Epidemiology of Cancer

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With thanks to Dr Kirsten Moysich for some slides
Epidemiology

- the branch of medicine that deals with the incidence, distribution, determinants and control of diseases and other factors relating to health

- Epidemiology is the study of the frequency and pattern of health events in a population
Cancer Incidence

The number of newly diagnosed cases for a specific cancer or for all cancers combined during a specific time period
Cancer Prevalence

The number of current cases for a specific cancer or for all cancers combined during a specific time period
Surveillance, Epidemiology, and End Results (SEER) Program
2015 Estimated Stats

- Estimated New Cases in 2015: 1,658,370
- % of All New Cancer Cases: 100.0%
- Estimated Deaths in 2015: 589,430
- % of All Cancer Deaths: 100.0%

# 2015 Estimated Stats

<table>
<thead>
<tr>
<th>Common Types of Cancer</th>
<th>Estimated New Cases 2015</th>
<th>Estimated Deaths 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast Cancer (Female)</td>
<td>231,840</td>
<td>40,290</td>
</tr>
<tr>
<td>Lung and Bronchus Cancer</td>
<td>221,200</td>
<td>158,040</td>
</tr>
<tr>
<td>Prostate Cancer</td>
<td>220,800</td>
<td>27,540</td>
</tr>
<tr>
<td>Colon and Rectum Cancer</td>
<td>132,700</td>
<td>49,700</td>
</tr>
<tr>
<td>Bladder Cancer</td>
<td>74,000</td>
<td>16,000</td>
</tr>
<tr>
<td>Melanoma of the Skin</td>
<td>73,870</td>
<td>9,940</td>
</tr>
<tr>
<td>Non–Hodgkin Lymphoma</td>
<td>71,850</td>
<td>19,790</td>
</tr>
<tr>
<td>Thyroid Cancer</td>
<td>62,450</td>
<td>1,950</td>
</tr>
<tr>
<td>Kidney and Renal Pelvis Cancer</td>
<td>61,560</td>
<td>14,080</td>
</tr>
<tr>
<td>Endometrial Cancer</td>
<td>54,870</td>
<td>10,170</td>
</tr>
<tr>
<td>All Cancer Sites</td>
<td>1,658,370</td>
<td>589,430</td>
</tr>
</tbody>
</table>

Age adjusted to the 2000 US census
Rates of new cases of the most common cancers, delay-adjusted cancer incidence, 1975-2011

Age-Adjusted U.S. Mortality Rates
By Cancer Site
Ages < 20, All Races, Both Sexes
1975–2012

Rate per 100,000

Year of Death


Age adjusted to the 2000 US census
Cancer Mortality

The number of deaths for a specific cancer or for all cancers combined during a specific time period
## US Mortality, 2013

<table>
<thead>
<tr>
<th>Rank</th>
<th>Cause of Death</th>
<th># of deaths</th>
<th>% of all deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart Diseases</td>
<td>611,105</td>
<td>23.5</td>
</tr>
<tr>
<td>2</td>
<td>Cancer</td>
<td>584,881</td>
<td>22.5</td>
</tr>
<tr>
<td>3</td>
<td>Chronic lower respiratory diseases</td>
<td>149,205</td>
<td>5.7</td>
</tr>
<tr>
<td>4</td>
<td>Accidents (unintentional injuries)</td>
<td>130,557</td>
<td>5.0</td>
</tr>
<tr>
<td>5</td>
<td>Cerebrovascular diseases</td>
<td>128,978</td>
<td>5.0</td>
</tr>
<tr>
<td>6</td>
<td>Alzheimer disease</td>
<td>84,767</td>
<td>3.3</td>
</tr>
<tr>
<td>7</td>
<td>Diabetes mellitus</td>
<td>75,578</td>
<td>2.9</td>
</tr>
<tr>
<td>8</td>
<td>Influenza &amp; pneumonia</td>
<td>56,979</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>Nephritis, nephrotic synd, nephrosis</td>
<td>47,112</td>
<td>1.8</td>
</tr>
<tr>
<td>10</td>
<td>Intentional harm (suicide)</td>
<td>41,149</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Change in the US Death Rates* by Cause, 1950 & 2005

* Age-adjusted to 2000 US standard population.
Sources: 1950 Mortality Data - CDC/NCHS, NVSS, Mortality Revised.
Age-Adjusted U.S. Mortality Rates
By Sex
All Sites, All Ages, All Races,
1975–2012

Total Number of Cancer Deaths Averted from 1991 to 2009 in Men and 1992 to 2009 in Women

The blue line represents the actual number of cancer deaths recorded in each year, and the red line represents the number of cancer deaths that would have been expected if cancer death rates had remained at their peak.
Cancer Death Rates* Among Men, US, 1930-2009

*Age-adjusted to the 2000 US standard population.
National Center for Health Statistics, Centers for Disease Control and Prevention.
Cancer Death Rates* Among Women, US, 1930-2009

*Age-adjusted to the 2000 US standard population.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All sites</td>
<td>49</td>
<td>56</td>
<td>68</td>
</tr>
<tr>
<td>Breast (female)</td>
<td>75</td>
<td>84</td>
<td>90</td>
</tr>
<tr>
<td>Colon</td>
<td>51</td>
<td>61</td>
<td>65</td>
</tr>
<tr>
<td>Leukemia</td>
<td>34</td>
<td>43</td>
<td>58</td>
</tr>
<tr>
<td>Lung &amp; bronchus</td>
<td>12</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Melanoma</td>
<td>82</td>
<td>88</td>
<td>93</td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma</td>
<td>47</td>
<td>51</td>
<td>71</td>
</tr>
<tr>
<td>Ovary</td>
<td>36</td>
<td>38</td>
<td>43</td>
</tr>
<tr>
<td>Pancreas</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Prostate</td>
<td>68</td>
<td>83</td>
<td>100</td>
</tr>
<tr>
<td>Rectum</td>
<td>48</td>
<td>58</td>
<td>68</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>73</td>
<td>79</td>
<td>80</td>
</tr>
</tbody>
</table>

5-year relative survival rates based on patients diagnosed from 2002 to 2008, all followed through 2009.
Geographic Variation
Estimated Numbers of New Cases and Deaths – by Sex and Site - 2000

- Men: 5.3 million cases, 4.7 million deaths
- Women: 4.7 million cases, 2.7 million deaths

- Lung: Men (902, 337), Women (810, 293)
- Breast: Men (810, 370), Women (1050, 446)
- Colon/Rectum: Men (499, 234), Women (1050, 446)
- Stomach: Men (558, 318), Women (165)
- Liver: Men (398, 166), Women (165)
- Prostate: Men (543, 233), Women (471)
- Cervix uteri: Men (279, 111), Women (233)
- Oesophagus: Men (227, 133), Women (111)
- Bladder: Men (260, 76), Women (99)
- Non-Hodgkin lymphoma: Men (167, 121), Women (93)
- Leukaemia: Men (144, 113), Women (86)
- Oral cavity: Men (170, 97), Women (81)
- Pancreas: Men (116, 101), Women (101)
- Kidney: Men (119, 71), Women (67)
- Ovary: Men (114, 192)

Estimated Numbers of New Cases of the 12 Most Common Cancers in Developed and Developing Countries – Males - 2000

Estimated Numbers of New Cases of the 12 Most Common Cancers in Developed and Developing Countries – Females - 2000

Geographic Variation

Exposure to Carcinogens
Incidence of Lung Cancer: 
Age-Standardized Rates Males -2000

Incidence of Lung Cancer: Age-Standardized Rates Females - 2000

Cancer Mortality Rates by County (Age-adjusted 1970 US Population)
Lung, Trachea, Bronchus, and Pleura: White Males, 1970-94

US = 69.40/100,000

91.04-150.47 (highest 10%)
83.81-91.03
78.16-83.80
73.80-78.15
69.41-73.79
65.15-69.40
60.75-65.14
54.51-60.74
46.12-54.50
13.17-46.11 (lowest 10%)
Sparse data (43 counties: 0.01% of deaths)
Incidence of Liver Cancer: Age-Standardized Rates - 2000

Prevalence of Hepatitis B Virus Surface Antigen Carriers

Geographic Variation

Lifestyle Factors
Incidence of Breast Cancer: Age-Standardized Rates - 2000

Incidence of Colorectal Cancer: Age-Standardized Rates- 2000

Relative risk of mortality from cancer of the stomach, liver, and colon among Japanese men in Japan, Japanese men in California, and sons of Japanese immigrants compared with white men in California.
Racial Variation
Multiple Myeloma, by Race & Sex

**Incidence**

**Mortality**
Non Hodgkin Lymphoma, by Race & Sex

Incidence

Mortality
Risk Factors

Un-modifiable
Age and Disease

• # 1 risk factor for most diseases, including cancer
  – chronic exposure to etiologic agent
  – exposure to multiple etiologic agents
  – latent period
  – decreased immune function
  – increased comorbidity
Projections of Cancer Cases between 2000 and 2050

Thousands

3000
2250
1500
750
0

Source: SEER program, NCI and US Census Bureau
Risk Factors – Un-modifiable

- Family history of cancer
- Reproductive factors
- Physical / ethnic characteristics
- Residential or occupational characteristics
Risk Factors – Un-modifiable

- Family history of cancer
  - Colon cancer
    - Adenomous polyposis coli (APC), hereditary non-polyposis colon cancer (HNPCC)
  - Breast cancer
    - BRCA1, BRCA2, ATM
  - Ovarian cancer
    - BRCA1, BRCA2
  - Prostate Cancer
Risk Factors – Un-modifiable

- Reproductive factors
  - Breast cancer
    - Age at menarche, age at menopause, age at first birth, parity, breastfeeding
  - Ovarian cancer
    - Parity, breast feeding
  - Endometrial cancer
    - Age at menopause, infertility, breast feeding
Risk Factors – Un-modifiable

• Physical / ethnic characteristics
  – Melanoma
    • Skin type, eye color
  – Breast and ovarian cancer
    • Ashkenazi Jewish ethnicity
  – Prostate cancer
    • African-American ethnicity
Risk Factors – Un-modifiable

- Residential or occupational characteristics
  - Leukemia, thyroid cancer, breast cancer, lung cancer
    - Radiation exposure
  - Bladder cancer
    - Dye workers (Benzidine)
  - Lung cancer
    - Asbestos workers
  - Liver cancer
    - Vinyl chloride manufacture
Risk Factors

Modifiable
Tobacco Use

• Major preventable cause of disease and premature death in the US

• Increased risk for cancer of the lung, mouth, larynx, pharynx, esophagus, pancreas, kidney, bladder, and uterine cervix, colorectal and acute myeloid leukemia

• 30% of all cancer deaths and 87% of lung cancer deaths can be attributed to tobacco

• In 2014, tobacco use is responsible for 1 in 5 deaths or about 480,000 deaths per year
  – 159,260 of these from lung cancer

Tobacco Use in the US, 1900-2004

*Age-adjusted to 2000 US standard population.
Trends in Cigarette Smoking, Adults 18 and Older, US, 1965-2011


Prevalence (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>White</th>
<th>African American</th>
<th>Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>40</td>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>1995</td>
<td>40</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>1997</td>
<td>39</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>1999</td>
<td>31</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td>2001</td>
<td>23</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>2003</td>
<td>23</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>2005</td>
<td>19</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>2007</td>
<td>8</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>2009</td>
<td>7</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>2011</td>
<td>15</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

*Smoked cigarettes on one or more of the 30 days preceding the survey. Whites and African Americans are non-Hispanic.
Source: Youth Risk Behavior Surveillance System, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, 2012.

*Smoked cigarettes on one or more of the 30 days preceding the survey. Whites and African Americans are non-Hispanic.
Source: Youth Risk Behavior Surveillance System, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, 2012.
ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention

• Eat a variety of healthful foods, with an emphasis on plant sources
  – Eat five or more servings of vegetables and fruit each day
  – Choose whole grains in preference to processed (refined) grains and sugars
  – Limit consumption of red meats, especially high-fat and processed meats
  – Choose foods that help maintain a healthful weight
Trends in Consumption of Five or More Recommended Vegetable and Fruit Servings for Cancer Prevention, Adults ≥18, US, 1994-2005

Note: Data from participating states and the District of Columbia were aggregated to represent the United States.
ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention

- Adopt a physically active lifestyle
  - Engage in at least moderate activity for 30 minutes or more on 5 or more days of the week
  - 45 minutes or more of moderate to vigorous activity on 5 or more days per week may further enhance reductions in the risk of breast and colon cancer

Note: Data from participating states and the District of Columbia were aggregated to represent the United States. Educational attainment is for adults 25 and older.

ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention

- Maintain a healthful weight throughout life
  - Balance caloric intake with physical activity
  - Lose weight if currently overweight or obese
## Obesity Definition

<table>
<thead>
<tr>
<th>Category</th>
<th>BMI Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>BMI &lt; 18.5</td>
</tr>
<tr>
<td>Normal weight</td>
<td>BMI 18.5 - 24.9</td>
</tr>
<tr>
<td>Overweight</td>
<td>BMI 25.0 – 29.9</td>
</tr>
<tr>
<td>Obese class I</td>
<td>BMI 30.0 – 34.9</td>
</tr>
<tr>
<td>Obese class II</td>
<td>BMI 35.0 – 39.9</td>
</tr>
<tr>
<td>Obese class III</td>
<td>BMI &gt; 40</td>
</tr>
</tbody>
</table>

Obesity Trends* Among U.S. Adults
(*BMI ≥30, or about 30 lbs. overweight for 5’4” person)
*Obesity=body mass index ≥ 30 kg/m²; estimates are age adjusted to the 2000 US standard population.

*Overweight is defined as at or above the 95th percentile for body mass index by age and sex based on reference data.

Secular Changes in Environment

- Food eaten outside of home
- Food availability
- Portion size shifts
- Food marketing
- Transportation
- Neighborhood safety
- City planning
- TV, video, computer work
- Economy and employment shifts
Health Consequences

- Overweight & Obesity is associated with:
  - Heart disease & cerebrovascular accidents
  - Type 2 Diabetes
  - Gallstones or gallbladder disease
  - Osteoarthritis
  - Gout
  - Sleep apnea
  - Hypertension
  - Hyperlipidemia
  - Pregnancy complications
  - Irregular menses

*JADA* 104(6): 984-1001, 2004
Overweight, Obesity, and Mortality from Cancer in a Prospectively Studied Cohort of U.S. Adults

Eugenia E. Calle, Ph.D., Carmen Rodriguez, M.D., M.P.H., Kimberly Walker-Thurmond, B.A., and Michael J. Thun, M.D.

Body-mass index associated with higher rates of death due to cancer of the esophagus, colon and rectum, liver, gallbladder, pancreas, and kidney, non-Hodgkin's lymphoma, multiple myeloma, stomach, prostate, breast, uterus, cervix, and ovary.

Current patterns of overweight/obesity in the US could account for 14% of all deaths from cancer in men and 20% of those in women.
Screening
Malignant Progression of Human Cancer

Genetic Alteration
Environmental Exposure

Normal Tissue → Premalignant Lesions → Primary Tumor → Metastasis

- Normal Cell
- Premalignant Cell
- Malignant Cell without Metastatic Ability
- Malignant Cell with Metastatic Ability
Screening Guidelines for the Early Detection of Breast Cancer

- Yearly mammograms are starting at age 40
- Clinical breast exam every 3 years for women in their 20s and 30s, and every year for women 40 and older
- Breast self-exam is an option for women starting in their 20s
- Screening MRI is recommended for women with an approximately 20%-25% or greater lifetime risk of breast cancer, including women with a strong family history of breast or ovarian cancer and women treated for Hodgkin Lymphoma

Source: American Cancer Society, [www.cancer.org](http://www.cancer.org)
Percent of women aged 50-74 years who had mammography within the past 2 years by race/ethnicity, 1987-2013

- All Races
- Non-Hispanic White
- Non-Hispanic Black
- Hispanic

Year:
- 1987
- 2000
- 2013

Percent of women:
Rates of new cases of late stage breast cancer, 1980-2011

- Rising 1980-1986
  - APC = 1.05*
- Rising 1993-2001
  - APC = 1.48*
- Stable 2004-2011
  - APC = -0.29

Healthy People 2020 Target (38.9)

- Falling 1986-1993
  - APC = -2.83*
- NSC 2001-2004
  - APC = -2.30

Recent Trend 2007-2011
- Stable
  - AAPC = -0.29
Screening Guidelines for the Early Detection of Cervical Cancer

- Start about 3 yrs after a woman begins having intercourse, but no later than age 21
- Every year with regular Pap tests or every 2 yrs using liquid-based tests
- At or after age 30, women who have had three normal test results in a row may get screened every 2-3 years
- Woman with certain risk factors such as HIV or weakened immune system should get screened more frequently
- Women 70 and older who have had 3 or more consecutive negative Pap tests in the last 10 yrs may choose to stop cervical cancer screening
- Screening after a total hysterectomy (with removal of the cervix) is not necessary unless the surgery was done as a treatment for cervical cancer.

Source: American Cancer Society, www.cancer.org
Percent of women aged 21-65 years who had a pap smear test within the past 3 years by race/ethnicity, 1987-2013

[Graph showing trends over time with different markers for race/ethnicity]
Screening Guidelines for Early Detection of Colorectal Cancer & Adenomas

Beginning at age 50, men and women should follow one of the following examination schedules:
• Flexible sigmoidoscopy (FSIG) every five years
• Colonoscopy every ten years
• Double-contrast barium enema every five years
• CT colonography every five years
• Fecal occult blood test (FOBT) or a fecal immunochemical test (FIT) every year
• Stool DNA test (interval uncertain)

People who are at moderate or high risk for colorectal cancer should talk with a doctor about a different testing schedule.

Source: American Cancer Society, www.cancer.org
Income

Education

Colorectal test use rates for adults aged 50-75 years by poverty income level, 2000-2013

Colorectal test use rates for adults aged 50-75 years by highest level of education obtained, 2000-2013

http://progressreport.cancer.gov/sites/default/files/graphs/
Screening Guidelines for Early Detection of Prostate Cancer

• Prostate-specific antigen (PSA) test and digital rectal examination (DRE) should be offered annually, beginning at age 50, to men who have a life expectancy of at least 10 years.

• Men at high risk (African-American men and men with a strong family history) should begin testing at age 45.

• For men at average risk and high risk, information should be provided about what is known and what is uncertain about the benefits and limitations of early detection and treatment of prostate cancer so that they can make an informed decision about testing.

Source: American Cancer Society, www.cancer.org
Recent* Prostate-Specific Antigen (PSA) Test Prevalence (%), by Educational Attainment and Health Insurance Status, Men 50 Years and Older, US, 2001-2006

*A prostate-specific antigen (PSA) test within the past year. Note: Data from participating states and the District of Columbia were aggregated to represent the United States.

Recent* Digital Rectal Examination (DRE) Prevalence (%), by Educational Attainment and Health Insurance Status, Men 50 Years and Older, US, 2001-2006

*A digital rectal examination (DRE) within the past year. Note: Data from participating states and the District of Columbia were aggregated to represent the United States.