The Burden of Work-related Cancer in Great Britain

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Aims of the overall study

- Current Burden of Occupational Cancer:
  - Estimate size of current burden based on past exposures at work
  - to identify important cancer sites
  - to identify industries and occupations for targeting for reduction measures
  - Estimation carried out for all substances and circumstances (e.g. work as a painter or welder) in the workplace defined by International Agency for Research on Cancer as **definite** (group 1) and **probable** (group 2A) human carcinogens

- Prediction of Future Burden of Occupational Cancer
  - Estimate size of future burden based on current and past exposures
  - Identify cancer sites, carcinogens and industry sectors where the burden is greatest
  - Demonstrate effects of measures to reduce exposure

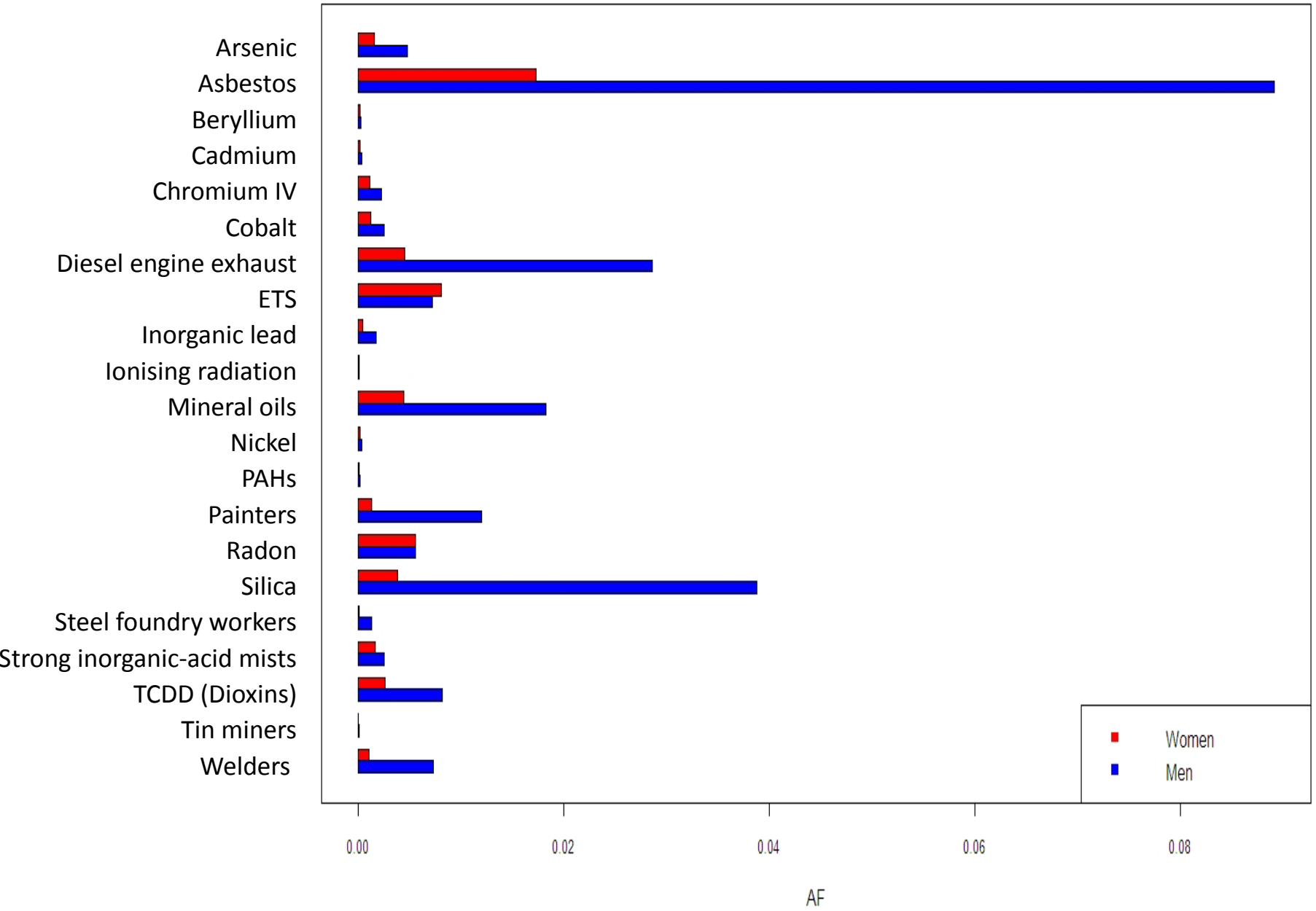
Methods

- Measure of burden: Attributable Fraction (AF) - proportion of cases attributable to exposure; needs
  - risk of disease associated with the exposure of concern: obtained from relevant published literature
  - proportion exposed in the population
- To take into account latency (length of time before disease risk increases) we defined the risk exposure period (REP) for:
  - Solid tumours: 10-50 years; 1956-95
  - Leukaemia: up to 20 years; 1986-2005
- Proportion exposed over the REP is:
  number ever exposed/number ever worked
- Estimated using national data sources (CAREX, LFS, CoE)
- Adjusted for turnover, change in numbers employed over REP e.g. Manufacturing decreasing, service sector increasing

Cancer site:	Attributable Fraction(%)			Attrib Deaths (2005)			Attrib. Registrations (2004)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Bladder	7.1	1.9	5.3	215	30	245	496	54	550
Bone	0.0	0.0	0.0	0	0	0	0	0	0
Brain	0.5	0.1	0.3	10	1	11	12	2	14
Breast		4.6	4.6		555	555		1,969	1,969
Cervix		0.7	0.7		7	7		18	18
Kidney	0.04	0.04	0.04	1	1	1	2	1	3
Larynx	2.9	1.6	2.6	17	3	20	50	6	56
Leukaemia	0.9	0.5	0.7	18	5	23	30	9	38
Liver	0.2	0.1	0.2	4	2	5	4	1	5
Lung	21.1	5.3	14.5	4,020	725	4,745	4,627	815	5,442
Lympho-haematopoietic	0.004	0.002	0.003	0	0	0	0	0	0
Melanoma (eye)	2.9	0.4	1.6	1	0	1	6	1	6
Mesothelioma	97.0	82.5	94.9	1,699	238	1,937	1,699	238	1,937
Multiple Myeloma	0.4	0.1	0.3	5	1	6	8	2	10
Nasopharynx	10.8	2.4	8.0	7	1	8	14	1	15
NHL	2.1	1.1	1.7	43	14	57	102	39	140
NMSC	6.9	1.1	4.5	20	2	23	2,513	349	2,862
Oesophagus	3.3	1.1	2.5	156	28	184	159	29	188
Ovary		0.5	0.5		23	23		33	33
Pancreas	0.02	0.01	0.01	1	0	1	1	0	1
Sinonasal	43.3	19.8	32.7	27	10	38	95	31	126
Soft Tissue Sarcoma	3.4	1.1	2.4	11	3	13	22	4	27
Stomach	3.0	0.3	1.9	101	6	108	149	9	157
Thyroid	0.12	0.02	0.05	0	0	0	1	0	1
Total	8.2	2.3	**5.3**	6,355	1,655	**8,010**	9,988	3,611	**13,598**
Total GB cancers 15+yrs				77,912	72,212	150,124	175,399	168,184	343,583

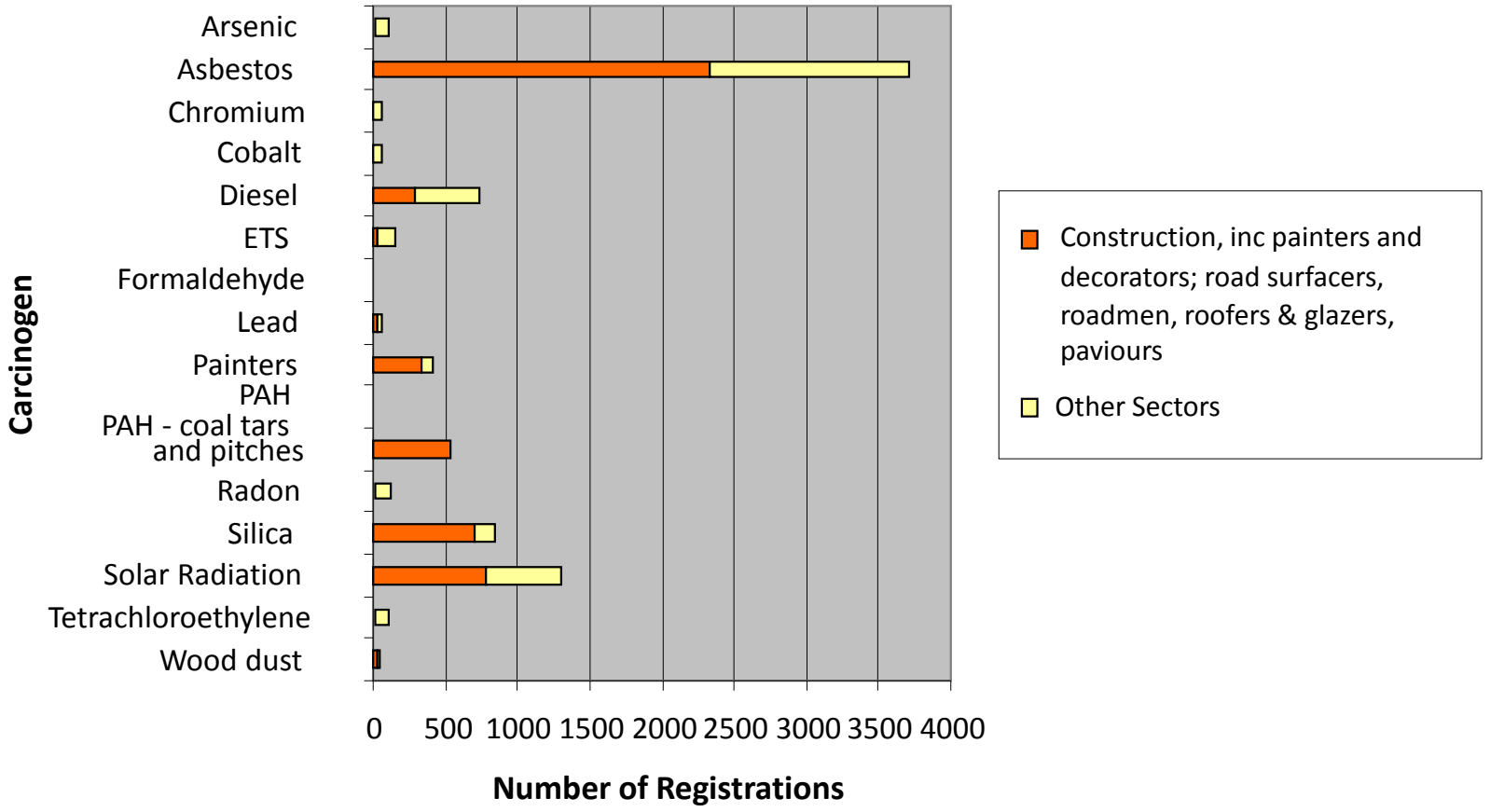
Cancer Site	Asbestos	Shift work	Min. oils	Solar rad^{n}	Silica	DEE	PAHs (Tars)	Painters	Dioxins	ETS	Radon	Welders	All
Bladder			296			106		71					550
Brain													14
Breast		1,957											1,969
Cervix													18
Kidney													3
Larynx	8												56
Leukaemia													38
Liver													5
Lung	2,223		470		907	695		282	215	284	209	175	5,442
LH cancers													1
Melanoma eye													6
Mesothelioma	1,937												1,937
Multiple Myeloma													10
Nasopharynx													15
NHL									74				140
NMSC			902	1,541			475						2,862
Oesophagus													188
Ovary													33
Pancreas													1
Sinonasal			55										126
STS									27				27
Stomach	47							83					157
Thyroid													1
Total Attrib. Registrations	**4,216**	**1,957**	**1,722**	**1,541**	**907**	**801**	**475**	**437**	**316**	**284**	**209**	**175**	**13,598**

Lung cancer AF by carcinogen/occupation



Industry	Asbestos	Shift work	Min. oils	Solar rad^{n}	Silica	DEE	PAHs (tars)	Painters	Dioxins	ETS	All
Total Agriculture, farming				**135**					**55**		**263**
Iron and steel basic industries			0	0		0	4		75		135
Manufacture industrial chemicals	64				1	1			11		121
Manufacture of instruments, photographic and optical goods			203								206
Manufacture machinery not electrical			0		8	2					111
Manufacture of other chemical products	69				10	1					123
Manufacture transport equipment	115		0	5	11	2					188
Metal workers			1,252								1,250
Mining	197			31	29	43					302
Non-ferrous metal industries				9	4	2			50		159
Painters (not construction)								102			102
Printing, publishing et c			267	3		0					286
Welders											182
Total manufacturing etc	**535**		**1,722**	**163**	**200**	**80**	**4**	**102**	**254**		**3,944**
Construction	2,773			841	707	290				36	4,816
Painters/decorators (construction)								334			335
Roofers/road workers (construction)							471				541
Total Construction	**2,773**			**841**	**707**	**290**	**471**	**334**		**36**	**5439**
Land transport	133			6		350				3	505
Personal/household services	361		7	14		29				22	804
Public admin./defence				240						20	273
Shift work		1,957									1,957
Wholesale, retail, restaurants	66			6		6			7	118	269
Total service industry	**573**	**1,957**	**7**	**402**		**431**			**7**	**248**	**4,177**
Total Attrib. Registrations	**4,216**	**1,957**	**1,722**	**1,541**	**907**	**801**	**475**	**437**	**316**	**284**	**13,598**

Cancer Registrations Attributable to Work in the Construction Industry - Men



Predicting Future Burden

- Attributable Fractions and attributable numbers of deaths and cancer registrations estimated for a series of forecast years, e.g. 2010, 2020 … 2060
- Define the risk exposure period (REP) for each year e.g. for 2030, 1981 – 2020
- Changing balance between past and future exposure
- Forecasted AFs take into account employment turnover and changes in different industry sector employment trends
- Method developed to shift the proportion of workers exposed in different exposure level categories (H/M/L/B) across time as exposures gradually decrease
- Predicted numbers based on demographic change only i.e. Assuming all non-occupational risk factors e.g. Smoking stay same as 2004/5
- Method provides a tool for comparing ‘doing nothing’ (baseline scenario) with various interventions
- Methods applied to top 14 carcinogens/occupations identified as accounting for 85.7% of total current (2004) cancer registrations

Change in future exposure: Intervention Scenarios

Can test:

- Introduction of a range of possible exposure standards or reduction of a current exposure limit
- Improved compliance to an existing exposure standard
- Comparison of lowering an exposure standard versus improved compliance
- Planned intervention such as engineering controls or introduction of personal protective equipment
- Industry closure

Also can vary:

- Timing of introduction (2010, 2020 etc)
- Compliance levels e.g. according to workplace size (self-employed, 1-49, 50-249, 250+ employees)

Intervention scenario results compared to the 'baseline – no change' or 'baseline - trend' scenario to assess relative impact on reducing attributable numbers

Intervention Scenarios for Priority Carcinogens

No appropriate exposure measurements

- ETS (lung cancer) – test compliance to smoking bans
- Radon (lung cancer) – reduce exposed nos. by 10% per decade
- Solar radiation (NMSC) – move workers into lower exposure (time spent outdoors) categories

Occupational circumstances, no specified 'carcinogen'

- Shift work (breast cancer) - move workers into lower duration of exposure categories
- Painters, welders – reduce excess risk

Some exposure data – standards can be tested

- RCS (lung cancer) – test existing and stricter standards, estimate current compliance and test effect of variable compliance
- Arsenic, strong acids, tetrachloroethylene, TCDD – test possible standards based on H/L exposure boundary estimates, or L/B below which excess risk is zero
- DEE – test suggested OEL

Carcinogens where occupational standards/limits exist or could be introduced

- Example: silica
  - Reduce exposure limit from 0.1 to 0.05 mg/m^3 in all workplaces, in 2010, with the same proportion exposed above the new limit as above the old
  - Reduce exposure limit again to 0.025 mg/m^3
  - Improve compliance from 33% to 90% in all workplaces
  - Try doing both for all workplaces
  - Successively enforce the new limit and improve compliance in workplaces of different sizes

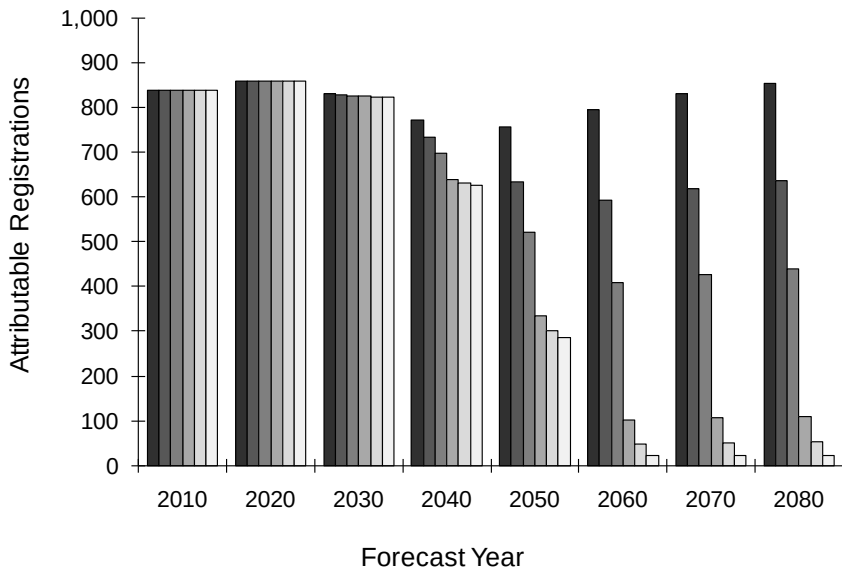
Testing reduction of exposure standard and changes in compliance
Forecast lung cancers for 2060 for Respirable Crystalline Silica

	2010		
	Attributable Fraction	**Attributable registrations**	**Avoided registrations**
	3.3	803	
	2060		
Base-line: exposure limit 0.1mg/m^3, compliance 33%	1.08	794	
Exposure limit 0.05mg/m^3, compliance 33%	0.80	592	**202**
Exposure limit 0.025mg/m^3, compliance 33%	0.56	409	**385**
Exposure limit 0.1mg/m^3, compliance 90%	0.14	102	**693**
Exposure limit 0.05mg/m^3, compliance 90%	0.07	49	**745**
Exposure limit 0.025mg/m^3, compliance 90%	0.03	21	**773**

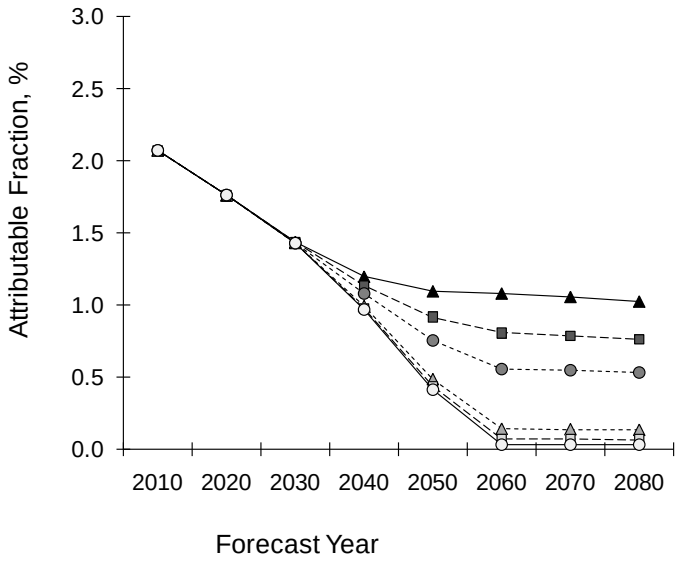
Lung cancer from exposure to RCS

Effect of reducing the exposure standard for RCS versus compliance

A) Attributable registrations



B) AFs



(1) Baseline: exposure limit 0.1mg/m^3 maintained, compliance 33%

(2) Exposure limit 0.05mg/m^3 from 2010, compliance 33%

(10) Exposure limit 0.025mg/m^3 from 2010, compliance 33%

(11) Exposure limit 0.1mg/m^3 maintained, compliance 90%

(12) Exposure limit 0.05mg/m^3 from 2010, compliance 90%

(13) Exposure limit 0.025mg/m^3 from 2010, compliance 90%

Testing improvement in compliance by workplace size
Forecast lung cancers for 2060 for Respirable Crystalline Silica

	2010		
	Attributable Fraction %	**Attributable registrations**	**Avoided registrations**
	3.3	803	
	2060		
Base-line: exposure limit 0.1mg/m^3, compliance 33%	1.08	794	
Exposure limit 0.05mg/m^3, compliance 33%	0.80	592	**202**
Exposure limit 0.05mg/m^3, % compliance changes by employed workplace size and self employed			
33% < 250, self employed; 90% 250+	0.68	499	**295**
33% < 50, self employed; 90% 50+	0.61	451	**344**
33% self employed; 90% all sizes employed	0.35	261	**533**
90% all workplaces	0.07	49	**745**

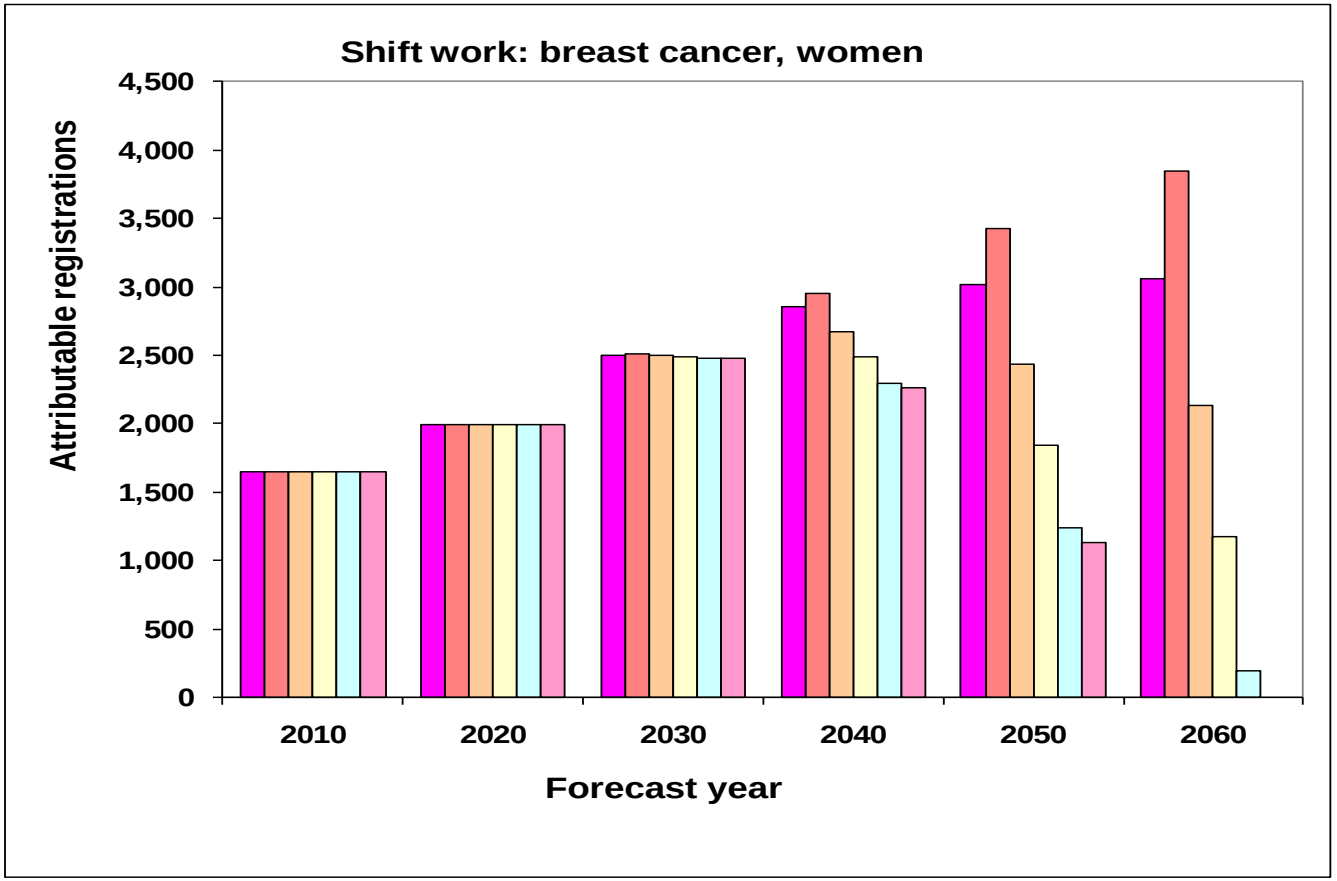
Occupational Circumstances no 'exposure data' Example: Shift Work (Night work)

- Breast cancer: important contribution to the total current occupational cancer burden
- Exposure defined by nature of occupation – unknown agent, no exposure data
- Evidence of dose response with duration of night work

Duration	Relative Risk	Proportion 'exposed'
<5 years:	0.95	30%
5-14 years:	1.29	40%
15+ years:	2.21	30%

- Intervention scenarios expressed as limiting proportions in night work for durations of 15+ and 5+ years

Shift (Night) Work: Attributable Cancers



(1) Current employment levels maintained, 30% <5, 40% 5-14, 30% 15+ years night shift work
(2) Linear employment trends to 2021-30
(3) 50%<5, 30% 5-14, 20% 15+ years night shift work
(4) 70%<5, 20% 5-14, 10% 15+
(5) 90%<5, 10% 5-14, 0% 15+
(6) 100% <5 years

Summary of Future Burden Results

- 14 agents account for 85.7% current occupation attributable cancer (2004), 12,000 cancers in 2010
- Will rise to nearly 13,000 by 2060 given current trends in employment and exposure levels (>12,300 if current levels maintained). Aging population is a factor.
- No impact seen until 2030 because of general increase in cancers due to aging population
- With modest intervention over 2,000 cancers can be avoided by 2060 (including 376 lung, 928 breast cancers, 432 NMSC)
- With stronger interventions nearly 8,500 can be avoided by 2060 (including 1,732 lung, 3,062 breast and 3,287 NMSC)
- Methods enables effective interventions to be identified
- Need to monitor exposure levels in future to assess whether interventions have been successful

Uncertainties and the impact on the burden estimation

Source of Uncertainty	Potential impact on burden estimate
Exclusion of IARC group 2B and unknown carcinogens e.g. for electrical workers and leukaemia	↓
Inappropriate choice of source study for risk estimate	↑↓
Imprecision in source risk estimate	↑↓
Source risk estimate from study of highly exposed workers applied to lower exposed target population	↑
Risk estimate biased down by healthy worker effect, exposure misclassification in both study and reference population	↓
Inaccurate latency/risk exposure period, e.g. most recent 20 years used for leukaemia, up to 50 years solid tumours	↓
Effect of unmeasured confounders	↑↓
Unknown proportion exposed at different levels	↑↓

Summary

- Robust methodological approach developed for estimation of burden for all IARC 1, 2A occupational carcinogens

- Outputs: Current burden results
  - Preliminary work on 6 cancer sites: Occupational and Environmental Medicine 2008, 65, 789-800;
  - Results from all sites: Br J Cancer 2010, 102: 1428-1437 + Technical report on HSE website
  - Supplement (13 papers) of current burden detailed results
    - Br J Cancer 2012;107(S1):S1-S108
    - 23 technical reports available at http://www.hse.gov.uk/cancer/
  - Papers in preparation reporting
    - DALYs/inequality of burden
    - Evaluation of impact of source of bias and uncertainty

- Outputs: Future burden
  - Methodology paper: Am J Epidem 2011, 173, 1069-1077+ technical report on HSE website
  - Future burden results: in press Cancer Prevention Research