Occupational Exposure to Diesel Exhaust

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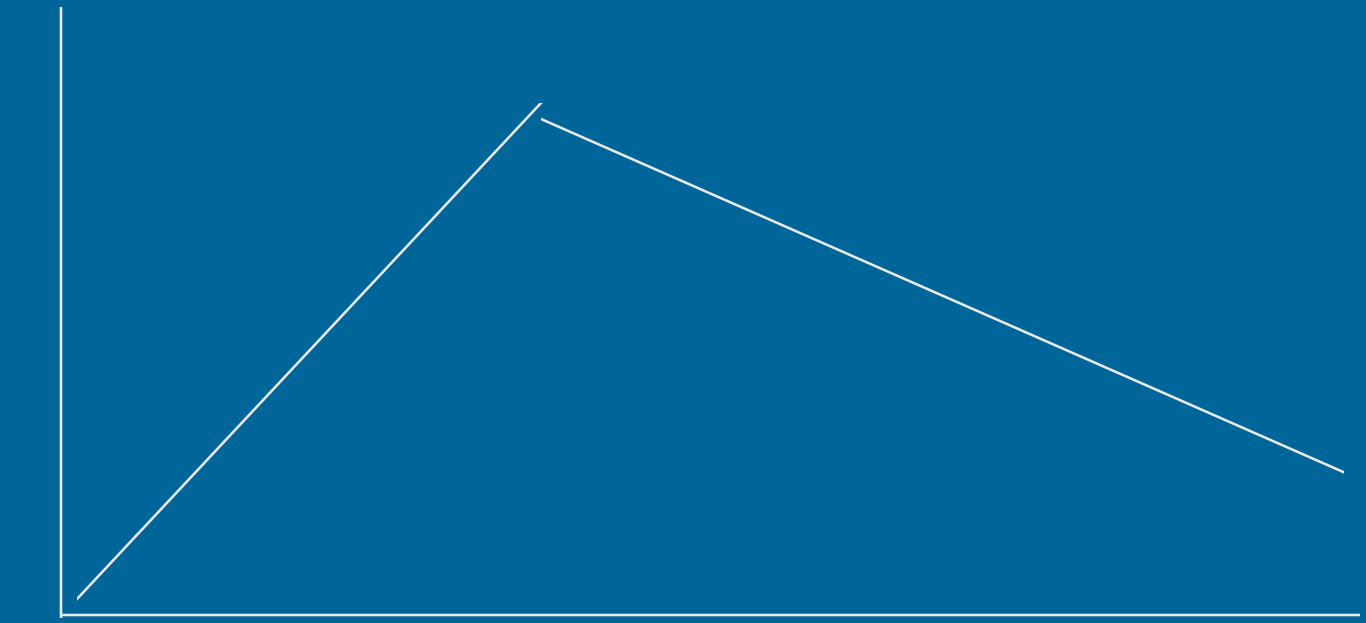
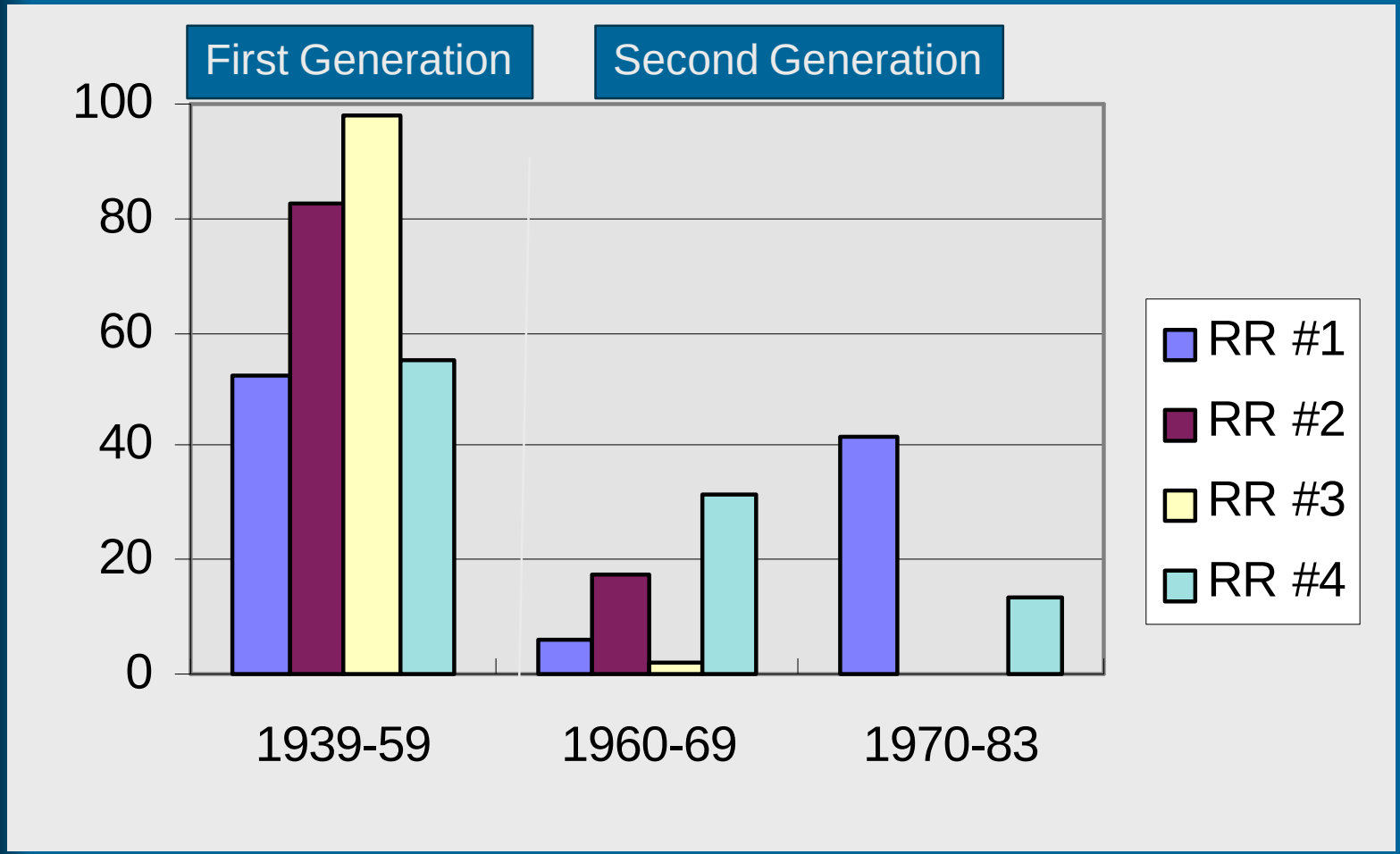
Diesel Exposure Groups of Railroad Workers

Career Group	Job Group	# samples
Clerks	Clerks	59
Engineer/Firer	Freight	55
	Yard	50
	Passenger	23
Braker/conductor	Freight Conductor	62
	Freight Braker	21
	Passenger	35
	Yard	32
Shop	all	176

Exposure Profile Over Time



Era of Locomotives Studied by Woskie



Woskie et al. statement

"After the initial dieselization occurred in the early 1950's, a second generation of more efficient diesel locomotives was introduced into the larger companies during the 1960's… There were anecdotal reports that the older, first generation locomotives were "smokier" than the second generation diesels, a change which may have decreased diesel exposures of the train crew over time. *Most (55-98%) of the locomotives on the rosters of the small railroads we sampled were first generation diesels built before 1960, many of the larger US. railroads have more modern, second generation diesels." [italics added]*

Woskie et al., 1988, p. 399

Woskie statement #2

based on the information on the previous slide, "it is assumed that the national career group exposures for the braker/conductor and engineer/firer groups represent the national average level and variability of exposures that occurred during the period of the epidemiological studies."

Woskie et al., 1988 p. 401

Particle Concentration, Railroad #1 by % First Generation Locomotives

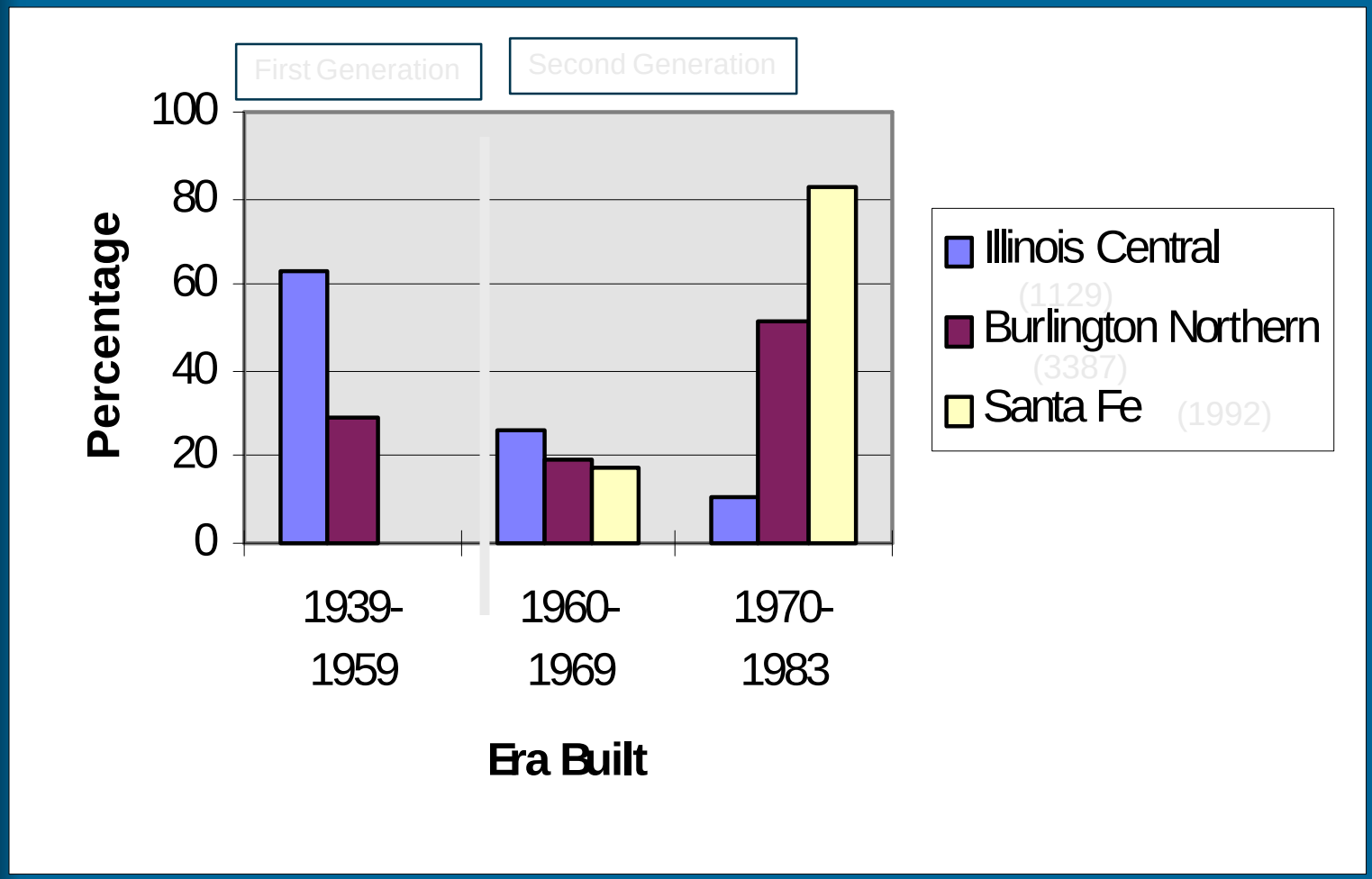
Job Group	% 1st Gen.	ARP, ug/m3
Freight Engineer/Firer	0%	105
Yard Engineer/Firer	100%	82
Passenger Engineer/Firer	87%	51
Freight Conductor	0%	117
Freight Braker	0%	106
Passsenger Braker/Condtr	87%	104
Yard Braker/Conductor	100%	47

Nitrogen Dioxide Exposures by Railroad and Job Group, Geometric Means (ppb)

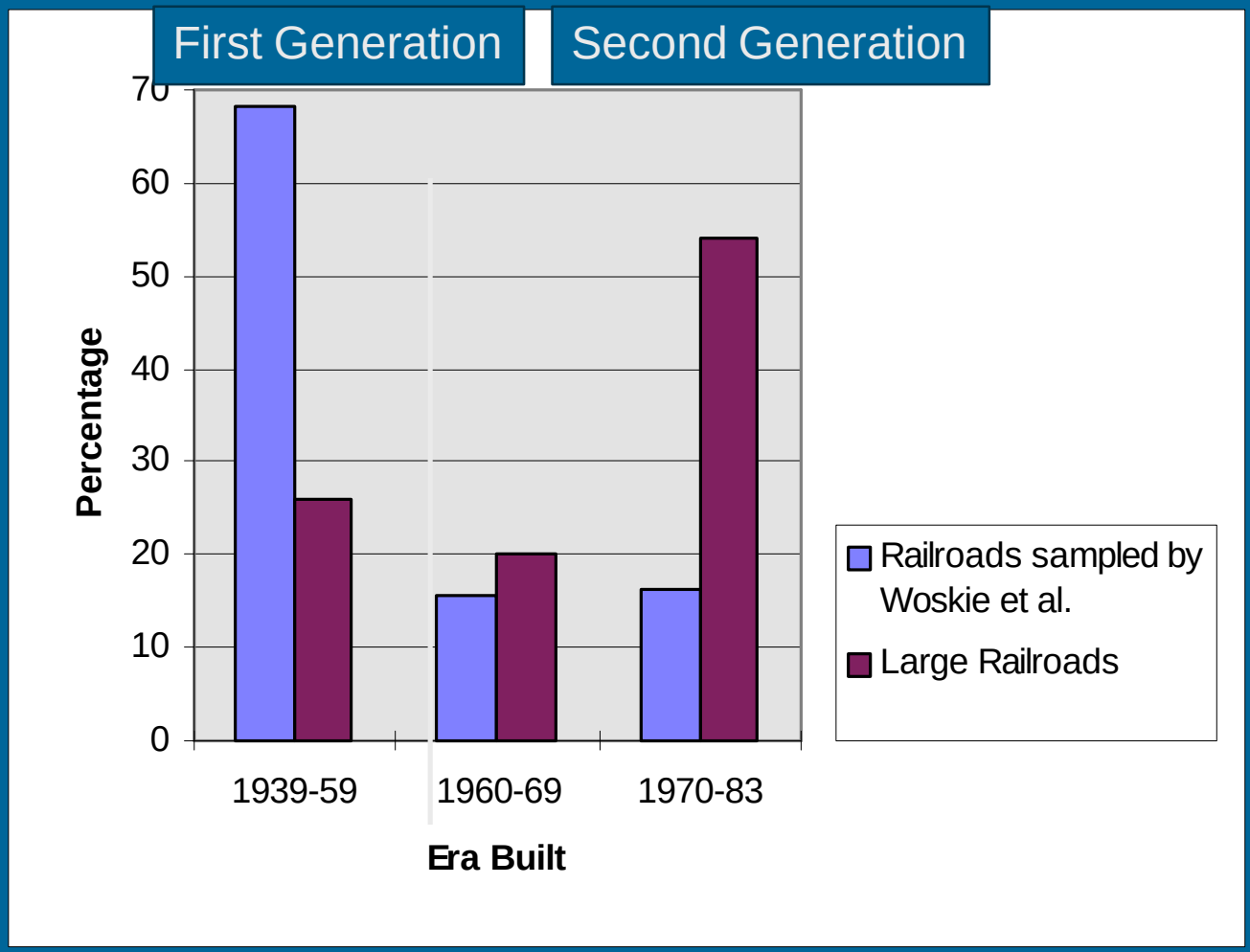
Job Group	RR# 1	RR# 2	RR# 3	RR# 4
Clerk	38	15	20	22
Frt. Engineer/Firer	**36**	**30**	**21**	**18**
Yard Engineer/Fr	**24**	**14**	**14**	**16**
Frt. Conductor	**46**	**180**	**40**	**20**
Frt. Braker	**71**	**33**	**30**	**6**
Yard Braker/Cndr	**22**	**12**	**10**	**11**
Electrician	84	74	94	67
Machinist	99	81	104	52

Diesel locomotives are not PCs

Age of Locomotives in Larger Railroads, 1982-1983



Comparison Between Age of Locomotives in Woskie and among Large Railroads, 1982-83



Options for Background Correction

- do nothing
- subtract value for clerks (unexposed)
  [33 ug/m3]
- subtract ambient RSP
  [10-20 ug/m3]

Estimates of Diesel Exhaust Exposures in Occupations other than Railroad Workers

- Bus Garage Workers
- Mechanics
- Heavy Equipment Operators
- Drivers

Surrogates of Diesel Exhaust Particles

- RSP, respirable particles ; median aero. dia. 3.5 um

  RSP[all] =

  RSP[diesel] + RSP[ETS] + RSP[other] + RSP[bkgd]

- ARP, adjusted respirable particles

  ARP = RSP[all] - RSP[ETS]

  = RSP[diesel] + RSP[other] +RSP[bkgd]

- C[e], elemental carbon; C[o], organic carbon

  RSP[diesel] = C[e] + C[o]

Aim: To Convert all Conc. to RSP[diesel]

London bus garage workers, 1959 & 1979 Commins et al (1957); Waller et al (1985)

- Measured reflectance, corrected for roof value
- Reflectance < TSP (TSP / Refl ~ 1 - 3)
- assume reflectance ~ RSP[diesel]
- no significant change between 1959 and 1979
- Area samples, mostly highest areas
- I took TWA when buses were running (c. 20 hours) at highest areas and assumed the maximum average personal exposure would be half that
- RSP[diesel] ~ 80 and 300 ug/m3 at 2 garages

Diesel Exhaust Exposure of Bus Garage Workers

- Waller (1957) and Commins (1985)
  RSP[diesel] ~ 80 - 300 ug/m3
- Gamble (1987): 4 garages had average RSP of
  120 160 350 610 (included smokers, RSP[ETS])
  average of all nonsmokers: 230 ug/m3
- Birch & Cary (1996): Ohio garages, personal exposure to C[e] = 98 ug/m3, C[o] = 80 ug/m3
  ==> estimate RSP[diesel] ~ 180 ug/m3
- Conclusion: RSP[diesel] ~ 50-200ug/m3, max 500

Diesel Exhaust Exposure of Mechanics

- Bus garage workers: 50 - 200 ug/m3
- Zaebst (1991) truck mechanics: C[e] = 27 ug/m3, so estimate RSP[diesel] ~ 2 x C[e] = 54 ug/m3
- Woskie (1988): railroad mechanics,
  ARP = 150-250 ug/m3 > RSP[diesel]
- Birch & Cary (1996): automotive repair shops
  mostly gasoline: C[e] = 3 -7
  mostly diesel: C[e] = 7 - 70 => RSP[diesel] ~ 14-140

Conclusion: RSP[diesel] ~ 15 - 150, max 400 - 500

Diesel Exhaust Exposure of Heavy Equipment Operators

- Fowler (1985): personal sampling on members of Local 3 in California, multiple surrogates for diesel
- C[e] = 3.2 ug/m3 => RSP[diesel] ~ 6.4 ug/m3
- Note that construction jobs are not typically 40 hours per week for 50 weeks a year over a lifetime, so that actual cumulative exposure may be lower
- Conclusion: RSP[diesel] ~ 5 - 10 ug/m3, max 50

Diesel Exhaust of Truck Drivers

- Zaebst (1991) measured C[e] exposures for local and road drivers
- C[e] ~ 5.4 (local) and 5.1 (road) =>

  RSP[diesel] ~ 10 - 11
- Fowler (1985) measured C[e] for highway drivers

  C[e] ~ 7.2 => RSP[diesel] ~ 14.4
- Conclusion: RSP[diesel] ~ 10 -15
- Drivers may have over 40 hours/week exposure from driving and sleeping in cab near highway
- Older exhaust design may mean higher exposures

Summary of Diesel Exhaust Exposures

Occupation	RSP[diesel], ug/m3 Range	Max.	Comments
Bus Garage Workers	50 - 200	400 - 500	
Mechanics	15 - 150	400 - 500	highly variable
Heavy Equipment Operators	5 - 10	50	may work less time=>*lower Cum. Expos.*
Truck Drivers	10 - 15		may be exposed more; past may have been higher=> *higher Cum Expos.*

Diesel Exhaust Exposures of Railroad Workers

- Exposure profile of roof is most appropriate
- Woskie data represents exposures typical of first generation locomotives predominantly
- Background correction by subtracting clerk ARP values is probably an over-correction; ambient RSP is a better surrogate
- Mix of locomotives means roof slope from 1959 to 1980 is less steep; ratio may be 2 - 3
- Train crew exposure (Woskie): ARP = 80 ug/m3

  RSP[diesel] ~ 60 - 70 ug/m3