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Cancers Caused by Occupation in Great Britain

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This study was funded by the Health and Safety Executive

Aims of the study

- Aims of the study:
 - to develop and apply methodology to estimate current attributable risk, cancer numbers and DALYs caused by work
 - to identify important cancer sites
 - to identify industries and occupations for targeting for reduction measures
 - To estimate the future occupational cancer burden in GB under different scenarios of changing exposure
- Selection of carcinogens and occupations for estimation:
 - classified by IARC as group 1 (established) and 2A (probable) carcinogens
 - with strong or suggestive evidence of carcinogenicity in humans
 - 24 cancer sites; 42 carcinogenic agents or occupations; over 100 industry sectors

Measure of Burden

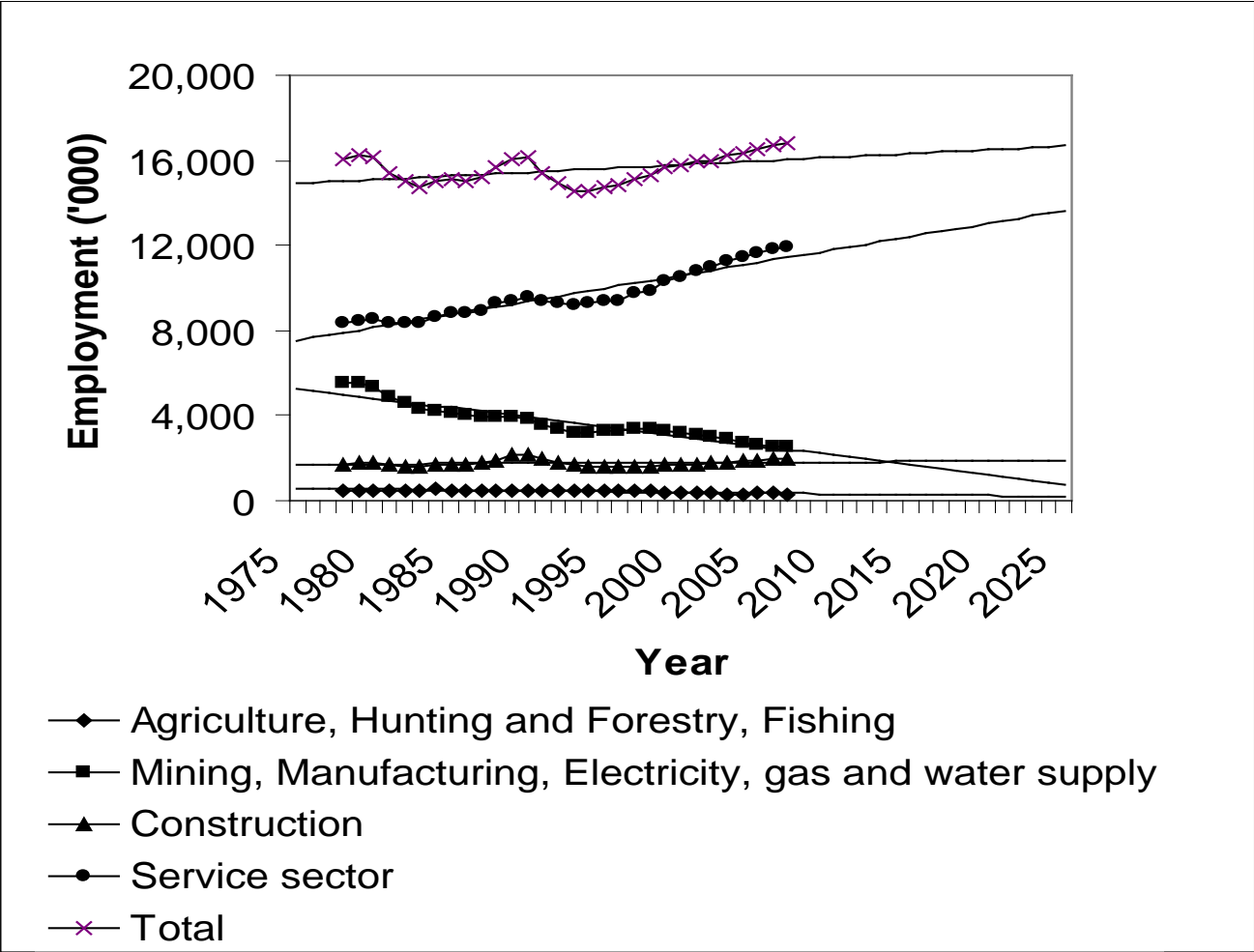
- Measure of burden used is the AF - proportion of cases attributable to exposure; needs
 - risk of disease associated with the exposure of concern (e.g. relative risk (RR))
 - proportion exposed in the population
- RR from published literature: meta-analyses, pooled studies, narrative reviews where available
- Selected studies with comparable exposures to GB:
 - Large sample size
 - Clear case definition
 - Appropriate comparison population
 - Controlled for confounders where possible
 - Adequate exposure assessment
- Risk estimates obtained for overall 'higher' level of exposure and lower/background exposure

Estimating the Proportion Exposed

- 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:
$$\text{number ever exposed} / \text{number ever worked}$$
- Estimated using national data sources (CAREX, LFS, CoE)
- Adjusted for turnover, change in numbers employed over REP

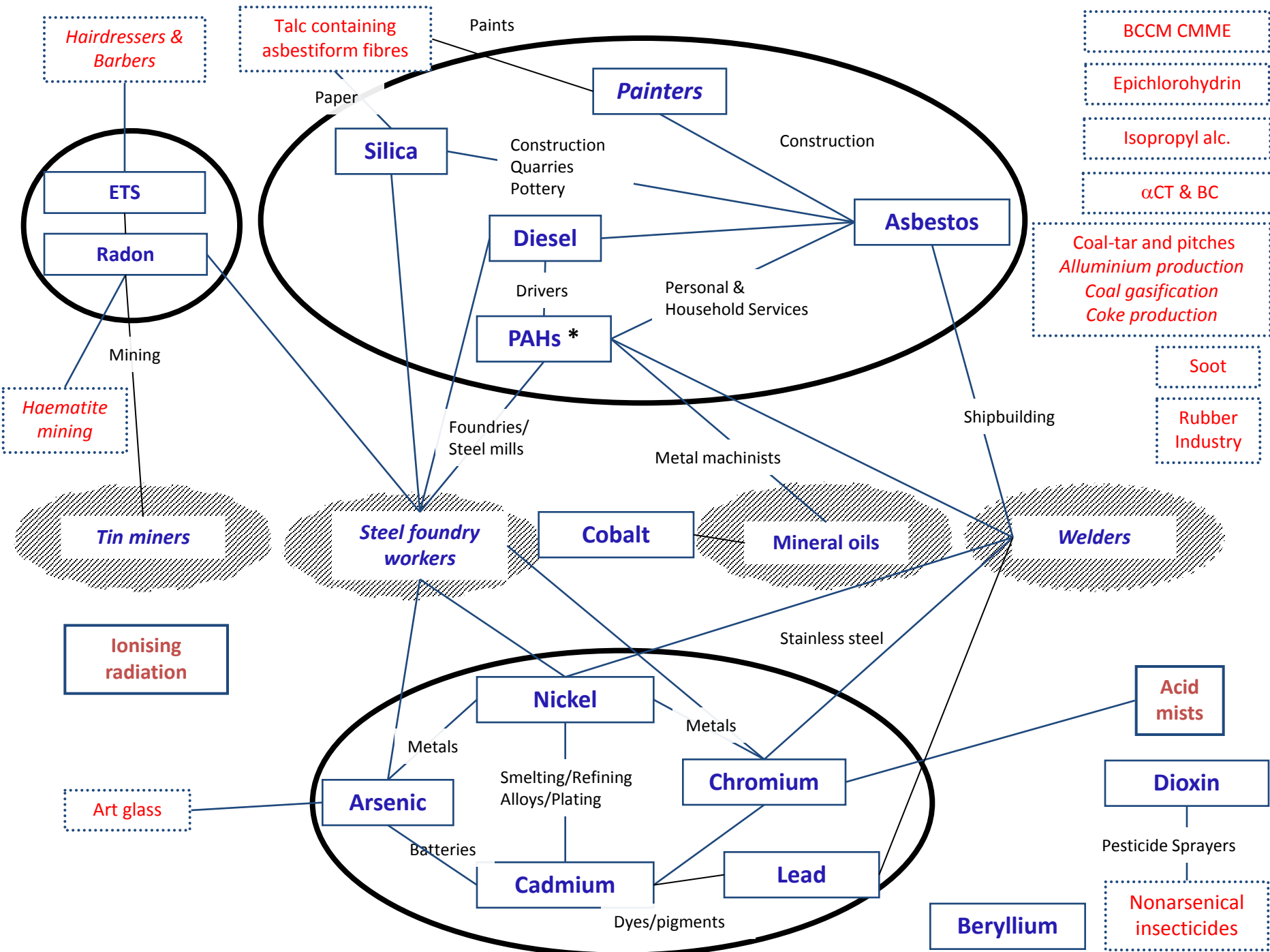
Trends in employment structure in Great Britain, based on Labour Force

Survey data from 1975 to 2007 and projected to 2025, men

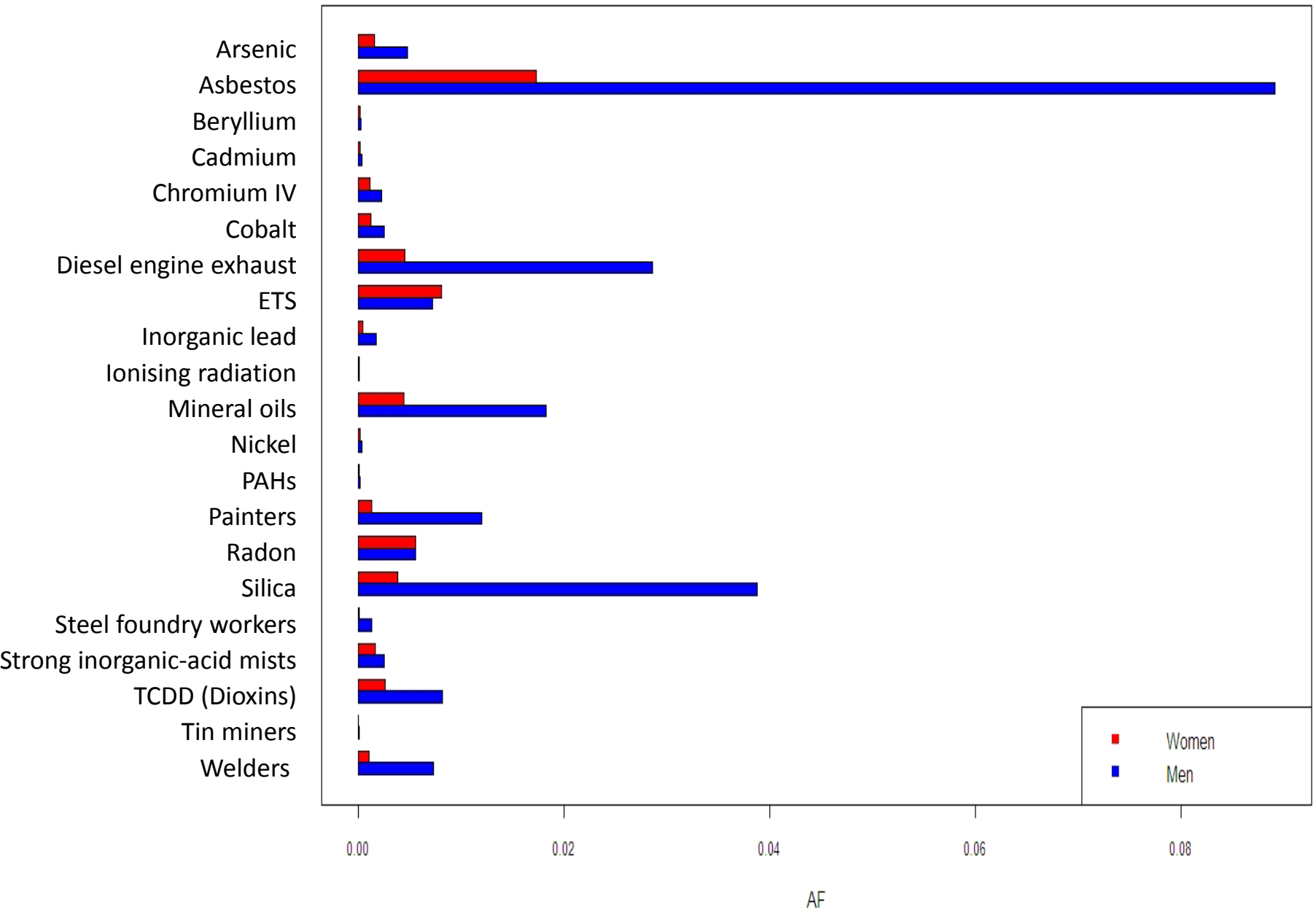


Cancer site:	Attributable Fraction(%)			Attrib Deaths (2005)			Attrib. Registrations (2004)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Bladder	7.1	1.9	5.3	215	30	245	496	54	550
Bone	0.0	0.0	0.0	0	0	0	0	0	0
Brain	0.5	0.1	0.3	10	1	11	12	2	14
Breast		4.6	4.6		555	555		1,969	1,969
Cervix		0.7	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

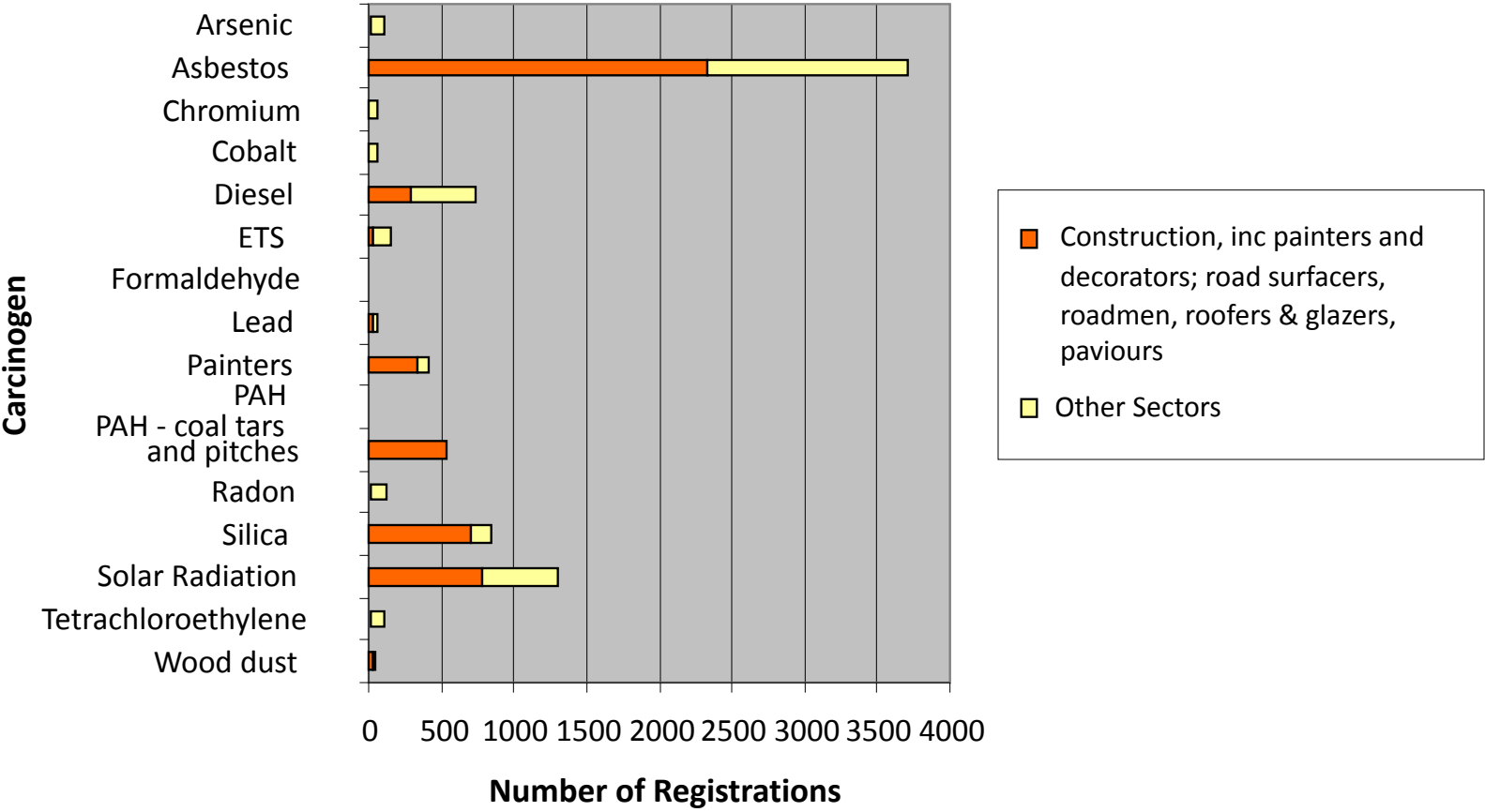


Lung cancer AF by carcinogen/occupation

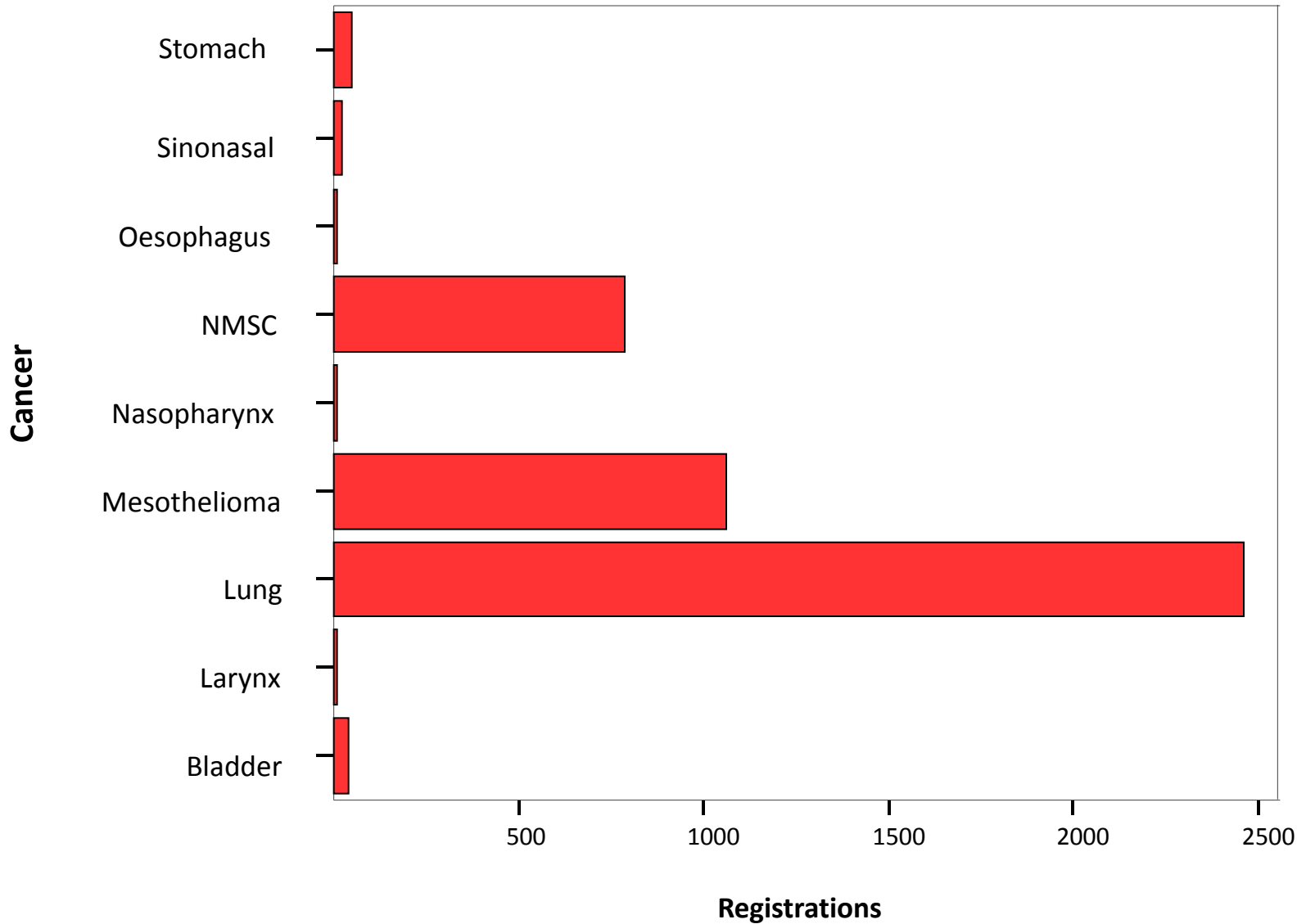


Industry	Asbestos	Shift work	Min. oils	Solar rad ⁿ	Silica	DEE	PAHs (tars)	Painters	Dioxins	ETS	All
Total Agriculture, farming				135					55		263
Iron and steel basic industries			0	0		0	4		75		135
Manufacture industrial chemicals	64				1	1			11		121
Manufacture of instruments, photographic and optical 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



Attributable Registrations by Cancer Site for Work in the Construction Industry: Men



Cancer Site	YLD (years)	YLL (years)	DALY (years)	Deaths (2005)	Average YLL (years)
Bladder	567	2543	3110	245	9.6
Brain	10	221	232	11	20.1
Breast	4196	9600	13797	555	17.3
Cervix	39	156	195	7	22.3
Larynx	123	290	414	20	14.5
Leukaemia	33	390	442	24	16.3
Lung	3164	62848	66080	4745	13.2
Mesothelioma	796	26942	27738	1937	13.9
Nasopharynx	24	155	183	8	19.4
NHL	65	964	1029	57	16.9
NMSC	67	203	277	23	8.8
Oesophagus	163	2528	2691	184	13.7
Ovary	35	383	418	23	16.7
Sinonasal	181	622	2691	38	16.4
STS	38	286	336	13	22.0
Stomach	129	1324	1460	108	12.3
Total	9662	109672	119491	8010	13.7

Summary of Outputs Available

- Separately for
 - cancer site (24),
 - carcinogens (42)
 - industry sector (>60)
- AF%
- AN (deaths and registrations)
- YLL (numbers and average)
- YLD (numbers and average)
- DALY (YLL + YLD)
- All these separately for men, women and total

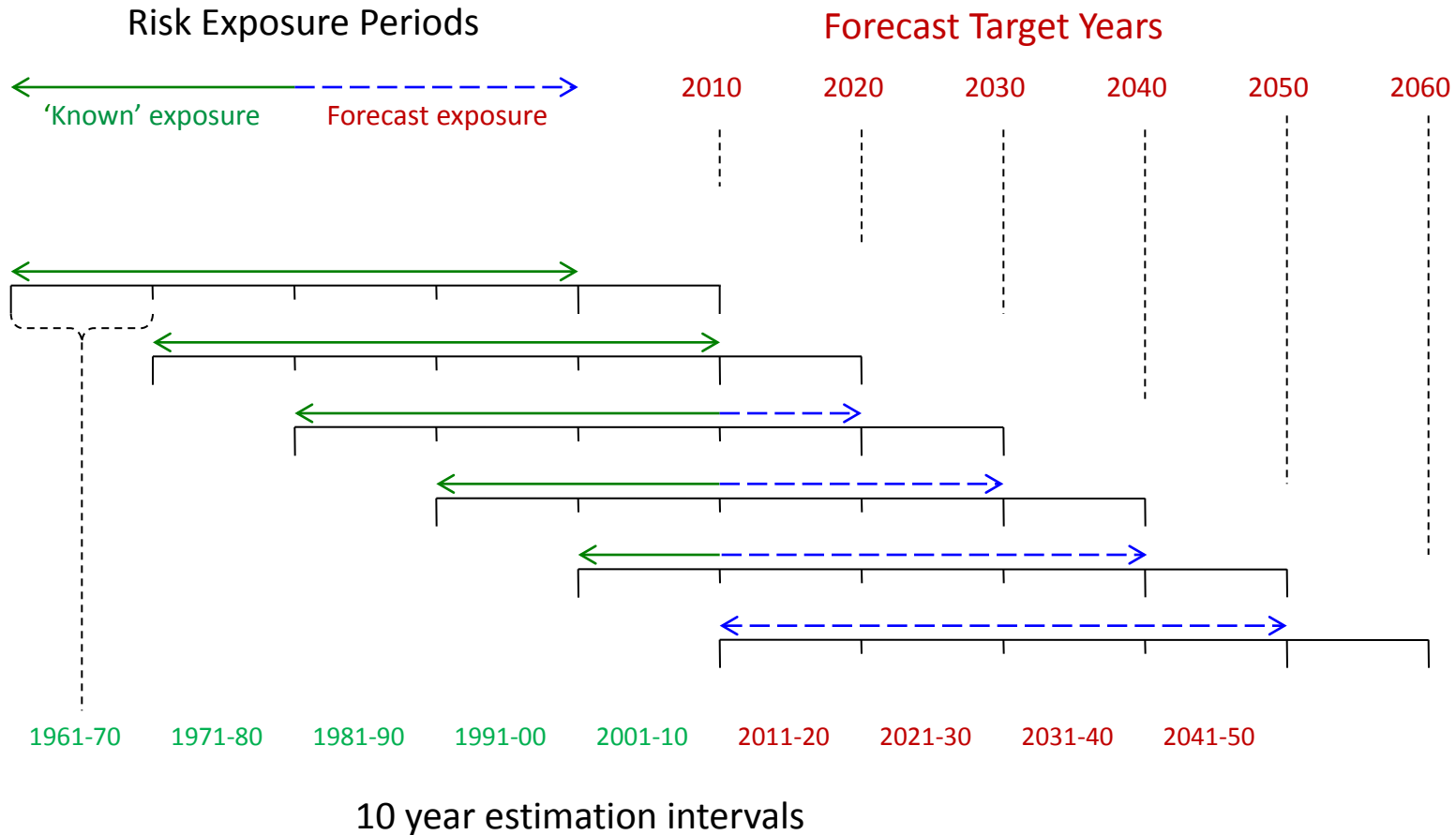
Uncertainties and the impact on the burden estimation

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	↑↓

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
- Some past and some future exposure until 2060
- Method provides a tool for comparing 'doing nothing' with various interventions
- The interventions effectively shifts the proportion of workers exposed at different exposure levels (e.g. H/M/L/B) across time from higher to lower exposures; exposures gradually decrease due to interventions
- Methods applied to top 14 carcinogens/occupations identified as accounting for 85.7% of total current (2004) cancer registrations
- Forecast GB total cancers (deaths and registrations) based ONLY on demographic projections (ONS) and assuming all non-occupational risk factors stay the same as 2004/5

Forecast Risk Exposure Periods – 10-50 year latency





Carcinogen or Occupation	Total Current Burden Cancer Registrations (% of total burden)	Cancer Sites
Asbestos	4216 (30.8%)	Larynx, Lung , Mesothelioma , Stomach
Shift work (+ Flight Personnel)	1957 (14.3%)	Breast
Mineral oils	1730	Bladder , Lung , NMSC , Sinonasal
Solar radiation	1541 (11.3%)	NMSC
Silica	907 (6.6%)	Lung
Diesel engine exhaust	801 (5.9%)	Bladder , Lung
PAHs - Coal tars and pitches	545 (4.0%)	NMSC
Painters	359 (3.2%)	Bladder, Lung , Stomach
Dioxins	316 (2.3%)	Lung , NHL, STS
Environmental Tobacco Smoke (non-smokers)	284 (2.1%)	Lung
Radon	209 (1.5%)	Lung
Welders	175 (1.3%)	Lung , Melanoma (eye)
Tetrachloroethylene	164 (1.2%)	Cervix, NHL , Oesophagus
Arsenic	129 (0.9%)	Lung
Strong inorganic-acid mists	122 (0.9%)	Larynx, Lung
Chromium	89	Lung , Sinonasal
Non-arsenical insecticides	73	Brain, Leukaemia, Multiple myeloma, NHL

Change in future exposure: Possible Scenarios

- Estimates made for alternative scenarios of changes in exposure levels and/or numbers exposed
- (1) **Baseline scenario** - based on pattern of past exposure, but no future change in exposed numbers or exposure levels
- (2) **Baseline trend scenario** - based on pattern of past and current exposure, and on linear projections up to 20 years into the future, after which levels assumed constant due to prediction uncertainty.
- (3) **'Intervention scenarios'** also based on past and current exposures, and suitably chosen target exposure levels in the future

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:

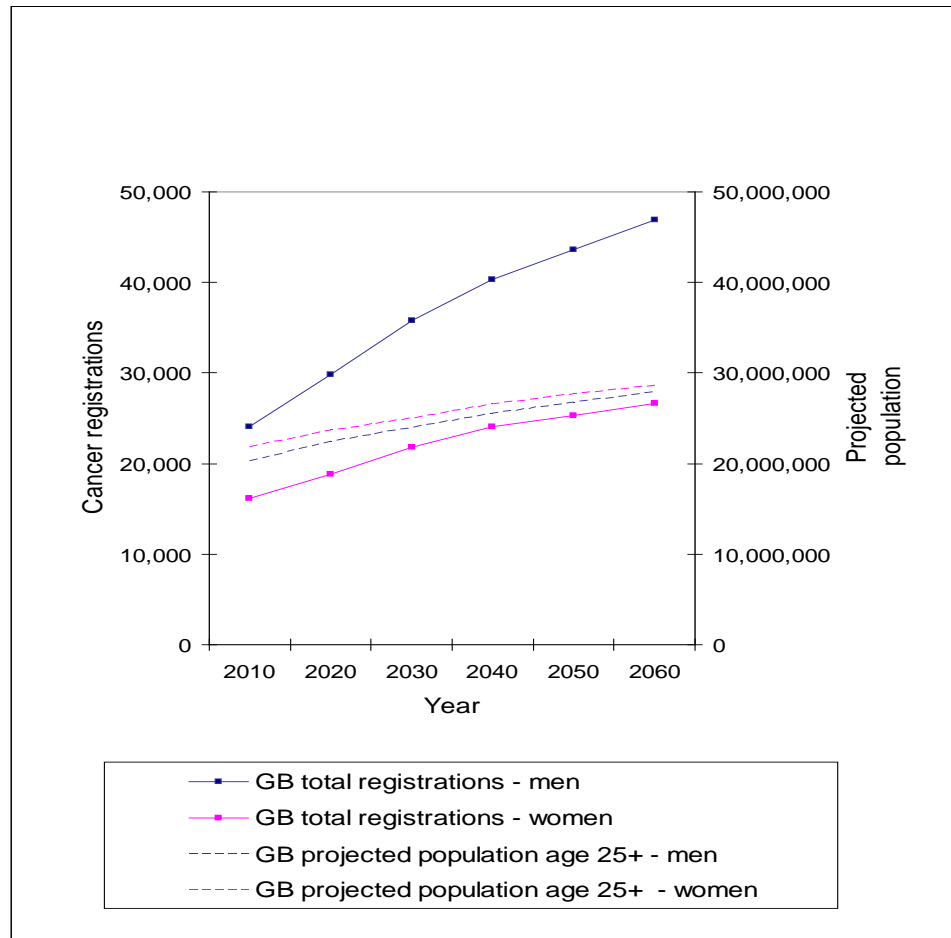
- **Timing** of introduction (2010, 2020 etc)
- Compliance levels e.g. according to **workplace size** (self-employed, 1-49, 50-249, 250+ employees)

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

Carcinogens where occupational standards/limits exist or could be introduced

- Arsenic, Diesel Engine Exhaust, Silica, Strong inorganic acid mists, Tetrachloroethylene, TCDD (dioxins)
- Example: silica
 - Reduce exposure limit from 0.1 to 0.05 mg/m³ 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/m³
 - 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

Forecast lung cancer registrations, age 25+, based on population projections and 2004/5 cancer rates by age



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

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'

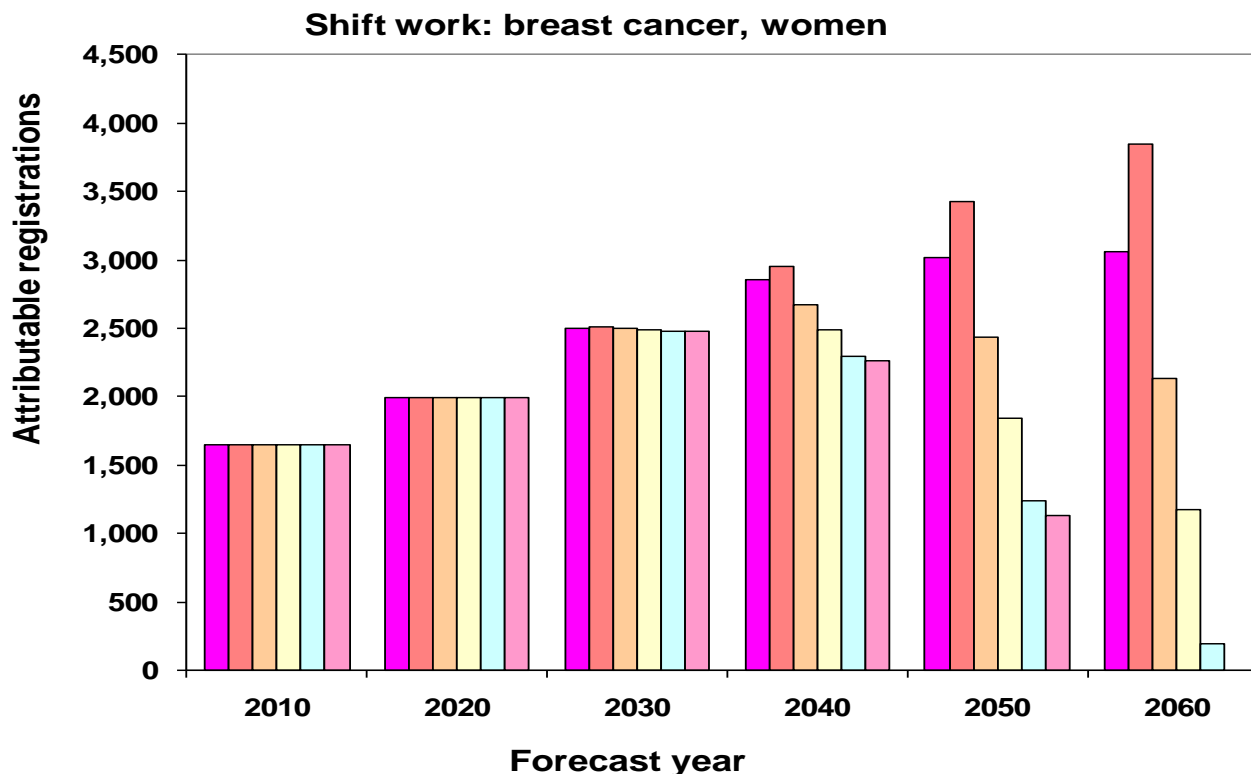
Example: Shift Work (Night work)

- Breast cancer: AF 4.6%, approx. 555 deaths and 2000 cancer registrations; contributes 14.3% of total current occupational cancer burden
- Exposure defined by nature of occupation – unknown agent, no exposure data
- Estimates of numbers of night shift workers from Labour Force Survey and British Airways 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

Substances with no suitable exposure data for standard setting. Example: Solar Radiation

- Non-Melanoma Skin Cancer: AF 6.9%, 23 deaths, 2862 cancer registrations (good survival); contributes 11.3% of total current occupational cancer burden
- Numbers exposed characterised as: mainly outdoor (H), farmer (M) and mixed indoor and outdoor (L) exposure

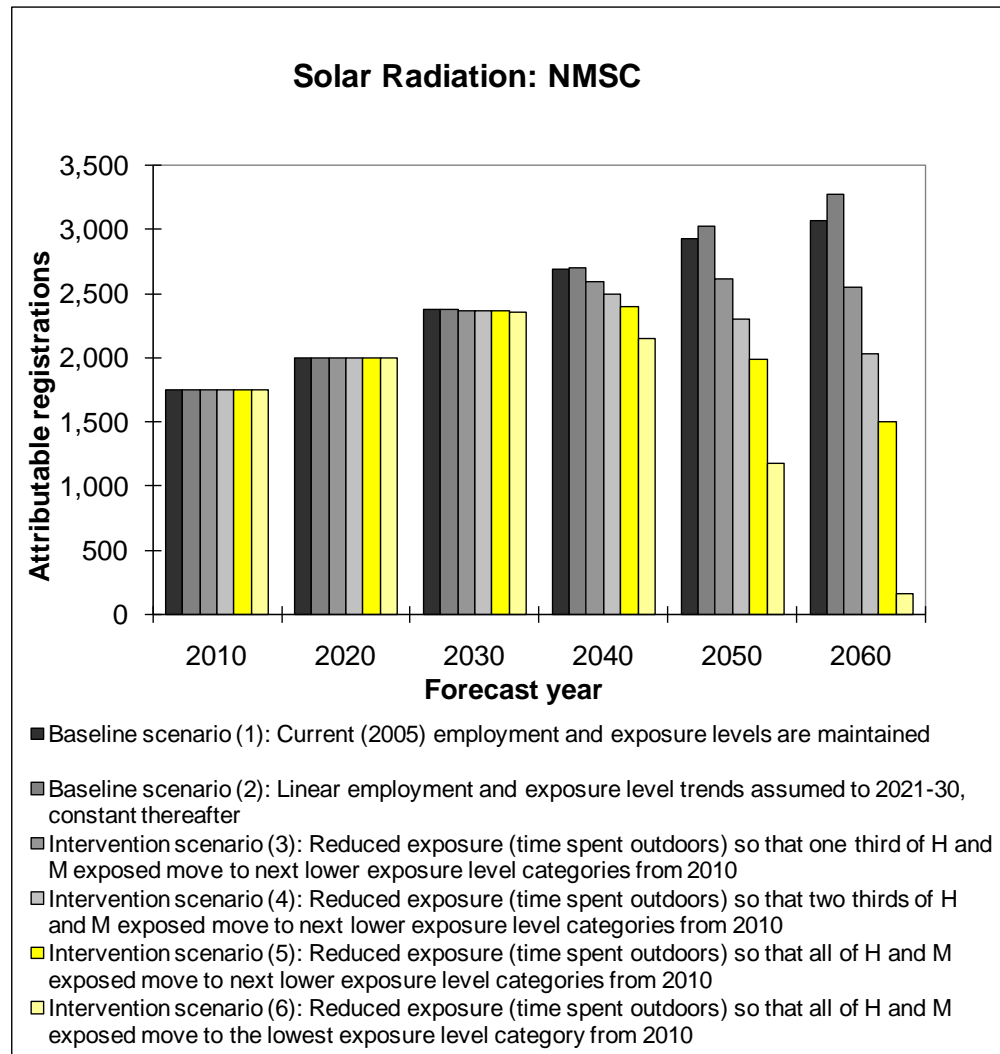
Relative Risk Industry Sectors

H	1.30	Fishing, Construction, Utilities, Land and Water Transport, Mining, Petroleum refineries, Armed Forces, Personal & Household Services, Recreational and Sanitary Services
M	1.15	Farming, Forestry
L	1.01	All other industries

- No exposure level data suitable for setting exposure limits
- Test effect of reduced exposure as moving to lower exposure classes

Solar radiation

- Test reducing outdoor (H) and farmer (M) exposed numbers by 33%, 67% or 100% in 2010
- Attributable cancers fall by 1/6th, 1/3rd or a half by 2060, or
- 95% if all move to the lowest (mixed indoor and outdoor) risk category



Solar Radiation: Reduction by industry sector

Scenario:	Total workers ever exposed over the REP	Attributable Registrations					
		Base (1))	Trend (2)	(3)	(4)	(5)	(6)
Industry /Job category		2060					
Other mining	48,213	25	10	21	17	13	1
Electricity, gas and steam	90,181	41	15	34	27	21	1
Water works and supply	44,451	20	7	17	13	10	1
Fishing	27,831	17	12	14	12	9	1
Construction	1,623,493	1463	1565	1225	985	742	50
Public administration and defence	441,359	542	620	454	365	275	19
Sanitary and similar services	145,433	149	180	125	100	75	5
Personal and household services	29,131	30	36	25	20	15	1
Recreational and cultural services	118,132	121	146	101	81	61	4
Land transport	372,474	382	461	319	256	193	13
Water transport	39,171	40	48	34	27	20	1
Forestry and logging	33,967	10	7	7	4	1	1
Agriculture and hunting	549,572	169	115	117	64	11	12
Total	5,563,663	3069	3279	2552	2030	1503	163

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

Summary

- Adapted for WHO Global Burden update; Used to inform socio-economic impact analysis of effect of introducing limits for certain carcinogens for DG Employment
- On-going work: Evaluation of impact of source of bias and uncertainty
- Outputs: Current burden results
 - Preliminary work on 6 cancer sites: Occupational and Environmental Medicine 2008, 65, 789-800;
 - Results from all sites: British Journal of Cancer 2010, 102: 1428-1437 + Technical report on HSE website
 - Supplement (13 papers) submitted on current burden detailed results to BJC, 2011 + approx. 24 technical reports + database
 - Paper in preparation reporting DALYs/inequality of burden
- Outputs: Future burden
 - Methodology paper: American Journal of Epidemiology 2011, 173, 1069-1077+ Technical report on HSE website
 - Future burden results: submitted to International Journal of Epidemiology + Technical report on HSE website
 - Data and programs will be shared with HSE so they can use them to inform future policy considerations