

Introduction to epidemiology

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What is epidemiology?

- ▶ The word is derived from two Greek components
- ▶ “Epi” = Upon
- ▶ “Demos” = Population (e.g. Democracy)
- ▶ So . . . Epidemiology is the study of something that acts upon populations

How does epidemiology compare with parasitology?

- ▶ Epidemiology tends to place the focus on the population affected by the disease.
- ▶ Parasitology tends more to focus on the parasite causing disease
- ▶ Historically bacteria and viruses were not treated as classic parasites (due partly to their invisibility)
- ▶ Bacteria and viruses tend to have simpler life histories, although they may still occur in multiple hosts
- ▶ Modern epidemiology also looks at non transmissible illnesses associated with life style and environment.
- ▶ Epidemiology provides guidance for **Public health policy**

What are communicable and non-communicable illnesses?

- ▶ Transmissible (communicable) diseases pass from person to person, or organism to organism
- ▶ Contagious diseases spread within a population.
- ▶ A disease can be transmissible but not contagious, if the rate of spread is normally very low
- ▶ Not all communicable diseases lead to epidemics
- ▶ A communicable disease can persist at a low level in the population

What do we usually die of?

- ▶ In a typical year death as a direct result of a communicable illness has become relatively uncommon in the UK
- ▶ The most common causes of death are cardiovascular illnesses and cancer
- ▶ So .. many public health measures now concern altering life styles associated with risks of non communicable illnesses (smoking, obesity, lack of exercise)
- ▶ However as we have now been reminded . . . communicable diseases can have very major societal impacts (Bloom and Cadarette 2019)
- ▶ They can cause epidemics/pandemics

What do we suffer from most?

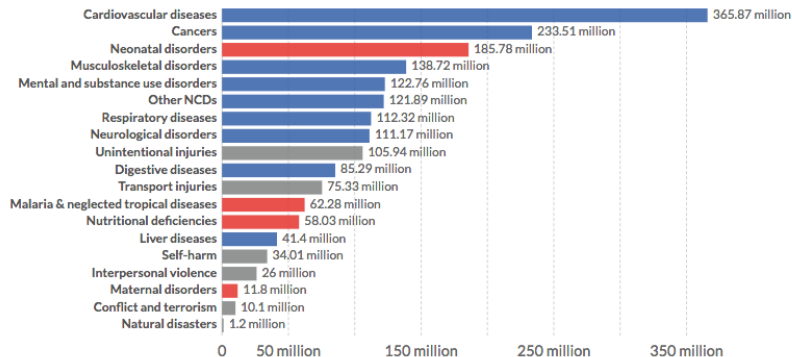
(Naghavi and Abajobir 2017)

Burden of disease by cause, World, 2017

Total disease burden, measured in Disability-Adjusted Life Years (DALYs) by sub-category of disease or injury. DALYs measure the total burden of disease – both from years of life lost due to premature death and years lived with a disability. One DALY equals one lost year of healthy life.

Our World
in Data

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Source: IHME, Global Burden of Disease

OurWorldInData.org/burden-of-disease • CC BY

▶ 1990

○ 2017

CHART

TABLE

SOURCES

↓ DOWNLOAD



(6 million deaths from SARS-CoV-2 over two years)

Is the burden of disease expected to decline?

(Mathers and Loncar 2006)

Table 1. Projected Average Annual Rates of Change in Age-Standardized Death Rates for Selected Causes: World, 2002–2020

Group	Cause	Average Annual Change (Percent) in Age-Standardized Death Rate	
		Males	Females
All Causes		-0.8	-1.1
Group I		-1.4	-1.9
	Tuberculosis	-5.4	-5.3
	HIV/AIDS	3.0	2.1
	Malaria	-1.3	-1.5
	Other infectious diseases	-3.4	-3.3
	Respiratory infections	-2.7	-3.4
	Perinatal conditions ^a	-1.7	-1.9
	Other Group I	-3.0	-3.6
Group II		0.0	-0.8
	Cancer	-0.2	-0.4
	Lung cancer	0.1	0.3
	Diabetes mellitus	1.1	1.3
	Cardiovascular diseases	-1.1	-1.2
	Respiratory diseases	0.3	-0.1
	Digestive diseases	-1.3	-1.7
	Other Group II	-0.7	-1.1
Group III		0.0	-0.2
	Unintentional injuries	-0.2	-0.2
	Road traffic accidents	1.1	1.1
	Intentional injuries	0.2	-0.2
	Self-inflicted injuries	-0.3	-0.4
	Violence	0.4	0.2

Why study communicable diseases?

- ▶ A major cause of death, particularly HIV in sub-Saharan Africa
- ▶ Many communicable diseases cause morbidity (symptoms) and greatly reduced quality of life even if they do not lead to mortality
- ▶ Epidemics have major societal impacts
- ▶ Developing vaccines provides insights into key aspects of biology
 - ▶ Oncology (relevant for cancer studies)
 - ▶ Genetics

What are the key terms to know?

- ▶ **Outbreak:** Spread of a contagious agent that is limited to a defined local population at risk
- ▶ **Epidemic:** An outbreak that extends to a wider geographical area
- ▶ **Pandemic:** An epidemic that potentially impacts the entire global population
- ▶ **Endemic:** Continuous presence of the contagious agent in a population or reservoir species

Key terms

- ▶ Population at risk : number of potential infections
- ▶ Exposure: contact with disease causing agent
- ▶ Incidence : number of new cases
- ▶ Prevalence : Proportion of population affected
- ▶ Morbidity: Effects falling short of death
- ▶ Mortality: Death
- ▶ Virulence: Pathogenicity of the infectious agent
- ▶ Transmissibility: Infectiousness of the agent

What are the origins of epidemiology as a science?

- ▶ The underlying cause of disease were not well understood until the 20th century
- ▶ Early epidemiologists aimed to understand the cause of incidence, prevalence and spread, rather than to study the agent
- ▶ The classic text book example: Cholera in London

Who was John Snow?

- ▶ Founding father of epidemiology
- ▶ Discovered how cholera spread between people.

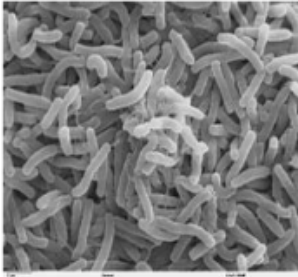


How did Snow identify the source?

- ▶ Cholera first thought to be caused by a “miasma” in the air
- ▶ “The result of my inquiry is, that there has been no particular outbreak or prevalence of cholera in this part of London except among the persons who were in the habit of drinking the water of the Broad street pump”
- ▶ Cholera was eliminated in the UK through provision of sewage treatment.
- ▶ Finding the source and the route of transmission was the key.
- ▶ However the **cause** of cholera was still not known

Vibrio cholerae

Now known to be a bacteria



How have epidemics changed history?

- ▶ Black death: Led to the end of the feudal system
- ▶ “Guns germs and steel”: Diseases (particularly smallpox) introduced to the new world led to the collapse of the Mayan, Aztec and Inca empires. J Diamond as reviewed by (Brooks 1999)
- ▶ Spanish flu: Could have produced some of the social conditions that led to the second world war.
- ▶ SARS-CoV-2 (Covid-19): Clearly had a major impact on lives throughout the world

Yersinia pestis: Bacteria



Smallpox: Variola virus

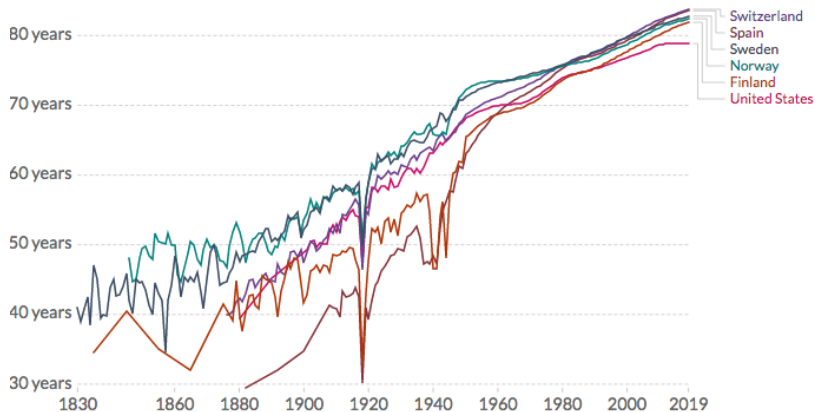


H1N1: Flu viral strain



H1N1 1918: Impact on life expectancy

► Median age of death 28



source: Riley (2005), Clio Infra (2015), and UN Population Division (2019)

OurWorldInData.org/life-expectancy • CC BY

Note: Shown is period life expectancy at birth, the average number of years a newborn would live if the pattern of mortality in the given year were to stay the same throughout its life.

H1NI 1918

- ▶ Flu typically results in 500,000 deaths per year throughout the world (Mills, Robins, and Lipsitch 2004)
- ▶ 1918 deaths. (Spreeuwenberg, Kroneman, and Paget 2018)
17.4 million deaths
- ▶ Patterson and Pyle (1991) 24.7 to 39.3 million
- ▶ Other estimates even higher

“Spanish flu”

- ▶ Epidemics often mistakenly named after country of supposed origin.
- ▶ Spanish flu may actually have begun in New York (Olson et al. 2005)
- ▶ Young people were at greater risk than the older population (not the usual pattern.)
- ▶ This could have been due to acquired immunity of the older population exposed to the “Russian” flu
- ▶ May also have been exacerbated by poor health of returnees from the war

Influenza pandemics (Krammer et al. 2018)

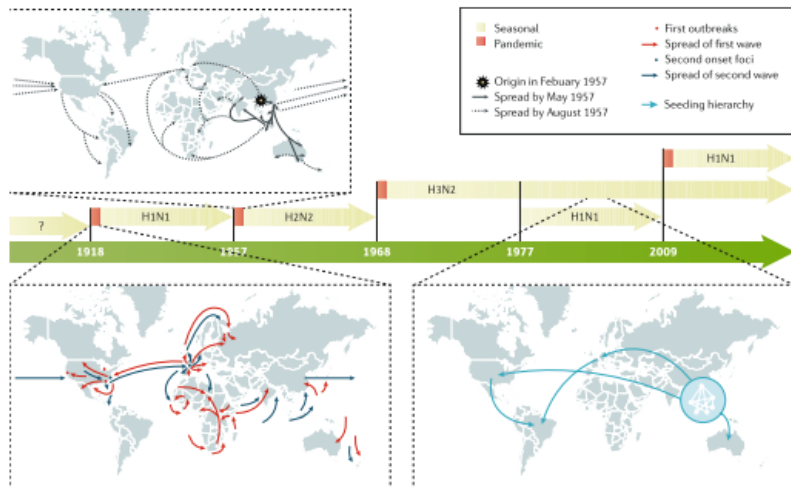
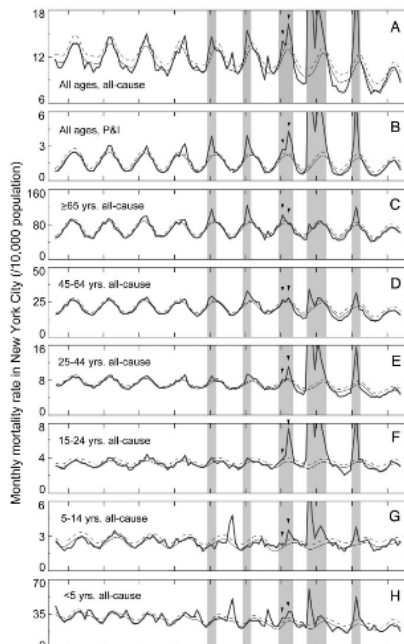


Fig. 2 | **Influenza pandemics.** In the past 100 years, four pandemics of human influenza have occurred, with the 1918 pandemic caused by an influenza A H1N1 virus being the most devastating, as it was associated with >40 million deaths²⁹⁴.

Mortality patterns in 1918



2020 SARS-CoV-2 pandemic

- ▶ Current estimate
- ▶ 483 million cases worldwide
- ▶ 6 million deaths worldwide (around 10% of global annual mortality, over 2 years)
- ▶ Ongoing
- ▶ Economic impact unquantified.

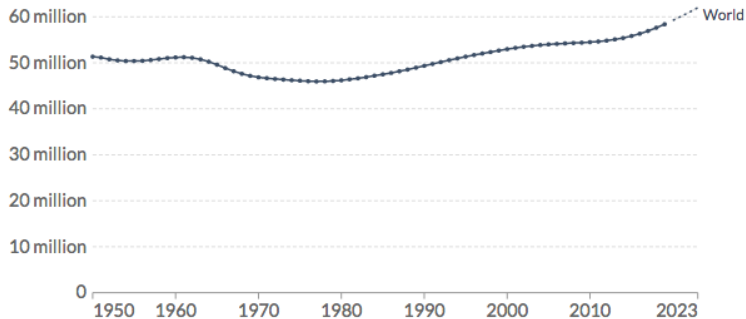
Worldwide mortality

Number of deaths per year, World

The dotted line shows the medium variant of the UN population projections.

Our World
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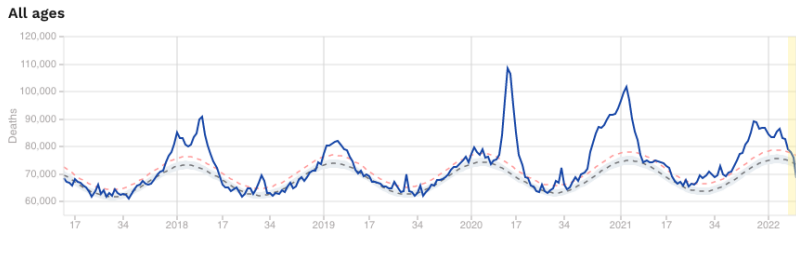
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Will the SARS-CoV-2 pandemic change global demographic parameters?

- ▶ Very minor increase in overall mortality ($<5\%$)
- ▶ No noticeable change in the overall life expectancy
- ▶ Most deaths in 2020 to 2022 were still from all the other typical causes, particularly in the young
- ▶ This contrasts with the 1918 flu, which did reduce life expectancy

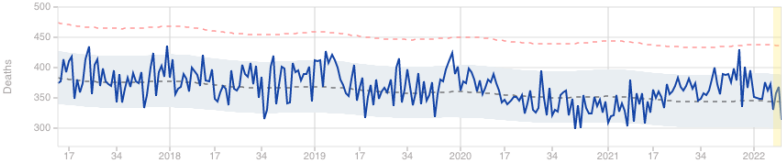
Excess deaths in Europe during SARS-CoV-2 epidemic



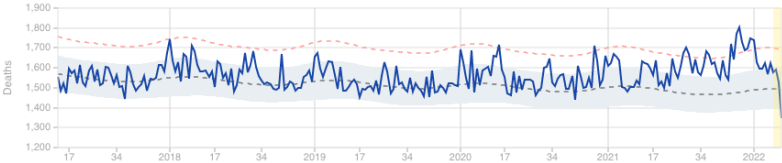
<https://www.euromomo.eu/graphs-and-maps/>

Excess deaths in Europe during SARS-CoV-2 epidemic

0-14 years



15-44 years

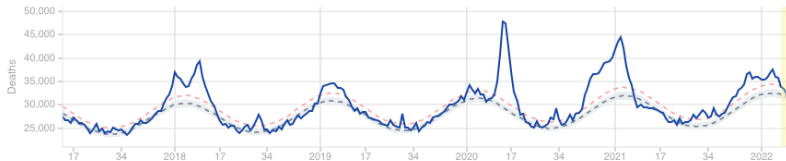


Excess deaths in Europe during SARS-CoV-2 epidemic

65+ years

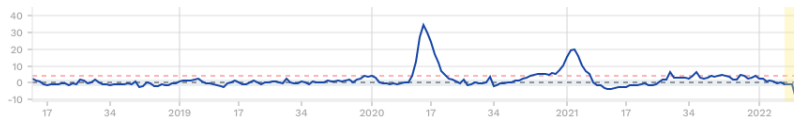


85+ years



Excess deaths in England during SARS-CoV-2 epidemic

UK (England)



Conclusions

- ▶ Epidemics can have dramatic impacts on human society (as we are too well aware of)
- ▶ Understanding source and transmission extremely important
- ▶ Patterns of epidemic development in space and time can be mapped and modelled
- ▶ We also need to understand the disease causing agent (the “epi” in epidemiology)

Links

<https://ourworldindata.org/spanish-flu-largest-influenza-pandemic-in-history>

<https://ourworldindata.org/child-mortality>

<https://www.worldometers.info/coronavirus/> (And multiple dashboards and data sources)

References and further reading

- Bloom, David E., and Daniel Cadarette. 2019. "Infectious disease threats in the twenty-first century: Strengthening the global response." *Frontiers in Immunology* 10 (MAR): 1–12. <https://doi.org/10.3389/fimmu.2019.00549>.
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- Mathers, Colin D., and Dejan Loncar. 2006. "Projections of global mortality and burden of disease from 2002 to 2030." *PLoS Medicine* 3 (11): 2011–30. <https://doi.org/10.1371/journal.pmed.0030442>.
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