Occupationally Related Cancer Risk Among Coke Oven Workers: 30 Years of Follow-Up

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This study concerns the update of cause-specific mortality among coke oven workers. Updated information provides 3 decades of work history and vital status follow-up on 15,818 workers. Mortality patterns are summarized by race, cumulative exposure, and period of follow-up. The findings are consistent with those from earlier assessments, indicating that occupational exposure to coke oven emissions is associated with significant excess mortality from cancer of the respiratory system and of the prostate. Depending on the segment of the population considered, the respiratory cancer risk for coke oven workers ranged as high as 4.45 times that for non-oven workers. Relative risk values for cancer of the prostate ranged as high as 1.93. Rates of respiratory cancer across period of follow-up are declining, suggesting that the implementation of emissions control and occupational exposure limits has been beneficial.

The cause-specific mortality patterns of two large steelworker cohorts have been monitored since the early 1960s by the Department of Biostatistics of the Graduate School of Public Health, University of Pittsburgh.[1–14] Information obtained from this research was used by federal agencies to establish occupational exposure limits and to estimate carcinogenic risk in communities exposure to emissions from coke plants. The cohorts include approximately 59,000 men from steel company plants in Allegheny County, Pennsylvania (Allegheny County Cohort) and 9,800 men from coke oven plants outside of Allegheny County, Pennsylvania (non-Allegheny County cohort). Among other findings, the results of previous investigators have shown a highly significant excess mortality among steelworkers employed as coke oven workers.[4–6,11–14] This paper focuses on mortality risk among coke oven workers and presents the first report of updated patterns of caw-specific mortality experienced by coke oven workers through 1982. This updated information provides 30 years of work history and vital status follow-up for 15,818 individuals representing all the workers included in the non-Allegheny County cohort and a subset of workers in the Allegheny County cohort. This represents a substantial enhancement of follow-up from that previously reponed. On average, the updated data contained 14.5 additional years of work experience and 7 years of additional viral status information for each worker. The number of ob-

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served total deaths was increased by 7%, and the observed number of deaths due to respiratory cancer and cancer of the prostate were each increased by more than 25%. In addition to providing data for assessing the long-term carcinogenic risk from occupational exposure to coke oven emissions, an important aspect of obtaining long-term follow-up data is that it can be used to assess patterns of carcinogenic risk across periods of time before and after the implementation of environmental emission controls and occupational exposure limits.

Materials and Methods

The non-Allegheny County cohort comprises coke oven workers and frequency-matched non-oven steelworkers employed from 1951 to 1955 at 10 coke oven plants outside of Allegheny County. These plants are located in areas throughout the United States and Canada. The original Allegheny County cohort consists of workers employed in 1953 at seven steel plants within the county, two of which are coke oven facilities. The Allegheny County cohort subset reported in this study includes all coke oven workers from these two facilities, and a matched sample of non-coke oven workers. For both cohorts, the sampling of non-oven workers was performed at a 2:1 ratio (when possible) where non-oven workers were matched by age, race, and date of first employment.

The specific methodology for constructing the cohorts, classifying work areas, and obtaining updated work history and vital status information has been detailed in previous reports.[1,3–6,12] The population of individuals classified as coke oven and non-coke oven control workers has changed slightly from that described in prior analysis. Coke oven work history experienced by individuals subsequent to previous assessments required the reclassification from non-oven to oven worker of 23 individuals. Also, in the process of updating information it was possible to verify work histories included in prior analysis. On occasion, when verifying the classification of work histories previously obtained, descriptions of some workers' jobs were discovered that were more detailed than those available previously. As a result of this more detailed information, the classification of 32 additional workers was modified.

Previously, work history information on file was complete only through 1966 for the non-Allegheny County cohort and through 1970 for the Allegheny County cohort. Vital status was complete only through 1975. In this report, all work history and vital status information were extended through 1982. Original plant work records were reviewed and abstracted by staff of the Department of Biostatistics. The identification of vital status for those no longer employed in the steel industry was obtained from employer benefit records and from the Social Security Administration. Verification of all deaths was made by obtaining a copy of the death certificate from the appropriate state bureau of vital statistics. To be consistent with the classification scheme used in prior updates, the underlying cause of death for each newly identified decedent was coded according to the seventh revision of the international classification of diseases.[13] To maintain continuity of job categorization, 311 jobs were also coded according to the previously defined classification strategy. These classifications were defined on the basis of the physical location in which a worker was stationed during the performance of his assigned job.

Coke oven jobs were subsequently grouped into three main categories. The categories include jobs in which: (1) all of the work effort was spent on the top of the ovens (topside full-time); (2) part of the work effort was on top and some of the side of the ovens (topside part-time); and (3) all of the work effort was on the side of the ovens (side). Workers at jobs on the top area of the ovens received the highest levels of exposure to coke oven emissions. Exposure to coke oven emissions for each group was measured in terms of coal tar pitch volatiles (CTPV), the class of polynuclear aromatic hydrocarbons that is the benzene-soluble fraction of total particulate matter.[16] The average daily exposure for the job categories was determined in previously published work as 3.15 mg/m^3 for topside full-time jobs, 1.99 mg/m^3 for topside part-time jobs, and 0.88 mg/m^3 for side jobs.[14] The measurements used to develop these averages were obtained by an extensive industrial hygiene survey conducted in the late 1960s. Unfortunately, exposure measurements for subsequent periods are not available. Thus, the development of a definitive cumulative exposure measure that would incorporate changes in exposure patterns over time was not possible. However, a weighted exposure index accounting for the relative differences in exposure intensity of the three classifications of coke oven jobs was determined for each worker and used as an indirect measure of exposure-response. This index was defined as the sum, over all jobs, of the product of the number of months at a job and the weight for that job. The weights chosen for topside full-time, topside part-time, and side oven jobs were the average exposure to CTPV of 3.15, 1.99, and 0.88, respectively.

Internally standardized estimates of relative risks for cause-specific mortality were calculated using an extension of the Mantel-Haenszel statistic, using non-oven workers as the baseline. The estimates were tested for statistical significance using a summary χ^2 with one degree of freedom.[17,18] In addition, tests of trend were performed to evaluate the exposure-response relationship for years of employment and for levels of weighted exposure index." Mortality among coke oven workers was assessed by race for 33 categories of cause of death. Patterns of mortality from cancer of the lung, trachea, and bronchus and from prostate cancer were further assessed through com-

TABLE 1
Number of Workers by Cohort and Race

Cohort	Race	Coke Oven Workers	Nonoven Workers	Total
Allegheny County	White	985	1967	2932
	Nonwhite	1060	2065	3125
	Total	2025	4032	6057
Non-Allegheny County	White	1436	2886	4322
	Nonwhite	1860	3579	5439
	Total	3296	6465	9761
Total	White	2401	4853	7254
	Nonwhite	2920	5644	8564
	Total	5321	10,407	15.818

parisons of relative risk by years of coke oven employment, CTPV. cumulative exposure levels and period of follow-up. All relative risks were adjusted for age, race, coke plant and period of follow-up, as appropriate. These analyses were accomplished using the software package OC-MAP.[20-22] In the circumstances when the expected number of deaths for a given analysis was less than 5, the relative risk was not reported.

Results

The distribution of workers by cohort, work area, and race is shown in Table 1. A total of 15,818 men are included in the analysis. Of these, 5,321 are coke oven workers and 10,497 are non-oven workers. The proportion of nonwhites from each cohort is similar: 56% for non-Allegheny County and 52% for Allegheny County. There is substantial variation in the racial distribution by work area, which is evident in both cohorts. Table 2 provides the distribution of coke oven workers by work areas at time of entry into the study. Overall, 69% of coke oven workers who worked topside full-time are nonwhite. Among those who worked topside part-time, only 9% are nonwhite. Among non-oven workers, 54% are nonwhite.

The relative risk of cause-specific mortality among coke oven workers is shown in Table 3. Statistically significant excess mortality is present for several categories of deaths. The relative risk for all causes of death is 1.11 ($P < .001$). This increase in total mortality is primarily the result of excesses in deaths due to cancer, particularly deaths due to respiratory and genito-urinary cancer. The relative risk for all cancers is 1.38 ($P < .001$), for respiratory cancer 2.07 ($P < .001$), and for genito-urinary cancer 1.49 ($P < .01$). The excess death from respiratory cancer is attributable to elevated risks from cancer of the lungs, bronchus, and trachea, where the relative risk is 2.13 ($P < .001$). The excess death from genito-urinary cancer is due to elevated risks from prostate cancer where the relative risk is 1.60 ($P < .01$). These findings are consistent across racial categories (Table 4). However, the excess risks are greater among the nonwhite workers than for the white worker;.

To further assess the nature of respiratory cancer risk. determinations of relative risks by three measures of exposure to coke oven emission were undertaken. This included evaluations by years of employment at coke oven jobs, by years of employment at jobs on top of the coke ovens, and by CTPV cumulative exposure. Table 5 provides the relative risk of death from cancer of the lung, bronchus, and trachea among coke oven workers by 5-year increments of employment at coke oven jobs. The risks for individuals who worked less than 5 years at oven jobs

TABLE 2
Distribution of Coke Oven Workers by Cohort, Race, and Work Area at Time of Entry into the Study

Cohort	Race	Topside Full-Time		Topside Part-Time		Side Oven		Total	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Allegheny County	White	77	25.4	304	97.4	584	41.4	965	47.7
	Nonwhite	226	74 6	a	2.6	826	58.6	1060	52.3
	Total	303	100.0	312	100.0	1410	100.0	2025	100.0
Non-Allegheny County	White	286	32.5	324	85.9	826	40.5	1436	43.6
	Nonwhite	594	67.5	53	14.1	1213	59 5	1860	56.4
	Total	880	100.0	377	100.0	2039	100.0	3296	100.0
Total	White	363	30.7	628	91.1	1410	40.9	2401	45.1
	Nonwhite	a20	68.3	61	8.9	2039	59.1	2920	54.9
	Total	1183	100.0	689	100.0	3449	100.0	5321	100.0

TABLE 3
Relative Risk of Cause-Specific Mortality Among All Coke Oven Workers

Cause of Death	No. of Deaths	Relative Risk	95% Confidence Limits
All causes	2291	1.08***	I 02–1.14
All cancers	566	1.34***	1.19–1.50
Buccal and pharyngeal	12	1.25	0.60–2.66
Digestive and peritoneal	199	0.88	0.70–1.11
Large intestine	25	0.89	0.41–1.12
Pancreas	25	1.11	0.66–1.86
Other digestive	69	0.90	0.67–1.22
Respiratory	264	1.89***	1.55–2.25
Lungs, bronchus, trachea	255	1.95***	1.59–2.33
Other respiratory	9	0.98	0.41–2.34
Genito-urinary	87	1.49**	1.11–2.01
Prostate	sa	1.57*	1.09-2.30
Testis and other genital	1	t	†
Kidney	12	2.03	0.89–4.53
Bladder and other urinary	16	1.14	0.61–2.12
Lymphatic and hematopoietic	40	1.26	am-1.90
Skin	4	t	†
All Other Cancer	40	1.01	0.67–1.51
Cardiovascular-renal disease	1079	1.02	0.94–1.10
Vascular lesions of CNS	*163*	0.90	0.74–1.09
Arteriosclerotic HD	701	1.03	0.94–1.14
Hypertensive HD	83	1.03	0.78–1.36
Other cardiovascular-renal	132	*1.12*	0.89–1.41
Nonmalignant respiratory	125	1.18	0.93–1.49
Nonmalignant digestive	81	*0.82*	0.62–1.06
Cirrhosis of liver	36	*0.69*	0.46–1.03
Other nonmalignant digest	45	0.97	0.66–1.41
Tuberculosis	15	1.13	0.57–2.28
Diabetes mellitus	23	*0.60*	0.37–1.02
Accidents	130	1.04	0.83–1 *30*
Homicides and suicides	56	1.04	0.78–1.41
Ill-defined causes	66	1.17	0.84–1.63
All other causes	140	1.04	0.84–1.30

*$P < .05$. **$P < .01$. ***$P < .001$.
† Not determined when expected values were less than 5.
CNS, central nervous system: HD, heart disease.

is 1.33. The rates peak for those wha worked 15 to 19 years at such jobs is 2.91. This trend of increasing risk with increasing years of employment is highly significant ($P < .001$). Table 6 provides this same type of analysis, but is based on years of employment on topside coke oven jobs, the jobs that have the highest levels *of* exposure to *coke* oven emissions. An even stronger exposure-response *relationship* is evident using this definition uf coke oven exposure. The relative risk for an individual working less than five years at top-side jobs is 1.67. The relative risk for an individual who worked 15 years or more *at* topside jobs is about *2.6* times as high *at* about 4.4 *(trend test: $P < .001$).* Relative risk by levels of weighted exposure index also revealed a strong exposure-response relationship (Table 7). The risks across categories of exposure exhibited more than a 3-fold increase (trend test: $P < .001$).

Efforts to assess exposure-response relationship for deaths due *to* cancer of the prostate were restricted due to the relative infrequency of this event. Assessment was *thus* limited to the analysis across weighted exposure groupings. which had to be collapsed to only four categories. The results of this analysis is shown in Table 8. From this data the existence of an exposure-response relationship is not clear. The relative risks for those in the highest and lowest exposure categories are similar at 1.4, whereas *the* relative risk for those in the middle exposure category is 19).

To determine if the risk of lung cancer mortality among the cohort was constant over time, relative risks by categories of weighted exposure index *were* determined for three periods of follow-up: through 1965, *1966* to *1975,* and 1976 to 198? (Table 9). When controlling for exposure index, there appears to *be* an attenuation *of* risk over time for all categories except *that* of 1 *to* 199. The attenuation is apparent in : 1966-to-1975 interval and is sustained in the post-1975 interval. Depending on the category of exposure index, the relative risks before 1966 *are* about 1.5 to 4 times greater than those after 1975.

Discussion

The results presented here are *consistent with the* findings reported from previous updates of both the Allegheny and non-Allegheny County cohorts. Occupational exposure to coke oven emissions is associated with excess mortality from cancer of the respiratory system and cancer of the prostate. The nature of the association for cancer of the respiratory system is very strong. Generally speaking, the relative risks by subgroups are large and statistically highly significant. Exposure-response relationships are evident when considering both years of employment at coke oven jobs and weighted exposure index. In addition the magnitude of the exposure-response relationship *is* enhanced with a *condition* on years of employment at those jobs with the intense exposure, specifically jobs on top of the coke oven, These findings provide strong evidence supporting the contention that the noted association *between* respiratory cancer occupational exposure to coke oven emission is in *fact* a casual associ-

TABLE 4
Relative Risk of Cause-Specific Mortality Among All Coke Oven Workers by Race

Cause of Death	White			Nonwhite		
	No. of Deaths	Relative Risk	95% Confidence Limits	No. of Deaths	Relative Risk	95% Confidence Limits
All causes	891	1.04	0.96–1.13	1400	1.11**	1.04–1.20
All cancers	213	1.24*	1.05–1.48	353	1.42***	1.21–1.66
Buccal and pharyngeal	7	1.52	0.56–4.31	5	†	†
Digestive and peritoneal	46	0.87	0.61–1.23	73	0.89	0.66–1.22
Large intestine	8	0.44*	0.20–0.94	17	1.02	0.51–2.02
Pancreas	11	1.05	0.52–2.16	14	1.17	0.56–2.43
Other digestive	27	1.09	0.68–1.74	42	0.79	0.54–1.18
Respiratory	86	1.59**	1.19–2.12	179	2.12***	1.64–2.70
lungs, bronchus, trachea	92	1.62**	1.20–2.17	173	2.22***	1.70–2.84
Other respiratory	3	†	†	6	0.89	0.30–2.69
Genito-urinary	37	1.57*	1.03–2.44	50	1.42	0.94–2.12
Prostate	19	1.77	0.96–3.26	39	1.47	0.93–2.37
Testis and other genital	0	†	†	1	†	†
Kidney	8	†	†	4	†	†
Bladder and other urinary	10	0.94	0.44–1.97	6	7.93	0.61–5.84
Lymphatic and hematopoietic	17	1.14	0.64–2.05	23	1.39	0.78–2.48
Skin	2	†	†	2	†	†
All other cancer	19	1.13	0.65–1.97	21	0.90	0.50–1.59
Cardiovascular-renal disease	450	0.99	0.88–1.11	629	1.05	0.94–1.16
Vascular lesions of CNS	54	0.89	0.64–1.22	109	0.91	0.71–1.16
Arteriosclerotic HD	33	1.00	0.88–1.14	368	1.07	0.93–1.24
Hypertensive HD	14	0.92	0.49–1.71	69	1.06	0.78–1.45
Other cardiovascular-renal	49	1.09	0.76–1.56	83	1.14	0.84–1.53
Nonmalignant respiratory	50	1.12	0.79–1.59	75	1.24	0.89–1.70
Nonmalignant digestive	33	0.71	0.47–1.05	40	0.96	0.65–1.41
Cirrhosis of liver	12	0.50*	0.26–0.92	24	0.90	0.53–1.53
Other nonmalignant digestive	21	0.92	0.55–1.54	24	1.03	0.59–1.79
Tuberculosis	3	†	†	123	0.98	0.46–2.10
Diabetes mellitus	6	0.47	0.20–1.11	17	0.71	0.38–1.37
Accidents	57	1.13	0.82–1.56	73	0.96	0.71–1.31
Homicides and suicides	19	1.14	0.65–1.99	47	1.00	0.69–1.44
Ill-defined causes	20	1.74	0.94–3.27	46	1.00	0.68–1.48
All other causes	40	0.92	0.63–1.34	100	1.71	0.86–1.45

* $P < .05$, ** $P < .01$, *** $P < .001$.
† Not determined if the observed and expected values were less than 5.
CNS, central nervous system; HD, heart disease.

tion. Similar findings have been reported from studies conducted throughout the world.[23–28]

Smoking histories of the workers included in this study are not available. Although we were not able to control for smoking in our analysis, it is not likely that differences between coke oven workers and non-oven control workers in regard to smoking habits could be so substantial as to change inferences regarding the association of coke oven exposure and respiratory cancer. This conclusion is based on three findings. First, there is a strong exposure-response relationship. If the association between coke oven employment and respiratory cancer was artifactual, caused by a difference in smoking pattern, one would not expect to see such significant exposure-response findings. Second, the non-oven workers were plant-specific internal controls matched by age, race, and date of hire. They represent blue-collar colleagues of the coke oven workers who for the most part reside in the same communities as the coke oven workers. Based on socioeconomic and demographic factors, it is unlikely that there is any substantial differences in smoking habits between the coke oven workers and non-oven controls. Third, the respiratory cancer risk for some top-side–category coke oven workers with at least 10 years of employment show a 4.5-fold increase compared with non-oven workers. Differences in smoking habits between these workers and controls would have to be very extreme to negate a relative risk of this magnitude.[29] Estimates of the effect

TABLE 5
Relative Risk of Death from Cancer of me Lung. Bronchus, and Trachea Among All Coke Oven Workers

Years of Coke Oven Employment	No. at Risk	No. of Deaths	Relative Risk	95% Confidence Limits
0	10,497	203	1.00	
1-5	1724	39	1.33	0.92–1.89
5-9	524	18	1.37	0.92–2.51
10–14	503	26	1.82*	1.26–2.89
15–19	533	47	2.91**	2.27–4.52
≥20	2037	125	2.71**	1.76–2.85
P-value				
Trend tact			<.001	

*$P < .05$, **$P < .001$.

TABLE 6
Relative Risk of Death from Cancer of the Lung, Bronchus, and Trachea among All Coke Oven Workers Who Worked Top-Side Jobs

Years of Top-Side Coke Oven Employment	No. at Risk	No. of Deaths	Relative Risk	95% Confidence Limits
0	10,497	203	1.00	
1–5	856	31	1.67*	1.41–2.51
5–9	362	24	2.58**	1.75–4.23
10–14	231	24	4.25**	291–7.14
15–13	152	20	4.45**	2.79–7.56
≥20	248	27	4.34**	2.89–6.97
P-value				
Trend lest			<.0001	

*$P < .05$, **$P < .001$.

TABLE 7
Relative Risk of Death from Cancer of the Lung, Bronchus, and Trachea Among All Coke Oven Workers by Weighted Exposure Index

Weighted Exposure Index (mg/m^3 - mo)	No. at Risk	No. of Deaths	Relative Risk	95% Confidence Limits
0	10,497	203	1.00	
1–49	1576	34	1.24	0.85–1.81
50–199	1062	43	1.56	1.13–2.27
200–349	976	56	1.95*	1.48–2.79
350–499	682	39	2.02'	1.55–3.19
500–649	348	27	2.69*	1.98–4.57
≥650	677	56	3.13'	2.43–4.56
P-value				
Trend test			<.001	

*$P < .001$.

of confounding indicate that a difference as large as 90% smokers in coke oven workers and 30% smokers in controls would be sufficient to negate conclusions of association for relative risks of only 2.5 or lower.[30]

The reduction of respiratory cancer mortality risk over intervals of Cotlow-up suggests that efforts that primarily began in the early 1970s to implement emissions controls and to reduce levels of occupational exposure through the use of protective devices (respirators, work-area isolation cabins, etc) have been beneficial. However, an alternative explanation could be that intensity of exposure is a critical factor and that those who obtain a certain level of exposure in the first interval of follow-up have a greater intensity of exposun: than those who obtain the same level of exposure after 30 years of follow-up. Additional work should be undertaken to resolve this issue. A worthwhile assessment would be to compare the results from this study with those from a similar investigation conduced among a new cohort of workers using a point in time. around 1975 as the time window of employment for cohort entry. However. the most efficient time to undertake such an investigation would be after 1995, when available follow-up would exceed 20 years, thereby providing a reasonable likelihood of detecting occupationally related lung cancers. Sample-size considerations may necessitate an even longer period of follow-up. Employment in the steel industry has been declining for many years, and the number of individuals entering the industry as new employees has been low. Thus, a 1975-based cohort would be much smaller than those available from earlier time periods and would contain only a small proportion of employees whose work history was concentrated in periods after enactment of occupational exposure standards.

In contrast to the findings regarding respiratory cancer, excess mortality from cancer of the prostate has not been a consistent finding in other studies among steelworkers. Interpreting the nature of the noted ciation between exposure to coke oven emissions and prostate in this study is not as straightforward as it is for respiratory cancer. This difficulty is primarily due to the sparseness of data for stratified evaluation. There were only 58 cancers of the prostate observed in the entire worker population. Thus, cross-classification of risks by type of coke oven job and duration of employment is limited. As such, it is difficult to make sound conclusions regarding exposure-response relationship with this disease.

TABLE 8
Relative Risk of Death from Cancer of the Prostate Among All Cake Oven Workers by weighted Exposure Index

Weighted Exposure Index (mg/m³ - mo)	No. at Risk	No. of Deaths	Relative Rick	95% Confidence Limits
0	10,497	61	1.00	
1–199	2638	21	1.43	0.81–2.37
200–399	1276	20	1.93'	1.11–3.21
≥400	1407	17	1.44	0.80–2.41
P-value				
Trend test			0.11	

* $P < .001$.

TABLE 9
Relative Risk of Death from Cancer of the Lung, Bronchus, and Trachea Among All Coke Oven Workers by Weighted Exposure Index and Period of Follow-Up

Item	Weighted Exposure Index (mg/m³ - mo)	Period of Follow-Up: Through 1965	1966–1975	1976–1982
No. at risk	0	10,497	9426	8010
	1–199	3072	2314	1840
	200–399	1304	1181	855
	400–599	534	550	453
	≥600	411	465	439
No. of deaths	0	44	72	87
	1–199	17	33	27
	200–399	22	26	23
	200–599	9	17	17
	≥600	27	22	15
Relative risk	0	1.00	1.00	1.00
	1–199	1.09	1.86	1.28
	200–399	3.00**	1.71	1.65*
	400–599	3.35**	2.40**	2.29**
	≥600	6.76**	2.95**	1.67
P-value				
Trend test		<.001	<.001	.021

* $P < .05$, ** $P < .001$.

Prostate cancer is essentially a disease of older men. Death from this disease among workers under 60 years of age is relatively rare, with the majority of deaths occurring after age 74. Based on age of last follow-up, the proportion of workers over the age of 74 was only 16.7% and 10.0% for the Allegheny County and Nan-Allegheny County cohorts, respectively. To adequately evaluate the association between prostate cancer and occupational exposure to coke oven emissions, it may be necessary to follow the cohorts for several more years to obtain the increased numbers of observed cases required for an adequate evaluation of this cancer risk. Approximately 59% of all the men being followed in these cohorts were still alive at the end of 1982. About half are under age 60, and 80% are under age 70. Thus. additional follow-up could provide information useful for this type of evaluation.

The association between CTPV exposure and respiratory cancer could be explored further by mathematical modeling with multistage[31] and two-stage[32] models of carcinogenesis. Work to incorporate time-dependent exposure patterns into these models and to develop computer software to handle large-cohort datasets has been recently completed by our group.[33-37] Nonupdated information from subsets of the cohort was used for this work. Findings from the preliminary assessments made in conjunction with this work suggest a possible late-stage carcinogcoic effect of exposure to coke oven emissions in addition to an early-stage effect. We will attempt in future to assess the validity of these findings by undertaking a comprehensive quantitative risk assessment applying the extended models to the full complement of data now available for the cohort.

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The Radar That May Save Lives, If Allowed To

As thunderstorms rumble across the summer sky, the Federal Aviation Administration is two years behind schedule on a planned 47-airport radar system that could warn pilots of violent wind shifts. This month's . . . crash of a US Air DC-9 might have been prevented if Charlotte's jetport had what is known as Terminal Doppler Weather Radar. Charlotte was scheduled to get a 120-foot high Doppler tower a year ago, but the government and the property owner could not agree on a price for the land. Charlotte is not alone. The towers must sit 8 to 12 miles from the airports and in line with runways. New Yorkers, objecting to ugly towers near their homes and worried about radiation (a fear the FAA terms groundless) have blocked systems at Kennedy and LaGuardia airports. Other sites are snagged in disputes over wetlands, hazardous dumps, and Indian artifacts. In all, only 10 towers have been delivered. The first one to help planes land—at Houston—is scheduled to begin service this month.

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