Title：Exploring the Correlation between Particulate Matter Concentration and Traffic Accidents in Major Metropolitan Areas of Northern, Central, and Southern Taiwan

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Introduction：Traffic accidents (TAs) have been a leading cause of death. Air pollution, especially $PM_{2.5}$ levels, may raise accident risks, as evidenced by past multi-vehicle crashes. However, related studies in Taiwan remain limited. This study aimed to analyze the differences in the injury severity and the types of road users affected by air quality.

Methodology：

We collected Road Traffic Accident Investigation Reports for Taipei, Taichung, and Kaohsiung in 2020 and established a database focusing on the primary parties involved, excluding passengers, unlicensed, and drunk drivers. Hourly particulate matter (PM) concentrations at the time and location of each accident were obtained using data from the Ministry of Environment. After excluding weather conditions that could potentially affect visibility (humidity >90%, rainfall >20mm), the PM concentrations were divided into quartiles (Q1 to Q4).Chi-square tests were used to analyze differences in the number of accidents, injury severity, and road user impact at different PM levels.

Result：Significant differences were observed in injury severity linked to $PM_{10}$and $PM_{2.5}$levels. Higher PM concentrations (Q4) led to more fatalities and injuries, whereas lower levels (Q1) had more non-injury accidents. Further analysis of the distribution of accidents involving different types of road users at different PM_{10} and $PM_{2.5}$ concentration levels, revealed that the number of motorcycle and bicycle accidents gradually increased with higher concentrations. Additionally, comparing the number of accidents among different road user types between Q1 and Q4 showed significant differences. More accidents involving cars occurred at lower PM_{10} and $PM_{2.5}$ levels, while the number of accidents involving motorcycles, bicycles, and pedestrians significantly increased at higher concentrations.

Conclusion：The study revealed a significant correlation between high PM concentration and the severity of TA injuries and types of road users affected, particularly motorcycles, bicycles, and pedestrians.

Contribution：Our results emphasize the critical impact of air quality on traffic accidents, suggesting the necessity for further investigation into both injuries severity and road users affected.

Keywords: traffic accident, particulate matter pollution, injury, road user

Exploring the Correlation between Particulate Matter Concentration and Traffic Accidents in Major Metropolitan Areas in Taiwan

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Introduction

Traffic accidents have been a leading cause of death. Air pollution, especially particulate matter (PM) levels, may affect the environmental factors for road users to raise accident risks. This study aimed to analyze the differences in the injury severity and the types of road users affected by PM exposure.

Material and Methods

- ✓ Collected Road Traffic Accident Investigation Reports for Taipei, Taichung, and Kaohsiung in Taiwan in 2020 and focusing on the primary parties, excluding passengers, unlicensed, and drunk drivers.
- ✓ Hourly particulate matter (PM) concentrations at the time and location of each accident were obtained using data from the Ministry of Environment in Taiwan.
- ✓ Excluding traffic accidents that occurred under weather conditions of RH >90% and Rainfall >20mm.

Results

Table 1. The distributions of PM levels for traffic accident in different conditions.

Variables	$PM_{2.5}$ (μg/m³)		PM_{10} (μg/m³)	
	Q1[a]	Q4[a]	Q1[a]	Q4[a]
	mean ± SD	mean ± SD	mean ± SD	mean ± SD
Total	5.94±1.56	33.2±8.21	12.5±4.08	62.7±13.9
Region				
Taipei	6.28±1.56	30.7±5.80	12.3±4.31	56.9±10.8
Taichung	6.35±1.32	32.5±7.73	13.2±3.64	59.4±12.0
Kaohsiung	5.42±1.58	33.8±8.56	12.0±4.24	64.0±14.3
Season				
spring	6.06±1.49	31.7±6.81	13.0±3.93	59.4±11.4
summer	5.67±1.58	29.8±4.73	12.4±4.04	59.6±18.9
fall	6.68±1.32	31.5±5.68	13.1±4.04	61.4±12.9
winter	6.41±1.37	35.2±9.68	12.0±4.26	65.6±15.2
Time				
day	5.94±1.55	33.4±8.38	12.1±4.27	64.6±14.8
night	5.96±1.58	32.8±7.80	12.7±3.98	61.8±13.4
Injury severity				
death	6.50±1.22	35.2±9.65	10.1±4.39	67.1±16.3
injury	5.92±1.56	33.3±8.26	12.6±4.08	63.1±14.0
non-injury	5.98±1.55	33.1±8.16	12.5±4.07	62.1±13.8
Road user types				
car driver	5.97±1.55	32.9±8.10	12.5±4.05	61.9±13.7
motorcyclist	5.93±1.56	33.3±8.31	12.5±4.10	63.0±13.9
bicyclist	5.88±1.65	33.6±8.27	12.8±4.17	63.4±14.9
pedestrian	6.14±1.46	33.3±7.28	12.7±3.98	63.9±15.1

[a] All traffic accident's PM concentrations were ranked and divided into quartiles (Q1 to Q4).

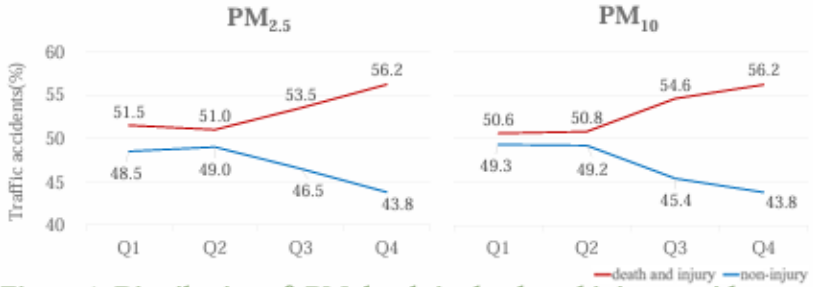

Figure 1. Distribution of PM levels in death and injury accidents compared to non-injury accidents.

Figure 2. Distribution of PM levels in different road user types.

Table 2. The correlation between PM levels and injury severity in season and different time.

Variables	Injury severity	$PM_{2.5}$ Levels		PM_{10} Levels	
		Q1 (N=9822)	Q4 (N=9524)	Q1 (N=9865)	Q4 (N=9679)
		N (%)	N (%)	N (%)	N (%)
Total	death and injury	5062 (51.5)	5357 (56.2)*	4993 (50.6)	5440 (56.2)*
	non-injury	4760 (48.5)	4167 (43.8)	4873 (49.4)	4239 (43.8)
Spring	death and injury	769 (51.3)	1393 (55.0)	791 (51.0)	1422 (56.2)*
	non-injury	730 (48.7)	1141 (45.0)	760 (49.0)	1110 (43.8)
Summer	death and injury	3055 (52.4)	70 (49.6)	2791 (51.8)	41 (48.2)
	non-injury	2775 (47.6)	71 (50.4)	2594 (48.2)	44 (51.8)
Fall	death and injury	550 (52.2)	1440 (58.8)*	605 (49.3)	1642 (57.7)*
	non-injury	504 (47.8)	1010 (41.2)	621 (50.7)	1202 (42.3)
Winter	death and injury	688 (47.8)	2454 (55.8)*	805 (47.3)	2335 (55.4)*
	non-injury	751 (52.2)	1945 (44.2)	898 (52.7)	1883 (44.6)
Day	death and injury	3710 (51.4)	3804 (56.1)*	3489 (50.7)	3766 (56.2)*
	non-injury	3519 (48.6)	2980 (43.9)	3399 (49.3)	2938 (43.8)
Night	death and injury	1352 (52.0)	1553 (56.7)*	1503 (50.5)	1674 (56.3)*
	non-injury	1250 (48.0)	1187 (43.3)	1474 (49.5)	1301 (43.7)

* Using Chi-square test, the proportion of death and injury is significantly higher (p<0.01).

Table 3. The correlation between PM levels and road user types in different time.

Variables	Road user types	$PM_{2.5}$ Levels		PM_{10} Levels	
		Q1 (N=9822)	Q4 (N=9524)	Q1 (N=9865)	Q4 (N=9679)
		N (%)	N (%)	N (%)	N (%)
Total[ab]	car driver (Ref)	4106 (41.8)	3508 (36.8)	4234 (42.9)	3548 (36.7)
	motorcyclist	5326 (54.2)	5581 (58.6)*	5258 (53.3)	5669 (58.6)*
	bicyclist	297 (3.02)	310 (3.25)	278 (2.82)	338 (3.49)*
	pedestrian	93 (0.95)	125 (1.31)*	95 (0.96)	124 (1.28)*
Day[ab]	car driver (Ref)	3003 (41.6)	2498 (36.8)	2934 (42.6)	2488 (36.5)
	motorcyclist	3926 (54.4)	3985 (58.7)*	3690 (53.6)	3942 (58.8)*
	bicyclist	236 (3.27)	236 (3.48)	209 (3.03)	244 (3.64)*
	pedestrian	55 (0.76)	65 (0.96)	55 (0.80)	70 (1.04)
Night[ab]	car driver (Ref)	1103 (42.4)	1010 (36.9)	1300 (43.7)	1100 (37.0)
	motorcyclist	1400 (53.8)	1696 (58.2)*	1568 (52.7)	1727 (58.1)*
	bicyclist	61 (2.34)	74 (2.70)	69 (2.32)	94 (3.16)*
	pedestrian	38 (1.46)	60 (2.19)*	40 (1.34)	54 (1.82)

[a] Using Chi-square test, there is a significant difference in the distribution of PM2.5 levels(p<0.01).
[b] Using Chi-square test, there is a significant difference in the distribution of PM10 levels(p<0.01).
* Using car drivers as the reference group, the proportion of accidents in Q4 is significantly higher (p<0.01).

Conclusion

Among road users, motorcyclist, bicyclist and pedestrian had high proportion of traffic accident by PM exposure. The study revealed a significant correlation between high PM concentration and the serious severity of traffic accident injuries.