



香港賽馬會慈善信託基金  
The Hong Kong Jockey Club Charities Trust

# The 9th Global Conference of the Alliance for Healthy Cities

## “SMARTER HEALTHY CITIES BEYOND COVID-19”

3-5 November 2021

# Temperature change and health outcomes in Taichung city

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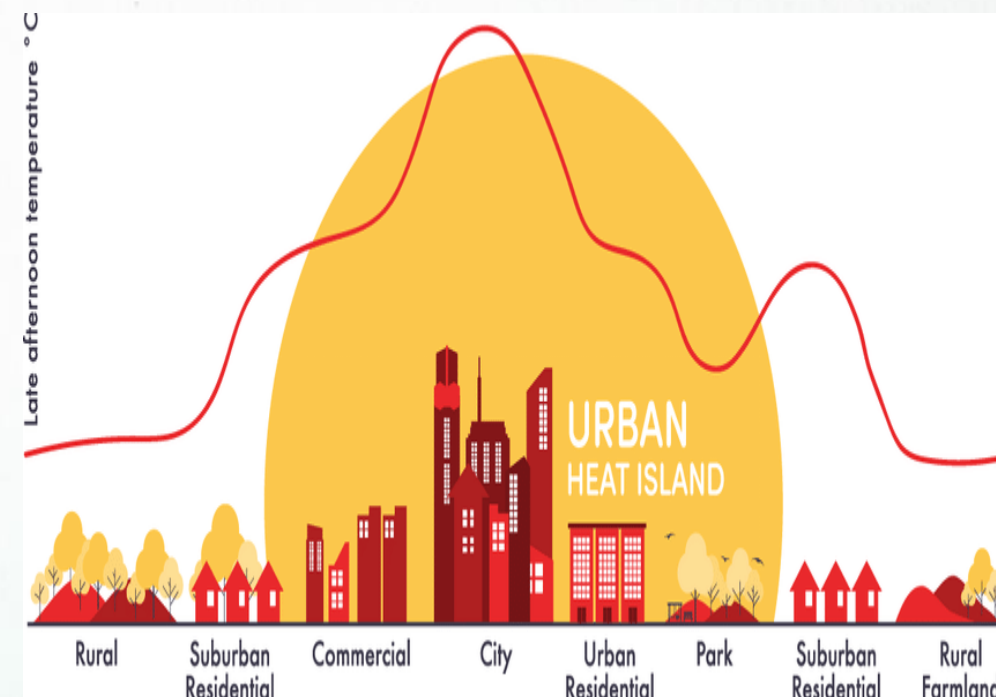
**Taiwan Green Low Carbon Association  
Alliance of Healthy Cities, Taiwan**

**Taipei Healthy City Promotion Association**

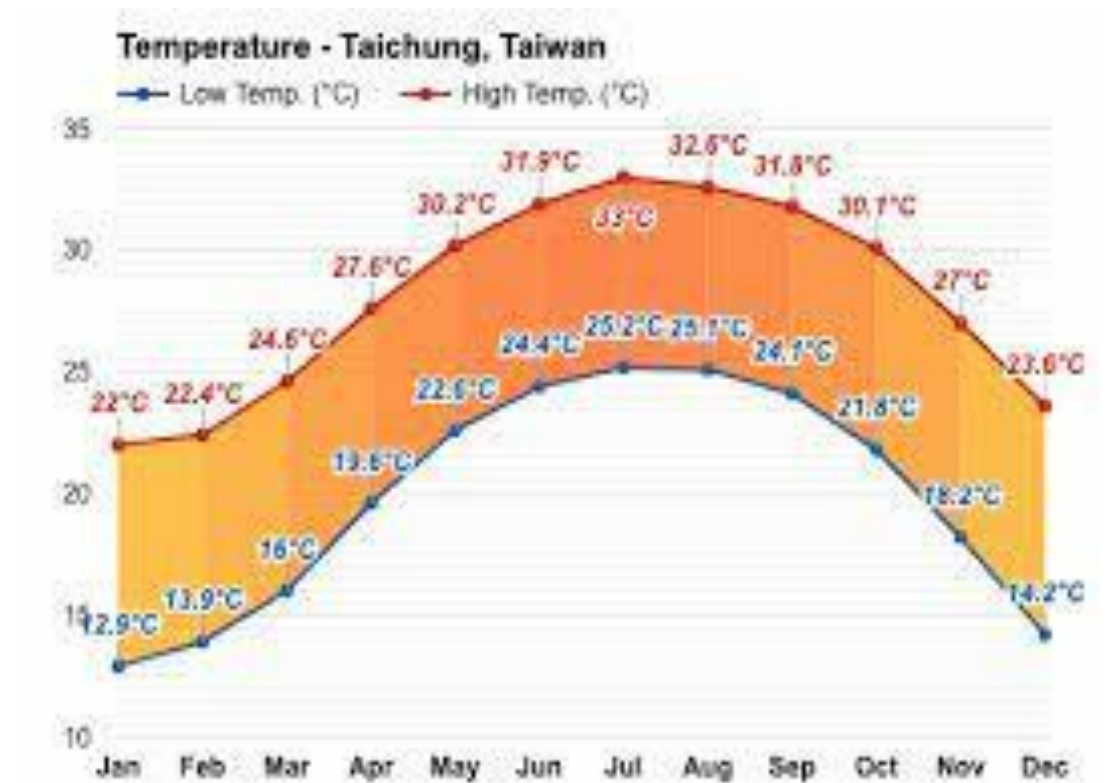
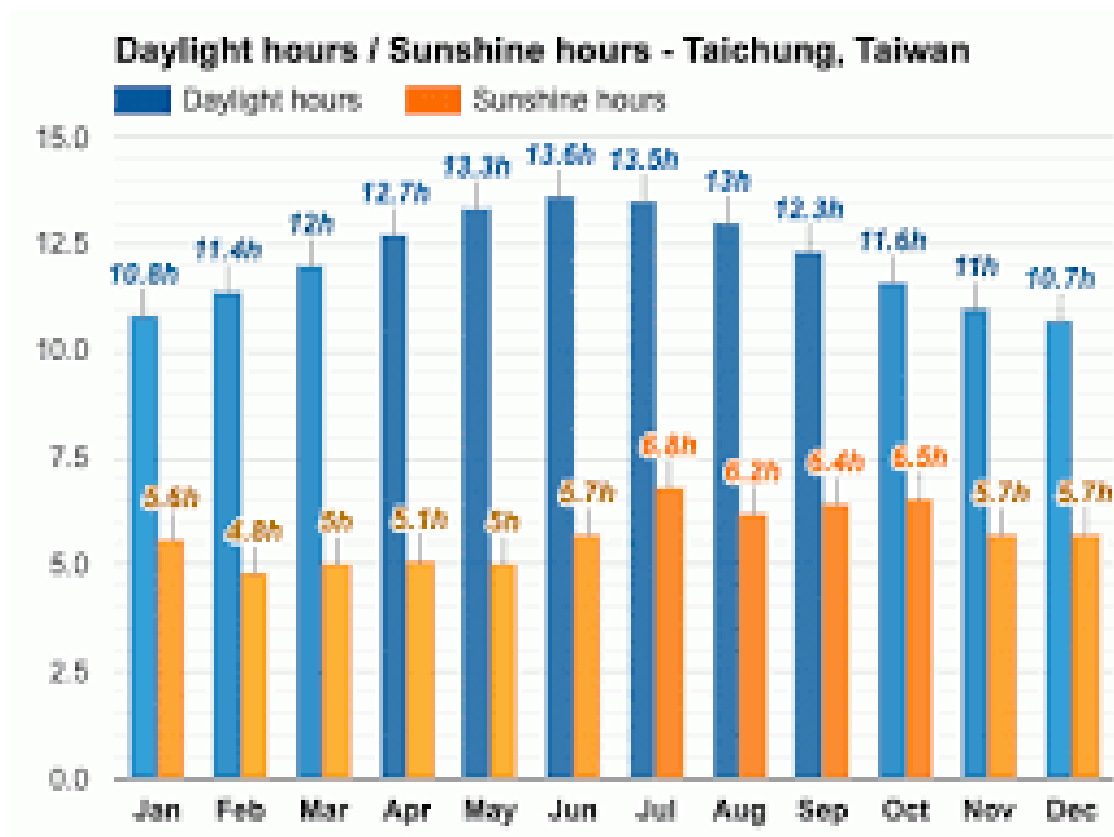


# Backgrounds

- Urban heat island changes the micrometeorology of urban area and can alter the convective rainfall. This study investigated the effects of urban heat island and increased temperature on convective rainfall in Taichung City. Spatial analysis of temperature data revealed the urban heat island effect in Taichung. The urban heat island intensity is estimated 0.14° per decade. Convective rainfall events were extracted from long-term hourly rainfall records in urban region. Rainfall characteristics of convective rainfall event, including rainfall depth, intensity, and maximum intensity, were analyzed.



# Daylight hours and temperature in Taichung City



# Evidences of temperature changes and health outcomes in Taichung

**Table 1** Average daily number of chronic obstructive pulmonary disease (COPD) emergency room (ER) admissions, average daily temperature (ADT) and daily temperature range (DTR)

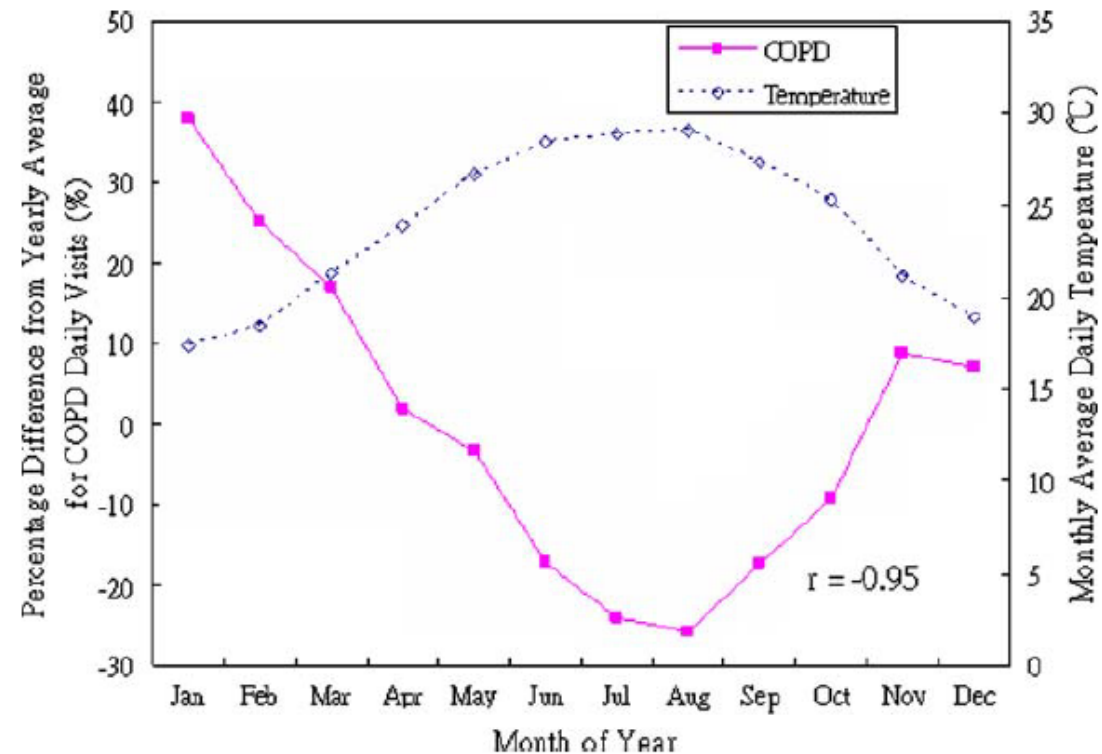
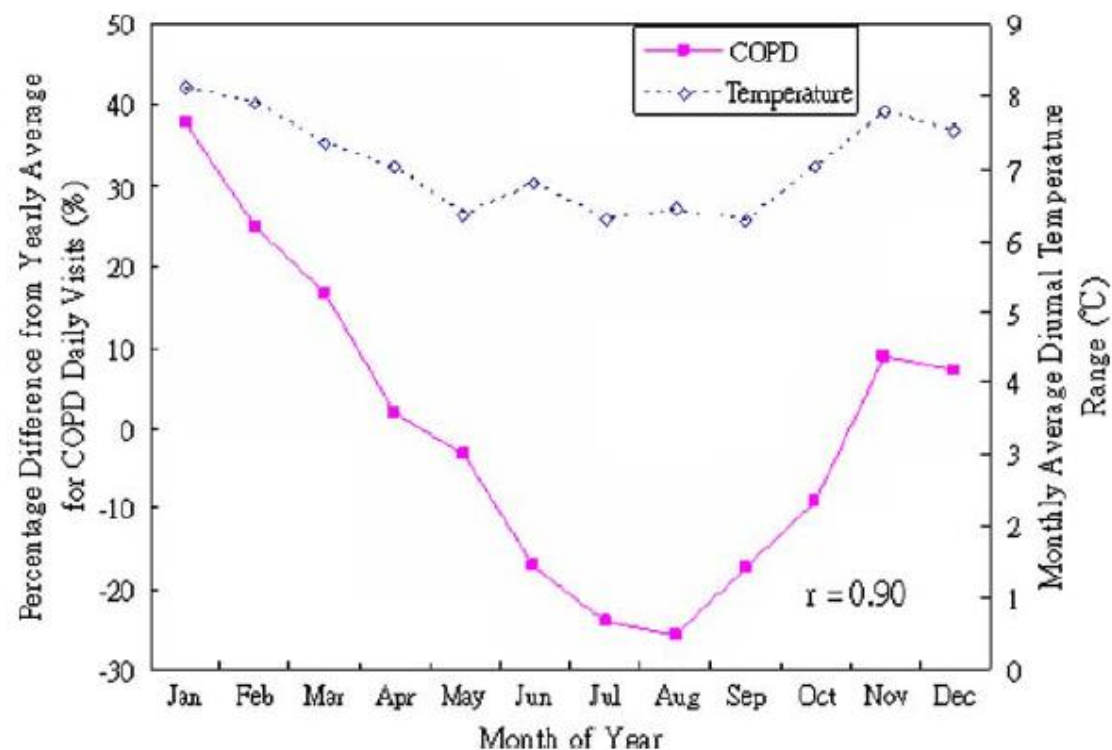
COPD admissions	Total	Mean±SD	Percentile				
			10th	25th	50th	75th	90th
Daily visits (persons)	3,263	4.50±2.47	2	3	4	6	8
Temperature (°C)	Valid days	Mean±SD					
		ADT		DTR			
Yearly average	725	23.9±4.81		7.06±2.08			
Month							
January	62	17.38±2.66		8.11±2.47			
February	56	18.47±2.24		7.88±2.18			
March	62	21.24±2.94		7.36±2.65			
April	60	23.90±2.78		7.03±1.72			
May	62	26.72±2.06		6.34±1.46			
June	60	28.38±2.44		6.80±2.05			
July	62	28.79±1.33		6.29±1.42			
August	62	29.08±1.35		6.43±1.44			
September	60	27.29±1.33		6.26±1.85			
October	57	25.32±3.29		7.01±1.85			
November	60	21.16±2.49		7.78±2.06			
December	62	18.91±3.61		7.53±2.33			



**Table 2** The relative risk of COPD ER admissions affected by air pollutants, day of the week, and ADT using a multivariate Poisson model. *RR* Relative risk, *CI* confidence interval

Parameter	Univariate analysis				Multivariate analysis			
	RR	95% CI		<i>P</i>	RR	95% CI		<i>P</i>
<b>Air pollutants</b>								
SO <sub>2</sub>	1.059	1.034	1.085	<.001	1.01	0.975	1.045	0.592
CO	1.357	1.212	1.520	<.001	1.131	0.9	1.422	0.291
O <sub>3</sub>	1.001	0.997	1.005	0.568	1.003	0.998	1.007	0.309
PM <sub>10</sub>	1.003	1.002	1.004	<.001	1.001	0.999	1.003	0.317
NO <sub>2</sub>	1.014	1.010	1.018	<.001	0.995	0.985	1.005	0.347
Day of week	0.853	0.792	0.918	<.001	0.855	0.793	0.921	<.001
<b>Average daily temperature (°C)</b>								
<22.95	1.502	1.317	1.712	<.001	1.495	1.295	1.727	<.001
22.95–26.58	1.225	1.060	1.415	0.006	1.202	1.034	1.397	0.016
26.58–28.30	1.052	0.908	1.220	0.499	1.062	0.913	1.234	0.438
28.30–29.42	1.000	0.842	1.187	1.000	1.021	0.858	1.216	0.812
≥29.4	1				1			

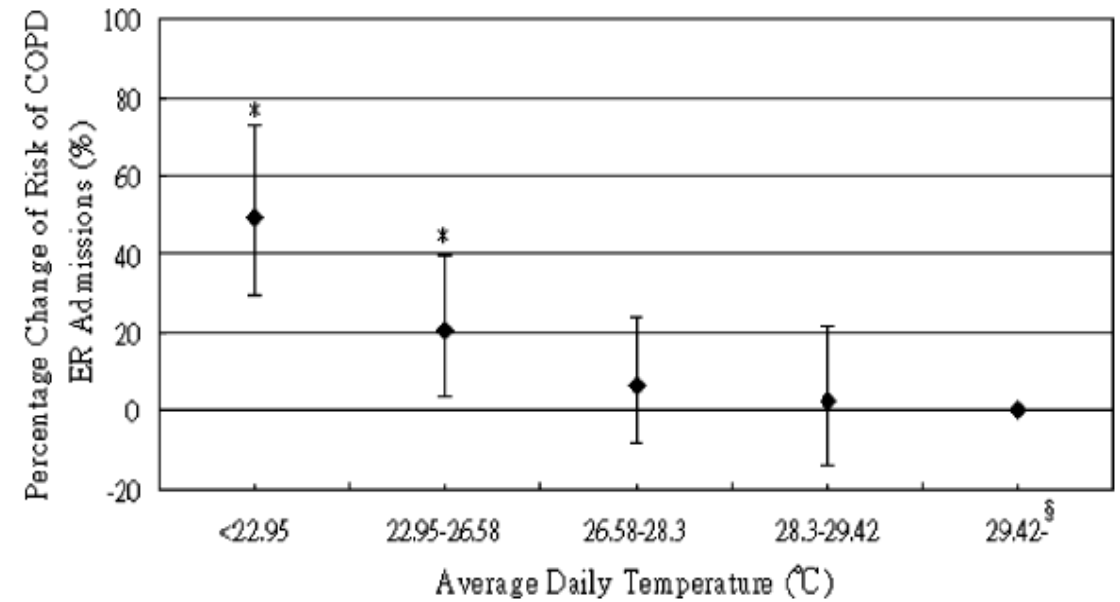
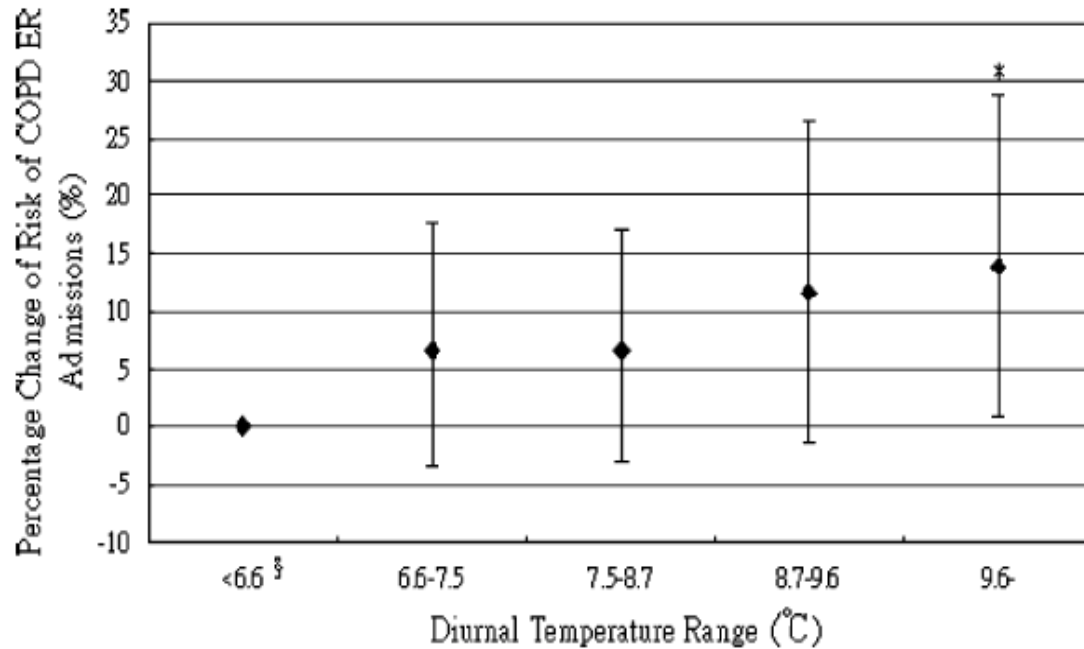
Relationships between percentage differences based on yearly average chronic obstructive pulmonary disease (COPD) emergency room admissions (solid line) and monthly average daily temperature (ADT) (dotted line)



**Table 3** The relative risk of COPD ER admissions affected by air pollutants, day of the week, and DTR using a multivariate Poisson model

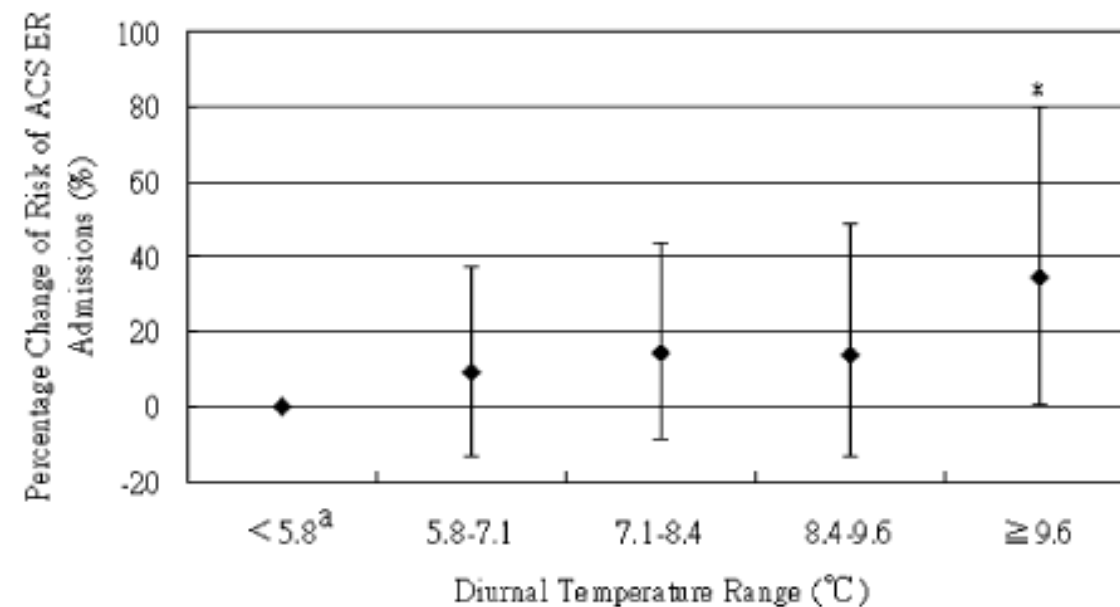
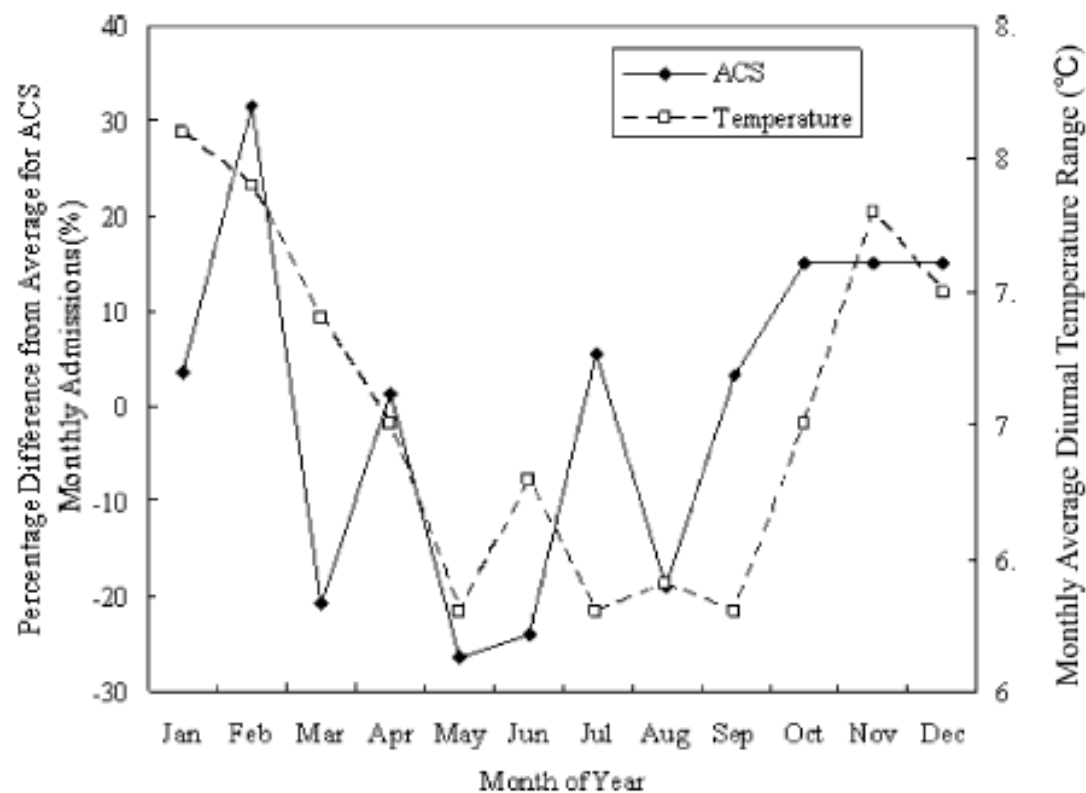
Parameter	Univariate analysis				Multivariate analysis			
	RR	95%CI		<i>P</i>	RR	95%CI		<i>P</i>
Air pollutants								
SO <sub>2</sub>	1.060	1.034	1.085	<.001	1.007	0.974	1.041	0.698
CO	1.347	1.203	1.507	<.001	0.919	0.732	1.155	0.469
O <sub>3</sub>	1.001	0.997	1.005	0.617	0.997	0.992	1.002	0.203
PM <sub>10</sub>	1.003	1.002	1.004	<.001	1.002	1.000	1.004	0.083
NO <sub>2</sub>	1.014	1.009	1.018	<.001	1.008	0.998	1.018	0.113
Day of week	0.856	0.795	0.921	<.001	0.865	0.803	0.933	<.001
DTR (°C)								
<6.6	1				1			
6.6–7.5	1.074	0.974	1.184	0.154	1.066	0.966	1.176	0.207
7.5–8.7	1.112	1.015	1.219	0.023	1.066	0.971	1.171	0.178
8.7–9.6	1.200	1.065	1.353	0.003	1.116	0.986	1.264	0.082
≥9.6	1.229	1.091	1.383	<.001	1.139	1.008	1.288	0.037

## Percentage change of risk of COPD ER admissions correlated with average daily temperature and DTR

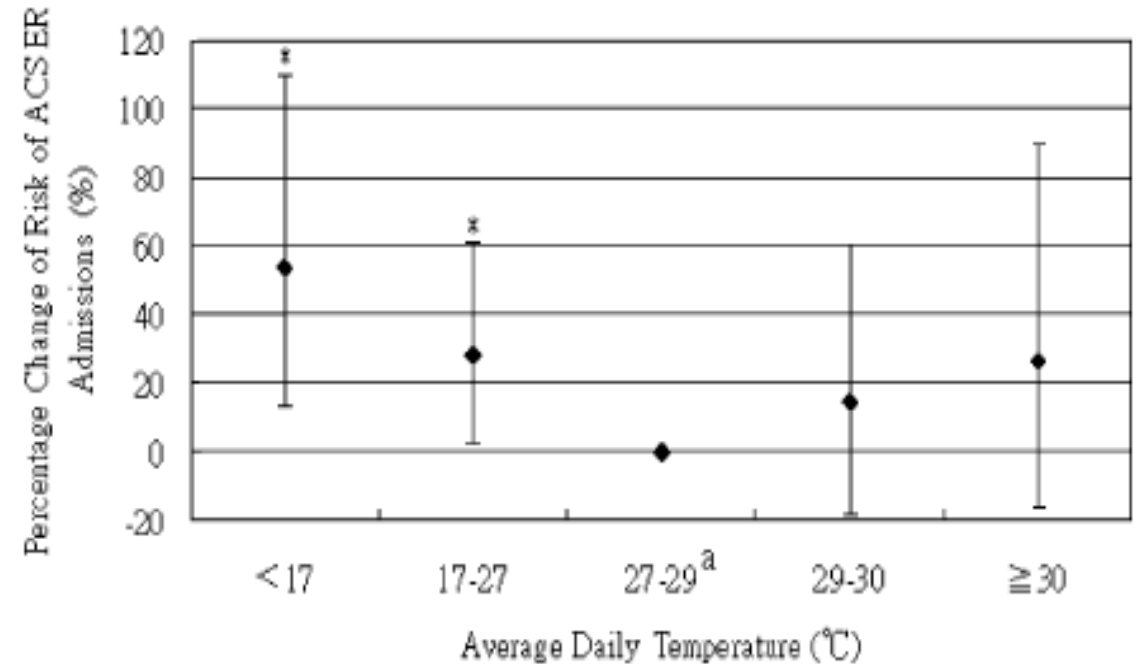
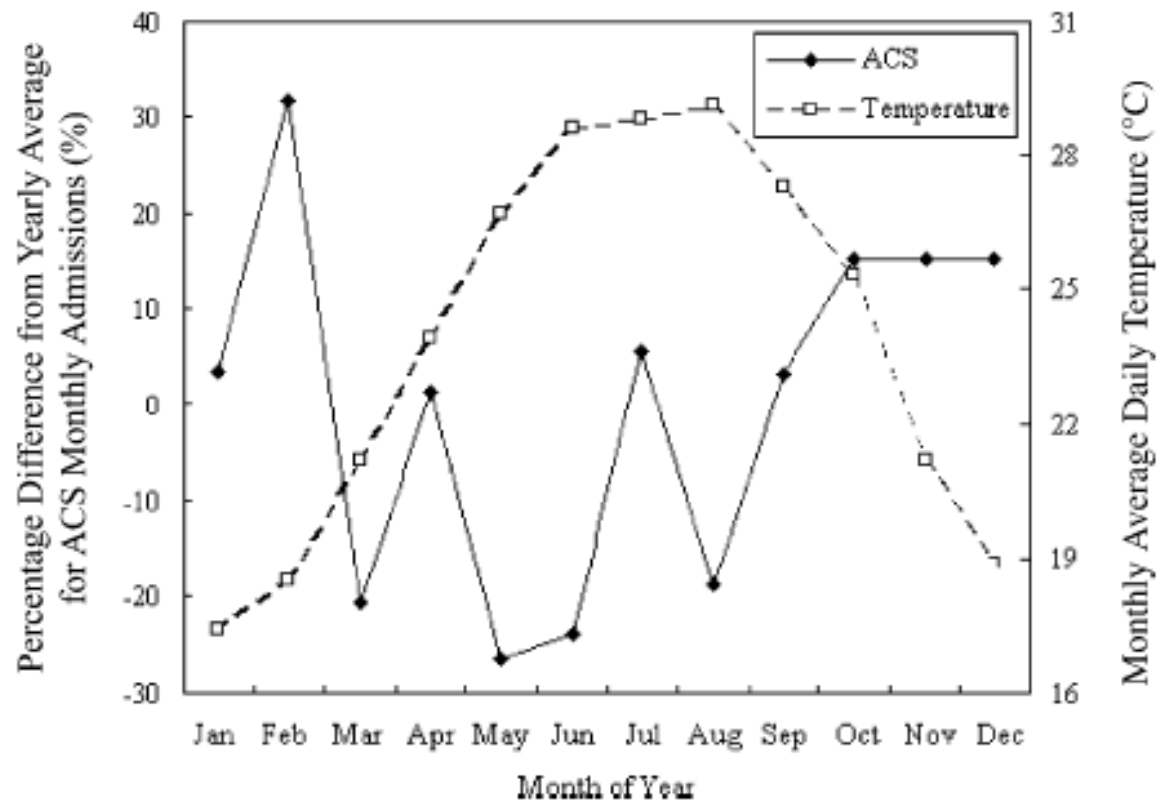




Percentage differences of yearly average ACS ER admissions (solid line) correlated with monthly average diurnal temperature range (dashed line)



Percentage differences ACS ER admissions (solid line)  
correlated with monthly average daily temperature (dashed  
line)



# Conclusions

1. Daily ambient diurnal temperature range (DTR) correlated well with daily COPD admissions to an ER. When DTR exceeded 9.6°C, the risk of COPD admission was higher than the baseline value. COPD morbidity increased significantly with lower outdoor average daily temperature (ADT) and higher temperature variation, even though winter temperatures in this subtropical region are relatively mild.
2. The average daily temperature and DTR correlated significantly with daily ACS admissions to an ER. When ADT fell below 17.0°C or the DTR range exceeded a threshold of 5.8°C the risk of ACS attack was higher than baseline data.

# Sustainable development index in Taichung city

構面	指標	指標中文
Social	1 Average personal income	平均個人收入
	2 Female/male employment rate	女性/男性就業率
	3 Unemployment rate	失業率
	4 Average daily per capita water	人均日均用水量（升）（不包括工業用水）
	5 Electricity consumption per p	人均用電量
Economic	6 Urban population density	城市人口密度
	7 Number of households below	貧困線以下的家庭數量
	8 Crime rate	犯罪率
	9 Annual casualties from public	每年公共災害造成的傷亡人數
	10 Annual number of transportati	年交通事故數
	11 Per capita attendance of art a	藝術文化活動人均出席人數
	12 Average number of students p	每間教室的平均學生人數
	13 Ratio of the population with a	受過大學教育的人口比例
	14 Rate of expansion of urban de	城市開發用地（包括住宅、商業、工業和公共設施）的擴張率
	15 Per capital floor area of priva	人均私人住宅建築面積
	16 Public facility area ratio to ur	公共設施面積占城市用地面積比例
	17 Per capita park and green area	人均公園和綠地
	18 Riverside park and green area	每人河濱公園和綠地面積
	19 Sewerage and waste removal	污水和廢棄物清除效率
	20 Rate of sanitary sewerage to t	生活污水佔整個污水系統的比率
	21 Car ownership rate	汽車擁有率
	22 Motorcycle ownership rate	摩托車擁有率
	23 Areas covered with public tra	公共交通系統覆蓋的地區
Environm	24 Green resourse index	綠色資源指數
	25 Permeable rate in urban lands	城市土地滲透率
	26 Number of days with PSI>100	PSI>100 的天數
	27 Per capita CO2 emissions	人均二氧化碳排放量
	28 Tap-water quality	自來水質量
	29 Per capita daily waste produc	人均每日垃圾產生量
	30 Ratio of solid waste composte	固體廢物堆肥佔廢物總產量的比率
Institution	31 Environmental and ecological	環境生態預算佔總預算的比例
	32 Social welfare expenditure rat	社會福利支出佔總支出的比例
	33 Government expenditure on p	政府在污染防治和資源回收方面的開支
	34 Appellate statistics of court c	環境污染案件上訴統計

# Trends of SDI in Taichung city in 2010-2019

台中市永續城市綜合指數10年趨勢圖

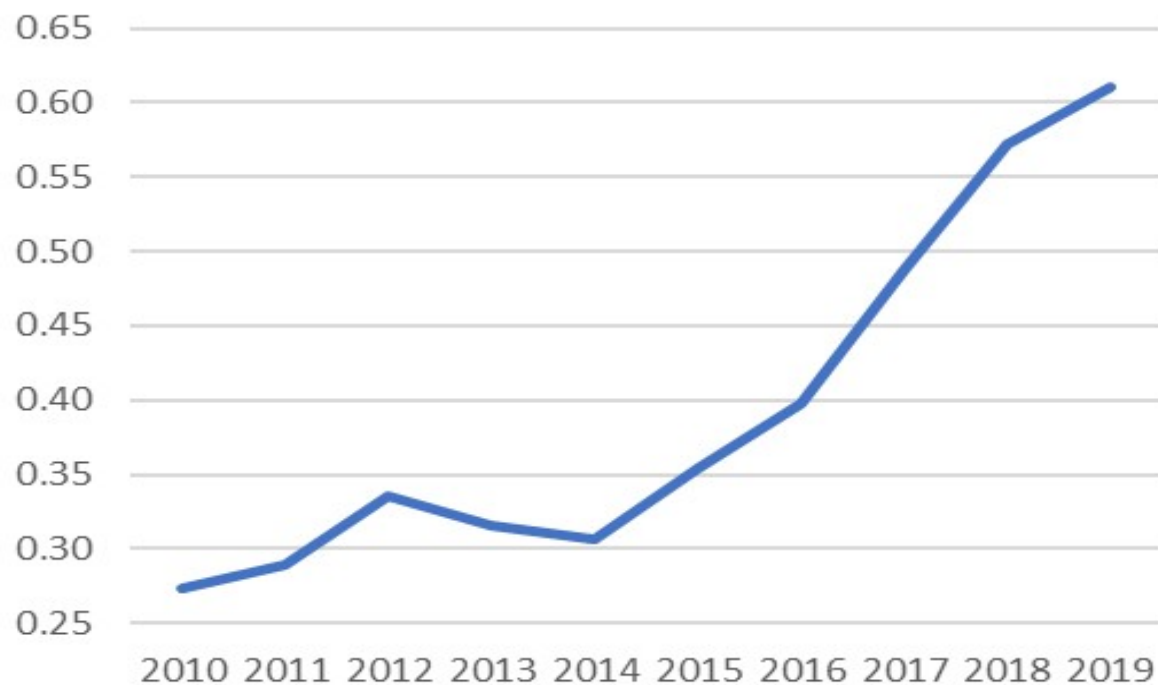


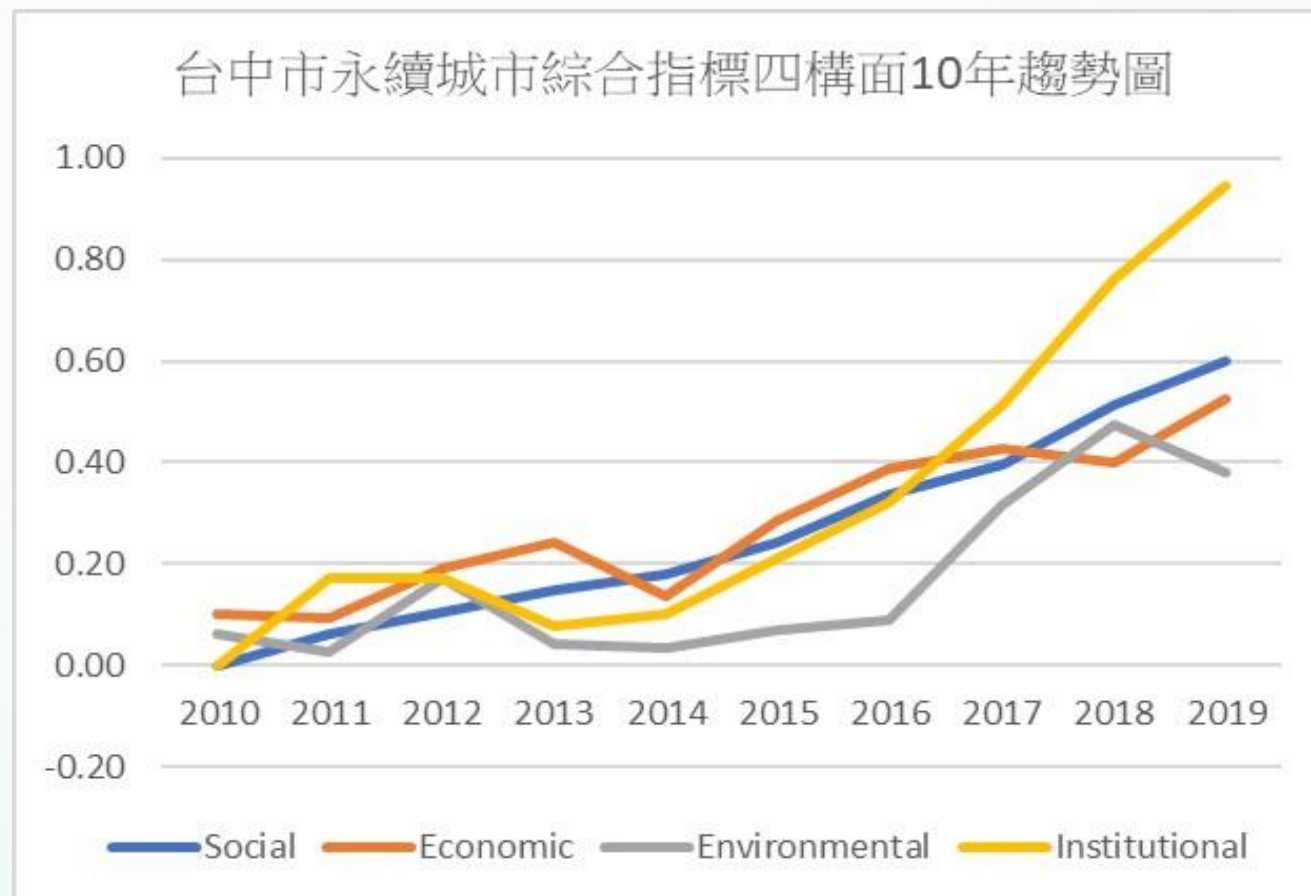
表1 城市可持续发展能力分级标准

Table 2 Classification criterion of urban sustainable development ability

等级 Grade	指数值 Value	定性评价 Qualitative evaluation
I	>0.75	能力优良 Excellent
II	0.5 ~ 0.75	能力较好 Better
III	0.25 ~ 0.5	能力一般 General
IV	<0.25	能力较差 Bad



# Four domains of SDI in Taichung city



# Framework of Sustainable development in Taichung City

國際趨勢  
SDG



永續宜居環境  
(綠色低碳層面)



中央政府  
政策規劃

台中市政府  
治理能力



市民福祉及價值  
(社會經濟層面)

組織架構  
運作模式



健康的環境



市民需求  
城市發展

學術機構  
支持及輔導



健康生活  
友善環境



生活品質  
幸福宜居



