Health Risk Assessment For Diesel Exhaust: Comments And Critique

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Overview

- Are there gaps in the epidemiological studies?
- What are the limitations for risk assessment?
- What are the research needs?
  - Railroad worker cohort
  - Other studies

RESULTS OF EPIDEMIOLOGICAL STUDIES

- Increased risk of lung cancer in workers whose job titles indicate there has been occupational exposure
- Relative risk in the 1.2 to 1.5 range (20%-50% excess)
- Consistent finding in different studies (truck drivers, railroad workers, bus garages, dock workers) as summarized in meta-analyses

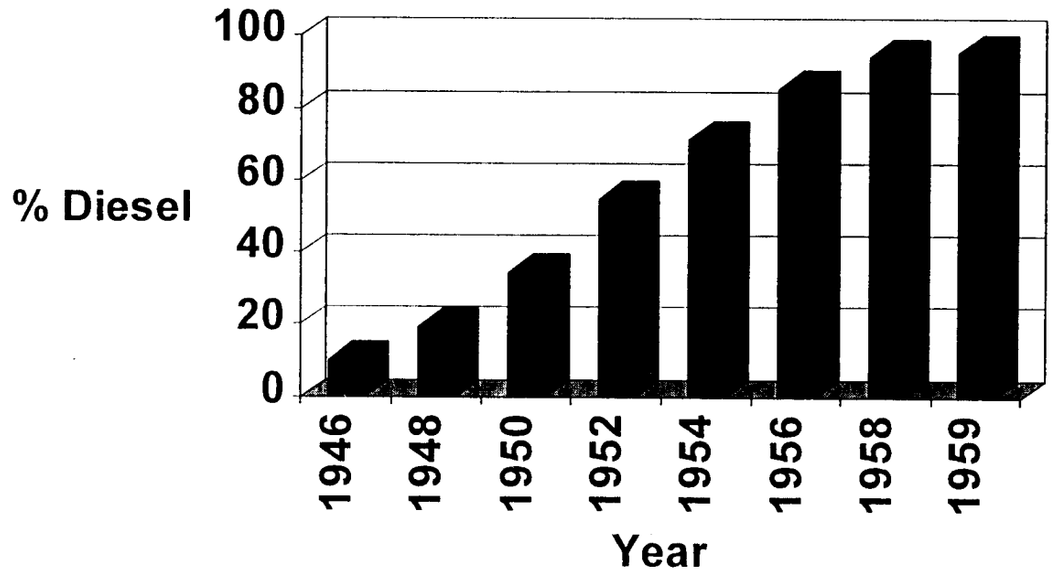
Diesel Exhaust Epidemiology And Lung Cancer

- For studies of lung cancer an empirical induction period (latency) of $\geq$ 10 years, and preferably $\geq$20 years is desirable

- Few studies were able to examine the effects of $\geq$ 20 years from first exposure or 20 years of exposure (7 studies)

- Previously it was not possible to study workers with a long duration of exposure/follow-up because of when diesels were introduced

Railroad Worker Studies: Transition From Steam To Diesel Engines In The U.S.



U.S. Railroad Worker Studies

- Yearly job code reported to Railroad Retirement Board
- Exposed: shop workers, engineers/firemen, hostlers, brakemen/conductors
- Diesel exposure based on yearly job code

Railroad Worker: Exposure And Follow-Up

- Cohort: follow-up 1959-1976 (18 years); missing deaths 1977-1980
- Exposure: 20% by 1948, 55% by 1952, nearly all by 1959
- Unable to determine which worker in a diesel exposed job was actually exposed before 1959

RR Worker Cohort Study: Follow-Up 1959-1976

Based On Diesel Exposed Job In 1959

1959 AGE	Relative Risk
40-44	1.58 (1.14,2.20)
45-49	1.28 (0.95,1.71)
50-54	1.21 (0.93, 1.58)
55-59	1.13 (0.87, 1.43)
60-64	0.98 (0.72, 1.34)

Cohort Study 1959-1976: Relative Risk For Each Exposure Category Based On 1959 Job

1959 AGE	ENGINE	BRAKE	SHOP
40-44	1.83*	1.59*	1.32
45-49	1.31	1.28	1.22
50-54	1.65*	1.15	0.97
55-59	1.01	1.24	1.12
60-64	0.72	1.30	0.93

RR Worker Case-Control Study

- Deaths collected 1981-1982
- Case age≤64 at death: relative odds=1.41 (1.06, 1.88) for 20 years of exposure after 1959. Exposure category also a surrogate for pre-1959 exposure
- Case age≥65 at death: no elevated risk due to work in a diesel exposed job
- Results adjusted for cigarette smoking

National Average Adjusted Respirable Particulate Exposures

Job Category	N	ug/m^3
Clerks	59	33
Signal Maintainers	13	58
Engineer/Fireman		
Freight	55	80
Yard	50	64
Passenger	23	48

National Average Adjusted Respirable Particulate Exposures

Job Category	N	ug/m^3
Brakeman/Conductor		
Freight Conductor	62	65
Freight Brakeman	21	101
Passenger	35	106
Yard	32	79
Hostler	8	216
Shop Electrician	42	162
Shop Machinist	110	158

Exposure ≥ 20 Years

- Steenland et al. (1990)
  - Diesel trucks gradually introduced 1950's and 1960's; large companies by 1960; deaths collected 1982-83
  - Long haul driver ≥28 years OR=1.47 (0.94, 2.31)
  - ≥18 years after 1959 OR=1.55 (0.97,2.47)
  - Exposure based on Teamster job history
  - Adjusted for smoking

TEAMSTERS UNION STUDY

- Long haul driver RR = 1.27 (25.5 ug/m^3)
- Short haul driver RR = 1.31 (27.0 ug/m^3)
- Mechanics RR = 1.69 (133.0 ug/m^3)
- Dock workers RR = 0.92 (117.5 ug/m^3)
- Highway: 17 ug/m^3
- Residential: 7ug/m^3

Exposure ≥ 20 Years

- Rafnsson and Gunnarsdottir (1991)
  - Nearly all Reykjavik trucks diesel since 1950
  - ≥30 year latency and >30 years exposure based on union membership SMR=2.32; but <2 years exposure SMR=2.70
  - No smoking data

- Boeffetta et al. (1990)
  - Hospital based case-control study
  - ≥31 years in an occupation with probable exposure; OR=1.49 (0.72, 3.11), smoking adjusted

Exposure ≥ 20 Years

- Swanson et al. (1993)
  - Detroit cancer cases 1984-1987
  - Drivers of heavy trucks ≥20 years OR=2.5 (1.4, 4.4)
  - Increasing trend with years employed (self-report) smoking adjusted , smoking adjusted

- Gustavsson et al. (1990)
  - Stockholm buses diesel since 1945; included garage workers who had worked for at least 6 months between 1945-1970; mortality 1952-1986
  - Increasing relative risk with increasing exposure index (years x intensity score)

Conclusions: Epidemiological Studies

- Consistency of results suggests that the results are likely to be explained by exposure to diesel exhaust

- The relationship between amount/duration of exposure with lung cancer risk is limited by
  - Inadequate information on historical exposure
  - Lack of studies of workers with exposure characterized over 20 to 30 years

RR Worker Exposure-Response Relationships

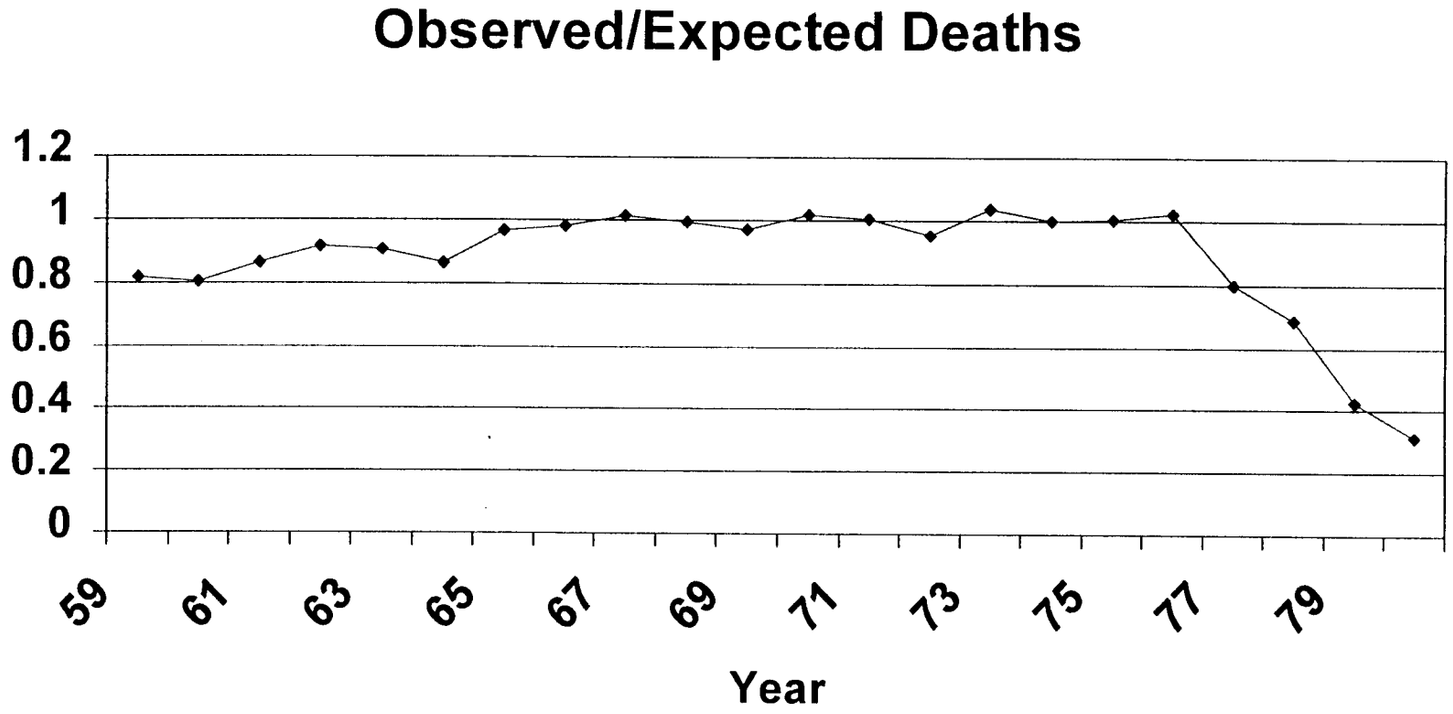
- In published papers, exposure was consider to start in 1959 due to uncertainty of predicting who was actually exposed before 1959

- Accounting for exposure before 1959 is important in understanding the relationship between exposure duration and intensity and risk of lung cancer

Case-Control Study Exposure-Response

- Risk of lung cancer estimated from the case-control study was assumed to increase over 20 years based on regression results
- Risk actually accumulated over 20 to 30 years or more, depending on the likelihood of pre-1959 exposure
- Calculated slope in document may overestimate risk

Cohort Study Exposure-Response
Death Ascertainment



Cohort Study Exposure-Response

- In the '5-year' lag models presented , deaths in group with '15-17' years of exposure after 1959 could only occur during 1978-1980

- Missing deaths 1977-1980 prelude an accurate risk assessment using deaths during these years

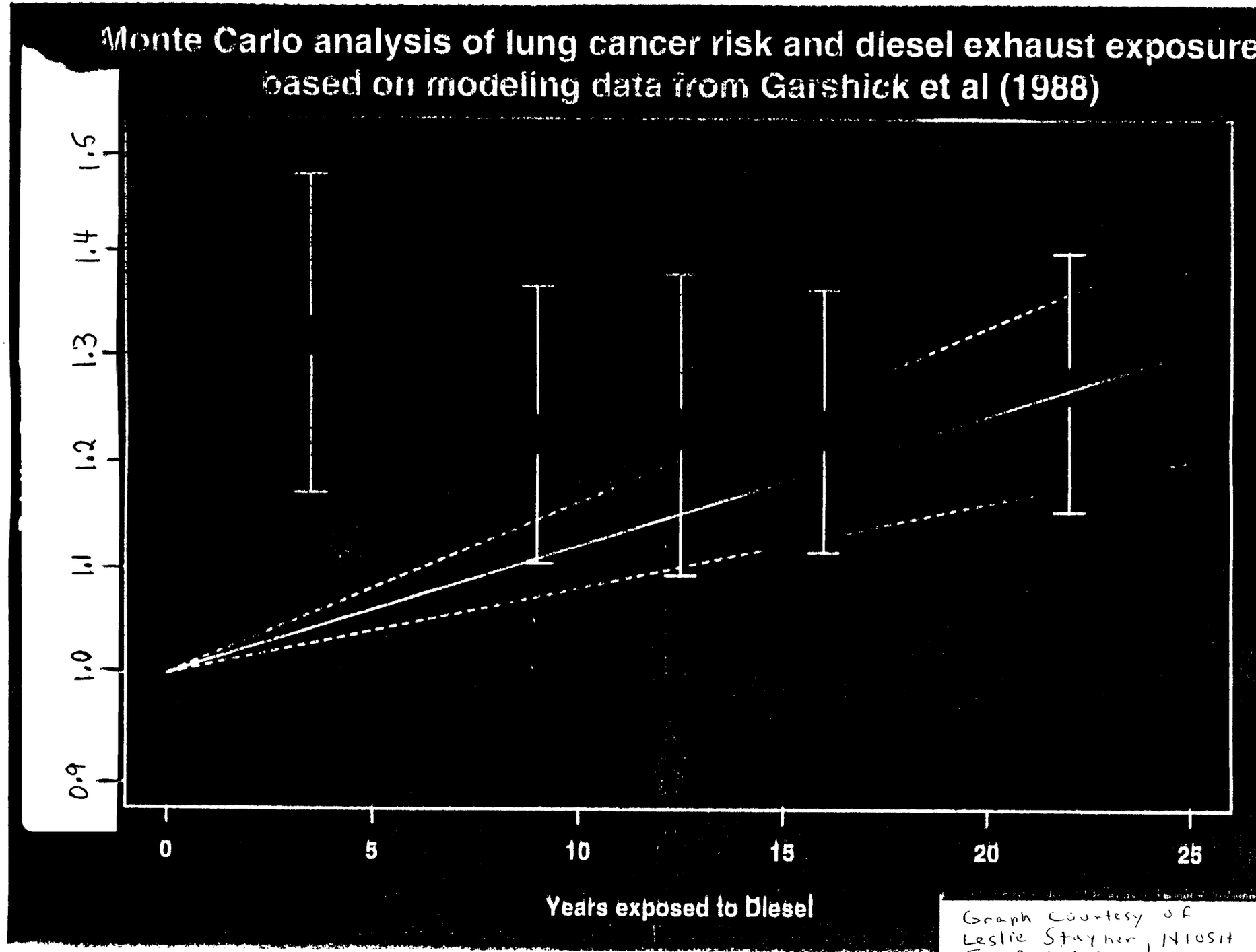
- These years of follow-up are important for risk assessment because workers with the greatest duration of exposure would be expected to have deaths in these years

Cohort Study Exposure-Response: Questions

- The use of 10-year attained age categories is used rather than 5-year age categories to adjust for age

- In Figure 7-3, does exposure start in 1952 rather than 1959, and would the results be the same if attained age in 5-year categories were used to adjust for age?

- Starting exposure time in 1952 ignores exposure for roughly 45% of the cohort before 1952; Monte Carlo analysis is one approach to understanding the uncertainty in the relationship between exposure and outcome.



Graph Courtesy of Leslie Stayner, NIOSH For entire Cohort

RR Worker Historical Exposure Assessment

- Historical records about transition to diesel and change in rosters of railroads over time to newer diesels are available

- Last railroad employer available on data tape; would permit estimation of start of exposure for workers

- Records describing emissions factors and fuel consumption for a variety of engines might permit better estimation of historical exposures

CURRENT RISK ASSESSMENT LIMITATIONS

- Death information available through 1976. Follow-up would improve the description of the exposure-response relationship with more confidence.

- Uncertainty of exposure assignment pre-1959; no historical measurements available. Additional information about RR would improve exposure assignments.

- No specific marker of exposure measured.

Research Needs

- Assess lung cancer risk over a long period of exposure and time since first exposure. Effect of exposures in the 1960's should be detectable in the late 1980's and beyond

- Include large numbers of subjects over a range of exposures to describe risk

- Use state-of-the-art exposure measurements

- Conduct an extensive retrospective exposure assessment to link personal exposure to outcome