Biological basis of COPD from vapors, gas, dust and fumes (VGDF)


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One of the oldest health hazard of the human kind; home environment smoke from cooking and heating

It became a health hazard as soon as humans learned to use fire.

The Bloembos Cave, South Africa; «home cooking» for ±80,000 y.
PHILOSOPHICAL
TRANSACTIONS.

May the 25th. 1686.

THE CONTENTS.

A. Account of an Engine that consumes Smoak, shown lately at St. Germans Fair in Paris; Communicated by Mr. Justell, R.S.S. 2. An Extract of the Journals des Sca-

To burn all sorts of Wood in the middle of a Room without making any Smoak, is a thing so extraordinary, that all those that have heard speak of it, as well Philosophers as others, have asserted it impossible: but Mr. Daleme Engineer, professing his discoveries, has found out a Machine, which is very little and portable, consumes all the Smoak of all sorts of Wood whatsoever, and that so, that the most curious eye cannot discover it in the Room, nor the nicest Nose smell it, albo the Fire be perfectly open. This has given such satisfaction to all that have seen it, and to the King himself, that he has caused the Experiment to be made several times before Him.

This Engine is made after the manner represented in Fig. 1, and is composed of several hoops of hammer’d Iron of about 4 or 5 Inches diameter, which butt one into the other: It stands upright in the middle of the Room, upon a sort of Tripod made on purpose, it is the place where the Fire is made, where if you put little pieces
«Smoke-house» in Norway ±1750
Sources of biomass fuel

Developing countries:
- Coal-/coke bricks
- Forestry crops (wood)
- Agricultural crops and residues
- Animal excreta mixed with various materials (dung)
- Municipal solid waste

Western countries:
- Forestry crops and residues
- Agricultural crops and residues
- Sewage
- Industrial residues
- Municipal solid waste
- Animal residues

It is the difference in use that makes differences in exposure
Distribution of “stove bricks”, Lijang, Yonan, 2007

Photo: S Langråd
About two billion people worldwide are cooking on open fire.

Mumbai

PR China

VietNam
Biomass combustion serves a diversity of purposes in different parts of the world

- Most *developing* countries utilize a diversity of primitive combinations of biomass (frequently dung) for *cooking* and *heating*, generally resulting in very high levels of home exposure to combustion smoke.

- In many *developed* countries wood, coal or coke is used for heating and cooking, resulting sometimes in intermediate levels of exposure.

- Uses of biomass in *developed* countries has given a new source of energy: water-borne heating, power generation and for many other energy needs, generally resulting in relatively low environmental concentration and exposure to biomass smoke.

- These three sources of pollution result in orders of magnitude in differences in untoward health outcomes.
Estimated $\text{PM}_{10}$ Concentration in World Cities (pop = 100,000+)
Different estimates of premature deaths due to household air pollution

A burning issue

Nearly 3 billion people burn wood, dung and other types of biomass in open stoves to cook their food and heat their homes. The World Health Organization has estimated the number of deaths caused by household air pollution (HAP) from burning biomass and coal.

Cause of death from household air pollution in 2012

- 6% Lung cancer
- 12% Acute lower respiratory infections
- 22% Chronic obstructive pulmonary disease
- 34% Stroke
- 26% Ischaemic heart disease

Total deaths from HAP 4.3 million

Total deaths attributable to HAP in 2012, by region

- Africa 581,300
- The Americas 81,300
- Eastern Mediterranean 200,800
- Europe 117,200
- Southeast Asia 1,691,600
- Western Pacific 1,620,100
Global untoward health effects of biomass combustion smoke particles: premature deaths

Urban outdoor air pollution: ~ 800,000
Household use of solid fuels: ~ 1,600,000
Environmental tobacco smoke: ~ 300,000
Exposure at work ~ 250,000*
Total ~ 3 million/y

With active smoking: ~ 8 million

Compare with global totals for
Dirty water: 2 million
HIV: 3 million
All cancer: 7 million
Malnutrition: 4 million

* This figure represents an underestimation (SL)
Dung as fuel seems to cause the highest incidence of disease

- In developing countries some 80% of households in the rural areas rely on biomass fuels for cooking and often heating as well - and accordingly suffer from high indoor air pollution.

- A major fraction of combustions products from biomass fuel consist of fine particles \((0.1 < d < 2.5 \, \mu m)\) - which deposits in the tracheobronchial region of the human respiratory tract - and ultrafine particles \((d < 0.1 \, \mu m)\) - deposited in the pulmonary/alveolar region.

- Thus, xenobiotics contained in or carried by ultrafine particles act locally and can be easily translocated in the human body via systemic circulation.
Toxic pollutants in biomass fuel smoke from poor combustion

- Small particles, CO, NO$_2$
- Hydrocarbons
  - saturated hydrocarbons such as $n$-hexane
  - unsaturated hydrocarbons such as 1,3 butadiene
  - mono-aromatics such as benzene & styrene
  - polycyclic aromatics such as benzo(α)pyrene
- Oxygenated organics
  - aldehydes including formaldehyde & acrolein
  - alcohols and acids such as methanol
  - phenols such as catechol & cresol
  - quinones such as hydroquinone
- Semi-quinone-type and other radicals
- Chlorinated organics such as methylene chloride and dioxin

Naehler et al. 2007, JIT
Different makings of the «Tandir» in Turkey

*Tandir* also serves heating of the dwelling, resulting in pollution with oxides of nitrogen, sulphur dioxide and unburned hydrocarbons (on soot particles).
A 55-year-old woman, a non-smoker (Anatolia), was admitted with dry coughing associated with non-pleuritic rightsided chest pain. Had been exposed to fumes from primitive biomass for 20+ y. Her husband was a smoker.

Biomass-induced lung diseases; Turkey

These authors have seen many non-smoking female patients referred with respiratory complaints and a clinical picture of the chronic lung diseases which would have been expected if they had been heavy smokers.

- **Bronchiolitis obliterans** has been reported due to heavy exposure to toxic fumes from combustion.

- In the case of **nitrogen dioxide**, the radiological appearance may be **nodules** either throughout the lung or predominantly in the lower lobes, while normal chest radiographs or **hyperinflation** may be seen with sulphur dioxide (SO$_2$).

Toxic compounds and outcome results

- The mechanism of disease is varied. Hydrochloric acid, phosgene, nitrogen dioxide, sulphur dioxide and ammonia for example react with water to produce strong acids and alkali damaging the epithelium by direct toxicity.

- NO$_2$ is poorly soluble in water and penetrates deeper into the lung and may, with other smoke components, damage the cell’s lipid membrane through release of oxygen radicals.

- Biomass-related health hazards are mainly seen in women, who almost always are the ones performing the tasks of cooking. Exposure may be life-long starting at birth for children who accompany their mothers from pregnancy to infancy but then greater in girls who accompany their mothers throughout their developing years.

Mice exposed to biomass smoke and tobacco smoke

- Mice were exposed to biomass smoke for 30 minutes twice a day for one week and compared to unexposed mice and mice that were exposed to one-week of cigarette smoke as per our standard protocol. Lung lavage cellularity was significantly increased in biomass and cigarette smoke-exposed mice compared to non-exposed controls (530 x10⁶ vs. 180 x 10⁶).

- Though the overall particulate matter exposure for the biomass-exposed mice was 200 mg/m³/day vs. 480 mg/m³/day for cigarette smoke, both groups had similar inflammatory responses. The overall number of macrophages in the lavage was significantly increased in the biomass and smoke-exposed mice. The increase in lavage neutrophiles was only significant in the mice exposed to biomass smoke.

Mehra D, Geraghty PM, Hardigan AA, Foronjy R. A Comparison of the Inflammatory and Proteolytic Effects of Dung Biomass and Cigarette Smoke Exposure in the Lung. PLOS ONE. 2012;7 00-00. [India]
Characteristic features of cytokines: functional pleiotropy and redundancy.

Cytokines include interleukins, interferons, colony-stimulating factors, and many growth factors. They are produced by many different cell types and often show overlapping activities regulating proliferation or differentiation, depending on the type and developmental state of the target cells involved.

The cytokines interleukin-6 (IL-6), IL-1, and TNFα are elevated in most, if not all, inflammatory states and have been recognized as targets of therapeutic intervention.

Suggested mechanisms; how cytokines are involved in causation of COPD

Chung KF. Cytokines in chronic obstructive pulmonary disease. DOI: 10.1183/09031936.01.00229701 Published 2 July 2001
"Cytokine fingerprints" COPD

- Today we have what one could call cytokine "fingerprints" in the sputum - even better in BAL fluid - as diagnostic tools for COPD as well as for asthma.
- However, these tools are of limited help to prevent COPD and other lung diseases among people exposed to biomass fuel smoke.
- We need a tool that can identify minor changes in the lungs before diseases occur: preferably a "cytokine fingerprint" that can identify hazardous exposure before any untoward health outcome occur.
- Such fingerprints could be applied - along with knowledge on toxic properties of components of exposure - to prevent further exposure.
Exposure-related cytokine fingerprints - realistic?

- In order to accomplish this, there is need for research on how quickly and to what extent cytokines in sputum and BAL-fluid are expressed in relation to current high exposure to smoke from combustion of different types of biomass fuel.
- We also need research on how versatile predictors such fingerprints would be for the different diseases that may occur after exposure to biomass smoke.
Applicable in the West

- In the developed countries we may have the necessary resources needed for such screening.
- However, once again - a tool unlikely to be beneficial to people exposed to biomass fuel smoke in countries that are most need of the tool.
Thank you for your attention!