The Impact of Metabolic Syndrome on Air Pollution (PM2.5)-related Atherogenesis in Modernizing China: A Report from CATHAY Study

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Background

- **Cardiovascular disease (CVD) is the leading cause of mortality worldwide.**

In 2015,

422.7 million cases of CVD

17.9 million CVD deaths

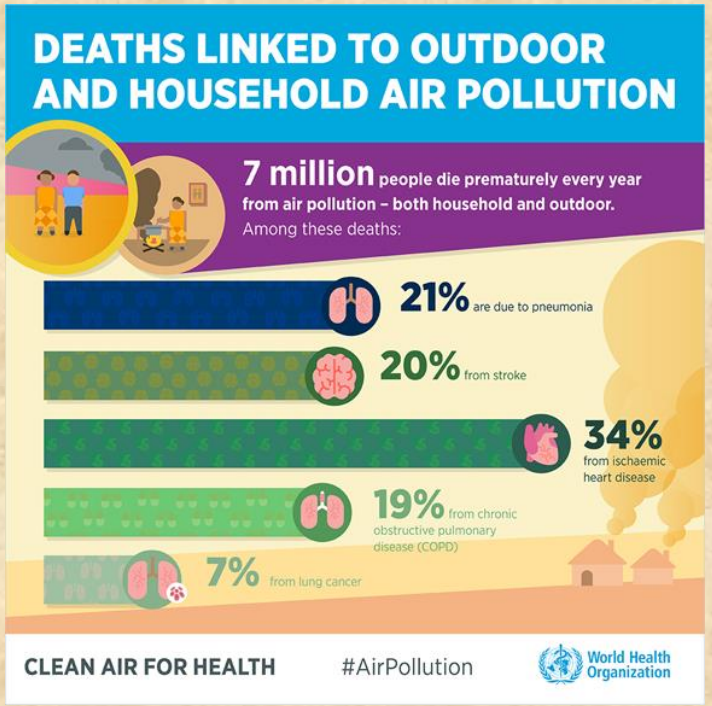
A number of traditional risk factors:

Modifiable:

- **Smoking**
- **Physical inactivity**
- **Unhealthy diet**
- **Hypertension**
- **Obesity**
- **Abnormal lipids profile**
- **Diabetes**
- **Socioeconomic status**

Unmodifiable:

- **Age**
- **Sex,**
- **Family history**
- **Ethnicity**



- **In addition to the traditional risk factors, there is emerging evidence showing that air pollution and Metabolic Syndrome are novel risk factors.**

Metabolic Syndrome (IDF Criteria)

Prevalence: USA 32% - 41.4%

Other western countries: 22-43.3%

- MS is associated with Insulin resistance
  DM, Stroke & CVS

Prevalence in China: 5.3% - 15%

Report from CATHAY Study

- Higher in male vs female & Urban vs Rural
- Farmer 17.2%, Ex-farmer 43.2%
- Worse atherosclerotic surrogates: Higher Carotid IMT in Ex-farmer (0.71±0.16mm) vs Farming residents (0.64±0.11mm)

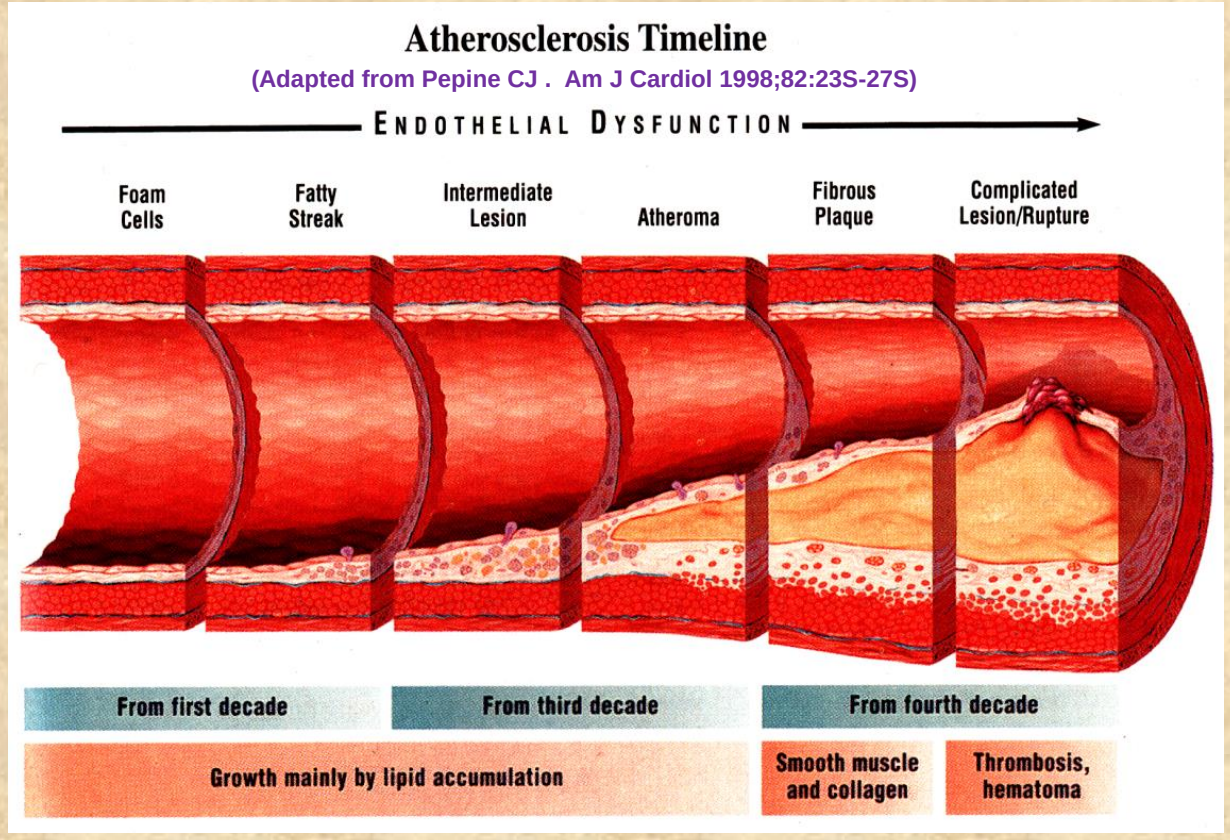
Air Pollution (PM2.5) on Atherogenesis in China

	Lowest AP Tertile (N=552)	Top AP Tertile (N=552)	P-Values (Bonferroni adjusted)
Smokers (%)	8%	28%	<0.0001
$PM_{2.5}$ (μg/m3)	42.9±4.9	83.8±9.7	<0.001
SBP (mmHg)	119.1±17.8	123.4±16.5	<0.001
DBP (mmHg)	75.2±10.2	79.6±10.8	<0.001
LDL-C (mmol/l)	3.2±1.0	2.5±0.8	<0.001
TG (mmol/l)	1.19±0.76	1.50±1.50	<0.001
FMD (%)	8.7±0.6	7.76±0.5	<0.0001
Carotid IMT (mm)	0.63±0.15	0.68±0.13	<0.0001

PM2.5, smoking, BP, LDL-C, TG, FMD and IMT are significantly different between the 2 tertiles

Air Pollution & Metabolic Syndrome Interaction on Atherogenesis

- To establish the impact of MS on AP-related atherogenesis as a potential surrogate marker for atherosclerosis (coronary artery disease and stroke) prevention



Plaque Burden

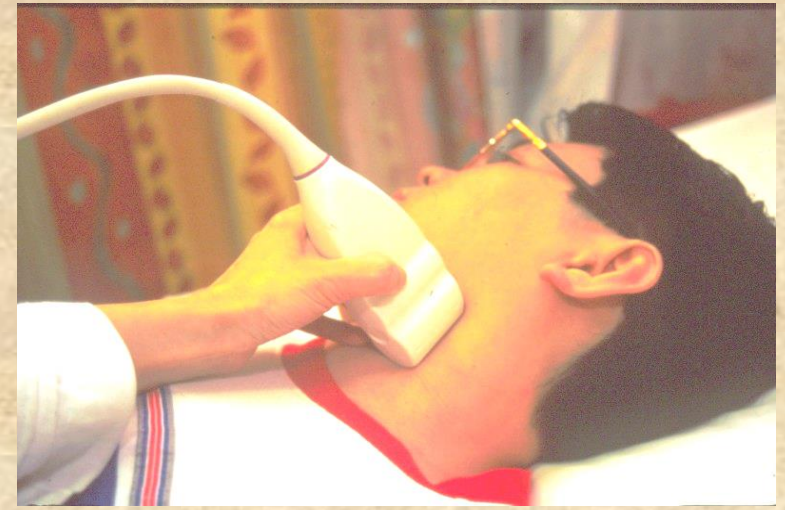
Methods – 1

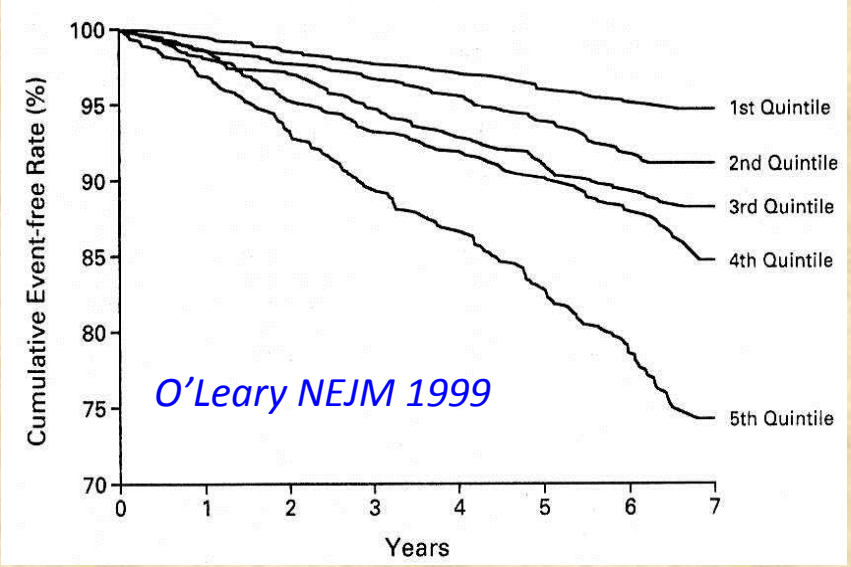
- CATHAY Study (Chinese Atherosclerosis in the Aged and Young)
- 1557 Chinese (Han) adults (aged 46.0+11.2 yr, male 47%) were studied in:
  - Hong Kong (150)
  - Macau (209)
  - Pan Yu (168)
  - Yu County (coal mine in Shanxi, 367)
  - 3-gorges Territories (Yangtze River Dam Territories, 663)
- CV Risk Profiles: smoking, BMI, WHR, SBP, DBP, LDL-C, TG, fasting glucose
- Brachial Flow-mediated dilation (vascular reactivity) and Carotid IMT measured by ultrasound
- Metabolic Syndrome by IDF criteria
- Multivariate regression analyses performed

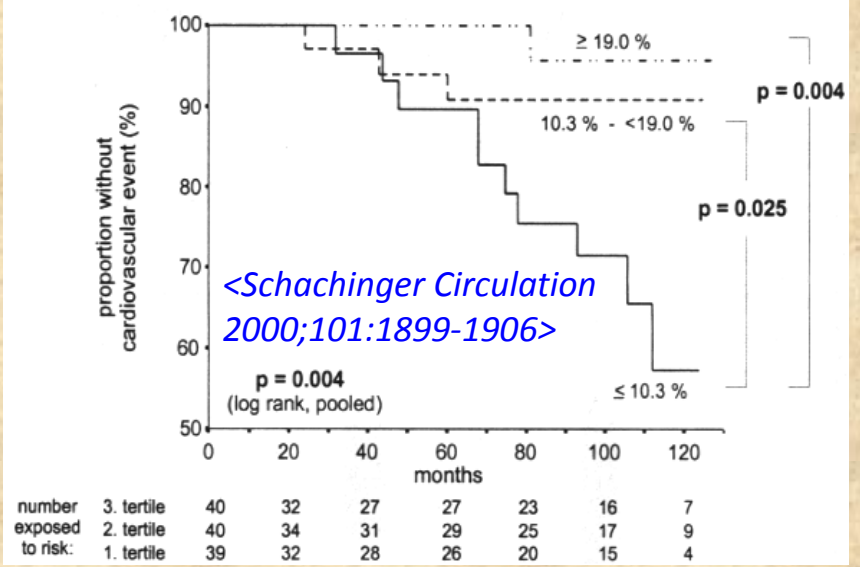
Surrogate Markers of Atherosclerosis

Flow-mediated dilation of brachial artery (FMD) and carotid intima-media thickness (IMT) as surrogate atherogsclerosis markers were measured by high resolution B-mode ultrasound at baseline, 6 months and 12 months.

CV=1%
R=0.99







Definition of Metabolic Syndrome*

Factors	NCEP-ATP (III)	WHO	IDF Asian
Central obesity Male Female	 102cm (40”) 88cm (34.6”)	 > 90cm (35.4”) > 85cm (33.5”)	 > 90cm (35.4”) > 80cm (31.5”)
Low HDL-C Male Female	 < 1.03 mmol/L < 1.3 mmol/L	 < 1.03 mmol/L < 1.3 mmol/L	 < 1.03 mmol/L < 1.29 mmol/L
High TG	≥1.7 mmol/L	≥1.7 mmol/L	≥1.7 mmol/L
High fasting glucose	≥6.1 mmol/L	≥6.1 mmol/L	≥5.6 mmol/L
Hypertension	≥140/85 mmHg	≥130/85 mmHg	≥130/85 mmHg

*** MS:≥ 3 Factors**

Methods-2

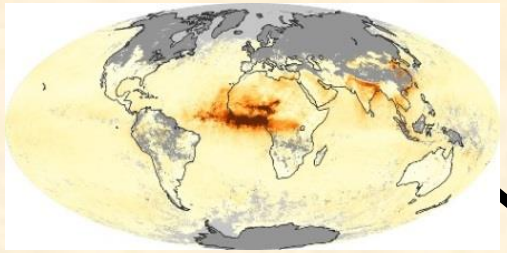
$PM_{2.5}$ Air Pollution Exposure

----Spatiotemporal model

MODIS

Satellite

NASA

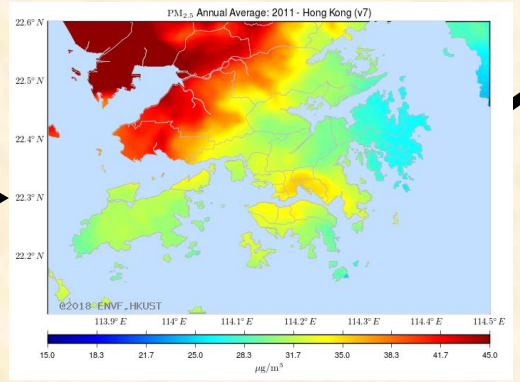


Aerosol optical depth (AOD)

Ground-level $PM_{2.5}$ Concentrations

Residential Address

GIS



Geocoding Map

NASA: US National Aeronautics and Space Administration; GIS: Geographic Information System.

Mean Yearly Air Pollution (PM2.5) Exposure

Year	County-City	Locations	PM2.5 (μg/m^3)
1996-2002	Hong Kong	Southern China	34.0-36.2
1998-2001	Macau	Southern China	42.6
1996-1997	Pan Yu	Southern China (Near Guangzhou)	53.6
2000-2003	Yu County	Shanxi (coalmine)	70.3-73.0
2005-2007	Wu Shan	3 gorges territories	72.2-86.9
2006	Da Cheong	3 gorges territories	93.8
2007	Fu Ling	3 gorges territories	48.1
2007	Kai County	3 gorges territories	47.9

CATHAY – Impact of MS on IMT/ FMD

	MS Cohort (N=340) 21.8%	MS negative Cohort (N=1217)	P-Values (Bonferroni adjustment)
$PM_{2.5}$ (µg/m3)	65.6±17.2	61.5±18.9	0.95
Age (yrs)	51.0±9.7	46.1±12.9	0.04
Male (%)	46.2	48.1	0.90
Smoking (%)	26.7	26.4	0.99
SBP (mmHg)	134.6±17.1	118.8±15.8	<0.001
DBP (mmHg)	86.1±9.7	76.4±10.0	<0.001
Waist (cm)	87.1±8.6	76.1±8.4	0.03
LDL-C (mmol/l)	2.9±1.0	2.8±1.0	0.062
TG (mmol/l)	2.1±1.6	1.1±0.8	<0.001
HDL-C (mmol/l)	1.01±0.21	1.27±0.35	<0.001
Glucose (mmol/l)	6.0 ±1.3	5.3±0.9	<0.001
Brachial FMD (%)	7.3±2.0	8.1±2.6	<0.0001
Carotid IMT (mm)	0.7±0.13	0.63±0.14	<0.0001

Multiple Regression Analysis of AP and MS Impact

Risk Factors	Beta-Value	P-value
PM2.5	0.422	<0.001
Metabolic Syndrome	0.103	<0.0001
Male gender	0.228	<0.0001
Age	0.188	<0.0001
BMI	0.066	0.013
LDL-C	0.102	<0.0001
Smoking Status	0.052	0.058
Location 1_2_3_4	0.51	0.002

Model R^2=0.443, F-value=98.9, P-value<0.0001

Multivariate Regression Analysis of MS on Carotid IMT

	MS Cohort*		MS negative Cohort**	
Risk Factors	Beta-Value	P-value	Beta-Value	P-value
Male gender	0.210	0.004	0.075	0.05
Age	0.247	<0.0001	0.446	<0.0001
SBP	0.393	<0.0001	0.209	<0.0001
DBP	0.215	0.035	-0.087	0.082
Smoking	0.069	0.295	0.03	0.410
BMI	0.003	0.959	0.006	0.860
WHR	0.093	0.156	0.079	0.028
Blood Glucose	0.007	0.910	0.040	0.201
LDL-C	0.154	0.019	0.093	0.007
Blood Triglycerides	0.380	0.001	-0.031	0.329
PM2.5	0.380	<0.001	0.34	<0.0001
Locations 1_2_3_4	0.130	0.241	0.082	0.216

*R2=0.223, F value=14.8, p<0.001

**R2=0.469, F value 131.6, p<0.001

CONCLUSION: Both AP and MS have independent impact on atherogenic process in China, with implication in atherosclerosis prevention.

Practical Strategies to Combat AP & MS –related Atherosclerosis in Modernizing China

Health Education/ Counselling

- Less CHO balanced diet (Cooking and Ingredients)
- Active lifestyles – physical activities
- CVS risk factors and management

Air Pollution Intervention

- Country & global wide policies on AP
- Personalized strategies – Air filtering devices
- Facial masks or anti-inflammatory medicines (Montelukast)

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Thank You