Cancer Epidemiology
EPI 252/PH258 – Spring 2014

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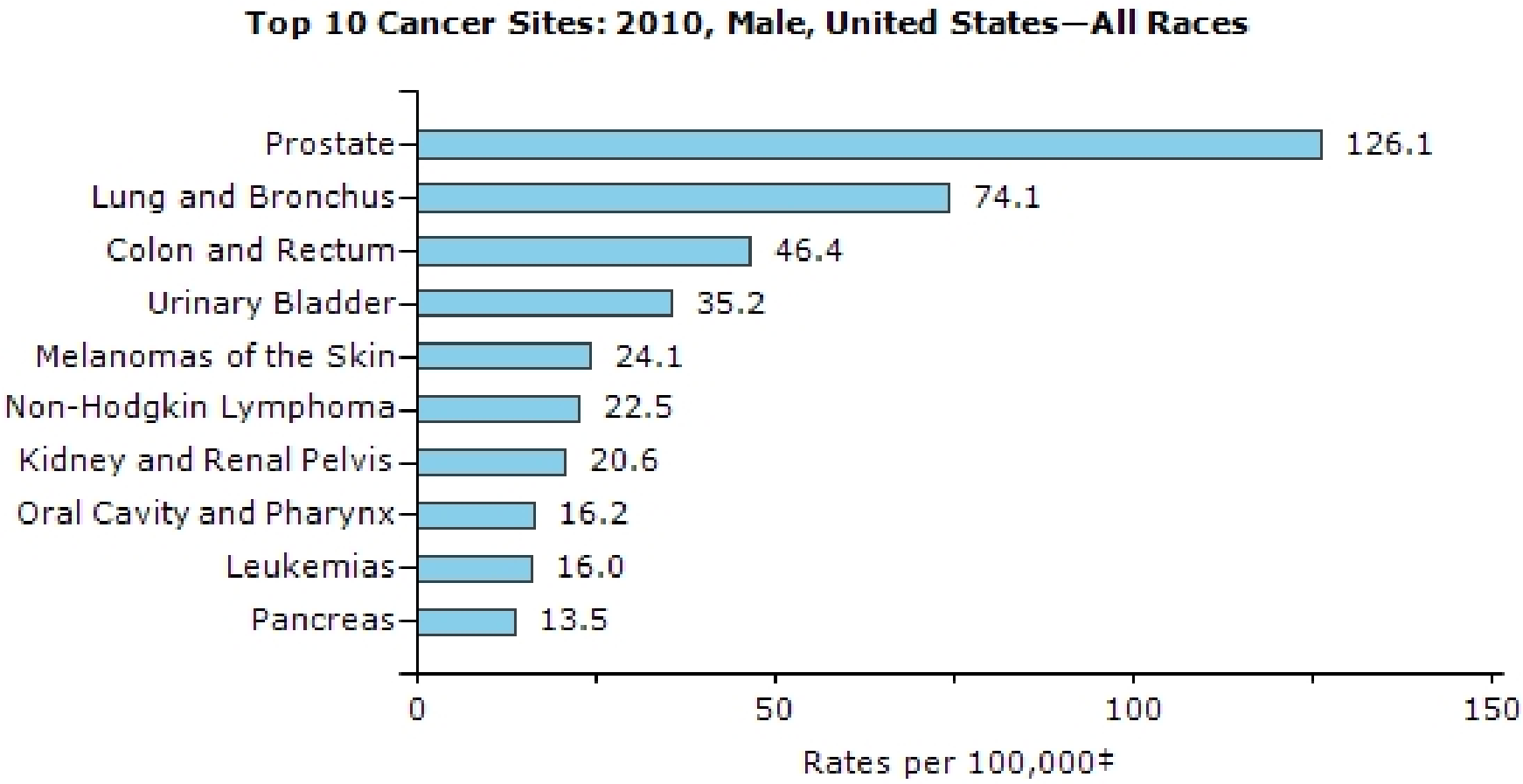
Overall Burden in the US

- Every year, cancer claims the lives of more than half a million.
- Cancer is the second leading cause of death after heart disease.

  ~ One of every four deaths is due to cancer

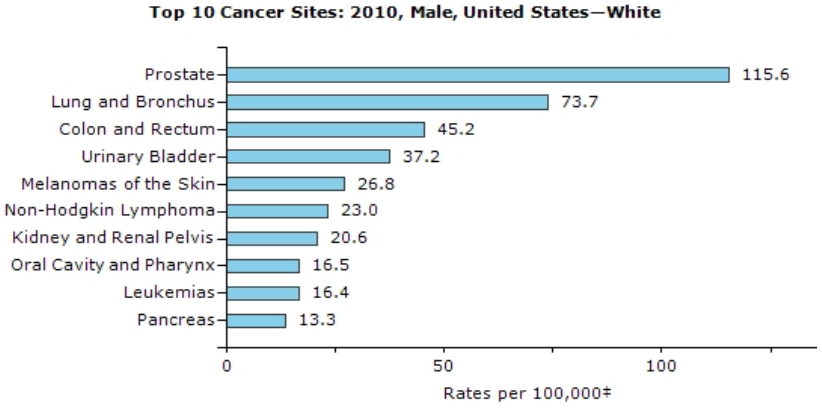
  ~574,700 people total died of cancer in 2010

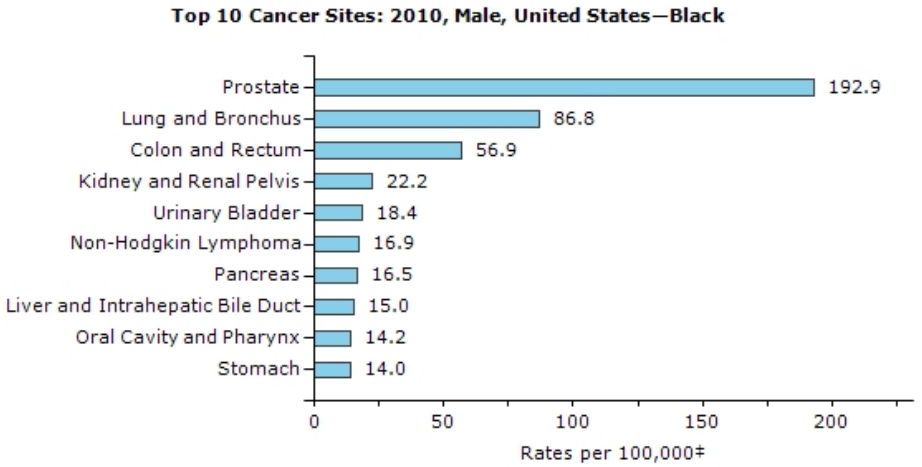
  ~1,600 people a day

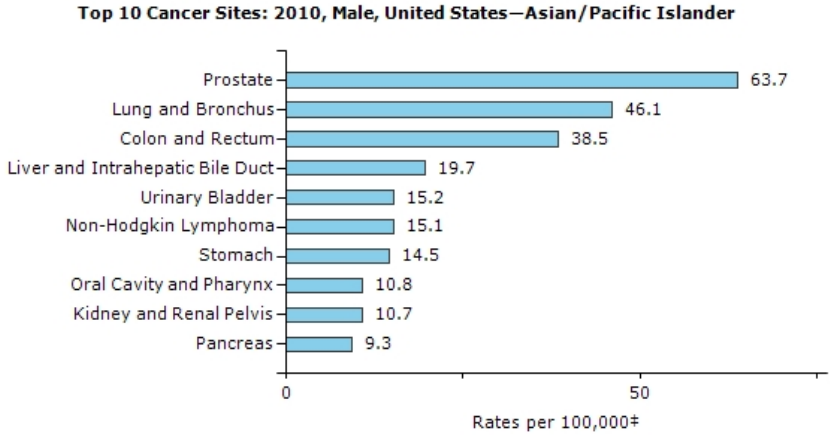


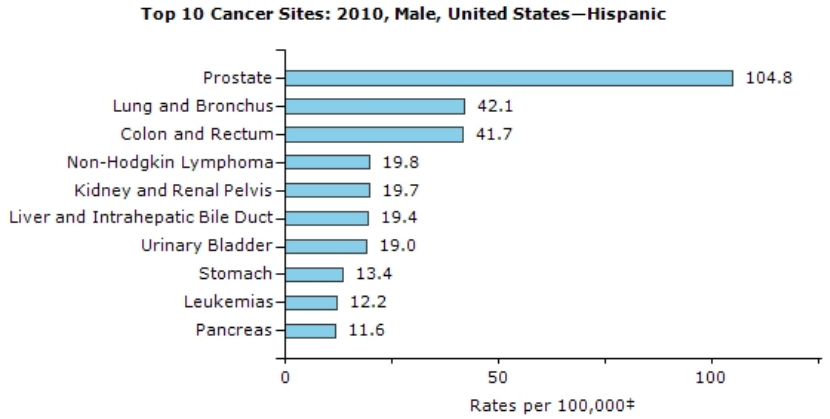
Source: http://apps.nccd.cdc.gov/uscs/

Health Disparity, Men









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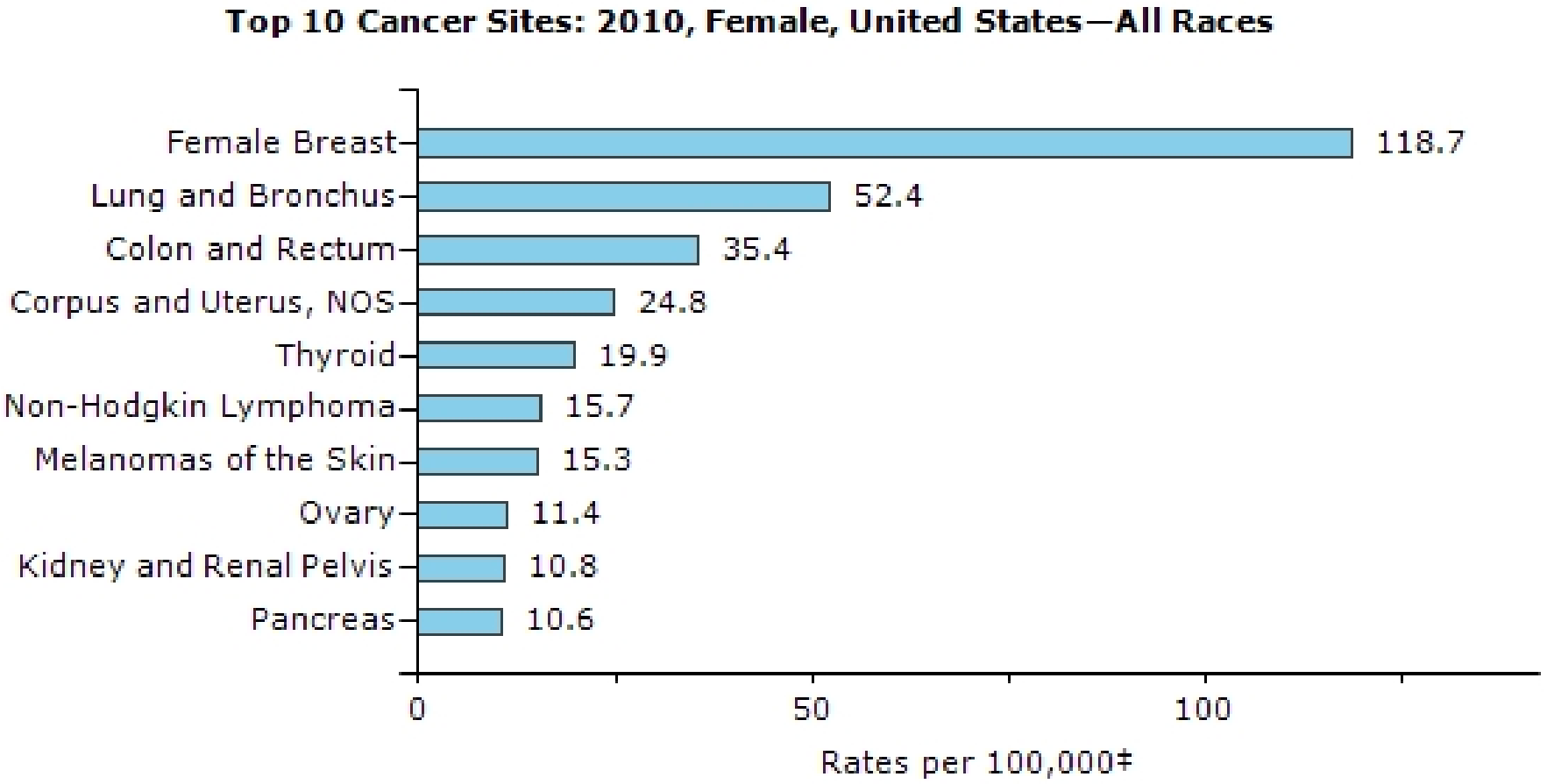
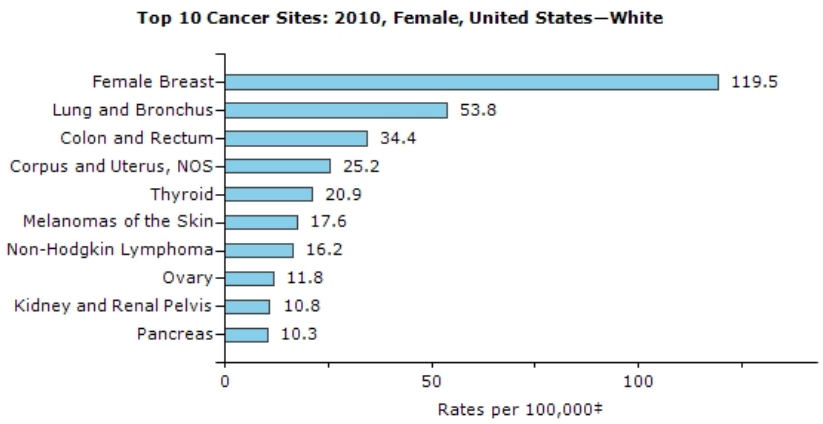
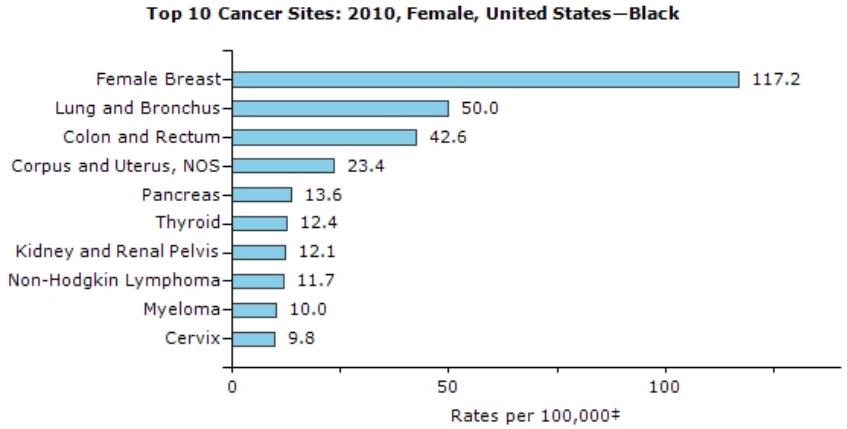
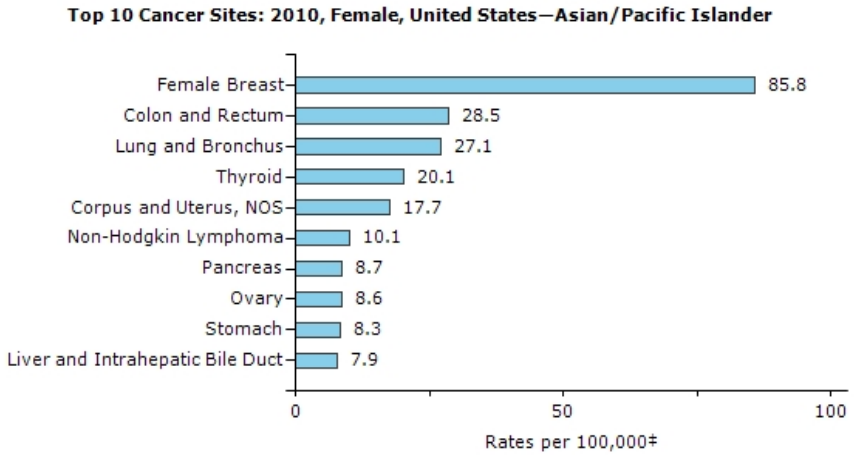


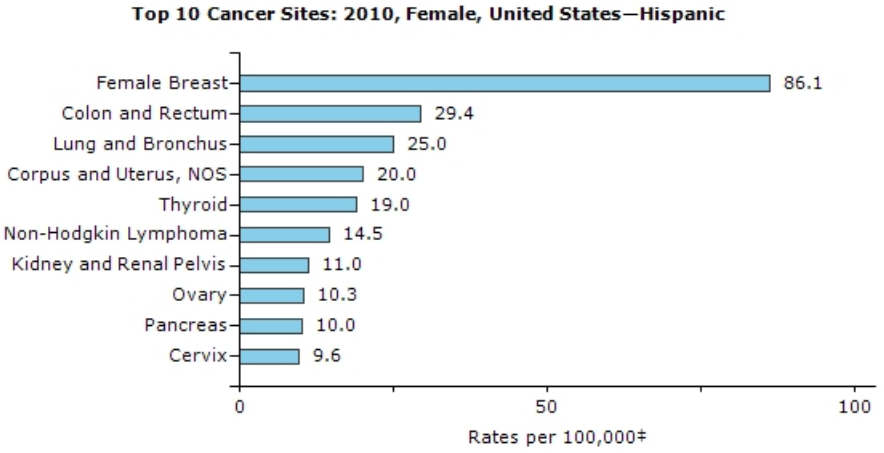
Source: http://apps.nccd.cdc.gov/uscs/

Health Disparity, Women



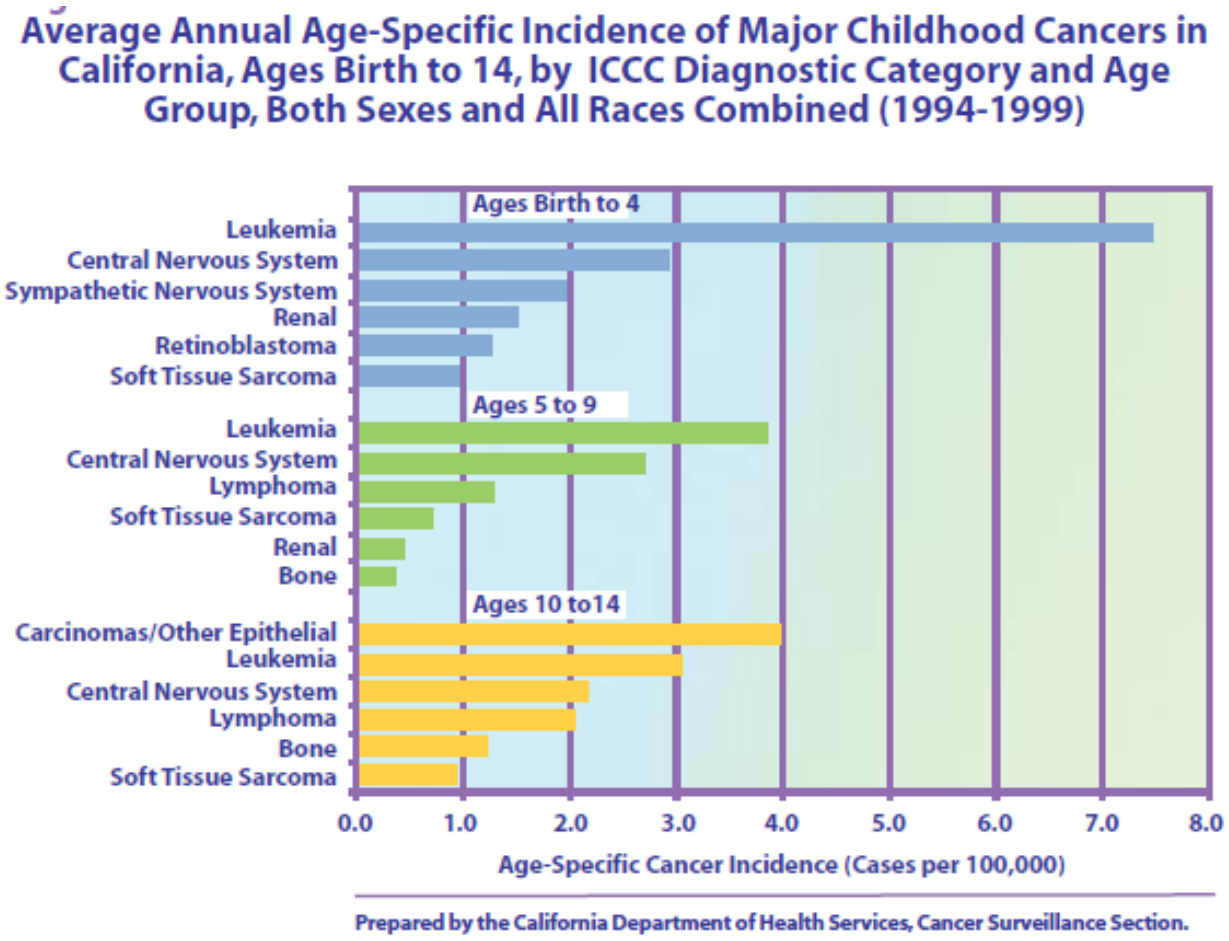






Source: http://apps.nccd.cdc.gov/uscs/

Childhood Cancers, California

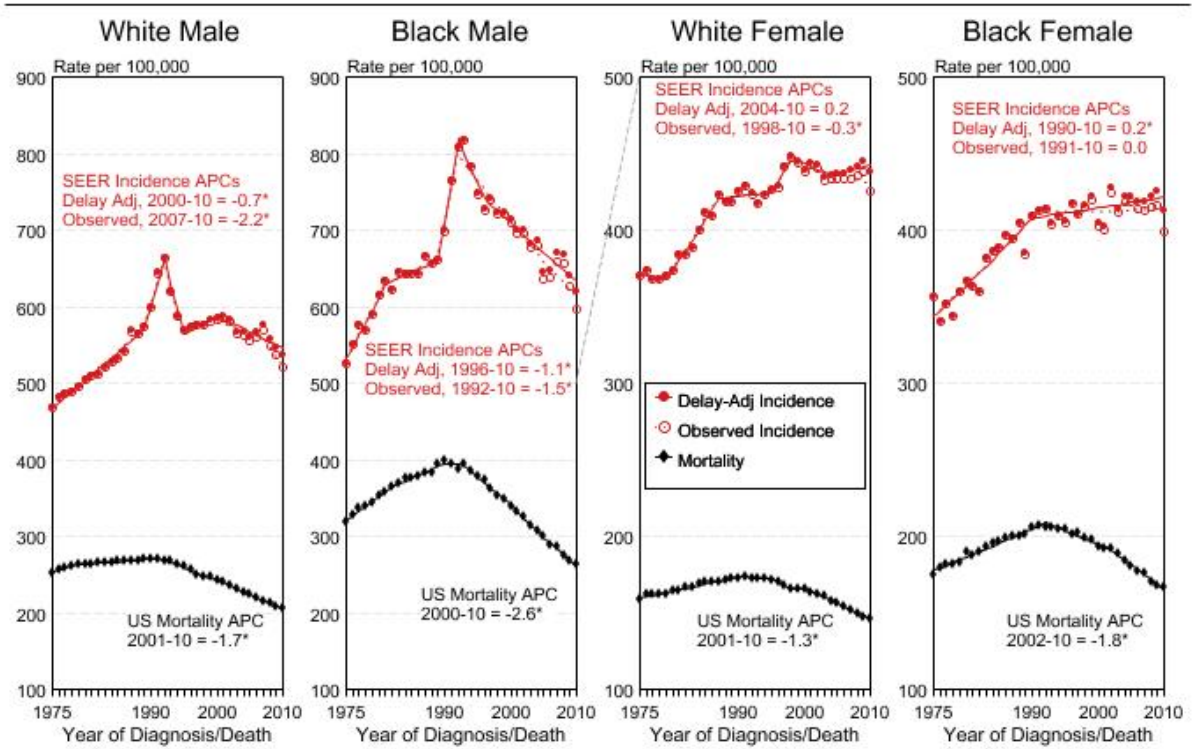


Campleman SL, Wright WE. Childhood Cancer in California 1988 to 1999 Volume I: Birth to Age 14. Sacramento, CA: California Department of Health Services, Cancer Surveillance Section, July 2004.

Incidence and Mortality Trend

Figure 2.1

SEER Observed Incidence, SEER Delay Adjusted Incidence and US Death Rates[a]
All Cancer Sites, by Race and Sex



[a] Source: SEER 9 areas and US Mortality Files (National Center for Health Statistics, CDC).
Rates are age-adjusted to the 2000 US Std Population (19 age groups - Census P25-1103).
Regression lines and APCs are calculated using the Joinpoint Regression Program Version 4.0.3, April 2013, National Cancer Institute.
The APC is the Annual Percent Change for the regression line segments. The APC shown on the graph is for the most recent trend.
* The APC is significantly different from zero ($p < 0.05$).

Source: http://seer.cancer.gov/csr/1975_2010/browse_csr.php

Annual Report to the Nation on the Status of Cancer, 1975–2009, Featuring the Burden and Trends in Human Papillomavirus (HPV)–Associated Cancers and HPV Vaccination Coverage Levels

Ahmedin Jemal, Edgar P. Simard, Christina Dorell, Anne-Michelle Noone, Lauri E. Markowitz, Betsy Kohler, Christie Eheman, Mona Saraiya, Priti Bandi, Debbie Saslow, Kathleen A. Cronin, Meg Watson, Mark Schiffman, S. Jane Henley, Maria J. Schymura, Robert N. Anderson, David Yankey, Brenda K. Edwards

Manuscript received August 15, 2012; revised October 18, 2012; accepted October 19, 2012.

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Background The American Cancer Society (ACS), the Centers for Disease Control and Prevention (CDC), the National Cancer Institute (NCI), and the North American Association of Central Cancer Registries (NAACCR) collaborate annually to provide updates on cancer incidence and death rates and trends in these outcomes for the United States. This year's report includes incidence trends for human papillomavirus (HPV)–associated cancers and HPV vaccination (recommended for adolescents aged 11–12 years).

Methods Data on cancer incidence were obtained from the CDC, NCI, and NAACCR, and data on mortality were obtained from the CDC. Long- (1975/1992–2009) and short-term (2000–2009) trends in age-standardized incidence and death rates for all cancers combined and for the leading cancers among men and among women were examined by joinpoint analysis. Prevalence of HPV vaccination coverage during 2008 and 2010 and of Papanicolaou (Pap) testing during 2010 were obtained from national surveys.

Results Death rates continued to decline for all cancers combined for men and women of all major racial and ethnic groups and for most major cancer sites; rates for both sexes combined decreased by 1.5% per year from 2000 to 2009. Overall incidence rates decreased in men but stabilized in women. Incidence rates increased for two HPV-associated cancers (oropharynx, anus) and some cancers not associated with HPV (eg, liver, kidney, thyroid). Nationally, 32.0% (95% confidence interval [CI] = 30.3% to 33.6%) of girls aged 13 to 17 years in 2010 had received three doses of the HPV vaccine, and coverage was statistically significantly lower among the uninsured (14.1%, 95% CI = 9.4% to 20.6%) and in some Southern states (eg, 20.0% in Alabama [95% CI = 13.9% to 27.9%] and Mississippi [95% CI = 13.8% to 28.2%]), where cervical cancer rates were highest and recent Pap testing prevalence was the lowest.

Conclusions The overall trends in declining cancer death rates continue. However, increases in incidence rates for some HPV-associated cancers and low vaccination coverage among adolescents underscore the need for additional prevention efforts for HPV-associated cancers, including efforts to increase vaccination coverage.

J Natl Cancer Inst

Cancer Sites with Increasing Incidence

- Men
  - Kidney
  - Pancreas
  - Liver
  - Thyroid
  - Melanoma
  - Myeloma
- Women
  - Kidney
  - Pancreas
  - Liver
  - Thyroid
  - Melanoma
  - Leukemia
  - Uterus

Major Causes of Cancers – 1980's

Proportions of cancer deaths attributed to various different factors

Text section No.	Factor or class of factors	Per cent of all cancer deaths: Best Estimate	Per cent of all cancer deaths: Range of acceptable Estimates
5.1	Tobacco	30	25–40
5.2	Alcohol	3	2–4
5.3	Diet	35	10–70
5.4	Food Additives	<1	-5[a]–2
5.5	Reproductive [b] and sexual behaviour	7	1–13
5.6	Occupation	4	2–8
5.7	Pollution	2	<1–5
5.8	Industrial products	<1	<1–2
5.9	Medicines and medical procedures	1	0.5–3
5.10	Geographical factors [c]	3	2–4
5.11	Infections	10?	1–?
5.12	Unknown	?	?

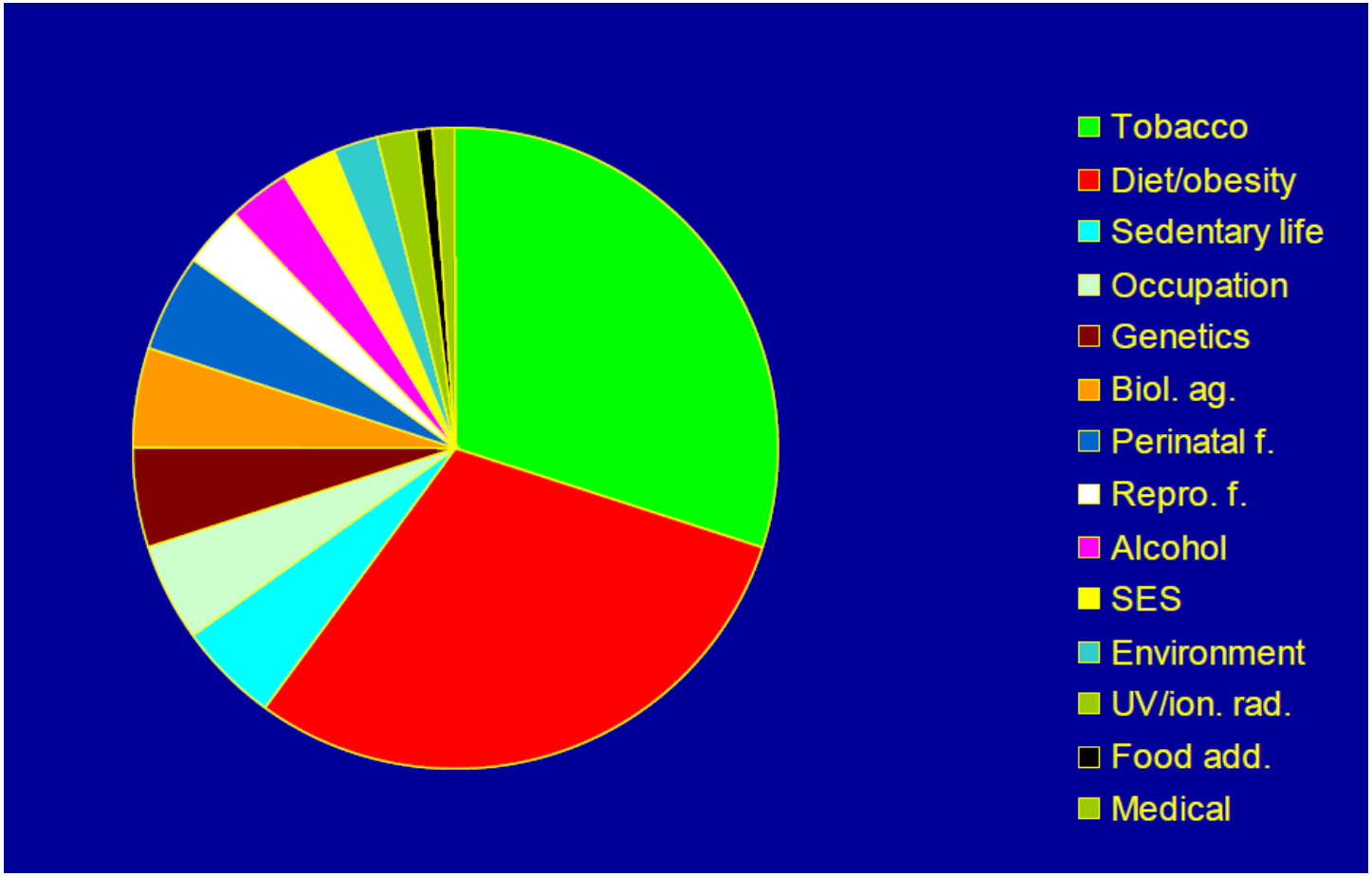
a Allowing for a possibly protective effect of antioxidants and other preservatives.

b See section 5.5 for intended meaning.

c Only about one per cent, not three per cent could reasonably be described as "avoidable" (see text). Geophysical factors also cause a much greater proportion of non-fatal cancers (up to 30 per cent of all cancers, depending on ethnic mix and latitude) because of the importance of UV light in causing the relatively non-fatal basal cell and squamous cell carcinomas of sunlight-exposed skin.

(Table from *The Causes of Cancer* JNCI, Volume 6, June 1981)

Major Causes of Cancers – 1990's



Major Causes of Cancers – 2010

The fraction of cancer attributable to lifestyle and environmental factors in the UK in 2010

R Peto[*,1]

[1]*University of Oxford, Oxford, UK*

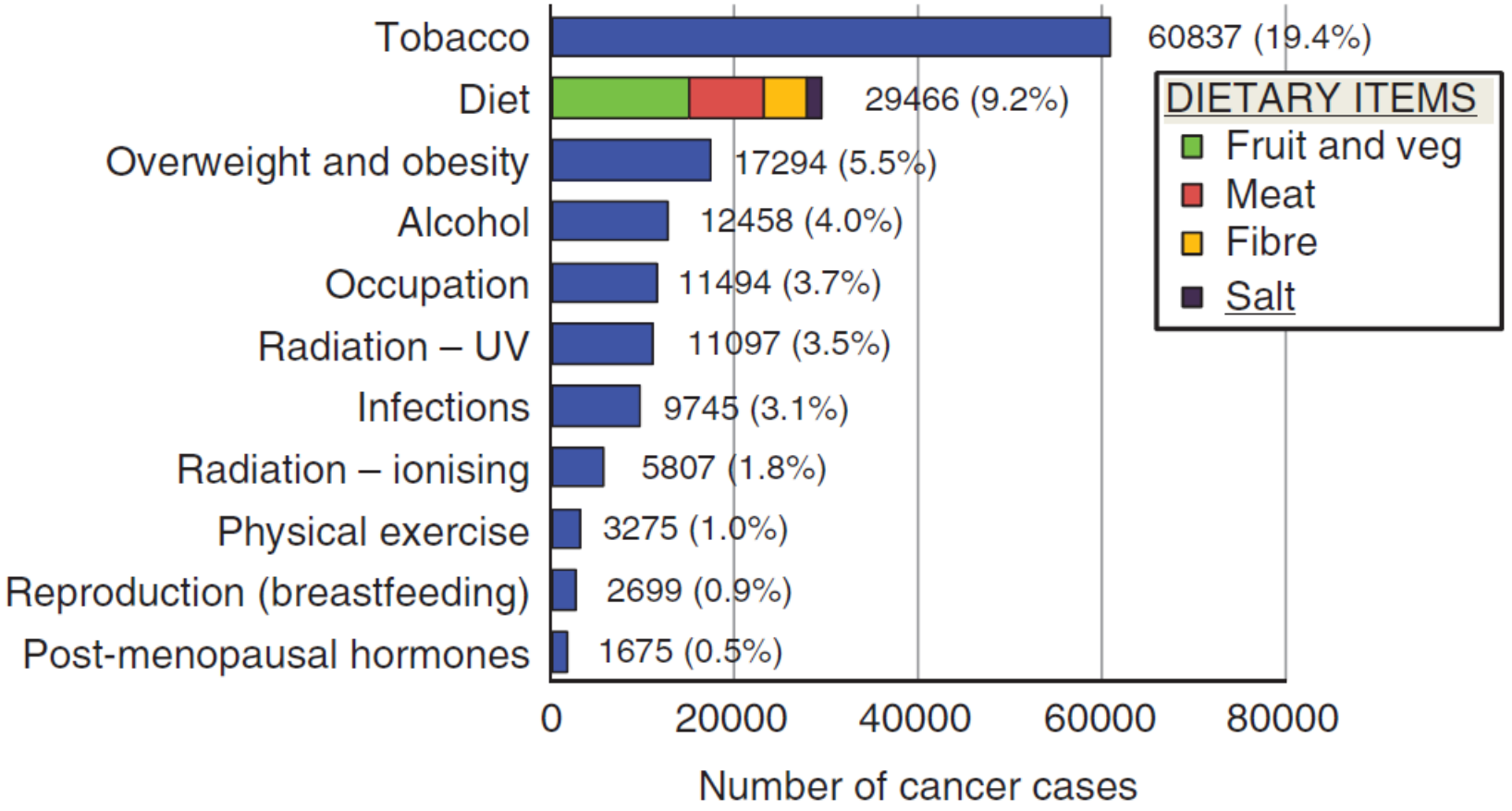
British Journal of Cancer advance online publication, ; doi:10.1038/bjc.2011.473 www.bjcancer.com

This supplement provides up-to-date estimates of the numbers (and percentages) of new cancer cases in the UK that are attributable to factors that have been established by international consensus as potentially avoidable causes of the disease. It therefore offers a useful guide to the relative importance of different preventive interventions.

Excluded from consideration are factors that, although known to be effective in reducing the risk of numerically important cancers, do not offer acceptable or practical preventive strategies at present. Early and multiple childbearing (to prevent breast cancer) and the widespread use of anti-androgen drugs (to prevent prostate cancer) quantify cancer mortality, for about 25% of all deaths from cancer, plus similar numbers of deaths from other diseases).

Taken together, the causative factors reviewed in this supplement account for an estimated 43% of all new cases of cancer in the UK (approximately 134 000 new cases in 2010), and about 50% of all cancer deaths. Most of these cases of cancer (excluding a few thousand due to the natural background of ionising radiation, or due to certain infections that are currently neither preventable nor treatable) could have been prevented by methods that would also prevent many premature deaths from other non-communicable disease. Over the past 40 years in the UK, the probability of death

Number and % of Cancer Cases in the UK Attributable to Various Exposures



British Journal of Cancer (2011) **105**(S2), S6–S13

IARC: International Agency for Research on Cancer

REVIEW

Preventable Exposures Associated With Human Cancers

Vincent James Cogliano, Robert Baan, Kurt Straif, Yann Grosse, Béatrice Lauby-Secretan, Fatiha El Ghissassi, Véronique Bouvard, Lamia Benbrahim-Tallaa, Neela Guha, Crystal Freeman, Laurent Galichet, Christopher P. Wild

Manuscript received November 10, 2010; revised October 13, 2011; accepted October 14, 2011.

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Information on the causes of cancer at specific sites is important to cancer control planners, cancer researchers, cancer patients, and the general public. The International Agency for Research on Cancer (IARC) Monograph series, which has classified human carcinogens for more than 40 years, recently completed a review to provide up-to-date information on the cancer sites associated with more than 100 carcinogenic agents. Based on IARC's review, we listed the cancer sites associated with each agent and then rearranged this information to list the known and suspected causes of cancer at each site. We also summarized the rationale for classifications that were based on mechanistic data. This information, based on the forthcoming IARC Monographs Volume 100, offers insights into the current state-of-the-science of carcinogen identification. Use of mechanistic data to identify carcinogens is increasing, and epidemiological research is identifying additional carcinogens and cancer sites or confirming carcinogenic potential under conditions of lower exposure. Nevertheless, some common human cancers still have few (or no) identified causal agents.

J Natl Cancer Inst 2011;103:1827–1839

IARC Classification

Carcinogenic Agents	Cancer sites with sufficient evidence in humans	Cancer sites with limited evidence in humans	Mechanistic studies (animal/in vivo/ in vitro studies)
Chemicals & Mixtures			
Occupations			
Metals			
Dusts & Fibers			
Radiation			
Biological agents			
Personal habits			
Drugs			

Group 1: Carcinogenic to humans
Group 2A: Probably carcinogenic to humans
Group 2B: Possibly carcinogenic to humans
Group 3: Unclassifiable
Group 4: Probably not carcinogenic to humans

Current Perspective on the Global and United States Cancer Burden Attributable to Lifestyle and Environmental Risk Factors

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Annu. Rev. Public Health 2013. 34:97–117

The *Annual Review of Public Health* is online at publhealth.annualreviews.org

Keywords

cancer epidemiology, cancer prevention, population attributable fractions, multistep carcinogenesis

Table 3 Attributable fractions for selected causes of cancer mortality in the United States and France, and cancer incidence in the United Kingdom

Risk factor	Doll & Peto, United States, 1970s (27)	WHO, France, 2000 (149)	Parkin, United Kingdom, 2010 (96)	Schottenfeld et al., United States, 2000–2010
Tobacco	30% (range	24%	19%	30%
Men	20–40%)	33%	23%	30–35%
Women		6%	16%	20–25%
Alcohol	3% (range 2–4%)	7%	4%	3–4%
Men		9%	4–5%	4–6%
Women		3%	3%	1–2%
Ionizing radiation	1–2%[a]	–	2%	2–3%
Solar radiation	1–2%[a]	0.7%	3.5%[b]	1–2%
Occupation	4% (range	–	–	–
Men	2%–8%)	3–4%	4–5%	3–5%
Women		<1%	<1%	≤1%
Infectious agents	10%	4%	–	≤5–8%
Men		3%	2–3%	–
Women		4%	3–4%	–
Excess body mass	35%[c]	–	5%–6%	≤10%
Men		1–2%	4%	5–10%[d]
Women		3%	6–7%	8–15%[d]
Physical inactivity	–	2%	1%	<5%
Men		<1%	<1%	–
Women		3%	1–2%	–

[a]Solar and ionizing radiations summarized by Doll & Peto under "geophysical."
[b]Cutaneous melanoma.
[c]Excess body mass combined with physical inactivity and other dietary factors.
[d]Higher estimates in nonsmoking population.

SUMMARY POINTS

1. Cancer incidence in low- and middle-income countries (LMICs) is projected to rise because of aging and expansion of the at-risk population, increasing urbanization, and the persistence of exposures to HIV-related cancers, other cancer-causing biologic agents, various forms of tobacco, and various sources of occupational and environmental carcinogenic agents.
2. LMICs experience higher proportions of uterine cervical, oropharyngeal, esophageal, stomach, and liver cancers than do the industrialized countries. Lung and breast cancer are leading global causes of cancer mortality.
3. The epidemiology and pathogenesis of eight lifestyle risk factors are estimated to be determinants of ~60% of cancer mortality in the United States. These risk factors include tobacco, alcohol, ionizing and solar radiations, occupations, biologic agents, obesity, and physical inactivity.

Tobacco

No single measure is known that would have as great an impact on the number of deaths attributable to cancer as a reduction in the use of tobacco.

Doll & Peto (27)

Tobacco Smoke

Complex mixture of thousands of compounds

Numbers and classes of agents that are carcinogenic:

10	polynuclear aromatic hydrocarbons
6	heterocyclic hydrocarbons
4	volatile hydrocarbons
3	nitro hydrocarbons
4	aromatic amines
8	N-heterocyclic amines
11	N-nitrosamines
2	aldehydes
10	organic compounds
3	phenolic compounds
9	inorganic compounds

IARC Monograph Vol 83, 2004.

Secondhand Smoke (SHS)

- Approximately 20-70% (average 47%) of children worldwide are exposed to SHS depending upon country and socio-economic status.
- Contains more than 4,000 chemicals: at least 250 are known to be harmful, and 50 of these are known to cause cancer
- SHS classified as known human carcinogen by IARC (2002)

MMWR, 2007.
IARC Monographs Vol 83 and 100, 2004 and 2009.

Tobacco-attributable cancer burden in the UK in 2010

DM Parkin[*,1]

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British Journal of Cancer (2011) **105,** S6–S13; doi:10.1038/bjc.2011.475 www.bjcancer.com

Table 1 Estimated relative risks (RR) for current smokers aged ⩾35 compared with never-smokers

Cancer	Male	Female
Lung[a]	21.3	12.5
Oral cavity and pharynx[b]	10.9	5.1
Oesophagus[b]	6.8	7.8
Stomach[a]	2.2	1.5
Liver[a]	2.3	1.5
Pancreas[a]	2.2	2.2
Colon–rectum[c]	1.24	1.30
Larynx[b]	14.6	13.0
Cervix[a]	—	1.5
Ovary (mucinous)[d]	—	2.1
Urinary bladder[a]	3.0	2.4
Kidney and renal pelvis[a]	2.5	1.5
Acute myeloid leukaemia[a]	1.9	1.2

[a]From Ezzati *et al* (2005). [b]From US Department of Health and Human Services (2004). [c]From Hannan *et al* (2009). [d]From Jordan *et al* (2006).

Table 4 Relative risks of lung cancer from exposure to ETS (IARC, 2004)

	RR by sex	
Source of exposure to ETS	**Males**	**Females**
At home (spouse)	1.37	1.24
At work (occupational)	1.12	1.19

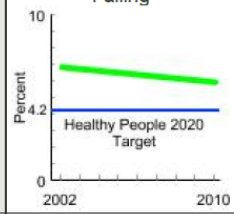
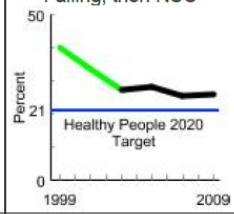
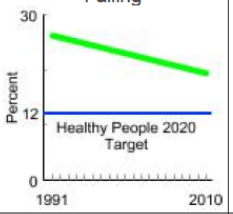
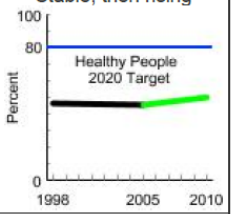
Abbreviations: ETS = environmental tobacco smoke; RR = relative risk.

National Cancer Institute Healthy People Target

http://progressreport.cancer.gov/archive.asp

Measure	Desired Direction	Recent Trend*	Recent Trend Time Period
PREVENTION			
Age at smoking initiation	Rising	Falling	2006-2010
Youth smoking	Falling	NSC	2005-2009
Adult smoking	Falling	Falling	2006-2010
• Non-Hispanic whites	Falling	Falling	2006-2010
• Non-Hispanic blacks	Falling	Falling	2006-2010
• Hispanic	Falling	Falling	2006-2010
Quitting smoking	Rising	Rising	2006-2010
• Non-Hispanic whites	Rising	Rising	2006-2010
• Non-Hispanic blacks	Rising	Rising	2006-2010
• Hispanic	Rising	Rising	2006-2010
Doctor advice to quit smoking	Rising	Rising	2002-2010
Dentist advice to quit smoking	Rising	NSC	2002-2010

Trend key:
- green - headed in the right direction
- red - headed in the wrong direction
- black - stable or non-significant change (NSC)
- blue - Healthy People 2020 target

	Smoking Initiation 2002–2010	Youth smoking 1991–2009	Adult smoking 1991–2010	Quitting smoking 1998–2010
Measure	Percentage of individuals in the groups aged 12–17 years and 18-25 years who said they had initiated smoking during the past 12 months. (Example: 12-17 years)	Percentage of high school students who were current cigarette, cigar, or smokeless tobacco users: Students (Grades 9–12) who reported having used cigarettes, cigars, or smokeless tobacco in the 30 days before the survey.	Percentage of adults who were current cigarette smokers: Adults aged 18 and older who reported smoking 100 or more cigarettes in their lifetime and who, at the time of the interview, continued to smoke every day or some days.	Percentage of adult smokers aged 18 years and older who attempted smoking cessation in the past 12 months. This includes both current smokers who quit smoking for one day or longer and smokers who quit less than one year ago.
Recent summary trend*	Falling 2006–2010	Non-significant change 2005–2009	Falling 2006–2010	Rising 2006–2010
Desired direction	**Falling ▼**	**Falling ▼**	**Falling ▼**	**Rising ▲**
Trend details	Falling 	Falling, then NSC 	Falling 	Stable, then rising 
Most recent estimate	In the 12-17 age group, males and females had similar smoking initiation rates in 2010 (males, 5.7 percent; females, 6.0 percent).	Among high school students in 2009, 19.5 percent were current cigarette smokers, 8.9 percent were current users of smokeless tobacco, 14 percent were current cigar smokers (including little cigars). 26 percent were current users of "any tobacco" product.	In 2010, 19.3 percent of adults aged 18 and older - 21.2 percent of men and 17.5 percent of women - were current cigarette smokers.	In 2010, 50.2 percent of smokers ages 18 and older - 48.7 percent for men, 51.9 percent for women - stopped smoking for one day or longer because they were trying to quit.
Healthy People 2020 target	Decrease the percentage to initiate cigarette smoking to 4.2 percent to initiate cigarette smoking in the 12-17 age group.	Decrease the proportion of high school students who currently: smoke cigarettes to 16 percent; use smokeless tobacco to 6.9 percent; smoke cigars to 8 percent; use any tobacco product to 21 percent.	Reduce to 12% the proportion of adult current cigarette smokers. Reduce to 0.3 percent the proportion of adult current smokeless tobacco users.	Increase to 80% the proportion of adult everyday smokers ages 18 and older, who stopped smoking for a day or longer because they were trying to quit.
	Smoking Initiation	Youth Smoking	Adult Smoking	Quitting Smoking

Obesity: Energy Consumption and Expenditure

[T]he role of overnutrition should perhaps come first rather than a list of aspects of diet which may affect the incidence of cancer, even though the relevant mechanisms remain obscure.

Doll & Peto (27)

8.

Cancers attributable to overweight and obesity in the UK in 2010

DM Parkin[*,1] **and L Boyd**[2]

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Table 4 Numbers and proportion of cases occurring at selected sites attributable to overweight and obesity (UK 2010)

	Excess attributable cases (PAF)		
Cancer	**Male**	**Female**	**Persons**
Oesophagus	1538 (26.9)	315 (11.2)	1853 (21.7)
Gallbladder	381 (9.7)	91 (17.8)	128 (18.3)
Pancreas	523 (12.8)	494 (11.5)	1017 (12.2)
Colorectum	3009 (13.6)	2162 (12.2)	5172 (13.0)
Breast	—	4194 (8.7)	4194 (8.7)
Endometrium	—	2759 (33.7)	2759 (33.7)
Kidney	1422 (25.0)	749 (22.2)	2171 (24.0)
All cancers[a]	6530 (4.1)	10764 (6.9)	17294 (5.5)

Abbreviations: PAF = population-attributable fraction (%). [a]Excluding non-melanoma skin cancer.

Healthy People Target
Diet and Cancer

Measure	Desired Direction	Recent Trend*	Recent Trend Time Period
PREVENTION			
Fruit and vegetable consumption	Rising	NSC	2000-2004
Red meat consumption	Falling	NSC	2000-2004
Fat consumption	Falling	Rising	2004-2008
Alcohol consumption	Falling	Rising	2006-2009
No leisure-time physical activity	Falling	Falling	2006-2010
• Non-Hispanic whites	Falling	Falling	2006-2010
• Non-Hispanic blacks	Falling	Falling	2006-2010
• Hispanic	Falling	Falling	2006-2010
Weight (both sexes)			
• Healthy weight	Rising	Falling	2006-2010
• Overweight	Falling	Stable	2006-2010
• Obese	Falling	Rising	2006-2010

http://progressreport.cancer.gov/archive.asp

Infectious Agents

It would not be surprising if viral infections were eventually shown to be an essential factor in the proportion of various types of cancer. Infections with bacteria or parasites may contribute to the production of disease in other ways. We would, therefore, suggest a figure of about 10% as a very uncertain best estimate of the proportion of cancer deaths attributable to infectious agents.

Doll & Peto (27)

Table 2 Biologic agents and human cancers[a]

Agent	Organ site(s)
Viruses	
HPV	Uterine cervix, oropharyngeal, anogenital
HBV/HCV	Liver, non-Hodgkin lymphoma (HCV)
EBV	Lymphoid tissues: non-Hodgkin lymphomas, including Burkitt, AIDS-related, posttransplant lymphoproliferative disorders; Hodgkin lymphoma; Epithelial tissues: nasopharyngeal carcinoma, gastric carcinoma (?)
HHV-8	Kaposi sarcoma, primary effusion lymphoma, Castleman's multicentric lymphoproliferative disease
HTLV-1	T-cell leukemia, lymphoma
MCPyV	Merkel cell carcinoma (neuroendocrine tumor of dermis)
Bacteria	
Helicobacter pylori	Stomach: carcinoma, B-cell MALT lymphoma (mucosa-associated lymphoid tumor)
Parasites	
Schistosoma haematobium	Urinary bladder
Liver flukes	Liver, bile duct, cholangiocarcinoma
Fungi	
Aspergillus (aflatoxin)	Liver

[a]Abbreviations: EBV, Epstein-Barr virus; HBV, hepatitis B virus; HCV, hepatitis C virus; HHV-8, human herpes virus 8; HPV, human papilloma virus; HTLV-1, human T lymphotropic virus type 1; MCPyV, Merkel cell polyoma virus.