ORIGINAL ARTICLE

Assessing the impact of national level interventions on workplace respiratory disease in the UK: part 2—regulatory activity by the Health and Safety Executive

S J Stocks,[1] R McNamee,[2] S Turner,[1] M Carder,[1] R M Agius[1]

[1]Centre for Occupational and Environmental Health, Centre for Epidemiology, Institute of Population Health, University of Manchester, Manchester, UK
[2]Centre for Biostatistics, Centre for Epidemiology, Institute of Population Health, University of Manchester, Manchester, UK

Correspondence to
Dr S J Stocks, COEH, 4th Floor Ellen Wilkinson Building, Centre for Epidemiology, Institute of Population Health, University of Manchester, Oxford Rd, Manchester M13 9PT, UK; jill.stocks@manchester.ac.uk

Received 15 August 2012
Revised 11 March 2013
Accepted 22 March 2013
Published Online First 20 April 2013

ABSTRACT

Objective To investigate whether interventions implemented by the UK Health and Safety Executive addressing exposure to isocyanate-based spray paints in motor vehicle repair (MVR), flour dust in craft bakeries, rosin-based solder flux fume (RBSFF) in the electronics industry, metalworking fluids and wood dust coincided with a decline in incidence of work-related short latency respiratory disease (SLRD) or asthma in the target groups.

Method Changes in the incidence of SLRD reported to a UK-based surveillance scheme were compared using a longitudinal, negative binomial regression model with β distributed random effects. An interrupted time series design was used and comparisons according to inclusion or exclusion in the target group were made by including a statistical interactions expressed as a ratio of incidence rate ratios (RIRRs) in the model.

Results The incidence of SLRD attributed to flour dust significantly increased relative to all other agents (RIRR: 1.10; 95% CI 1.06 to 1.16) whereas SLRD attributed to RBSFF significantly declined relative to all other agents (0.94; 0.90 to 0.99). No significant changes in the incidence of SLRD attributed to wood dust (1.03; 0.91 to 1.16) or spray paints (1.03; 0.95 to 1.11) relative to all other agents were observed. A higher proportion of reports originated from the industries targeted by the intervention for RBSFF (65/107; 61%) than spray painting (27/93; 27%) or wood dust (16/42; 38%).

Conclusions These data support a beneficial effect of interventions to reduce exposure to RBSFF but an increase in SLRD attributed to flour dust may indicate increased exposure or increased awareness of the problem.

What this paper adds

- Over the last decade, the UK Health and Safety Executive (HSE) has implemented inspection packs aiming to reduce the incidence of work-related asthma in targeted occupational groups coinciding with a steady decline in incidence of reports of work-related short latency respiratory disease (SLRD) to SWORD, a UK-based surveillance scheme.
- We have compared changes in the incidence of SLRD reported to SWORD attributed to specific agents and/or occupational groups within predefined time periods relevant to the release of the HSE inspection packs.
- SLRD and asthma attributed to flour remain a problem in the UK despite interventions by the UK HSE targeting craft bakeries; reducing exposure to flour dust should remain a high priority.
- There was a steady and sustained reduction in the incidence of SLRD and asthma attributed to the use of RBSFF relative to other agents spanning changes in exposure limits and HSE inspection pack release.
- For some exposures, the majority of reports to SWORD originated outside the industries targeted by the interventions; future interventions should aim to match industries and exposures more closely where possible.

INTRODUCTION

Previously we have related changes in legislation and market forces to temporal changes in the incidence of work-related ill-health reported to the Health and Occupation Reporting network, a UK-based surveillance scheme.[1–3] Here, we apply the same methods to evaluate national level interventions aiming to reduce work-related respiratory disease introduced by the UK Health and Safety Executive (HSE).

In 2000, the UK Health and Safety Commission published 'Revitalising Health and Safety' (RHS), a 10-year occupational health strategy for Great Britain that included a target of 30% reduction in incident cases of occupational asthma between 2001 and 2010.[4] Specific actions taken to achieve this included publishing an Approved Code of Practice on the control of occupational asthma as an annexe to the Control of Substances Hazardous to Health Regulations (2003);[5] the establishment of an Asthma Project Board (2001) comprising representatives from industries, unions, charities and health professionals;[6] and the provision of new guidance backed up by enforcement by the HSE (2004).[7] The declining incidence of asthma reported to SWORD between 2001 and 2011 provides evidence towards the RHS target of a 30% reduction in work-related asthma being achieved.[8]

The collaboration between the HSE and the Asthma Project Board yielded a plan of action targeting the most frequent causes of work-related asthma including latex, glutaraldehyde, flour and

▶ http://dx.doi.org/10.1136/oemed-2012-101123

To cite: Stocks SJ, McNamee R, Turner S, *et al*. *Occup Environ Med* 2013;**70**:483–490.

Table 1 Summary of interventions and events expected to impact on work-related SLRD investigated using SWORD data

ID	Intervention	Key dates	Groups compared
1	HSE inspection pack: Control of isocyanate exposure in MVR bodyshops; includes SHADS Introduction of a WEL for isocyanates	2004–2007	Causal agent: spray paint/other agents Employed in MVR/other sectors Employed in motor vehicle manufacture/other sectors
2	Introduction of a MEL for flour Introduction of a WEL for flour	April 2001 April 2005	Causal agent: flour or baking enzymes/other agents Employed in food industry; causal agent: flour or baking enzymes/other agents
	HSE inspection pack: Craft bakeries: exposure to flour dust and enzymes in improvers; includes training of Local Authority inspectors	2006–2008	Attributed to flour in bakers; retail baker/industrial baker
3	HSE Inspection pack; Controlling inhalation exposure to metalworking fluids Removal of MEL (not replaced with WEL) for metalworking fluids	2005–2006	Causal agent: metalworking fluid/other agents
4	Introduction of MEL for rosin-based solder flux fume Introduction of a WEL for rosin-based solder flux fume HSE Inspection pack: Controlling inhalation exposure to rosin based solder fume	March 1999 April 2005 2007–2008	Causal agent: solder/other agents
5	HSE Inspection pack: Wood dust: Controlling inhalation exposure; includes SHADS Introduction of a WEL for wood dust	2002–2007	Causal agent: wood dust/other agents

HSE, UK Health and Safety Executive; ID, identification number links to text and results in table 2; MEL, maximum exposure limit; SHADS, Safety and Health Awareness Days; WEL, workplace exposure limit.

grain, isocyanates, wood dust, colophony, laboratory animals and resins and glues.[6] In 2004, the Health and Safety Commission launched the Disease Reduction Programme, which aimed to change behaviour in key industries, thereby reducing occupational diseases caused by exposure to harmful substances. The Field Operations Division of the HSE targeted the occupational groups and agents prioritised by the Respiratory Disease Project using a topic-based inspection approach that included raising awareness, inspections and evaluation of the intervention.[9] The interventions aimed to reduce exposure to isocyanates in motor vehicle repair (MVR), flour dust and enzymes in improvers in craft bakeries, metalworking fluids (MWFs) in known users, rosin-based solder flux fume (RBSFF) in the electronics industry and wood dust in woodworking industries (table 1).[10–14] Maximum exposure limits (MELs) were already in place for RBSFF (1999), flour dust (2001), isocyanates and wood dust (both pre-1989).

The aim of this study is to investigate whether the implementation of HSE topic-based inspection packs directed at reducing short latency respiratory disease (SLRD; includes asthma, allergic alveolitis, rhinitis and inhalation accidents) in specific causal agent/occupation combinations (table 1) coincided with a temporally consistent decline in incidence of reports returned to SWORD in the target group relative to all other causal agents.

METHODS

The SWORD scheme and statistical analysis used in this study are described in detail elsewhere.[1–3] Briefly, reports of SLRD were returned to SWORD by respiratory physicians. Some physicians reported every month whereas others reported during 1 month per year. Time periods representing the time before, during and after the intervention were selected prospectively, and blind to the data. The preintervention period (a minimum of 2 years preceding the intervention) was taken as the reference time period and compared with the time period representing the intervention or postintervention time periods. Incidence rate ratios (IRRs) reflecting changes in the incidence of SLRD or asthma relative to the reference period within reporters (including zero reports) were estimated using the xtnbreg command in intercooled Stata V.8. The model was a longitudinal negative binomial (ie, overdispersed) regression model with β distributed random effects that also controlled for seasonal variation, reporter type (core or sample) and first month as a new reporter as described previously.[15] Formal tests of whether there were differences in the IRRs for SLRD or asthma attributed to the agent targeted by the intervention and all other suspected agents were conducted by inclusion of interaction terms in the statistical models. Each interaction term estimates the ratio of two IRRs (RIRR) for the time periods specified: one for the target group and one for the non-target group. The 95% CIs were calculated for each RIRR and considered significant when the CI did not include 1. Where sufficient cases were reported, secondary comparisons were made within the occupational sector targeted by the intervention; for example, in the case of flour, the main comparison was flour with all other agents in all workers, then a further comparison restricted to the food-manufacturing sector was made. The individual annual IRRs relative to 2001 for the agents targeted by the interventions were plotted but this was done after selection of the time periods to be compared in the analysis in order to ensure unbiased selection of the time periods representing the interventions (figure 1). The reference year 2001 was selected because this was the start date for the HSE's RHS strategic plan. Alternative models in which time was represented by yearly dummy variables (with 2001 as the reference) and with annual interaction terms (annual RIRR) corresponding to the product of the target group membership and each year were also fitted to provide an estimate of the relative change in incidence over continuous time. Reports from Northern Ireland were not included in the analysis (table 1) because the topic-based inspection packs were implemented in Great Britain only.

The interventions (topic-based inspection packs) used to target causal agent/occupation combinations selected by the HSE are described briefly below and are summarised in table 1. A more detailed description is available on the HSE website.[10–14]

1. Control of isocyanate exposure in MVR bodyshops[10]: This intervention from 2004 to 2007 comprised 28 Health and Safety Awareness Days (SHADs) addressing the consequences of asthma, the importance of allowing sufficient clearance time before entering the spray painting booth without personal protective equipment, the legal requirements and biological monitoring. Businesses attending the SHADs were excused from inspection and those declining were more likely to be inspected.

Table 2 Statistical interactions expressed as RIRRs representing an estimate of the ratio of the individual IRRs for the defined groups (A–J) for the stated time periods as defined in the methods

ID	Control of isocyanate exposure in MVR	Time periods	Type of ill-health	Time periods compared	A. All workers: spray paint vs other agent		B. MVR vs other industries (all agents)		C. Motor vehicle manufacture vs other industries (all agents)	
					RIRR	95% CIs	RIRR	95% CIs	RIRR	95% CIs
1	HSE intervention (2004–2007)	time1=2001–2003	SLRD	time2/time1	1.21	0.74 to 1.97	0.34	0.12 to 0.95	1.38	0.92 to 2.07
		time2=2004–2007		time3/time1	1.03	0.56 to 1.87	1.67	0.78 to 3.61	1.05	0.64 to 1.70
		time3=2008–2010	Asthma	time2/time1	1.26	0.75 to 2.09	0.39	0.14 to 1.12	1.26	0.83 to 1.92
				time3/time1	1.29	0.70 to 2.40	1.85	0.80 to 4.28	0.93	0.55 to 1.58
ID	**Craft bakeries: exposure to flour dust and enzymes in improvers**	**Time periods**	**Type of ill-health**	**Time periods compared**	**D. All workers: flour vs other agents**		**E. Food industry: flour vs other agents**		**F. Attributed to flour in bakers: retail vs industrial**	
					RIRR	95% CIs	RIRR	95% CIs	RIRR	95% CIs
2a	Introduction of a MEL (April 2001)	time1=May 1999–Apr 2001	SLRD	time2/time1	1.54	0.89 to 2.68	1.60	0.66 to 3.86	8.45	2.36 to 30.33
	Introduction of a WEL (25 April 2005)	time2=May 2001–Apr 2003		time3/time1	2.09	1.22 to 3.57	2.05	0.85 to 4.92	3.63	1.17 to 11.20
	HSE inspection pack (2006–2008)	time3=May 2003–Apr 2005		time4/time1	2.35	1.42 to 3.89	2.30	1.00 to 5.31	2.50	0.88 to 7.17
		time4=May 2005–2008		time5/time1	3.03	1.69 to 5.43	4.69	1.49 to 14.74	5.49	1.65 to 18.23
		time5=2009–2010	Asthma	time2/time1	1.37	0.76 to 2.47	1.37	0.54 to 3.48	7.03	1.85 to 26.76
				time3/time1	1.95	1.11 to 3.42	1.90	0.75 to 4.77	3.12	0.95 to 10.27
				time4/time1	2.24	1.33 to 3.79	2.32	0.96 to 5.60	2.50	0.83 to 7.57
				time5/time1	2.90	1.55 to 5.43	5.36	1.35 to 21.23	5.79	1.56 to 21.40
2b	Introduction of a WEL (25 April 2005)	time3=May 2003–Apr 2005	SLRD	time4/time3	1.12	0.73 to 1.74	1.13	0.51 to 2.48	0.69	0.30 to 1.59
	HSE inspection pack (2006–2008)	time4=May 2005–2008		time5/time3	1.45	0.86 to 2.45	2.29	0.75 to 6.96	1.52	0.55 to 4.16
		time5=2009–2010		time5/time4	1.29	0.79 to 2.10	2.03	0.69 to 5.99	2.19	0.87 to 5.52
			Asthma	time4/time3	1.15	0.72 to 1.84	1.22	0.52 to 2.88	0.80	0.33 to 1.93
				time5/time3	1.49	0.83 to 2.66	2.83	0.73 to 11.03	1.85	0.60 to 5.68
				time5/time4	1.29	0.75 to 2.23	2.32	0.61 to 8.79	2.31	0.82 to 6.50
ID	**Controlling inhalation exposure to metalworking fluids**	**Time periods**	**Type of ill-health**	**Time periods compared**	**G. All workers: MWF vs other agents**		**H. All workers: MWF vs other agents (excluding one reporter*)**			
					RIRR	95% CIs	RIRR	95% CIs		
3	HSE inspection pack and removal of MEL without replacement with WEL (2005–2006)	time1=2002–2004	SLRD	time2/time1	2.20	1.19 to 4.06	2.69	0.87 to 8.33		
		time2=2005–2006		time3/time1	2.02	1.05 to 3.89	4.61	1.55 to 13.72		
		time3=2007–2008	Asthma	time2/time1	2.20	1.10 to 4.43	1.59	0.39 to 6.44		
				time3/time1	1.12	0.47 to 2.70	2.06	0.51 to 8.37		
ID	**Controlling inhalation exposure to rosin based solder fume**	**Time periods**	**Type of ill-health**	**Time periods compared**	**I. All workers: solder vs other agents**					
					RIRR	95% CIs				
4	Introduction MEL (March 1999)	time1=Jan 1996–Mar 1999	SLRD	time2/time1	0.96	0.58–1.59				
	Introduction of WEL (25 April 2005)	time2=Apr 1999–May 2002		time3/time1	0.64	0.35 to 1.16				
	HSE inspection pack (2007–2008)	time3=Jun 2002–Apr 2005		time4/time1	0.45	0.23 to 0.88				
		time4=May 2005–Dec 2008		time5/time1	0.69	0.30 to 1.57				
		time5=Jan 2009–Dec 2010	Asthma	time2/time1	0.92	0.55 to 1.55				
				time3/time1	0.64	0.34 to 1.19				
				time4/time1	0.48	0.25 to 0.94				
				time5/time1	0.73	0.30 to 1.77				

Continued

Table 2 Continued

ID	Wood dust: Controlling inhalation exposure	Time periods	Type of ill-health	Time periods compared	J. All workers: wood dust vs other agents	
					RIRR	95% CIs
5	Introduction of WEL (25 April 2005)	time1=2002–2004	SLRD	time2/time1	0.89	0.42 to 1.87
	HSE inspection pack (2002–2007)	time2=2005–2007		time3/time1	1.18	0.56 to 2.48
		time3=2008–2010	Asthma	time2/time1	1.04	0.48 to 2.26
				time3/time1	1.31	0.58 to 2.97

The RIRR can be considered an estimate of the magnitude of the difference in the change in incidence between the groups over the defined time periods.
*Analysis G was repeated excluding the reporter investigating the outbreak of respiratory disease related to MWF.[16 17]
HSE, UK Health and Safety Executive; MEL, maximum exposure limit; MWF, metalworking fluid; RIRR, ratio of incidence rate ratios or interaction term; SLRD, short latency respiratory disease (includes asthma, allergic alveolitis, rhinitis, inhalation accidents); WEL, workplace exposure limit.

Simultaneously the HSE provided guidance to booth and paint manufacturers, training venues and trade associations. In the latter stages of the intervention, the focus shifted towards inspection and enforcement with the release of an inspection pack during October 2007 and increased frequency of inspections. All cases attributed to spray painting were included in the analysis, irrespective of whether isocyanates were specified. The analysis compared spray paints with all other agents in all workers (table 2, column A) as well as workers in MVR (table 2, column B) and motor vehicle manufacturing with all other workers (table 2, column C).

2. Craft bakeries and exposure to flour dust and enzymes in improvers[11]: This intervention was undertaken in partnership with Local Authority (LA) environmental health officers. During 2006–2007, HSE inspectors visited a proportion of medium-sized and plant-sized bakeries and 10 one-day training events, including a session on flour dust, were attended by almost 900 LA environmental health officers. In December 2008, an inspection pack was released with LA inspectors being asked to carry out inspections focusing on exposure to flour and enzymes in LA-enforced bakeries (craft or retail bakeries). In addition, the HSE met with representatives from major supermarkets, LA regulatory services, trade union and other partners and agreed to develop standards for the control of flour dust in in-store bakeries. Other events potentially impacting on exposure to flour dust included the introduction of a MEL in 2001, subsequently replaced by a workplace exposure limit (WEL) in 2005. All cases attributed to flour or enzymes used in baking were included in the analysis. The analysis compared flour/bakery enzymes with all other agents in all workers (table 2, column D) and within workers employed in food manufacturing including bakeries (table 2, column E). Cases attributed to flour/enzymes in retail bakers and industrial bakers were also compared (table 2, column F).
3. Controlling inhalation exposure to MWFs[12]: This intervention consisted of questionnaires sent to all large users of MWFs during 2005–2006 and visits to 43 of these, with 11 improvement notices being served with respect to inadequate management of MWFs. In June 2006, all known small users were invited to a half-day SHAD, with non-attendees being prioritised for a visit upon release of an inspection pack focussing on the risks associated with MWF among small users. All cases attributed to MWFs were included in the analysis. The analysis compared MWFs with all other agents in all workers (table 2, column G) and was repeated excluding a reporter involved in investigating a large outbreak of asthma and allergic alveolitis attributed to MWFs (table 2, column H).[16 17] This was felt to be necessary as many of these cases did not arise through the usual referral route but during an investigation undertaken at the request of the HSE.
4. Controlling inhalation exposure to rosin-based solder flux fume (RBSFF)[13]: This topic-based inspection pack specified that inspections during 2007–2008 were to concentrate on control of exposure to RBSFF in electronics companies who routinely carry out soldering, especially those not visited by the HSE in the past 2 years, or with previous poor compliance, or where local knowledge has identified significant asthma risks. Inspections were focussed on companies manufacturing office machinery, computers and other information processing equipment, electric motors,

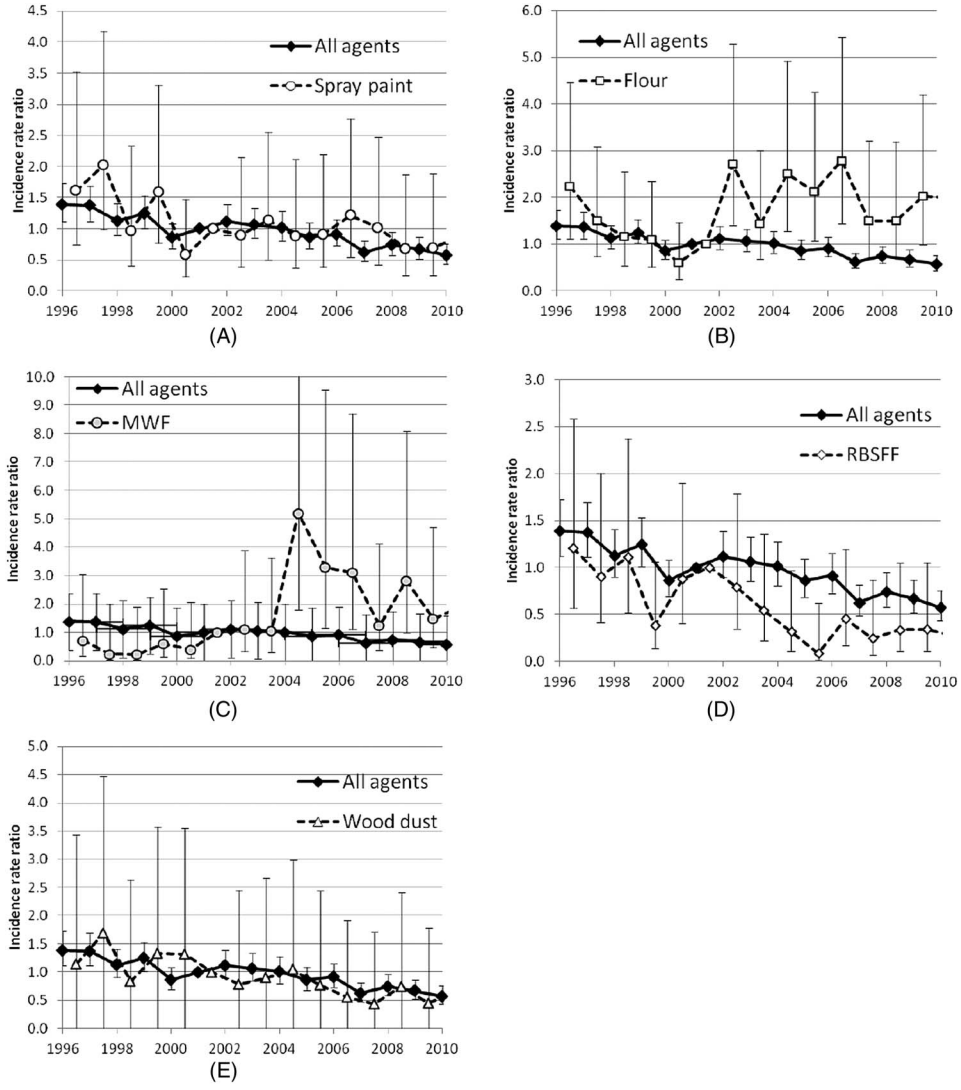

Figure 1 Annual incidence rate ratios relative to 2001 for short latency respiratory disease reported to SWORD attributed to all agents (A–E) and spray paint (A), flour (B), metalworking fluids (MWFs, C), rosin-based solder flux fume (RBSFF, D) and wood dust (E).

generators and transformers, electronic valves and tubes, telegraph and telephone apparatus and equipment, radio and electronic capital goods, television and radio receivers, sound or video recording, medical and surgical equipment and orthopaedic appliances, electronic instruments and appliances, and electronic industrial process control equipment. Other events potentially impacting on exposure to RBSFF included the introduction of a MEL (1999) and several guidance documents published by the HSE (2001 onwards). All cases attributed to soldering were included in the analysis, which compared soldering with all other agents in all workers (table 2, column I).

5. Wood dust—controlling inhalation exposure[14]: This intervention consisted of a series of SHADs delivered to woodworkers from 2002 to 2006; those attending were not inspected by the HSE in the following year. In August 2006, an inspection pack was released with inspections focussed on those less likely to be compliant (eg, not attended the SHADs; previous inspection finding inadequate control; not recently inspected) or routinely perform sanding, routing, profiling and high speed or fine cutting or use large amounts of medium density fibreboard. The industries and occupations targeted were sawmilling, planning and timber treatment; builders' joinery and carpentry; manufacturing of veneers, boards, wooden containers, cork, furniture, brooms and brushes and other products of wood. During 2006–2007, 260 visits were planned and a further 30 SHADs. Another event potentially impacting exposure to wood dust was the replacement of the existing MEL with a WEL in 2005. All cases attributed to wood dust were included in the analysis, which compared wood dust with all other agents in all workers (table 2, column J).

RESULTS

The main results of the analysis are the RIRRs comparing the incidence before the HSE inspection pack intervention (table 1) with the incidence during or after the intervention for the target group relative to all other reports (table 2 A,D,G,I,J). For example, the RIRR in 2a D, table 2 time2/time1 of 1.54 (0.89–2.68) compares the IRR for May01–Apr03 (time2)/May99–Apr01 (time1) for SLRD attributed to flour with the IRR for the same time periods attributed to all agents excluding flour; similarly the RIRR in 2a D, table 2 time3/time1 of 2.09 (1.22–3.57) compares May03–Apr05 (time3)/May99–Apr01 (time1). This can be interpreted as an increase in SLRD attributed to flour relative to all other agents approximately 2 years after the introduction of an MEL but no increase was observed

immediately following the change in legislation. This could be interpreted in several ways; however, the median lag from onset of symptoms to reporting to SWORD (20 months) is consistent with an increased incidence of SLRD in response to the introduction of an MEL possibly due to increased case ascertainment or increasing numbers of workers at risk.

The annual change in incidence for the agent targeted in each intervention is shown in figure 1. The annual RIRR (relative to the first year of the period analysed) that compares the IRR for each agent shown in figure 1 with the IRR for all other agents for the time period analysed is quoted in the following text.

From 2001 to 2010, there were 93 reports of SLRD attributed to spray painting, 68 (73%) of which specified isocyanates. Of the 93, 27 (29%) worked in MVR, 28 (30%) in motor vehicle manufacturing, 16 (17%) in ship or aircraft manufacture/repair and 22 (24%) in other industries. In total, there were 308 reports of SLRD in motor vehicle manufacturing and 33 in MVR. There were no significant changes in the incidence of SLRD or asthma attributed to spray paint corresponding to the intervention period (table 2, 1 A, time2/time1,) or post-intervention (table 2, 1 A, time3/time1) but there was a significant reduction in SLRD attributed to all agents in MVR workers relative to all other workers during the intervention period (table 2, 1 B, time2/time1) not seen in motor vehicle manufacturing workers (table 2, 1 C, time2/time1). Throughout the period of analysis (2001–2010), the estimated incidence of SLRD and asthma attributed to spray painting remained similar to all other agents (annual RIRR SLRD 1.03; 0.95–1.11; asthma 1.06; 0.98–1.14; figure 1A).

From May 1999 to December 2010, there were 244 reports of SLRD attributed to flour or bakery enzymes, of which 149 (61%) worked in retail bakeries, 77 (32%) worked in industrial bakeries, 10 (4%) worked in other food manufacturing industries and 8 (3%) in other industries. The introduction of an MEL for flour in April 2001 did not coincide with a significant change in SLRD/asthma attributed to flour in all workers (table 2, 2a D, time2/time1), or when restricted to the food industry (table 2, 2a E, time2/time1), but did coincide with a significant increase in SLRD/asthma attributed to flour in retail bakery workers relative to industrial bakery workers (table 2, 2a F, time2/time1). Throughout the period of analysis (1999–2010), there was a significant increase in the estimated incidence of SLRD (annual RIRR 1.10; 1.06–1.16, figure 1B) and asthma (1.10; 1.05–1.16) attributed to flour relative to all other agents, particularly during 2003–2005 (table 2, 2a D, time3/time1), which did not correspond to any of the events prospectively identified. The introduction of a WEL or the HSE craft bakeries intervention did not appear to impact on the steady increase in incidence of SLRD/asthma attributed to flour relative to all other agents, in all workers (table 2, 2b D) or within the food industry (table 2, 2b E).

From 2002 to 2008, there were 160 reports of SLRD attributed to MWF. However 131 of these reports originated from one reporter who had investigated a large outbreak of respiratory disease caused by MWF during 2004 coinciding with the time of the intervention (figure 1C).[16 17] Therefore including all reports showed significant increases in SLRD attributed to MWFs during intervention and postintervention (table 2, 3 G, time2/time1 and time3/time1). The analysis was repeated excluding this reporter and the significant increase for SLRD postintervention remained (table 2, 3 H, time3/time1) but this was based on only 29 reports.

From 1996 to 2010, there were 107 reports of SLRD attributed to soldering, of which 84 (79%) specified rosin or colophony, 20 (19%) did not specify the type of solder and 3 (3%) specified rosin-free solder. A large proportion of reports originated from the industries targeted by the HSE inspection pack (65/107; 61%). There was no significant change in incidence of SLRD or asthma attributed to solder relative to all other agents corresponding to any of the individual interventions (table 2, 4 I) but throughout the period of analysis (1996–2010) the estimated incidence of SLRD (annual RIRR 0.94; 0.90–0.99, figure 1D) and asthma (0.95; 0.90–1.00) attributed to soldering declined significantly relative to all other agents.

From 2002 to 2010, there were 42 reports of SLRD attributed to wood dust, of which 16 (38%) originated from the industries targeted by the HSE inspection pack. No significant changes in the incidence of SLRD or asthma attributed to wood dust corresponding to the HSE intervention occurred (table 2, 5 J) and throughout the period of analysis the estimated change in incidence of SLRD (annual RIRR 1.03; 0.91–1.16, figure 1E) and asthma (1.05; 0.92–1.19) attributed to wood dust remained similar to all other agents (figure 1E).

Altogether these agents that are the focus of the HSE inspection packs (MWF, RBSFF, spray paints, flour, wood dust) represent 635/2382 (27%) of the SLRD cases reported to SWORD from 2000 to 2010.

DISCUSSION

The significant decline in incidence of SLRD and asthma reported to SWORD supporting the RHS aim to reduce work-related asthma by 30%[8] is encouraging. However a number of caveats should be considered before using decline in reported incidence as a proxy for a real decline in incidence. Some of the bias inherent in the voluntary reporting scheme, such as type of reporter (monthly or annual) and harvesting of cases when joining the scheme, is accounted for in the model but other sources of bias such as reduced reporting after longer membership time (reporter fatigue) are not taken into account. Therefore, the declining trend in reporting is composed of a real change in incidence, changes in reporting behaviour and other unpredictable bias arising from the nature of voluntary reporting. As these effects cannot be separated, the comparison between the target and non-target group (RIRR) is used to take into account bias occurring equally across all work-related SLRDs and causal agents as would be expected for reporter fatigue. However, this means that reports included in the target group for one comparison may be included in the non-target group in another comparison. In this analysis, the majority of the reports will only be used in the non-target group (73%) but one should be aware that changes in the non-target group, as well as the target group, will affect the RIRR. Besides these specific interventions, the HSE has invested considerable effort into reducing work-related respiratory disease since 2001, so it is likely that at least part of the decline is a real decline in incidence, not just changes in reporting behaviour. Since changes in the groups targeted by the inspection packs are compared with this overall decline, the decline in the targeted group needs to be significantly steeper than the overall declining trend to support the argument of a beneficial effect. In the case of soldering, the declining trend is steeper than the overall trend, suggesting specific interventions have had an effect, whereas for wood dust and spray paint the declining trends are keeping pace with the overall declining trend, neither supporting nor ruling out the possibility of an impact for these interventions. For flour, the increasing trend is in the opposite direction of the overall trend suggesting that the intervention is either ineffective or has resulted in increased case ascertainment or reporting.

The significant increase in SLRD/asthma attributed to flour in retail bakers relative to industrial bakers coinciding with the introduction of a MEL (table 2, 2a F, time2/time1) suggests that industrial bakeries were more proactive in their response to the new exposure limit. The increase in the reported incidence of SLRD/asthma attributed to flour relative to other agents occurring during the consultation period prior to the introduction of a WEL (time3, May 2003–April 2005) does not coincide with any of the prospectively defined interventions and may reflect changes in the industry such as increasing demand for freshly baked bread. The observation that this increase remained despite the introduction of a WEL and the HSE craft bakery inspection pack (table 2, 2a and 2b D) suggests that the interventions had been ineffective or that the collaboration with LA environmental health inspectors had the unintended effect of increasing awareness of the problem resulting in increased case reporting to SWORD. If the latter were true, a postintervention dip in incidence would be expected (2b D, table 2, time5/time4); this was not observed and the gradual increase in SLRD/asthma attributed flour relative to other agents continues. As SLRD/asthma attributed to flour comprises a large number of reports to SWORD, and the trend is opposite to the general declining trend, the results for flour are more convincing than for some of the other agents discussed in this paper. Continued emphasis by the HSE on reducing exposure to flour dust will hopefully result in a reduction in reports to SWORD in future years.

These data did not show any changes in SLRD attributed to spray painting relative to all other agents in all workers in response to the release of the inspection pack despite a reported reduction in urinary levels of hexamethylene diamine, a biomarker of exposure to hexamethylene di-isocyanate, in sprayers attending the SHADS by the HSE.[18] However spray painting in MVR accounts for only 29% of reports of spray painting; therefore, most sprayers were not targeted by this intervention. Targeting other sources of isocyanate exposure and/or occupational groups may be a more effective means to reduce isocyanate exposure. The significant reduction in SLRD in MVR workers relative to all other workers during the 3 year intervention period is consistent with a positive effect of the campaign (table 2, 1 B , time2/time1) that was not sustained in to the postintervention period (table 2, 1 B, time3/time1). This might reflect temporary improvements in behaviour resulting from increased inspections but as the number of reports from the target group was small this should not be overinterpreted.

The significant decline in SLRD/asthma attributed to soldering relative to all other agents from 1996 onwards suggests that the introduction of a stringent MEL for RBSFF in 1999 and the ongoing HSE campaign started in 2001 was effective. However, this did not coincide with any specific HSE-led intervention. Although the majority of reporters specified colophony, it is likely that the term colophony is used for any type of flux; therefore, all cases attributed to soldering were included in the analysis. Furthermore some products labelled as rosin-free may contain modified natural rosin or synthetic fluxes that contain resin acids similar to those found in natural rosin.

The incidence of SLRD attributed to wood dust remained unchanged relative to all other agents; again low numbers of cases may have contributed to this but the observation that only about one-third of reports came from the industries targeted by the HSE inspection pack suggests that targeting a wider range of industries might improve the impact of the intervention.

It was not possible to provide evidence for an impact of the HSE intervention on MWFs due to the over-riding effect of the investigation of SLRD attributed to MWFs. During 2003–2004, 12 cases of extrinsic allergic alveolitis occurred in a car engine manufacturing plant. This prompted an investigation that identified 87 workers meeting the criteria for occupational lung disease.[16 17] These cases were most likely reported to SWORD explaining the peak in SLRD attributed to MWFs during 2004. As these cases did not arise through the normal referral route and this outbreak influenced the decision to remove the existing MEL and not replace it with a WEL, we cannot infer that there is a relationship with the HSE intervention. It serves as a reminder of the importance of being fully aware of competing effects when using this method that only identifies a temporal coincidence consistent with the selected event and cannot exclude reverse causation, that is, an outbreak of disease may affect policy rather than policy affecting the incidence of disease, or the impact of other events influencing the target and control group differently. The analysis for MWFs is included for completeness, that is, all the inspection pack interventions undertaken by the HSE are included within this paper.

The total number of RIRRs reported in this paper is 62; therefore, some significant interactions might occur due to random chance. Concerns may be reduced by focusing solely on the five main comparisons made for each agent (table 2 A, D, G, I, J) or by focussing on one type of disease; asthma is a large subset of SLRD. The other analyses are included to focus in on the occupational group in order to more closely resemble the target group of the intervention, and may be considered to be of secondary importance.

Overall these data are consistent with a reduction in the incidence of SLRD/asthma attributed to RBSFF following the introduction of a WEL and the release of an HSE inspection pack. In contrast, similar interventions targeting isocyanates attributed to spray painting in MVR and wood dust in woodworking industries did not coincide with a detectable decline in incidence, although these incidences did decline equally with the overall trend. This may be partly due to the mismatching of exposures and target industries by the HSE; the targeted electronics industries contributed a larger proportion of reports attributed to RBSFF than did MVR for isocyanates or woodworking industries for wood dust. The inspection packs may have been effective within the targeted group but as many reports of the agent originated from non-target industries the effect of the intervention was hidden, for example, the observed reduction in SLRD in the MVR industry relative to all other industries for all agents (table 2, 1 B, time2/time1) but no change in SLRD attributed to spray painting relative to all other agents (table 2, 1 A, time2/time1). There were insufficient cases originating from the target industries to analyse the data to this level for wood dust and RBSFF.

This method has advantages in investigating the effectiveness of the inspection pack approach in that it provides independence from the body implementing the interventions (HSE) and assesses the impact at a national level. However, it cannot investigate the interventions specifically in those targeted by the HSE, some of whom may be particularly non-compliant. The inspection pack includes an evaluation aspect and if published would make an interesting comparison with these data. However, we were unable to obtain an objective measurement of the resources invested in each intervention by the HSE. The observation that the occupational groups targeted by the inspection packs tended to include only a small proportion of reports for a particular agent may be the reason why beneficial effects were not often seen and should be considered when designing future interventions.

Acknowledgements Thanks are due to all physicians reporting to SWORD.

Contributors SJS designed the study, undertook the analysis and wrote the manuscript. RM developed the statistical method and commented on the manuscript. ST commented on the manuscript. MC managed the data collection. RA commented on the manuscript.

Funding The SWORD project is partly funded by the UK Health and Safety Executive. Any opinions and conclusions expressed herein are solely those of the authors and not the funding body.

Competing interests None.

Ethics approval NRES NW 11/NW/0832.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Data requests to THOR should be made in writing to melanie.carder@manchester.ac.uk.

REFERENCES

1 Meredith SK, Taylor VM, McDonald JC. Occupational respiratory disease in the United Kingdom 1989: a report to the British Thoracic Society and the Society of Occupational Medicine by the SWORD project group. *Br J Ind Med* 1991;48:292–8.
2 Turner S, McNamee R, Agius R, *et al*. Evaluating interventions aimed at reducing occupational exposure to latex and rubber glove allergens. *Occup Environ Med* 2012;69:925–31.
3 Stocks SJ, McNamee R, Turner S, *et al*. Assessing the impact of national level interventions on workplace respiratory disease in the UK: part 1—changes in workplace exposure legislation and market forces. *Occup Environ Med* 2013 http://dx.doi.org/10.1136/oemed-2012-101123
4 Revitalising Health and Safety (RHS) Strategy Statement 2000; Her Majesty's Stationery Office. http://www.hse.gov.uk/revitalising/strategy.pdf (accessed Aug 2012).
5 Adey D. Tackling Occupational Asthma. Health and Safety Commission advisory committee on toxic substances; ACTS/47/2002, ACTS/05/2003. http://www.hse.gov.uk/aboutus/meetings/iacs/acts/211102/paper47.pdf (accessed Aug 2012). http://www.hse.gov.uk/aboutus/meetings/iacs/acts/130303/paper05.pdf (accessed Aug 2012).
6 *Control of substances hazardous to health*. 5th edn. The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance. HSE Books, 2005. http://www.hse.gov.uk/pubns/priced/l5.pdf (accessed Aug 2012).
7 Control of Substances Hazardous to Health Regulations 2002 (as amended in 2004) General enforcement guidance and advice OC 273/20 (Version 2). 2007. http://www.hse.gov.uk/foi/internalops/fod/oc/200–299/273_20.pdf (accessed Aug 2012).
8 Carder M, McNamee R, Holland F, *et al*. Time trends in the incidence of work-related ill-health in the UK, 1996–2010: estimation from THOR surveillance data; Report to HSE submitted September 2011. http://www.hse.gov.uk/statistics/pdf/thortrends11.pdf (accessed Aug 2012).
9 Evaluation of FOD's Topic Based Inspection. *Research report 368*. HSE Books, 2005. http://www.hse.gov.uk/research/rrpdf/rr368.pdf (accessed Aug 2012).
10 Topic inspection pack: Control of isocyanate exposure in motor vehicle repair (MVR) bodyshops Disease Reduction Programme. Version 7. 2007. http://www.hse.gov.uk/foi/internalops/fod/inspect/mvrtopicpack.pdf (accessed Aug 2012).
11 Topic inspection pack: Craft bakeries: exposure to flour dust and enzymes in improvers. Version 2. 2008. http://www.hse.gov.uk/foi/internalops/fod/inspect/craftbakery.pdf (accessed Aug 2012).
12 Topic inspection pack: Controlling inhalation exposure to metalworking fluids Version 1. 2006. http://www.hse.gov.uk/foi/internalops/fod/inspect/metalworkingfluids.pdf (accessed Aug 2012).
13 Topic inspection pack: Controlling inhalation exposure to rosin based solder fume. Version 1. 2007. http://www.hse.gov.uk/foi/internalops/fod/inspect/solderfume.pdf (accessed Aug 2012).
14 Topic inspection pack: Wood dust: Controlling inhalation exposure. Version 1. 2006. http://www.docstoc.com/docs/87688197/TOPIC-INSPECTION-PACK-WOOD-DUST (accessed Aug 2012).
15 McNamee R, Carder M, Chen Y, *et al*. Measurement of trends in incidence of work-related skin and respiratory diseases, UK 1996–2005. *Occup Environ Med* 2008;65:808–14.
16 Robertson W, Robertson AS, Burge CBSG, *et al*. Clinical investigation of an outbreak of alveolitis and asthma in a car engine manufacturing plant. *Thorax* 2007;62:981–90.
17 Outbreak of respiratory disease at Powertrain Ltd, HSE Books 04/2006. http://www.hse.gov.uk/metalworking/experience/powertrain.pdf (accessed Dec 2012).
18 Jones K, Cocker J, Piney M. Isocyanate exposure control in motor vehicle paint spraying: evidence from biological monitoring. *Ann Occup Hyg* 2013;57:200–2009.