submitted to HSE in 2006[2] to the 3% currently observed). This probably reflects the fact that compared to EPIDERM (where reports are predominantly of CD and neoplasia, and have been throughout the study period), case reports to SWORD encompass a wider diagnostic range with the proportion of the total cases attributed to each diagnosis exhibiting some variation throughout the study period.

There was no evidence of reporter 'fatigue' (manifesting as an increase in zero cases reports over membership time) in the SWORD 'core' reporters (probably reflecting the strong commitment of stalwart 'core' SWORD reporters) but there was some evidence of this phenomenon amongst SWORD 'sample' reporters. However, as seen for EPIDERM, SWORD 'sample' reporters contribute proportionally less data than their 'core' counterparts (21%) thus the impact of 'fatigue' on the trend estimate for total respiratory disease is probably small (a possible reduction in the annual decrease from approximately -3.1% to -2.6%).

The estimated average, annual decrease in asthma incidence was 7% per year (and has remained at between 7-8% with the addition of each successive year of data since 2010). The annual plots also suggest much of the decrease occurred in the earlier part of the period with a relatively flat trend since approximately 2007. However, in addition to investigating asthma trends overall it is important to view these 'overall' changes in incidence in conjunction with the results from other studies investigating changes in incidence of WRI related to specific agents, Government interventions etc. Most recently Stocks *et al* observed a decline in asthma attributed to isocyanates or paint spraying (but a non-significant decline amongst motor vehicle repair workers)[32]. Work is also ongoing to investigate trends in asthma incidence (amongst other things) in relation to exposure to cleaning agents. Previously, Stocks *et al* have also observed a significant reduction in reports of asthma attributed to agents with a work exposure limit (WEL) relative to those without a WEL[33]. However, for some agents, for example flour, a significant increase in the incidence of asthma (relative to other agents) was observed[34]. This is disappointing to note especially in view of longstanding attempts at dissemination of knowledge of asthma risks associated with flour and other substances involved in baking.

Of interest, in collaboration with others, we have recently begun to investigate the application of the Airborne Chemical Exposure Job Exposure Matrix (ACE-JEM), based on the Standard Occupational Classification (SOC2000)[35], to refine (SWORD derived) incidence rates attributed to specific chemicals/groups of chemicals. Initially this has been broadly applied to refine asthma incidence rates attributed to 'asthmagens' but other applications (e.g. other respiratory diseases and to more specific chemicals) are planned. This body of work has direct links to the investigation of trends in incidence (e.g. by more accurately defining the exposed population).

The SWI also collects data on work-related respiratory disease although they do not disaggregate beyond 'breathing or lung problems'. The 3-year average SWI derived incidence rate for this group suggest a decline in incidence from 42 per 100,000 employed in 2009/10-2011/12 to 34 per 100,000 employed in 2010/11, 2011/12, 2013/14 followed by a slight increase to 37 in 2011/12, 2013/14, 2014/15[30]. Trends in asthma were also investigated by the Modernet consortium with the results suggesting similarities across the participating EU countries, with an overall decline in the incidence of asthma[31].

Aside from asthma, chest physicians participating in SWORD largely report the (primarily) asbestos related diseases, namely, mesothelioma, benign pleural plaques and pneumoconiosis. An average, annual decrease in mesothelioma of approximately 3% was observed which was similar to the estimate reported in 2015[11]. After an apparent drop in incidence between 2013 and 2014, there appears to be little change in incidence between 2014 and 2015. As discussed previously, this decreasing or flat trend is contrary to what is expected as other evidence (including epidemiological studies from Peto *et al* and the mesothelioma death registers) suggests the incidence is rising with a possible peak, expected in 2016[36, 37]. The apparent decline in (SWORD derived) mesothelioma incidence may reflect changes in clinical practice during the study period. NHS reforms in the late 1990's/early 2000s saw an increase in the number of appointed specialists (and a move away from single-handed specialists)[38]. This may have diluted the reporting of occupational lung diseases to SWORD (although recruitment to SWORD is ongoing, numbers have declined over time). In addition, SWORD reporters, particularly those comprising the 'core' group, tend towards a specialist interest in asthma. It is therefore possible, particularly with the development of cancer multi-disciplinary team meetings (MDTs), that long-latency respiratory disease (LLRD) cases previously seen by SWORD reporters are increasingly seen by chest physicians specialising in lung cancer (who may not participate in SWORD). This issue continues to be discussed at the annual meetings of the SWORD Advisory Committee, with one suggestion being that THOR could approach lung cancer specialists and/or possibly the non-specialist physicians who organise and run the rapid access systems and ask them to report to SWORD.

A relatively flat trend was also observed for benign pleural plaques and again although there was a suggestion of a decrease in incidence between 2013 and 2014 a further decrease between 2014 and 2015 was not apparent. As discussed previously, this probably reflects the fact that individuals presenting with this abnormality alone (in England and Wales) are no longer financially compensated[39] and therefore, referrals to chest physicians are less common. Consultation with key chest physicians also suggests that patients with pleural effusions are increasingly managed within acute or general care and are therefore much less likely to have an occupational history taken or to be seen by a chest physician. For example, there

has been a shift away from referring elderly patients with poorer performance status for invasive diagnostic procedures.

In contrast, reports from chest physicians to SWORD continue to suggest an increase in pneumoconiosis incidence. Since a significant proportion (approximately 22%) of these cases were attributed to agents other than asbestos (for example, silica and coal) it was postulated that the observed increase in incidence could be attributed to these 'other' agents. However, analyses of trend by agent (asbestos versus all other) suggested the increase was due to asbestosis rather than 'other' pneumoconiosis[40]. Both the data sources on compensation claims to the IIDB and those of cause of death (death certificates) also support an increase in asbestosis incidence during the study period[37]. However, part of the observed increase in asbestosis incidence may be due to changes to the diagnostic criteria (resulting in asbestosis being more readily diagnosed)[41].

These and other issues relating to LLRD cases reported to SWORD are discussed in a recent article prepared for peer review[40]. In addition to a general overview of LLRD cases reported to SWORD, the article discusses incidence, trends in incidence and variations in incidence by occupation. Of interest, it also benchmarks the SWORD data (i.e. proportions by occupation) with mesothelioma mortality data (proportional mortality ratios – PMRs). With a few notable exceptions, there was generally a good correlation between SWORD mesothelioma cases and PMRs by occupation.

MUSCULOSKELETAL AND MENTAL ILL-HEALTH (THOR-GP): The only currently HSE funded THOR data source on work-related MSDs and mental ill-health is THOR-GP although trends for these two disease groups have also been reported previously for occupational physicians reporting to OPRA[2-7], rheumatologists reporting to MOSS[2-6] and psychiatrists reporting to SOSMI[2-6]. Because of the well documented extensive change from predominantly 'core' to 100% 'sample' reporting (and the resulting possible impact on incidence)[20], trends based on THOR-GP data are presented separately for 'core' (2006-2009) and 'sample' (2011 onwards) only.

Trends based on 'core' data have been reported previously but have been included here for completeness. Data from 'core' reporters suggest average, annual decreases in incidence of GP reported MSDs (2006-2009) of approximately 16% (total MSDs), 20% (spine/back disorders), and 15% (upper limb disorders). A decrease in incidence of mental ill-health was also observed for 'core' reporters, with similar estimates for total cases and the two subgroups of anxiety and depression and work stress (11-13%). As discussed, there was some evidence that GP 'core' reporters were experiencing fatigue (manifesting as an increase in excess zeros over time), which if true (and if applicable across the different disease groups) would mean these trends would be attenuated slightly.

Since 'core' reporting has now ceased, it is trends based on 'sample' data that are

more informative for current and future trends. These data also suggest an overall decrease in incidence of work-related MSDs (2011-2015), but one that is less steep than that observed for 'core' reporters over the earlier period (9% compared to 16%). Although the annual plot suggests the relatively large decrease observed between 2013 and 2014 has not been followed by a further decrease between 2014 and 2015, it is difficult to draw any firm conclusions at this stage (confidence intervals are wide and overlapping). 'Sample' only trends for the MSD sub-groups have also been presented. In general a larger decrease was observed for spine/back disorders compared to upper limb and lower limb disorders. However, confidence intervals are again very wide making it difficult to draw any firm conclusions at this stage.

An overall downward trend in (sample) GP reported mental ill-health was also observed (2011-2015) and this was larger than that observed for MSDs over the same period (16% compared to 9%). Similarly, unlike the trend observed for MSDs there appeared to be a continued decrease in incidence in mental ill-health between 2014 and 2015 (although confidence intervals are again wide and overlapping). Large, statistically significant annual decreases in incidence were also observed for anxiety and depression and other work stress. As discussed, investigations of fatigue have not suggested any evidence of this phenomenon for GP 'sample' reporters.

To date, although some work has been carried out investigating THOR derived musculoskeletal and/or mental ill-health trends for specific sectors (e.g. health and social care)[42] or specific workers (e.g. doctors – work not yet published) the impact of interventions to reduce the incidence of work-related mental ill-health or musculoskeletal disorders has not yet been investigated (using THOR data). This likely reflects the increased complexity of assessing the impact of interventions for these two disease groups (compared to skin and respiratory). However, work has recently been initiated to map the THOR mental ill-health data to the HSE management standards with a view to also investigate the impact of these standards on incidence.

The other main dataset collecting data on work-related musculoskeletal and mental ill-health in the UK (for comparison with THOR data) is the SWI. Unlike THOR-GP data, data from the SWI suggest little change in incidence of both work-related musculoskeletal disorders and work related 'stress, depression or anxiety'. The last three published SWI estimates (encompassing 2009 to 2015) were between 530 and 540 per 100,000 employed for musculoskeletal disorders and between 740 and 750 for 'stress, depression and anxiety'[30].

5. CONCLUSIONS

This report demonstrates the utility of THOR data to investigate trends in incidence of medically reported WRI. The current report builds upon previous annual reports,

each of which not only update the trends estimates (with a further year of data) but also describe any ongoing methodological developments. Additional reports have also been submitted, describing further investigations into important issues such as reporter fatigue. Overall the observed trends have remained relatively unchanged with the addition of each successive year of data and are in accordance with those expected as a result of Government initiatives (for example, the general decline in incidence of asthma, contact dermatitis and contact urticaria). However, others have shown more variation (for example, the asbestos related diseases). Furthermore, trends related to specific sectors or agents often appear discordant with the 'overall' trends by manifesting an increase (for example asthma and flour or CD and handwashing), thus showing the value of THOR in identifying real and significant adverse or desired trends in relation to specific exposures. Ongoing work, including benchmarking with other data sources and investigating trends in relation to specific sectors or agents will help clarify these issues further.

ACKNOWLEDGEMENTS

THOR is partially funded by the Health and Safety Executive and has also received funding from other sources. We are grateful to the physicians who report to THOR for their continuing support. The opinions expressed in this report are of the researchers and not necessarily those of the HSE.

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APPENDIX A SUMMARY OF REPORTER FATIGUE INVESTIGATIONS

1) **The probability of a zero return as a function of membership time:** the percentage increase, per year of membership, in the *odds* of a returned card having zero cases was estimated. These analyses were initially carried out for SWORD (1999-2004) and EPIDERM (1996-2004) and subsequently for THOR-GP (June 2005-2008). Separate analyses were carried out for 'core' and 'sample' reporters (except for THOR-GP, which was exclusively core reporting during this period). These analyses sought to separate the true trend with calendar time from a trend with membership time (used as a proxy for fatigue). Membership time was included as a covariate in the usual model which also included calendar time, season, and whether or not it was the first return. ***Results:*** Results were inconclusive due to wide confidence intervals caused by high collinearity between membership time and calendar time, especially for EPIDERM, SWORD and THOR-GP core reporters. There was some evidence for EPIDERM sample reporters that blank returns increased as a function of membership time (by 6% per year) but not for SWORD sample.

2) **Calendar time trends in incidence adjusted for membership time:** The results of the analyses described in 1) suggested it might be possible to separate out the effects of calendar time and membership time for sample reporters. Therefore, the percentage change in incidence of total cases (EPIDERM 1996-2004, SWORD 1999-2004), 'adjusted' for an independent effect of membership time on incidence was estimated. Variables included in the MLM were 'calendar time', 'membership time', season, and first report.
   Results: Results suggested evidence of fatigue for EPIDERM sample reporters but not for SWORD sample reporters. On including 'membership time' in the models, the estimated annual change in incidence of cases reported to EPIDERM became -0.4% (95% CIs: -6.5, 6.2) instead of -3.2% whilst for SWORD it showed little change from -7.3% (95% CIs: -11.8, -2.7) to 7.1% (95% CIs: -12.0, -2.0).

3) **Descriptive analysis using the FATCATS/CALCATS approach:** i.e. zero return rates broken down simultaneously by categories of membership time (2 year intervals) (FATCATS) and calendar time (2 year intervals) (CALCATS). This was initially undertaken for EPIDERM (1996-2006) and SWORD (1999-2006), and subsequently for THOR-GP (June 2005-2008).
   Results: EPIDERM and SWORD core: little evidence that for any given calendar period the proportion of zero returns increased with membership time or that for any given membership period the proportion of zero returns increased with calendar time. EPIDERM and SWORD sample: some evidence of the former but not of the latter phenomenon. THOR-GP core: little evidence of the former but some evidence of the latter phenomenon.

4) **GEE (generalised estimating equations) modelling on zero returns in relation to time: The GEE modelling approach is an alternative to the random effects (RE) approach. It was used as a sensitivity analysis – to see if consistent with the results from RE approach.** Zero return rates were modelled as a function of membership time, with adjustment for calendar time. Membership time was included in the model as either a continuous variable (years) or categorised (2 year intervals). Analyses were carried out on core and sample reporters combined (EPIDERM 1996-2006 and SWORD 1999-2006).
Results: Results suggested an increase in zero cases of 4% and 2% per membership year (EPIDERM and SWORD, respectively) but these trends were not statistically significant (EPIDERM p=0.08, SWORD p=0.20). In models where membership time was categorised, the odds ratios for all membership categories were higher than 1 (the reference year was <2 years membership) and seemed to settle around 1.3% after 6 years membership for EPIDERM whilst for SWORD there was no suggestion of an increase with membership time.

5) **Estimation of calendar time trends in incidence rates with membership restrictions:** The percentage change in incidence of WRI was estimated 'as usual' using the methodology described under Section 2.4 but reporters were categorised by membership time (2 year intervals) and separate analyses were carried out for each group. Analyses were carried out for core and sample reporters combined (EPIDERM 1996-2006, SWORD 1999-2006).
Results: The trends estimates suggested that there was some evidence that EPIDERM reporters, but not SWORD reporters, in the longer membership categories might be more influenced by fatigue (manifesting as an increase in zeros).

6) **Modelling of zeros and non-response with membership time:** Longitudinal logistic GEE and RE models were fitted to investigate the relationship between non-response and zero response with membership time i.e. whether the probability of either type of response changes as membership time increases, and whether one type of response is more likely than the other (and whether this changes with membership time).
Results: EPIDERM sample: there was strong evidence that both non-returns and zero returns (given a return) increased with membership time; the estimated odds were 13% and 7%, respectively. The conditional probability of a zero (i.e., given a zero case or non-return) declined over time (by 9% per membership year); we would expect this to decline if non-response increased more rapidly than zero returns. For the other reporters/schemes the estimated odds of non-response, zero response, and the conditional probability of a zero were EPIDERM core: 31%, 7% and 21%, respectively; SWORD sample: 17%, 4% and 14%. SWORD core: 33%, 7% and 18%, respectively.

All these analyses were conducted on total cases for each scheme. The implicit assumption is that fatigue was a general phenomenon affecting the reports as a whole for a given reporter and is not specific to a diagnostic group.

Table A1 Evidence of fatigue as exhibited by an increase in zero returns over time

Analyses	EPIDERM		SWORD		THOR-GP	
	Core	**Sample**	**Core**	**Sample**	**Core**	**Sample**
1*	/	Yes	/	No	/	/
2	/	Yes	/	No	/	/
3	No	Yes?	No	Yes?	Yes?	/
4**	Yes?		No		/	/
5	Yes?		No		/	/
6	Yes?	Yes	Yes?	Yes?	/	/

*It was not possible to separate out the effect of calendar time and membership time due to high collinearity between the two variables

**Analyses for SWORD and EPIDERM were on all reporters combined. This analysis was not repeated for THOR-GP

APPENDIX B DESCRIPTIVE ANALYSES

Table B1 Reporting activity of reporters in EPIDERM, 1996-2015

	CORE	SAMPLE
Total reporters ever in 1996-2015	58	395
Total active[a] reporters in 1996-2015	56	364
Response rate**	85%	74%
% of returns that are blank	18%	62%
Number of reporters who responded at least once but never returned a case	1	113
Number of reporters who have never responded	2	31

[a] Active reporter is someone who returns a card
[b] Response rate = cards returned/cards sent out

Figure B1 Number of reporters in EPIDERM by year and reporter type, 1996-2015

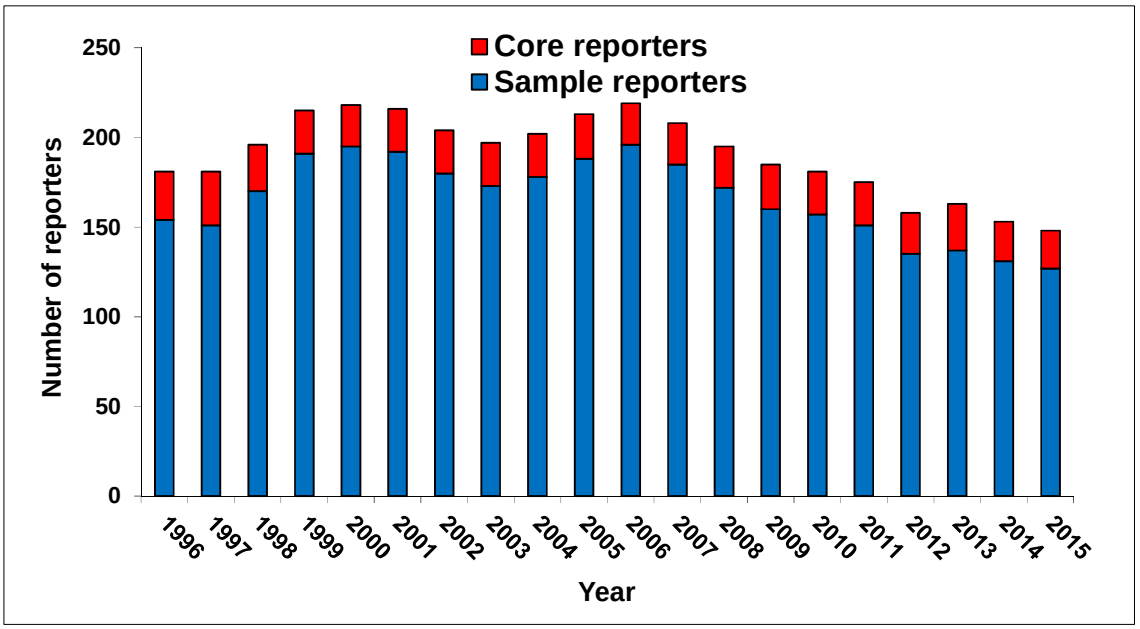
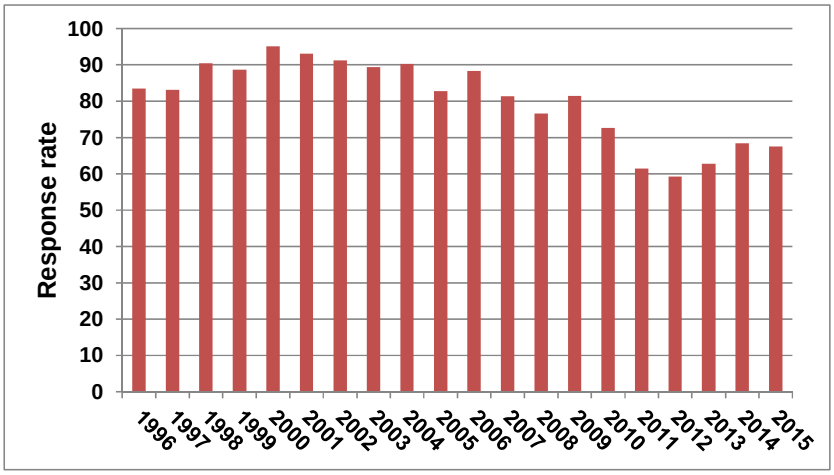
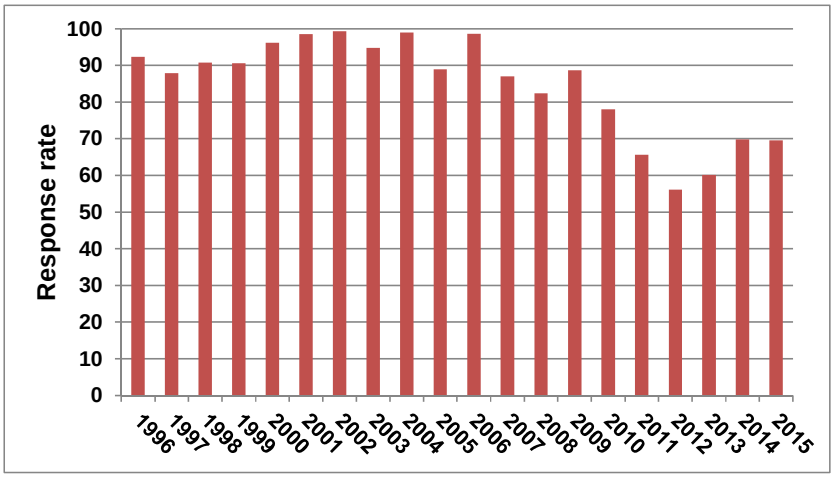


Figure B2 Response rates (cards returned/cards sent out) per year

a) All reporters



b) Core reporters



c) Sample reporters

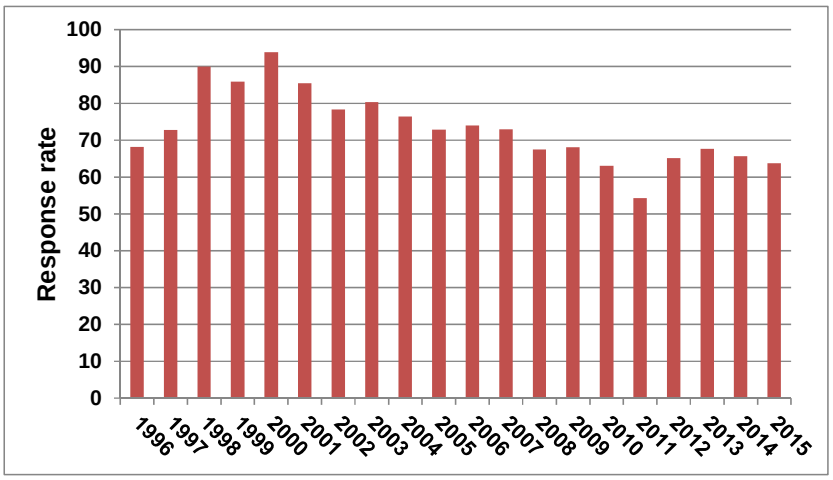


Figure B3 Number of active reporters per month – EPIDERM, 1996-2015

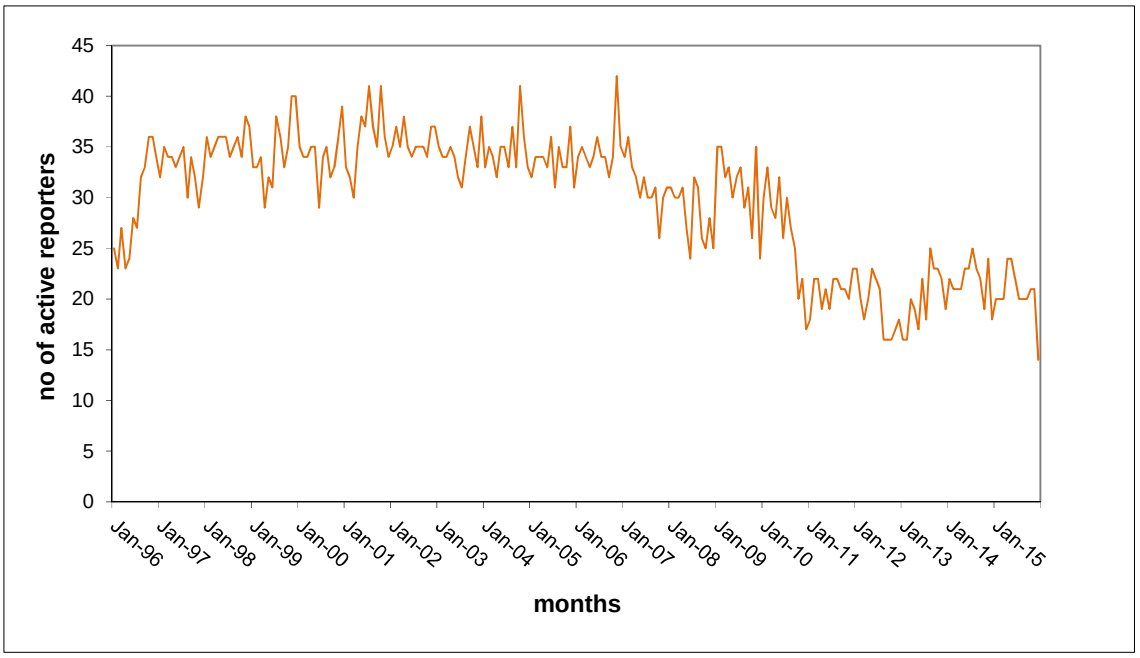
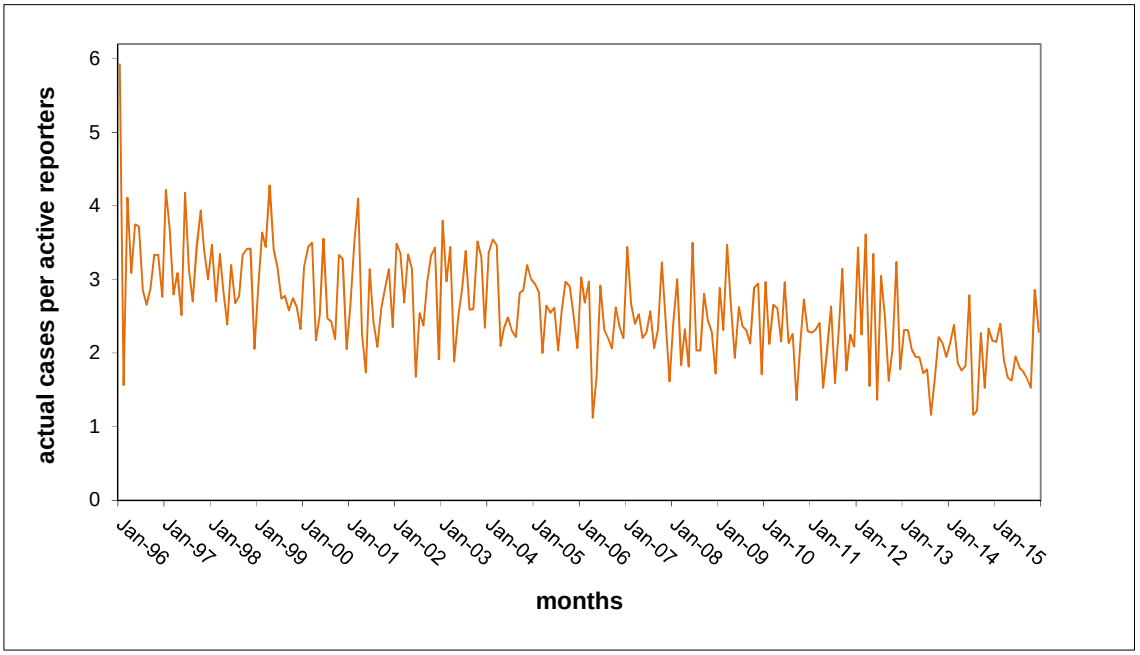
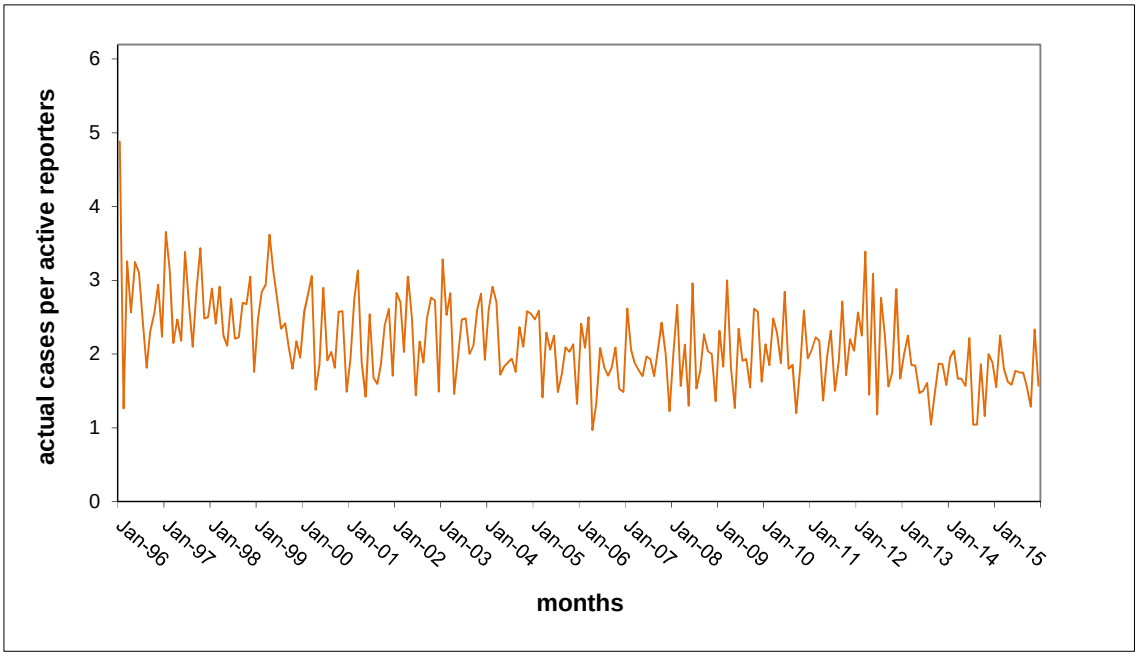


Figure B4 Cases per active reporter per month – EPIDERM, 1996-2015

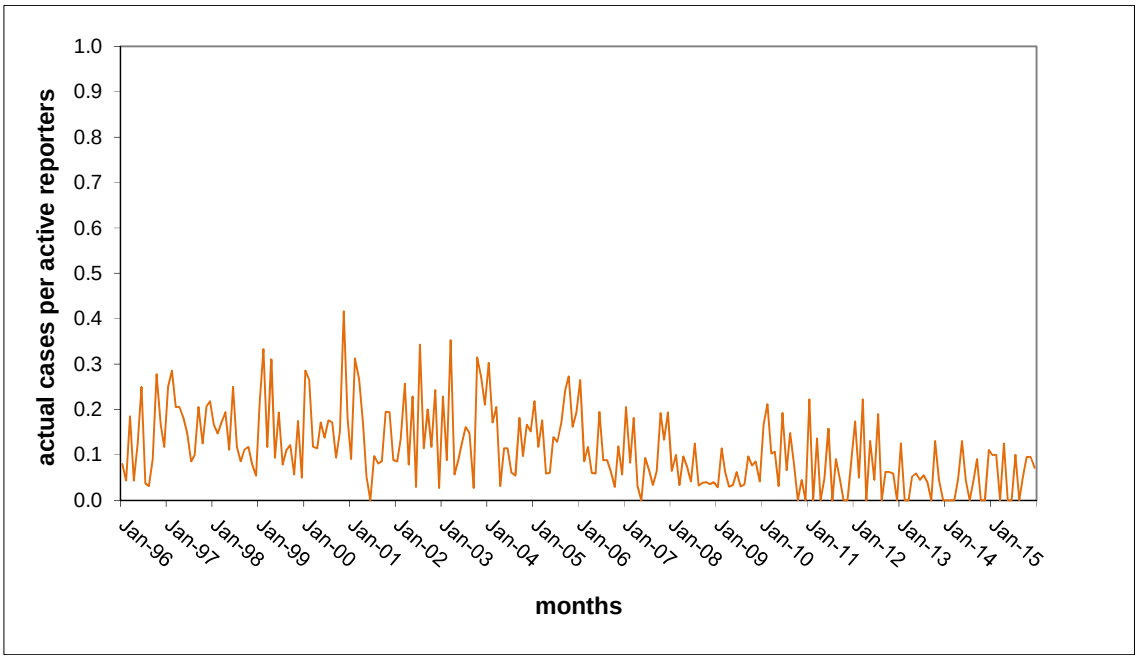
a) Total cases



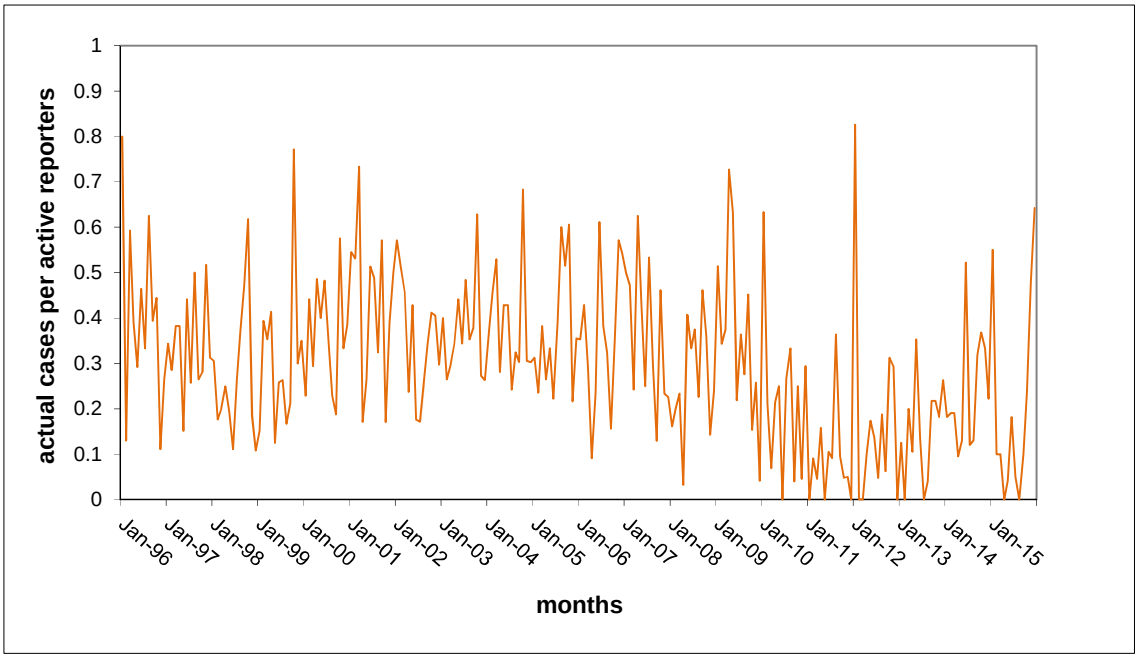
b) Contact dermatitis



c) Contact urticaria (note scale change)



d) Neoplasia



e) Other skin (other than contact dermatitis) (note scale change)

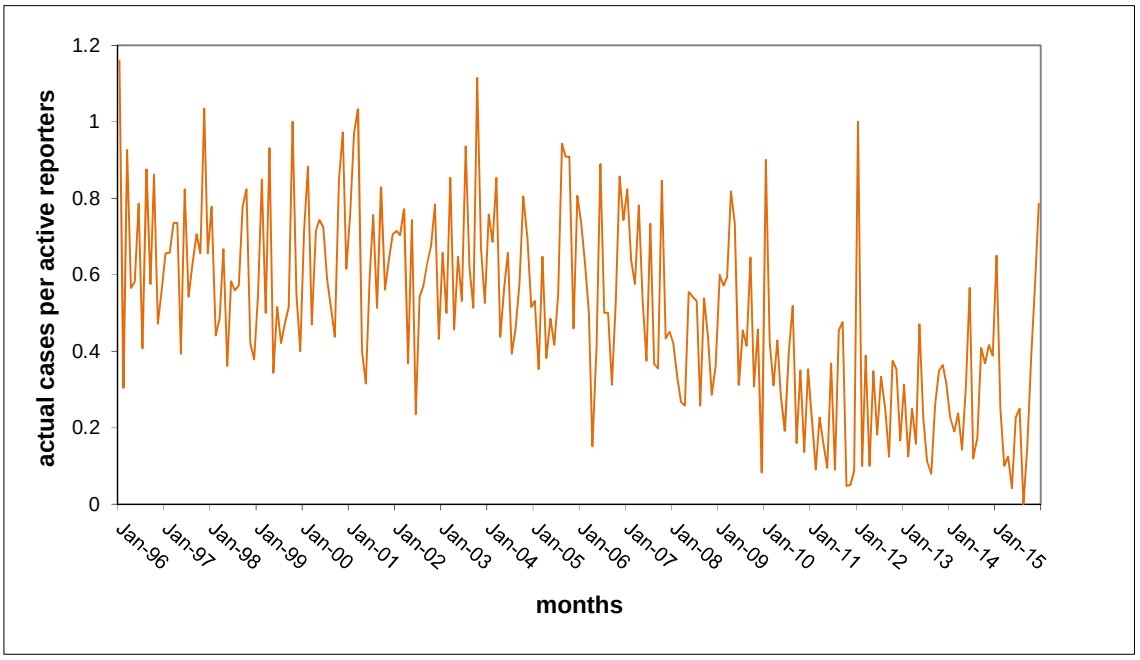


Table B2 Cases reported per month by disease category and type of reporter, EPIDERM, 1996-2015

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
	Total active reporters ever in 1996-2015	395				56				364			
	Mean no. of active[a] reporters per month	30.22	16	42	6.27	19.76	9.00	26.00	4.06	10.45	3.00	20.00	3.18
Disease group													
All cases	Total cases	18917				16610				2297			
	Mean cases per month	78.82	26	148	29.31	69.21	17.00	147.00	27.65	9.69	0.00	33.00	6.46
	Mean cases per active reporter per month	2.60	1.12	5.92	0.68	3.46	1.39	7.74	0.99	0.96	0.00	4.17	0.65
Contact dermatitis (CD)	Total cases	15540				13950				1581			
	Mean cases per month	64.75	22	122	23.59	58.13	12.00	121.00	22.38	6.67	0.00	23.00	4.69
	Mean cases per active reporter per month	2.15	0.97	4.88	0.57	2.94	1.20	6.37	0.81	0.66	0.00	2.83	0.48
Allergic CD	Total cases	5757				5076				677			
	Mean cases per month	23.99	3	58	11.15	21.15	3.00	54.00	10.22	2.86	0.00	12.00	2.68
	Mean cases per active reporter per month	0.79	0.21	1.66	0.29	1.06	0.23	2.44	0.40	0.28	0.00	1.83	0.27
Irritant CD	Total cases	6895				6306				585			
	Mean cases per month	28.73	8	58	11.02	26.28	5.00	58.00	10.79	2.47	0.00	12.00	2.21
	Mean cases per active reporter per month	0.96	0.41	2.32	0.31	1.33	0.50	3.05	0.44	0.25	0.00	1.38	0.23
Mixed CD	Total cases	2500				2282				218			
	Mean cases per month	10.42	1	27	4.99	9.51	1.00	25.00	4.87	0.92	0.00	5.00	1.13
	Mean cases per active reporter per month	0.35	0.05	0.92	0.15	0.49	0.05	1.21	0.22	0.10	0.00	0.75	0.13

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
Other[b] cases	Total cases	3819				3073				745			
	Mean cases per month	15.91	0	39	8.96	12.80	0.00	33.00	7.99	3.14	0.00	20.00	3.41
	Mean cases per active reporter per month	0.51	0	1.16	0.24	0.61	0.00	1.78	0.35	0.31	0.00	2.22	0.35
Contact urticaria	Total cases	862				814				48			
	Mean cases per month	3.59	0	15	2.90	3.39	0.00	14.00	2.82	0.20	0.00	3.00	0.50
	Mean cases per active reporter per month	0.11	0	0.42	0.08	0.16	0.00	0.78	0.13	0.02	0.00	0.33	0.05
Neoplasia	Total cases	2268				1704				564			
	Mean cases per month	9.45	0	28	6.03	7.10	0.00	20.00	5.00	2.38	0.00	19.00	3.13
	Mean cases per active reporter per month	0.30	0	0.83	0.18	0.34	0.00	1.05	0.23	0.24	0.00	2.11	0.32

[a]Active reporter is someone who returns a card
[b]other than contact dermatitis

Table B3 Reporting activity of reporters in SWORD, 1999-2015

	CORE	SAMPLE
Total reporters ever in 1999-2015	50	828
Total active[a] reporters in 1999-2015	45	774
Response rate[b]	82%	72%
% of returns that are zero returns (i.e. no cases to report)	29%	73%
Number of reporters who responded at least once but never returned a case	1	252
Number of reporters who have never responded	5	54

[a] Active reporter is someone who returns a card
[b]Response rate = cards returned/cards sent out

Figure B5 Number of reporters in SWORD by year and reporter type

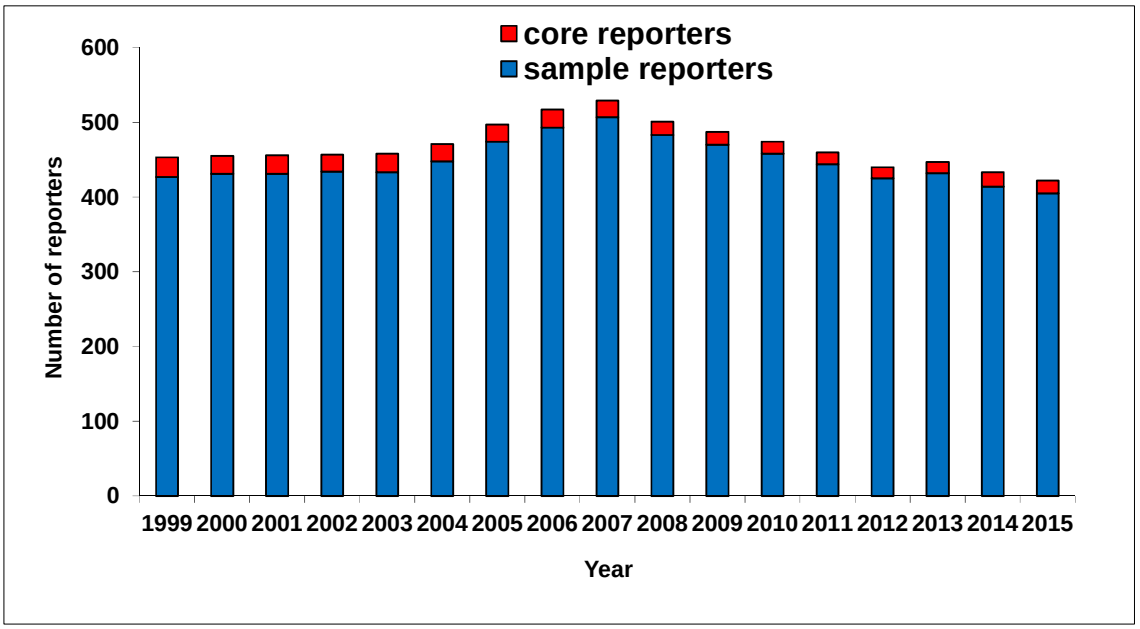
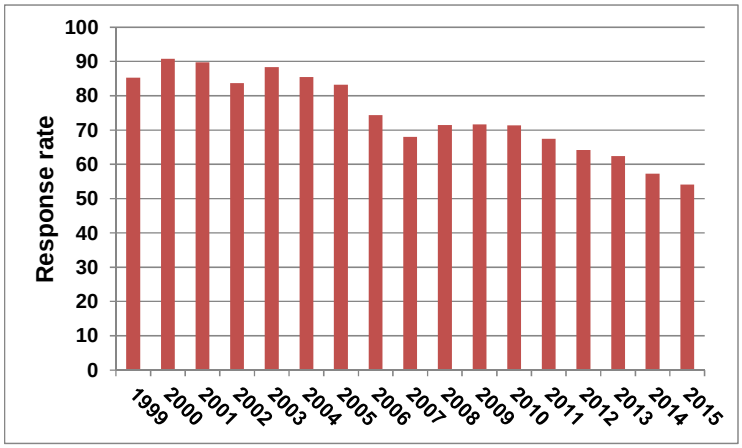
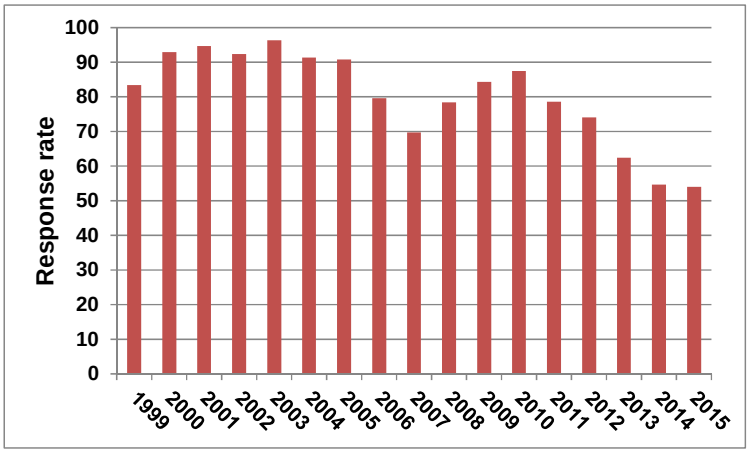


Figure B6 Response rates (cards returned/cards sent out) per year

a) All reporters



b) Core reporters



c) Sample reporters

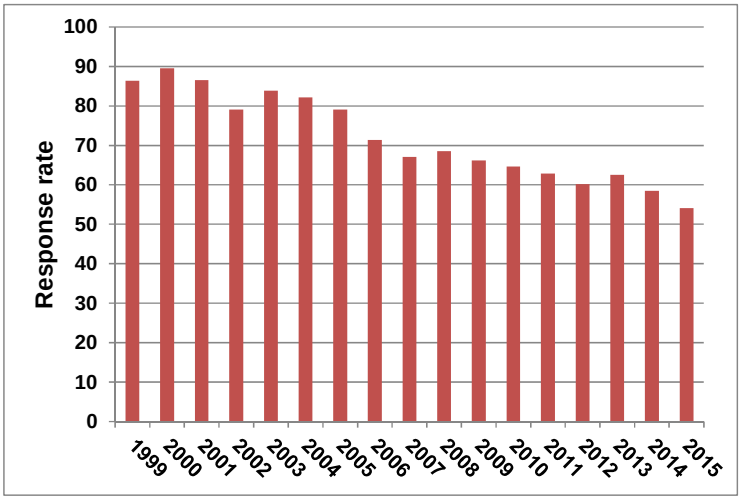


Figure B7 Number of active reporters per month – SWORD

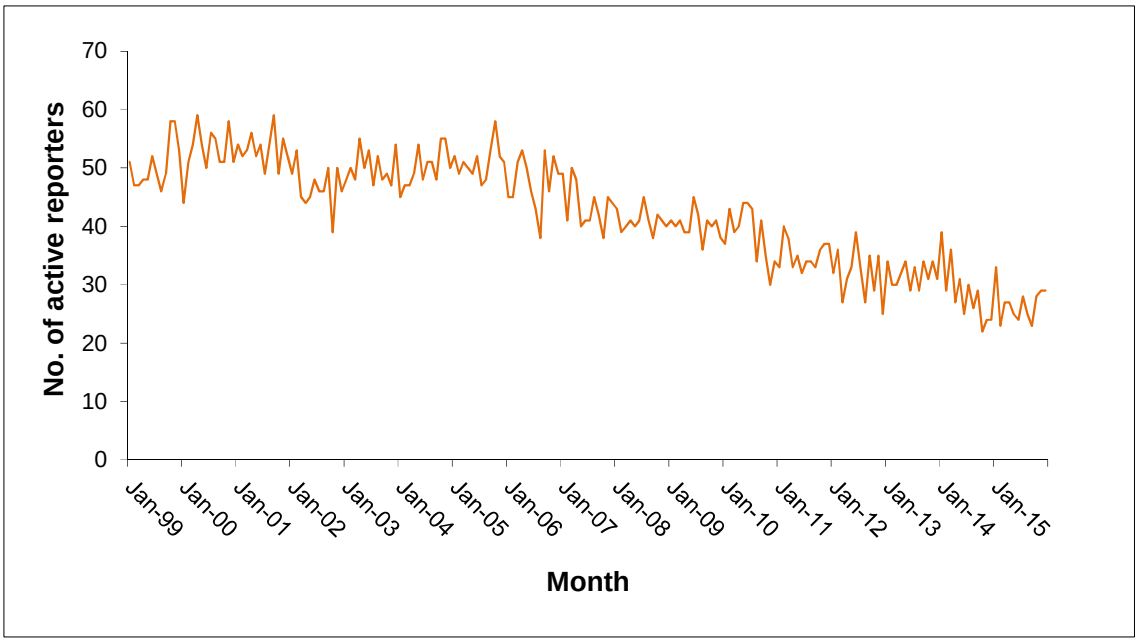
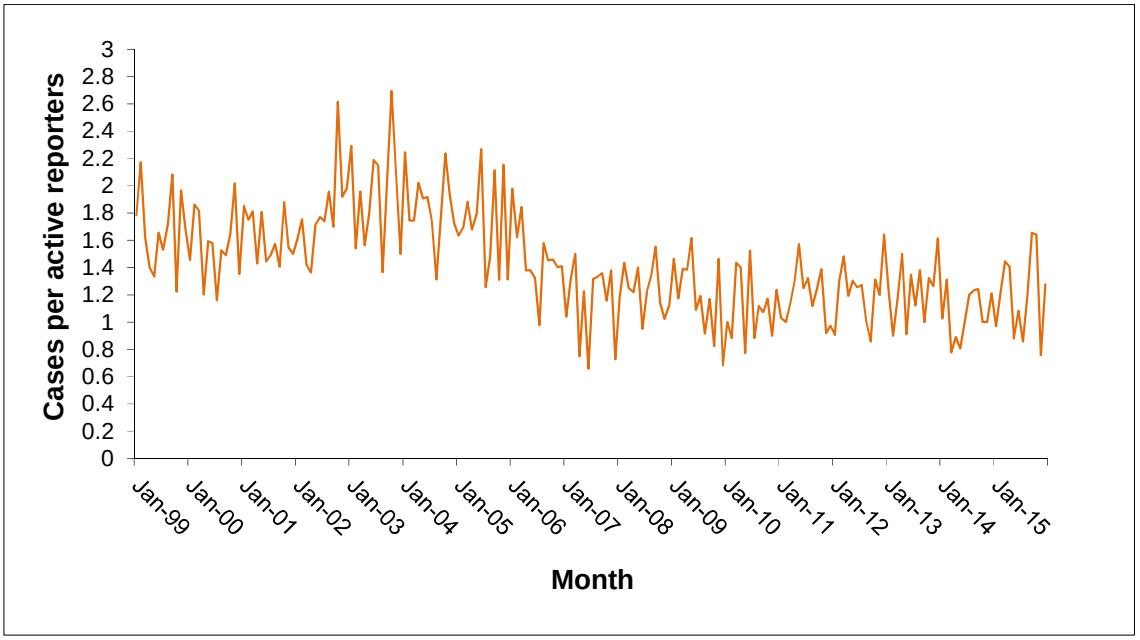
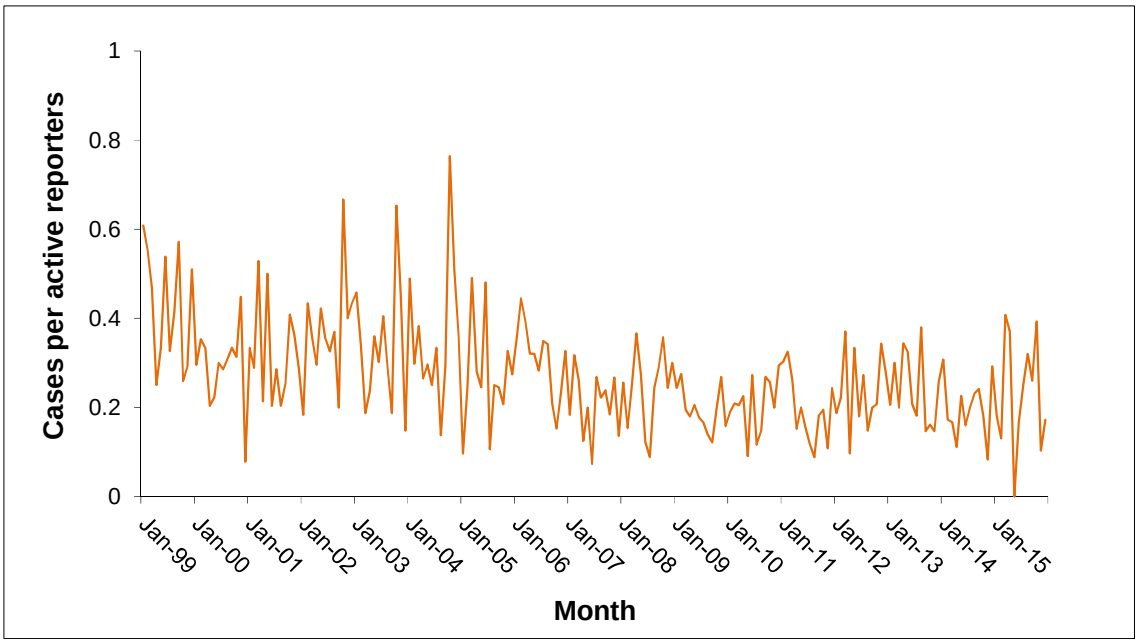


Figure B8 Cases per active reporter per month – SWORD

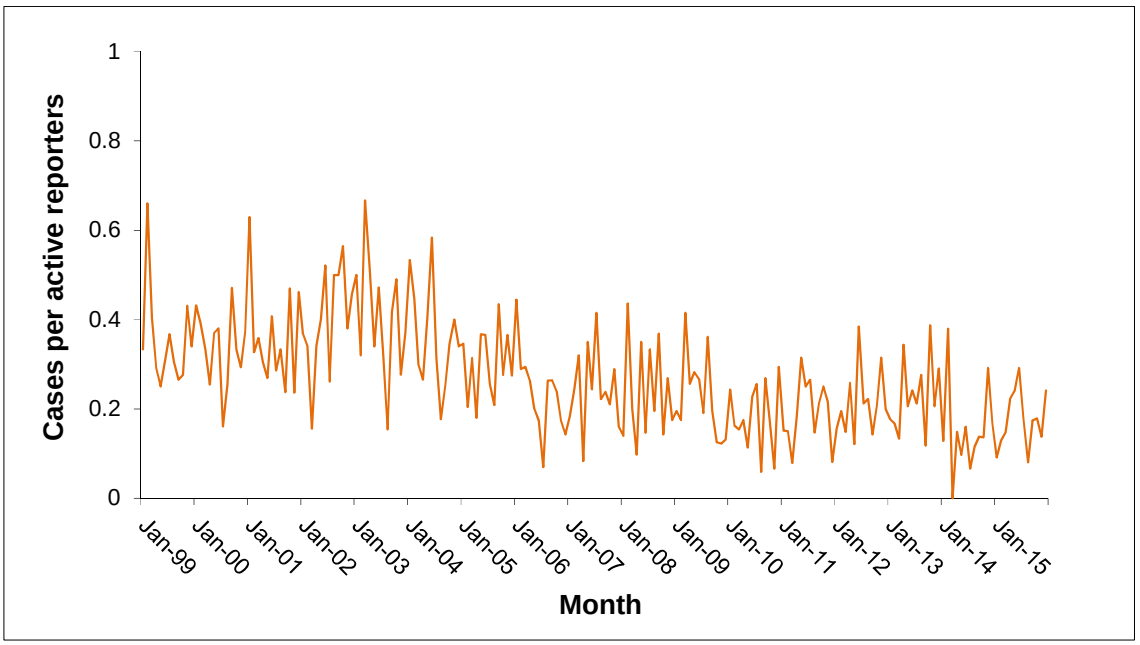
a) Total cases



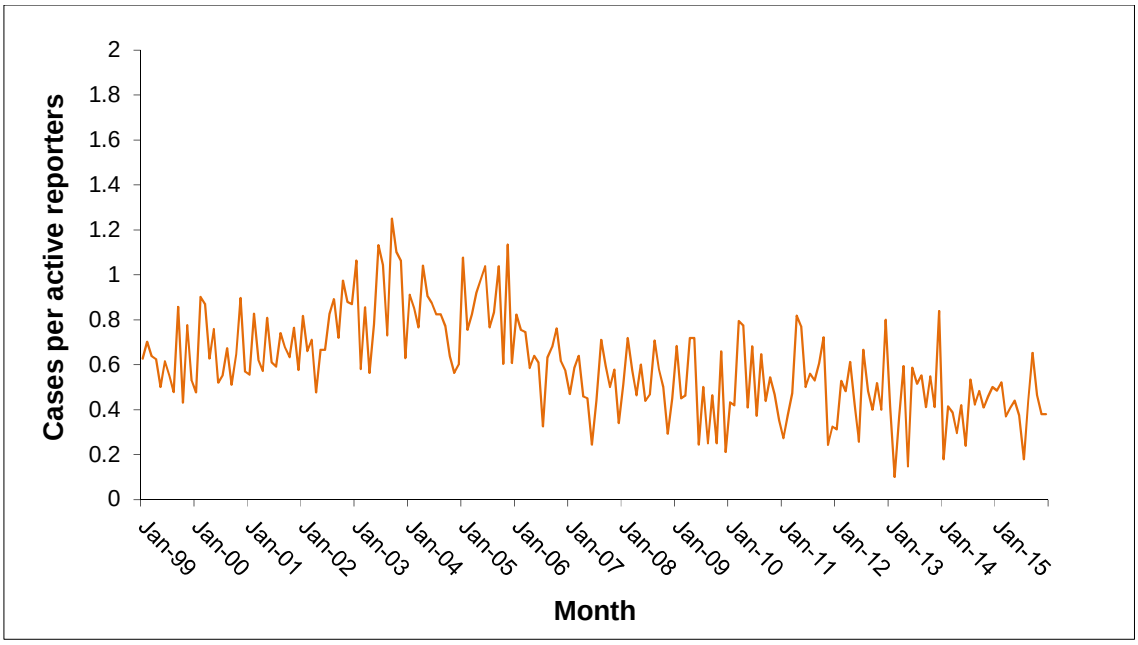
b) Asthma (note scale change)



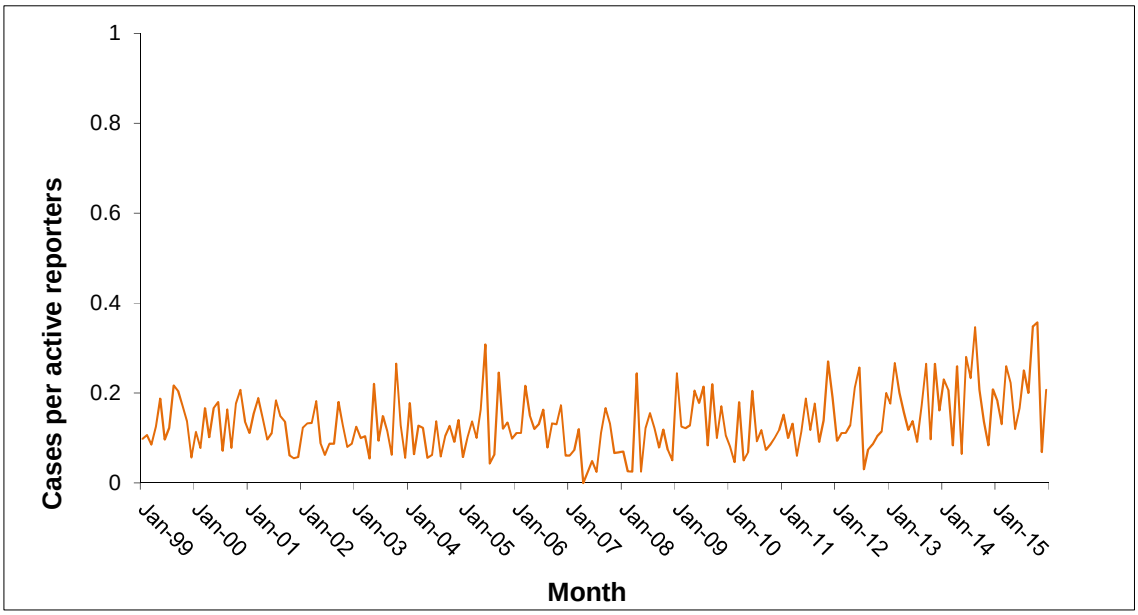
c) Mesothelioma



d) Non-malignant pleural disease (note scale change)



e) Pneumoconiosis (note scale change)



f) Other (than those specified above) respiratory disease

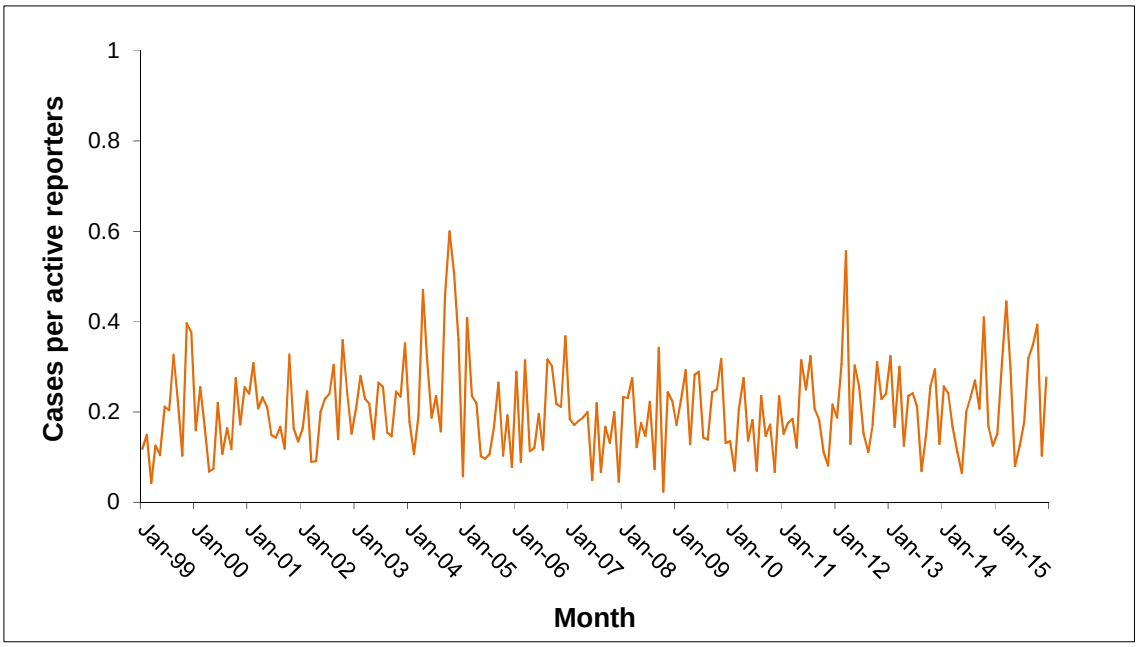


Table B4 Cases reported per month by disease category and type of reporter, SWORD, 1999-2015

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
	Total active reporters ever in 1999-2015	799				45				774			
	Mean no. of active[a] reporters per month	42.32	22.00	59.00	9.28	15.50	7.00	24.00	4.62	26.82	13.00	38.00	5.36
Disease group													
All cases	Total cases	12686				10040				2646			
	Mean cases per month	62.19	0.00	132.00	25.89	49.22	9.00	112.00	23.94	12.97	3.00	35.00	6.27
	Mean cases per active reporter per month	1.43	0.66	2.69	0.38	3.07	1.29	5.78	0.89	0.48	0.09	1.10	0.20
Asthma	Total cases	2436				2173				263			
	Mean cases per month	11.94	0.00	42.00	6.68	10.65	0.00	42.00	6.06	1.29	0.00	9.00	1.42
	Mean cases per active reporter per month	0.27	0.00	0.76	0.12	0.67	0.00	2.33	0.29	0.05	0.00	0.28	0.05
Mesothelioma	Total cases	2448				1586				862			
	Mean cases per month	12.00	0.00	34.00	6.83	7.77	0.00	27.00	5.78	4.23	0.00	11.00	2.64
	Mean cases per active reporter per month	0.27	0.00	0.67	0.12	0.46	0.00	1.69	0.28	0.16	0.00	0.45	0.09
Non-malignant pleural plaques	Total cases	5400				4401				999			
	Mean cases per month	26.47	0.00	60.00	12.84	21.57	2.00	59.00	12.37	4.90	0.00	17.00	3.40
	Mean cases per active reporter per month	0.60	0.10	1.25	0.21	1.32	0.20	2.84	0.51	0.18	0.00	0.65	0.12
Pneumoconiosis	Total cases	1121				907				214			
	Mean cases per month	5.50	0.00	16.00	2.65	4.45	0.00	13.00	2.35	1.05	0.00	5.00	1.17

	Statistic		All Reporters				Core reporters				Sample reporters			
			Min	Max	SD		Min	Max	SD		Min	Max	SD	
	Mean cases per active reporter per month	0.13	0.00	0.36	0.07	0.31	0.00	1.00	0.18	0.04	0.00	0.21	0.05
Other cases[b]	Total cases	1783				1427				356			
	Mean cases per month	8.74	0.00	33.00	4.69	7.00	1.00	28.00	4.26	1.75	0.00	13.00	1.80
	Mean cases per active reporter per month	0.21	0.02	0.60	0.10	0.47	0.05	1.56	0.26	0.06	0.00	0.45	0.06

[a]Active reporter is someone who returns a card

[b]Other than those specified above i.e SWORD categories: inhalation accidents, allergic alveolitis, bronchitis/emphysema, infectious disease, lung cancer and 'other' (the latter includes rhinitis). NOTE: A case may have more than one diagnosis

Table B5 Reporting activity of reporters in THOR-GP, 2006-2015

	CORE[a]	SAMPLE
Total reporters ever in 2006-2015	442	319
Total active[b] reporters in 2006-2015	332	267
Response rate[c]	58%	69%
% of returns that are zero returns (i.e. no cases to report)	60%	41%
Number of reporters who responded at least once but never returned a case	46	51
Number of reporters who have never responded	110	52

[a]Core reporting stopped in 2010
[b]Active reporter is someone who returns a card
[c]Response rate = cards returned/cards sent out

Figure B9 Number of reporters in THOR-GP by year and reporter type

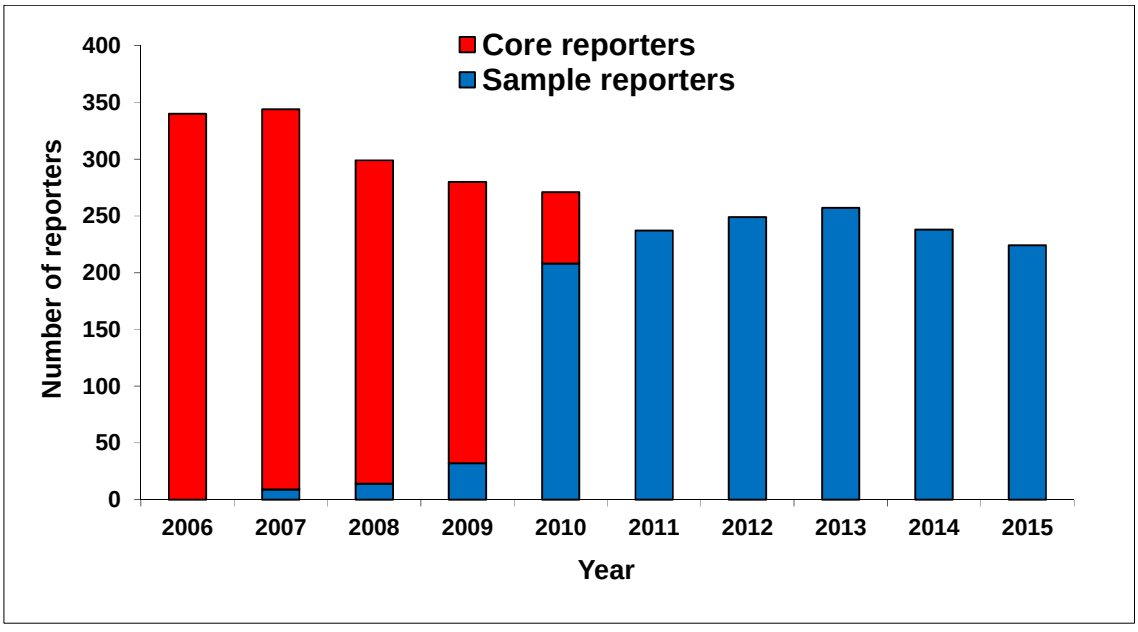
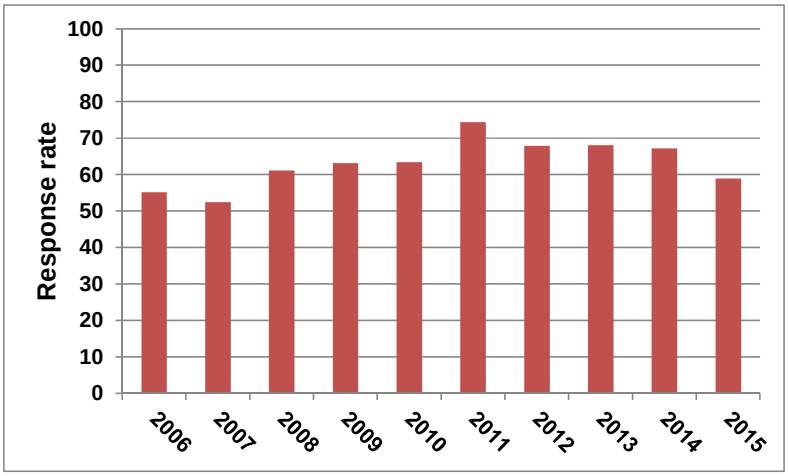
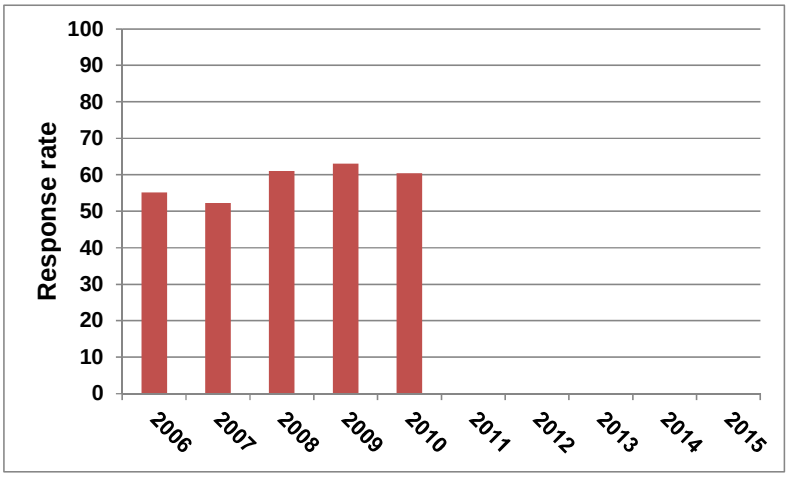


Figure B10 Response rates (cards returned/cards sent out) per year

a) All reporters



b) Core reporters



c) Sample reporters

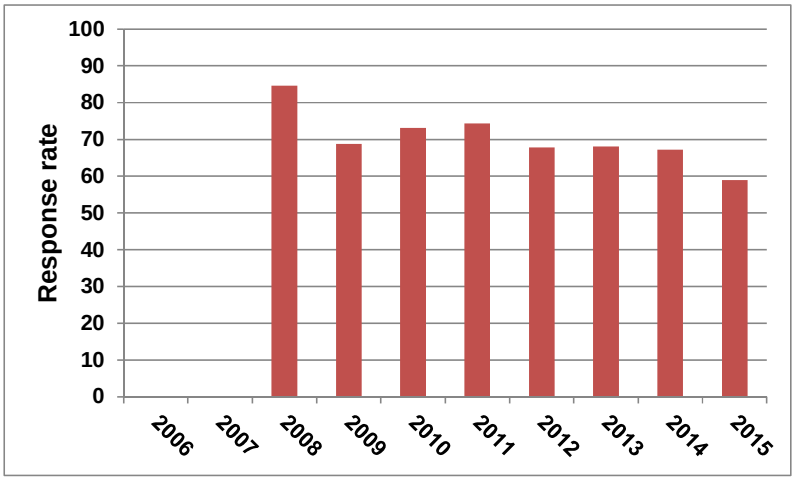


Figure B11 Number of active reporters per month – THOR-GP

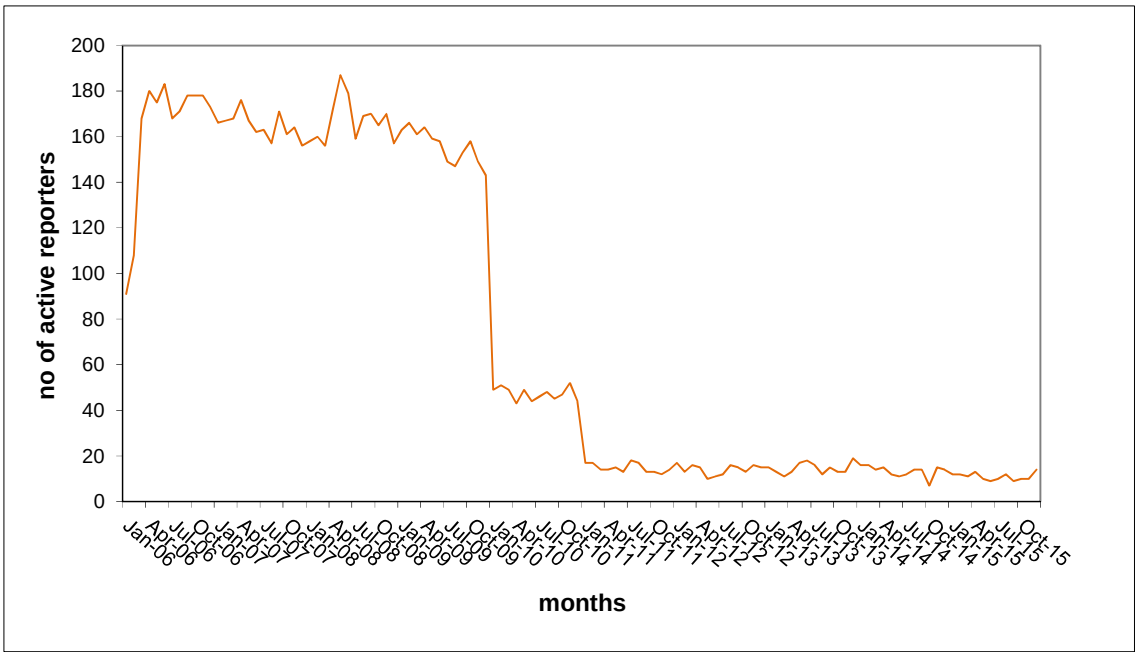
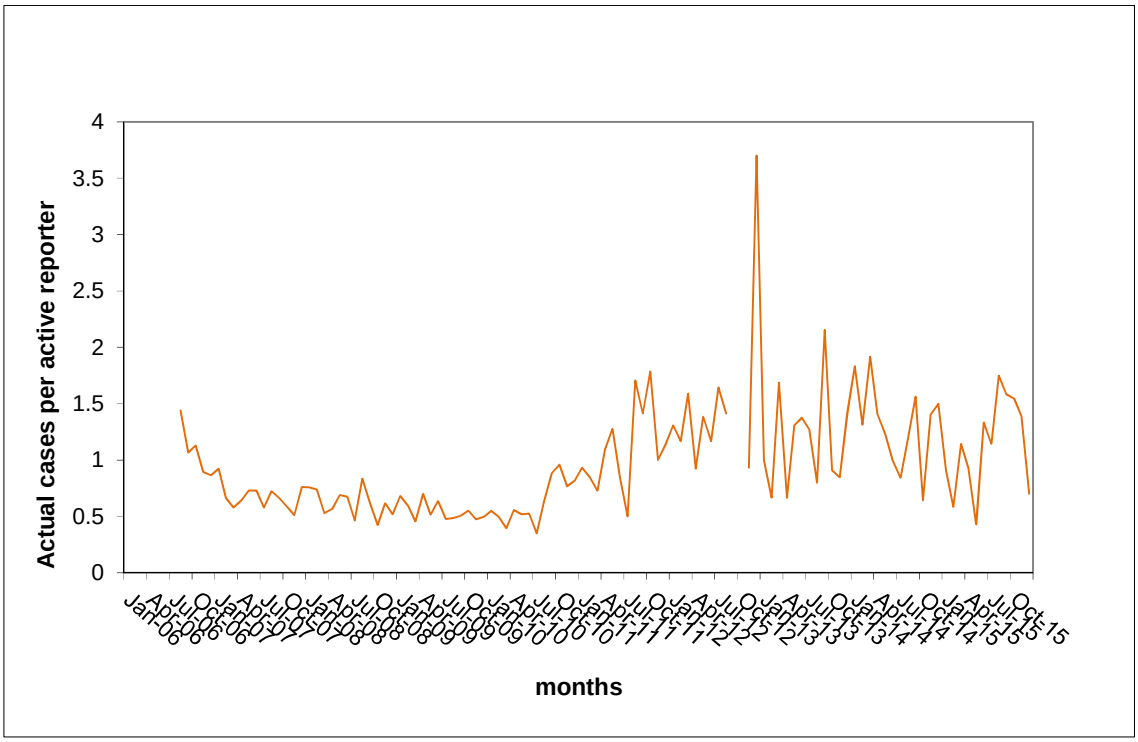
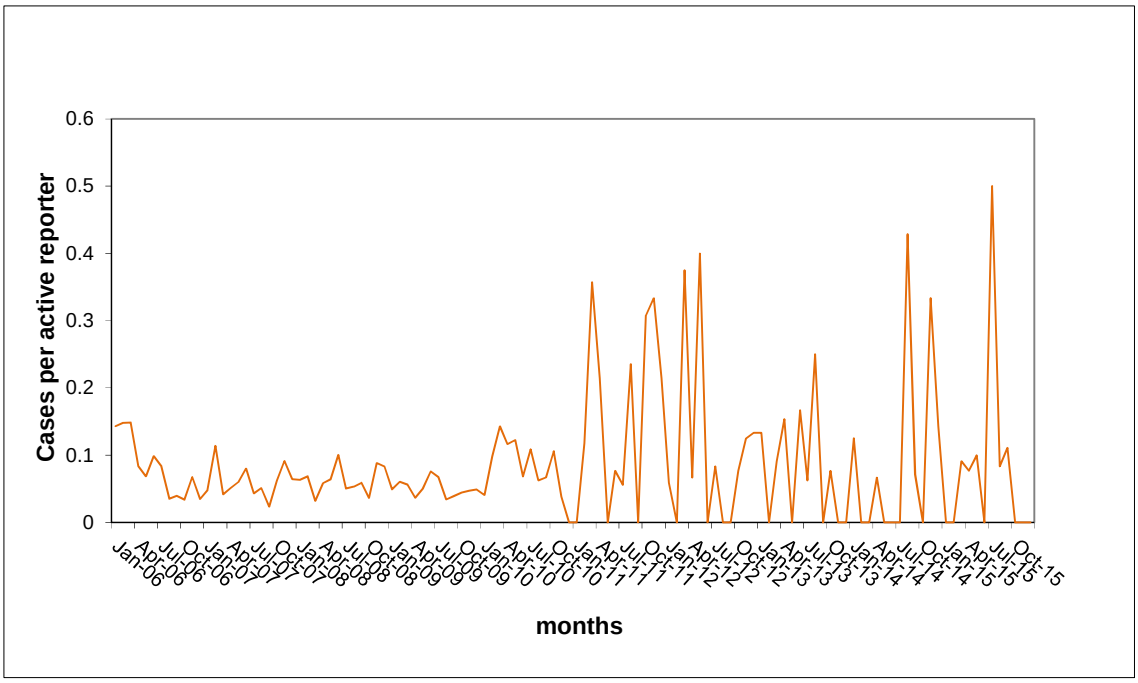


Figure B12 Cases per active reporter per month – THOR-GP

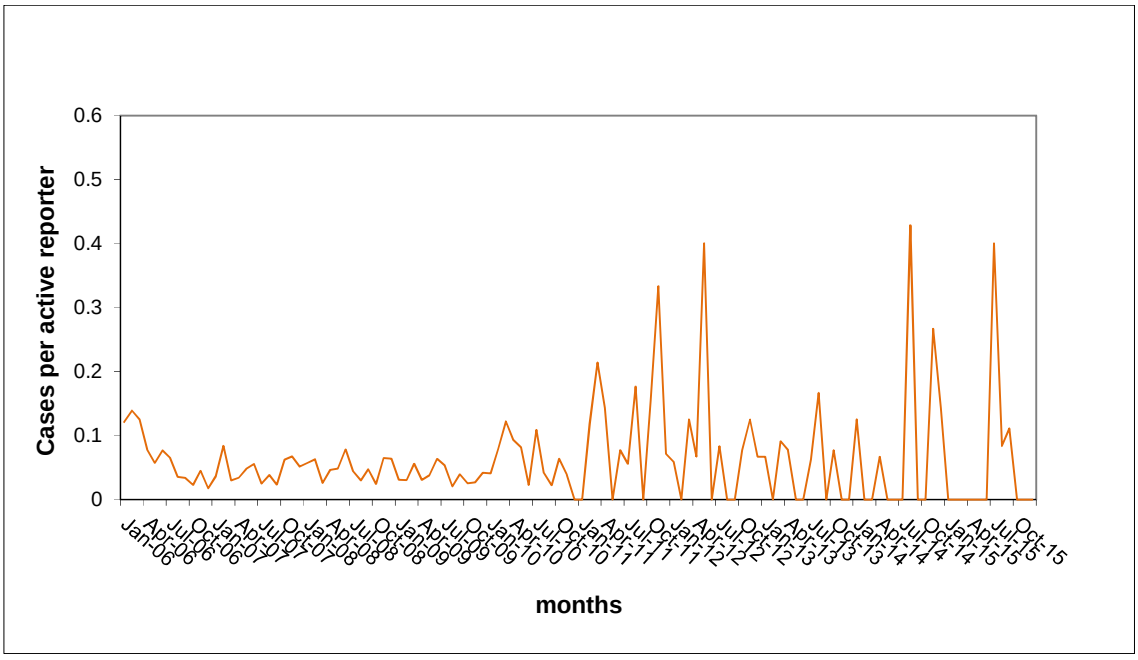
a) Total cases



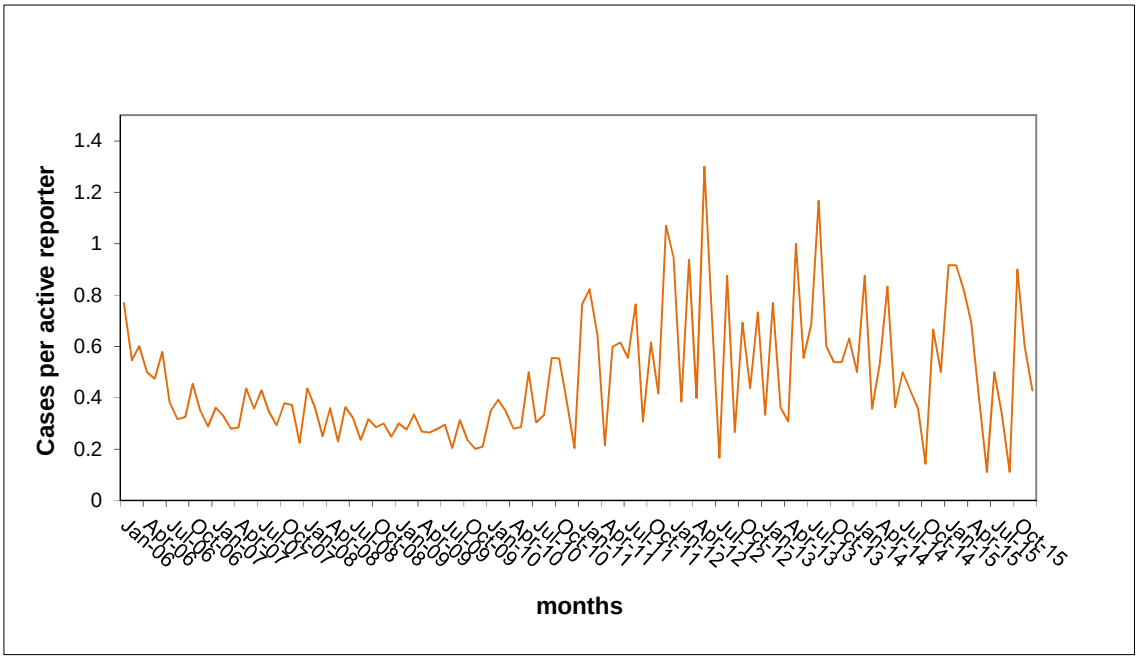
b) Total skin (note scale change)



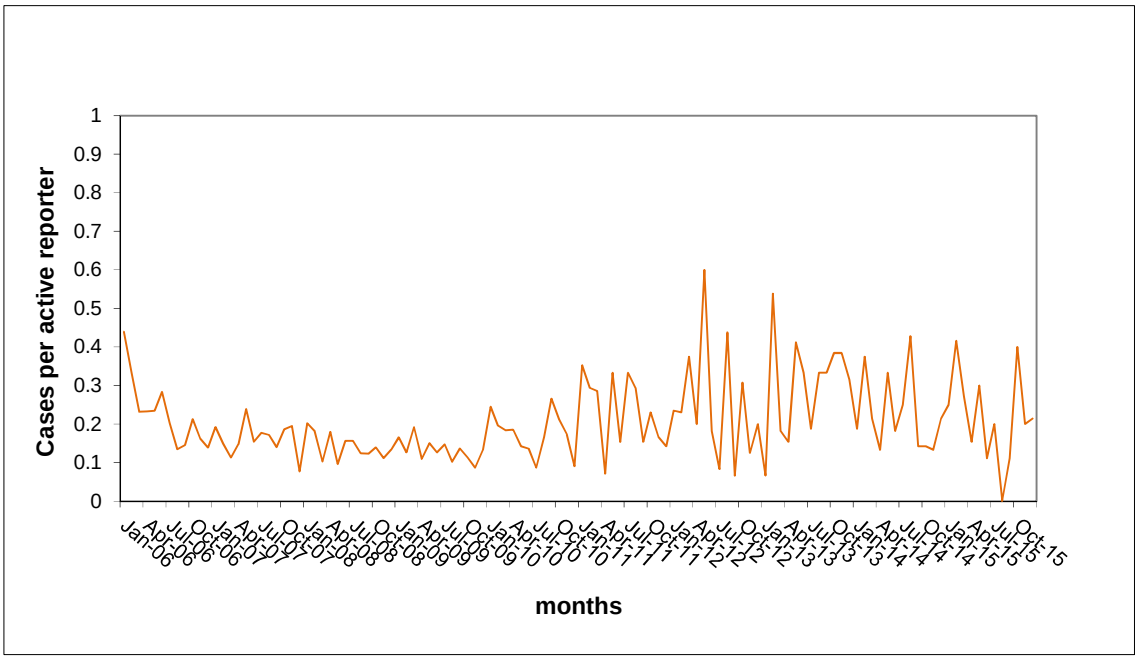
c) Contact dermatitis



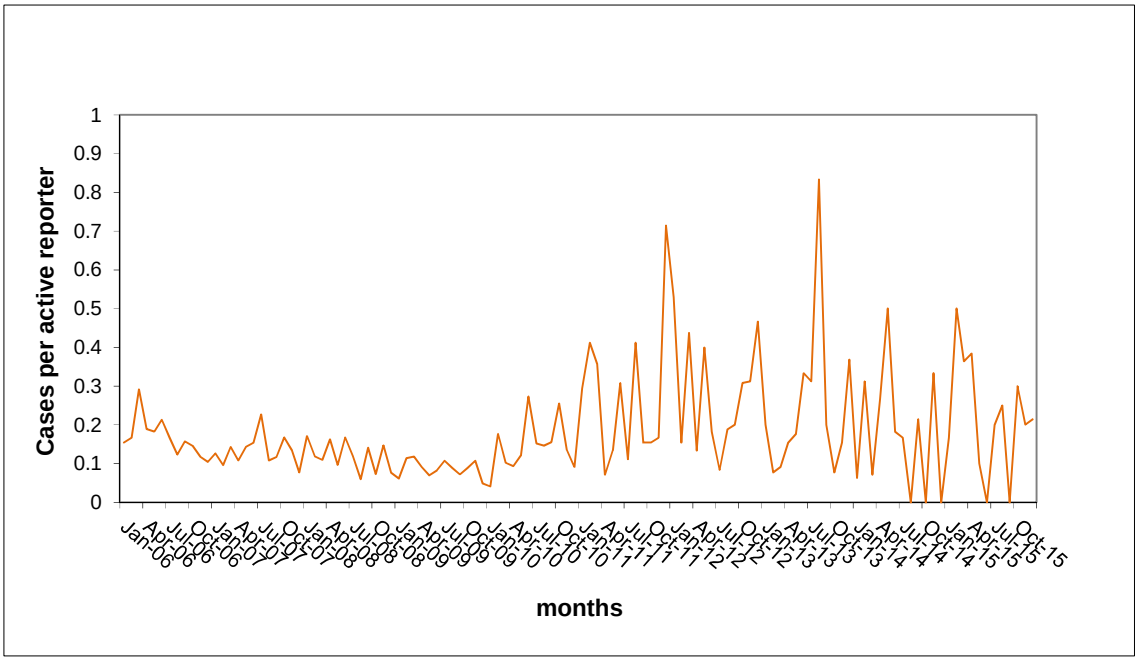
d) Total musculoskeletal (note scale change)



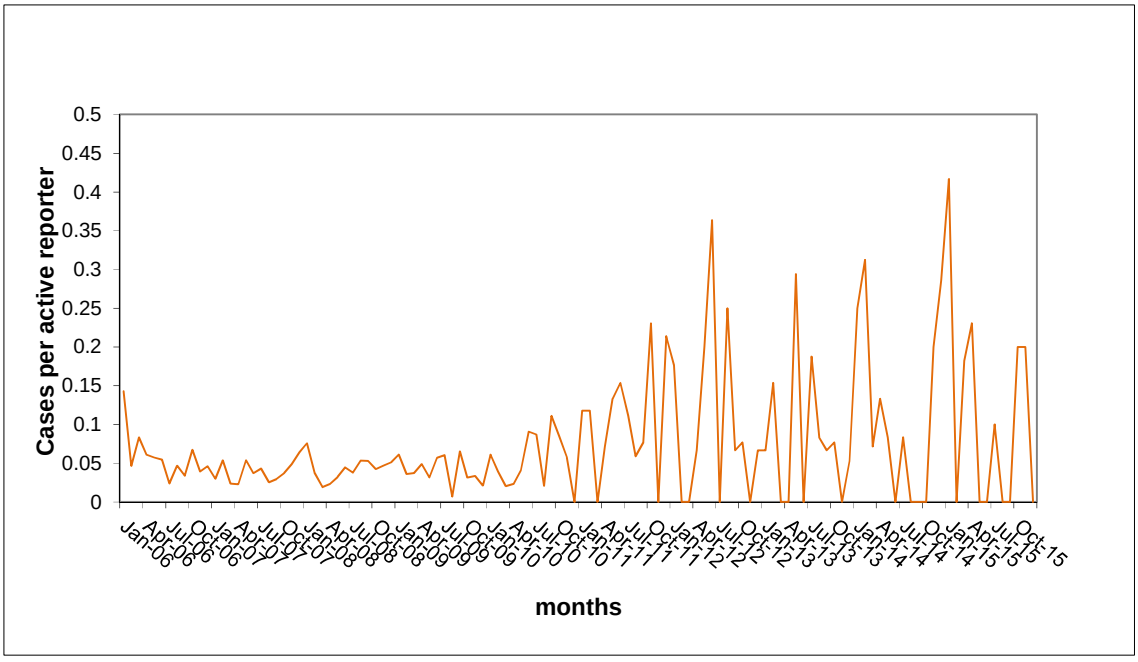
e) Upper limb (note scale change)



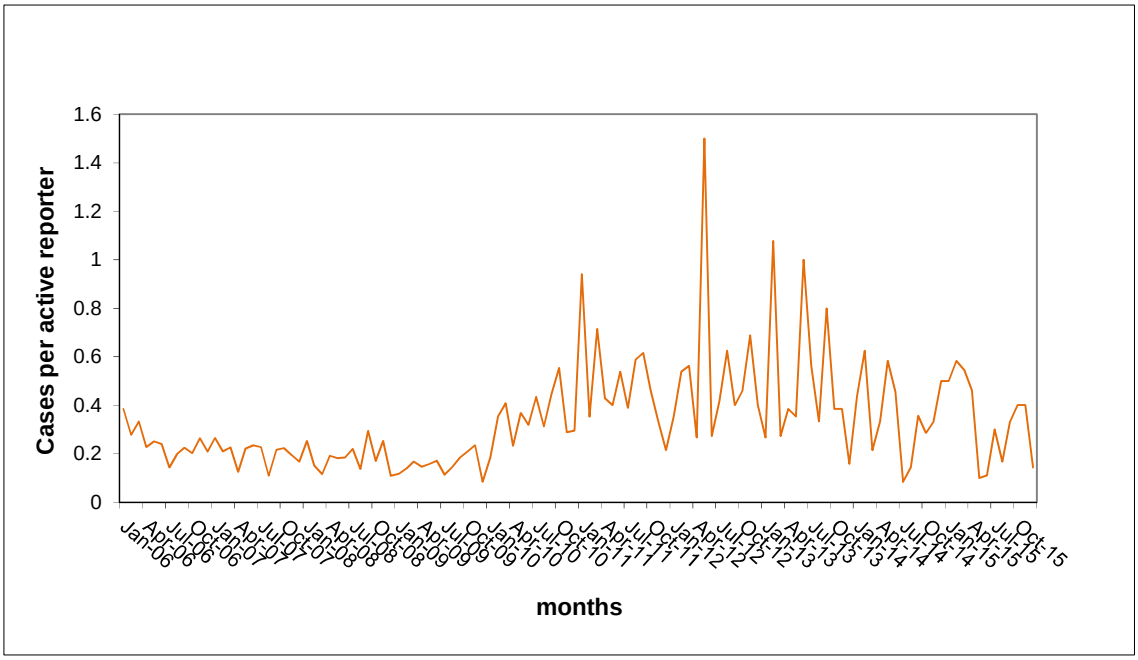
f) Spine/back



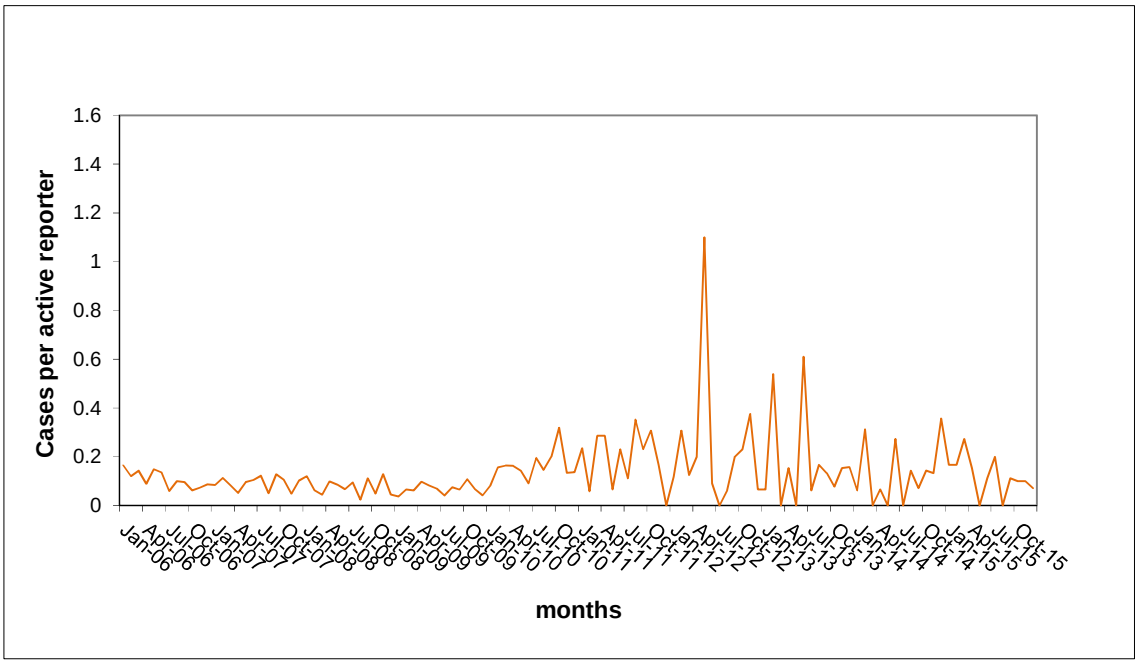
g) Lower limb (note scale change)



h) Total mental ill-health (note scale change)



i) Anxiety and depression



j) Other work stress

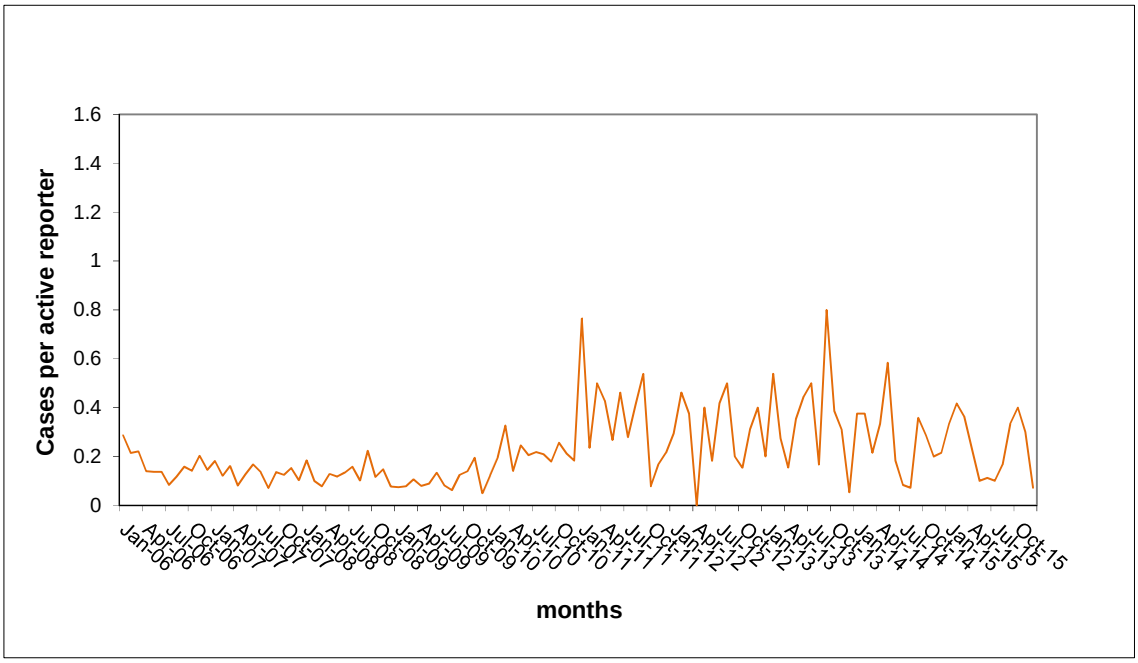


Table B6 Cases reported per month by disease category and type of reporter, THOR-GP, 2006-2015

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
	Total active reporters ever in 2006-2015	428				332				267			
	Mean no. of active[a] reporters per month	76.51	7	187	71.97	136.23	31	185	53.33	9.31	0	19	6.18
Disease group													
All cases	Total cases	6473				5115				1357			
	Mean cases per month	53.94	2	190	45.32	85.25	11	190	42.39	12.56	0	37	9.76
	Mean cases per active reporter per month	0.95	0.22	3.70	0.48	0.62	0.33	1.44	0.20	1.48	0	7	1.19
All skin	Total cases	623				508				115			
	Mean cases per month	5.19	0	25	5.17	8.47	0	25	5.06	1.06	0	6	1.48
	Mean cases per active reporter per month	0.09	0.00	0.50	0.10	0.06	0	0.17	0.03	0.15	0	2	0.28
Contact dermatitis	Total cases	478				400				78			
	Mean cases per month	3.98	0	21	4.23	6.67	0	21	4.25	0.72	0	6	1.13
	Mean cases per active reporter per month	0.06	0.00	0.43	0.08	0.05	0	0.14	0.03	0.09	0	1	0.17
All musculoskeletal	Total cases	3371				2713				658			
	Mean cases per month	28.09	1	106	25.24	45.22	5	106	24.53	6.09	0	17	4.91
	Mean cases per active reporter per month	0.47	0.11	1.30	0.24	0.32	0.15	0.77	0.12	0.73	0	5	0.72
Upper limb[b]	Total cases	1581				1304				277			
	Mean cases per month	13.18	0	52	12.41	21.73	1	52	11.87	2.56	0	8	2.14
	Mean cases per active reporter per month	0.21	0.00	0.60	0.10	0.15	0.03	0.44	0.07	0.31	0	2	0.33
Spine/back[c]	Total cases	1281				1007				274			

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
	Mean cases per month	10.68	0	49	10.07	16.78	0	49	10.67	2.54	0	10	2.62
	Mean cases per active reporter per month	0.19	0.00	0.83	0.14	0.11	0	0.29	0.05	0.29	0	2	0.32
Lower limb[d]	Total cases	465				356				109			
	Mean cases per month	3.88	0	14	3.48	5.93	0	14	3.52	1.01	0	5	1.34
	Mean cases per active reporter per month	0.08	0.00	0.42	0.08	0.04	0	0.14	0.02	0.12	0	2	0.25
All mental ill-health	Total cases	2102				1604				498			
	Mean cases per month	17.52	1	56	13.95	26.73	3	56	13.03	4.61	0	18	4.19
	Mean cases per active reporter per month	0.34	0.08	1.50	0.22	0.20	0.08	0.44	0.07	0.49	0	2.5	0.41
Anxiety/depression	Total cases	896				700				196			
	Mean cases per month	7.47	0	26	6.65	11.67	1	26	6.33	1.81	0	11	2.31
	Mean cases per active reporter per month	0.14	0.00	1.10	0.13	0.09	0.02	0.21	0.04	0.17	0	1.5	0.24
Other work stress	Total cases	1385				1051				334			
	Mean cases per month	11.54	0	38	9.40	17.52	0	38	9.26	3.09	0	13	2.81
	Mean cases per active reporter per month	0.23	0.00	0.80	0.15	0.13	0	0.29	0.05	0.33	0	1	0.26

[a]Active reporter is someone who returns a card
[b]Upper limb = hand/wrist/arm, elbow and shoulder
[c]Spine/back = neck/thoracic spine and lumbar spine/trunk
[d]Lower limb = ankle/knee/foot
NOTE: A case may have more than one diagnosis