## Monitoring the health consequences of tobacco use

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**Division of Cancer Prevention and Control** 



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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 tobaccoattributable burden
- Become familiar with resources for tobacco-attributable burden

#### Health consequences of tobacco use



#### Smoking epidemic – United States



## Stages of the smoking epidemic in developed countries



Source: Thun MJ et al. Tob Control 2012;21:96-101 ©2012 by BMJ Publishing Group Ltd

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



Thun MJ et al. Tob Control 2012;21:96-101 ©2012 by BMJ Publishing Group Ltd

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**Estimated smoking prevalence by SDI** 

GBD. Smoking prevalence and attributable disease burden. Lancet 2017;389:1885-1906. doi: https://doi.org/10.1016/S0140-6736(17)30819-X. ©2018 Creative Commons Attribution License

## 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

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# 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

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#### Lung cancer death rates over time by country



International Agency for Research on Cancer (IARC) - 17.10.2018

Source: http://gco.iarc.fr

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## 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)

Hurt RD et al. Arch Intern Med. 2012;172(21):1635-1641. doi:10.1001/2013.jamainternmed.46 Reproduced with permission from Arch Intern Med. 2012;172(21):1635-1641. Copyright© 2012 American Medical Association. All rights reserved.

#### Effect of tobacco control legislation on asthma



B Asthma exacerbations requiring hospital attendance

Faber T et al. Lancet Public Health. 2017 Sep 5;2(9):e420-e437. doi: 10.1016/S2468-2667(17)30144-5 ©2018 <u>Creative Commons Attribution License</u>

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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
  - AF = (Rate in exposed Rate in unexposed) / (Rate in exposed)
  - AF = (Relative Risk 1)/Relative Risk
- Examples:
  - How many smokers will die prematurely?
    - Given RR=2.0, AF = (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, AF = (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 = PAR / Rate in total population
  - PAF = [prevalence of exposure x (RR-1)] / [prevalence of exposure(RR-1) + 1]
  - PAF = 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



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## 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

More information: http://www.who.int/healthinfo/global\_burden\_disease/metrics\_daly/en/

## 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

$$\mathrm{SIR} = \frac{\mathrm{C_{LC}} - \mathrm{N_{LC}}}{\mathrm{S_{LC}^*} - \mathrm{N_{LC}^*}} \times \frac{\mathrm{N_{LC}^*}}{\mathrm{N_{LC}}}$$

- *C<sub>LC</sub>* is the observed lung cancer death rate in population of interest (obtained from WHO or other mortality data source)
- N<sub>LC</sub> 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

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#### 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

Source: Oeberg et al, The Lancet, Vol. 377, 2011

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Öberg M et al. Lancet 2010; DOI:10.1016/S0140-6736(10)61388-8

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Source: Oeberg et al, The Lancet, Vol. 377, 2011

#### Deaths attributable to smokeless tobacco use, 2010



Sinha DN et al. BMJ 2018;27:35-42. doi:10.1136/tobaccocontrol-2016-053302 ©2016 by BMJ Publishing Group Ltd

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## 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 tobaccoattributable 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: <u>www.cdc.gov/cancer</u>



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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.

