Meta-Analysis of the Fine Particulate Matters-Associated Occupational Health Risks

Nan-Hung Hsieh¹, Shun-Hui Chung²

¹Department of Veterinary Integrative Biosciences, Texas A&M University, College Station, TX ²Institute of Labor, Occupational Safety And Health, Ministry of Labor, New Taipei City, Taiwan





Motivation

Fine particulate matter (PM) is the recognized risk factor that can cause respiratory and other diseases. Some environmental regulations have been established to protect public people from health concerns. However, it still needs more criterion to understand the fine PM-induced health effects for each occupational population and to further conduct the health protection strategy. This study aims to provide a quantitative summary the fine PM-associated health risk for workers in workplaces.

Methods

Literature search. Relevant studies were identified in several stages, beginning with a systematic search using the keywords of fine particulate matter, workplace, and occupational in the abstract, with the results restricted to studies of occupational population. An initial search was conducted in July 2015 and updated automatically through December 2015. **Inclusion and exclusion criteria.** studies were included in the current meta-analysis if they provided quantitative risk estimates of hazard ratio, risk ratio, or odds ratio. **Statistical analyses.** All study estimates were converted to risk ratio to represent the change under fine PM exposure. Estimates from the studies were combined using both fixed- and random-effects model, which allowed between-study heterogeneity to contribute to the variance.

Review of Workplace Fine PM and Occupational Mortality

Reference	Cohort	Exposure	Cause	CaseNo.
Sjogren et al.	234 welder	Hexavalent	Ischaemic heart	10
1987		chromium	disease (IHD)	
Steenland et al.	92 control dockworkers	Diesel fume	Lung cancer (LC)	70
1998	604 control long-haul			609
	drivers			121
	134 control short-haul drivers			
	50 control truck			37
	mechanics			
	143 control other			99
	potentially exposed			
Randem et al.	8,610 male asphalt	Bitumen fume	Cerebrovascular	73/214
2003	workers	and PAH	disease (CBD)/IHD	
Finkelstein et al.	1,009 Heavy	Diesel fume	CBD/IHD	38/259
2004	equipment operators			
	271 boilermakers			9/59
	1,533 electricians			61/332
	201 insulators			5/34
	220 painters			5/40
	3,561 plumbers			190/876
	505 sheet metal			22/92
Laden et al.	54,319 male in the	Diesel fume	CBD/IHD	167/1,133
2007	trucking industry			
Toren et al.	248,087 male	Diesel fume	CBD/IHD	423/1,720
2007	construction workers			
		Asphalt fume		45/171
		Metal fume		205/831
Garshick et al.	29,324 male workers	Diesel fume	LC	179
2012	in trucking industry	in diffewrent		202
		levels		248
Silverman et al.	228 control male miners	Diesel fume	LC	50
2012	157 control male miners			49
	123 control male miners			50
Costello et al.	39,412 autoworkers	Metal fume	IHD	67
2013		in different		68
		levels		68
				67
Mohner et al. 2013	5,862 potash miners	Diesel fume	LC	68

Review of Ambient Fine PM and Occupational Mortality

Reference	Cohort	Cause	CaseNo.
Puett et al. 2009	66,250 women from the Nurses' Health study	Coronary heart disease	1,348
Hart et al. 2011	53,814 men in the U.S. trucking industry	All-causes	4,806
		Cardiovascular disease	1,682
		Ischemic heart disease	1,109
Lipsett et al. 2011	73,489 women from the California Teachers Study	Cardiovascular disease	1,630
Puett et al. 2011	17,545 male from Health Professionals	All-cause	2,813
	Follow-Up Study prospective cohort	Cardiovascular disease	1,661
		IHD	746
Weichenthal et al.	83,378 subjects included farmers, their	All-cause	3,961
2014	spouses, and commercial pesticide applicators.	Cardiovascular disease	1,055
Ostro et al. 2015	133,479 current and former female teachers	All-cause	6,285
	and administrators	Cardiovascular disease	2,400
		IHD	1,085
Hart et al. 2015	108,767 members of the Nurses' Health Study 2000-2006	All-cause	8,617

Workplace Fine PM-associated occupational mortality

We summarized the result of the fine PM-associated mortality of respiratory and other diseases, which include lung cancer, ischemic heart disease, and cerebrovascular disease. The result shows that lung cancer has the highest risk ratio with insignificant heterogeneity. Random-effects estimation also indicated the consistencies between studies.

A) Ischemic Heart Disease Mortality

								Weight	Weight
Study	TE	seTE	Risk	Ratio		RR	95%-CI	(fixed)	(random)
Sjogren et al., 1987	-0.71	0.3874 -	+	<u> </u>		0 49	[0.23; 1.05]	0.1%	1.4%
Randem et al., 2003		0.0682		_: ;			[0.75; 0.98]	3.6%	6.7%
Finkelstein et al., 2004		0.0569		: ı			[0.97; 1.22]	5.1%	6.9%
Finkelstein et al., 2004		0.1153	+				[0.69; 1.09]	1.2%	5.5%
Finkelstein et al., 2004		0.0465	-	⊢			[0.79; 0.94]	7.6%	7.1%
Finkelstein et al., 2004		0.1768		<u> </u>			[0.73, 0.34]	0.5%	4.0%
Finkelstein et al., 2004		0.1766					[0.62; 1.14]	0.7%	4.5%
Finkelstein et al., 2004		0.0438	-	■			[0.82; 0.97]	8.6%	7.2%
Finkelstein et al., 2004		0.0436	_				[0.62, 0.97]	1.7%	5.9%
Landen et al., 2007		0.0903		-			[1.33; 1.49]	19.7%	7.4%
•								29.4%	
Toren et al., 2007		0.0237		<u>.</u>			[1.13; 1.24]		7.5%
Toren et al., 2007		0.0773					[0.96; 1.30]	2.8%	6.4%
Toren et al., 2007		0.0327					[0.95; 1.08]	15.4%	7.3%
Costello et al., 2013		0.1590		+	_		[1.04; 1.94]	0.7%	4.4%
Costello et al., 2013	0.12	0.1593	_	 		1.13	[0.83; 1.54]	0.7%	4.3%
Costello et al., 2013	-0.13	0.1625	+	<u> </u>		0.88	[0.64; 1.21]	0.6%	4.3%
Costello et al., 2013	0.25	0.1461		<u> </u>		1.29	[0.97; 1.72]	0.8%	4.7%
Costello et al., 2013	0.43	0.1475				1.53	[1.15; 2.04]	0.8%	4.6%
Fixed effect model				\		1.10	[1.08; 1.13]	100.0%	
Random effects mode	I			\(\)			[0.92; 1.13]		100.0%
Heterogeneity: $I^2 = 91\%$,		42. $p < 0.0$)1				_ , - 1		
		, -	0.5	1	2				
			3.3	•	_				

B) Cerebrovascular Disease Mortality

Study	TE seTE	Risk Ratio	RR	95%–CI	Weight (fixed)	Weight (random)
Randem et al., 2003	0.13 0.1210	: ! : "	1.14	[0.90; 1.45]	3.0%	9.9%
Finkelstein et al., 2004	-0.15 0.1768	- + : :	0.86	[0.61; 1.22]	1.4%	7.4%
Finkelstein et al., 2004	-0.24 0.3372	- <u> </u>	0.79	[0.41; 1.53]	0.4%	3.3%
Finkelstein et al., 2004	-0.06 0.1375		0.94	[0.72; 1.23]	2.3%	9.2%
Finkelstein et al., 2004	-0.48 0.4964 —	: 	0.62	[0.23; 1.64]	0.2%	1.8%
Finkelstein et al., 2004	-0.56 0.4775 —		0.57	[0.22; 1.45]	0.2%	1.9%
Finkelstein et al., 2004	0.08 0.0650	 	1.08	[0.95; 1.23]	10.4%	12.6%
Finkelstein et al., 2004	0.04 0.2109	- 	1.04	[0.69; 1.57]	1.0%	6.2%
Landen et al., 2007	0.34 0.0290	+	1.41	[1.33; 1.49]	52.1%	13.8%
Toren et al., 2007	0.09 0.0491	 ;	1.09	[0.99; 1.20]	18.2%	13.2%
Toren et al., 2007	0.17 0.1552	- 	1.18	[0.87; 1.60]	1.8%	8.4%
Toren et al., 2007	-0.08 0.0694	-= ;	0.92	[0.80; 1.05]	9.1%	12.4%
Fixed effect model			1.22	[1.17; 1.27]	100.0%	
Random effects mode			1.04	[0.91; 1.20]		100.0%
Heterogeneity: $I^2 = 83\%$,	$c^- = 0.0349, p < 0.01$	0.5 1 2				

C) Lung Cancer Mortality

Study	TE	seTE	Risk	Ratio		RR	95%-CI	Weight (fixed)	Weight (random)
Steeland et al., 1998	0.24	0.2153	_	-		1.27	[0.83; 1.94]	9.3%	9.3%
Steeland et al., 1998	0.27	0.2442	_	 •		1.31	[0.81; 2.11]	7.2%	7.3%
Steeland et al., 1998	0.52	0.3091		+	-	1.69	[0.92; 3.10]	4.5%	4.6%
Steeland et al., 1998	-0.08	0.2643		++		0.92	[0.55; 1.54]	6.1%	6.2%
Steeland et al., 1998	0.36	0.2549	_	1		1.44	[0.87; 2.37]	6.6%	6.7%
Garshick et al., 2012	0.16	0.1477	_			1.17	[0.88; 1.56]	19.7%	19.1%
Garshick et al., 2012	0.23	0.1740	-			1.26	[0.90; 1.77]	14.2%	14.0%
Garshick et al., 2012	0.34	0.2036		+ -		1.41	[0.95; 2.10]	10.4%	10.4%
Silverman et al., 2012	-0.30	0.3159		 		0.74	[0.40; 1.37]	4.3%	4.4%
Silverman et al., 2012	0.43	0.3159				1.54	[0.83; 2.86]	4.3%	4.4%
Silverman et al., 2012	1.04	0.4049				2.83	[1.28; 6.26]	2.6%	2.7%
Mohner et al., 2013	0.04	0.1995		-		1.04	[0.70; 1.54]	10.8%	10.8%
Fixed effect model				\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ 		1.25	[1.10; 1.42]	100.0%	
Random effects mode	ĺ			\limits		1.25	[1.09; 1.42]		100.0%
Heterogeneity: $I^2 = 3\%$, τ^2	$^2 = 0.0015$	5, p = 0.42							
		0.	.2 0.5	1 2	5				

Environmental Fine PM-associated occupational mortality

To understand the ambient fine PM-associated the health risk of mortality, this study finds that the cardiovascular disease mortality and heart disease mortality are related to fine PM exposure for workers who have no occupational exposure to fine PM in the workplaces. However, we can only find few reference that focuses on the relationship between fine PM and occupational population.

A) All-Cause Mortality

Study	TE	seTE	Risk	Ratio		RR	95%-CI	Weight (fixed)	Weight (random)
Puett et al., 2011	-0.11 C).0849 —		<u> </u>		0.90	[0.76; 1.06]	2.7%	10.9%
Hart et al., 2011	0.10 0	0.0325		<u>:</u>		1.10	[1.03; 1.17]	18.4%	26.1%
Weichenth et al., 2014	-0.050).1165 —	+	i.	-	0.95	[0.76; 1.19]	1.4%	6.8%
Hart et al., 2015	0.11 0	0.0362		() ()			[1.04; 1.20]	14.8%	24.7%
Ostro et al., 2015	0.01	0.0176	+	1 0 0		1.01	[0.98; 1.05]	62.7%	31.5%
Fixed effect model						1.04	[1.01; 1.07]	100.0%	
Random effects mode						1.04	[0.98; 1.11]		100.0%
Heterogeneity: $I^2 = 70\%$,	$\tau^2 = 0.0033$	3, <i>p</i> < 0.01							
		(0.8 1		1.25				

B) Cardiovascular Mortality

Study	TE	seTE	Risk Ratio	RR	95%-CI	Weight (fixed)	Weight (random)
Puett et al., 2011	0.05	0.1084		1.05	[0.85; 1.30]	5.1%	5.1%
Hart et al., 2011	0.05	0.0635		1.05	[0.93; 1.19]	14.9%	14.9%
Lipsett et al., 2011	0.07	0.0575	+-	1.07	[0.96; 1.20]	18.2%	18.2%
Weichenth et al., 2014	0.27	0.2264		1.31	[0.84; 2.04]	1.2%	1.2%
Ostro et al., 2015	0.05	0.0315		1.05	[0.99; 1.12]	60.6%	60.6%
Fixed effect model				1.06	[1.01; 1.11]	100.0%	
Random effects model		_	\diamond	1.06	[1.01; 1.11]		100.0%
Heterogeneity: $I^2 = 0\%$, τ^2	= 0, p	= 0.91	I	I			
		0.	5 1	2			

C) Heart Disease Mortality

Study	TE	seTE	Ris	sk Ratio		RR	95%-CI	Weight (fixed)	Weight (random)
Puett et al., 2009	0.70	0.3220		1	-	2.02	[1.07; 3.80]	1.5%	5.0%
Puett et al., 2011	0.02	0.1645	_	1		1.02	[0.74; 1.41]	5.6%	15.1%
Hart et al., 2011	0.02	0.0777		1)		1.02	[0.88; 1.19]	25.1%	34.7%
Ostro et al., 2015	0.17	0.0473		1		1.18	[1.08; 1.29]	67.8%	45.3%
Fixed effect model				\Rightarrow		1.14	[1.05; 1.23]	100.0%	
Random effects model				\Diamond		1.13	[0.97; 1.31]		100.0%
Heterogeneity: $I^2 = 52\%$, τ^2	$^{2} = 0.0$	102, $p = 0.10$	I	l	l				
			0.5	1	2				

Discussion

- ▶ In this analysis, we focused attention on fine PM, which is prominent component of the air pollution. We divided the two different scenarios to quantify and understand the exposure risk for the occupational population. Current result shows that most studies had investigated the exposure risk of fine PM in the workplace. However, we also need to pay more attention to the occupational population who may have potential exposure risk to fine PM from ambient environment.
- ▶ Most of the data were obtained from cohort studies; We did not place any restrictions based on whether or not a study adjusted for specific confounders. Therefore, homogeneity tests found the difference in estimates between exposure assessment techniques.
- A large number of hypothetical studies would be required to construct a symmetrical analysis and change the results of our meta-analyses. Results for mortality risk of lung cancer from fine PM was robust to influence analyses in occupational exposure, where the meta-estimate was recalculated with the systematic exclusion of each study.

Acknowledgements

The authors appreciate the useful discussion and suggestion from the members of Institute of Labor, Occupational Safety And Health, Ministry of Labor.

Source code

The R source code of this study were put on the github https://github.com/nanhung/MetaPM. We appreciate your valuable comments to improve this study.