Epidemiology

Spring 2016
Class 1: Introduction

Ali Walker
Faculty of Health Sciences
University of Lethbridge

epidemiologists

…sort of, and only for the camera.

Class 1: Learning Objectives

1. Define epidemiology
2. Learn the *cycle* of epidemiologic work
3. Understand the *4 key aspects* of epidemiology
4. Learn key points about the history of epidemiology

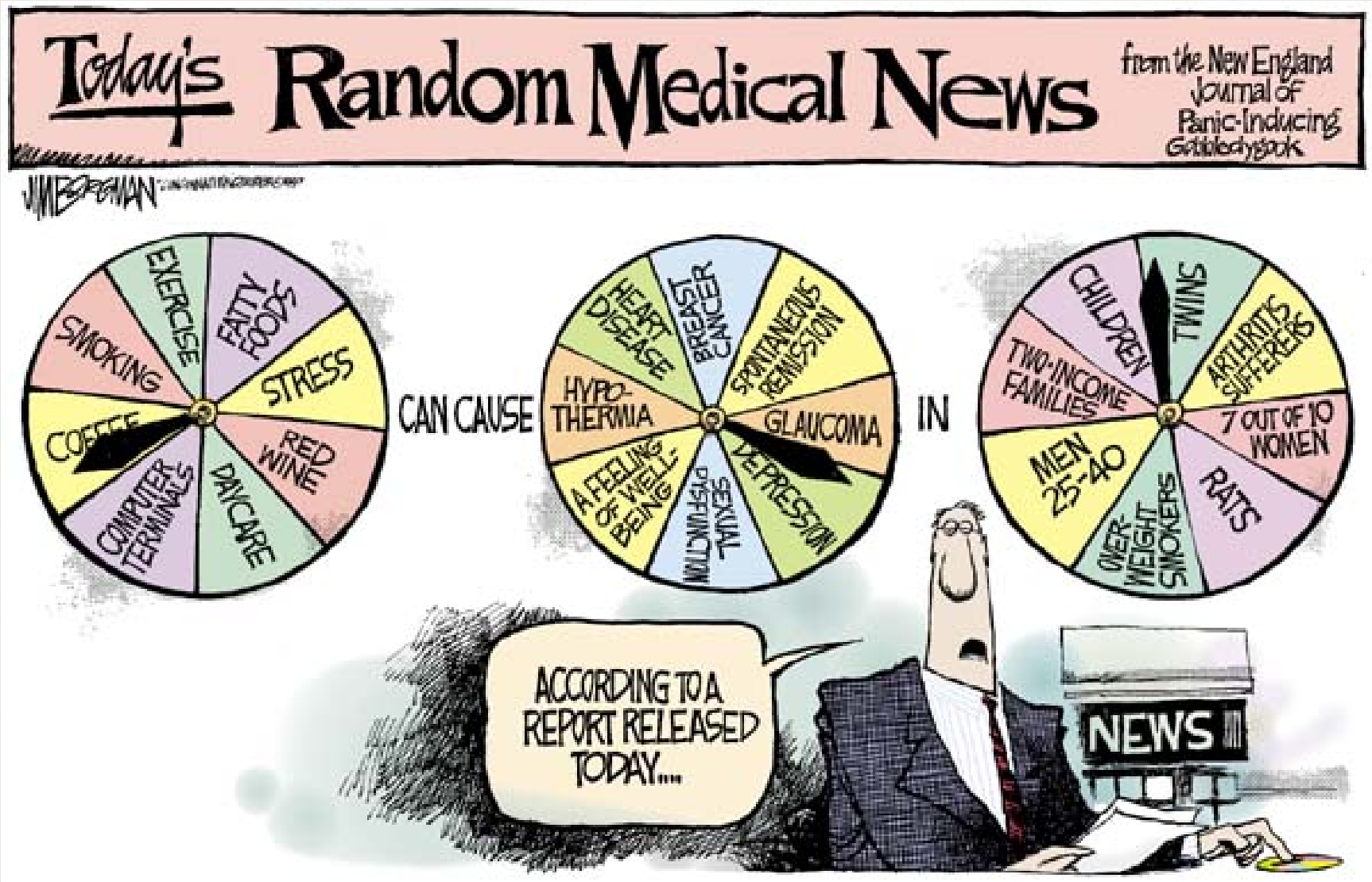
What is Epidemiology?

Its all Greek to me…

epi (upon) + ***demos*** (people) + ***logy*** (study of)

Translation (not the definition):

the study of that which is upon the people

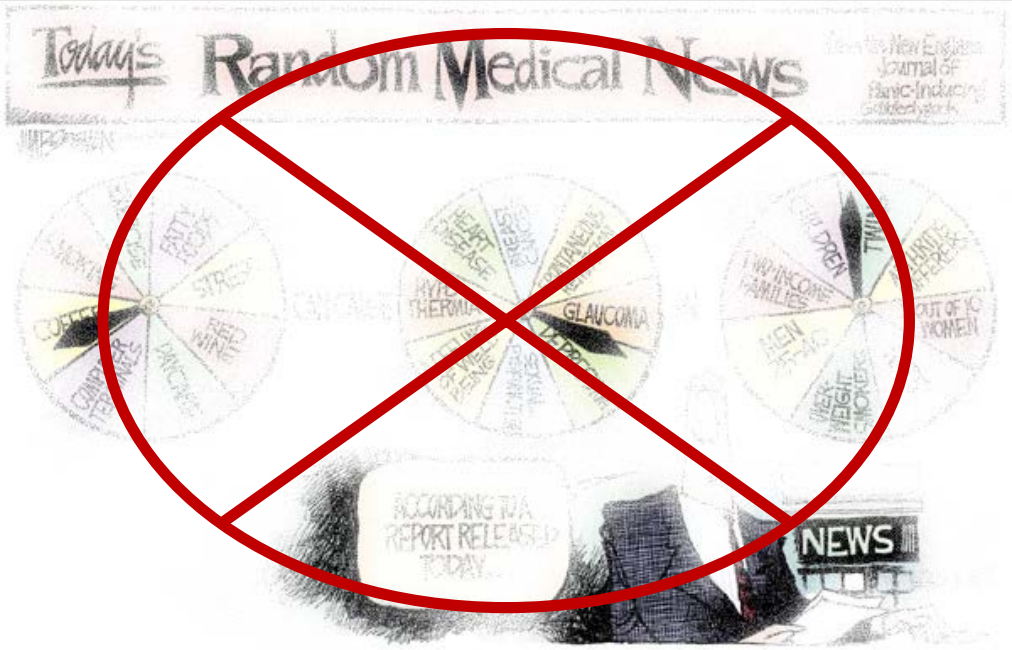


Cartoon by Jim Borgman, first published by the Cincinnati Inquirer and King Features Syndicate 1997 Apr 27; Forum section: 1 and reprinted in the New York Times, 27 April 1997, E4.

Definition of Epidemiology

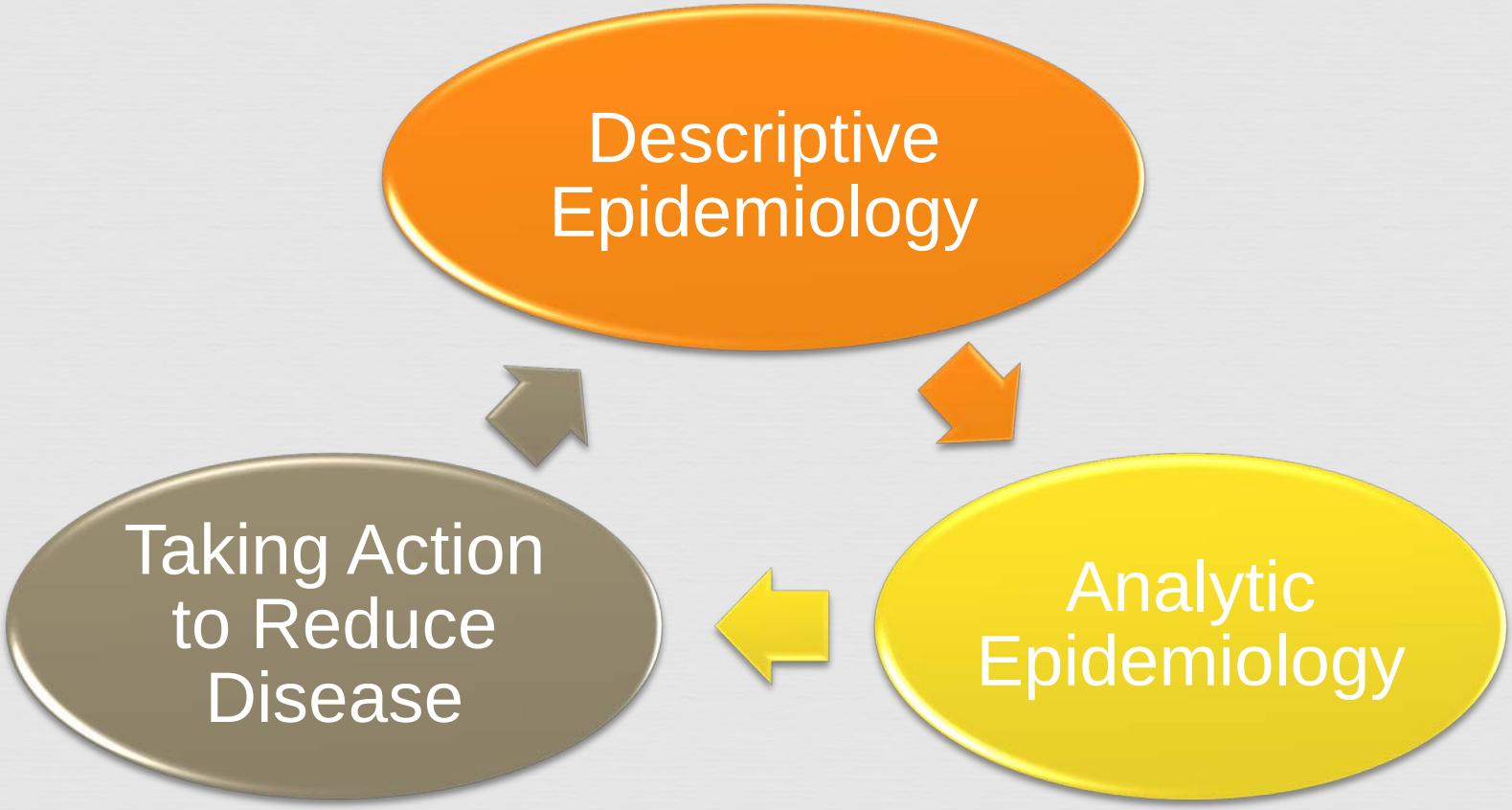
Epidemiology is the study of the **DISTIRUBUTION** and **DETERMINANTS** of health-related states or events in human **POPULATIONS**, and the **APPLICATION** of this study to control health problems.

(Porta, 2008, as cited in Webb and Bain, 2011)

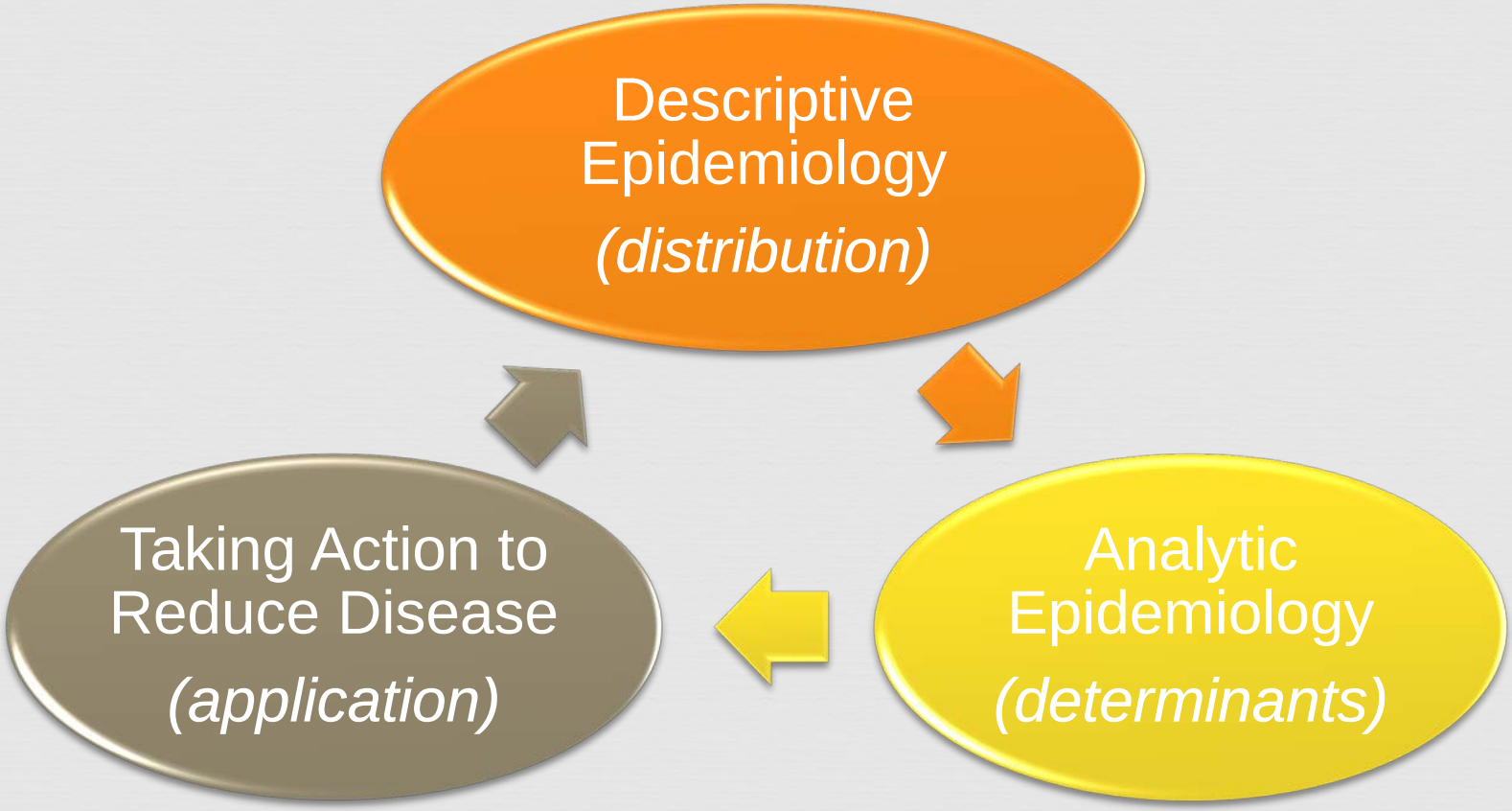


BASIC assumption of Epidemiology is that diseases do not occur randomly within populations, but rather follow predictable patterns that can be studied in relation to their determinants. (CDC, 2012; Patten, 2015)

Cycle in Epidemiologic Work



Cycle in Epidemiologic Work



Epidemiologic research methods are **a powerful tool** for studying the health of populations.

Epidemiology frequently resembles **detective work** because the causes, patterns, and protective determinants of a disease are often unknown.

4 Key Aspects of Epidemiology

(H – P – D – D)

1. Health Phenomena

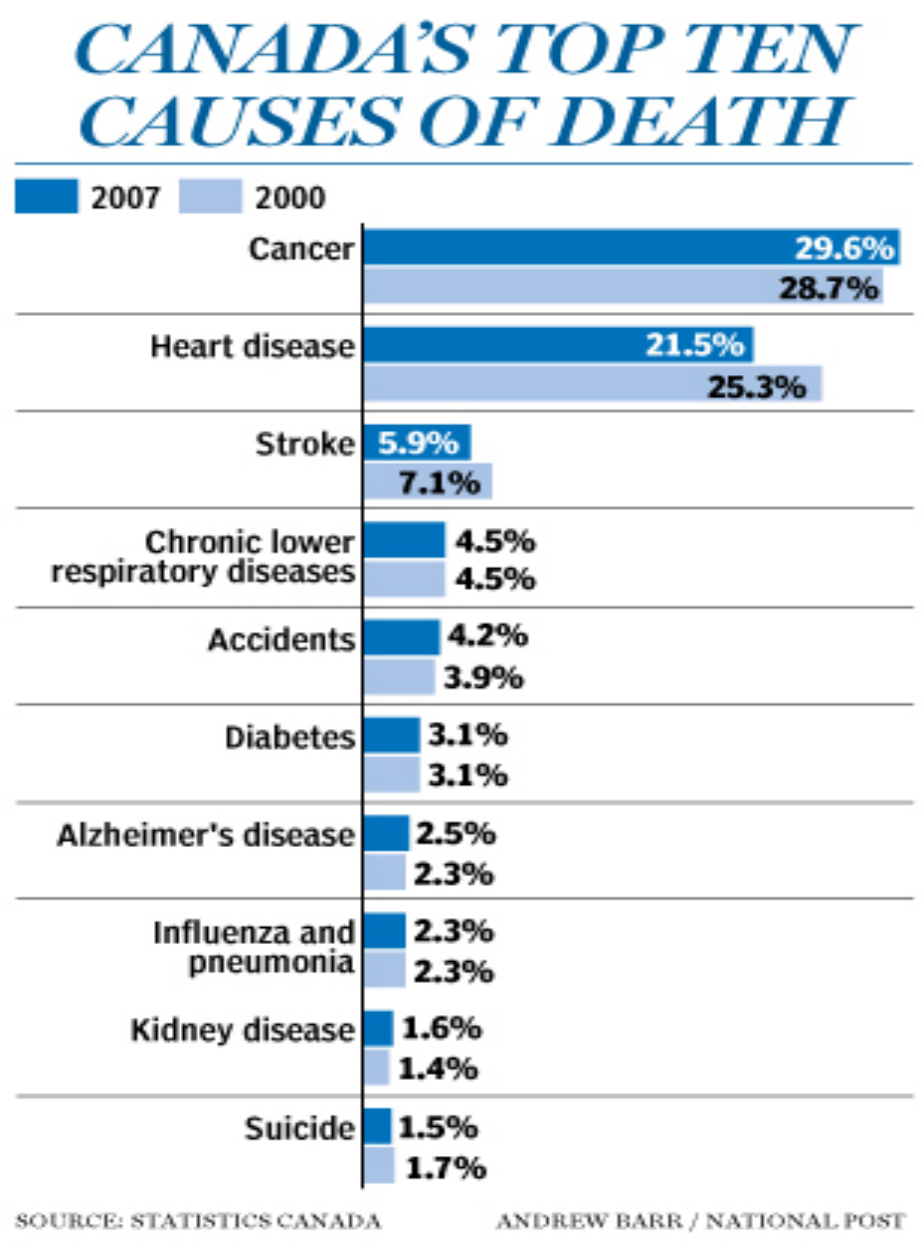
(i.e. health related states or events)

- Chronic disease
- Infectious disease
- Injury
- Disability
- Positive health states

In epidemiology we are interested in measurements of **morbidity** (illness) and **mortality** (death)

Top 3 Killers in Canada:

1. **Cancer**
2. **Heart Disease**
3. **Stroke**



Epidemiology is interested in **positive health-states** too

Besse Cooper had her **116th** birthday in 2012

For this course,

“DISEASE”

=

any health phenomenon of interest

2. **P**opulation-Focused

- We look at the health of populations, not individuals (although relevant to individuals)

- Epidemiology is often called "**population medicine**"

What is a “population”?

- Groups of people
- Removes individual experiences to find patterns in groups
- Groups may be defined geographically or politically
- Groups may also be defined based on certain characteristics (e.g. snowboarders, level of IQ, women who participate in morning yoga classes…)

Major Population Health Shifts

- **Demographic Transition**: Shift from high birth & death rates in farm societies to lower birth & death rates in industrialized countries.

- **Epidemiologic Transition**: In developed countries chronic disease has replaced infectious disease as the major causes of morbidity and mortality.

Epidemiology has a Different Focus

Example: Characteristics of Diabetes

Clinical Description

- Hyperglycemia
- Excessive thirst
- Fatigue
- Blurry vision

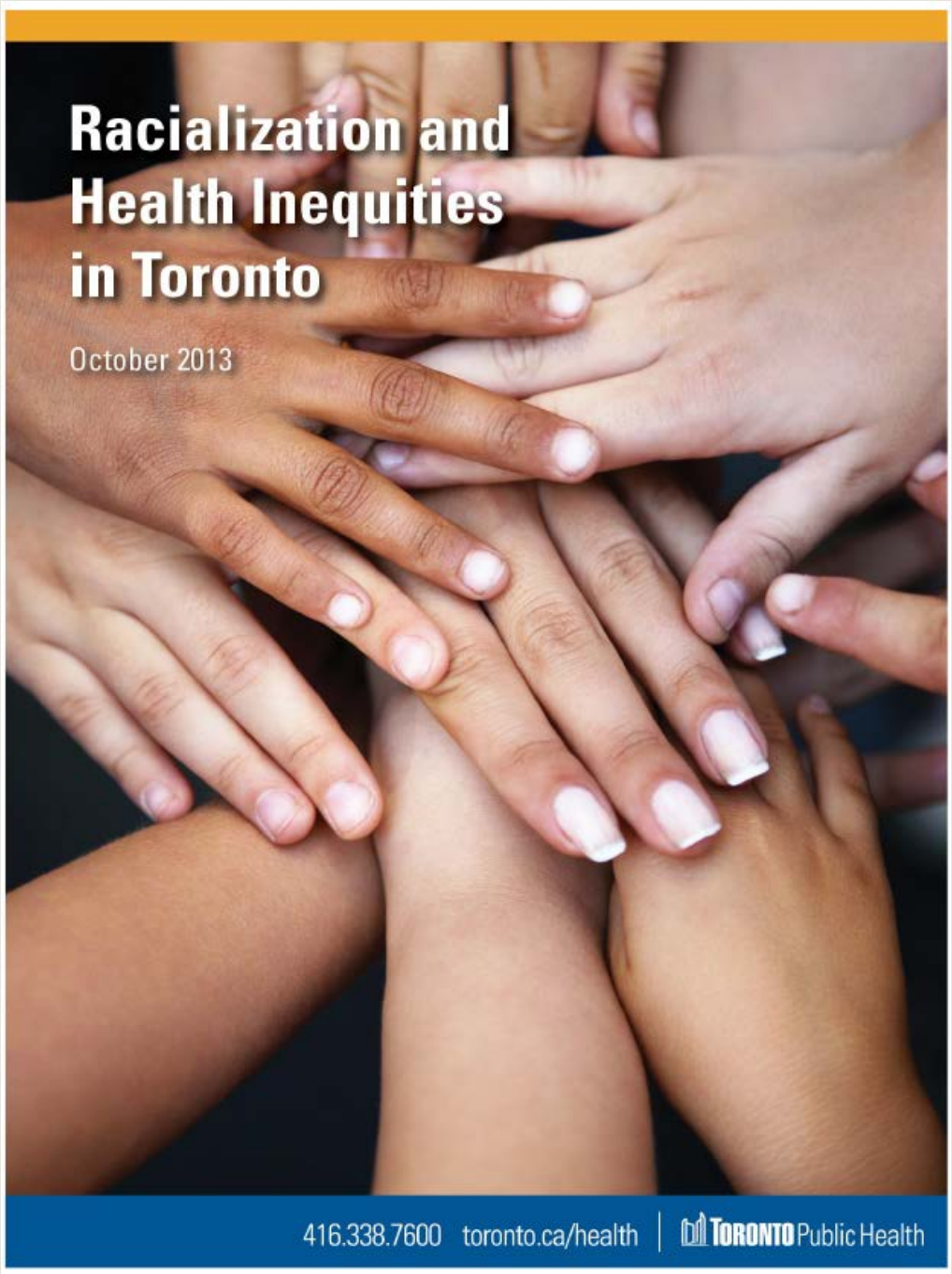
Epidemiologic Description

- 2.4 million Canadians have diabetes (6.8%)
- Higher in males than females
- Rates are lowest in Alberta, Quebec and Nunavut
- 1 in 10 deaths in Canada avoided if diabetes cured.

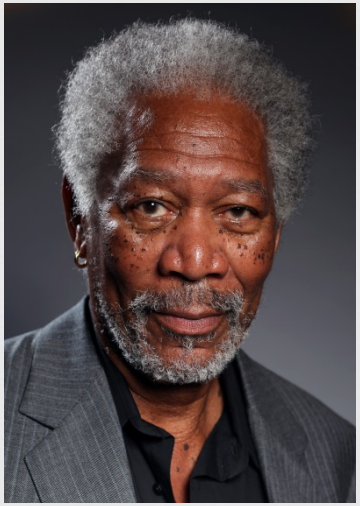
(PHAC, 2011)

3. Distribution

- Describe the distribution of disease by:
  - **PERSON**
  - **PLACE**
  - **TIME**



Person



Which of these men is a greater risk for developing testicular cancer? LINK to answer.

Link to Report

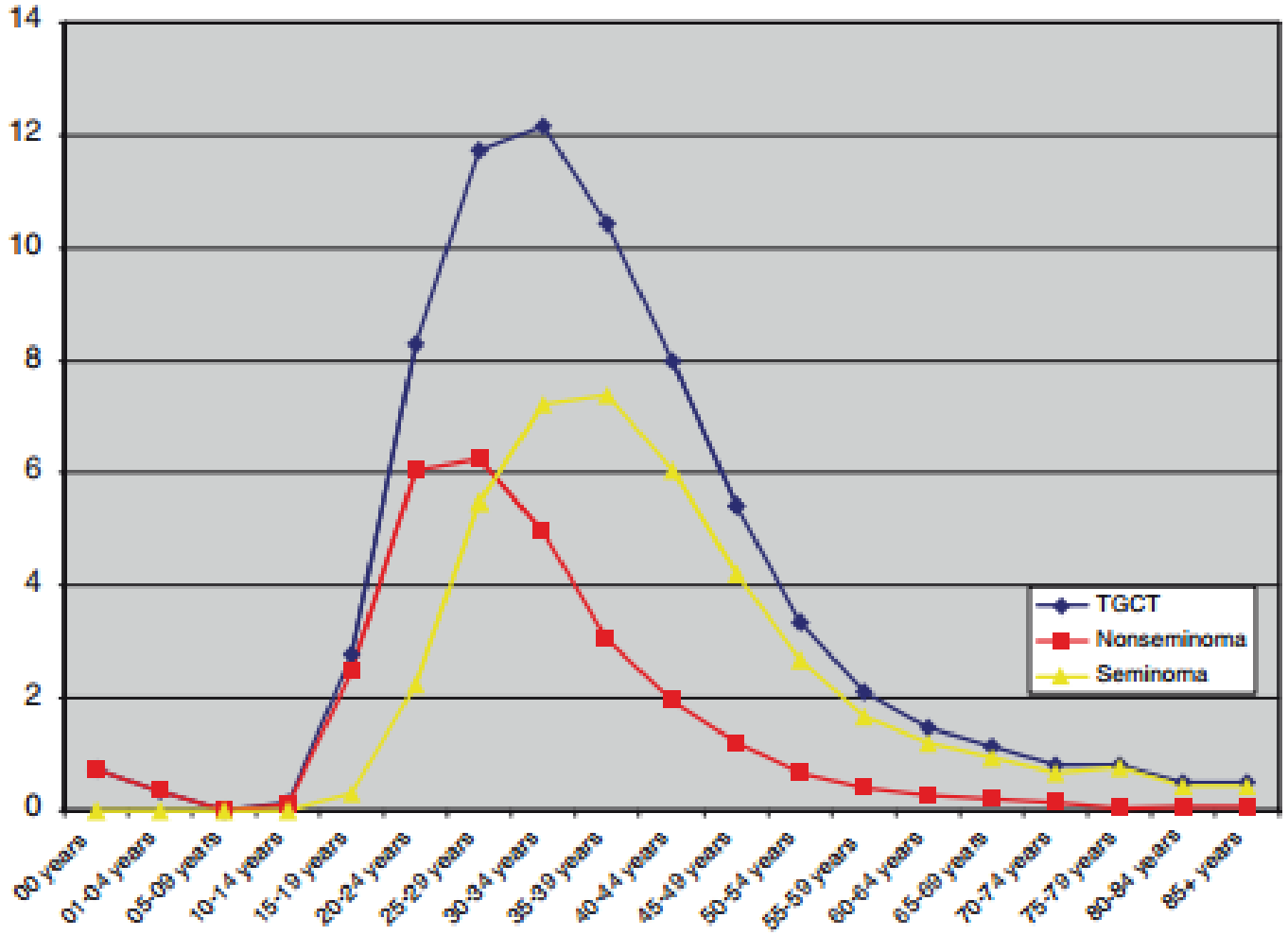
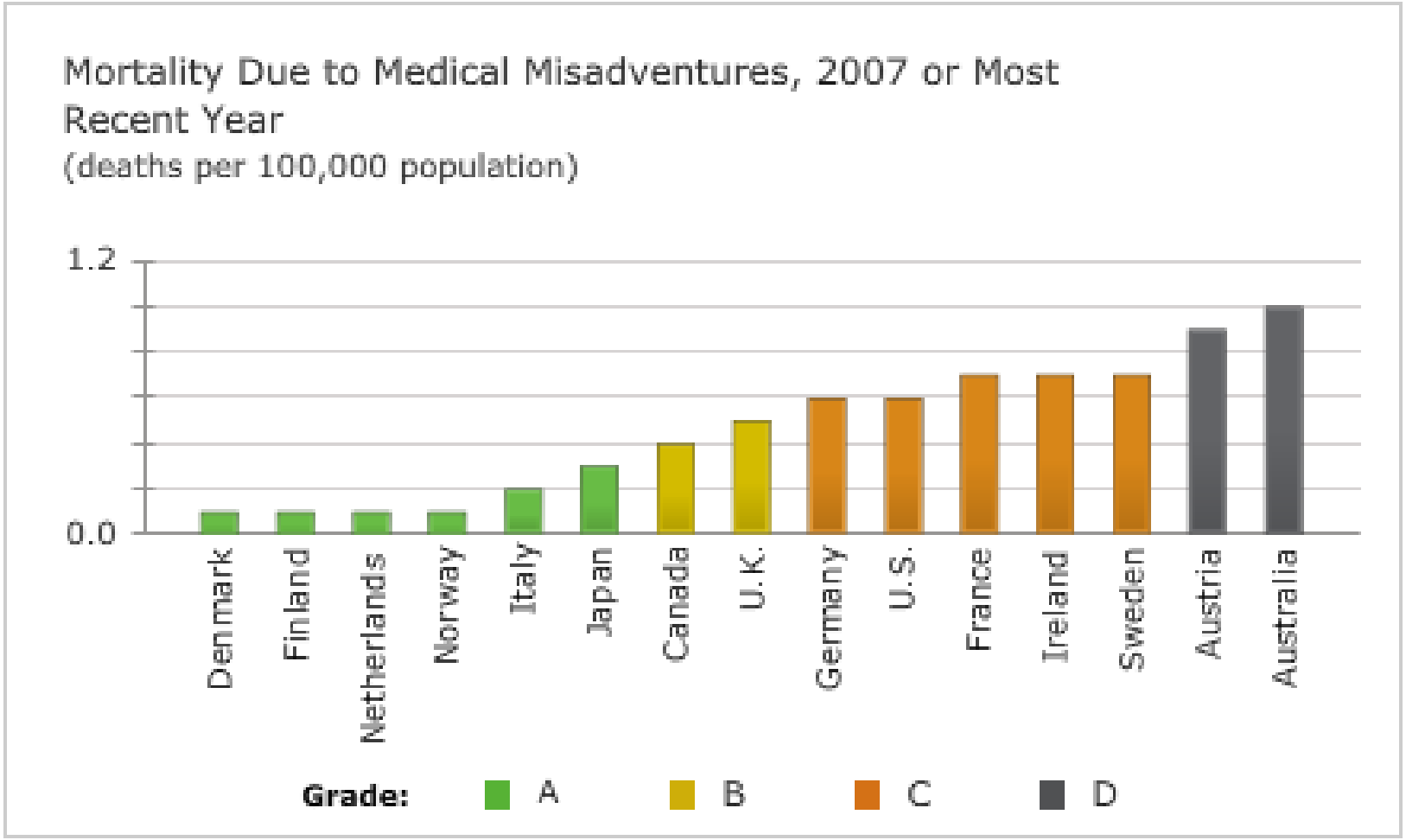


Fig. 2.1 Incidence of testicular germ cell tumors (TGCT), seminoma, and nonseminoma by age. SEER-9 registries, 1973–2005

Place

Link to Report



Testicular Cancer By Global Location LINK

Fig. 2.1 Incidence of testicular germ cell tumors (TGCT), seminoma, and nonseminoma by age. SEER-9 registries, 1973–2005

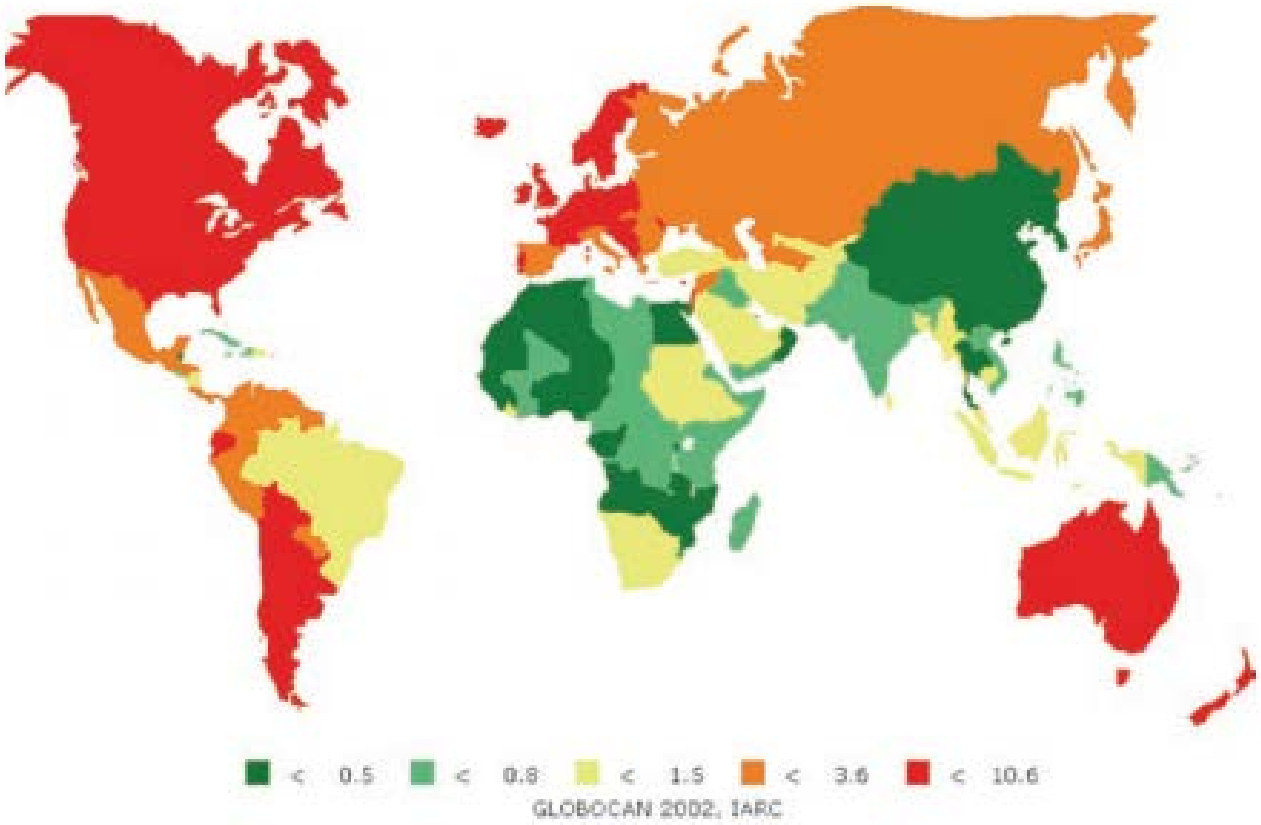
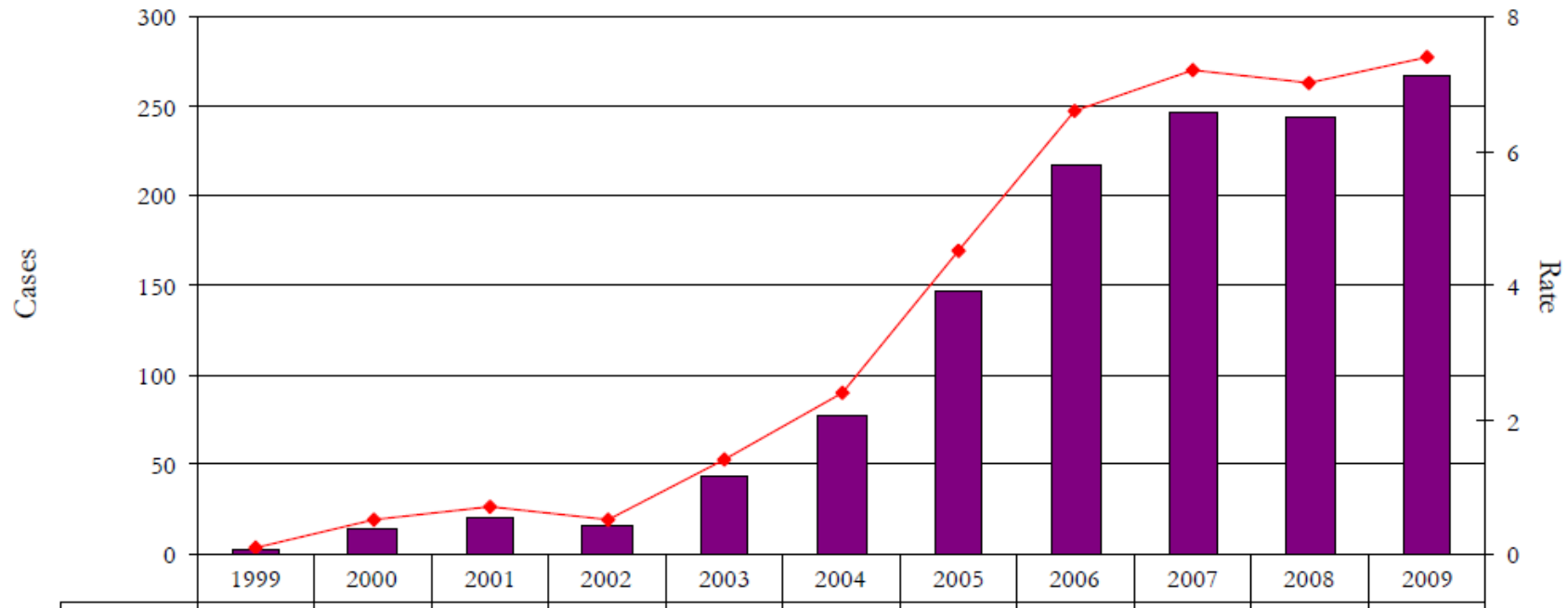


Fig. 2.2 Testis age-standardized incidence rate per 100,000

Figure 1: Number of infectious syphilis cases and rates per 100,000 by year in Alberta, 2009.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cases	2	15	21	16	43	77	146	217	246	244	267
Rate	0.1	0.5	0.7	0.5	1.4	2.4	4.5	6.6	7.2	7.0	7.4

Link to full Report

Time

PMC full text: Clin Epidemiol. 2013; 5: 417–427.
Published online 2013 Oct 17. doi: 10.2147/CLEP.S34430
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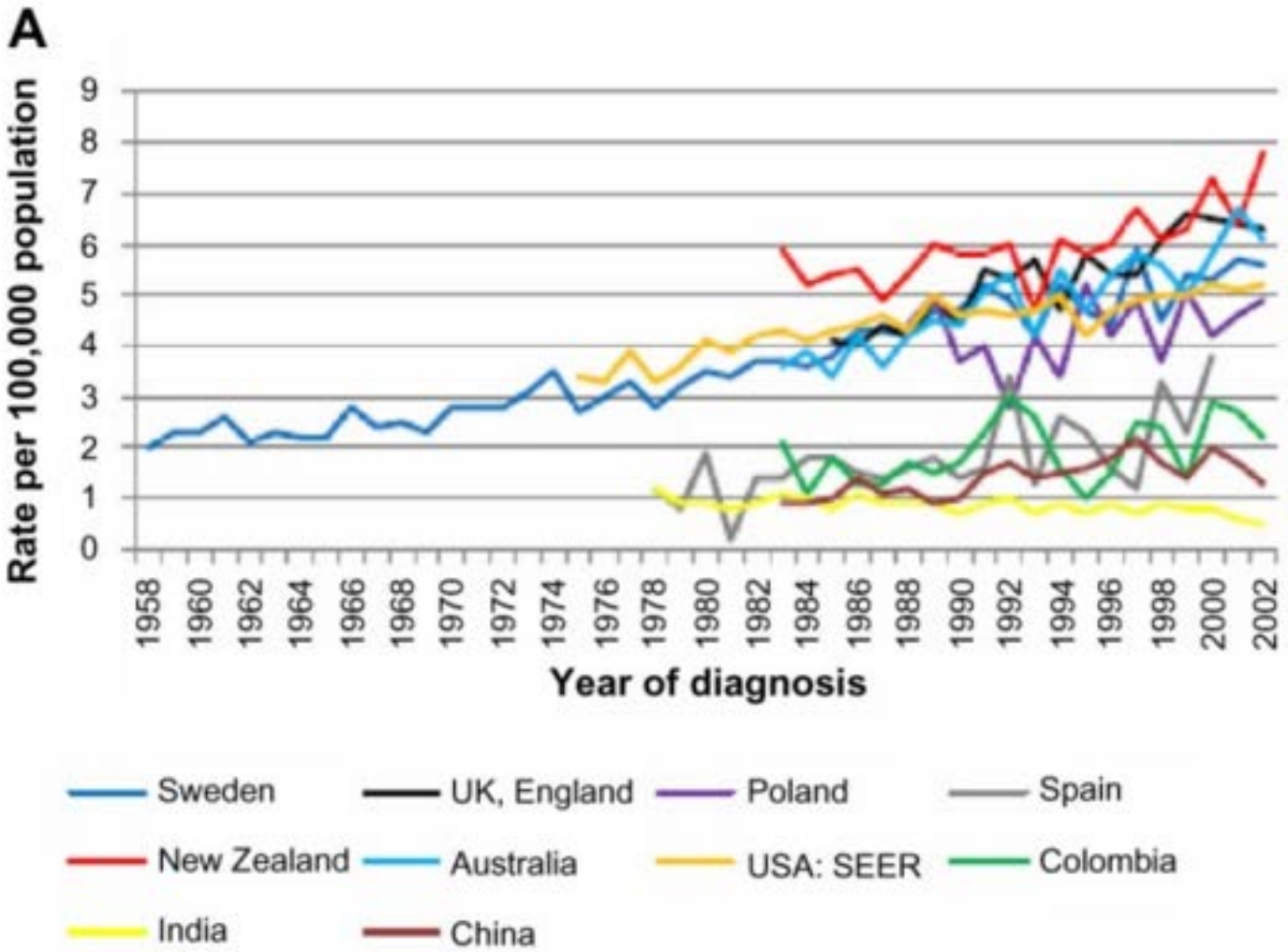
Figure 1



Testicular Cancer Incidence over time: LINK to article

4. Determinants

Determinants of health are those factor(s) which influence the health-state/events of individuals and communities. The context of people's lives determine their health.

Analytic epidemiology seeks to discover associations/causation between specific determinants and health outcomes.

4. Determinants

Key determinants associated with health phenomena:

1. **Biologic** – Bacteria, viruses, fungi (and human's susceptibility to their characteristics)
2. **Environmental** – Air pollution, chemicals, built environment
3. **Individual** – Lifestyle choices, health behaviors, genetics
4. **Social** – Poverty, discrimination, income inequality

Does Drinking Coffee Determine Health-states/events?

See corresponding editorial on page 787.

Coffee consumption and risk of chronic disease in the European Prospective Investigation into Cancer and Nutrition (EPIC)–Germany study[1–3]

Anna Floegel, Tobias Pischon, Manuela M Bergmann, Birgit Teucher, Rudolf Kaaks, and Heiner Boeing

ABSTRACT

Background: Early studies suggested that coffee consumption may increase the risk of chronic disease.

Objective: We investigated prospectively the association between coffee consumption and the risk of chronic diseases, including type 2 diabetes (T2D), myocardial infarction (MI), stroke, and cancer.

Design: We used data from 42,659 participants in the European Prospective Investigation into Cancer and Nutrition (EPIC)–Germany study. Coffee consumption was assessed by self-administered food-frequency questionnaire at baseline, and data on medically verified incident chronic diseases were collected by active and passive follow-up procedures. HRs and 95% CIs were calculated with multivariate Cox regression models and compared by competing risk analysis.

Results: During 8.9 y of follow-up, we observed 1432 cases of T2D, 394 of MI, 310 of stroke, and 1801 of cancer as first qualifying events. Caffeinated (HR: 0.94; 95% CI: 0.84, 1.05) or decaffeinated (HR: 1.05; 95% CI: 0.84, 1.31) coffee consumption (≥4 cups/d compared with <1 cup/d; 1 cup was defined as 150 mL) was

cognitive function, and increased the heart rate (4). However, the effect of coffee consumption on chronic disease risk is still being debated. In randomized controlled trials it was observed that acute coffee ingestion caused an increase in blood pressure (5, 6) and led to an elevation in plasma concentrations of total and LDL cholesterol and homocysteine (7–9). Case-control studies reported a positive association (3, 10, 11), or a J-shaped relation (12), between coffee consumption and the risk of CVD[4]. Moreover, some studies reported an acute elevation in the risk of MI and stroke in the hour of coffee ingestion (13, 14). These findings contributed to the belief that coffee is harmful (15), which is widespread among the general public and is also supported by current dietary recommendations that favor low to moderate coffee consumption. Prospective cohort studies, however, reported conflicting results: some studies suggested a positive association between coffee consumption and risk of CVD (16, 17), whereas others reported no association (18, 19) or even an inverse association (20–22). Most

ican Journal of Clinical Nutrition

Social Determinants of Health

Individual-Level

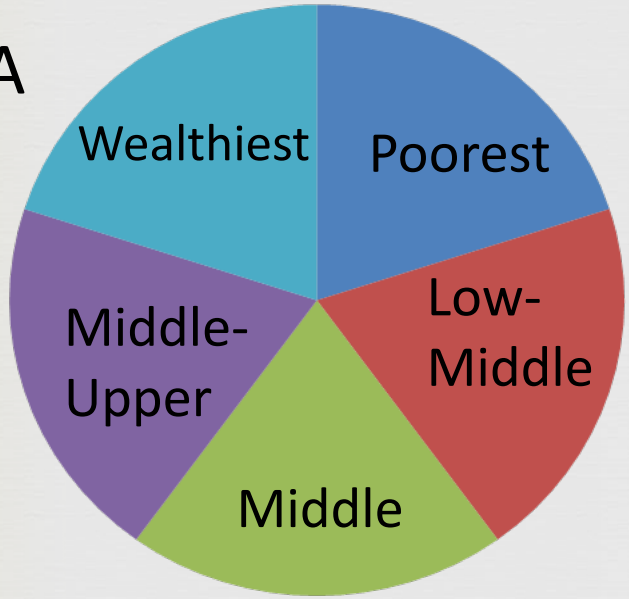
- Household income
- Personal education
- Employment
- Housing
- Food insecurity
- Early child trauma
- Discrimination
- Social support

Group-Level

- Per capita income - the mean income of people in a country, province, or city.
- Per capita education
- Unemployment level
- Neighbourhood quality
- Income inequality

Wealth Distribution – Which is Canada?

A



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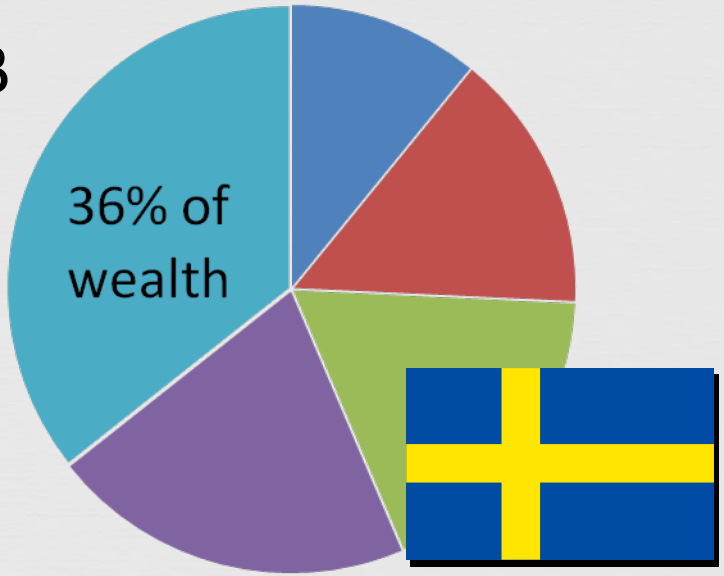

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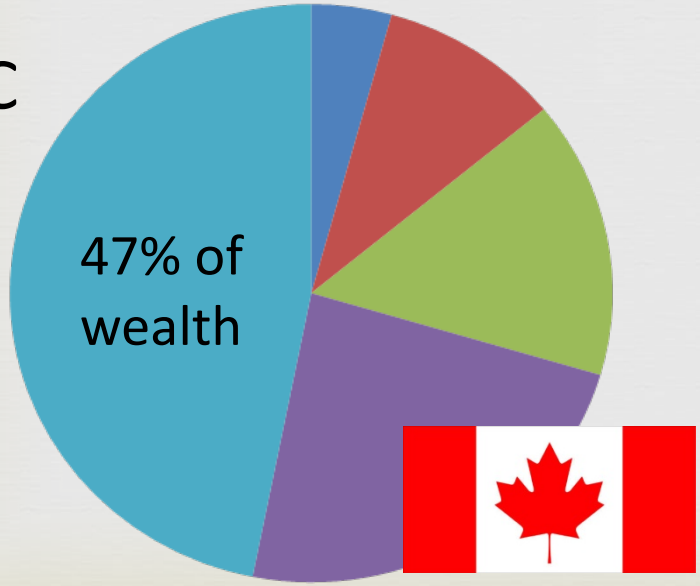

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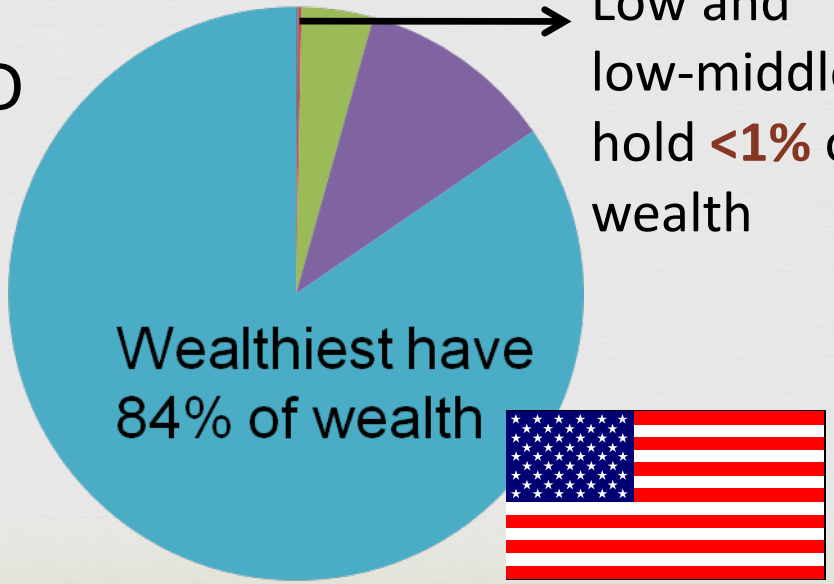
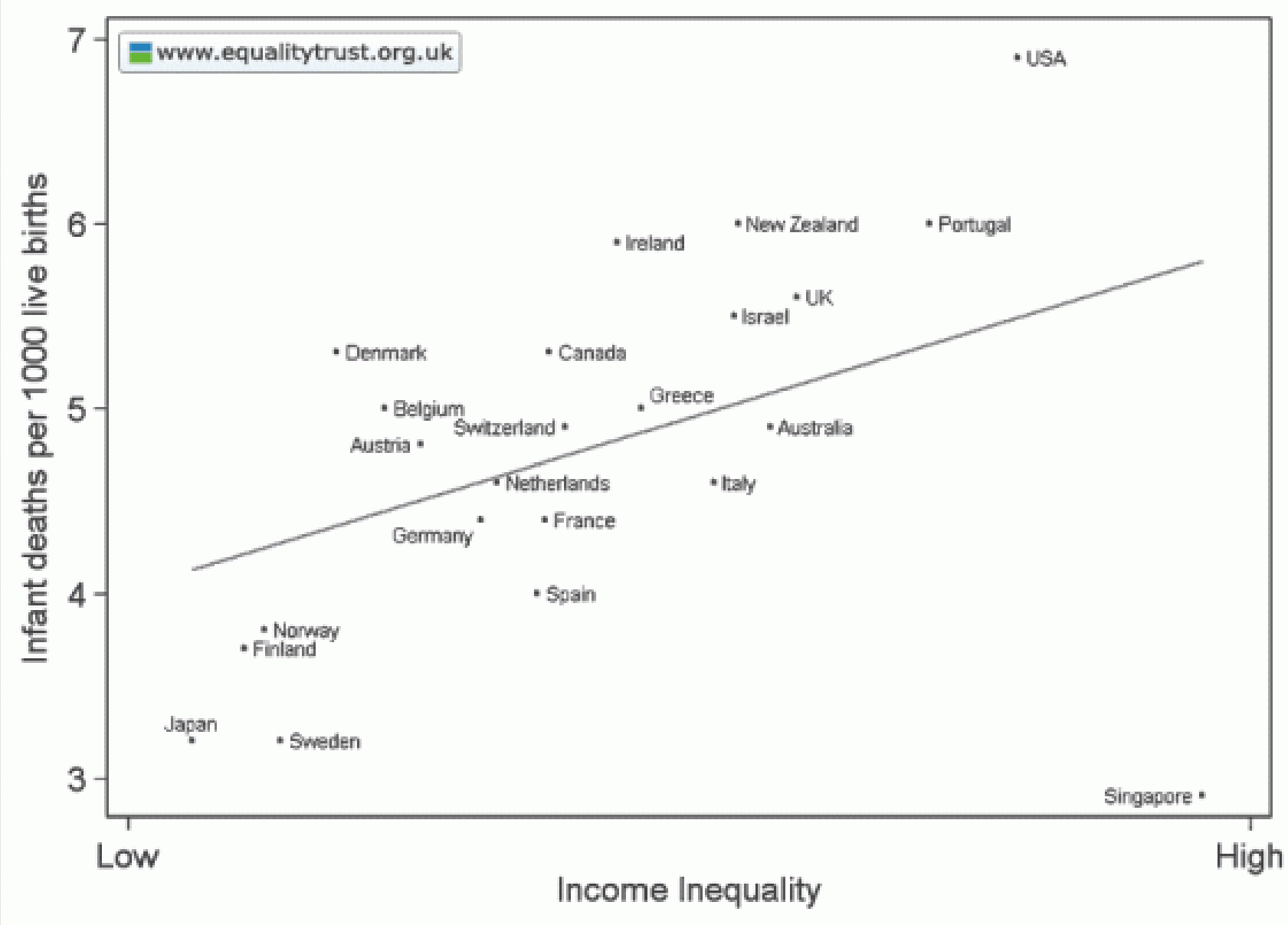
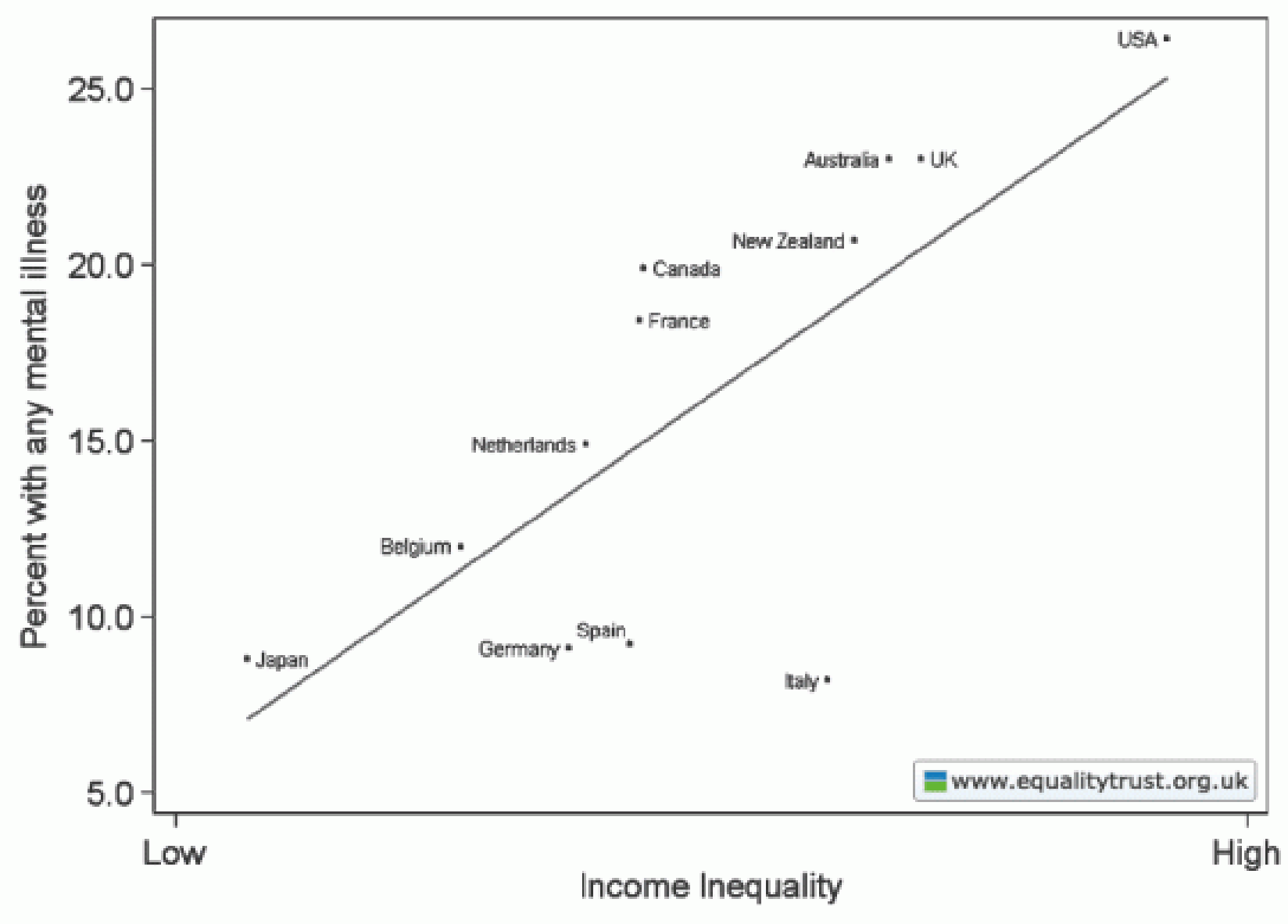


Low and low-middle hold **<1%** of wealth

4. Determinants



4. Determinants



What are the 4 key aspects of epidemiology?

1. _____

2. _____

3. _____

4. _____

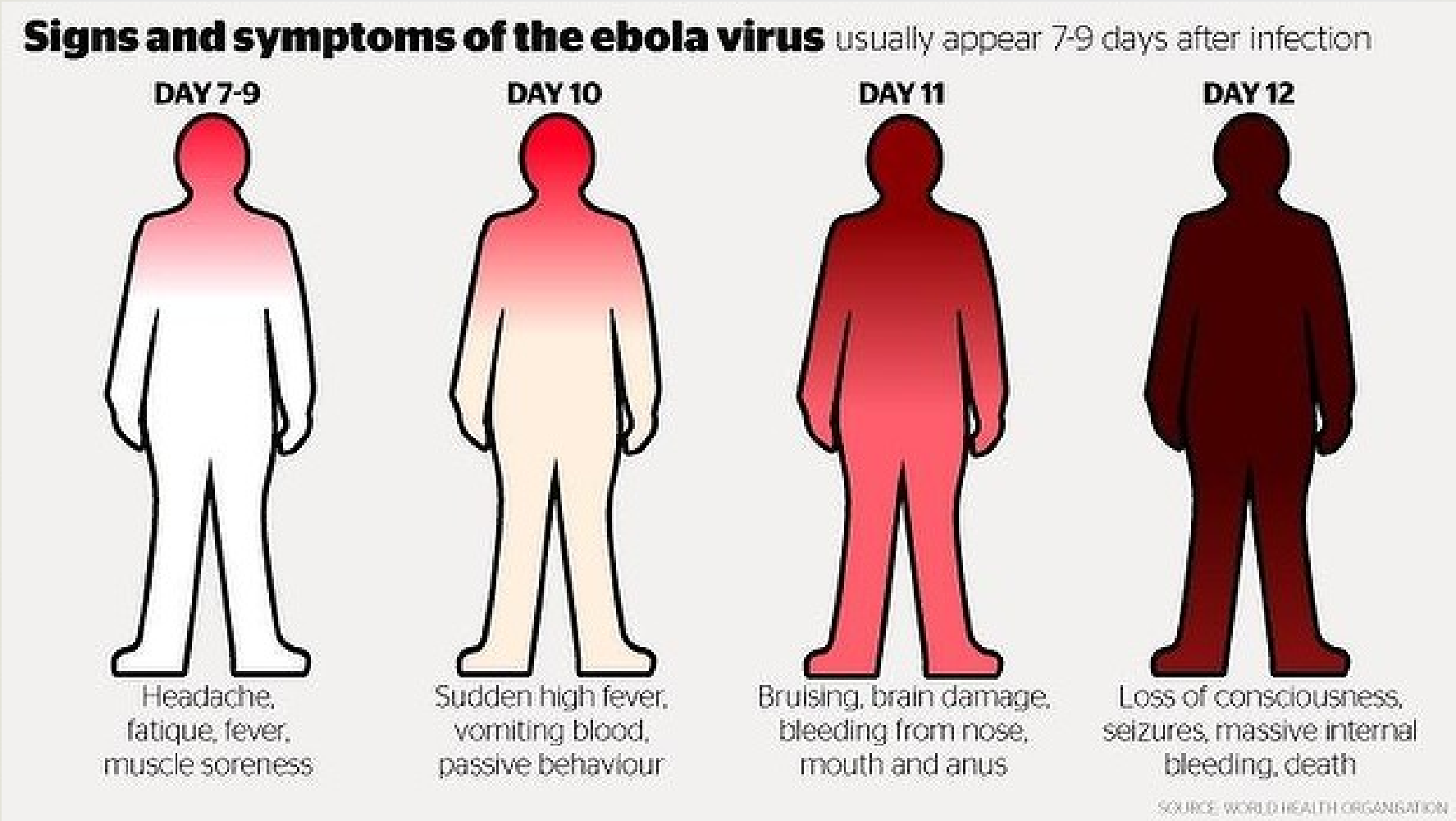
4 Key Aspects of Epidemiology

A Case Example

Ebola Virus

1. Health Phenomenon: **Ebola**

- **Agent:** **Virus** - mutated into 5 virus strains
- **Transmission** – Rapid & direct via all body fluids (blood, mucus, urine, vomit, semen, saliva)
- **Incubation period** – 2 to 21 days
- **Symptoms** - **hemorrhagic fever** – disturbing internal and external bleeding due to disseminated intravascular coagulation.
- **Survival rate** – 10% to 75% depending on strain (current outbreak: 47% survive)
- **Treatment** - No cure or vaccine


Signs and symptoms of the ebola virus usually appear 7-9 days after infection
DAY 7-9
Headache, fatique, fever, muscle soreness
DAY 10
Sudden high fever, vomiting blood, passive behaviour
DAY 11
Bruising, brain damage, bleeding from nose, mouth and anus
DAY 12
Loss of consciousness, seizures, massive internal bleeding, death
SOURCE: WORLD HEALTH ORGANISATION

3. Distribution

- Describe the distribution of disease by:
  - **PERSON**
  - **PLACE**
  - **TIME**

3. Distribution of Ebola

Person: Children & adults equal - no one is immune

Place: Largest outbreaks in Guinea, Liberia, Sierra Leone.

http://healthmap.org/ebola/

Time: Ebola outbreak increasing rapidly with time.

- "The virus is moving faster than anyone anticipated and that's why we need to move now. The number of cases is increasing so quickly that for every day's delay it becomes that much harder to stop it." Centres for Disease Control

4. Determinants of Ebola Outbreak

1. **Biologic** – Highly infectious virus, highly virulent, not susceptible to treatments

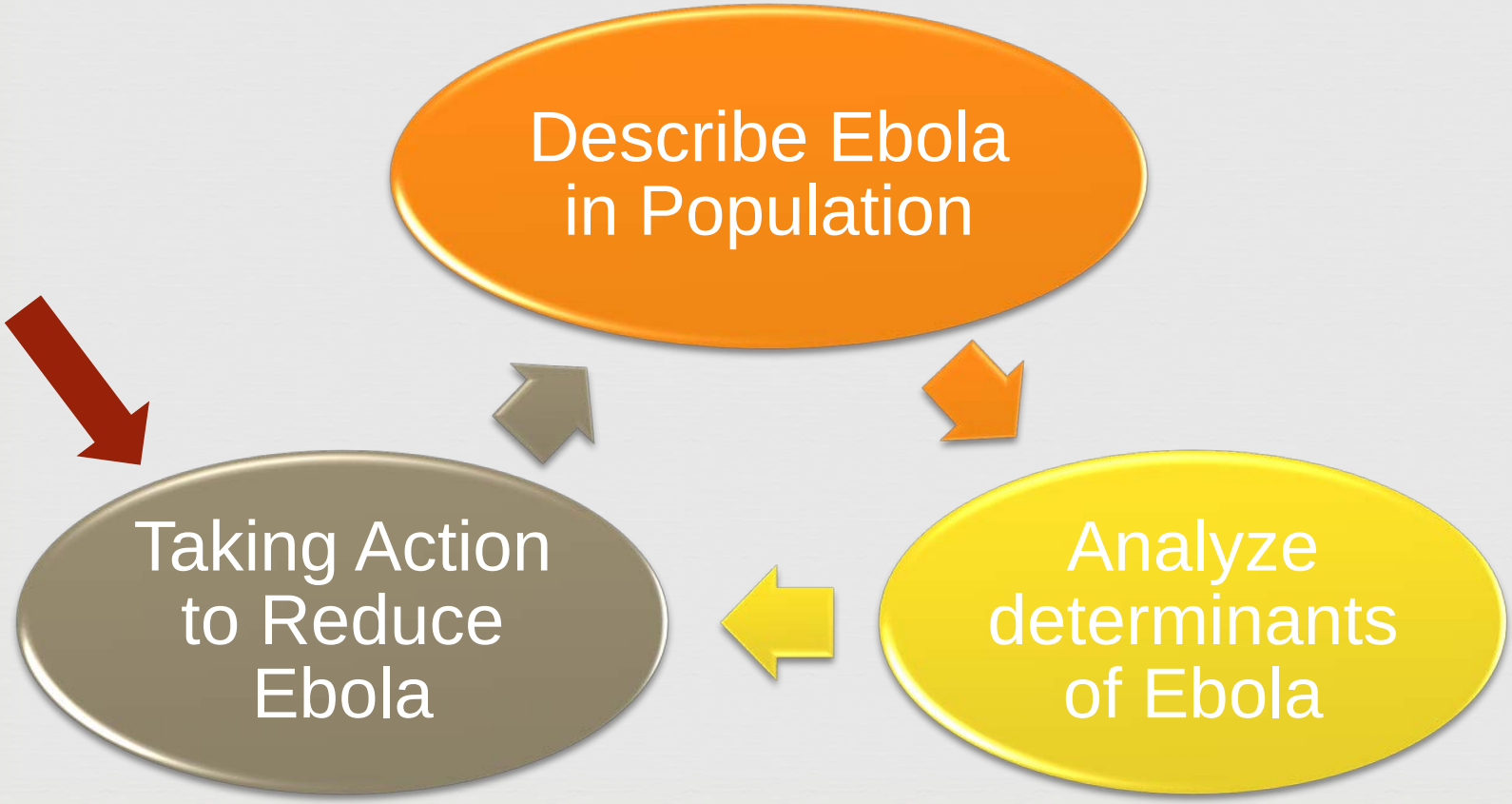
2. **Environmental** – Transmission in densely populated cities, climate, weak health system, no epidemiologic surveillance system, globalization

3. **Individual** – Lack knowledge about transmission, do no comply with preventative measures, no immunity

4. **Social** – Poverty, cultural practices (e.g. burial practices), family support

CBC News - Ebola Outbreak Accelerating

Cycle in Epidemiologic Work



Ebola outbreak: 'We need action now,' says CDC director Tom Frieden

Ebola treatment reduced to places where people go to die: international president of Doctors Without Borders

CBC News Posted: Sep 02, 2014 11:12 AM ET | Last Updated: Sep 02, 2014 1:35 PM ET

A medical worker at the John Fitzgerald Kennedy Hospital in Monrovia, Liberia, watches a demonstration during a strike for salaries and better security against the Ebola epidemic on Monday. The U.S. Centers for Disease Control says the outbreak needs more resources, expertise and a global, unified response. (Dominique Faget/AFP/Getty)

Link to news story: Sept 2, 2014

14 shares

Despite tremendous efforts to fight the Ebola outbreak on the part of

Sciencexpress Reports

Genomic surveillance elucidates Ebola virus origin and transmission during the 2014 outbreak

Stephen K. Gire,[1,2*] Augustine Goba,[3*†] Kristian G. Andersen,[1,2*†] Rachel S. G. Sealfon,[2,4*] Daniel J. Park,[2*] Lansana Kanneh,[3] Simbirie Jalloh,[3] Mambu Momoh,[3,5] Mohamed Fullah,[3,5‡] Gytis Dudas,[6] Shirlee Wohl,[1,2,7] Lina M. Moses,[8] Nathan L. Yozwiak,[1,2] Sarah Winnicki,[1,2] Christian B. Matranga,[2] Christine M. Malboeuf,[2] James Qu,[2] Adrianne D. Gladden,[2] Stephen F. Schaffner,[1,2] Xiao Yang,[2] Pan-Pan Jiang,[1,2] Mahan Nekoui,[1,2] Andres Colubri,[1] Moinya Ruth Coomber,[3] Mbalu Fonnie,[3‡] Alex Moigboi,[3‡] Michael Gbakie,[3] Fatima K. Kamara,[3] Veronica Tucker,[3] Edwin Konuwa,[3] Sidiki Saffa,[3] Josephine Sellu,[3] Abdul Azziz Jalloh,[3] Alice Kovoma,[3‡] James Koninga,[3] Ibrahim Mustapha,[3] Kandeh Kargbo,[3] Momoh Foday,[3] Mohamed Yillah,[3] Franklyn Kanneh,[3] Willie Robert,[3] James L. B. Massally,[3] Sinéad B. Chapman,[2] James Bochicchio,[2] Cheryl Murphy,[2] Chad Nusbaum,[2] Sarah Young,[2] Bruce W. Birren,[2] Donald S. Grant,[3] John S. Scheiffelin,[8] Eric S. Lander,[2,7,9] Christian Happi,[10] Sahr M. Gevao,[11] Andreas Gnirke,[2§] Andrew Rambaut,[6,12,13§] Robert F. Garry,[8§] S. Humarr Khan,[3‡§] Pardis C. Sabeti[1,2†§]

[1]Center for Systems Biology, Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA 02138, USA. [2]Broad Institute of MIT and Harvard, Cambridge, MA 02142, USA. [3]Kenema Government Hospital, Kenema, Sierra Leone. [4]Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology, Cambridge, MA 02139, USA. [5]Eastern Polytechnic College, Kenema, Sierra Leone. [6]Institute of Evolutionary Biology, University of Edinburgh, Edinburgh EH9 3JT, UK. [7]Systems Biology, Harvard Medical School, Boston, MA 02115, USA. [8]Tulane University Medical Center, New Orleans, LA 70112, USA. [9]Department of Biology, Massachusetts Institute of Technology, Cambridge, MA 02139, USA. [10]Redeemer's University, Ogun State, Nigeria. [11]University of Sierra Leone, Freetown, Sierra Leone. [12]Fogarty International Center, National Institutes of Health, Bethesda, MD 20892, USA. [13]Centre for Immunity, Infection and Evolution, University of Edinburgh, Edinburgh EH9 3JT, UK.

*These authors contributed equally to this work.

†Corresponding author. E-mail: andersen@broadinstitute.org (K.G.A.); augstgoba@yahoo.com (A.G.); psabeti@oeb.harvard.edu (P.C.S.)

‡Deceased.

§These authors jointly supervised this work.

In its largest outbreak, Ebola virus disease is spreading through Guinea, Liberia, Sierra Leone, and Nigeria. We sequenced 99 Ebola virus genomes from 78 patients in Sierra Leone to ~2,000x coverage. We observed a rapid accumulation of interhost and intrahost genetic variation, allowing us to characterize patterns of viral transmission over the initial weeks of the epidemic. This West African variant likely diverged from Middle African lineages ~2004, crossed from Guinea to Sierra Leone in May 2014, and has exhibited sustained human-to-human transmission subsequently, with no evidence of additional zoonotic sources. Since many of the mutations alter protein sequences and other biologically meaningful targets, they should be monitored for impact on diagnostics, vaccines, and therapies critical to outbreak response.

mented (*4*, *5*). Its emergence in the major cities of Conakry (Guinea), Freetown (Sierra Leone), Monrovia (Liberia), and Lagos (Nigeria) raises the specter of increasing local and international dissemination.

In an ongoing public health crisis, where accurate and timely information is crucial, new genomic technologies can provide near real-time insights into the pathogen's origin, transmission dynamics, and evolution. We used massively parallel viral sequencing to understand how and when EBOV entered human populations in the 2014 West African outbreak, whether the outbreak is continuing to be fed by new transmissions from its natural reservoir, and how the virus changed, both before and after its recent jump to humans.

In March 2014, Kenema Government Hospital (KGH) established EBOV surveillance in Kenema, Sierra Leone, near the origin of the 2014 outbreak (Fig. 1C and fig. S1) (*6*). Following standards for field-based tests in previous (*7*) and current (*3*) outbreaks, KGH performed conventional PCR-based EBOV diagnostics (*8*) (fig. S2); all tests were negative through early May. On May 25, KGH scientists confirmed the first case of EVD in Sierra Leone. Investigation by the Ministry of Health and Sanitation (MoHS) uncovered an epidemiological link between this case and the burial of a traditional healer who had treated EVD patients in Guinea. Tracing led to 13 additional cases—all females who attended the burial. We obtained ethical approval from MoHS, the Sierra Leone Ethics and Scientific Review Committee, and our U.S. institutions to sequence patient samples in the U.S. using approved safety standards (*6*).

We evaluated four independent library preparation methods and two sequencing platforms (*9*) (table S1) for our first batch of 15 inactivated EVD samples from 12 patients. Nextera library construction and Illumina sequencing provided the most complete genome assembly and reliable intrahost single nucleotide variant (iSNV, fre-

Downloaded from www.sciencemag.org on September 3, 2014

Link to paper

CBCnews | World

IN THE NEWS
- U.S. in Iraq
- Ebola outbreak

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Ebola outbreak threatens food security in hardest-hit countries

Labour shortages on farms, bushmeat restrictions could lead to widespread hunger

Thomson Reuters Posted: Sep 02, 2014 3:30 AM ET | Last Updated: Sep 02, 2014 9:33 AM ET

The Ebola outbreak in West Africa has sent food prices sky-rocketing and threatens harvests in the countries hardest hit by the epidemic, the UN said. (Reuters)

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The world's worst Ebola epidemic has put harvests at risk and sent food prices soaring in West Africa, the UN Food and Agriculture Organisation (FAO) said on Tuesday, warning the problem would intensify in coming months.

- **Experimental Ebola treatment sparks who-you-know debate**
- **ANALYSIS | It's not the virus, but Africa that's changed**
- **Senegal monitors contacts of 1st Ebola patient**

The FAO issued a special alert for Liberia, Sierra Leone and Guinea, the three countries most affected by the outbreak, which has killed around

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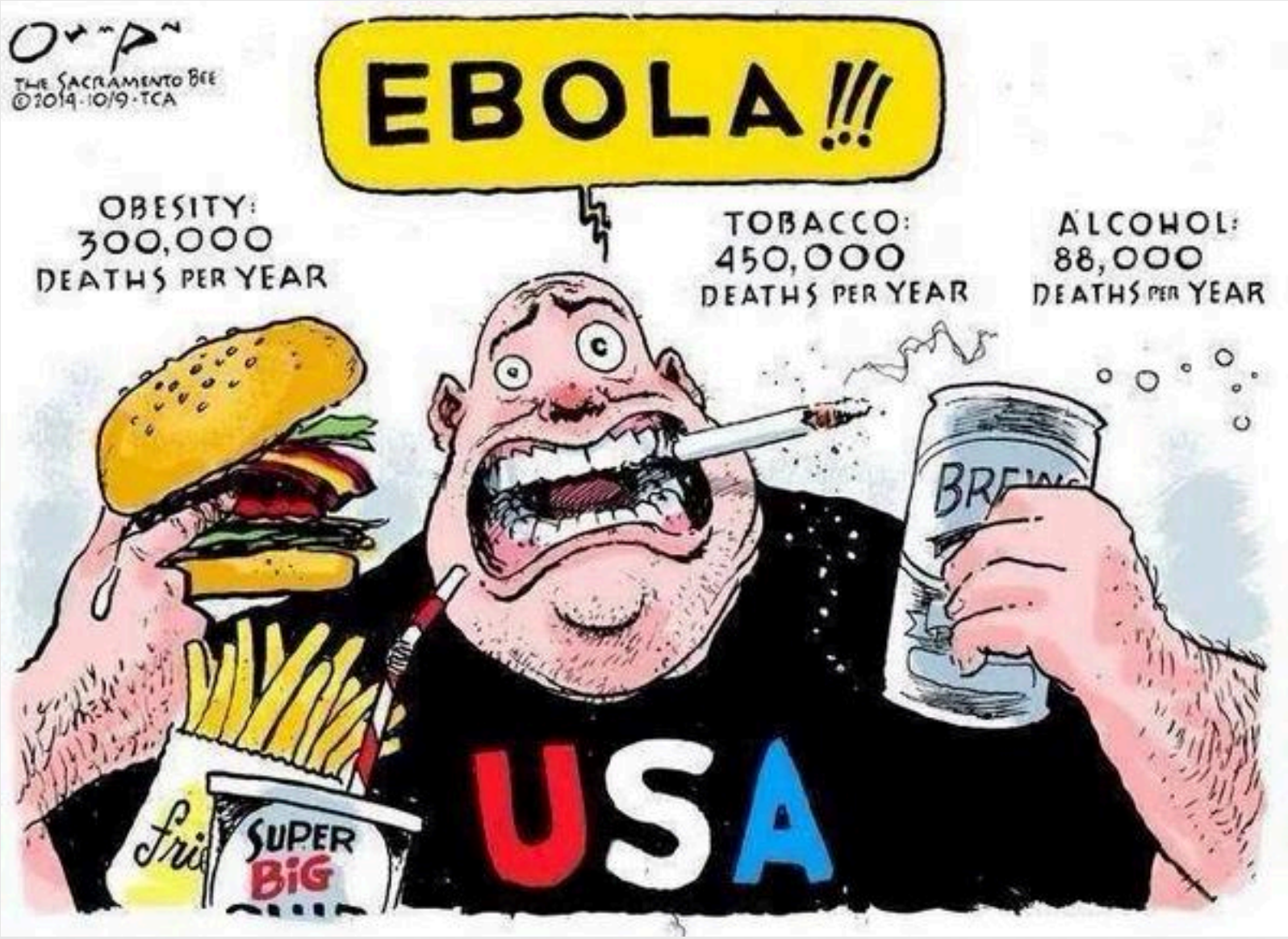
Must Watch

Journalist executed by ISIS: reports

4:22

ISIS has released a video showing what appears to

- Weak health systems are breaking down



https://pbs.twimg.com/media/BzlqbNpIgAAjcdG.jpg

Is Epidemiology all about Epidemics?

- **Endemic** – infectious and chronic diseases found in some places, not others
- **Epidemic** – infectious and chronic diseases found at some times, not others
- **Pandemic** – An epidemic that spreads across continents or worldwide

Epidemic = Plague?

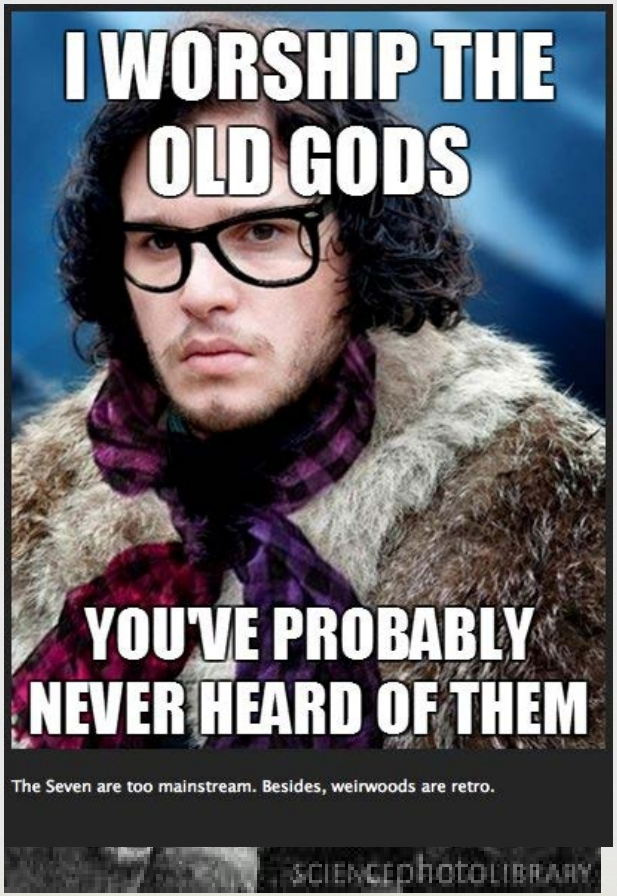
- Most people think epidemic = plague…not always.
- Plague is a *specific* disease caused by the bacteria *Yersinia pestis*, or *Y. pestis* for short.
- There are three types of plague: *pneumonic*, *septicemic*, and *bubonic*.
- The most famous is *bubonic plague*, which is transmitted from rats to humans by fleas and is characterized by swollen glands and lesions in the armpit and groin region.

The Black Death – Mid 1300s

- Claimed more than a quarter of the European population in 4 yrs
- Spread by the bite of a rat flea infected with the ***Yersinia pestis*** bacterium.
- Probably nothing ever came so close to **exterminating the human species**.

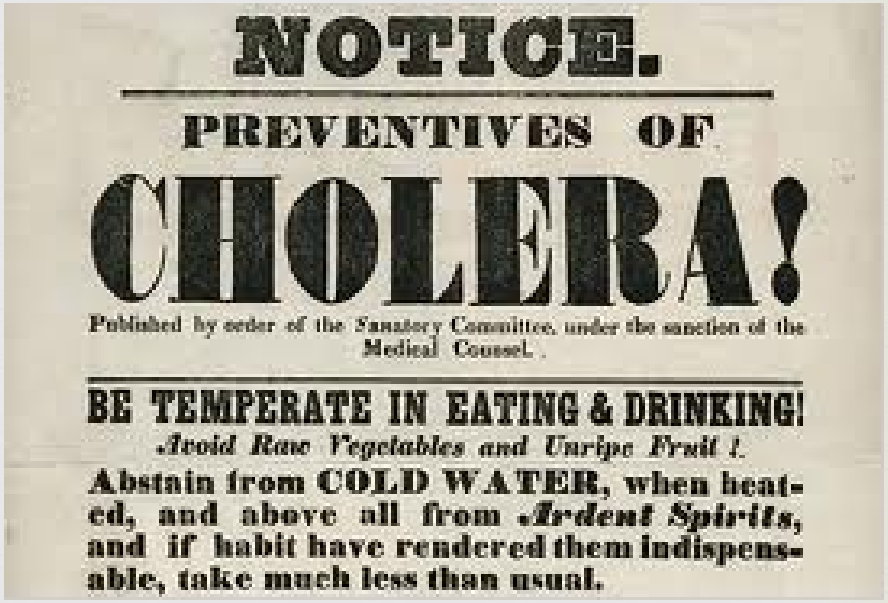
Who was John Snow?

- John Snow was an English physician.
- He investigated a **cholera outbreak** that occurred in in London in the 1800s.



Cholera Primer

- Infection of the small intestine caused by a bacterium.
- Transmission occurs by consuming water or food contaminated by an infected person.
- Leads to dehydration, electrolyte imbalance, and sometimes death.
- One of earliest infections to be studied using epidemiologic methods



NOTICE.

PREVENTIVES OF

CHOLERA!

Published by order of the Sanatory Committee, under the sanction of the Medical Counsel.

BE TEMPERATE IN EATING & DRINKING!

Avoid Raw Vegetables and Unripe Fruit!

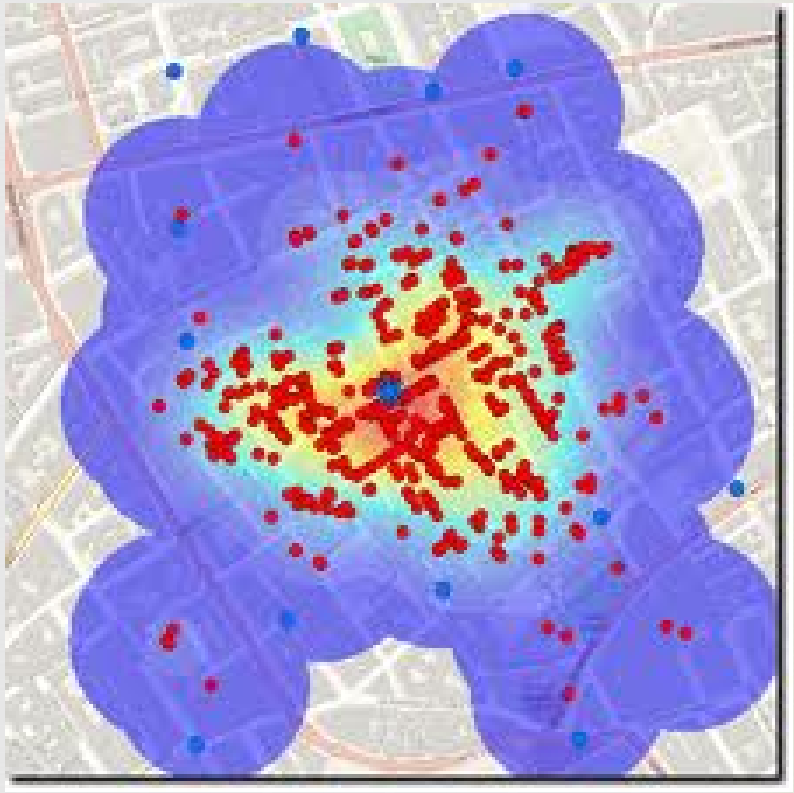
Abstain from COLD WATER, when heated, and above all from *Ardent Spirits*, and if habit have rendered them indispensable, take much less than usual.

Finding the Correct Determinant for Cholera

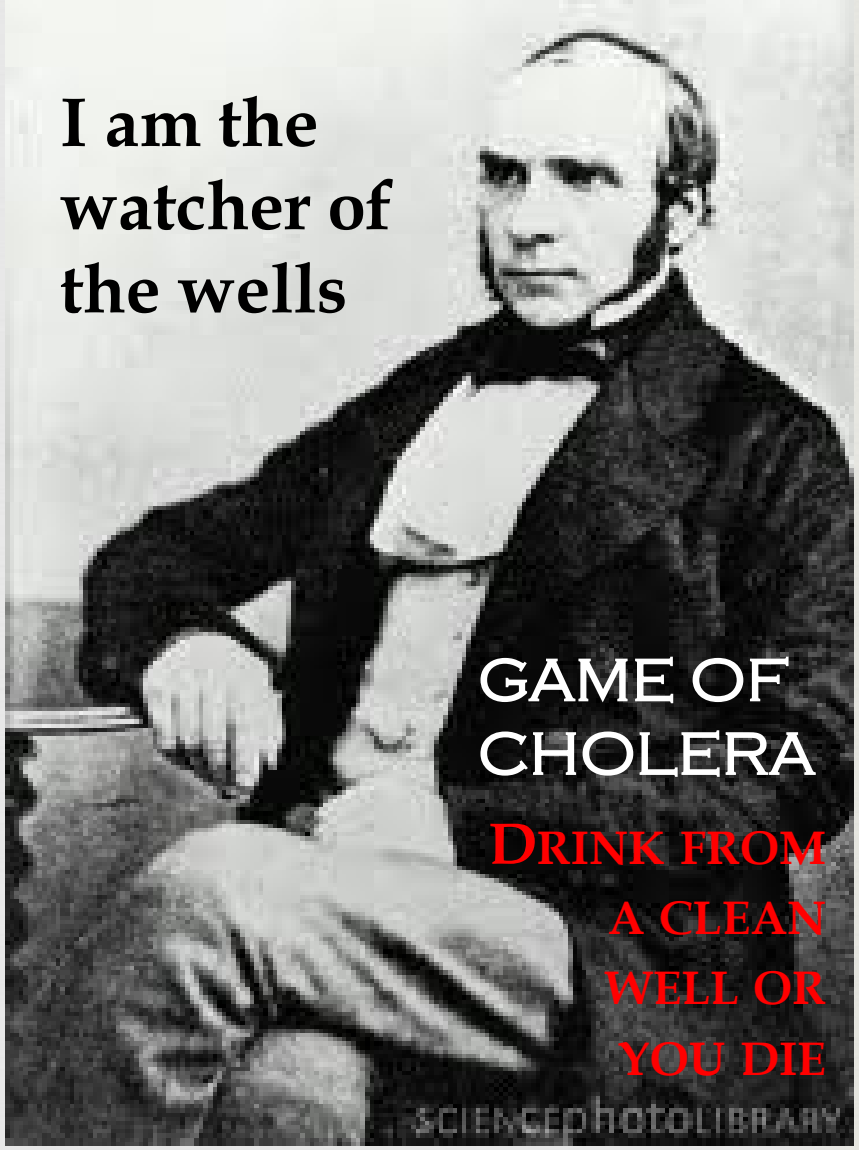
- **Miasma Theory** - epidemics like cholera were caused by the smell from putrefying animal matter and the exhalations of fever victims
  - "All smell is disease"
- **But…** Snow observed 2 water companies supplied water from the Thames River to houses in the same area.
- The Lambeth Company moved its source of water to part of the river less polluted with sewage.
- Snow noted that during the next cholera outbreak those served by the Lambeth Company had fewer cases of cholera.

Cholera in London – 1800s

- Snow linked the cholera epidemic to contaminated water supplies.
- He used a spot map of cases.
- Found 500 fatal attacks in 10 days in radius of a single water pump – the Broad Street pump
- Removed pump handle and epidemic abated.



I AM THE WATCHER
ON THE WALL
GAME OF THRONES
YOU WIN OR YOU DIE
AN EPIC NEW SERIES
ONLY ON HBO
SUNDAY, APRIL 17, 9PM


I am the watcher of the wells
GAME OF CHOLERA
DRINK FROM A CLEAN WELL OR YOU DIE
SCIENCEPHOTOLIBRARY

How Snow`s work sets the stage for what we will learn in this course

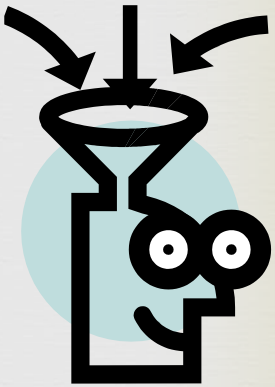
- He identified a situation in which people were divided into 2 groups differing only by the source of their water
- He **measured the distribution** of cholera in each group.
- He calculated **how many times more common** cholera deaths were for those using each well – we will come back to this measure (a relative risk).
- He used this information to reach a conclusion that contaminated water was **the determinant** of cholera.
- He made **recommendations for prevention**. (then took action)

Course: Learning Objectives

1. **Identify and describe principles & concepts in epidemiology**

2. **Identify and describe measures & study designs in this field**

3. **Describe common applications of epidemiology**



Syllabus

For Next Class

- Purchase/register iClicker (instructions on Moodle)
- Review Syllabus
- Familiarize yourself with the Moodle course
- Assigned readings