Impacts of SDS on Air quality, Economy and Health

Majdi H. Altoukhi MSPH, CMP, Ph.D

Sand & Dust storms Warning Regional Center
SDS-WAS Node GCC
Jeddah, Saudi Arabia
• Introduction
• Effect of air pollution and sandstorms on public health
• Effect of air pollution on economy & sustainable development
Introduction

Air pollution today has become a major health risk and exposure to air pollution, both ambient and indoor increases the risk of diseases such as lung cancer, stroke, heart disease and chronic bronchitis.
Air pollution accounts for more than 1 in 9 deaths globally. It is estimated to have contributed to 6.67 million deaths (5.90 to 7.49 million) worldwide in 2019. In 2019, air pollution was the 4th leading risk factor for death globally.

Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015
Air pollution accounts globally for early death every 5 seconds (OECD 2019)

Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015
### 2005 V.S. 2021 WHO air quality guidelines (AQGs)

Preventable PM2.5 deaths avoided if new AQGs met globally: ~80%  
Source: WHO

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Time</th>
<th>2005 AQGs</th>
<th>2021 AQGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM2.5 $\mu$g/m$^3$</td>
<td>Annual</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>PM10 $\mu$g/m$^3$</td>
<td>Annual</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>24-hour</td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>Ozone (O3) $\mu$g/m$^3$</td>
<td>Peak Season*+</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>8-hour**</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO$\text{}_2$) $\mu$g/m$^3$</td>
<td>Annual</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>24-hour*</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>Sulfur dioxide (SO$\text{}_2$) $\mu$g/m$^3$</td>
<td>24-hour</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Carbon monoxide (CO) mg/m$^3$</td>
<td>24-hour*</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

*New averaging time for 2021. **Peak season – average of daily maximum 8-hour mean ozone concentration during the six consecutive months with the highest six-month running-average of ozone concentration.
دراسة التعرض لآثار تلوث الهواء (ESCAPE) الأوروبية - أكبر دراسة على الإطلاق في أوروبا في الآثار الصحية الضارة لتلوث الهواء - أن المخاطر الصحية (مثل سرطان الرئة) تحدث بتركيزات أقل بكثير من القيم الحدية الموضحة في الجدول.

(2013Raaschou-Nielsen et al.,; 2014Beelen et al.,)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PM_{2.5}</td>
<td>10 µg/m³ (micrograms per cubic metre) annual mean 25 µg/m³ 24-hour mean</td>
<td>25 µg/m³ annual mean (labelled as target value as of 2010, and as limit value as of 2015)</td>
</tr>
<tr>
<td>PM_{10}</td>
<td>20 µg/m³ annual mean 50 µg/m³ 24-hour mean</td>
<td>50 µg/m³ 24-hour mean (not to be exceeded more than 35 times a calendar year) 40 µg/m³ annual mean</td>
</tr>
<tr>
<td>O_{3}</td>
<td>100 µg/m³ 8-hour mean</td>
<td>240 µg/m³ 1-hour mean</td>
</tr>
<tr>
<td>NO_{2}</td>
<td>40 µg/m³ annual mean 200 µg/m³ 1-hour mean</td>
<td>40 µg/m³ annual mean 200 µg/m³ 1-hour mean (not to be exceeded more than 18 times a calendar year)</td>
</tr>
<tr>
<td>SO_{2}</td>
<td>20 µg/m³ 24-hour mean 500 µg/m³ 10-minute mean</td>
<td>125 µg/m³ 24-hour mean (not to be exceeded more than 3 times a calendar year) 350 µg/m³ 1-hour mean (not to be exceeded more than 24 times a calendar year)</td>
</tr>
</tbody>
</table>
Impact of air pollution on public health

Asthma
Bronchitis
COPD
Damage to Respiratory system
Cardiovascular diseases
Allergies & Sensitives
Reduced Lung Function
Premature Mortality
Children under the age of five in low-income countries are more than 60 times as likely to die from exposure to air pollution as children in high-income countries.

WHY

• They breathe more rapidly than adults and so absorb more pollutants.
• They also live closer to the ground, where some pollutants reach peak concentrations – at a time when their brains and bodies are still developing.
Indoor air pollution kills 1.5 million people annually around the world, because the key to human health is clean air, and the amount of air entering the human body is about 15 thousand liters per day

More than 90% of the world’s children breathe toxic air every day, WHO, 2018
تلوث الهواء داخل المنزل

يتوفي 3.8 مليون شخص في مرحلة مبكرة من العمر كل عام جراء تعرضهم لتلوث الهواء داخل المنزل (2016). وينجم تلوث الهواء داخل المنزل في الغالب من استخدام الكربون لإضاءة وانواع الوقود الصلب كالخشب لإشعال الموائد والثياب المفتوحة.

%18
جراء الإصابة بسكان دماغية

%27
جراء الإصابة بمرض القلب الاعراضي

%20
جراء الإصابة بالانسداد الرئوي المفتوح

%8
جراء الإصابة بسرطان الرئة

%27
جراء الإصابة بالالتهاب الرئوي

#AirPollution

هواء نظيف من أجل الصحة

منظمة الصحة العالمية
• The air we breathe contains 21% oxygen, but our bodies only use 5%, the rest is exhaled
• Human beings take in about 550 liters of pure oxygen per day
تلوث الهواء - القاتل الصامت

يطرح تلوث الهواء خطراً بليعاً كبيراً على الصحة.

من خلال تلخيص مستويات تلوث الهواء يمكن للبلدان أن تقلل من:

- السكتة الدماغية
- أمراض القلب
- سرطان الرئة
- ومرض الأنسداد الرئوي المزمن
- الرئة والربو

في كل عام، تحدث نحو 7 ملايين حالة وفاة نتيجة التعرض لـ "اللوث الحراري"، وهو عامل في تلوث الهواء الخارجي والمغلق، على حد سواء.

التقديرات الإقليمية حسب المجموعات الإقليمية لمنظمة الصحة العالمية:

- أكثر من مليوني حالة وفاة في إقليم جنوب شرق آسيا
- أكثر من مليوني حالة وفاة في إقليم غرب المحيط الهادئ
- مليون حالة وفاة في إقليم أمريكا الوسطى
- مليون حالة وفاة في إقليم أمريكا الجنوبية
- مليون حالة وفاة في إقليم الأوروبا
- أكثر من 300 ألف حالة وفاة في إقليم الأطراف.

دليل منظمة الصحة العالمية لنوعية الهواء تضع أهدافاً لحماية ملايين الأرواح من تلوث الهواء.

#تلوث_الهواء
Some components of the environment, such as pollen, fine dust, and house dust “mites,” are considered normal things for the average person, while the immune system of an allergy patient considers them to be foreign bodies.

It soon produces immune antibodies, most type (IgE), and the immune body reacts to natural antigens present in the environment, which are considered irritants or allergens.
The relation between dose, response, concentration and limits

- The "concentration response function" or "dose response relationship" can be calculated by linking exposure to pollutants and specific health effects.

Threshold levels of concentration or exposure

It is age dose relationship.
Two types of health-related costs associated with air pollution.

Market costs can include productivity losses due to illness (opportunity costs) and health care costs, such as hospital admission costs, the use of technologies or pharmaceuticals, etc. (resource costs).

Non-market or non-well-being costs mean premature death and disability (such as pain and stress) due to illness or caring for others.
تلوث الهواء يقتل 13 شخصاً كل دقيقة بسبب سرطان الرئة ومرض القلب والسكته
لنوقف حرق الوقود الأحفوري مثل النفط والحم وغاز الطبيعي
#HealthierTomorrow
تلوث الهواء يخفض متوسط عمر البشر

مقدار انخفاض متوسط العمر تبعاً للسبب (إحصائيات عام 2015):
3 سنوات بسبب تلوث الهواء (8.8 مليون وفاة)
2.2 سنة بسبب التبغ (7.2 مليون وفاة)
0.7 سنة بسبب فيروس نقص المناعة المكتسب (الإيدز) (1 مليون وفاة)
0.3 سنة بسبب أشكال العنف جميعها بما في ذلك الحروب (530 ألف وفاة)
Air Pollution
AROUND THE WORLD IN 2022

The World Health Organization estimates that air pollution leads to 7 million premature deaths every year. Out of the six common air pollutants, particulate matter measuring 2.5 microns or smaller in diameter, or PM2.5, is accepted as the most harmful to human health.

2022 Average PM2.5 Concentration in Select Major Cities
Micrograms per cubic meter (µg/m³)

<table>
<thead>
<tr>
<th>µg/m³</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exceeds WHO guideline by...</td>
<td>1-2x</td>
<td>2-3x</td>
<td>3-5x</td>
<td>5-7x</td>
<td>7-10x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Vancouver: 7.6
- Toronto: 8.5
- Los Angeles: 6.4
- Miami: 9.9
- Mexico City: 22.1
- Lima: 25.6
- Rio de Janeiro: 10.6
- Buenos Aires: 14.2
- Lagos: 36.1
- Mumbai: 46.7
- Jakarta: 3.3
- Beijing: 47.4
- Dubai: 43.7
- Cairo: 29.8
- Mumbai: 21.3
- Guangzhou: 14.6
- Tokyo: 5.2
- Sydney: 3.3
- London: 9.6
- Rome: 12.6
- Moscow: 10.8
- New York: 6.9

Located in a valley, the lack of wind intensity in Mexico City leads to reduced diffusion of vehicular pollutants in its atmosphere.

Dubai’s air pollution can be attributed to a potent mix of scorching temperatures, excessive humidity, and a significant reliance on personal vehicles.

Source: IQAir, WHO
Air pollution & premature death

Air pollution reduces enjoyment of the quality of life by
• causing loss of productive employment
• reduces incomes
• can have a lasting impact on productivity

For example
• By halting the growth of plants and reducing the productivity of agriculture
• making cities less attractive to talented workers, thus reducing the competitiveness of cities
Houseplants to purify the air

NASA LIST

Spider plant, Snake plant, Agleonema plant, Weeping plant, Bamboo plant, Rubber plant
An instrumental variables approach based on thermal inversions is used

The estimates show that 1μg/m3 increase in PM$_{2.5}$ concentration (causes a 0.8% reduction in real GDP that same year)

(OECD 2020)
• the global cost of health damages associated with exposure to air pollution is $8.1 trillion, equivalent to 6.1 percent of global GDP.

• People in low- and middle-income countries are most affected by mortality and morbidity from air pollution

(OECD 2020)
Almost nine million people around the world die prematurely every year because of outdoor air pollution.

\[ \text{NO}_2 \rightarrow 49,000 \text{ deaths in EU} \]
\[ \text{OZ} \rightarrow 24,000 \text{ deaths} \]
Global burden of disease

• GBD concept assesses exposure to outdoor (ambient) air pollution as well as indoor air pollution in homes that cook with solid fuels.
• GBD is an approach to global descriptive epidemiology. It is a systematic, scientific effort to quantify the comparative magnitude of health loss due to diseases, injuries, and risk factors by age, sex, and geographies for specific points in time
Global Burden of Disease 2019

More than 3.5 billion estimates of 369 diseases and injuries and 87 risk factors in 204 countries and territories.

HEALTHDATA.ORG/GBD
Global burden of disease
GBD

• collected and analyzed by a consortium of more than 9,000 researchers in 162 countries and territories. The data capture

• premature death and disability from 370 diseases and injuries

• in 204 countries and territories, by age and sex, from 1990 to the present
Indoor air pollution claimed the lives of nearly 3.2 million people in 2020, including more than 237,000 children under the age of five  \textbf{WHO 2022}

The GBD is then evaluated by the ratio of personal exposure to pollution to increased relative risk of disease like:

- Ischemic heart disease,
- stroke,
- chronic obstructive pulmonary disease,
- lung cancer,
- acute lower respiratory tract infections

and Pneumonia
GBD 2015 attribute 4.2 million deaths globally to fine particulate matter (PM$_{2.5}$) pollution, and another 254,000 cases to ozone gas

Cohen et al., 2017; Section 3.3
Quality Adjusted Life Years

QALY

سنوات العمر المعدلة حسب الجودة

• is a generic measure of disease burden
• Is the product of duration of life and a measurement of quality of life
• the value of health outcomes including both the quality and the quantity of life lived

One quality-adjusted life year = 1 year of life in perfect health
Quality Adjusted Life Years

QALYs

سنوات العمر المعدلة حسب الجودة
Disability Adjusted Life Years
DALYs
سنوات العمر المعدلة حسب الاعاقة

- It is a universal metric that allows researchers and policymakers to compare very different populations and health conditions across time.

- DALYs equal the sum of years of life lost (YLLs) and years lived with disability (YLDs). One DALY equals one lost year of healthy life.
Disability Adjusted Life Years

DALYs

سنوات العمر المعدلة حسب الإعاقة

الحساب الأساسي لسنة العمر المعدلة حسب الإعاقة المرتبطة بمرض أو حالة هو:

\[ \text{DALY} = \text{YoLL} + \text{YLD} \]

حيث تشير إلى "سنوات فقدان الحياة" من الوفاة المبكرة (معدل الوفيات) وYoLL إلى "سنوات الحياة الصحية المفقودة بسبب إعاقة" (معدل المرض). YLD.

• The basic calculation for the adjusted life year for disability associated with a disease or condition is:
• \[ \text{DALY} = \text{YoLL} + \text{YLD} \]
• YoLL refers to "years of loss of life" from premature death (mortality rate) and YLD to "healthy years of life lost due to disability" (disease rate).
Economic concept of environmental pollution

- affects the economy because the damage caused is negatively affects the economic resources of society
- is a type of market failure by excessive use of resources in the form of collective ownership or lack of ownership
- Thus, the market fails when property rights do not exist or when resources are not controlled to make the best use of them
Economic concept of environmental pollution

External effects

• All types of pollution in the economy are called external effects
• The effects in general are either negative or positive effects of the activities of a certain economic unit
• The units that affect the welfare economic can be defined as industrial or economic establishments or institutions or individuals
Economic costs are estimated in $ with two different approaches

- A well-being-based approach that values the increased risk of death from air pollution according to individuals' willingness to pay (WTP)

- An income-based approach that equates the financial cost of premature death with the present value of profits lost for life.

- Each of these methods is given equal importance, although they are designed for different purposes.
A welfare-based approach aims to measure the economic costs of fatal health risks to the individuals who make up society.

In the context of health, WTP:

- describe the maximum amount of money that a person is willing to pay to obtain a certain health outcome, such as the prevention or treatment of a disease.

- WTP is often used in health economics to assess the value that individuals or societies place on different health interventions and to inform decision makers about resource allocation in healthcare.
Value of a statistical life

VSL

• VSL stands for "Value of a Statistical Life." It is a measure used in economics and public policy to estimate the value that people place on reducing the risk of premature death or injury.

• VSL = calculated by
  • estimating how much people are willing to pay for safety improvements or
  • how much compensation they demand for accepting increased risks.
Value of a statistical life
VSL

• is an estimate based on statistical analysis and is not meant to represent the actual value of an individual human life. Rather

• it is a tool used to help policymakers make decisions about how to allocate resources to maximize the overall well-being of society.
Value of a statistical life

VSL

Also intended to make comparisons between countries regarding the value of life and death, the WTP-based approach is best suited for analyzing economic well-being and has become the standard approach in high-income countries for assessing pollution-related mortality risks.
## Expected health costs of high fog in Beijing

<table>
<thead>
<tr>
<th>Valuation Method</th>
<th>Endpoint</th>
<th>Cost per case (US$)</th>
<th>Cost per case (EU€)</th>
<th>Total cost (million US$)</th>
<th>Total cost (million EU€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSL</td>
<td>Mortality</td>
<td>273 513</td>
<td>233 006</td>
<td>189</td>
<td>161</td>
</tr>
<tr>
<td>WTP</td>
<td>Acute bronchitis</td>
<td>407</td>
<td>347</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Asthma</td>
<td>300</td>
<td>256</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>COI</td>
<td>Clinic visit</td>
<td>84</td>
<td>72</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Hospitalisation</td>
<td>2761</td>
<td>2352</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>254</strong></td>
<td><strong>216</strong></td>
</tr>
</tbody>
</table>
Current situation

• Air quality in GCC large cities suffer from high pollution due to population growth, mega infrastructure, and high-energy and water demands.
• Considered a primary environmental threat to public health (WHO, 2020)
apply economic evaluation in the form of cost-benefit analysis, to the problem
Equation = Balancing the cost of pollution control VS benefits obtained from control

This equation was applied as a test on Washington DC
If we want to evaluate the cost and return of some pollutants, we start with the following:

1- Quantitative estimation of environmental pollution by monitoring ambient air quality
2- Quantitative estimation of environmental pollution results
3- Negative impact on health and property due to pollution, loss of agricultural and livestock
شكرًا