The COCCI Syndemic and Residual Cardiovascular Risk

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Disclosures

• There are no relevant financial relationships with commercial interests to disclose.

• There are no “off-label” substances under discussion or being investigated for use in this presentation.
Objectives

• Explore the possible reasons why cardiovascular diseases remain the number one cause of mortality in this nation and globally
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• Understand potential interactions between obesity, metabolic syndrome, climate change/air pollution with subclinical inflammation
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• Understand potential interactions between obesity, metabolic syndrome, climate change/air pollution with subclinical inflammation

• Understand what is a *Syndemic*
Objectives

• Explore the possible reasons why cardiovascular diseases remain the number one cause of mortality in this nation and globally
• Understand potential interactions between obesity, metabolic syndrome, climate change/air pollution with subclinical inflammation
• Understand what is a Syndemic
• Grasp how we, as health care professionals, can make a difference
Over the past 50 years despite advances in coronary artery bypass & percutaneous intervention strategies, advanced therapies for myocardial infarction, unstable angina and heart failure…

Cardiovascular disease still remains the number one killer of adults in the United States
Deaths From Heart Disease: 1900-2002

Deaths From Heart Disease

No further progression since 1968?

Peak Rate Noted in 1968

Deaths From Heart Disease

No further progression since 1968?

Peak Rate Noted in 1968

Deaths From Heart Disease

Progress since 1968

Peak Rate Noted in 1968

CCU, CABG, PCI, more aggressive approach to risk factors: BP, lipids, glucose, smoking, inactivity

How about expanding to CVD?

From 1980 to 2014, CVD mortality decreased from 507/100,000 in 1980 to 253/100,000 in 2014 (50.2% decrease).

The actual CVD death rate in 2014 was 846,000 therefore an equal number CVD deaths were averted in 2014.

Roth JAMA 2017;317:1976
Cardiovascular Disease Mortality Trends
For U.S. Males and Females (1968-2016)

Data source: https://wonder.cdc.gov/mortSQL.html
Metabolic Syndrome
Obesity

hs CRP
Subclinical Inflammation
First Hint

Obesity +
Metabolic Syndrome
Obesity

• Is bad
Obesity

• Is bad

• Is prevalent
Obesity

- Is bad
- Is prevalent
- Is increasing
Obesity

• Is bad
• Is prevalent
• Is increasing
• Is hard to treat
Silent Progression of Vascular Disease: Who is at Risk?

20th Century

21st Century

1/3 die before patients

...self induced diseases amplify the genetics of atherosclerosis
All Obesity is NOT the same

A pound is not a pound and a BMI is not a BMI

Metabolically Healthy Obesity (MHO)

• Several definitions with most describing a person with high BMI but normal insulin sensitivity
  – Many definitions allow some metabolic risk

• Estimated prevalence varies from 20-30% among obese people

Boonchaya Curr Athero Rep 2014;16:441
Hinnouho Diab Care 2103;36:2294
Characteristics of MHO

- High BMI > 30 kg/m²
- Low visceral fat
- Low or normal TG
- High or normal HDL
- Low inflammatory markers (ie CRP)
- And no evidence of the metabolic syndrome

Boonchaya Curr Athero Rep 2014;16:441
Transition Metabolically Healthy (MHO) to Unhealthy Status (MUO)

- 3052 overweight/obese subjects followed for 10 years
  - 20.8% metabolically healthy (MHO) at baseline

Soriguer J Clin Endo Meta 2013;98:2318
Transition Metabolically Healthy (MHO) to Unhealthy Status (MUO)

- 3052 overweight/obese subjects followed for 10 years
  - 20.8% metabolically healthy (MHO) at baseline
- Half MHO transitioned to MUO over 10 yrs
  - Factors predicting MUO increased waist and waist/hip
  - Factors predicting continued MHO were healthy diet & exercise

Soriguer J Clin Endo Meta 2013;98:2318
The Flip Side: Normal Weight Metabolically Unhealthy (Central Obesity)

- 15,184 NHANES III subjects followed 14.3 yrs

- Persons with normal weight (BMI < 25) but central obesity had worst long term survival

- A BMI 22 and central obesity (Waist > 40” or W/H > 1.0 for male; (women > 35” or W/H > .85) had CVD risk 1.87x compared to same BMI but no central obesity

(Sahakyan Ann Int Med 2015;163:827)
Metabolically Abnormal Across the Spectrum of lower BMI

How Common? Ranges from 21%–44%
How about the waist?

International Diabetes Federation
Classification of Metabolic Syndrome

*Endorsed by 2009 Canadian Guidelines*

Central obesity (waist circumference) +
How about the waist?

International Diabetes Federation
Classification of Metabolic Syndrome

*Endorsed by 2009 Canadian Guidelines*

Central obesity (waist circumference) +

Plus two of the following factors:

- TG > 1.7 mmol/L (150 mg/dl)
- HDL-C < 1.03 mmol/L (40 mg/dl) men
- HDL-C < 1.3 mmol/L (50 mg/dl) women
- BP > 130/85 or treatment for hypertension
- FPG > 5.6 mmol/L (100 mg/dl)

Genest Can J Cardiol 2009;25:567
# Updated Waist Circumference Criteria for Different Ethnic Groups

<table>
<thead>
<tr>
<th>ATP III, AHA/ACC</th>
<th>Waist Circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>≥ 102 cm, 40 inches</td>
</tr>
<tr>
<td>Women</td>
<td>≥ 88 cm, 35 inches</td>
</tr>
<tr>
<td><strong>IDF: European, USA, Canada</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Middle East, Sub-Saharan Africa</strong></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>≥ 94 cm, 37 inches</td>
</tr>
<tr>
<td>Women</td>
<td>≥ 80 cm, 31 inches</td>
</tr>
<tr>
<td>**South Asian, Japanese, Chinese, **</td>
<td></td>
</tr>
<tr>
<td><strong>Ethnic Central &amp; South American</strong></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>≥ 90 cm, 35 inches</td>
</tr>
<tr>
<td>Women</td>
<td>≥ 80 cm, 31 inches</td>
</tr>
</tbody>
</table>

*Genest Can J Cardiol 2009;25:567*

*Alberti Lancet 2005;366:1059*
Metabolic Syndrome Increases CV Risk

- Original ATP III definition
- Modified ATP III definition

W = Women; M = Men

Estimated relative risk

Heterogeneity $P < 0.001$

Combined

Prevalence Metabolic Syndrome in Adults in USA

- NHANES 2003-2012 demonstrated the prevalence of metabolic syndrome is 35% in all adults and 50% in those aged > 60 yrs
- Those with 4 or 5 risk factors for metabolic syndrome had higher risk than those with only 3 risk factors

Aguilar JAMA 2015;313:1973
Prevalence of Metabolic Syndrome Using Different Diagnostic Criteria

- Substitute IDF criteria for ATP III criteria for waist circumference
  - Increases the prevalence by 1.4 to 1.5 fold

- Therefore if extrapolate to US population could raise metabolic syndrome to ~50% in adults and ~70% in elderly

Saad Arg Bras Cardiol 2015;102:263*
Climate Change
Air Pollution
Subclinical Inflammation
hs-CRP
Second Hint

Climate Change and Air Pollution
Why does CVD remain our number one killer?

Does Climate Change Play a Role?

Climate Change is the greatest threat to human health in the 21st century

Editorial BMJ
March 2014
Global Warming
An Inconvenient Truth

• U.N. Intergovernmental Panel on Climate Change (IPCC)
  – 600 scientists from 40 countries

• Concluded that evidence of the earth’s rising temperature was “unequivocal” & this warming was greater than 90% due to human activity

• Even if all greenhouse-gas emissions ended today, the earth would continue to warm through the rest of the century because of the amount of carbon already in the atmosphere

IPCC February 2007
Reaffirmed October 2014
2016 ACP Calls For Urgent Action on Climate Change

• A global effort is required to reduce anthropogenic greenhouse emissions (i.e., those caused by humans) and address the health impact of climate change

Crowley  Annals Int Med 2016; 164:608
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• Physicians are encouraged to become educated about climate change, its effect on human health, and how to respond to future challenges.
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• A global effort is required to reduce anthropogenic greenhouse emissions (i.e., those caused by humans) and address the health impact of climate change.

• Physicians are encouraged to become educated about climate change, its effect on human health, and how to respond to future challenges.

• Medical schools and continuing medical education providers should incorporate climate change-related coursework into curricula.

Crowley  Annals Int Med 2016; 164:608
18 of the hottest years ever recorded were noted in the past 19 years.

2018 recorded as the hottest year ever with July 2019 hottest month ever (measured since 1880) with CO\(_2\) level the highest in 800,000 years.

1968 when CO\(_2\) broached 300-320 ppm for the first time in over 50,000 years.

Projected

Haines NEJM 2019;380:23  Stott BMJ 2006;332:1385
National Oceanic and Atmospheric Admin 2017
Today’s Ton of CO$_2$ is Worse Than a Ton Emitted Decades Ago

Source: UCS; Data from Canadell et al. 2007, PNAS

PNAS (Proceedings of National Academy of Sciences of the USA)
Twin Epidemics of Obesity and Global Warming

Two Inconvenient Truths

BMI 25-30
BMI >30

CO₂ Content in Atmosphere

National Center for Chronic Disease Prevention National Center for Health Statistics
Flegal JAMA 2002;288:1723  National Oceanic and Atmospheric Admin 2017
Air Pollution and Atherosclerosis

- Air pollution is a heterogeneous mixture of gases and vapors interacting with solid and liquid particulate matter in atmosphere.

Clearfield Curr Ather Rep 2008;10:273
Brook Curr Athero Reports 2010;12:291
Air Pollution and Atherosclerosis

- Air pollution is a heterogeneous mixture of gases and vapors interacting with solid and liquid particulate matter in atmosphere.
- Although both gaseous (e.g., ozone) and particulate pollutants are linked, the evidence is strongest for particulate matter (PM) as the greater risk for CV disease.
Air Pollution and Atherosclerosis

• Air pollution is a heterogenous mixture of gases and vapors interacting with solid and liquid particulate matter in atmosphere

• Although both gaseous (eg, ozone) and particulate pollutants are linked, evidence is strongest for particulate matter (PM) as the greater risk for CV disease.
  – Most data to date (hundreds of studies) associate CV risk with PM <2.5 µm (PM$_{2.5}$) {size ~1/50 the width of a human hair or half size of RBC}
  – Approximate range in US for PM$_{2.5}$ = 5 to 35 µg/m$^3$ with annual mean Environmental Protection Agency standard of 12 µg/m$^3$

*Clearfield Curr Ather Rep 2008;10:273
Brook Curr Athero Reports 2010;12:291*
Particulate Matter (PM)

- PM with aerodynamic diameter < 10µm (PM$_{10}$) from crushing and grinding depositing in the extrathoracic and upper tracheo-bronchial
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- Fine particles <2.5 µm (PM$_{2.5}$) originate mostly from combustion (vehicle emissions, coal burning, industrial processes) and can be inhaled deeply into lung with portion depositing into alveoli and entering pulmonary circulation and possibly systemic circulation.

*Li Rev Environ Health 2012;27:133*
Particulate Matter (PM)

- PM with aerodynamic diameter < 10um (PM$_{10}$) from crushing and grinding depositing in the extrathoracic and upper tracheo-bronchia.

- Fine particles <2.5 um (P$_{2.5}$) originate mostly from combustion (vehicle emissions, coal burning, industrial processes) and can be inhaled deeply into lung with portion depositing into alveoli and entering pulmonary circulation and possibly systemic circulation.

- Ultrafine particles <0.1 µm (PM$_{0.1}$) primarily from vehicle emissions translocate from alveoli to systemic circulatory system.

*Li Rev Environ Health 2012;27:133*
Micrometers of Atmospheric PM

- Pollen
- Mold Spores
- House Dust Mite Allergens
- Bacteria
- Cat Allergens
- Viruses
- Heavy Dust
- Settling Dust
- Suspended Atmospheric Dust
- Cement Dust
- Fly Ash
- Oil Smoke
- Smog
- Tobacco Smoke
- Soot

Gaseous Contaminants

2.5 µm
Micrometers of Atmospheric PM

- 2.5 µm
Global Burden of Disease 1990-2017
Leading Adult Risk Factors for Global DALYs

Ambient PM$_{2.5}$ was the 7$^{th}$ ranking global mortality adult risk factor in 2017

<table>
<thead>
<tr>
<th>Rank 2017</th>
<th>Rank 2005</th>
<th>Rank 2015</th>
<th>Rank 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High BP</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2. Smoking</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>3. High FG</td>
<td>3</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>4. High BMI</td>
<td>4</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>5. Alcohol</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>6. High LDL (TC)</td>
<td>7</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>7. Ambient PM</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

DALY + Disability Adjusted Life Years
High LDL replaced high TC in 2017

Lancet 2016;388:1659
Lancet 2018;392:1923
Air Pollution: A Global Burden of Disease

• Exposure to PM$_{2.5}$ estimated to have caused 4.2 million deaths and 103.1 million disability-adjusted life-years (DALYs) in 2015
  – Representing 7.6% of total global deaths and 4.2% of global DALYs
• 3%-3.5% deaths in USA

Hadley Circ 2019;137:725
Cohen Lancet 2017;389:1907
Air Pollution: A Global Burden of Disease

- Exposure to PM$_{2.5}$ estimated to have caused 4.2 million deaths and 103.1 million disability-adjusted life-years (DALYs) in 2015
  - Representing 7.6% of total global deaths and 4.2% of global DALYs
- 3%-3.5% deaths in USA
  - 59% of these in east and south Asia.
  - Mostly reflecting attributable risk from CVD
- 23% ischemic HD deaths and 21% stroke deaths globally

Hadley Circ 2019;137:725
Cohen Lancet 2017;389:1907
2015 deaths attributable to ambient PM$_{2.5}$

Deaths (%)
- No data
- <3.0
- 3.0-3.5
- 3.6-4.0
- 4.1-4.4
- 4.5-4.8
- 4.9-5.5
- 5.6-6.7
- 6.8-7.3
- 7.4-8.5
- ≥8.6

Cohen Lancet 2017;389:1907
Deaths attributable to ambient particulate matter pollution by year and cause

Largest impact on CVD (57%)
Mechanistic Pathways where Particulate Matter (PM) can promote ACS

Particulate Matter induces pulmonary Oxidative stress & inflammation

- **Acute** activation of lung autonomic nervous system (ANS)
  - Can trigger ACS via Vasoconstriction & plaque instability

- Subacute & chronic response with systemic spill over into circulation
  - Systemic oxidative stress & inflammation
    - Cell inflammation
      - Activated WBC, Platelets, MPO
    - Increase cytokine Expression
      - IL-6, TNFα
    - Oxidized lipids & Dysfunctional HDL

- Activated liver
  - Acute phase response
    - ↑ clotting factors, Fibrinogen, CRP

- Activated or inflamed fat
  - ↑ Adipokines (PAI-1, resistin)

Brook Curr Athero Reports 2010;12:291
Shanley Epidemiol 2016:27:291
Traffic and Air Pollution
Acute Trigger for MI

• 36 epidemiologic studies evaluating population attributable acute triggers for MI (cocaine, heavy meal, stress, physical activity, smoking, anger, alcohol, sex, traffic exposure etc)

• Concluded that traffic exhaust is the single most serious preventable cause of heart attack in the general public, the cause of 7.4% of all attacks.

Nawrot Lancet 2011;377:732
Mechanistic Pathways where Particulate Matter (PM) can promote atherosclerosis

Particulate Matter induces pulmonary 
Oxidative stress & inflammation

Acute activation 
of lung autonomic nervous system 
(ANS)

Subacute & Chronic

PM deposited into oropharynx 
causing mucociliary clearance, inflammation and changes 
microbiome

Subacute & chronic 
response with 
systemic spill-over 
into circulation

Systemic oxidative 
stress & inflammation

Can trigger ACS via 
Vasoconstriction & 
plaque instability

Cell inflammation 
Activated WBC, Platelets,

Increase cytokine 
Expression 
IL-6, TNFα

Dysmetabolic 
Lipids, Insulin 
Resistance, 
Cortisol

Brook Curr Athero Reports 2010;12:291
Li Circulation 2017;136:618
Hamanaka Frontier Endo 2018;(9):680
Chronic Exposure

- Chronic exposure (years) lead to 6-13% increase in total mortality and 10-28% increase in CV mortality per 10 ug/m³ increase in PM$_{2.5}$

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- Chronic exposure (years) lead to 6-13% increase in total mortality and 10-28% increase in CV mortality per 10 ug/m$^3$ increase in PM$_{2.5}$
  
  - Suggests cumulative exposure promotes development of chronic underlying disease state that exponentially augments future CV risk over years by enhancing progression and vulnerability of atherosclerotic plaque

Three Examples of Chronic PM$_{2.5}$ Exposure and ASCVD

1. Multi-Ethnic Study of Atherosclerosis and Air Pollution
2. Medicare beneficiaries followed from 2000-2012
3. Harvard Six Cities Study
Multi-Ethnic Study of Atherosclerosis and Air Pollution

- In this prospective 10-year cohort study, measured coronary artery calcium by CT in 6795 participants aged 45–84 years enrolled in the (MESA Air) in six metropolitan areas in the USA.

*Kaufman Lancet 2016;388:696*
In this prospective 10-year cohort study, measured coronary artery calcium by CT in 6795 participants aged 45–84 years enrolled in the (MESA Air) in six metropolitan areas in the USA.

From 2000-2010 the participant specific pollutant concentrations averaged over a range from 9.2 to 22.6 μg PM$_{2.5}$/m$^3$
Multi-Ethnic Study of Atherosclerosis and Air Pollution

Increased PM$_{2.5}$ and traffic related air pollution within metropolitan areas in ranges *commonly* encountered worldwide, are associated with progression of CAC consistent with acceleration of atherosclerosis.

• For each 5 μg PM$_{2.5}$/m$^3$ increase, coronary calcium progressed by 4·1 Agatston units/yr

*Kaufman Lancet 2016;388:696*
Air Pollution and Mortality in US Medicare Population

- 60,295,443 Medicare beneficiaries followed from 2000-2012
  - Increase 10 ug/m$^3$ PM$_{2.5}$ increased all-cause mortality 7.3%

*Di NEJM 2017;376:2513*
Air Pollution and Mortality in US Medicare Population

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  - When analysis limited to those with baseline PM$_{2.5} < 12$ ug/m³ (ie below NAAQ Standard) an increase 10 ug/m³ PM$_{2.5}$ ↑ mortality 13.6%

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*Di NEJM 2017;376:2513*
Exposure to Air Pollution is Associated with Adverse CV Events

Harvard Six Cities Study (1977-1988)

Characteristics of the Study Population and Mean Air-Pollution Levels in Six Cities

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>PORTAGE, Wis.</th>
<th>TOPEKA, KANS.</th>
<th>WATERTOWN, MASS.</th>
<th>HARRIMAN, TENN.</th>
<th>ST. LOUIS</th>
<th>STEUBENVILLE, OHIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>1,631</td>
<td>1,239</td>
<td>1,336</td>
<td>1,258</td>
<td>1,296</td>
<td>1,351</td>
</tr>
<tr>
<td>Person-years of follow-up</td>
<td>21,618</td>
<td>16,111</td>
<td>19,882</td>
<td>17,836</td>
<td>17,715</td>
<td>17,914</td>
</tr>
<tr>
<td>No. of deaths</td>
<td>232</td>
<td>156</td>
<td>248</td>
<td>222</td>
<td>281</td>
<td>291</td>
</tr>
<tr>
<td>Deaths/1000 person-years</td>
<td>10.73</td>
<td>9.68</td>
<td>12.47</td>
<td>12.45</td>
<td>15.86</td>
<td>16.24</td>
</tr>
<tr>
<td>Female sex (%)</td>
<td>52</td>
<td>56</td>
<td>56</td>
<td>54</td>
<td>55</td>
<td>56</td>
</tr>
<tr>
<td>Smokers (%)</td>
<td>36</td>
<td>33</td>
<td>40</td>
<td>37</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Former smokers (%)</td>
<td>24</td>
<td>25</td>
<td>25</td>
<td>21</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Average pack-years of smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smokers</td>
<td>24.0</td>
<td>25.6</td>
<td>25.2</td>
<td>24.5</td>
<td>30.9</td>
<td>28.0</td>
</tr>
<tr>
<td>Former smokers</td>
<td>18.0</td>
<td>19.7</td>
<td>21.8</td>
<td>21.1</td>
<td>22.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Less than high-school education (%)</td>
<td>25</td>
<td>12</td>
<td>22</td>
<td>35</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Average age (yr)</td>
<td>48.4</td>
<td>48.3</td>
<td>48.5</td>
<td>49.4</td>
<td>51.8</td>
<td>51.6</td>
</tr>
<tr>
<td>Average body-mass index</td>
<td>26.3</td>
<td>25.3</td>
<td>25.5</td>
<td>25.1</td>
<td>26.0</td>
<td>26.4</td>
</tr>
<tr>
<td>Job exposure to dust or fumes (%)</td>
<td>53</td>
<td>28</td>
<td>38</td>
<td>50</td>
<td>40</td>
<td>48</td>
</tr>
<tr>
<td>Total particles (µg/m³)</td>
<td>37.7</td>
<td>56.6</td>
<td>49.2</td>
<td>49.4</td>
<td>72.5</td>
<td>57.0</td>
</tr>
<tr>
<td>Inhalable particles (µg/m³)</td>
<td>18.2</td>
<td>26.4</td>
<td>24.2</td>
<td>32.5</td>
<td>31.4</td>
<td>46.5</td>
</tr>
<tr>
<td>Fine particles (µg/m³)</td>
<td>11.0</td>
<td>12.5</td>
<td>14.9</td>
<td>20.8</td>
<td>19.0</td>
<td>29.6</td>
</tr>
<tr>
<td>Sulfate particles (µg/m³)</td>
<td>5.0</td>
<td>4.8</td>
<td>6.5</td>
<td>8.1</td>
<td>8.1</td>
<td>12.8</td>
</tr>
<tr>
<td>Aerosol acidity (nmol/m³)</td>
<td>10.5</td>
<td>11.6</td>
<td>20.3</td>
<td>36.1</td>
<td>10.3</td>
<td>25.2</td>
</tr>
<tr>
<td>Sulfur dioxide (ppb)</td>
<td>4.2</td>
<td>1.6</td>
<td>9.3</td>
<td>4.8</td>
<td>14.1</td>
<td>24.0</td>
</tr>
<tr>
<td>Nitrogen dioxide (ppb)</td>
<td>6.1</td>
<td>10.6</td>
<td>18.1</td>
<td>14.1</td>
<td>19.7</td>
<td>21.9</td>
</tr>
<tr>
<td>Ozone (ppb)</td>
<td>28.0</td>
<td>27.6</td>
<td>19.7</td>
<td>20.7</td>
<td>20.9</td>
<td>22.3</td>
</tr>
</tbody>
</table>

*Air-pollution values were measured in the following years: total particles, sulfur dioxide, nitrogen dioxide, and ozone, 1977 through 1985; inhalable and fine particles, 1979 through 1985; sulfate particles, 1979 through 1984; and aerosol acidity, 1985 through 1988.

Exposure to Air Pollution is Associated with Adverse CV Events

*Harvard Six Cities Study*

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**Cardiovascular deaths increased 28% with each 10 μg/m³ increase in fine particulate air pollution measuring less than 2.5 μg (PM$_{2.5}$)**

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### Characteristics of the Study Population and Mean Air-Pollution Levels in Six Cities

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>STEUBENVILLE, OHIO</th>
<th>BOSTON, MA</th>
<th>CHICAGO, IL</th>
<th>LOS ANGELES, CA</th>
<th>CLEVELAND, OHIO</th>
<th>BIRMINGHAM, AL</th>
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</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>1,351</td>
<td>1,311</td>
<td>1,294</td>
<td>1,286</td>
<td>1,351</td>
<td>1,311</td>
</tr>
<tr>
<td>Person-years</td>
<td>7,914</td>
<td>7,850</td>
<td>7,919</td>
<td>7,917</td>
<td>7,914</td>
<td>7,859</td>
</tr>
<tr>
<td>No. of deaths</td>
<td>31</td>
<td>27</td>
<td>29</td>
<td>31</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>Deaths/1000 person-years</td>
<td>56</td>
<td>49</td>
<td>51</td>
<td>61</td>
<td>59</td>
<td>55</td>
</tr>
<tr>
<td>Female sex (%)</td>
<td>53</td>
<td>53</td>
<td>53.5</td>
<td>53</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>Smokers (%)</td>
<td>26</td>
<td>35</td>
<td>35</td>
<td>26</td>
<td>26</td>
<td>35</td>
</tr>
<tr>
<td>Former smokers (%)</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Average pack-years since starting smoking</td>
<td>25</td>
<td>12</td>
<td>22</td>
<td>21.1</td>
<td>22.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Current smokers (%)</td>
<td>48.4</td>
<td>48.3</td>
<td>48.5</td>
<td>49.4</td>
<td>51.8</td>
<td>51.6</td>
</tr>
<tr>
<td>Former smokers (%)</td>
<td>48.4</td>
<td>48.3</td>
<td>48.5</td>
<td>49.4</td>
<td>51.8</td>
<td>51.6</td>
</tr>
<tr>
<td>Less than high-school education (%)</td>
<td>25</td>
<td>28</td>
<td>38</td>
<td>53</td>
<td>50</td>
<td>48</td>
</tr>
<tr>
<td>Average age (yr)</td>
<td>53</td>
<td>25</td>
<td>28</td>
<td>35</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Average body-mass index</td>
<td>26.3</td>
<td>25.3</td>
<td>25.5</td>
<td>25.1</td>
<td>26.0</td>
<td>26.4</td>
</tr>
<tr>
<td>Job exposure to dust or fumes (%)</td>
<td>53</td>
<td>28</td>
<td>38</td>
<td>50</td>
<td>40</td>
<td>48</td>
</tr>
<tr>
<td>Total particles (μg/m³)</td>
<td>34.1</td>
<td>56.6</td>
<td>49.2</td>
<td>49.4</td>
<td>72.5</td>
<td>89.9</td>
</tr>
<tr>
<td>Inhalable particles (μg/m³)</td>
<td>18.2</td>
<td>26.4</td>
<td>24.2</td>
<td>32.5</td>
<td>31.4</td>
<td>46.5</td>
</tr>
<tr>
<td>Fine particles (μg/m³)</td>
<td>11.0</td>
<td>12.5</td>
<td>14.9</td>
<td>20.8</td>
<td>19.0</td>
<td>29.6</td>
</tr>
<tr>
<td>Sulfate particles (μg/m³)</td>
<td>5.3</td>
<td>4.8</td>
<td>6.5</td>
<td>8.1</td>
<td>8.1</td>
<td>12.8</td>
</tr>
<tr>
<td>Aerosol acidity (nmol/m³)</td>
<td>10.5</td>
<td>11.6</td>
<td>20.3</td>
<td>36.1</td>
<td>10.3</td>
<td>25.2</td>
</tr>
<tr>
<td>Sulfur dioxide (ppb)</td>
<td>4.2</td>
<td>1.6</td>
<td>9.3</td>
<td>4.8</td>
<td>14.1</td>
<td>24.0</td>
</tr>
<tr>
<td>Nitrogen dioxide (ppb)</td>
<td>6.1</td>
<td>10.6</td>
<td>18.1</td>
<td>14.1</td>
<td>19.7</td>
<td>21.9</td>
</tr>
<tr>
<td>Ozone (ppb)</td>
<td>28.0</td>
<td>27.6</td>
<td>19.7</td>
<td>20.7</td>
<td>20.9</td>
<td>22.3</td>
</tr>
</tbody>
</table>

*Air-pollution values were measured in the following years: total particles, sulfur dioxide, nitrogen dioxide, and ozone, 1977 through 1985; inhalable and fine particles, 1979 through 1985; sulfate particles, 1979 through 1984; and aerosol acidity, 1985 through 1988.*

Pope JA MA 2002;287:1132
Extended Follow-up 1977-2009
Harvard Six Cities Study

Since 2001 the average PM$_{2.5}$ for all 6 cities $< 18$ ug/m$^3$
- Predicted decrease in CV mortality $\sim$30-40%
- and total mortality $\sim$15-20%
- Response relationship was linear down to PM$_{2.5}$ of $<5$ ug/m$^3$

Lepeule Environ Health Perspect 2012;120:965
Di NEJM 2017;376:2513
Exposure to Air Pollution is Associated with Adverse CV Events

*Harvard Six Cities Study*

52% of US population (166 million) live in areas of unhealthy air quality

- And >200 million are currently overweight or obese
Remember Transition Metabolically Healthy (MHO) to Unhealthy Status (MUO)

- 3052 overweight/obese subjects followed for 10 years
  - 20.8% metabolically healthy (MHO) at baseline
- Half MHO transitioned to MUO over 10 yrs
  - Factors predicting MUO were increased waist and waist/hip + increased exposure to PM$_{2.5}$
  - Factors predicting continued MHO were healthy diet & exercise

Lee Int J Hygiene and Environ Health 2019;222:533
# Global Burden of Disease 1990-2017

## Leading ADULT Risk Factors for Global DALYs

<table>
<thead>
<tr>
<th>Rank 2017</th>
<th>Rank 2015</th>
<th>Rank 2005</th>
<th>Rank 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High BP</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2. Smoking</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>3. High FG</td>
<td>3</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>4. High BMI</td>
<td>4</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>5. Alcohol</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>6. High LDL (TC)</td>
<td>7</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>7. Ambient PM</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>8. Low whole grain</td>
<td>11</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>9. High sodium</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

*DALY + Disability Adjusted Life Years*

*High LDL replaced high TC in 2017*

Lancet 2016;388:1659
Lancet 2018;392:1923
Obesity and Global Warming

Two Inconvenient Truths connected by both internal & external inflammation

National Center for Chronic Disease Prevention National Center for Health Statistics
Third Hint

Subclinical Inflammation as a mechanistic connection between obesity/metabolic syndrome and climate change/air pollution
ATP III: Components of Metabolic Syndrome

- Abdominal Obesity
- Atherogenic Dyslipidemia (↑TG, ↓HDL)
- Elevated Blood Pressure
- Insulin Resistance ± glucose intolerance
- Pro-inflammation
  - Obese subjects with metabolic syndrome had significantly greater amounts of small dense LDL particles and higher CRP than obese subjects without metabolic syndrome
The Heart Test That Could Save Your Life
AN EASY, NEW WAY TO HELP PREDICT YOUR RISK OF HEART ATTACK AND STROKE

The Missing Link to Metabolic Syndrome ???
Risk Factors for Future Cardiovascular Events: WHS

- Lipoprotein(a)
- Homocysteine
- IL-6
- TC
- LDLC
- sICAM-1
- SAA
- Apo B
- TC: HDLC
- hs-CRP
- hs-CRP + TC: HDLC

Relative Risk of Future Cardiovascular Events

Attributable Risk CRP > 3mg/L from CV Risk Factors

Weighted multiple logistic regression analysis

Miller Arch Int Med 2005;165:2063
Mechanistic Pathways where Particulate Matter (PM) can promote atherosclerosis

Particulate Matter induces pulmonary Oxidative stress & inflammation

Acute activation of lung autonomic nervous system (ANS)

PM deposited into oropharynx causing mucociliary clearance, inflammation and changes microbiome

Subacute & Chronic response with systemic spill-over into circulation

Systemic oxidative stress & inflammation

Cell inflammation Activated WBC, Platelets,

Increase cytokine Expression IL-6, TNFα

Dysmetabolic Lipids, Insulin Resistance, Cortisol

Remember this?

Brook Curr Athero Reports 2010;12:291
Li Circulation 2017;136:618
Hamanaka Frontier Endo 2018;(9):680
PM and obesity can symbiotically augment and enhance atherosclerosis

*Ember and Kerosene Scenario*

Particulate Matter induces pulmonary
Oxidative stress & inflammation

Acute activation of lung autonomic nervous system (ANS)

Can trigger ACS via Vasoconstriction & plaque instability

Subacute & Chronic

Systemic oxidative stress & inflammation

Subacute & chronic response with systemic spill-over into circulation

Further activate inflamed fat
↑ Adipokines (PAI-1, resistin)

Activates liver acute phase response
↑ clotting factors, Fibrinogen, CRP

↓↑ Dysmetabolic Lipids, Insulin Resistance, Cortisol

Cell inflammation
Activated WBC, Platelets,

Increase cytokine Expression
IL-6, TNFα
Mechanistic Link Between Inflammation, Immunity and Obesity

• The immune system is designed to combat bacterial infection

• However, with obesity (visceral) the immune system (Th-1) is constantly activated by inflammatory cytokines released by hypertrophic adipocytes and/or apoptotic adipocytes in visceral adipose

Chawla Nat Rev Immunol 2011;11:85
Winer Immuno and Cell Biol 2012;90:755
Link Between Inflammation, Immunity & Obesity/Air Pollution

Like a continuous bacterial infection

- The immune system designed to combat bacterial infection (Th1) is constantly activated in obesity (visceral) by inflammatory cytokines released by hypertrophic adipocytes and/or apoptotic adipocytes in visceral adipose

- This creates a state of persistent (*silent*) inflammation contributing to development of vascular and other chronic disease

Chawla Nat Rev Immunol 2011;11:85
Winer Immuno and Cell Biol 2012;90:755
Pathogenesis of Obesity Related Insulin Resistance and Visceral Fat Inflammation

Excess Energy → Adipocyte Expansion 
- Dysfunction

Inflammatory cytokines

M1 macrophage Recruitment

Pro-inflammatory Milieu: TNF, IL-1β, IL-6, IL-8, CRP

Hypoxemia, Oxidative Stress and ER Stress

Apoptotic

Th1 Activation

Lymphocyte recruitment

Th1 Polarization

Insulin Resistance Atherosclerosis

Schipper Trends in Endo & Metab 2012;23:407
Pathogenesis of $PM_{2.5}$ Related Insulin Resistance and Visceral Fat Inflammation

$PM_{2.5}$ increases adipocyte size, increases visceral fat mass & macrophage infiltration into adipose

Excess $PM_{2.5}$

Inflammatory cytokines

M1 macrophage Recruitment

Hypoxemia, Oxidative Stress and ER Stress

Apoptotic

Th1 Activation

Pro-inflammatory Milieu: TNF, IL-1B, IL-6, IL-8, CRP

Insulin Resistance Atherosclerosis

Innate

M1 Polarization

Adaptive

Hamanaka Front Endo 2018;(9):680
Schipper Trends in Endo & Metab 2012;23:407
CO\(_2\) and Inflammation

• CO\(_2\) stimulates leukocytes to produce microparticles (MP) activating the nucleotide-binding domain-like receptor 3 (NLRP3) inflammasome due to mitochondrial oxidative stress

• Short term exposure to high CO\(_2\) increases production of MP containing elements of IL-1\(\beta\) that can persist for hours

*Thom Free Radic Biol Med 2017;106:406*
NLRP3 & Chronic Inflammation in Obesity & PM

Cholesterol Crystals → Neutrophil Extracellular Traps → Atheroplane Flow → Hypoxia

Obesity → Inflammatory Factors
- ↑ iNOS, Endothelin-1
- ↑ Chemokines, Cytokines
- ↑ Adhesion Molecules
- ↑ Macrophage Activation
- ↑ Smooth Muscle Proliferation

Pro-IL-1β → Caspase-1 → Active IL-1β

PM2.5 → NLRP3 Inflammasome

IL-1β → IL-6

Fibrinogen → PAI-1

Liver → CRP

Vascular Inflammation → Endothelial Dysfunction → Atherosclerosis

Canakinumab, Anakinra, Colchicine, Tocilizumab

Ridker Cir Res 2016;118:145
Pavillard Pharmacol Res 2018;131:44
Rheinheimer Metabo 2017;74
Du Toxicol Letter 2018;290:123

hsCRP Risk
- High: >3
- Intermediate: 1-3
- Low: <1
Particulate Matter and Inflammation

- Ultrafine PM$_{1}$ (soot particles) induced macrophage release of IL-1$\alpha$, IL-1$\beta$, IL33
  - The inflammatory response was pronounced at low concentrations of PM
  - The release of these cytokines by PM$_{2.5}$ signaling pathways activating NLRP3 inflammasome

De Falco Sci Rep 2017:7:43016
Cevallos Innate Immun 2017;23(4):392
Ambient PM exaggerates adipose inflammation and insulin resistance in obesity

*Ember and Kerosene Scenario Part 2*

Excess Energy

Excess PM$_{2.5}$

Adipocyte

Inflammatory cytokines

M1 macrophage Recruitment

NLRP3

Pro-inflammatory Milieu: TNF, IL-1B, IL-6, IL-8, CRP

Adipocyte Dysfunction

Systemic oxidative stress & inflammation

Th1 Activation

Hypoxemia, Oxidative Stress and ER Stress

Apoptotic

Lymphocyte recruitment

Th1 Polarization

Insulin Resistance Atherosclerosis

Hamanaka Front Endo 2018;(9):680
Sun Circulation 2009;119:538
We have arrived

• In September 2011 the U.N. declared that for the first time in human history, chronic non-communicable diseases such as heart disease, cancer and diabetes pose a greater health burden worldwide than do infectious diseases, contributing to 35 million deaths annually.

• Today, worldwide, there are 30% more people who are *obese* than are undernourished.

*Lustig Nature 2012;482:27*
We Have Arrived Again?

- CDC age adjusted mortality data for 2015 compared to 2014 found death rates increased in 2015 (possibly first time in 100 years).

Ludwig JAMA 2016;315:2269
Ma JAMA 2015;314:1731
Life Expectancy

- CDC age adjusted mortality data for 2015 compared to 2014 found death rates increased in 2015 (possibly first time in 100 years).
- This CDC data for 2015, continued in 2016 2017 & 2018, suggests we may have reached a tipping point where technology advances can no longer compensate.

Ludwig JAMA 2016;315:2269
A HUGE CONCERN

WHY?

- There was little change in the death rate from the nation's No. 1 killer: heart disease.
- In the past, steady annual drops in heart disease death rates offset increases in other causes of death.

Ludwig JAMA 2016;315:2269
Ma JAMA 2015;314:1731
Cardiovascular Disease Mortality Trends
For U.S. Males and Females (1968-2016)

Data source: https://wonder.cdc.gov/mortSQL.html
A HUGE CONCERN

• Most notably this change in heart disease death involves causes of death associated with *obesity* and we still have no good plan on how best to address this.

• *CDC concluded obesity threatens to reverse decades of improvements in mortality.*

*Ludwig JAMA 2016;315:2269
Ma JAMA 2015;314:1731
https://www.newsmax.com/newsfront/death-rates-life-expectancy/2019*
BUT WAIT
WHAT ABOUT CLIMATE CHANGE
Why does CVD remain our number one killer?

Because Climate Change is the greatest threat to human health in the 21st century

Editorial BMJ
March 2014

OR, Another way to look at this
The other way to look at this

*Climate Change is the greatest global health opportunity of the 21st century*

Editorial Lancet
November 2015
What can we do about this?
Identify High CVD Risk Groups from Air Pollution/Climate Change

- Obesity (especially with metabolic syndrome)
- Advanced age
- Lower socioeconomic status
- Diabetes
- CAD
- Other CV risk factors (HBP, smoking, hyperlipidemia, dysmetabolic)
Clinical Screening Tool for Air Pollution Risk

- Three Questions
  - Does your household burn solid fuels (wood, coal, charcoal, dung) for cooking heating, lighting or other purposes?
  - Do you live or work in urban industrial center?
  - Do you spend time near heavy traffic?
What can we do?

- College students in Shanghai, China living in nonsmoking dormitories randomized to rooms with half having air purifiers in the dormitories and half with sham purifiers for 9 days each after washout of 12 days.
  - Estimated time weighted average student exposure to PM was decreased over 50% to estimated 24 µg/m³ vs 53.1 µg/m³ with sham.

*Li Circulation 2017;136(Aug):618*
Air Pollution and Stress Hormones

• Serum cortisol levels were 1.3 times higher for the students in the sham-treated dorms, with each 10-mcg increase in pollutant exposure associated with a 7.8% increase in cortisol.

• Glucose, insulin, insulin resistance, fatty acids and lipids also differed significantly between treatment assignments.

Li Circulation 2017;136(Aug):618
Some practical suggestions

- Accumulating evidence of CV morbidity/mortality associated with traffic related air pollution
  - Living near major roadway associated with 0.37 kg/m\(^2\) increase in BMI
  - Increasing distance between residences & major roads (> 150-300 m) can result in substantial CV health benefits
  - Use of HEPA filter air cleaners and air conditioners may decrease pollutants and reduce CVE (and possibly weight)

*High-efficiency particulate arrestance or HEPA*

*References:
Dorans Obesity 2016;24:2593
Zhong PNAS 2017;114:3513
Giles Environ Health Perspec 2011;119:29
Baccarelli Circ 2008;117:1802*
What is a syndemic?
Syndemics and the Biosocial Conception of Health

Population level clustering of social and health problems

- The syndemic model of health focuses on the biosocial complex, which consists of interacting co-present or sequential diseases and the social and environmental factors that promote and enhance the negative effects of disease interaction.

Singer Lancet 2017;389:941
Global Burden of Disease

• 84 metabolic, environmental, occupational & behavioral risk factors from 1990 to 2017 in 195 countries and territories
  – Risk exposure increasing for various risks, particularly metabolic risk factors

Lancet 2016;388:1659
Lancet 2018;392:1923
Global Burden of Disease 1990-2015

Number Disability Adjusted Life years

Lancet 2016;388:1659
Obesity Trends Among U.S. Adults

BRFSS, 2017

No state noted to have < 20%
Triple Whammy
Even More Correlations

High Obesity Rate

Adult Diabetes Rate

Soda Consumption

Cohen Lancet 2017; 389:1907
Percent adults meeting physical activity guidelines

**Quadruple Whammy**

Obesity + air pollution + soda + lack activity
Ultimate Whammy
Decreased Life Expectancy from Birth

Quintuple Whammy
Obesity Plus air pollution
Plus lack activity
Plus Increase DM/soda

80-81.3 yrs
78.4-80 yrs
77.2-78.4 yrs
75-77.2 yrs
Ultimate Whammy
Decreased Life Expectancy from Birth

CVD death rate/100,000
Ranges from 77 (Northern CA/Colorado) to 545 (Mississippi)

Patel Ann Int Med 2015;163:245
Roth JAMA 2017;317:1976

CVD death rate/100,000
Highest Mississippi, Kentucky, Oklahoma, Louisiana, Alabama

Insufficient data*
What a coincidence
1967-69

50 Years Ago

1) CV mortality peaked & held steady
2) CO$_2$ atmosphere reached 300 ppm
3) Obesity rates started to climb
4) Shift to lowering fat in diet
5) Increase diet fructose (HFCS)
6) Decrease physical activity
7) Changes in the microbiome
Syndemic Model

Health Condition 1

Adverse Interaction

Enhanced disease transmission, progression, and negative health outcomes

Health Condition 2

Singer Lancet 2017;389:941
Obesogens

• Compounds that disrupt hormonal (glucocorticoid) signaling in adipose cell cultures.

• Activate glucocorticoid receptor and promotes fat cell differentiation and lipid accumulation

• Environmental exposure to such compounds can be an unrecognized factor in the obesity epidemic
# Obesogens

<table>
<thead>
<tr>
<th>Use</th>
<th>Evidence of harm</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiibutyltin (TBT)</td>
<td>Lipid accumulation to develop large fat deposits</td>
<td>Activated PPARγ/RXR</td>
</tr>
<tr>
<td>Organochlorine (DDT, PCB)</td>
<td>Weight gain, increase fat mass, metabolic dysfunction</td>
<td>Glucocorticoid receptor &amp; PPARγ activation</td>
</tr>
<tr>
<td>Bisphenol A (BPA) &amp; Phthalates</td>
<td>Lipid accumulation, increase fat mass linked to obesity and DM</td>
<td>Estrogen, PPAR and glucocorticoid activation</td>
</tr>
<tr>
<td>Heavy metals (cadmium, arsenic, lead)</td>
<td>Increase risk T2DM, exposure arsenic in utero increased obesity</td>
<td>Mimic estrogen, disrupt glucose metabolism</td>
</tr>
</tbody>
</table>

*Grens Scientist 2015;29:34*
Air Pollution may be a cause of Obesity

• Polycyclic aromatic hydrocarbons (PAHs), which are formed during the incomplete combustion of organic materials (traffic emissions), were suggested to be obesogens.
Air Pollution may be a cause of Obesity

- Polycyclic aromatic hydrocarbons (PAHs), which are formed during the incomplete combustion of organic materials, were recently suggested to be obesogens.
  - Experimental studies demonstrated direct inhibition of lipolysis in adipocytes which causes fat mass gain in animal models.

- Environmental exposure to PAHs may be associated with childhood obesity regardless of tobacco exposure
  - However, simultaneous exposure to PAHs and tobacco smoke substantially increased the risk of obesity 20-30x compared to no exposure to either

Scinicariello Envirn Health Perspect 2014;122:129
General and Central Obesity with Polycyclic Aromatic Hydrocarbon with and without Tobacco Exposure


- Environmental exposure to PAHs may be associated with childhood obesity regardless of tobacco exposure.
- Even prenatal exposure to PAHs associated with predisposition to obesity in early childhood.
Nutrition Transition

- Global meat production increased 4-5x since 1960s with increase consumption from 20 kg to 43 kg per person per year
- Linked to growing incomes and changing dietary preferences
  - Livestock contributes 19% greenhouse gases plus uses 70% global agricultural land and prime source deforestation

Swinburn Lancet 2019; You BMC Nutr 2916;2:22
Obesity and Climate Change

- Population growth
- Urbanization
- Fossil Fuel Economy
- Motorized transportation
- Industrialization
- Agricultural productivity
- Meat consumption
- Elevated energy consumption
- Food supply price shock
- Nutrition transition
- Physical inactivity
- Obesogens
- Adaptive thermogenesis

Obesity: Climate Change Interactions

- Population growth
- Urbanization
- Fossil Fuel Economy
- Motorized transportation
- Industrialization
- Agricultural productivity
- Meat consumption
- Elevated energy consumption
- Nutrition transition
- Food supply price shock
- Obesogens
- Adaptive thermogenesis
- Obesity
- Physical inactivity

Syndemic Model for COCCI

Dysmetabolic Obesity

Adverse Interaction

Climate Change and Air Pollution

Inflammation

C CVD
O Obesity
C Climate
C Change
I Inflammation

COCCI Syndemic

Enhanced disease transmission, progression & negative health outcomes

Clearfield JAOA 2018;118:719
Swinburn Lancet 2019 Feb 23;393(10173):746
Executive Summary

The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report

Published: January 27, 2019

Cardiovascular Disease as a Result of the Interactions Between Obesity, Climate Change and Inflammation: The COCCI Syndemic

Published November 2018

Cardiovascular Disease as a Result of the Interactions Between Obesity, Climate Change and Inflammation: The COCCI Syndemic

Published: November 2018

Clearfield JAOA 2018;118:719
Swinburn Lancet 2019 Feb 23;393(10173):746
Syndemic Dilemma

• Many physicians believe that public health and societal issues “are not our job” and therefore ignore the increasing complexity of patient care

• Most physician’s clinical training explicitly focus on diagnosis and treatment without considering how social problems impact medical problems

Mendenhall Lancet 2017;389:951
Abraham Lincoln

You cannot escape the responsibility of tomorrow by evading it today

Kaelin JAMA 2017;318:611
Inconvenient Truths

- Climate change is real and so is the marked increase in obesity and metabolic syndrome.
- Increased air pollution, has been shown to induce ischemia, prothrombosis & inflammation all prevalent in obese metabolic syndrome patients.
- We have the unique opportunity to positively impact both of these inconvenient truths.
Inconvenient Truths

- Global warming is real and so is the marked increase in obesity and metabolic syndrome
- Increased air pollution, has been shown to induce ischemia, prothrombosis & inflammation all prevalent in obese metabolic syndrome patients
- We have the unique opportunity to positively impact both of these inconvenient truths
- Our children, our patients, and our planet are counting on us
IT IS INCREDIBLY PATHETIC THAT IT HAS TO BE US

Jerry Garcia