

Cancer Effects of Workplace PCE Exposure

Katherine Rushing

Advisor: Dr. Dannele Peck

Honors Program

Background

- Perchloroethylene
 - aka tetrachloroethylene, PCE, perc
 - 1934: first use as a dry cleaning solvent
 - 1948: PCE became leading chlorinated solvent
 - 1980: peak use in dry cleaning
- 1990: EPA proposed PCE emission standards
 - Transfer machines to dry-to-dry machines

Current Regulatory Environment

- 1996: National Emission Standard Hazardous Air Pollutants (NESHAP) Requirements
 - Obligated PCE dry cleaners to monitor emissions and record machine maintenance
- 2006: CA to phase out PCE dry cleaning by 2023
- 2008: National Perchloroethylene Air Emission Standards for Dry Cleaning Facilities banned transfer machines

Risks of PCE Exposure

- Listed as a Hazardous Air Pollutant
 - One of 33 that present the greatest threat to public health in urban areas
- Inhalation is primary exposure route
 - Transfer machines
 - Poorly maintained machines
 - Equipment leaks
 - Open solvent containers
 - Improperly processed clothes

Health Impacts of Exposure

- Higher risk for individuals working in or living near dry cleaning facilities
- Symptoms: depression of the central nervous system; damage to the liver and kidneys; impaired memory; confusion; dizziness; headache; drowsiness; eye, nose, and throat irritation (OSHA, 2005)
- “Reasonably anticipated to be a human carcinogen” (National Toxicology Program, 2010)

Market Behavior

- Dry cleaners do not bear the full social cost associated with PCE-related health problems in employees
- Market structure
 - Small, family-run firms; no nationwide firms with significant market share
- Replace “old” and inefficient machines
 - Cost \$20,000 to \$60,000
- Regulation?

Frequency of cancer cases in dry cleaning workers in the US as a result of exposure to PCE and associated costs and benefits

RISK ANALYSIS

Risk Analysis: Methods

- 1997: PCE concentrations 35,000-175,000 $\mu\text{g}/\text{m}^3$
- Four scenarios: extent to which “new” machines reduce exposure and proportion of “old” machines replaced
 - Base case: no new machines
 - New machines with 50% less PCE
 - New machines with 75% less PCE
 - New machines with 95% less PCE
- Replacing 50, 75, 95, 100% of machines

Risk Analysis: Methods

- Estimated lifetime cancer risk (ELCR)
- $ELCR = EPC \left(\frac{\mu g}{m^3} \right) * IUR \left(\frac{\mu g}{m^3} \right)^{-1} * TWF$
- Risks of less than 1 in 1,000,000 are negligible; risk of over 1 in 10,000 justifies mandatory remediation

Note

- Distribution of *average* ELCR, rather than a distribution of ELCR itself
- “On average, employees will experience $X_{\text{lower bound of 95\% CI}}$ to $X_{\text{upper bound of 95\% CI}}$ excess cancers in their lifetime”

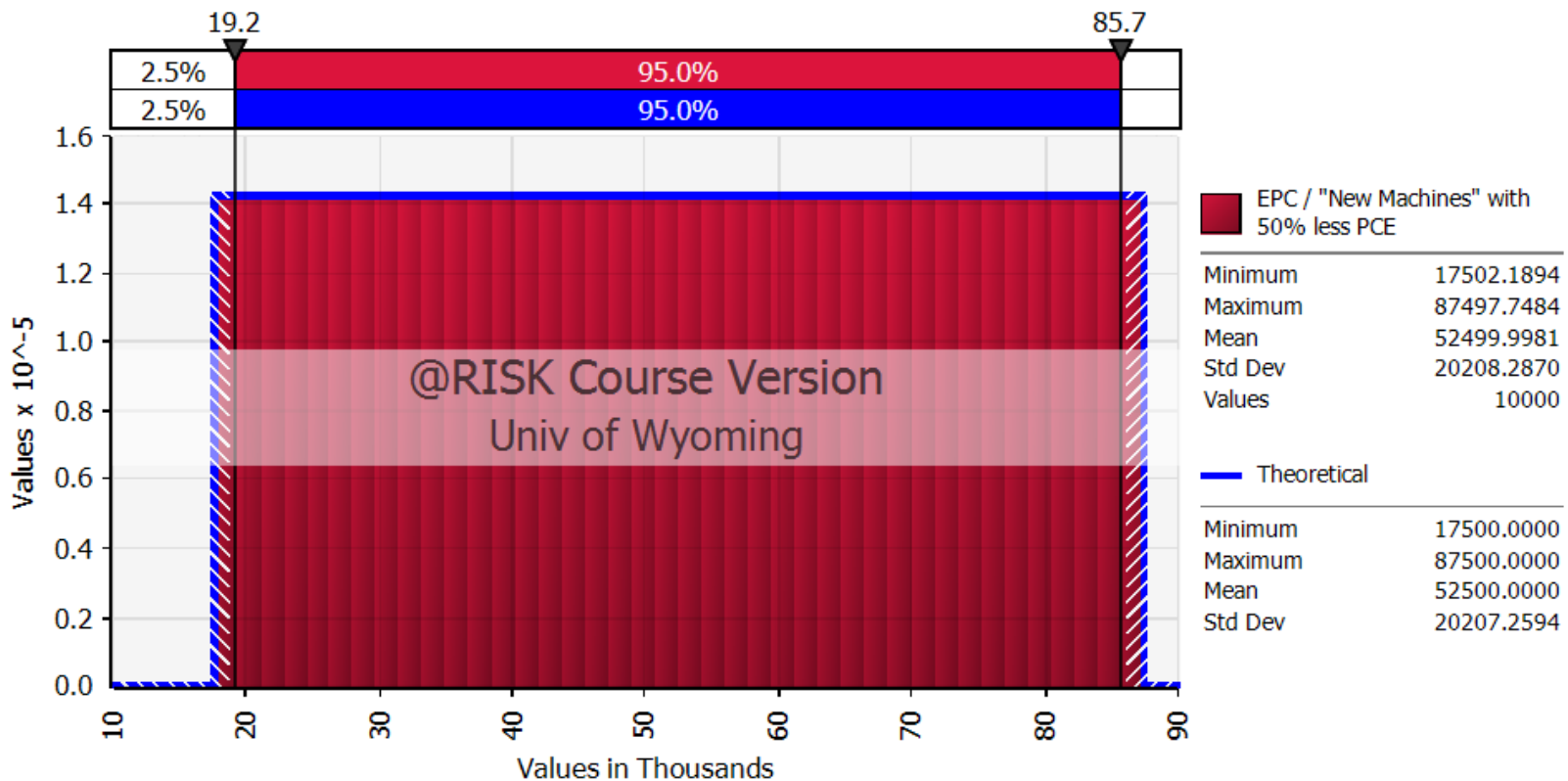
Risk Analysis: Methods

- ELCR applied to size of population (1,327,800) to find range of excess cancer cases among workers in dry cleaning
- Distributions of cancer cases used to find cancers avoided from replacing machines
- Cost to society per cancer per year: \$154,189
- Maximum benefits to society; per firm willingness to pay to avoid cancers

New Machines with 50% Less PCE Exposure

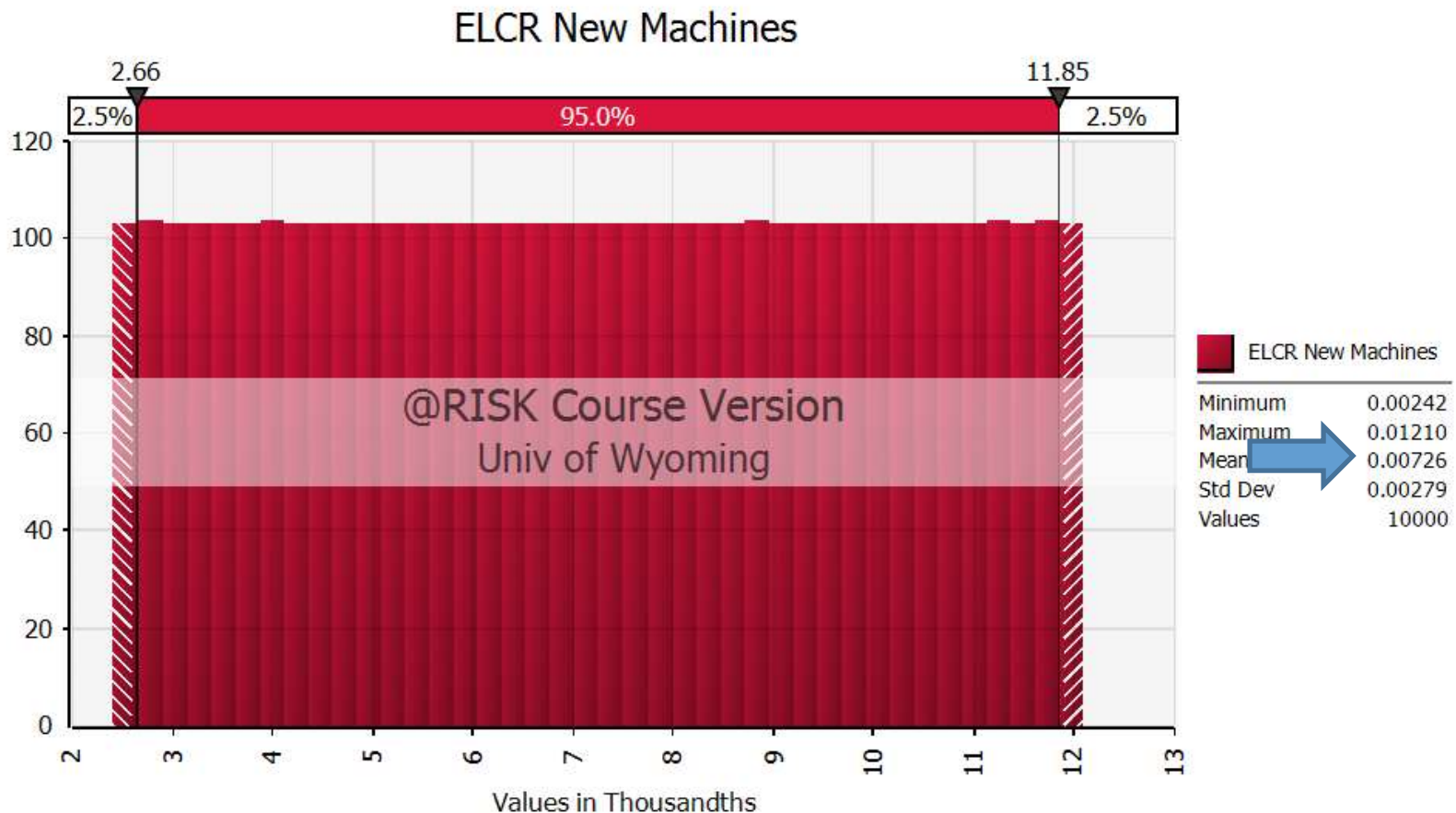
- PCE Concentrations: 19,200 to 85,700 $\mu\text{g}/\text{m}^3$

EPC / "New Machines" with 50% less PCE
 Comparison with Uniform(17500,87500)



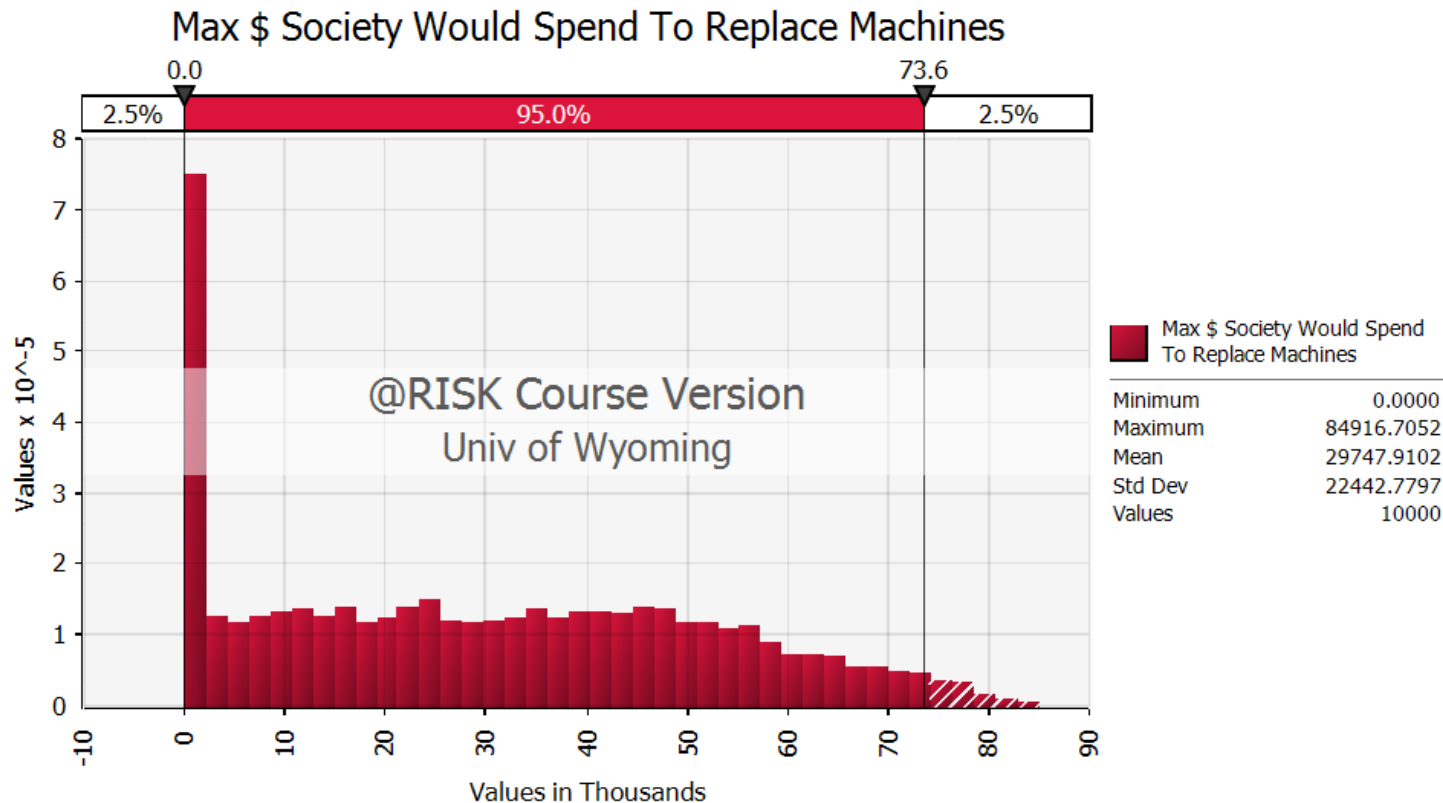
New Machines with 50% Less PCE Exposure

- ELCR is 0.00726 or 7.26 additional cancers per thousand people



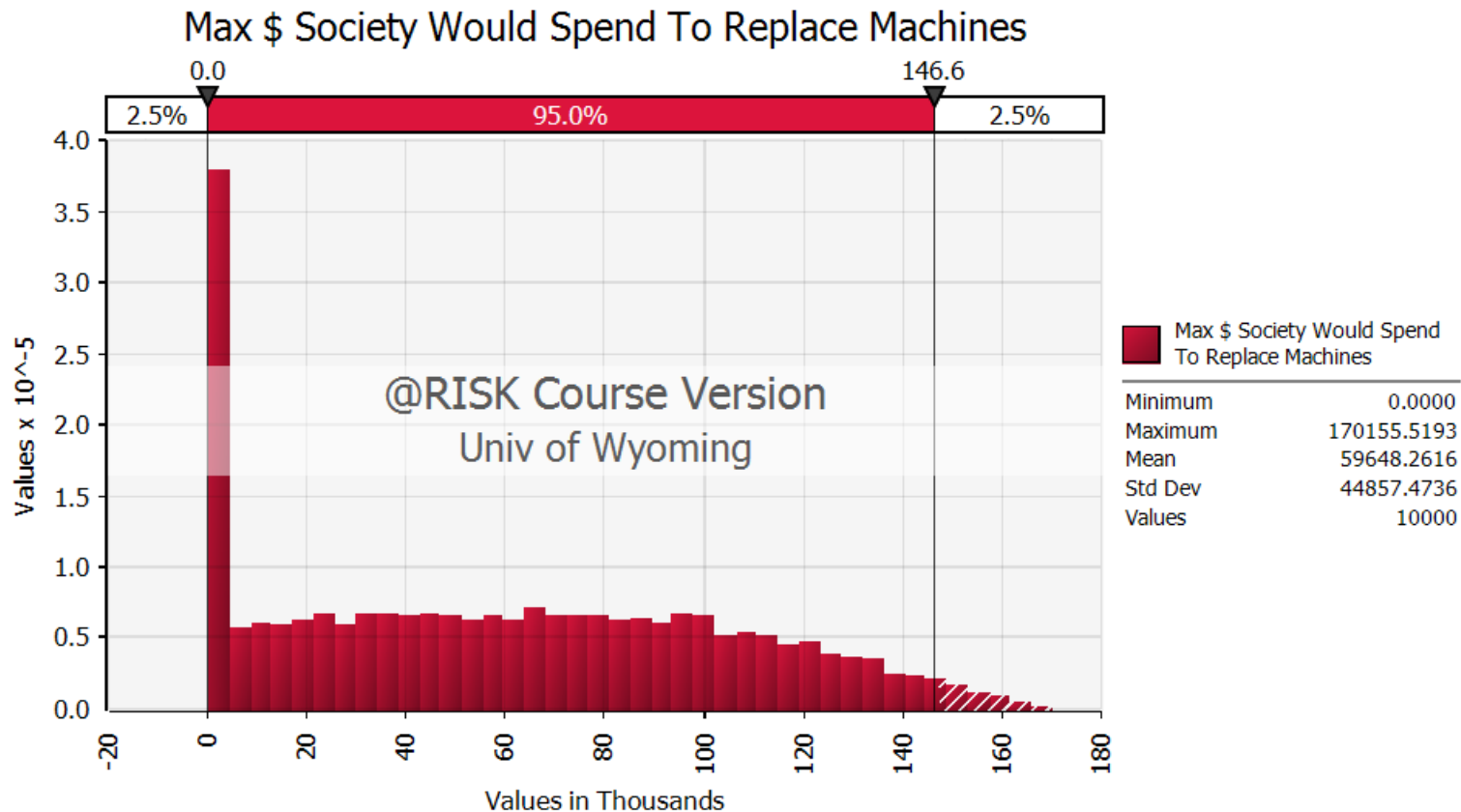
50% Replacement

- Mean # cancers avoided: 5,045
- Average willingness to pay per firm to avoid these cancers: \$29,747



100% Replacement

- Mean # cancers avoided: 10,102
- Average willingness to pay per firm to avoid these cancers: \$59,648



PCE Exposure Level	% New Machines	Sum of Cancers	# Cancers Avoided	Benefits from Cancers Avoided (\$)	Maximum Society Would Spend to Replace Machines (\$)
Base Case	0%	★ 19,274	0	-	-
New Machines 50% Less PCE	50%	14,456	5,045	776,212,219.56	29,747.91
	75%	12,046	7,551	1,167,000,000.00	44,749.74
	95%	10,119	9588	1,476,000,000.00	56,580.36
	100%	9,637	10,102	1,555,000,000.00	59,648.26
New Machines 75% Less PCE	50%	12,046	7,228	1,114,453,525.20	42,710.82
	75%	8,432	10,842	1,671,680,287.80	64,066.24
	95%	5,541	13,733	2,117,461,697.88	81,150.57
	100%	4,819	14,456	2,228,907,050.40	85,421.65
New Machines 95% Less PCE	50%	10,119	9,155	1,411,641,131.92	54,100.38
	75%	5,541	13,733	2,117,461,697.88	81,150.57
	95%	1,879	17,395	2,682,118,150.64	102,790.72
	★ 100%	964	18,310	2,823,282,263.83	108,200.75

Policy Implications

- Subsidy on new machines with no PCE
- Tax on dry cleaned clothes
 - Tax revenue used for subsidy
- End policies once desired amount of new machines is achieved, because society cannot extract any more benefit from additional machine replacement

Thank you!