Monitoring the health consequences of tobacco use

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Key Takeaways

• Become familiar with the health consequences of tobacco use
• Understand the stages of the smoking epidemic
• Become familiar with methods for estimating tobacco-attributable burden
• Become familiar with resources for tobacco-attributable burden
Health consequences of tobacco use

Cancers
- Larynx
- Esophagus
- Oropharynx
- Trachea, bronchus, and lung
- Acute myeloid leukemia
- Stomach
- Liver
- Pancreas
- Kidney and ureter
- Cervix
- Bladder
- Colorectal

Chronic Diseases
- Stroke
- Blindness, cataracts, age-related macular degeneration*
- Congenital defects—maternal smoking; oroﬁcial clefts*
- Periodontitis
- Aortic aneurysm, early abdominal aortic atherosclerosis in young adults
- Coronary heart disease
- Pneumonia
- Atherosclerotic peripheral vascular disease
- Chronic obstructive pulmonary disease, tuberculosis,* asthma, and other respiratory effects
- Diabetes*
- Reproductive effects in women (including reduced fertility)
- Hip fractures
- Ectopic pregnancy*
- Male sexual function—erectile dysfunction*
- Rheumatoid arthritis*
- Immune function*
- Overall diminished health

Source: www.cdc.gov/tobacco/data_statistics/sgr/50th-anniversary

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Smoking epidemic – United States

- Cigarette packs consumed per adult per year
- Lung cancer deaths in men
- Lung cancer deaths in women

Lung cancer death rate

0 100
0 100


Stages of the smoking epidemic in developed countries

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(Revised) Stages of the smoking epidemic
Separate for Men and Women

A MALES
% of smokers among adults
Stage 1 Stage 2 Stage 3 Stage 4
% of deaths caused by smoking

B FEMALES
% of smokers among adults
Stage 1 Stage 2 Stage 3 Stage 4
% of deaths caused by smoking

Thun MJ et al. Tob Control 2012;21:96-101
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Estimated smoking prevalence by SDI

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Health outcome measures

- Incidence
- Mortality
- Tobacco-attributable incidence or mortality
- Tobacco-attributable premature mortality
- Tobacco-attributable disability-adjusted life-years
- Medical costs
- Indirect costs
- Productivity losses
IARC Global Cancer Observatory

Source: http://gco.iarc.fr
Lung cancer incidence and death rates by world region, 2018

Estimated age-standardized incidence and mortality rates (World) in 2018, lung, both sexes, all ages

Source: [http://gco.iarc.fr](http://gco.iarc.fr)
Lung cancer death rates over time by country

Source: http://gco.iarc.fr
Effects of tobacco control: Early adopter California vs the rest of the US

- Smoking prevalence and health outcome data can be combined to tell a compelling story
- California adopted tobacco control strategies before the rest of the United States
- California now has lower smoking prevalence, particularly among younger adults
- Lung cancer death rates show a sharper, and earlier decline in California than in the rest of the United States

Effect of workplace smoke-free legislation on MI

Incidence (data points) of myocardial infarction (MI) and sudden cardiac death (SCD) in Olmsted County, Minnesota, 1995-2009, with smoothing spline (solid lines) and 95% CIs (shaded areas)

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Effect of tobacco control legislation on asthma

<table>
<thead>
<tr>
<th>Study</th>
<th>Direct risk change (95% CI)</th>
<th>Weight (%)</th>
<th>Risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciaccio (2016)</td>
<td>-17.00 (-18.50 to -15.50)</td>
<td>31.69</td>
<td>Low</td>
</tr>
<tr>
<td>Galán (2017)</td>
<td>-11.00 (-30.83 to 8.83)</td>
<td>8.58</td>
<td>Low</td>
</tr>
<tr>
<td>Gaudreau (2013)</td>
<td>11.00 (-55.00 to 77.00)</td>
<td>1.02</td>
<td>Moderate</td>
</tr>
<tr>
<td>Hawkins (2016)</td>
<td>-3.00 (-8.00 to 2.00)</td>
<td>27.40</td>
<td>Low</td>
</tr>
<tr>
<td>Millett (2013)</td>
<td>-8.90 (-10.90 to -6.90)</td>
<td>31.31</td>
<td>Moderate</td>
</tr>
<tr>
<td>Overall (p=0.000)</td>
<td>-9.83 (-16.62 to -3.04)</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

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Attributable Risk (AR)

- The incidence of disease in the exposed that is due to the exposure
- The rate in the exposed minus the **background risk** (estimated by the rate in the unexposed)
- Also known as **excess risk** or **risk difference**
- Specific to the population being studied because baseline incidence of cancer will vary from one population to another
- Calculated as
  - AR = (Rate in exposed – Rate in unexposed)
Attributable Fraction (AF)

• Also known as *attributable proportion among the exposed* or the *attributable risk percentage* or *excess risk percentage* or *excess fraction*

• The proportion of disease in the **exposed** group that is due to the exposure and would be eliminated if exposure were eliminated

• Can be calculated based on rates or relative risk
  - \( \text{AF} = \frac{(\text{Rate in exposed} - \text{Rate in unexposed})}{(\text{Rate in exposed})} \)
  - \( \text{AF} = \frac{(\text{Relative Risk} - 1)}{\text{Relative Risk}} \)

• Examples:
  - How many smokers will die prematurely?
    - Given RR=2.0, \( \text{AF} = \frac{(2-1)}{2} = 0.5 \) or half of smokers will die prematurely
  - What proportion of lung cancers among smokers are attributable to smoking?
    - Given RR=25, \( \text{AF} = \frac{(25-1)}{25} = 0.96 \), So, 96% of lung cancers among smokers are caused by smoking

• **Note:** RR depends on product and duration used – may be population-specific
Population Attributable Rate (PAR)

• The difference in the rate or risk of disease for the population compared to the rate in the unexposed group (the background risk)

• Can be calculated as:
  • PAR = Rate in total population – Rate in unexposed
  • PAR = (Rate in exposed – Rate in unexposed) x (prevalence of exposure)
**Population Attributable Fraction (PAF)**

- The fraction of the incidence of a disease in the population (exposed and unexposed) that is due to exposure.

- Can be calculated as:
  - \( PAF = \frac{PAR}{Rate \text{ in total population}} \)
  - \( PAF = \frac{[\text{prevalence of exposure} \times (RR-1)]}{[\text{prevalence of exposure}(RR-1) + 1]} \)
  - \( PAF = \text{prevalence among cases} \)

- Example
  - PAF for lung cancer in the United States is ~80% (based on sex- and age-specific RR and prevalence). So, 80% of lung cancers in the population (smokers & nonsmokers) are caused by smoking. 20% of lung cancers are caused by other things but these are not all among nonsmokers.

- **Note**: prevalence should be as specific as possible (stratified by age, sex, year, region) and may be lagged.
Population Attributable Mortality (PAM)

- PAM is the number of deaths in the population attributable to the exposure
- PAM = PAF * total deaths in population

Years of Life Lost (YLL)
Years Lost due to Disability (YLD)
Disability-adjusted life years lost (DALY)

• YLL measures the burden of **premature death** due to the exposure
  • YLL = PAM * remaining life expectancy at the midpoint of each age category

• YLD measures the burden of **disability** (morbidity) due to the exposure
  • YLD = (Disability Weight) * (number of incident cases) * (average duration of case until remission or death)
  • YLD = (Disability Weight) * (number of prevalent cases)

• DALY measures years of **healthy life lost**
  • DALY = YLL + YLD

Smoking Impact Ratio – Overview

Way to estimate smoking-attributable burden when information about smoking prevalence is not known

**Lung cancer** death rates can be used to estimate the proportion of deaths from *other* disease that are attributable to tobacco use
Smoking Impact Ratio – Formula

\[ SIR = \frac{C_{LC} - N_{LC}}{S_{LC}^* - N_{LC}^*} \times \frac{N_{LC}^*}{N_{LC}} \]

- \( C_{LC} \) is the observed lung cancer death rate in population of interest (obtained from WHO or other mortality data source)
- \( N_{LC} \) is the lung cancer death rate of never-smokers in the population of interest (estimated using cohort studies)
- \( S_{LC}^* \) is the lung cancer death rate in a reference population of smokers (from cohort studies)
- \( N_{LC}^* \) is the lung cancer death rate in a reference population of never-smokers (from cohort studies)
Global Burden of Disease Studies

• Aim: measure disability and death from a multitude of causes worldwide
  • 315 diseases and injuries
  • 79 risk factors
  • 195 countries

• Estimates of all-cause mortality, deaths by cause, years of life lost, years lived with disability, disability-adjusted life years, prevalence, acute prevalence, chronic prevalence, incidence, acute incidence, summary exposure value, life expectancy, healthy life expectancy, and maternal mortality ratio

http://www.healthdata.org/gbd/about/history
IHME Data Visualization Tool

http://www.healthdata.org/smoking-tobacco/data-visualizations
Deaths attributable to cigarette smoking, 2016

http://www.healthdata.org/smoking-tobacco/data-visualizations
Global burden of second-hand smoke, 2004

* The 6 WHO regions are used separating out high-income countries within each of these regions into a 7th group: High-income. See The global burden of disease: 2004 update, Annex C, for more information, at http://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/index.html


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Deaths attributable to smokeless tobacco use, 2010
Key Takeaways

• Become familiar with the health consequences of tobacco use
  • Diseases throughout the body, lung cancer is sentinel outcome
• Understand the stages of the smoking epidemic
  • 4-stage model, separate for males & females
• Become familiar with methods for estimating tobacco-attributable burden
  • Incidence & mortality, smoking-attributable mortality & DALYs
• Become familiar with resources for tobacco-attributable burden
  • IARC Global Cancer Observatory
  • IHME Global Burden of Disease Data Visualization
Go to the official federal source of cancer prevention information:
www.cdc.gov/cancer

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.