THOR
The Health and Occupation Research network

Time trends in the incidence of work-related ill-health in the UK, 1996-2017: estimation from THOR surveillance data

Report to the UK Health and Safety Executive

Carder M, Money A, Rusdhy S, Gittins M, van Tongeren M

Centre for Occupational and Environmental Health, Centre for Epidemiology, Division of Population Health, Health Services Research & Primary Care, School of Health Sciences, Faculty of Biology, Medicine and Health, the University of Manchester

http://www.coeh.man.ac.uk/thor

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- The incidence of dermatologist reported (EPIDERM) work-related skin disease initially fell (1996-2006), after which it plateaued (until 2012), with a possible further reduction (2012-2016) but little evidence of further change between 2016 and 2017. The average annual change in incidence between 1996 and 2017 was -4.1% (95% CIs: -4.5, -3.6).
- Adjusting for the impact of 'reporter fatigue' reduced the average annual percentage change in incidence to -3.1% (95% CIs: -3.4, -2.7).
- The incidence of work-related contact dermatitis (CD) showed a similar annual pattern with an overall annual average change in incidence (1996-2017) of -4.0% (95% CIs: -4.4, -3.5). Analyses of shorter-term trends suggested an annual average change of -4.1% (95% CIs: -5.3, -3.0) per year for 2006 to 2017 and a steeper change for the more recent period of 2012-2017 at -6.2% (95% CIs: -9.0, -3.2) per year.
- An overall annual change of -3.1% (95% CIs: -4.5, -1.7) was observed for the incidence of work-related skin neoplasia (EPIDERM). Although there continues to be differences between trends based on reports from 'core' and 'sample' dermatologists, both suggest that the incidence has remained relatively stable over the past 5 years. However, for both groups the confidence intervals on the annual plots are wide and overlapping. It is therefore difficult to draw any firm conclusions about neoplasia trends from these data.
- The incidence of chest physician work-related respiratory disease (SWORD) fell between 1999 and 2007, after which it remained relatively stable. The average annual percentage change in incidence (1999-2017) was -2.9% (95% CIs: -3.5, -2.3).
- Adjusting the estimate for the impact of 'reporter fatigue' resulted in a slight reduction in the average annual change in incidence to -1.8% (95% CIs: -2.4, -1.2).
- An initial overall decrease in asthma incidence (SWORD) was observed (1999-2007) followed by a relatively stable trend until 2014, after which incidence appears to have been increasing. The average annual change in asthma incidence between 1999 and 2017 was -6.4% (95% CIs: -7.5, -5.3); however, in the last 10 years (2007-2017) the incidence only changed by about -1.0% (95% CIs: -3.8, 2.0) per year. For the period 2014-2017 the incidence of occupational asthma actually increased by on average 16.8% per year (95% CIs: 1.9, 33.8).
- For mesothelioma and benign pleural disease, annual changes in incidence (1999-2017) of -3.6% (95% CIs: -4.8, -2.4) and -1.5% (95% CIs -2.5, -0.6) were observed, respectively. However, for both, the incidence was relatively stable over the last 4 years. These results (especially when considering information from other sources) should be viewed with caution as they may reflect change in clinical practice rather than a 'true' trend.
- Chest physician reports suggest that the incidence of pneumoconiosis started to increase from approximately 2007. However, reports for the last five years suggest a relatively stable incidence (although confidence intervals are fairly wide). For the period 1999-2017 the incidence increased on average by 3.6% per year (95% CIs: 1.8, 5.3); for the period 2007-2017, the incidence increased by 8.2% per year (95% CIs: 4.6, 11.9). The observed increase appears largely attributable to asbestos rather than other agents (e.g. silica or coal).

EXECUTIVE SUMMARY

This report describes temporal trends in incidence of work-related illness (WRI) in the UK as reported to the two constituent schemes of The Health and Occupation Research (THOR) network which were funded by the Health and Safety Executive (HSE) during 2017. These were EPIDERM (dermatologists) and SWORD (chest physicians). The current report updates previously submitted reports by the incorporation of a further year (2017) of data. Data were analysed using a 'multi-level' statistical model to investigate the relative incidence of reported cases over time whilst taking into account other factors that might influence the trend (such as the number of physicians reporting each year and 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 (2017).

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 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.

For trends in incidence for total skin and total respiratory cases, analyses were included after adjusting for '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. 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'.

WORK-RELATED SKIN DISEASE: A total of 19,695 actual cases of work-related skin disease have been reported to EPIDERM between 1996 and 2017, with the main diagnoses being contact dermatitis (CD: 82%), neoplasia (12%), and urticaria (5%). The annual average change in incidence of dermatologist reported work-related skin disease (1996-2017) was -4.1% (95% CIs: -4.5, -3.6). Adjusting this estimate for the impact of 'reporter fatigue' (manifesting as an excess of zeros), using the 'Zero-inflated negative binomial' (ZINB) model would change the estimate to -3.1% (95% CIs: -3.4, -2.7). The graphs showing relative risk by

year suggest an initial decrease in incidence in the earlier part of the study period (1996-2006) followed by a relatively flat trend (2006-2012), a further decrease between 2012 and 2016 with little change between 2016 and 2017. The estimated annual change in incidence of CD (1996-2017) was -4.0% (95% CIs:-4.4, -3.5). Analyses of shorter-term trends suggested an annual average change of -4.1% (95% CIs: -5.3, -3.0) per year for 2006 to 2017 and a steeper decline for the more recent period of 2012-2017 at -6.2% (95% CIs: -9.2, -3.7) per year.

An overall decrease in incidence of work-related skin neoplasia was observed at -3.1% (95% CIs: -4.5, -1.7). Although there is a disparity between trends based on reports from 'core' or 'sample' dermatologists, with a (overall) decrease in incidence suggested by the former and an increase or flat trend by the latter, both groups suggest that the incidence has been stable over the past 5 years. Of the two reporter groups, it has been suggested previously 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.

WORK-RELATED RESPIRATORY DISEASE: A total of 13,530 case reports of work-related respiratory disease were reported by chest physicians to SWORD between 1999 and 2017. Diagnoses included asthma (19%) with the remainder being the (primarily) asbestos related diseases, such as benign pleural plaques (42%), and mesothelioma (19%), as well as pneumoconiosis (10%). The average annual change in total work-related respiratory disease between 1999 and 2017 was -2.9% (95% CIs: -3.5, -2.3). After adjusting for the impact of 'reporter fatigue' (manifesting as an excess of zeros) using the ZINB model the annual average decline in incidence was changed to -1.8% (95% CIs: -2.4, -1.2). For asthma, an annual average change in incidence (1999-2017) of -6.4% (95% CIs: -7.5, -5.3) was observed. The graphs showing relative risk by year suggest an initial decrease in incidence (1999-2007) followed by a relatively flat trend until 2014 after which there is some evidence that incidence is increasing. For the period 2007-2017, the annual average change in incidence was -1.0% (95% CIs: -3.8, 2.0). This compares to an average annual increase of 16.8% (95%CIs: 1.9, 33.8) for the period 2014-2017.

Reports by chest physicians suggested an average annual change in mesothelioma incidence of -3.6% (95% CIs: -4.8, -2.4) per year. The annual plots show an overall relatively flat trend

for the period 1999 to 2007 followed by a fall in incidence between 2007 and 2014 and little change thereafter. An average annual change in incidence was also observed for benign pleural disease at -1.5 (95% CIs: -2.5, -0.6), the annual plots of which also suggested a relatively flat trend since 2014. 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 suggest that after an initial relatively flat trend, the incidence of pneumoconiosis began increasing (from approximately 2007). The average annual change (1999-2017) in incidence was 3.6% (95% CIs: 1.8, 5.3) and for 2007-2017 it was 8.2% (95% CIs: 4.6, 5.3). However, reports for the last five years suggest a relatively flat trend (although confidence intervals are fairly wide). The observed increase appears largely attributable to asbestos rather than other agents (e.g. silica or coal).

1 BACKGROUND

This is the latest report to describe the trend in incidence of work-related illness (WRI) based on data from two occupational disease surveillance systems supported by the Health and Safety Executive (HSE) for data collection during 2017: case reports of work-related skin disease reported to EPIDERM by dermatologists (1996-2017) and case reports of work-related respiratory disease reported to SWORD by chest physicians (1999-2017). These two 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]. Trends based on data collected by the other two extant THOR schemes (THOR-GP for general practitioners and OPRA for occupational physicians) are not reported here (HSE ceased funding data collection at the end of 2015 and 2011, respectively). The report builds on previous reports submitted to the HSE on an annual basis[2-13].

The approach taken to assess change in incidence of WRI over time using surveillance data collected by THOR is based (with some minor modifications over the years) on the methodology proposed by McNamee *et al* in a report submitted to HSE in 2005[14] and subsequently published in the peer reviewed literature[15]. 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[3-13].

One of the methodological issues addressed within this body of work has been the issue of 'reporter fatigue' (i.e. the longer a physician is in a scheme they may lose interest in reporting but still retain membership). Extensive analyses have been undertaken (and reported upon both in reports submitted to HSE and in the peer reviewed literature) 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, 16-20]. Based on this work, an estimate of the percentage change in incidence of total work-related skin disease and total work-related respiratory disease, after adjusting for 'reporter fatigue' (manifesting as an excess of zero reports), has also been include in this report.

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	1996-2017	1996-2017	1996-2017
SWORD	1989	1999-2017	1999-2017	1999-2017

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[21]. 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 (1996-2017). 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[22] 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) reporting each month with the remainder assigned to report on a 'sample' (one month per year) 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 (1999-2017 for SWORD). For this

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

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.

2.3 CATEGORIES OF DISEASE

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]. The resulting disease groups to be included in the analysis are shown in Table 2.

Table 2 Categories of disease included in the analyses

	Clinical specialist
Total skin	**Yes**
Contact dermatitis (CD)	**Yes**
• **Allergic CD**	**Yes**
• **Irritant CD**	**Yes**
• **Mixed CD**	**Yes**
Other skin (other than contact dermatitis)	**Yes**
Neoplasia	**Yes**
Contact urticaria	**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**

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' was 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 'month', 'reporter type' ('core' or 'sample'), and '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 for this decision was that 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 distribution the variance and mean are constrained to be equal, but this is not the case for the Negative Binomial distribution.

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, 2017 was taken as the reference year and the percentage increase or decrease in incidence compared to 2017 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 or linear 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.

Month – Variation in reporting within a year could occur due to seasonal variation in illness or seasonality in reporting behaviour (e.g. because of holidays). To address this, indicator variables for month (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.

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[23], 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.

This report continues with the approach first adopted in the trends report submitted to HSE in September 2017, 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 approach, suggested by the former HSE liaison officer (John Hodgson), follows the method described by Firth and de Menezes[24], which assigns a confidence (or comparison) interval to the reference category (2017 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.

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.
Calendar time treatment: non-parametric approach	Rate Ratio for each year compared to 2017 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 ADJUSTMENT FOR 'REPORTER FATIGUE'

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. Investigations 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, 16-19]. We have argued previously that an increase in non-response over time would

not necessarily bias trends estimates (since the rates are calculated based on responses received, not responses due to have been received); 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 zeros' 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 to investigate the presence of 'excess zeros' in THOR data. This approach has been written up and published[20]. Using this approach the impact of adjusting for excess zeros on the annual average percentage change in incidence of total work-related skin disease (EPIDERM, 1996-2017) and total work-related respiratory disease (SWORD, 1999-2017) was investigated. These adjustments have been carried out for total skin and total respiratory cases only. It cannot be assumed that the observed effect would be the same across the different diagnoses.

A brief overview of the methodology is provided below:

The zero-inflated negative binomial (ZINB) model

To account for the presence of excess zero cases within the reported data, the reported monthly number of (total work-related skin or total work-related respiratory) cases was fitted using a (ZINB) model with multi-level random effects.

This model has two parts; the first supposes that, on occasion, a reporter might return a zero report regardless of the actual number of cases seen, i.e. a false zero. This part of the model supposes a binary decision: return a false zero regardless of whether the reporter has seen any cases due to work or return 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 false 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.

3 RESULTS

3.1 OVERVIEW OF SCHEMES

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

3.1.1 EPIDERM (Dermatologists)

A total of 467 dermatologists participated in EPIDERM during the study period with 93% reporting at least once (i.e. either returning cases or declaring 'I have nothing to report this month') (Table B1). An average of 186 dermatologists participated in EPIDERM each year (Figure B1) and 2017 saw a small drop in the overall number of physicians in EPIDERM (from 146 in 2016 to 138 in 2017). Response rates (cards returned/cards sent out) per year showed an initial increase between 1996 and 2001, followed by an overall decline until 2012 after which they appeared to stabilise between 60-70% (Figure B2). The number of active reporters per month has remained at approximately 19 per month from 2016 to 2017 (Figure B3). The average cases per active reporter also remained similar at 1.7 in 2016 to 1.6 in 2017 (Figure B4). The majority of participants to EPIDERM are 'sample' reporters (86% in 2017); however, 'core' reporters report more cases per month (3.3) compared to 'sample' reporters (1) (Table B2). 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 (Chest physicians)

Active participation in SWORD during the study period was similar to EPIDERM with 93% of the 915 chest physicians participating during this period reporting at least once (Table B3). On average, 462 chest physicians participated in SWORD each year (Figure B5) and the total number of reporters in SWORD decreased slightly between 2016 and 2017 (413 to 405). Response rates (cards returned/cards sent out) decreased slightly in 2017 (compared to 2016) for both 'core' reporters (63% to 59%) and 'sample' reporters (56% to 53%) (Figure B6). The average number of active reporters per month (Figure B7) decreased slightly (from 29 to 27) between 2016 and 2017; the average number of cases per active reporter increased slightly from 1.2 in 2016 to 1.4 in 2017 (Figure B8). Similar to EPIDERM, the smaller group of chest physicians reporting as 'core' reported more cases per month (3.0) than 'sample' reporters (0.5) (Table B4). The majority of the diagnoses (42%) reported to SWORD during the study period were benign pleural disease. Of the remaining cases, 19% were mesothelioma, 19% asthma, 10% pneumoconiosis, and 14% 'other' respiratory disease.

3.2 TIME TRENDS BY DISEASE CATEGORY

3.2.1 WORK-RELATED SKIN DISEASE - DERMATOLOGISTS

The average annual percentage change in risk of work-related skin disease, as reported by dermatologists is shown in Table 4 whilst the relative risks by year are shown in Tables 5 to 12 and Figures 1 to 8.

The annual average change in incidence of dermatologist reported work-related skin disease (1996-2017) was -4.1% (95% CIs: -4.5, -3.6), which is nearly identical to the previous estimate of -4.0% (95% CIs: -4.4, -3.5) reported in 2017 (based on data for the period 1996-2016). The graphs (Figure 1) showing relative risk by year suggest an initial decrease in incidence in the earlier part of the study period (1996-2006) followed by a relatively flat trend (2006-2012), a further decrease between 2012 and 2016 with little change between 2016 and 2017.

The estimated annual change in incidence of contact dermatitis (CD) was similar at -4.0% (95% CIs:-4.4, -3.5) with a similar annual pattern (Figure 2). Analyses of shorter-term trends for CD suggested a very similar annual average change in CD incidence when considering only data from 2006 to 2017 (-4.1%; 95% CIs:-5.3, -3.0); however, when only data between 2012 and 2017 were considered the decline was somewhat larger (-6.2%; (95% CIs: -9.0, -3.2)).

Analysis by type of CD indicated a steeper change in the incidence of allergic CD (-5.3% (95% CIs: -5.9, -4.6)) compared to irritant CD (-3.0% (95% CIs: -3.7, -2.4)) or mixed CD (-2.7% (95% CIs: -3.6, -1.6)); these estimates were very similar to those reported last year. Figure 3 shows a decreasing relative risk by year (compared to 2017) for allergic CD between 1996 and 2006, followed by a period when there is relatively little change in the relative risks. For irritant CD (Figure 4), after an initial decrease in relative risk between 1999 and 2000, the trend is flat until about 2012, after which it appears to decrease to 2016. There is some evidence of an increase in incidence between 2016 and 2017.

The annual average change in incidence of dermatologist reported urticaria (Figure 6) remained largely unchanged with the addition of the 2017 data at -7.5% (95% CIs: -9.0, -6.0) compared to the previously reported -7.0% (95% CIs: -8.6, -5.5) (based on data for 1996-2016). Similarly, the trend in incidence for neoplasia (Figure 7) (-3.1%; 95% CIs: -4.5, -1.7) was very similar compared to that reported in 2017.

There continues to be some variation by reporter type ('core' versus 'sample'), most notably for neoplasia with data from 'core' reporters suggesting an annual average change of -4.9% (95% CIs: -6.5, -3.3) whilst data from 'sample' reporters suggested an increase of 1.8% (95% CIs: -0.9, 4.5). For urticaria there was evidence of a large change in incidence in cases returned by 'core' reporters (-8.1%; 95% CIs: -9.7, -6.6) compared to a smaller, non-statistically significant change in incidence based on cases returned by 'sample' reporters: (0.5%; 95% CIs: -5.7, 4.9).

After adjusting the average annual percentage change in incidence of total work-related skin disease for the impact of excess zeros (using the ZINB model), the annual decline changed from -4.1% (95% CIs: -4.5, -3.6) to -3.1% (95% CIs: -3.4,-2.7).

Table 4 **Average annual percentage change in reported incidence in work-related skin disease as reported by dermatologists to EPIDERM**

		ESTIMATED % CHANGE (95% CONFIDENCE INTERVAL)		
		All reporters	**Core reporters**	**Sample reporters**
	Year (continuous)			
Total skin	1996-2017	-4.1 (-4.5, -3.6)	-4.2 (-4.7, -3.8)	-2.6 (-3.9, -1.4)
	2006-2017	-4.8 (-5.9, -3.7)	-5.5 (-6.7, -4.3)	-1.5 (-4.3, 1.3)
	2012-2017	-6.5 (-9.2, -3.7)	-6.8 (-9.8, -3.6)	-3.1 (-8.9, 3.0)
Contact dermatitis (CD)	1996-2017	-4.0 (-4.4, -3.5)	-4.0 (-4.5, -3.5)	-3.7 (-5.1, -2.3)
	2006-2017	-4.1 (-5.3, -3.0)	-4.8 (-6.1, -3.6)	0.0 (-3.1, 3.1)
	2012-2017	-6.2 (-9.0, -3.2)	-6.2 (-9.4, -3.0)	-3.4 (-9.9, 3.6)
• **Allergic CD**	1996-2017	-5.3 (-5.9, -4.6)	-5.5 (-6.3, -4.8)	-3.7 (-5.6, -1.7)
• **Irritant CD**	1996-2017	-3.0 (-3.7, -2.4)	-3.1 (-3.8, -2.4)	-2.3 (-4.3, -0.3)
• **Mixed CD**	1996-2017	-2.7 (-3.6, -1.6)	-3.1 (-4.2, -2.0)	0.3 (-2.7, 3.5)
Urticaria	1996-2017	-7.5 (-9.0, -6.0)	-8.1 (-9.7, -6.6)	-0.5 (-5.7, 4.9)
Neoplasia	1996-2017	-3.1 (-4.5, -1.7)	-4.9 (-6.5, -3.3)	1.8 (-0.9, 4.5)
Other[a] skin	1996-2017	-5.9 (-6.8, -5.0)	-7.1 (-8.1, -6.1)	-0.6 (-2.7, 1.6)

[a]Other than contact dermatitis
Models adjusted for reporter type (where appropriate), month 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 75

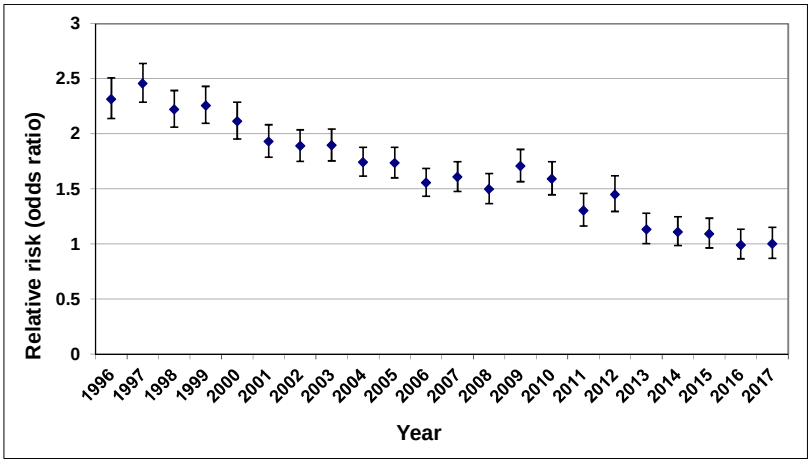
Table 5 **Relative risk by year, with 95% comparison intervals, total skin disease (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1996	2.32 (2.14,2.51)	2.50 (2.30,2.72)	1.36 (1.00,1.85)
1997	2.46 (2.29,2.64)	2.62 (2.43,2.81)	1.98 (1.53,2.55)
1998	2.22 (2.06,2.39)	2.37 (2.19,2.56)	1.74 (1.38,2.21)
1999	2.26 (2.10,2.43)	2.39 (2.21,2.59)	1.89 (1.54,2.31)
2000	2.11 (1.95,2.29)	2.29 (2.11,2.49)	1.50 (1.21,1.88)
2001	1.93 (1.79,2.08)	2.04 (1.88,2.22)	1.67 (1.35,2.07)
2002	1.89 (1.75,2.04)	2.00 (1.84,2.16)	1.65 (1.32,2.08)
2003	1.89 (1.76,2.04)	2.07 (1.91,2.24)	1.22 (0.94,1.58)
2004	1.74 (1.61,1.88)	1.85 (1.71,2.00)	1.40 (1.11,1.77)
2005	1.73 (1.60,1.88)	1.86 (1.71,2.03)	1.31 (1.03,1.65)
2006	1.55 (1.43,1.69)	1.61 (1.48,1.76)	1.54 (1.25,1.90)
2007	1.61 (1.48,1.75)	1.74 (1.59,1.90)	1.15 (0.90,1.47)
2008	1.50 (1.37,1.64)	1.63 (1.48,1.80)	0.99 (0.74,1.32)
2009	1.71 (1.57,1.86)	1.82 (1.66,1.99)	1.35 (1.04,1.77)
2010	1.59 (1.45,1.75)	1.70 (1.53,1.87)	1.26 (0.96,1.67)
2011	1.30 (1.16,1.46)	1.35 (1.19,1.53)	1.22 (0.91,1.64)
2012	1.45 (1.30,1.62)	1.52 (1.35,1.72)	1.30 (0.99,1.7)
2013	1.13 (1.00,1.28)	1.15 (1.00,1.31)	1.16 (0.88,1.55)
2014	1.11 (0.98,1.25)	1.14 (1.00,1.29)	1.02 (0.76,1.38)
2015	1.09 (0.96,1.23)	1.09 (0.95,1.24)	1.16 (0.87,1.56)
2016	0.99 (0.86,1.13)	0.97 (0.84,1.13)	1.12 (0.83,1.53)
2017	1.00 (0.87,1.15)	1.00 (0.86,1.17)	1.00 (0.72,1.39)

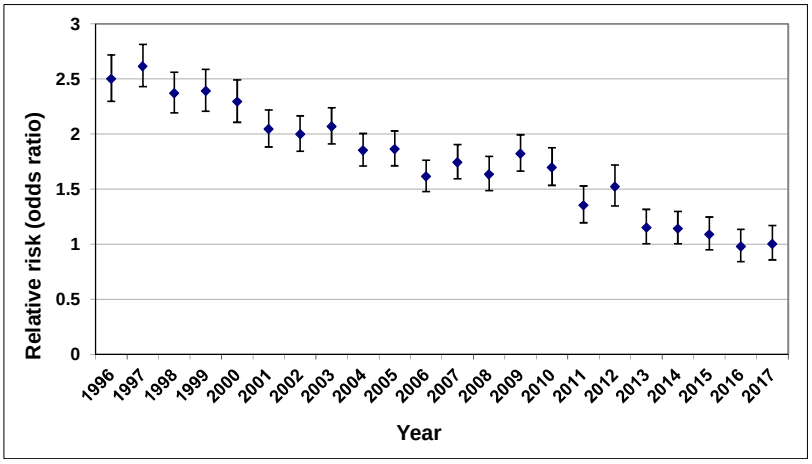
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 75

Figure 1 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, total skin**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

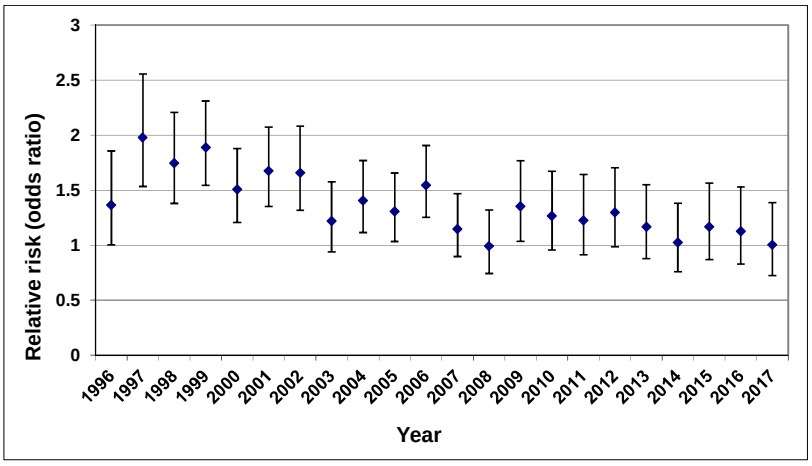


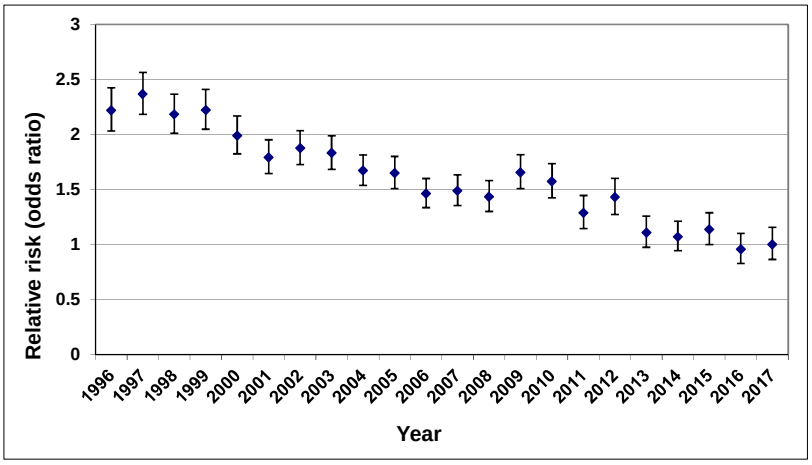
Table 6 **Relative risk by year, with 95% comparison intervals, all contact dermatitis (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1996	2.22 (2.03,2.42)	2.29 (2.09,2.51)	1.69 (1.23,2.34)
1997	2.37 (2.18,2.56)	2.44 (2.25,2.65)	2.23 (1.69,2.95)
1998	2.18 (2.01,2.37)	2.25 (2.07,2.45)	2.08 (1.62,2.67)
1999	2.22 (2.05,2.41)	2.24 (2.05,2.45)	2.44 (1.99,2.99)
2000	1.99 (1.82,2.17)	2.07 (1.88,2.27)	1.78 (1.40,2.26)
2001	1.79 (1.64,1.95)	1.87 (1.70,2.04)	1.59 (1.24,2.03)
2002	1.87 (1.73,2.03)	1.93 (1.77,2.11)	1.84 (1.44,2.36)
2003	1.83 (1.68,1.99)	1.94 (1.78,2.12)	1.31 (0.99,1.74)
2004	1.67 (1.54,1.81)	1.75 (1.61,1.91)	1.31 (0.99,1.74)
2005	1.65 (1.51,1.80)	1.71 (1.56,1.88)	1.46 (1.13,1.88)
2006	1.46 (1.33,1.60)	1.52 (1.37,1.67)	1.38 (1.07,1.78)
2007	1.49 (1.35,1.63)	1.59 (1.44,1.76)	0.99 (0.74,1.33)
2008	1.43 (1.30,1.58)	1.53 (1.38,1.70)	0.94 (0.68,1.31)
2009	1.66 (1.51,1.82)	1.74 (1.58,1.92)	1.24 (0.91,1.68)
2010	1.57 (1.42,1.74)	1.65 (1.49,1.83)	1.21 (0.88,1.66)
2011	1.29 (1.14,1.45)	1.31 (1.15,1.48)	1.28 (0.93,1.76)
2012	1.43 (1.27,1.60)	1.48 (1.31,1.68)	1.29 (0.94,1.76)
2013	1.11 (0.97,1.26)	1.10 (0.96,1.27)	1.22 (0.89,1.68)
2014	1.07 (0.94,1.21)	1.08 (0.94,1.24)	1.07 (0.77,1.48)
2015	1.14 (1.00,1.29)	1.12 (0.98,1.29)	1.22 (0.89,1.68)
2016	0.96 (0.83,1.10)	0.94 (0.81,1.10)	1.04 (0.74,1.46)
2017	1.00 (0.86,1.16)	1.00 (0.85,1.18)	1.00 (0.70,1.43)

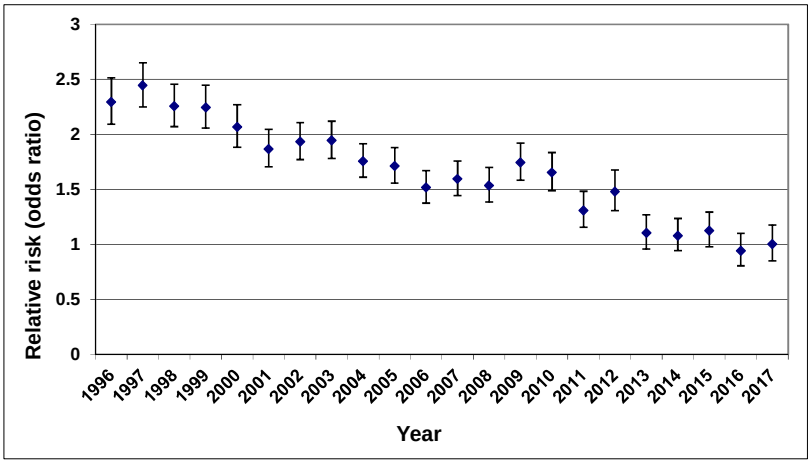
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 75

Figure 2 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, all contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

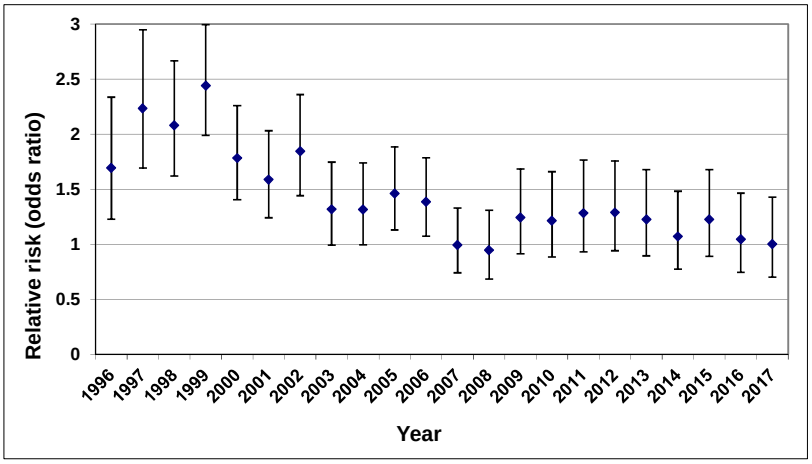


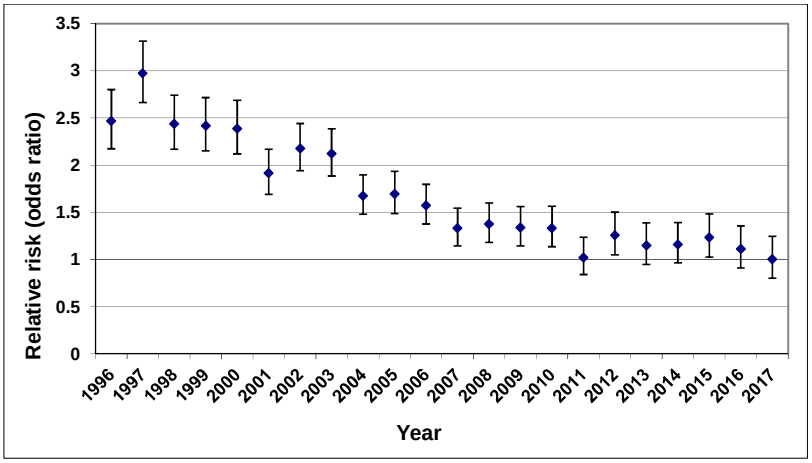
Table 7 **Relative risk by year, with 95% comparison intervals, allergic contact dermatitis (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1996	2.47 (2.17,2.80)	2.43 (2.11,2.80)	2.58 (1.65,4.03)
1997	2.97 (2.66,3.31)	2.89 (2.57,3.24)	3.84 (2.66,5.55)
1998	2.44 (2.17,2.74)	2.43 (2.15,2.75)	2.46 (1.65,3.68)
1999	2.42 (2.15,2.72)	2.34 (2.07,2.65)	3.19 (2.27,4.49)
2000	2.39 (2.12,2.69)	2.36 (2.08,2.68)	2.73 (1.95,3.82)
2001	1.91 (1.69,2.17)	1.94 (1.70,2.21)	1.69 (1.11,2.56)
2002	2.18 (1.94,2.44)	2.08 (1.84,2.35)	3.24 (2.33,4.52)
2003	2.12 (1.89,2.38)	2.09 (1.85,2.36)	2.41 (1.65,3.52)
2004	1.67 (1.48,1.90)	1.65 (1.45,1.88)	1.85 (1.21,2.83)
2005	1.70 (1.49,1.93)	1.6 (1.39,1.85)	2.56 (1.81,3.64)
2006	1.57 (1.37,1.80)	1.5 (1.30,1.73)	2.37 (1.65,3.41)
2007	1.33 (1.14,1.54)	1.27 (1.08,1.49)	1.91 (1.28,2.86)
2008	1.38 (1.18,1.60)	1.34 (1.14,1.57)	1.76 (1.13,2.74)
2009	1.34 (1.14,1.56)	1.31 (1.11,1.54)	1.51 (0.90,2.53)
2010	1.33 (1.14,1.56)	1.26 (1.06,1.49)	2.04 (1.29,3.22)
2011	1.02 (0.84,1.24)	0.91 (0.74,1.13)	2.24 (1.41,3.56)
2012	1.26 (1.05,1.50)	1.23 (1.02,1.49)	1.46 (0.87,2.46)
2013	1.15 (0.95,1.39)	1.05 (0.85,1.30)	1.91 (1.22,2.99)
2014	1.16 (0.96,1.39)	1.09 (0.90,1.33)	1.73 (1.07,2.81)
2015	1.23 (1.02,1.48)	1.13 (0.93,1.38)	2.05 (1.31,3.21)
2016	1.11 (0.91,1.36)	1.07 (0.86,1.32)	1.43 (0.83,2.47)
2017	1.00 (0.80,1.25)	1.00 (0.79,1.26)	1.00 (0.52,1.91)

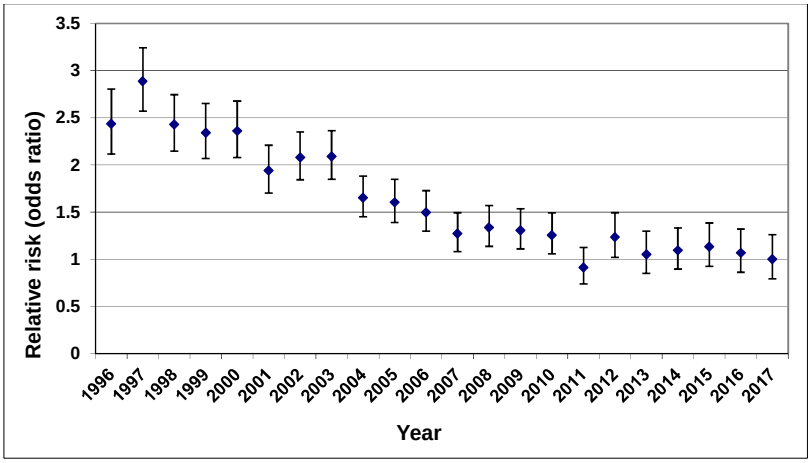
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 75

Figure 3 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, allergic contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters (note scale change)

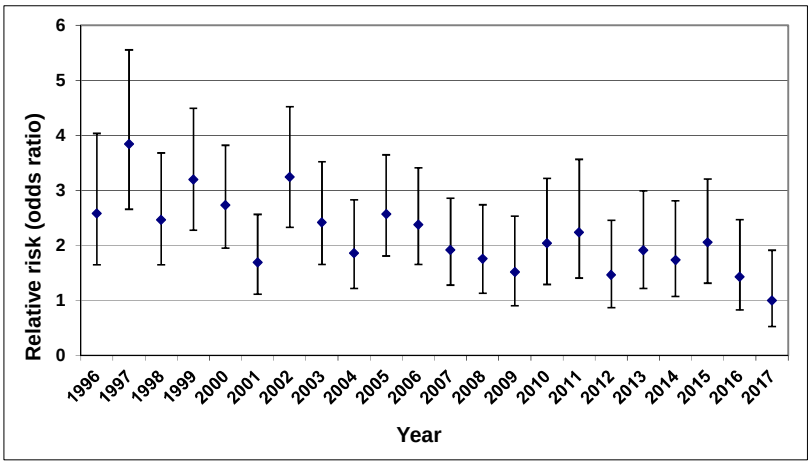


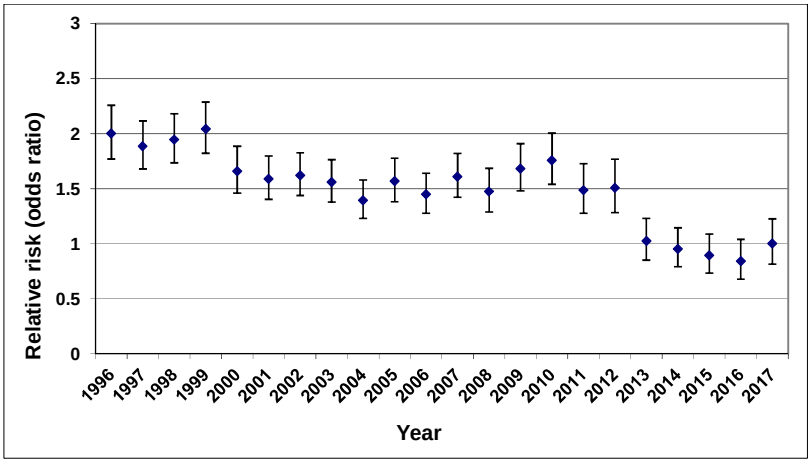
Table 8 **Relative risk by year, with 95% comparison intervals, irritant contact dermatitis (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1996	2.00 (1.77,2.26)	2.25 (1.97,2.57)	0.77 (0.42,1.40)
1997	1.88 (1.68,2.11)	2.12 (1.88,2.40)	1.09 (0.67,1.79)
1998	1.95 (1.74,2.18)	2.13 (1.89,2.41)	1.56 (1.09,2.23)
1999	2.04 (1.82,2.29)	2.26 (2.00,2.56)	1.48 (1.06,2.08)
2000	1.66 (1.46,1.89)	1.86 (1.62,2.13)	1.11 (0.76,1.63)
2001	1.59 (1.40,1.80)	1.72 (1.51,1.97)	1.41 (1.01,1.97)
2002	1.62 (1.44,1.83)	1.80 (1.59,2.05)	1.18 (0.79,1.75)
2003	1.56 (1.38,1.76)	1.77 (1.55,2.01)	0.93 (0.60,1.44)
2004	1.39 (1.23,1.58)	1.57 (1.38,1.79)	0.87 (0.56,1.34)
2005	1.57 (1.38,1.78)	1.76 (1.54,2.01)	1.02 (0.69,1.52)
2006	1.45 (1.28,1.64)	1.64 (1.44,1.87)	0.95 (0.64,1.41)
2007	1.61 (1.42,1.82)	1.89 (1.66,2.14)	0.61 (0.37,0.98)
2008	1.47 (1.29,1.69)	1.70 (1.48,1.96)	0.67 (0.40,1.12)
2009	1.68 (1.48,1.91)	1.95 (1.71,2.22)	0.65 (0.38,1.12)
2010	1.76 (1.54,2.00)	2.05 (1.79,2.34)	0.66 (0.39,1.14)
2011	1.49 (1.28,1.73)	1.68 (1.43,1.97)	0.84 (0.51,1.39)
2012	1.51 (1.28,1.77)	1.66 (1.39,1.97)	1.18 (0.76,1.83)
2013	1.02 (0.85,1.23)	1.10 (0.90,1.34)	0.91 (0.56,1.47)
2014	0.95 (0.79,1.14)	1.00 (0.82,1.22)	0.82 (0.51,1.31)
2015	0.89 (0.73,1.09)	0.92 (0.74,1.14)	0.86 (0.53,1.38)
2016	0.84 (0.68,1.04)	0.85 (0.67,1.07)	0.84 (0.52,1.35)
2017	1.00 (0.82,1.23)	1.00 (0.80,1.26)	1.00 (0.64,1.56)

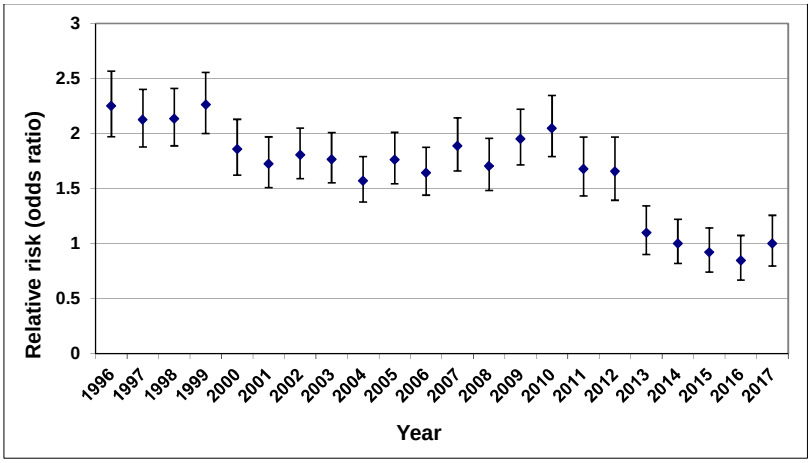
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 75

Figure 4 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, irritant contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

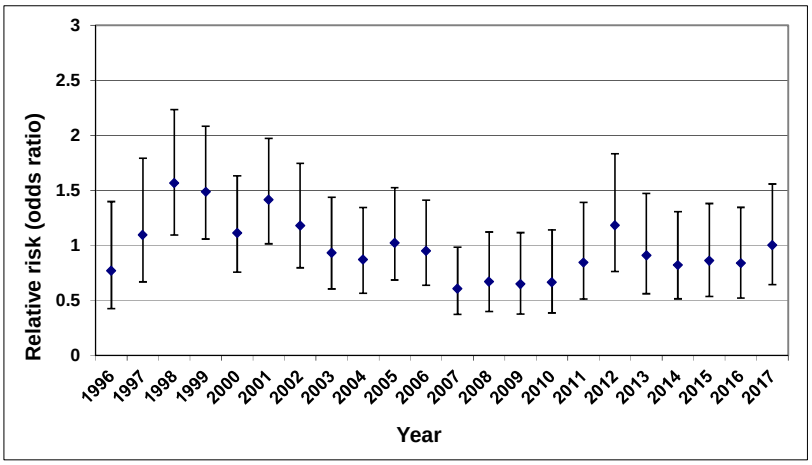


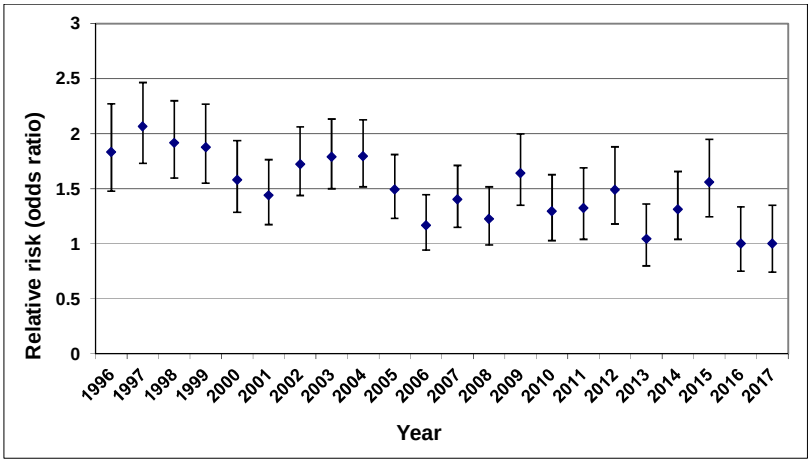
Table 9 **Relative risk by year, with 95% comparison intervals, mixed contact dermatitis (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1996	1.83 (1.48,2.27)	2.08 (1.66,2.61)	0.94 (0.42,2.08)
1997	2.07 (1.73,2.47)	2.28 (1.88,2.77)	1.44 (0.77,2.71)
1998	1.92 (1.60,2.30)	2.13 (1.74,2.61)	1.27 (0.71,2.26)
1999	1.87 (1.55,2.27)	2.07 (1.69,2.54)	1.31 (0.78,2.19)
2000	1.58 (1.29,1.94)	1.82 (1.46,2.26)	0.79 (0.42,1.47)
2001	1.44 (1.17,1.76)	1.71 (1.39,2.11)	0.49 (0.21,1.13)
2002	1.72 (1.44,2.06)	1.98 (1.64,2.39)	0.85 (0.44,1.67)
2003	1.79 (1.50,2.13)	2.13 (1.78,2.55)	0.43 (0.18,1.04)
2004	1.79 (1.52,2.12)	2.03 (1.70,2.42)	0.94 (0.52,1.72)
2005	1.49 (1.23,1.81)	1.72 (1.41,2.10)	0.72 (0.37,1.40)
2006	1.17 (0.94,1.45)	1.30 (1.04,1.63)	0.80 (0.44,1.47)
2007	1.40 (1.15,1.71)	1.68 (1.37,2.05)	0.32 (0.12,0.86)
2008	1.23 (0.99,1.52)	1.41 (1.13,1.77)	0.46 (0.20,1.05)
2009	1.64 (1.35,2.00)	1.96 (1.60,2.39)	0.29 (0.09,0.90)
2010	1.29 (1.03,1.63)	1.37 (1.07,1.76)	1.15 (0.63,2.10)
2011	1.33 (1.04,1.69)	1.40 (1.07,1.82)	1.05 (0.57,1.95)
2012	1.49 (1.18,1.88)	1.60 (1.24,2.06)	1.06 (0.57,1.98)
2013	1.04 (0.80,1.36)	1.07 (0.80,1.44)	0.87 (0.45,1.70)
2014	1.31 (1.04,1.66)	1.35 (1.06,1.72)	1.17 (0.65,2.11)
2015	1.56 (1.24,1.95)	1.59 (1.25,2.02)	1.22 (0.70,2.14)
2016	1.00 (0.75,1.34)	0.96 (0.69,1.33)	1.05 (0.57,1.93)
2017	1.00 (0.74,1.35)	1.00 (0.72,1.39)	1.00 (0.51,1.98)

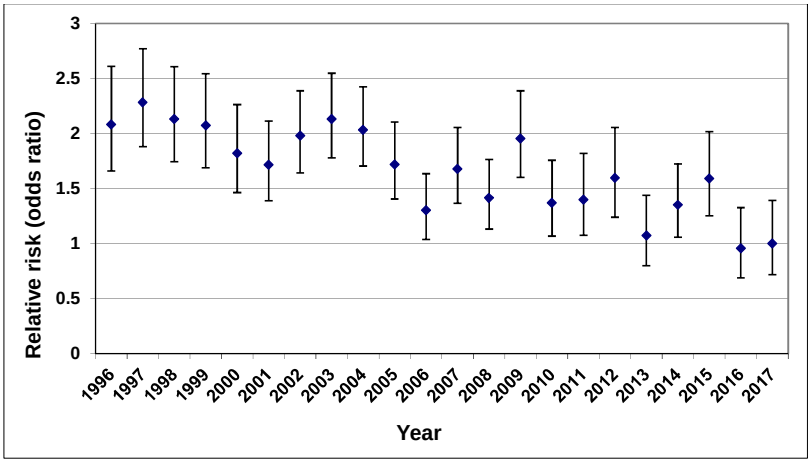
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 75

Figure 5 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, mixed contact dermatitis**

a) EPIDERM, all reporters



b) EPIDERM, core reporters



c) EPIDERM, sample reporters

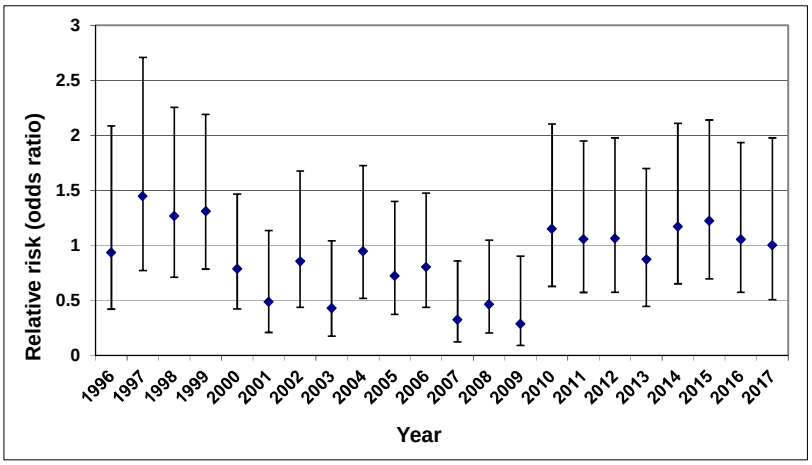


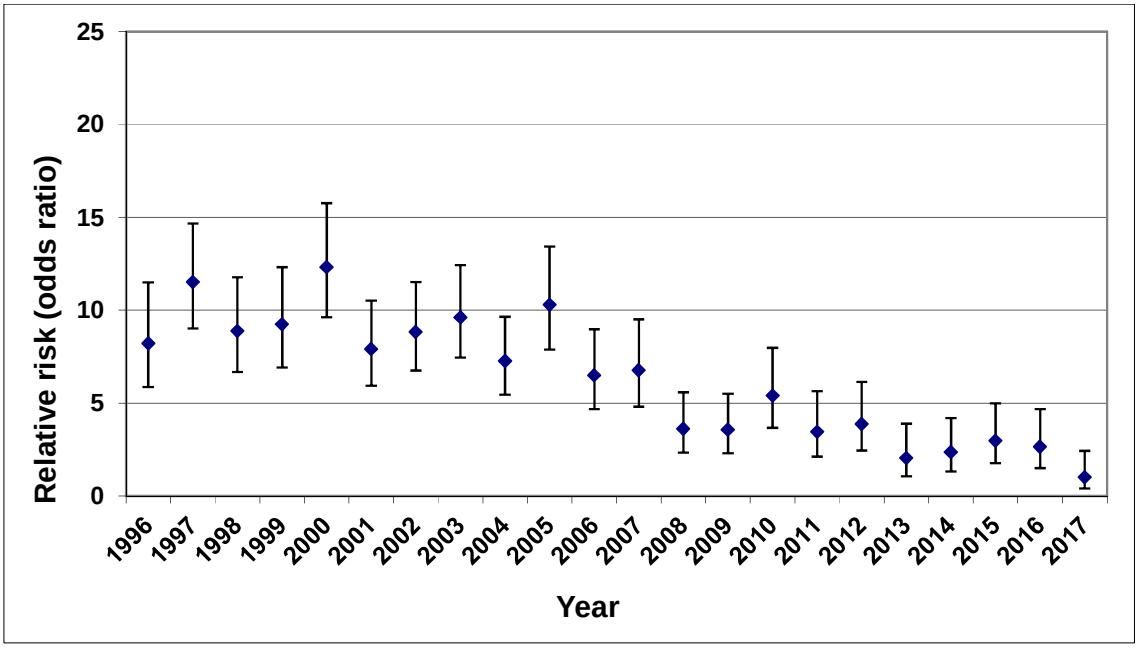
Table 10 **Relative risk by year, with 95% comparison intervals, contact urticaria (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)	
	All reporters	Core reporters
YEAR		
1996	8.22 (5.88,11.49)	10.54 (7.41,14.99)
1997	11.5 (9.02,14.67)	14.59 (11.29,18.86)
1998	8.87 (6.68,11.78)	11.38 (8.52,15.22)
1999	9.24 (6.92,12.33)	11.18 (8.23,15.18)
2000	12.32 (9.63,15.76)	16.04 (12.53,20.52)
2001	7.91 (5.94,10.53)	9.85 (7.33,13.22)
2002	8.82 (6.75,11.52)	11.40 (8.74,14.89)
2003	9.62 (7.44,12.43)	12.43 (9.63,16.06)
2004	7.26 (5.46,9.65)	8.98 (6.69,12.06)
2005	10.29 (7.89,13.44)	13.15 (10.02,17.26)
2006	6.49 (4.69,8.98)	7.2 (5.08,10.21)
2007	6.76 (4.81,9.50)	8.34 (5.89,11.8)
2008	3.62 (2.34,5.59)	4.20 (2.66,6.64)
2009	3.56 (2.31,5.50)	4.11 (2.60,6.49)
2010	5.41 (3.66,7.98)	6.45 (4.34,9.59)
2011	3.46 (2.12,5.64)	3.86 (2.29,6.52)
2012	3.88 (2.44,6.15)	4.62 (2.84,7.50)
2013	2.03 (1.06,3.89)	2.57 (1.34,4.91)
2014	2.36 (1.32,4.20)	2.45 (1.30,4.62)
2015	2.96 (1.76,4.98)	3.45 (2.01,5.91)
2016	2.64 (1.49,4.69)	2.47 (1.28,4.79)
2017	1.00 (0.41,2.43)	1.00 (0.37,2.70)

Models adjusted for reporter type (where appropriate), month 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 75

Figure 6 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, contact urticaria**

a) EPIDERM, all reporters



b) EPIDERM, core reporters

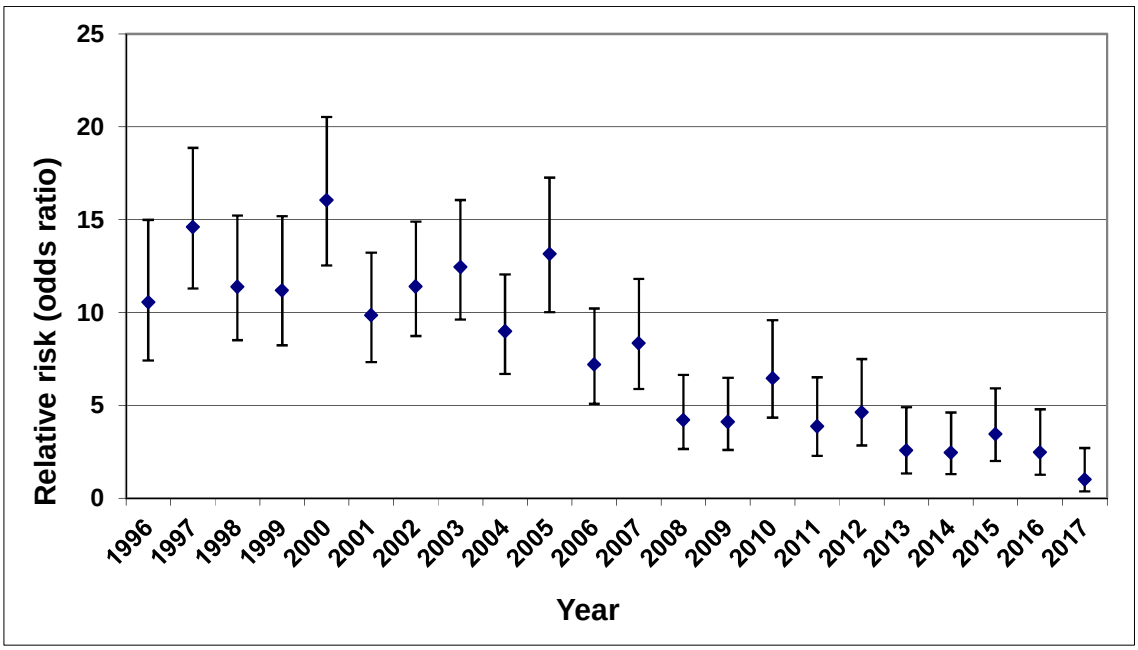


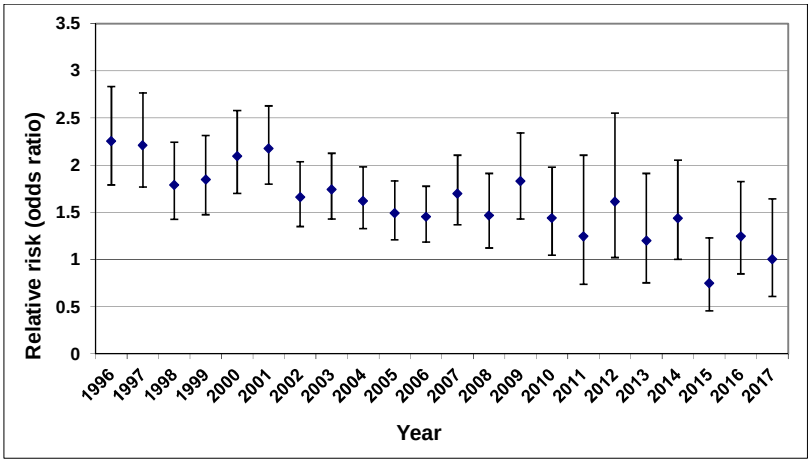
Table 11 **Relative risk by year, with 95% comparison intervals, neoplasia (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1996	2.25 (1.79,2.83)	6.80 (5.06,9.14)	0.47 (0.19,1.16)
1997	2.21 (1.77,2.77)	6.21 (4.62,8.34)	1.37 (0.76,2.46)
1998	1.79 (1.43,2.24)	4.89 (3.65,6.57)	0.92 (0.51,1.64)
1999	1.85 (1.48,2.31)	5.58 (4.15,7.49)	0.68 (0.37,1.27)
2000	2.09 (1.70,2.58)	5.95 (4.49,7.89)	1.00 (0.59,1.68)
2001	2.17 (1.80,2.63)	5.73 (4.36,7.51)	1.72 (1.11,2.66)
2002	1.66 (1.35,2.04)	4.45 (3.36,5.88)	1.16 (0.67,2.01)
2003	1.74 (1.43,2.13)	4.75 (3.62,6.24)	1.07 (0.62,1.83)
2004	1.62 (1.33,1.98)	4.19 (3.16,5.54)	1.35 (0.84,2.17)
2005	1.49 (1.21,1.83)	4.23 (3.20,5.60)	0.79 (0.44,1.42)
2006	1.45 (1.19,1.78)	3.44 (2.58,4.59)	1.74 (1.18,2.56)
2007	1.70 (1.37,2.11)	4.35 (3.21,5.89)	1.65 (1.08,2.54)
2008	1.46 (1.12,1.91)	4.00 (2.86,5.61)	1.05 (0.59,1.86)
2009	1.83 (1.43,2.34)	4.20 (3.04,5.80)	1.87 (1.15,3.06)
2010	1.44 (1.04,1.98)	3.17 (2.07,4.86)	1.47 (0.88,2.46)
2011	1.24 (0.74,2.11)	1.84 (0.57,5.95)	1.16 (0.65,2.09)
2012	1.61 (1.02,2.55)	1.45 (0.35,6.04)	1.67 (1.04,2.69)
2013	1.20 (0.75,1.91)	1.33 (0.52,3.40)	1.10 (0.62,1.96)
2014	1.44 (1.00,2.05)	1.64 (0.91,2.98)	1.12 (0.62,2.00)
2015	0.75 (0.46,1.23)	0.61 (0.25,1.48)	1.15 (0.59,2.24)
2016	1.24 (0.85,1.83)	1.23 (0.67,2.25)	1.29 (0.69,2.41)
2017	1.00 (0.61,1.64)	1.00 (0.40,2.48)	1.00 (0.51,1.97)

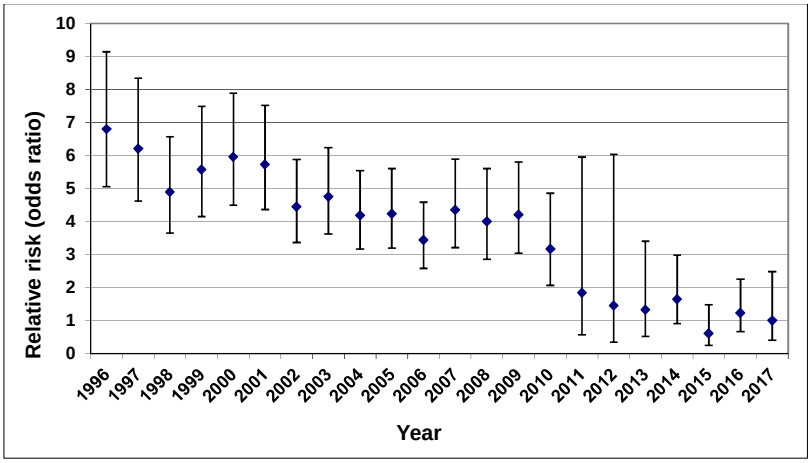
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 75

Figure 7 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, neoplasia**

a) EPIDERM, all reporters



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



c) EPIDERM, sample reporters

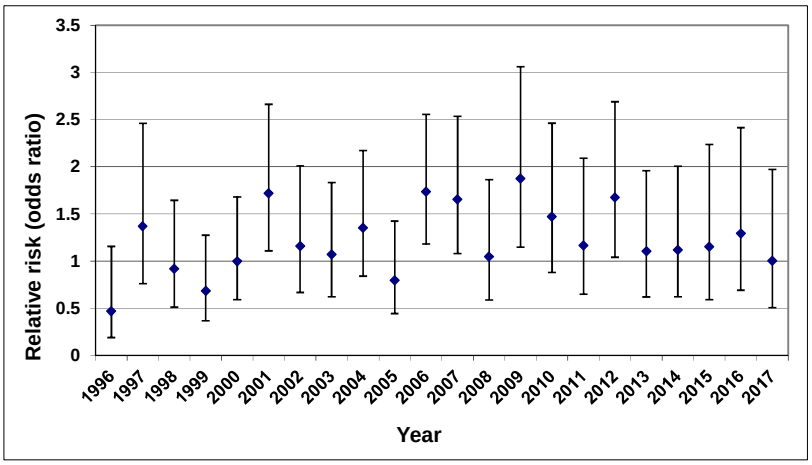


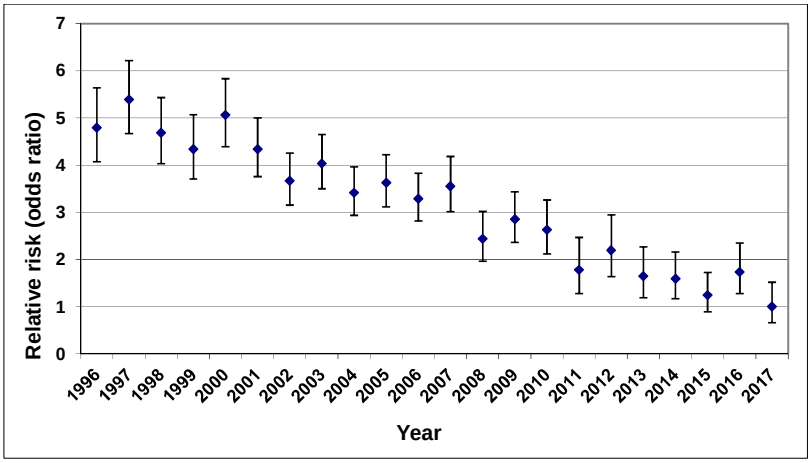
Table 12 **Relative risk by year, with 95% comparison intervals, other (than contact dermatitis) skin (2017 estimate = 1), as reported by dermatologists to EPIDERM**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1996	4.79 (4.07,5.64)	8.41 (7.12,9.94)	0.91 (0.49,1.70)
1997	5.39 (4.67,6.22)	8.88 (7.67,10.29)	1.86 (1.18,2.93)
1998	4.68 (4.03,5.43)	7.62 (6.50,8.94)	1.64 (1.10,2.43)
1999	4.34 (3.71,5.07)	7.41 (6.28,8.75)	1.31 (0.86,1.99)
2000	5.06 (4.39,5.83)	8.88 (7.65,10.30)	1.18 (0.77,1.81)
2001	4.33 (3.75,5.00)	6.92 (5.94,8.07)	1.86 (1.28,2.70)
2002	3.66 (3.15,4.26)	5.94 (5.08,6.95)	1.37 (0.87,2.15)
2003	4.03 (3.50,4.65)	6.73 (5.80,7.81)	1.16 (0.73,1.83)
2004	3.41 (2.94,3.96)	5.31 (4.51,6.24)	1.66 (1.14,2.42)
2005	3.63 (3.12,4.22)	6.18 (5.27,7.24)	1.04 (0.66,1.65)
2006	3.28 (2.82,3.83)	4.72 (3.96,5.62)	2.20 (1.60,3.01)
2007	3.55 (3.01,4.18)	5.65 (4.73,6.76)	1.73 (1.17,2.54)
2008	2.43 (1.96,3.02)	3.83 (3.03,4.83)	1.18 (0.72,1.95)
2009	2.85 (2.36,3.44)	4.13 (3.35,5.09)	1.97 (1.28,3.01)
2010	2.63 (2.12,3.26)	3.86 (3.02,4.94)	1.53 (0.96,2.44)
2011	1.78 (1.28,2.47)	2.06 (1.33,3.19)	1.42 (0.87,2.32)
2012	2.19 (1.63,2.95)	2.93 (2.01,4.26)	1.42 (0.89,2.26)
2013	1.64 (1.19,2.27)	2.07 (1.38,3.10)	1.10 (0.66,1.84)
2014	1.59 (1.17,2.16)	1.94 (1.33,2.83)	1.00 (0.58,1.71)
2015	1.24 (0.89,1.73)	1.34 (0.89,2.02)	1.11 (0.63,1.97)
2016	1.73 (1.28,2.35)	1.78 (1.22,2.60)	1.64 (1.01,2.66)
2017	1.00 (0.66,1.52)	1.00 (0.58,1.73)	1.00 (0.53,1.88)

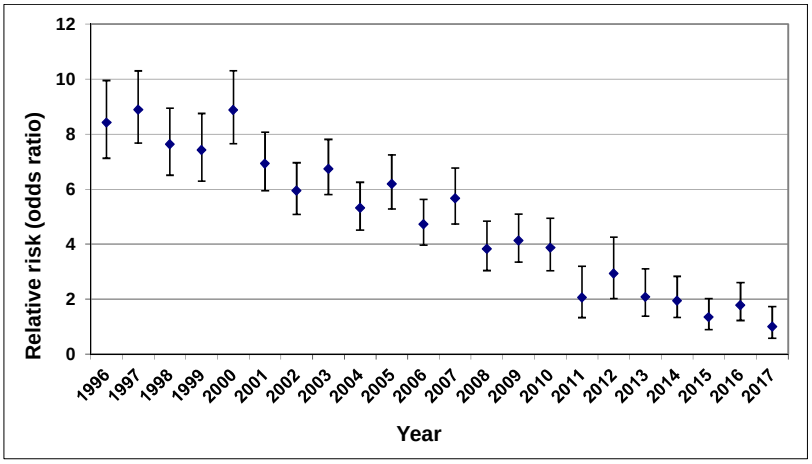
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B2 on page 75

Figure 8 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, skin (other than contact dermatitis)**

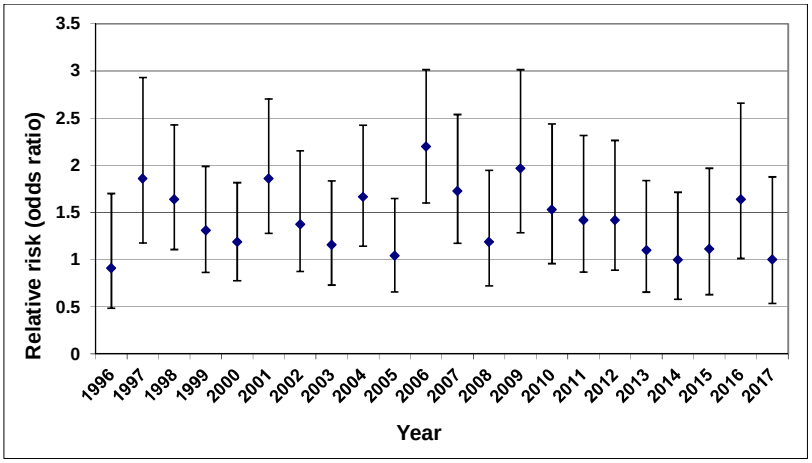
a) EPIDERM, all reporters



b) EPIDERM, core reporters (note scale change)



c) EPIDERM, sample reporters (note scale change)



3.2.2 WORK-RELATED RESPIRATORY DISEASE – CHEST PHYSICIANS

The average annual percentage change in risk of work-related respiratory disease, as reported by chest physicians to SWORD is shown in Table 13, whilst the relative risks by year are shown in Tables 14 to 21 and Figures 9 to 16.

The average annual percentage change in reported incidence of total respiratory disease (1999-2017) was -2.9% (95% CIs: -3.5, -2.3), which is slightly less than reported last year (-3.2%; 95% CIs: -3.8, -2.5). Similar to the pattern observed for total skin disease, the graphs (Figure 9) showing relative risk 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 change in the incidence of asthma between 1999 and 2017 was -6.4% (95% CIs: -7.5, -5.3). This compared to -6.8% (95% CIs: -7.9, -5.6) for the period 1999-2016. Figure 10 suggests an overall decrease in incidence until 2007, followed by a relatively flat trend until 2014 with some evidence of an increase in incidence thereafter. Analyses of shorter-term trends showed a much smaller annual average change of -1.0% (95% CIs: -3.8, 2.0) per year for the period 2007-2017 and an annual average increase of 16.8% (95% CIs: 1.9, 33.8) for the period 2014 to 2017.

A change in incidence was also observed for mesothelioma and benign pleural disease at -3.6% (95% CIs: -4.8, -2.4) and -1.5 (95% CIs: -2.5, -0.6) per year, respectively. For pneumoconiosis, an overall increase in incidence was observed at 3.6% (95% CIs: 1.8, 5.3) per year. The graph showing relative risk by year (Figure 15) for pneumoconiosis suggests a relatively flat trend in the earlier part of the study period (1999 to 2007), followed by a general increasing trend until 2013 and then a relatively flat trend thereafter. Analysis of shorter term trends (from 2007 to 2017) for pneumoconiosis suggested an annual average increase of 8.2% (95% CIs: 4.6, 11.9). Overall there was little variation by reporter type ('core' and 'sample').

After adjusting the average annual percentage change in incidence of total work-related respiratory disease for the impact of excess zeros (using the ZINB model), the annual decline changed from -2.9% (95% CIs: -3.5, -2.3) to -1.8% (95% CIs: -2.4,-1.2).

Table 13 **Average annual percentage change in reported incidence in work-related respiratory disease as reported by chest physicians to SWORD**

		ESTIMATED % CHANGE (95% CONFIDENCE INTERVAL)		
		SWORD		
		All reporters	Core reporters	Sample reporters
	Year (continuous)			
Total respiratory	**1999-2017**	-2.9 (-3.5, -2.3)	-2.9 (-3.7, -2.2)	-2.6 (-3.7, -1.6)
	2007-2017	-2.0 (-3.4, -0.6)	-1.2 (-2.8, 0.5)	-3.5 (-5.9, -1.1)
	2014-2017	2.8 (-3.4, 9.5)	10.8 (2.3, 19.9)	-5.5 (-14.4, 4.3)
Asthma	**1999-2017**	-6.4 (-7.5, -5.3)	-6.0 (-7.3, -4.7)	-8.0 (-10.6, -5.4)
	2007-2017	-1.0 (-3.8, 2.0)	0.0 (-3.2, 3.3)	-6.2 (-13.1, 1.3)
	2014-2017[a]	16.8 (1.9, 33.8)	/	/
Mesothelioma	**1999-2017**	-3.6 (-4.8, -2.4)	-4.1 (-5.8, -2.3)	-3.2 (-4.8, -1.6)
Benign pleural disease	**1999-2017**	-1.5 (-2.5, -0.6)	-1.9 (-3.1, -0.8)	-0.6 (-2.3, 1.1)
• **Predominantly plaques**	**1999-2017**	-1.3 (-2.4, -0.2)	-1.9 (-3.2, -0.6)	0.0 (-1.9, 2.0)
• **Predominantly diffuse**	**1999-2017**	-1.6 (-3.3, 0.2)	-2.6 (-4.5, -0.5)	1.8 (-2.0, 5.7)
Pneumoconiosis	**1999-2017**	3.6 (1.8, 5.3)	4.7 (2.5, 6.9)	1.2 (-1.8, 4.3)
	2007-2017	8.2 (4.6, 11.9)	9.9 (5.5, 14.4)	3.7 (-3.0, 10.8)
Other[b] **respiratory disease**	**1999-2017**	-1.2 (-2.5, 0.2)	-1.0 (-2.7, 0.7)	-0.9 (-3.3, 1.6)

[a]Number of cases not sufficient to enable meaningful analyses at the level of reporter type (core, sample)
[b]Other than those specified above
Models adjusted for reporter type (where appropriate), month 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 83

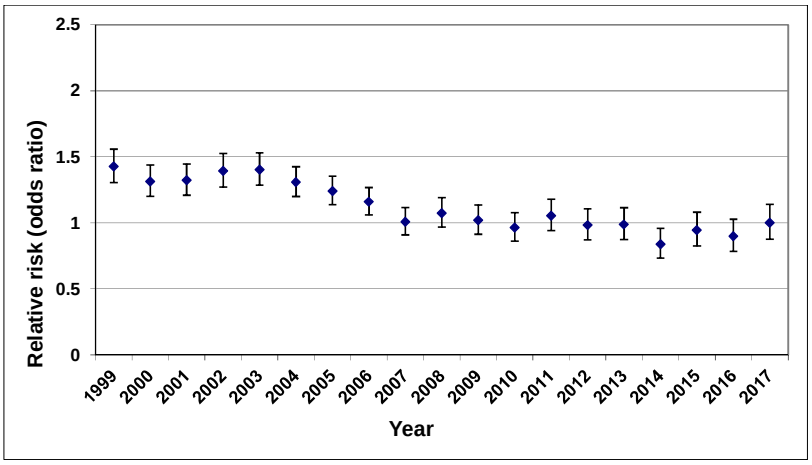
Table 14 **Relative risk by year, with 95% comparison intervals, total respiratory disease (2017 estimate = 1), as reported by chest physicians to SWORD**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1999	1.43 (1.31,1.56)	1.22 (1.10,1.36)	1.83 (1.55,2.15)
2000	1.31 (1.20,1.44)	1.16 (1.04,1.29)	1.56 (1.32,1.86)
2001	1.32 (1.21,1.45)	1.21 (1.09,1.34)	1.41 (1.17,1.69)
2002	1.39 (1.27,1.53)	1.31 (1.18,1.46)	1.35 (1.12,1.64)
2003	1.40 (1.29,1.53)	1.36 (1.24,1.50)	1.15 (0.94,1.41)
2004	1.31 (1.20,1.43)	1.26 (1.14,1.38)	1.15 (0.95,1.40)
2005	1.24 (1.14,1.35)	1.12 (1.02,1.24)	1.38 (1.16,1.65)
2006	1.16 (1.06,1.27)	1.02 (0.92,1.14)	1.40 (1.17,1.68)
2007	1.01 (0.91,1.12)	0.85 (0.75,0.96)	1.32 (1.09,1.58)
2008	1.07 (0.97,1.19)	0.92 (0.81,1.05)	1.33 (1.11,1.59)
2009	1.02 (0.91,1.14)	0.89 (0.78,1.01)	1.20 (0.98,1.47)
2010	0.96 (0.86,1.08)	0.86 (0.76,0.98)	1.06 (0.86,1.32)
2011	1.05 (0.94,1.18)	0.91 (0.80,1.05)	1.28 (1.04,1.56)
2012	0.98 (0.87,1.11)	0.87 (0.76,1.01)	1.12 (0.89,1.40)
2013	0.99 (0.87,1.11)	0.83 (0.71,0.96)	1.26 (1.02,1.55)
2014	0.84 (0.73,0.96)	0.68 (0.58,0.81)	1.08 (0.86,1.36)
2015	0.94 (0.83,1.08)	0.81 (0.68,0.95)	1.11 (0.86,1.42)
2016	0.90 (0.79,1.03)	0.91 (0.78,1.06)	0.87 (0.67,1.14)
2017	1.00 (0.88,1.14)	1.00 (0.86,1.17)	1.00 (0.78,1.29)

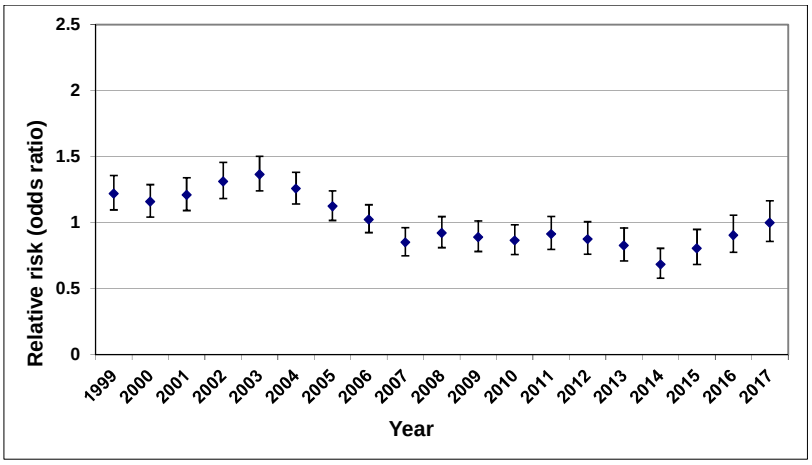
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 9 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, total respiratory disease**

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters

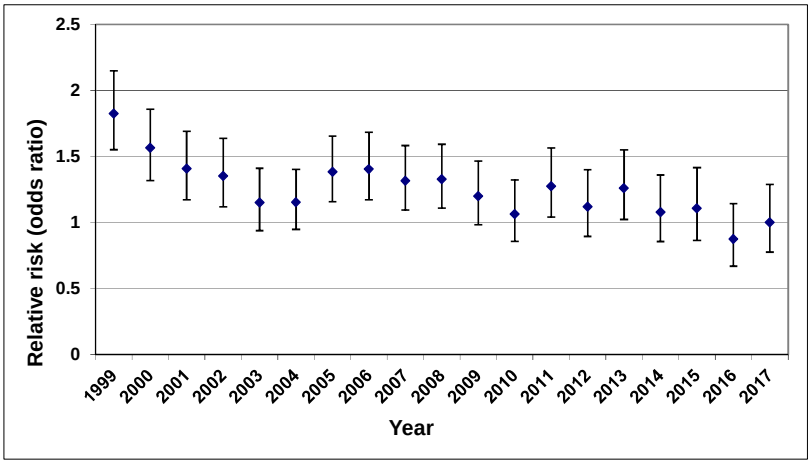


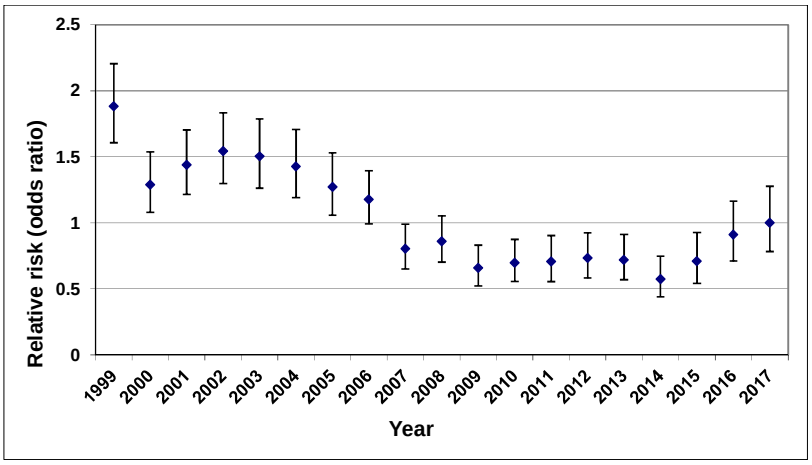
Table 15 **Relative risk by year, with 95% comparison intervals, asthma (2017 estimate = 1), as reported by chest physicians to SWORD**

	Relative risk (95% comparison interval)		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.88 (1.61,2.21)	1.62 (1.35,1.94)	2.83 (2.03,3.95)
2000	1.29 (1.08,1.54)	1.10 (0.90,1.34)	1.90 (1.29,2.80)
2001	1.44 (1.22,1.70)	1.34 (1.11,1.62)	1.31 (0.81,2.11)
2002	1.54 (1.3,1.83)	1.44 (1.19,1.75)	1.39 (0.86,2.24)
2003	1.50 (1.26,1.79)	1.44 (1.19,1.74)	1.11 (0.66,1.85)
2004	1.43 (1.19,1.71)	1.38 (1.13,1.68)	0.96 (0.55,1.65)
2005	1.27 (1.06,1.53)	1.17 (0.96,1.44)	1.27 (0.80,2.01)
2006	1.18 (0.99,1.39)	1.05 (0.87,1.26)	1.67 (1.08,2.58)
2007	0.80 (0.65,0.99)	0.72 (0.57,0.91)	0.97 (0.56,1.68)
2008	0.86 (0.70,1.05)	0.76 (0.61,0.96)	1.20 (0.72,1.99)
2009	0.66 (0.52,0.83)	0.60 (0.47,0.77)	0.73 (0.38,1.42)
2010	0.70 (0.56,0.88)	0.63 (0.49,0.81)	0.87 (0.47,1.63)
2011	0.71 (0.55,0.90)	0.67 (0.52,0.87)	0.62 (0.29,1.31)
2012	0.73 (0.58,0.93)	0.67 (0.53,0.86)	0.85 (0.43,1.67)
2013	0.72 (0.57,0.91)	0.66 (0.52,0.86)	0.71 (0.35,1.43)
2014	0.57 (0.44,0.75)	0.52 (0.39,0.69)	0.67 (0.32,1.42)
2015	0.71 (0.54,0.93)	0.72 (0.54,0.95)	0.42 (0.15,1.12)
2016	0.91 (0.71,1.16)	0.99 (0.76,1.28)	0.30 (0.10,0.93)
2017	1.00 (0.78,1.28)	1.00 (0.77,1.30)	1.00 (0.51,1.96)

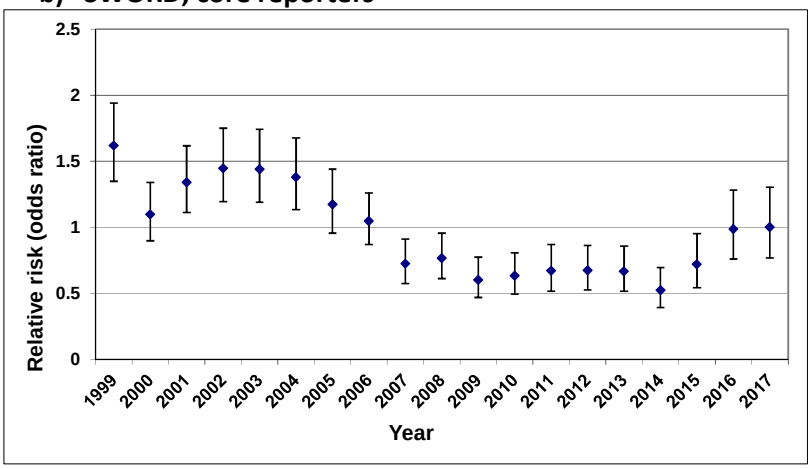
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 10 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, asthma**

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters (note scale change)

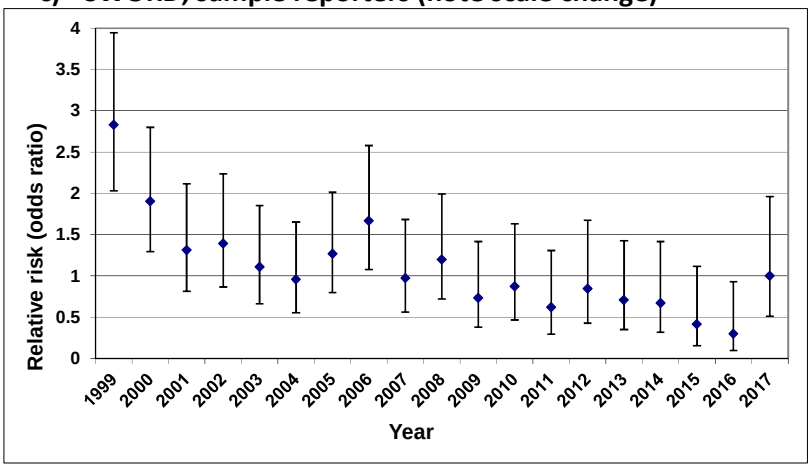


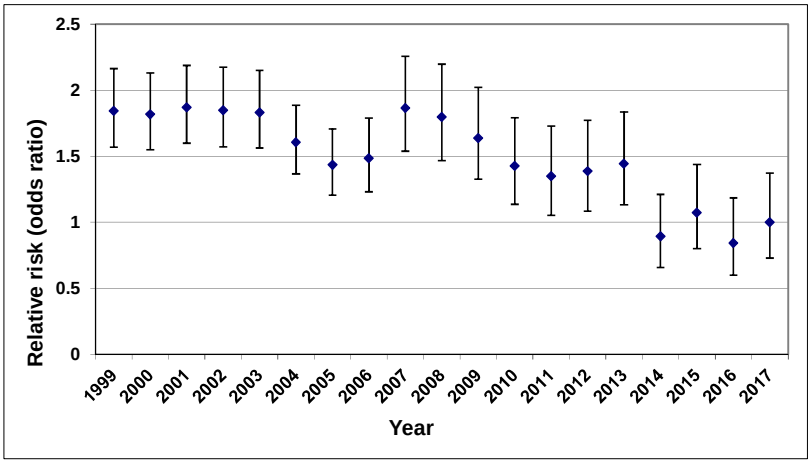
Table 16 **Relative risk by year, with 95% comparison intervals, mesothelioma (2017 estimate = 1), as reported by chest physicians to SWORD**

	Relative risk (95% comparison interval)		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.84 (1.57,2.16)	1.86 (1.50,2.31)	1.80 (1.40,2.31)
2000	1.82 (1.55,2.13)	2.02 (1.65,2.48)	1.53 (1.17,2.00)
2001	1.87 (1.60,2.19)	2.02 (1.65,2.46)	1.67 (1.29,2.17)
2002	1.85 (1.57,2.17)	2.06 (1.69,2.52)	1.55 (1.17,2.05)
2003	1.83 (1.56,2.15)	2.13 (1.76,2.59)	1.38 (1.04,1.84)
2004	1.60 (1.37,1.88)	1.90 (1.57,2.30)	1.17 (0.86,1.58)
2005	1.43 (1.20,1.71)	1.61 (1.29,2.00)	1.18 (0.88,1.59)
2006	1.48 (1.23,1.79)	1.77 (1.40,2.24)	1.12 (0.82,1.53)
2007	1.86 (1.54,2.26)	1.94 (1.48,2.56)	1.65 (1.27,2.15)
2008	1.80 (1.47,2.20)	2.46 (1.87,3.23)	1.19 (0.88,1.61)
2009	1.64 (1.33,2.02)	2.06 (1.55,2.72)	1.16 (0.84,1.61)
2010	1.43 (1.14,1.79)	1.59 (1.17,2.16)	1.20 (0.86,1.67)
2011	1.35 (1.05,1.73)	1.62 (1.17,2.25)	1.03 (0.71,1.48)
2012	1.39 (1.08,1.77)	1.29 (0.89,1.85)	1.38 (1.00,1.91)
2013	1.44 (1.13,1.84)	1.36 (0.94,1.98)	1.40 (1.02,1.92)
2014	0.89 (0.66,1.21)	0.78 (0.49,1.23)	0.88 (0.58,1.33)
2015	1.07 (0.80,1.44)	0.89 (0.57,1.40)	1.08 (0.72,1.62)
2016	0.84 (0.60,1.18)	1.01 (0.62,1.62)	0.71 (0.44,1.15)
2017	1.00 (0.73,1.37)	1.00 (0.62,1.62)	1.00 (0.66,1.51)

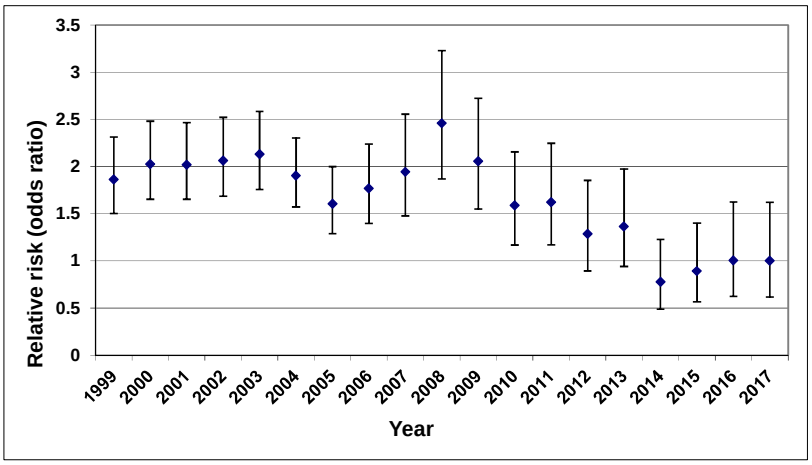
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 11 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, mesothelioma**

a) SWORD, all reporters



b) SWORD, core reporters (note scale change)



c) SWORD, sample reporters

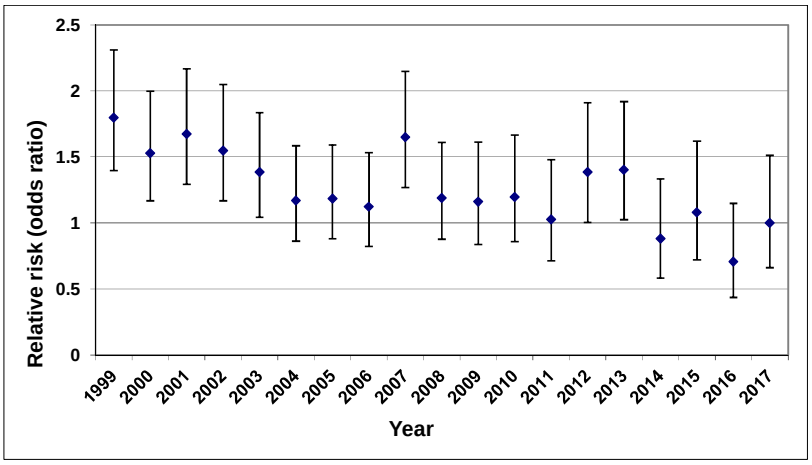


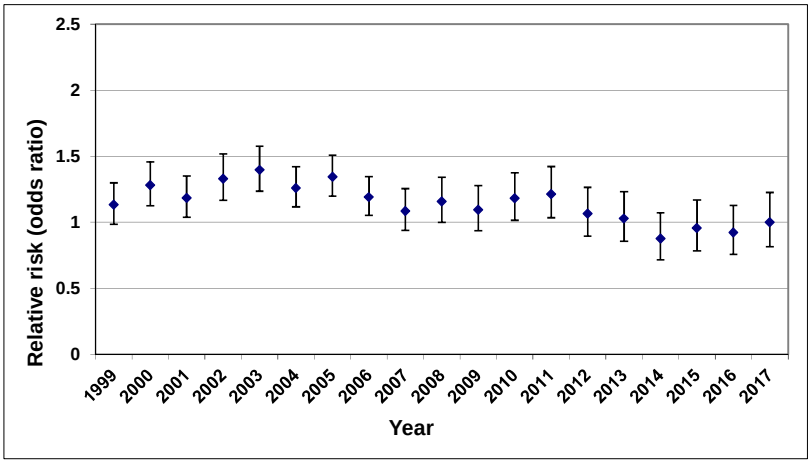
Table 17 Relative risk by year, with 95% comparison intervals, benign pleural plaques (2017 estimate = 1), as reported by chest physicians to SWORD

	Relative risk (95% comparison interval)		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.13 (0.98,1.30)	1.01 (0.86,1.18)	1.57 (1.18,2.10)
2000	1.28 (1.13,1.46)	1.20 (1.04,1.39)	1.45 (1.09,1.94)
2001	1.18 (1.04,1.35)	1.17 (1.02,1.35)	1.01 (0.71,1.44)
2002	1.33 (1.17,1.52)	1.31 (1.13,1.51)	1.18 (0.83,1.66)
2003	1.40 (1.24,1.58)	1.38 (1.21,1.57)	1.17 (0.84,1.62)
2004	1.26 (1.12,1.42)	1.20 (1.05,1.37)	1.26 (0.93,1.71)
2005	1.34 (1.20,1.51)	1.21 (1.06,1.37)	1.88 (1.46,2.42)
2006	1.19 (1.05,1.35)	1.00 (0.86,1.15)	1.95 (1.52,2.50)
2007	1.08 (0.94,1.26)	0.95 (0.81,1.13)	1.44 (1.08,1.92)
2008	1.16 (1.00,1.34)	0.95 (0.80,1.14)	1.73 (1.33,2.24)
2009	1.09 (0.94,1.28)	0.94 (0.78,1.13)	1.46 (1.09,1.95)
2010	1.18 (1.02,1.37)	1.08 (0.91,1.28)	1.34 (0.98,1.84)
2011	1.21 (1.03,1.42)	1.06 (0.88,1.28)	1.56 (1.16,2.11)
2012	1.06 (0.89,1.26)	0.94 (0.77,1.15)	1.36 (0.98,1.89)
2013	1.03 (0.86,1.23)	0.88 (0.71,1.10)	1.34 (0.96,1.86)
2014	0.88 (0.72,1.07)	0.73 (0.58,0.94)	1.14 (0.78,1.65)
2015	0.96 (0.78,1.17)	0.74 (0.58,0.95)	1.43 (1.00,2.04)
2016	0.92 (0.76,1.13)	0.86 (0.68,1.09)	1.12 (0.76,1.66)
2017	1.00 (0.82,1.22)	1.00 (0.80,1.26)	1.00 (0.66,1.52)

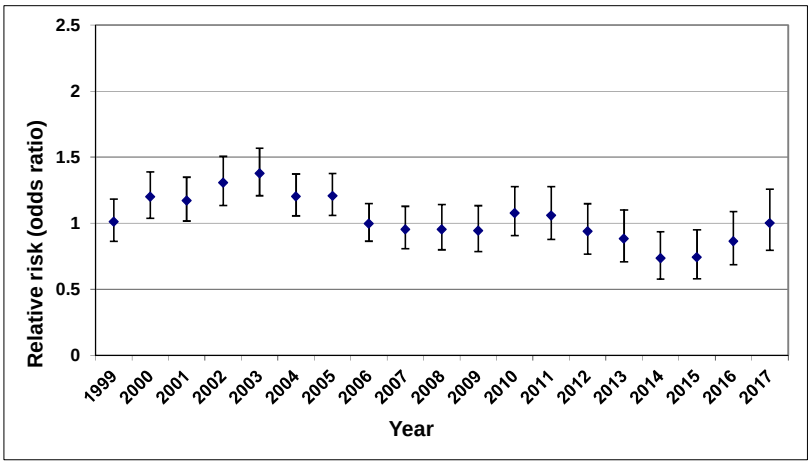
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 12 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, benign pleural plaques**

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters

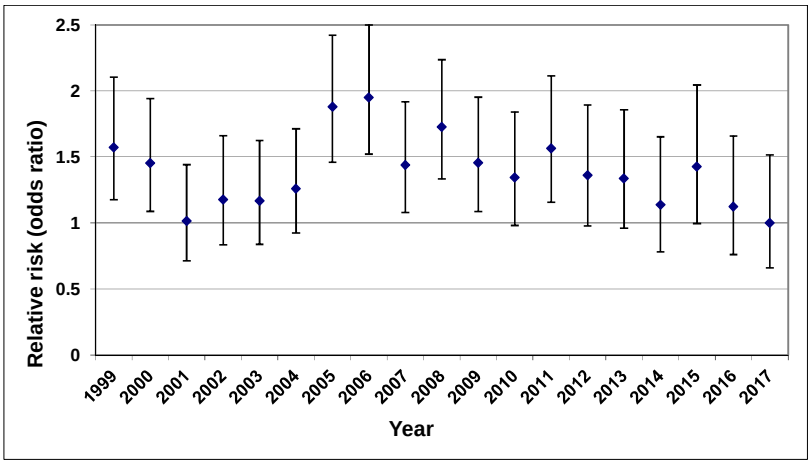


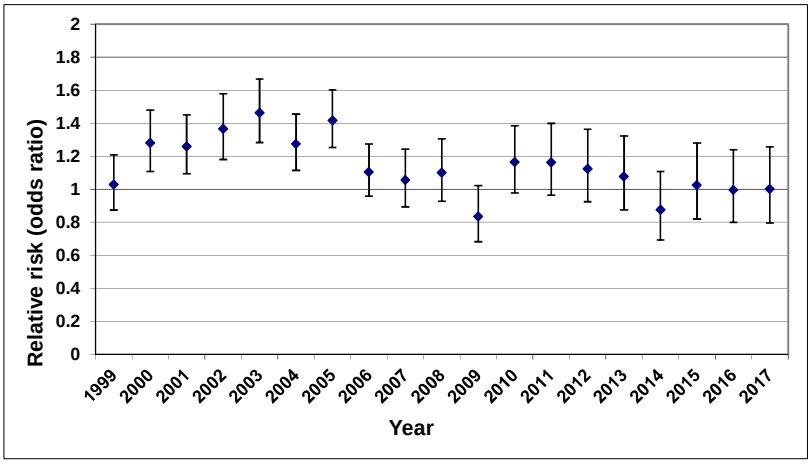
Table 18 **Relative risk by year, with 95% comparison intervals, benign pleural plaques – predominantly plaques (2017 estimate = 1), as reported by chest physicians to SWORD**

	Relative risk (95% comparison interval)		
	All reporters	Core reporters	Sample reporters
YEAR			
1999	1.03 (0.87,1.21)	1.03 (0.87,1.21)	0.85 (0.55,1.31)
2000	1.28 (1.11,1.48)	1.19 (1.02,1.38)	1.59 (1.16,2.20)
2001	1.26 (1.09,1.45)	1.22 (1.05,1.43)	1.26 (0.88,1.81)
2002	1.36 (1.18,1.58)	1.33 (1.14,1.56)	1.32 (0.91,1.90)
2003	1.46 (1.28,1.67)	1.42 (1.23,1.64)	1.42 (1.01,2.00)
2004	1.27 (1.11,1.45)	1.26 (1.09,1.46)	1.04 (0.71,1.52)
2005	1.42 (1.25,1.60)	1.28 (1.11,1.47)	2.05 (1.56,2.69)
2006	1.10 (0.96,1.27)	0.94 (0.80,1.11)	1.78 (1.33,2.39)
2007	1.05 (0.89,1.24)	0.95 (0.79,1.15)	1.32 (0.94,1.85)
2008	1.10 (0.93,1.31)	0.98 (0.81,1.2)	1.38 (0.99,1.93)
2009	0.83 (0.68,1.02)	0.84 (0.68,1.05)	0.64 (0.39,1.04)
2010	1.16 (0.98,1.38)	1.04 (0.85,1.27)	1.47 (1.04,2.09)
2011	1.16 (0.96,1.40)	1.05 (0.85,1.31)	1.38 (0.96,1.99)
2012	1.12 (0.92,1.36)	0.97 (0.77,1.23)	1.54 (1.08,2.20)
2013	1.08 (0.88,1.32)	0.90 (0.70,1.16)	1.51 (1.06,2.16)
2014	0.88 (0.69,1.11)	0.69 (0.52,0.93)	1.32 (0.88,1.97)
2015	1.02 (0.82,1.28)	0.76 (0.58,1.01)	1.67 (1.13,2.46)
2016	1.00 (0.80,1.24)	0.96 (0.74,1.23)	1.15 (0.73,1.81)
2017	1.00 (0.80,1.26)	1.00 (0.77,1.30)	1.00 (0.62,1.62)

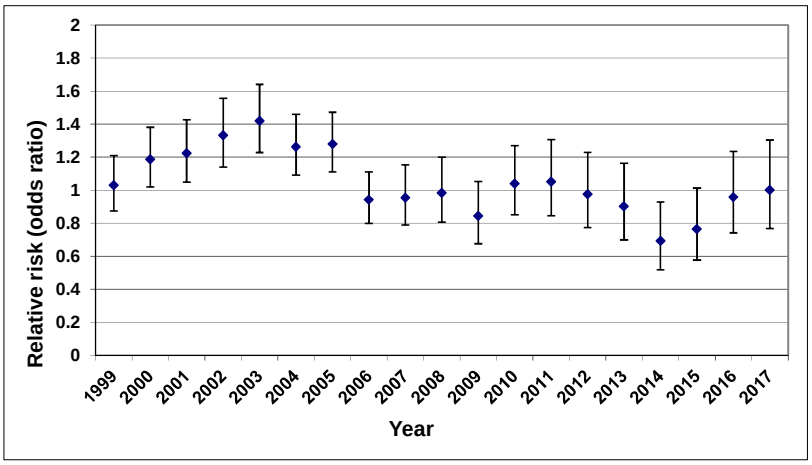
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 13 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, benign pleural plaques – predominantly plaques**

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters (note scale change)

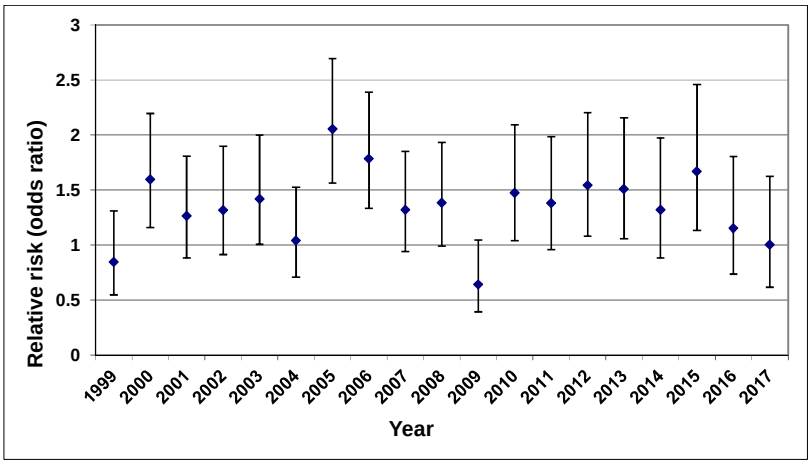


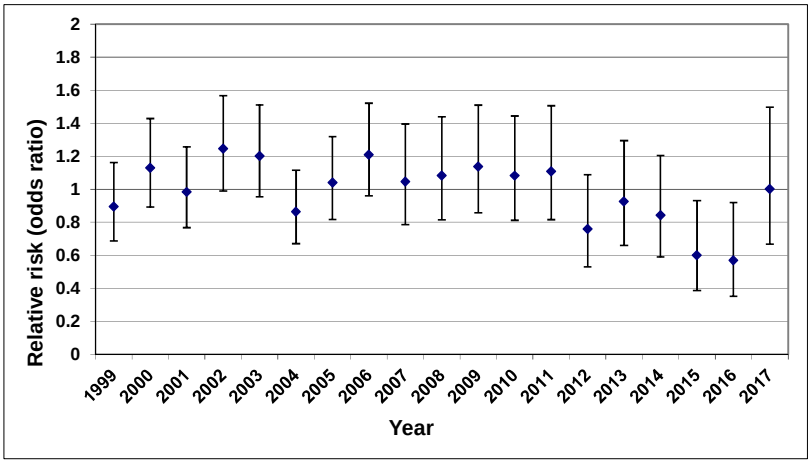
Table 19 **Relative risk by year, with 95% comparison intervals, benign pleural plaques – predominantly diffuse (2017 estimate = 1), as reported by chest physicians to SWORD**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1999	0.89 (0.69,1.16)	1.05 (0.80,1.39)	0.55 (0.23,1.33)
2000	1.13 (0.89,1.43)	1.38 (1.08,1.76)	0.49 (0.20,1.20)
2001	0.98 (0.77,1.26)	1.21 (0.93,1.56)	0.40 (0.15,1.08)
2002	1.25 (0.99,1.57)	1.48 (1.16,1.88)	0.83 (0.39,1.74)
2003	1.20 (0.95,1.51)	1.45 (1.14,1.84)	0.62 (0.28,1.37)
2004	0.86 (0.67,1.12)	1.07 (0.82,1.40)	0.28 (0.09,0.87)
2005	1.04 (0.82,1.32)	1.14 (0.87,1.47)	1.31 (0.74,2.32)
2006	1.21 (0.96,1.52)	1.21 (0.93,1.57)	1.73 (1.06,2.80)
2007	1.05 (0.78,1.40)	1.00 (0.71,1.40)	1.33 (0.77,2.31)
2008	1.08 (0.81,1.44)	1.02 (0.73,1.43)	1.39 (0.82,2.36)
2009	1.14 (0.86,1.51)	1.05 (0.75,1.46)	1.62 (0.96,2.74)
2010	1.08 (0.81,1.44)	1.30 (0.97,1.75)	0.33 (0.10,1.02)
2011	1.11 (0.82,1.51)	1.11 (0.79,1.58)	1.22 (0.64,2.34)
2012	0.76 (0.53,1.09)	0.86 (0.59,1.25)	0.45 (0.15,1.39)
2013	0.92 (0.66,1.29)	0.92 (0.63,1.36)	0.97 (0.48,1.97)
2014	0.84 (0.59,1.20)	0.89 (0.60,1.32)	0.66 (0.28,1.59)
2015	0.60 (0.39,0.93)	0.65 (0.40,1.05)	0.43 (0.14,1.35)
2016	0.57 (0.35,0.92)	0.58 (0.33,1.01)	0.55 (0.20,1.48)
2017	1.00 (0.67,1.50)	1.00 (0.62,1.61)	1.00 (0.46,2.16)

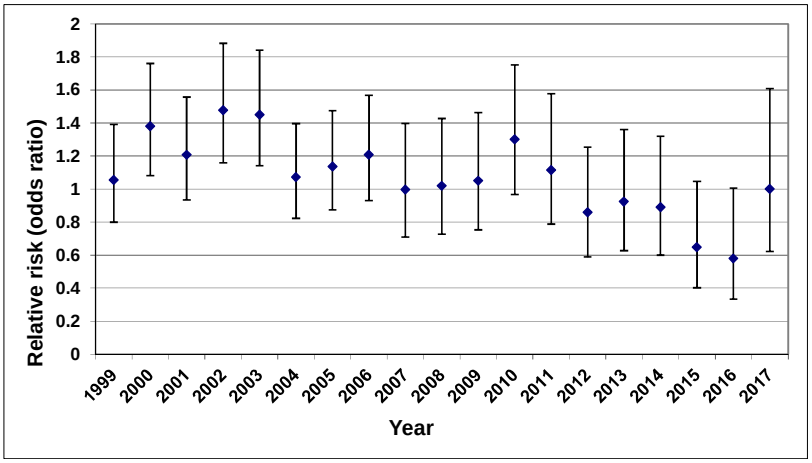
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 14 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, benign pleural plaques – predominantly diffuse**

a) SWORD, all reporters



b) SWORD, core reporters (note scale change)



c) SWORD, sample reporters

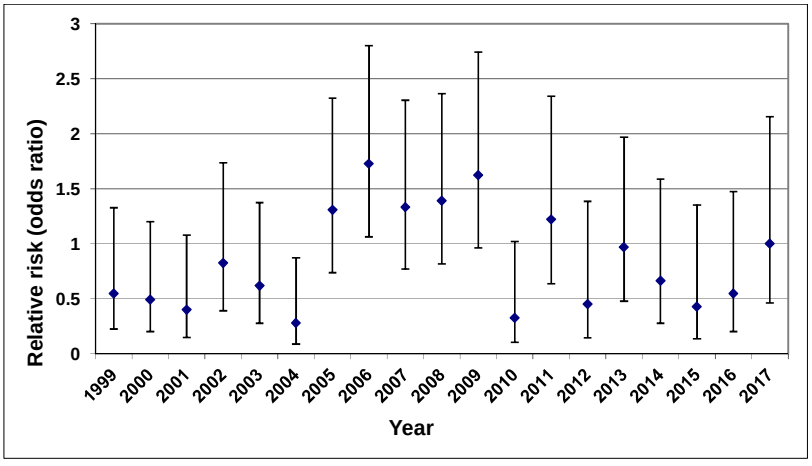


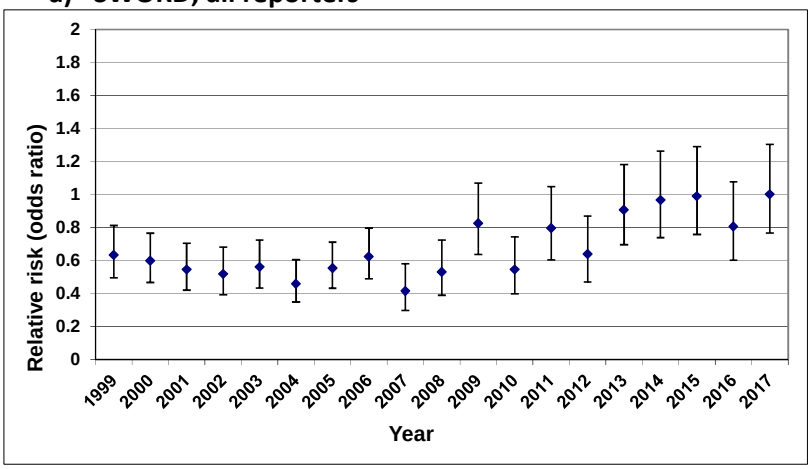
Table 20 **Relative risk by year, with 95% comparison intervals, pneumoconiosis (2017 estimate = 1), as reported by chest physicians to SWORD**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1999	0.63 (0.50,0.81)	0.45 (0.33,0.60)	2.01 (1.29,3.15)
2000	0.60 (0.47,0.77)	0.48 (0.36,0.64)	1.25 (0.71,2.20)
2001	0.54 (0.42,0.71)	0.40 (0.30,0.55)	1.57 (0.94,2.62)
2002	0.52 (0.39,0.68)	0.45 (0.34,0.61)	0.65 (0.29,1.46)
2003	0.56 (0.43,0.72)	0.49 (0.37,0.65)	0.75 (0.36,1.58)
2004	0.46 (0.35,0.60)	0.42 (0.32,0.57)	0.37 (0.14,1.00)
2005	0.55 (0.43,0.71)	0.46 (0.35,0.61)	1.10 (0.62,1.97)
2006	0.62 (0.49,0.80)	0.54 (0.41,0.71)	1.06 (0.58,1.94)
2007	0.42 (0.30,0.58)	0.30 (0.20,0.46)	1.11 (0.62,1.98)
2008	0.53 (0.39,0.72)	0.44 (0.30,0.63)	1.13 (0.63,2.05)
2009	0.82 (0.64,1.07)	0.75 (0.56,1.00)	1.13 (0.61,2.10)
2010	0.54 (0.40,0.74)	0.51 (0.36,0.71)	0.71 (0.32,1.57)
2011	0.80 (0.60,1.05)	0.67 (0.48,0.92)	1.63 (0.95,2.80)
2012	0.64 (0.47,0.87)	0.55 (0.38,0.78)	1.20 (0.62,2.32)
2013	0.91 (0.70,1.18)	0.74 (0.54,1.02)	1.93 (1.18,3.15)
2014	0.97 (0.74,1.26)	0.75 (0.54,1.04)	2.28 (1.41,3.68)
2015	0.99 (0.76,1.29)	0.90 (0.66,1.21)	1.71 (0.96,3.07)
2016	0.81 (0.60,1.08)	0.77 (0.55,1.07)	1.23 (0.62,2.45)
2017	1.00 (0.77,1.30)	1.00 (0.75,1.34)	1.00 (0.47,2.11)

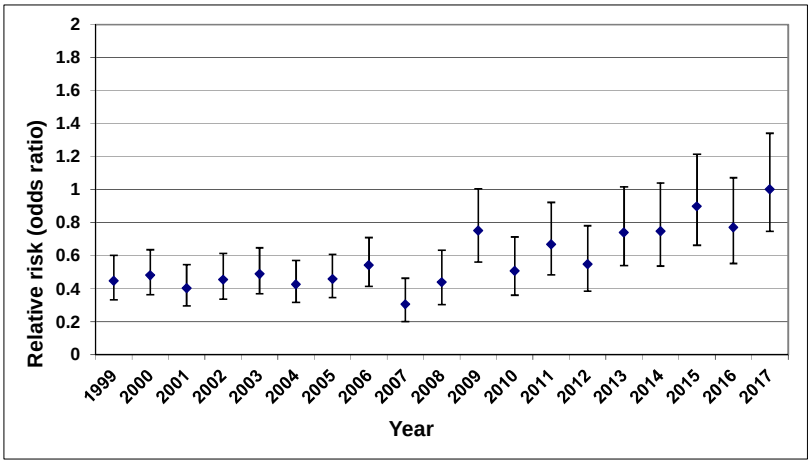
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 15 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, pneumoconiosis**

a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters (note scale change)

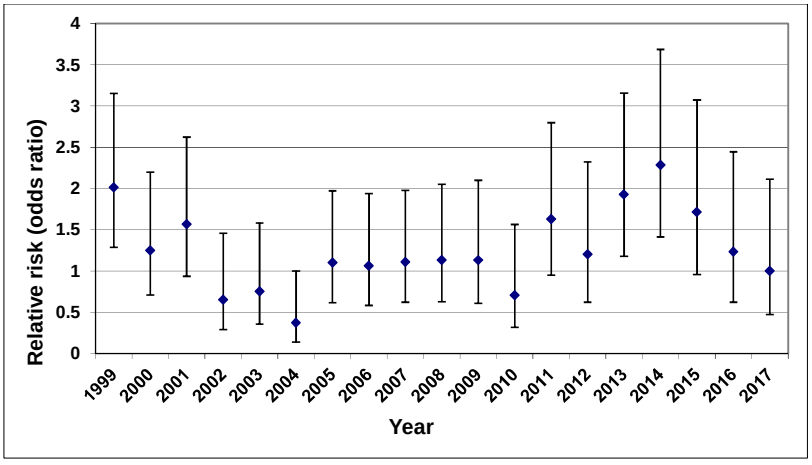


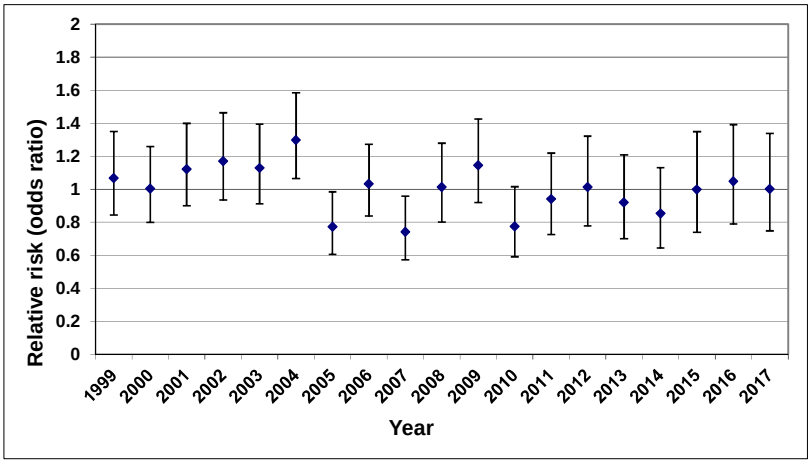
Table 21 **Relative risk by year, with 95% comparison intervals, other (than those investigated separately) respiratory disease (2017 estimate = 1), as reported by chest physicians to SWORD**

	Relative risk (95% comparison interval)		
	All reporters	**Core reporters**	**Sample reporters**
YEAR			
1999	1.07 (0.84,1.35)	0.99 (0.75,1.30)	1.08 (0.67,1.74)
2000	1.00 (0.80,1.26)	0.82 (0.63,1.08)	1.49 (0.99,2.25)
2001	1.12 (0.90,1.40)	0.96 (0.73,1.25)	1.52 (1.01,2.29)
2002	1.17 (0.93,1.46)	1.10 (0.85,1.43)	1.12 (0.70,1.79)
2003	1.13 (0.91,1.39)	1.04 (0.82,1.33)	1.17 (0.74,1.87)
2004	1.30 (1.06,1.58)	1.25 (1.00,1.57)	1.24 (0.80,1.93)
2005	0.77 (0.61,0.98)	0.69 (0.52,0.91)	0.98 (0.59,1.62)
2006	1.03 (0.84,1.27)	1.01 (0.80,1.27)	0.94 (0.57,1.57)
2007	0.74 (0.57,0.96)	0.66 (0.49,0.90)	0.89 (0.53,1.48)
2008	1.01 (0.80,1.28)	0.96 (0.73,1.25)	1.07 (0.66,1.74)
2009	1.14 (0.92,1.43)	1.00 (0.77,1.30)	1.46 (0.96,2.22)
2010	0.77 (0.59,1.02)	0.78 (0.58,1.05)	0.57 (0.28,1.14)
2011	0.94 (0.73,1.22)	0.69 (0.49,0.97)	1.79 (1.18,2.72)
2012	1.01 (0.78,1.32)	1.05 (0.79,1.40)	0.71 (0.37,1.37)
2013	0.92 (0.70,1.21)	0.72 (0.50,1.03)	1.41 (0.9,2.21)
2014	0.85 (0.64,1.13)	0.77 (0.56,1.08)	1.05 (0.60,1.85)
2015	1.00 (0.74,1.35)	1.01 (0.71,1.43)	0.87 (0.45,1.67)
2016	1.05 (0.79,1.39)	0.93 (0.66,1.33)	1.39 (0.85,2.26)
2017	1.00 (0.75,1.34)	1.00 (0.71,1.41)	1.00 (0.55,1.83)

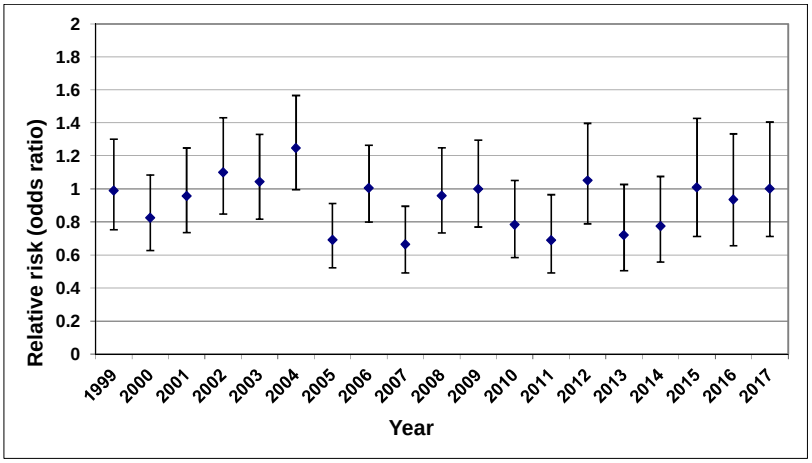
Models adjusted for reporter type (where appropriate), month and harvesting
Population offset included in the model
The number of actual cases on which each analysis is based is provided in Table B4 on page 83

Figure 16 **Relative risk by year (2017 estimate = 1), with 95% comparison intervals, other (than those investigated separately) respiratory disease**

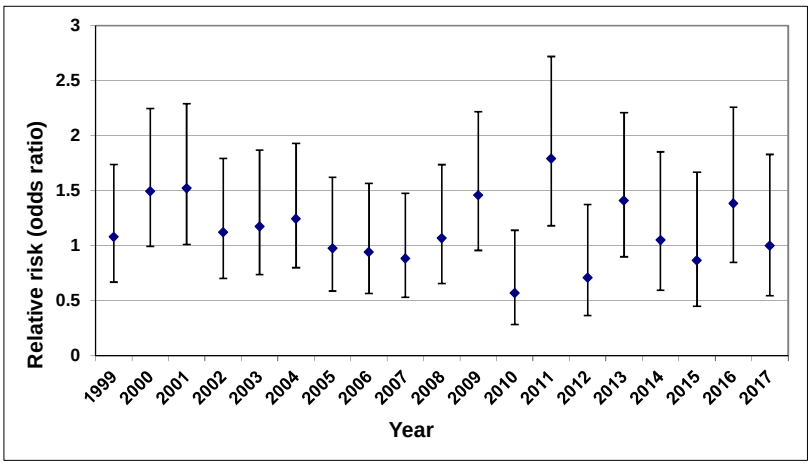
a) SWORD, all reporters



b) SWORD, core reporters



c) SWORD, sample reporters (note scale change)



4 DISCUSSION

This report provides an overview of temporal trends in incidence of WRI in the UK as reported by physicians participating in THOR. These trend reports are submitted annually to HSE[2-13] and this report provides an update on temporal trends in incidence after inclusion of the data collected in 2017. The current report includes only the trends for the two schemes for which 2017 data collection was funded by HSE (SWORD: chest physicians and EPIDERM: dermatologists). Trends in incidence of WRI based on data reported by other physicians to THOR (OPRA: occupational physicians and THOR-GP: general practitioners) have been reported previously (for the period 1996-2010 for OPRA and 2006-2015 for THOR-GP)[2-12].

Both the current and earlier reports have included a full description of the methodology. Essentially, a longitudinal, negative binomial (i.e. over-dispersed) Poisson model with random effects was fitted to the data. This model took into account change over time in the number of reporters and in other reporter characteristics which could independently impact on case density. This and previous reports have also provided a detailed account of the approach taken to investigate the potential impact of 'reporter fatigue' (i.e. a reporter may lose interest in reporting over time but still retain membership) on the estimates of trend. This culminated in an investigation of whether fatigue is manifested as an excess of zero reports in the data, and whether the proportion of zero reports has increased the longer a reporter has participated in the scheme. The results of these investigations, published in the peer reviewed literature[20], 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. As such, the current report includes estimates of the average annual change in incidence (for total skin and total respiratory disease only) which have been adjusted to take into account reporter fatigue (manifesting as an excess of zeros).

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

SKIN (EPIDERM): A total of 19,695 actual cases have been reported to EPIDERM in the period 1996-2017. Occupational skin disease is also reported to THOR-GP (GPs) and OPRA (occupational physicians) with trends for these two groups documented previously[2-12]. The largest proportion of diagnoses reported to EPIDERM is contact dermatitis (82%) followed by neoplasia (12%). Taking the reported cases overall, reports from dermatologists suggest an average annual decrease in incidence of total work-related skin disease of 4.1%. As previously reported, 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 (1996-2006) followed by a levelling out (2006-2012), a further drop between 2012 and 2016 then little suggestion of any change in incidence between 2016 and 2017. Investigations of fatigue (manifesting as an increase in

zeros over membership time) have suggested that although it appears to be present for both 'core' and 'sample' reporters it is more extensive in the latter. This could be because 'sample' reporters may be 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 impact of adjusting the overall estimate for fatigue is relatively small, changing the annual average decrease from 4% to 3% per year.

The observed trend for dermatologist reported CD remains similar to that observed for total skin disease at an annual average decrease of 4%. Estimates of trends for two shorter term periods (informed by apparent change points in the overall trend shown in the annual plots) have also been provided. For the period 2006-2017 the estimated annual average decrease in incidence was similar to the overall trend at 4.1% whilst for the more recent period of 2012-2017 there was suggestion of a steeper decline in incidence of 6.2% per year.

Although the overall trend for CD is downward, and therefore favourable (even when taking 'reporter fatigue' into account), it may hide increasing trends in incidence in specific contexts. We previously investigated change in incidence of CD related to specific agents, economic sectors and in relation to specific interventions aimed at reducing disease incidence[25-29]. We have shown an increase in the incidence of CD in nail technicians attributed to acrylates and in healthcare workers attributed to isothiazolinoes[25-26] and no significant change in incidence of CD attributed to fragrances (which was significantly different to the overall declining trend for CD)[27]. We have also shown an increase in irritant dermatitis amongst healthcare workers attributed to increased hand washing as a result of interventions aimed at reducing healthcare associated infections[28]. On a positive note we have also demonstrated a decline in CD incidence amongst healthcare workers and cement workers in response to specific Government interventions aimed at reducing exposure to latex and chromates, respectively[29, 30].

Results of analyses of the EPIDERM data suggest an overall larger decrease in allergic CD, compared to irritant and mixed allergic/irritant with an annual decrease of approximately 5% per year for allergic compared to 3% for both irritant and mixed CD. However, the graphs showing the annual variation suggest different patterns for allergic and irritant CD with much of the decline for the former occurring in the earlier part of the study period with little change since 2012 whilst for irritant CD the trend was relatively flat between 2000 and 2012 but with a decrease in incidence thereafter (although there is some evidence of an increase in irritant CD between 2016 and 2017). If taken at face value these findings may suggest that (besides the beneficial trends in allergic CD caused by the aforementioned Government interventions (UK/EU) aimed at reducing allergic CD attributed to specific agents as mentioned above) there are now favourable reductions in trends of irritant CD.

A statistically significant annual decrease of 8% in incidence continues to be observed for dermatologist reported contact urticaria. We also continue to see markedly different trends for 'core' and 'sample' reporters, with results based on 'core' data suggesting a decrease in incidence and results based on 'sample' data suggesting no change. It should be noted that only 5 actual cases of urticaria were reported to EPIDERM in 2017 (compared to an average of 14 per year over the preceding 5 years), 4 of which were from core reporters and 1 from sample reporters.

Similar to urticaria, relatively few cases of neoplasia were reported to EPIDERM in 2017 (33 actual cases, compared to 52 in 2016). Although there were disparities between trends based on data from 'core' and 'sample' dermatologists, data from both groups suggest that the incidence has been relatively flat and stable over the past 5 years. It has been suggested previously 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 reflecting the relatively small number of cases reported and it may be that other specialists, for example oncologists, would be a better source of information about trends in incidence for this disease. However, based on previous discussion with HSE and EPIDERM reporters it was decided not to pursue recruitment of skin oncologists, as HSE already has a good source of information on work-related neoplasia in the work carried out by Lesley Rushton (based on the attributable fraction)[31]. However, to avoid the risk of losing reporters/impacting on the reporting of other diagnoses, for example CD, and to enable novel (non UV) causes of work-related neoplasia to continue to be captured, it was agreed that the option to report neoplasia to EPIDERM would remain.

Trends based on reports to EPIDERM have been compared with trends from the Self-reported Work-related Illness (SWI) survey, conducted annually as part of the Labour Force Survey (LFS)[32]. Data from the SWI suggest a similar trend in incidence (of skin problems) over time with an earlier decrease from 31 per 100,000 (for the 3-year averaging period of 2007/8 to 2009/10) to 17 per 100,000 (2010/11 to 2011/12), followed by 19 per 100,000 (2014/15 to 2016/17)[33]. 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)[34]. These results also demonstrated similar CD trends across the different countries, with data for most countries suggesting a decline in incidence.

RESPIRATORY (SWORD): Chest physicians have reported a total of 13,530 actual cases of work-related respiratory disease to SWORD between 1999 and 2017. Data on work-related respiratory disease are also reported by OPs to OPRA and by GPs to THOR-GP with trends

for OPs reported previously (respiratory reports to THOR-GP were not sufficient in number to permit meaningful analysis)[2-7]. As discussed previously, case reports to SWORD encompass a wider diagnostic range (compared to EPIDERM) with the proportion of the total cases attributed to each diagnosis exhibiting some variation throughout the study period. This likely explains why the addition of each successive year of data appears to have more of an impact (compared to EPIDERM) 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.

Investigations of 'reporter fatigue' (manifesting as an increase in zero cases reports over membership time) suggests some evidence of this phenomenon amongst SWORD 'sample' reporters, but not amongst SWORD 'core' reporters. 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 relatively small (a reduction in the annual, average change from approximately -2.9% to -1.8%).

Compared to previous trend analyses, which generally showed annual declines of about 7-8% per year, the estimated average annual decrease in asthma incidence between 1999 and 2017 is now estimated at slightly lower at around 6% per year. This is a result of the increase in asthma reporting since 2014. The increase in asthma reporting and the factors that may be driving it were the subject of a recent short report (based on SWORD data) submitted to OEM[35]. The increase reporting may reflect an increase in the recognition of occupational causation of new onset asthma in adults, perhaps in response to improved guidance. Alternatively, or in addition, it could be that it is caused by changes in workplace exposures or an increase in numbers of exposed workers.

It is important to view these trends in incidence in conjunction with the results from other studies investigating the incidence of WRI related to specific agents. We have previously shown a decline in asthma attributed to isocyanates or paint spraying (but a non-significant decline amongst motor vehicle repair workers)[36,] and a significant reduction in reports of asthma attributed to agents with a work exposure limit (WEL) relative to those without a WEL[37]. In contrast, a significant increase in the incidence of asthma attributed to flour (relative to other agents) was observed[38].

Trends based on SWORD data can also be compared with trends based on data from the SWI, although the latter only provide data on 'breathing or lung problems'. The 3-year average SWI derived incidence rate for this group suggest a decline in incidence from 56 per 100,000 employed (2007/8 to 2009/10) to 34 per 100,000 employed (2010/11 to 2011/12), followed by an increase to 55 per 100,000 employed (2014/15 to 2016/17)[33]. 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[34].

In 2017, as in previous years, the majority (64%) of the diagnoses reported by chest physicians to SWORD were mesothelioma, benign pleural plaques and pneumoconiosis (primarily attributed to asbestos although other causes were also reported). For mesothelioma, an overall downward trend in incidence continues to be observed (of 3.6% per year). However, the incidence appears to be stable since 2014. These observed trends are in contrast to evidence from other data sources such as epidemiological studies by Peto *et al*[39] and the mesothelioma death registers which suggest that mesothelioma incidence has been rising over the same period with a peak in 2016[40]. Possible reasons for the observed disparities between mesothelioma trends derived from SWORD data compared to other data sources have been discussed previously. In brief, changes in clinical practice/referral procedures are likely to have diluted the reporting of such cases to SWORD. For example, long-latency respiratory disease diagnoses, such as mesothelioma, that were previously seen by SWORD reporters may increasingly be seen by chest physicians specialising in lung cancer, who may not participate in SWORD. One approach to address this would be to 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.

Although an overall decrease in incidence (of 1.5%) was also observed for benign pleural disease, the trend in incidence in recent years is fairly flat over the last four years. As discussed previously, since 2007 individuals presenting with this abnormality alone (in England and Wales) are no longer financially compensated[41] and therefore, referrals to chest physicians are probably 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. It is possible that factors such as these are militating against any 'natural' increase in disease incidence resulting in the observed flat trend.

Data from SWORD suggest that after an initial relatively flat trend, the incidence of pneumoconiosis started to increase from approximately 2007 by approximately 4% per year between 1999 and 2017. However, when only the data over the last 10 years were considered the incidence increased by approximately 8% per year, although the graphs suggest that the incidence of pneumoconiosis was stable over the last five years. Approximately 22% of the pneumoconiosis diagnoses reported to SWORD are attributed to agents other than asbestos (for example, silica and coal). Analysis of trends by specific agents (other than asbestos) is not possible due to insufficient case numbers. However, a comparison of asbestos versus non-asbestos pneumoconiosis (not reported here) suggested the increase was due to asbestosis rather than 'other' pneumoconiosis. Both the data sources on compensation claims to the IIDB and those of cause of death on death certificates also support a general increase in asbestosis incidence during the study

period[42,43]. However, the observed increase in asbestosis incidence may be (partly) explained by changes to the diagnostic criteria (resulting in asbestosis being more readily diagnosed)[44].

In addition to the analyses documented here we are currently applying the MLM methodology to address the research priorities highlighted within the HSE Sector strategies[45]. Initial work has been undertaken to map EPIDERM and SWORD data to the HSE defined sectors, to calculate incidence rates for each sector and to assess which sectors have sufficient numbers to enable meaningful analysis of short and longer-term trends. Following further consultation with HSE, it is anticipated that THOR data will be utilised to determine trends in incidence and to evaluate intervention strategies within these specific sectors. It will be of particular interest to continue to investigate whether the recently observed increase in asthma incidence can be attributed to specific sectors, agents or to interventions such as improved guidance. In general, rather than (or in addition to) COEH determining which topics are most important, HSE could identify specific campaigns, interventions of interest, and (if feasible) this methodology can be applied to help evaluate their effectiveness.

5 CONCLUSIONS

This report provides updated trend estimates of incidence of work-related illness using THOR data, adding a further year of data. For contact dermatitis the overall trend has remained relatively unchanged with the addition of each successive year of data, including the addition of the 2017 data. For asthma, the downward trend in incidence has appeared to come to an end, with an increasing trend since 2014.

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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, month, 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 reporters.

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', month, 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%, respectively. 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

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

The most recent (and we believe improved) approach to investigate reporter fatigue (manifesting as an excess of zeros) has been the application of a zero-inflated negative binomial (ZINB) model. These analyses have now been published in the literature with an overview provided below.

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) and SWORD (1999-2012). The impact of adjusting for excess zeros on the annual average percentage change in incidence of total work-related skin disease (EPIDERM) and total work-related respiratory disease (SWORD) is shown in Table A2.

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 reporter fatigue as implied by '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).

Table A2 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

*****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

APPENDIX B DESCRIPTIVE ANALYSES

Table B1 Reporting activity of reporters in EPIDERM, 1996-2017

	CORE	SAMPLE
Total reporters ever in 1996-2017	60	407
Total active[a] reporters in 1996-2017	58	374
Response rate**	84%	74%
% of returns that are blank	18%	62%
Number of reporters who responded at least once but never returned a case	2	120
Number of reporters who have never responded	2	33

[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, 1996-2017

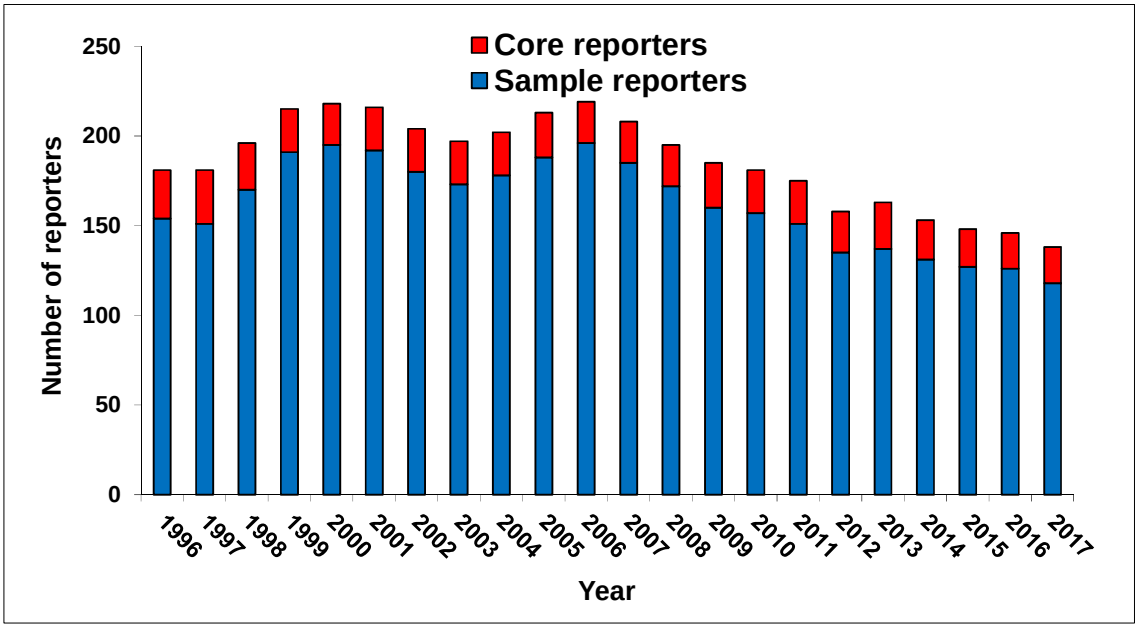
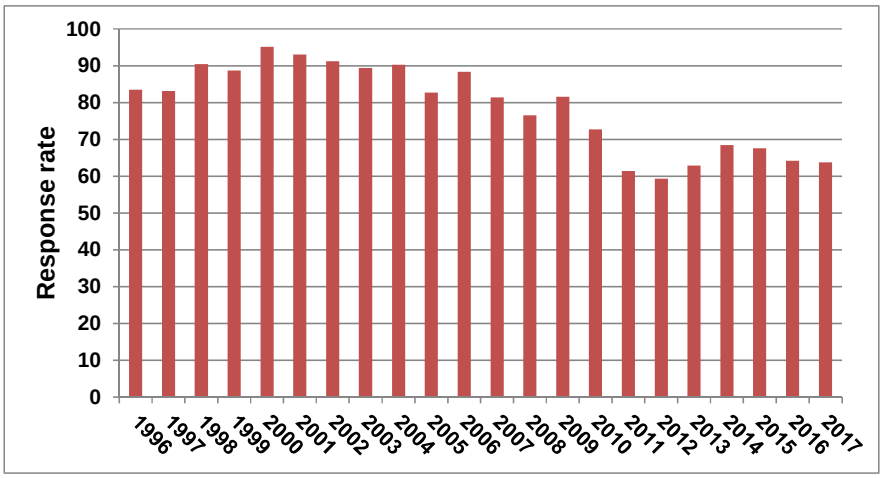
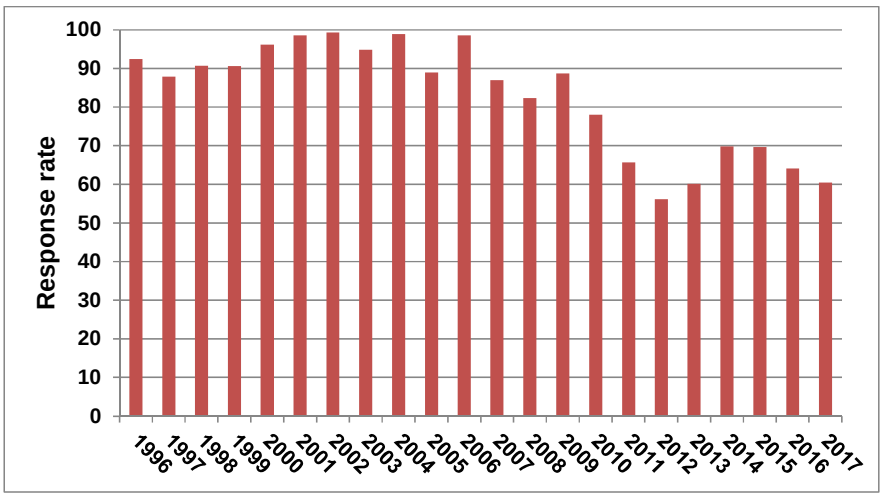


Figure B2 Response rates (cards returned/cards sent out) per year

a) All reporters



b) Core reporters



c) Sample reporters

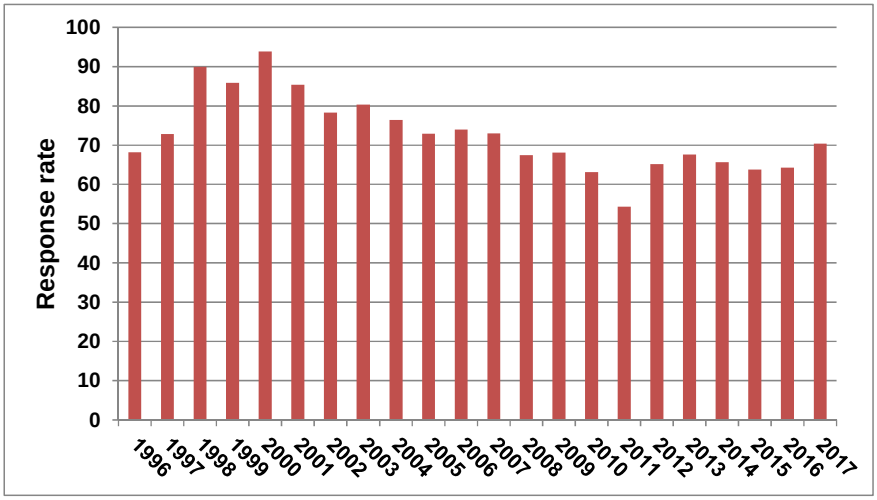


Figure B3 Number of active reporters per month – EPIDERM, 1996-2017

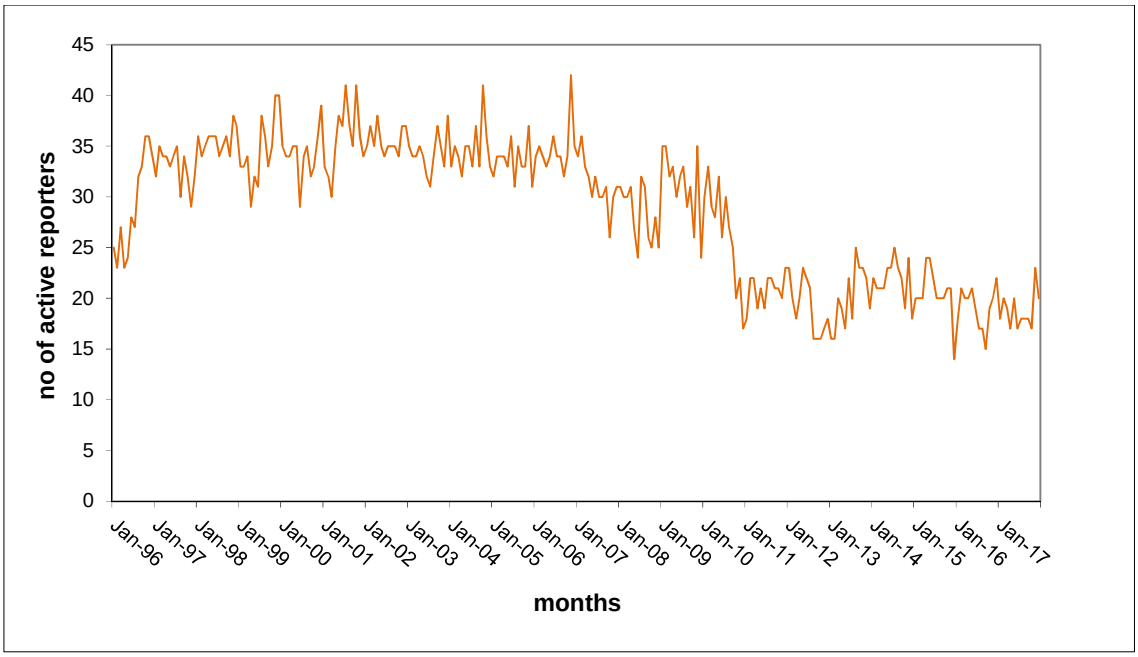
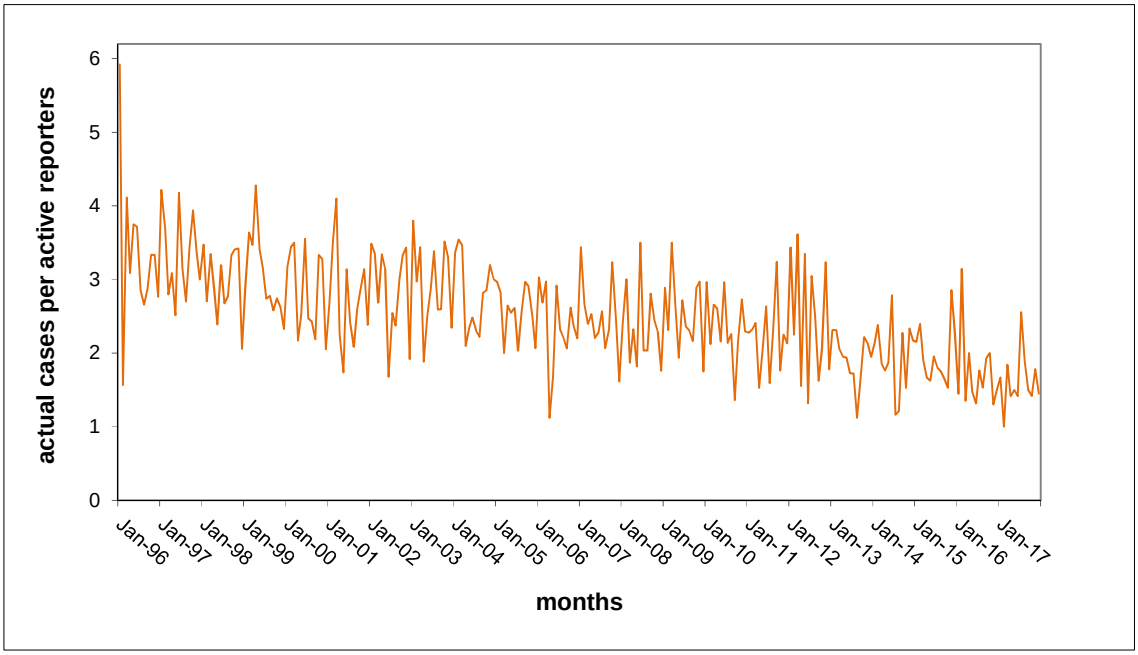
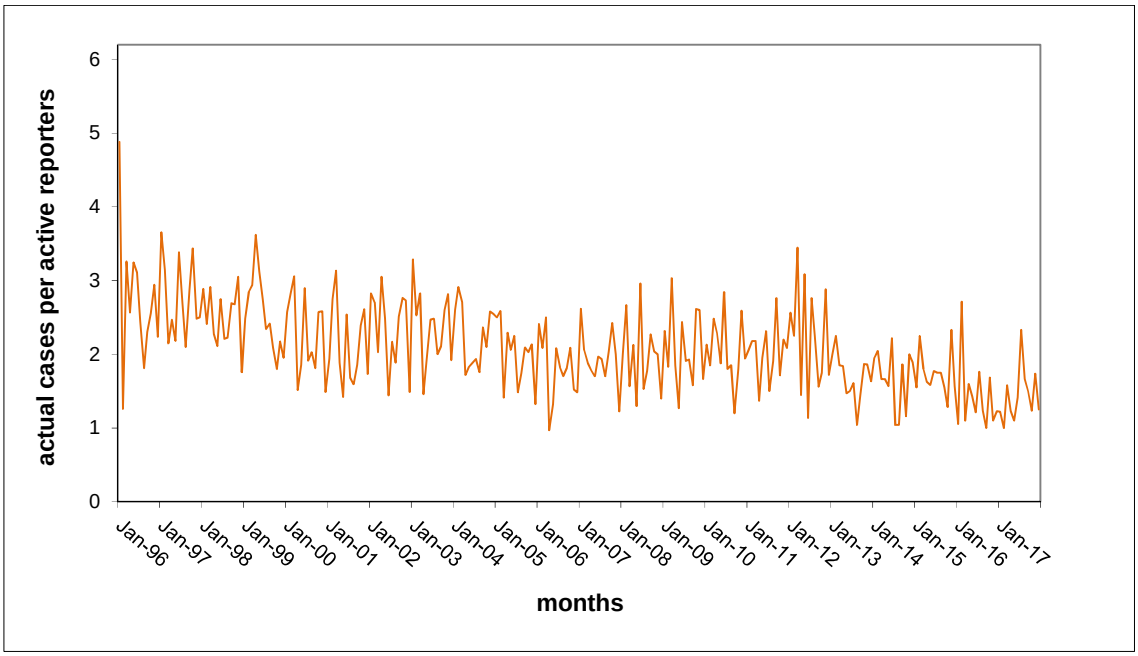


Figure B4 Cases per active reporter per month – EPIDERM, 1996-2017

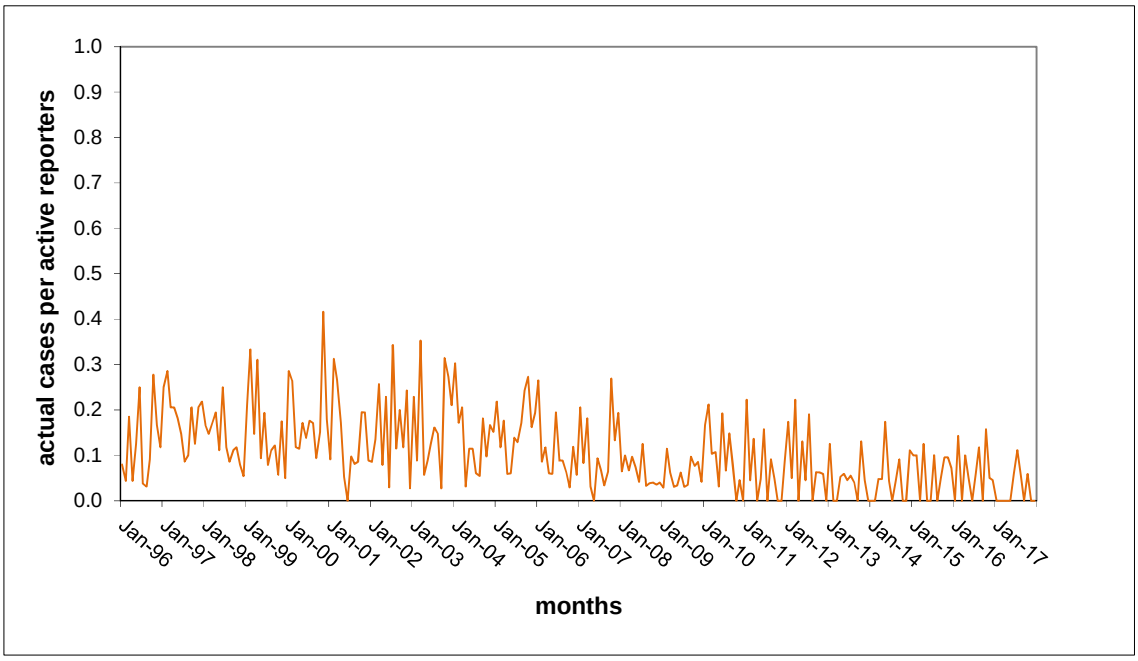
a) Total cases



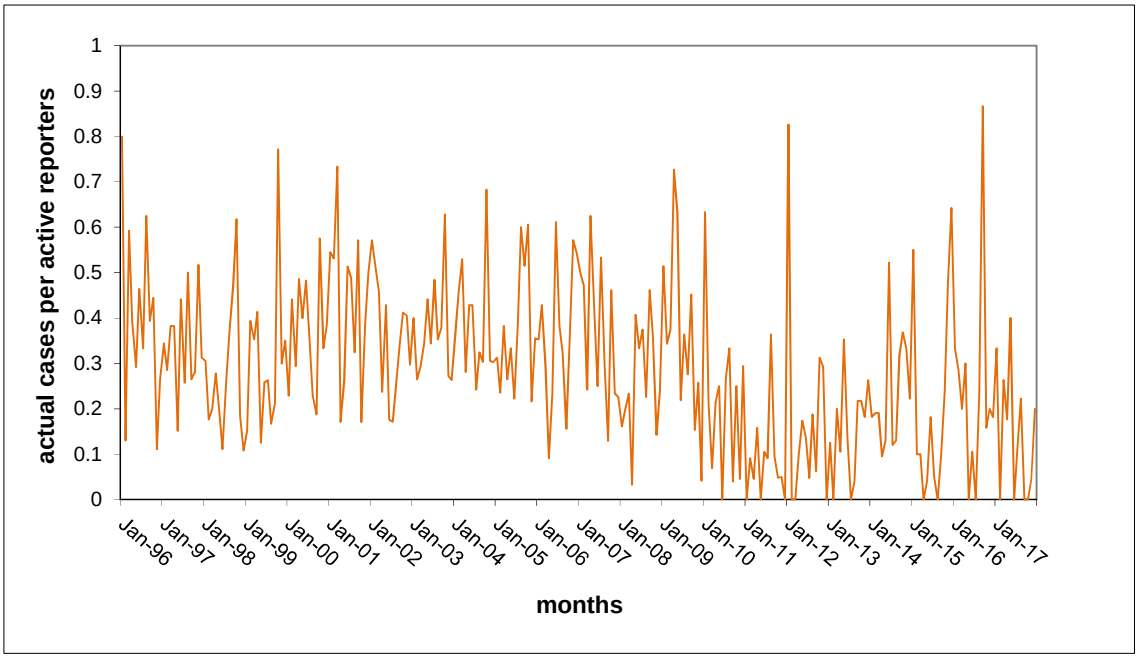
b) Contact dermatitis



c) Contact urticaria (note scale change)



d) Neoplasia



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

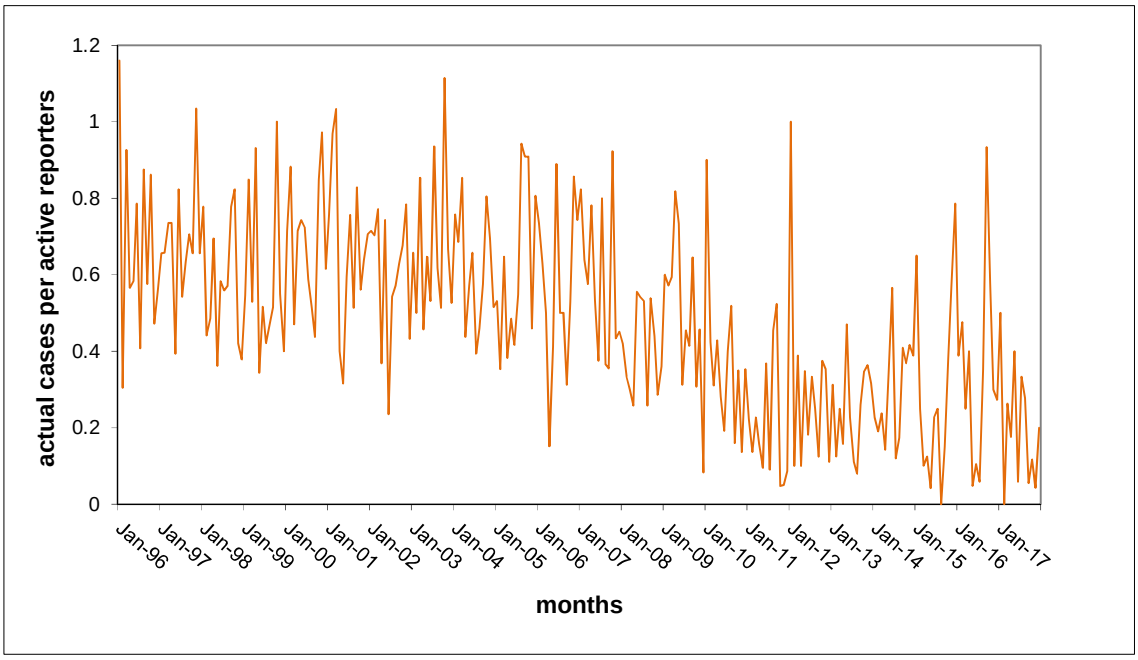


Table B2 Cases reported per month by disease category and type of reporter, EPIDERM, 1996-2017

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
	Total active reporters ever in 1996-2017	407				58				374			
	Mean no. of active[a] reporters per month	28.75	14.00	42.00	6.95	18.79	9.00	26.00	4.54	9.96	3.00	20.00	3.25
Disease group													
All cases	Total cases	19695				17219				2476			
	Mean cases per month	74.60	20.00	148.00	31.22	65.22	14.00	147.00	29.37	9.38	0.00	33.00	6.48
	Mean cases per active reporter per month	2.52	1.00	5.92	0.72	3.34	1.38	7.74	1.03	0.96	0.00	4.50	0.68
Contact dermatitis (CD)	Total cases	16210				14504				1706			
	Mean cases per month	61.40	15.00	122.00	25.10	54.94	12.00	121.00	23.74	6.46	0.00	23.00	4.72
	Mean cases per active reporter per month	2.09	0.97	4.88	0.60	2.84	1.20	6.37	0.85	0.66	0.00	3.00	0.50
Allergic CD	Total cases	6000				5287				713			
	Mean cases per month	22.73	3.00	58.00	11.41	20.03	3.00	54.00	10.40	2.70	0.00	12.00	2.62
	Mean cases per active reporter per month	0.76	0.21	1.66	0.28	1.03	0.23	2.44	0.40	0.27	0.00	2.00	0.26
Irritant CD	Total cases	7183				6539				644			
	Mean cases per month	27.21	4.00	58.00	11.76	24.77	3.00	58.00	11.47	2.44	0.00	14.00	2.30
	Mean cases per active reporter per month	0.93	0.27	2.32	0.33	1.28	0.23	3.05	0.47	0.26	0.00	2.00	0.27
Mixed CD	Total cases	2629				2385				244			
	Mean cases per month	9.96	1.00	27.00	5.06	9.03	0.00	25.00	4.94	0.92	0.00	5.00	1.17
	Mean cases per active reporter per month	0.35	0.05	0.92	0.15	0.47	0.00	1.21	0.22	0.10	0.00	0.75	0.14
Other[b] cases	Total cases	3950				3142				808			

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
	Mean cases per month	14.96	0.00	39.00	9.17	11.90	0.00	33.00	8.19	3.06	0.00	20.00	3.40
	Mean cases per active reporter per month	0.49	0.00	1.16	0.25	0.58	0.00	1.78	0.35	0.31	0.00	2.33	0.37
Contact urticaria	Total cases	888				835				53			
	Mean cases per month	3.36	0.00	15.00	2.89	3.16	0.00	14.00	2.81	0.20	0.00	3.00	0.49
	Mean cases per active reporter per month	0.11	0.00	0.42	0.08	0.16	0.00	0.78	0.13	0.02	0.00	0.33	0.05
Neoplasia	Total cases	2354				1746				608			
	Mean cases per month	8.92	0.00	28.00	6.06	6.61	0.00	20.00	5.03	2.30	0.00	19.00	3.10
	Mean cases per active reporter per month	0.29	0.00	0.87	0.18	0.32	0.00	1.05	0.23	0.24	0.00	2.17	0.33

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

Table B3 Reporting activity of reporters in SWORD, 1999-2017

	CORE	SAMPLE
Total reporters ever in 1999-2017	51	864
Total active[a] reporters in 1999-2017	47	807
Response rate[b]	80%	70%
% of returns that are zero returns (i.e. no cases to report)	28%	73%
Number of reporters who responded at least once but never returned a case	1	263
Number of reporters who have never responded	4	57

[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

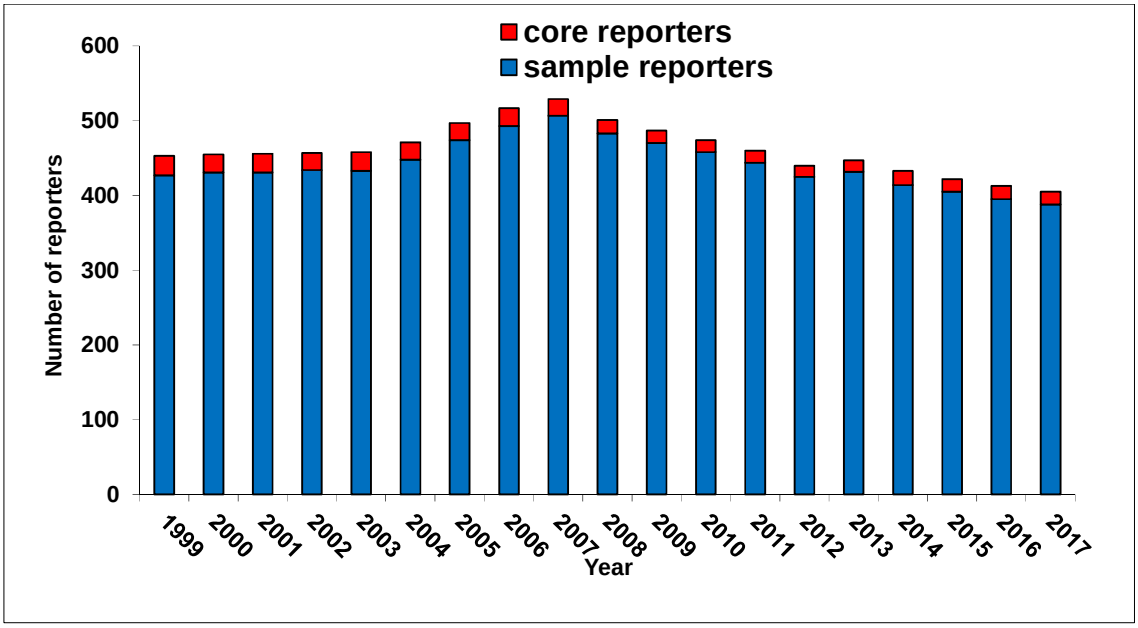
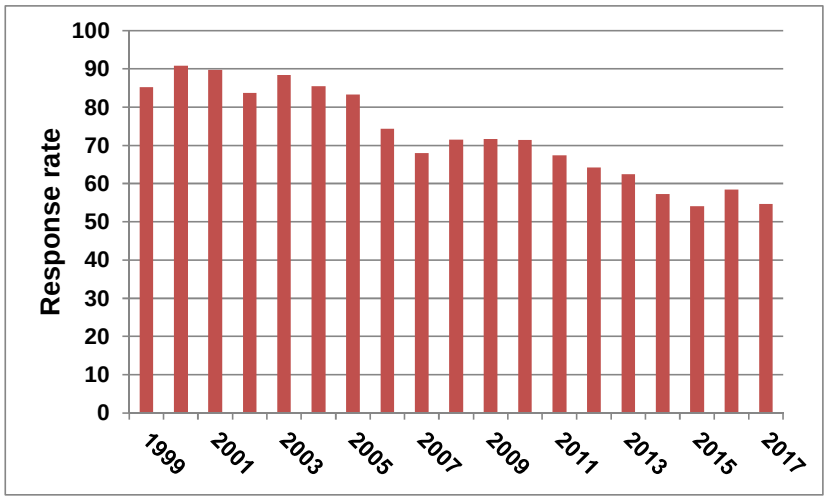
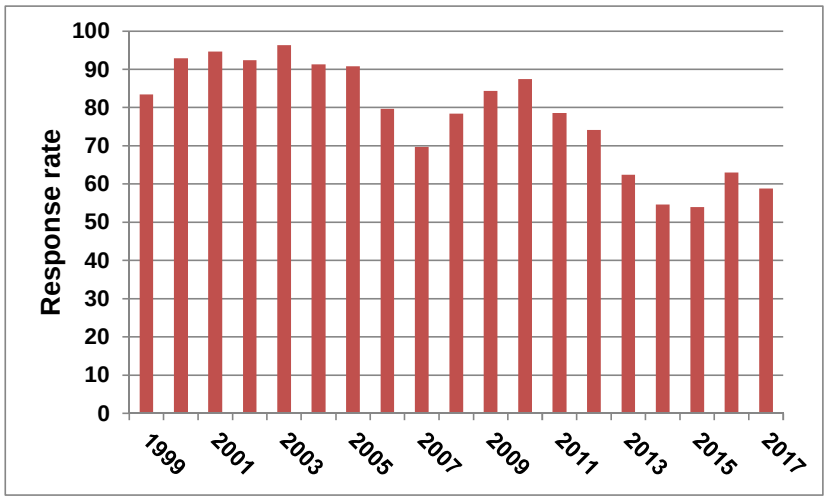


Figure B6 Response rates (cards returned/cards sent out) per year

a) All reporters



b) Core reporters



c) Sample reporters

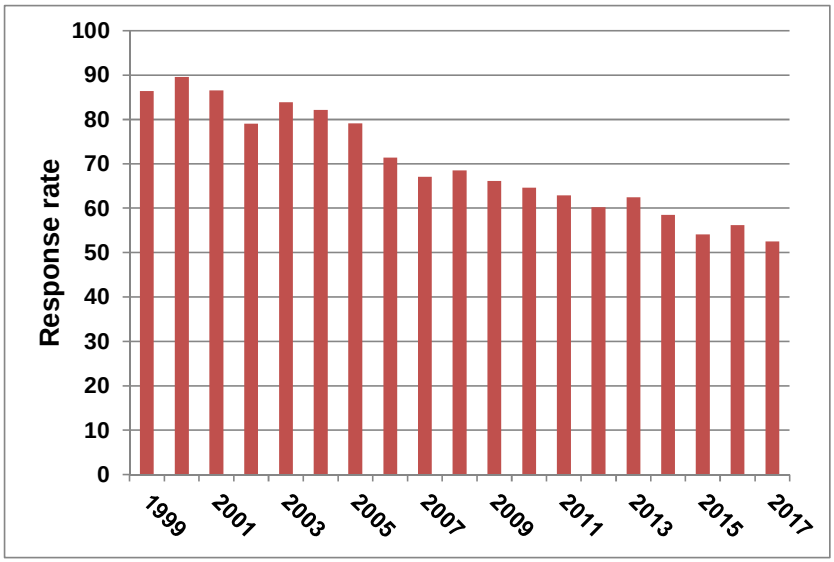


Figure B7 Number of active reporters per month – SWORD

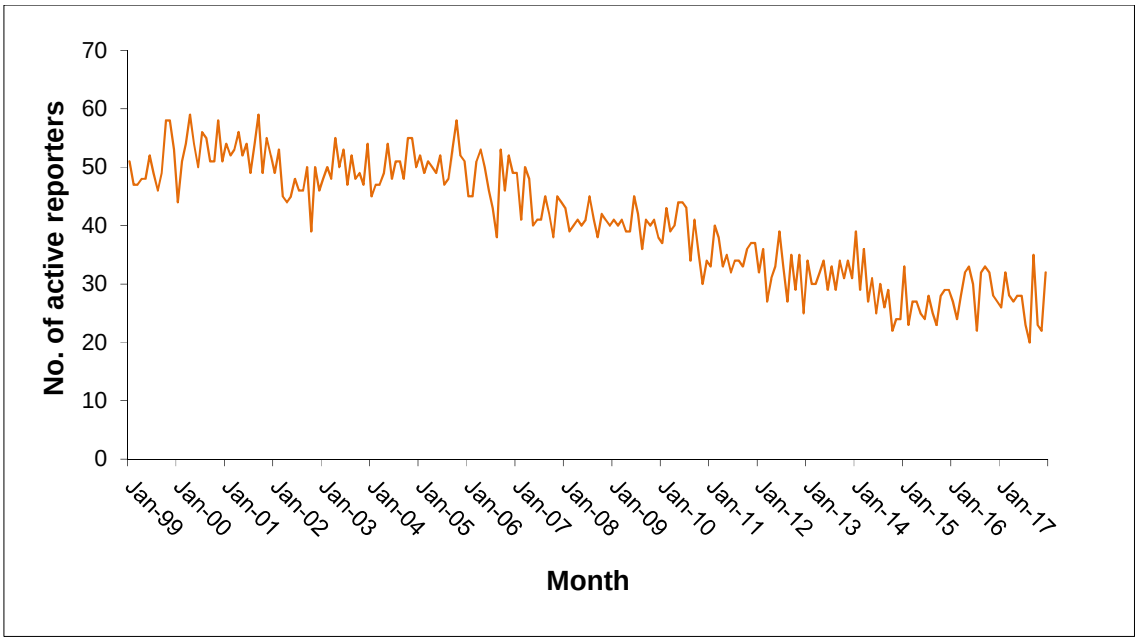
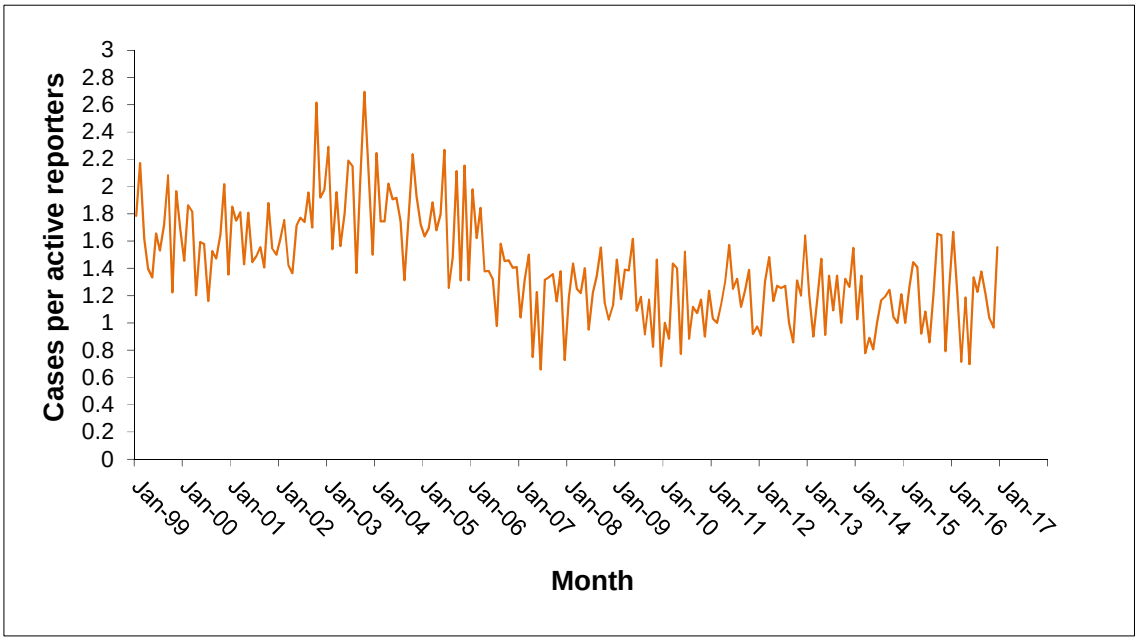
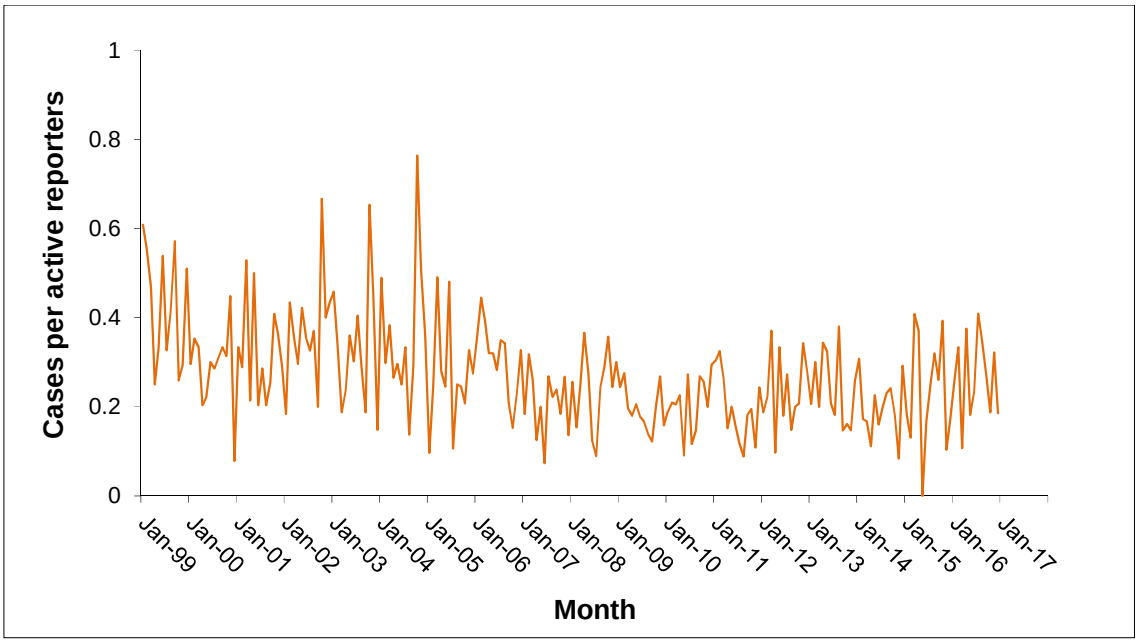


Figure B8 Cases per active reporter per month – SWORD

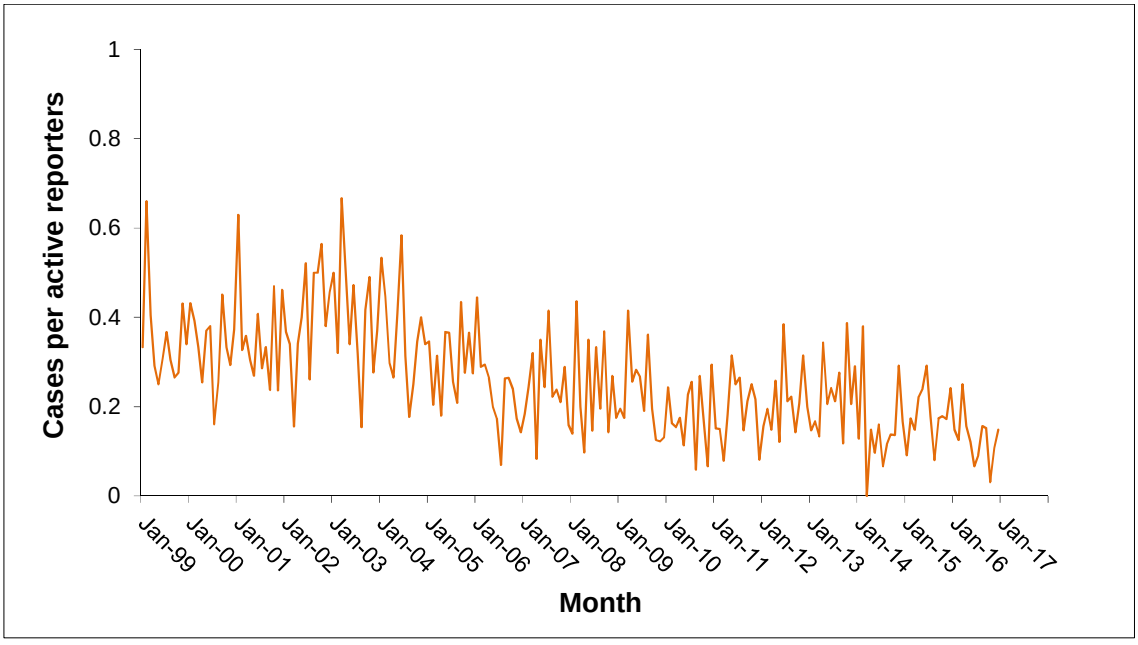
a) Total cases



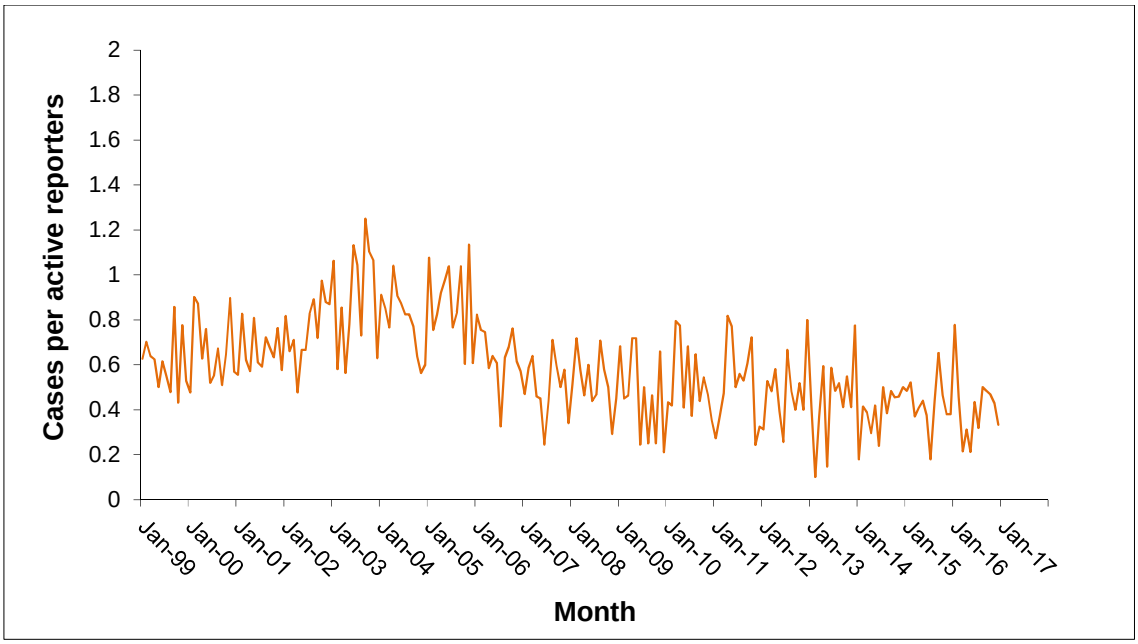
b) Asthma (note scale change)



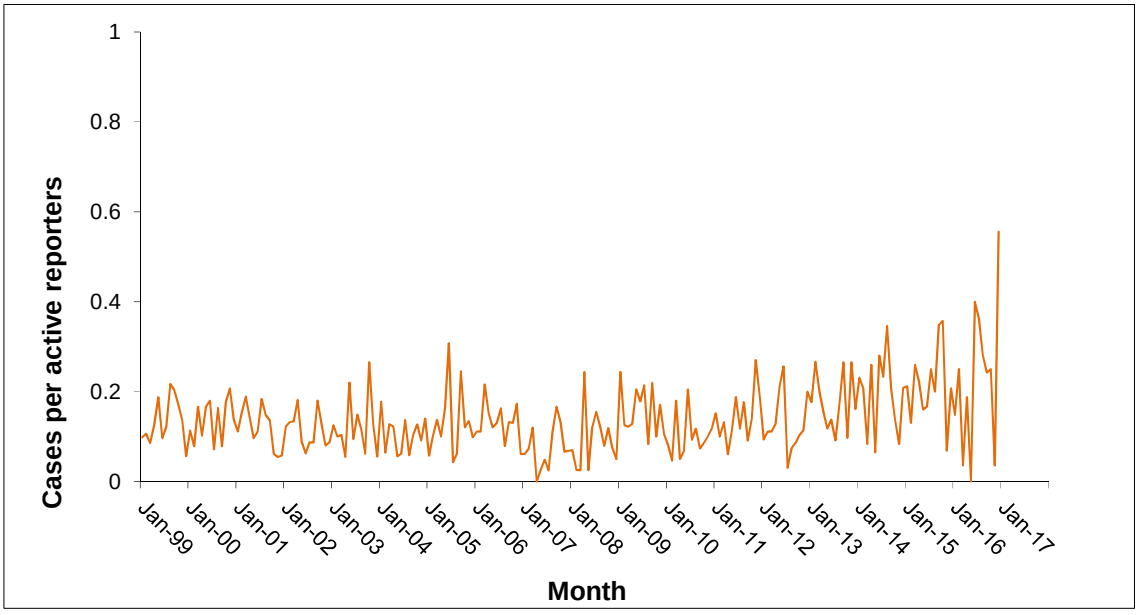
c) Mesothelioma



d) Benign pleural disease (note scale change)



e) Pneumoconiosis (note scale change)



f) Other (than those specified above) respiratory disease

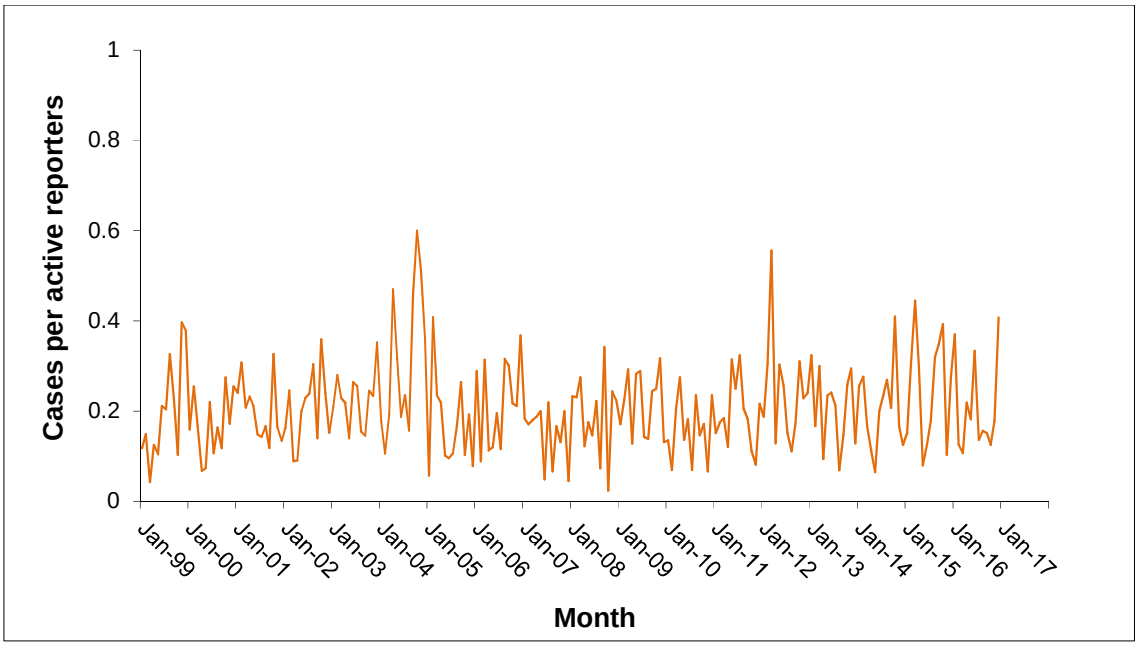


Table B4 Cases reported per month by disease category and type of reporter, SWORD, 1999-2017

		All Reporters				Core reporters				Sample reporters			
	Statistic		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**		**Min**	**Max**	**SD**
	Total active reporters ever in 1999-2017	834				47				807			
	Mean no. of active[a] reporters per month	40.82	22.00	59.00	9.56	18.75	14.00	24.00	3.29	25.87	11.00	38.00	5.92
Disease group													
All cases	Total cases	13530				10728				2802			
	Mean cases per month	59.34	20.00	132.00	26.00	47.05	10.00	112.00	23.61	12.29	0.00	35.00	6.33
	Mean cases per active reporter per month	1.41	0.66	2.69	0.38	3.04	1.40	5.78	0.87	0.47	0.00	1.06	0.20
Asthma	Total cases	2630				2354				276			
	Mean cases per month	11.54	0.00	42.00	6.51	10.32	0.00	42.00	5.89	1.21	0.00	9.00	1.40
	Mean cases per active reporter per month	0.27	0.00	0.76	0.12	0.68	0.00	2.33	0.29	0.04	0.00	0.28	0.05
Mesothelioma	Total cases	2540				1630				910			
	Mean cases per month	11.14	0.00	34.00	6.94	7.15	0.00	27.00	5.77	3.99	0.00	11.00	2.64
	Mean cases per active reporter per month	0.26	0.00	0.67	0.12	0.43	0.00	1.69	0.28	0.15	0.00	0.45	0.09
Benign pleural plaques	Total cases	5690				4638				1052			
	Mean cases per month	24.96	3.00	60.00	13.01	20.34	2.00	59.00	12.31	4.61	0.00	17.00	3.37
	Mean cases per active reporter per month	0.58	0.10	1.25	0.22	1.28	0.20	2.84	0.51	0.18	0.00	0.71	0.12
Pneumoconiosis	Total cases	1297				1065				232			
	Mean cases per month	5.69	0.00	16.00	2.90	4.67	0.00	15.00	2.60	1.02	0.00	5.00	1.15
	Mean cases per active reporter per month	0.15	0.00	0.65	0.09	0.34	0.00	1.36	0.23	0.04	0.00	0.21	0.05
Other cases[b]	Total cases	1922				1538				384			

Statistic	All Reporters				Core reporters				Sample reporters			
		Min	Max	SD		Min	Max	SD		Min	Max	SD
Mean cases per month	8.43	1.00	33.00	4.60	6.75	1.00	28.00	4.14	1.68	0.00	13.00	1.76
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	0.07

[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