

Digital Health

Spring 2025

UNIVERSIDAD POLITÉCNICA DE MADRID



#8 Biomedical informatics and bioethics: Tools for population health worldwide

Agenda

- Questions from last week?
- Learning objectives: Discipline literacy, critical analysis skills, applied and integrative learning, ethical reasoning, global or civic engagement, written communications, oral communications, soft skills
- Lecture, videos, discussion, readings
- Guest lectures
- Review for midterm exam
- Next session: Bioscience, diagnostics, pharma, medical device, clinical research



Population Health

- **Population health** refers to the health status and health outcomes within a **group of people** rather than the health of an individual

Population Health

- Population health is an art, process, science and a product of enhancing the health outcomes of people within specific communities.
- It includes patterns of health determinants and policies exploring social and environmental determinants as well.



Blue Zones

- Watch
- <https://www.bing.com/videos/riverview/relatedvideo?q=blue%20zones%20in%20the%20world&mid=630622A45F215CF8A61A630622A45F215CF8A61A&ajaxhist=0>
- Controversy surrounding lack of birth certificates, pension fraud, and data errors
- United Nations Late-life data shows extreme longevity appears to be concentrated in Monaco, Malawi, Kenya, Western Sahara, Puerto Rico, and other regi

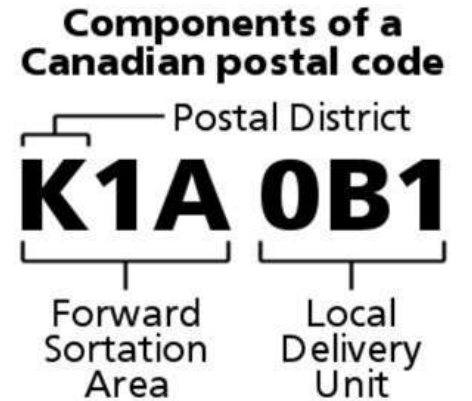


Population Health



- Studied the health outcomes of 45 million patient records—including 56,000 twins and more than 724,000 siblings
- Found that environmental and socioeconomic factors impact health more than genetics
- Found that obesity and diabetes are more influenced by environment than family medical history
- Think about the environment
 - Are you breathing air from highway pollution?
 - Do you have grocery stores nearby with fruits and vegetables?
 - Do you have a safe nearby park to exercise?
- Harvard Medical School, 2019 (Nature Genetics)

Population Health



- What is your postal code (zip code)?
 - More important than your genetic code to your overall health
- [Bing Videos](#) (first 3.5 min)
- Example
 - In the U.S., in some cities, average life expectancies in certain communities are 20-30 years shorter than those mere miles away.
 - In the U.S., there are **food deserts** with no grocery stores

Population Health



- Focus on prevention to decrease incidence of disease, decrease costs, improve outcomes
- Identify high risk individuals or areas for interventions
- Applies public health concepts to chronic disease management with comprehensive data analysis
- Large data sets are needed. Enabled by uniform and centralized EMRs, often government or opensource data sets

4 Examples of Population Health Studies

Cancer in Spain

Measles

Opioid dependence

AIDS in Africa

Population Health: Cancer in Spain



REDECAN: Spanish Network of Cancer Registries

- Established in 2010 with the aim of obtaining and providing the health authorities and the scientific community with the results on incidence, survival and prevalence of cancer in Spain.
- Cooperative body of the population-based cancer registries of 16 autonomous communities



Figura 1. Registros poblacionales de cáncer de España que han aportado datos para el cálculo de las estimaciones de la incidencia del cáncer en España, 2025

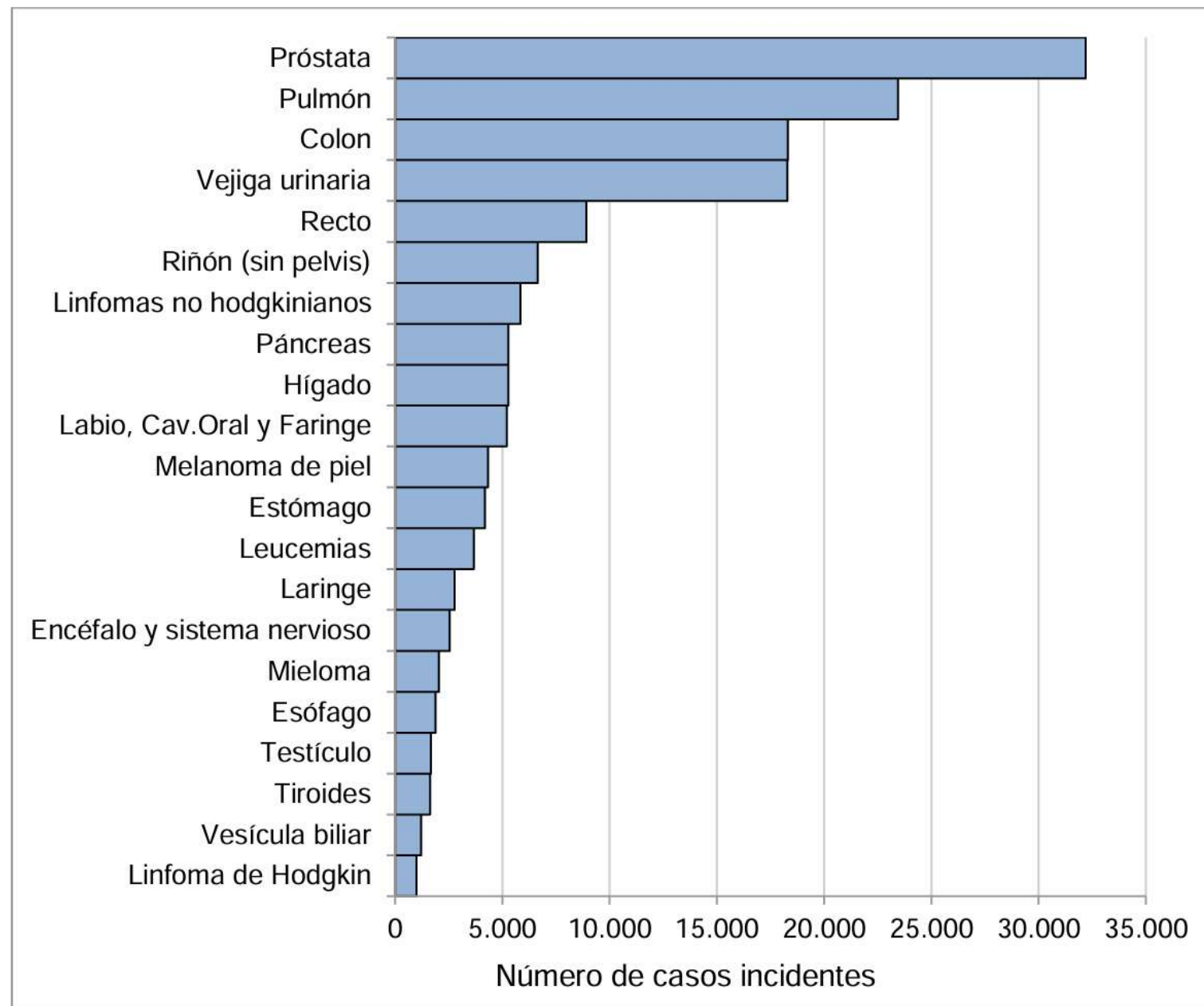


Fuente: Red Española de Registros de Cáncer

Population Health: Cancer in Spain

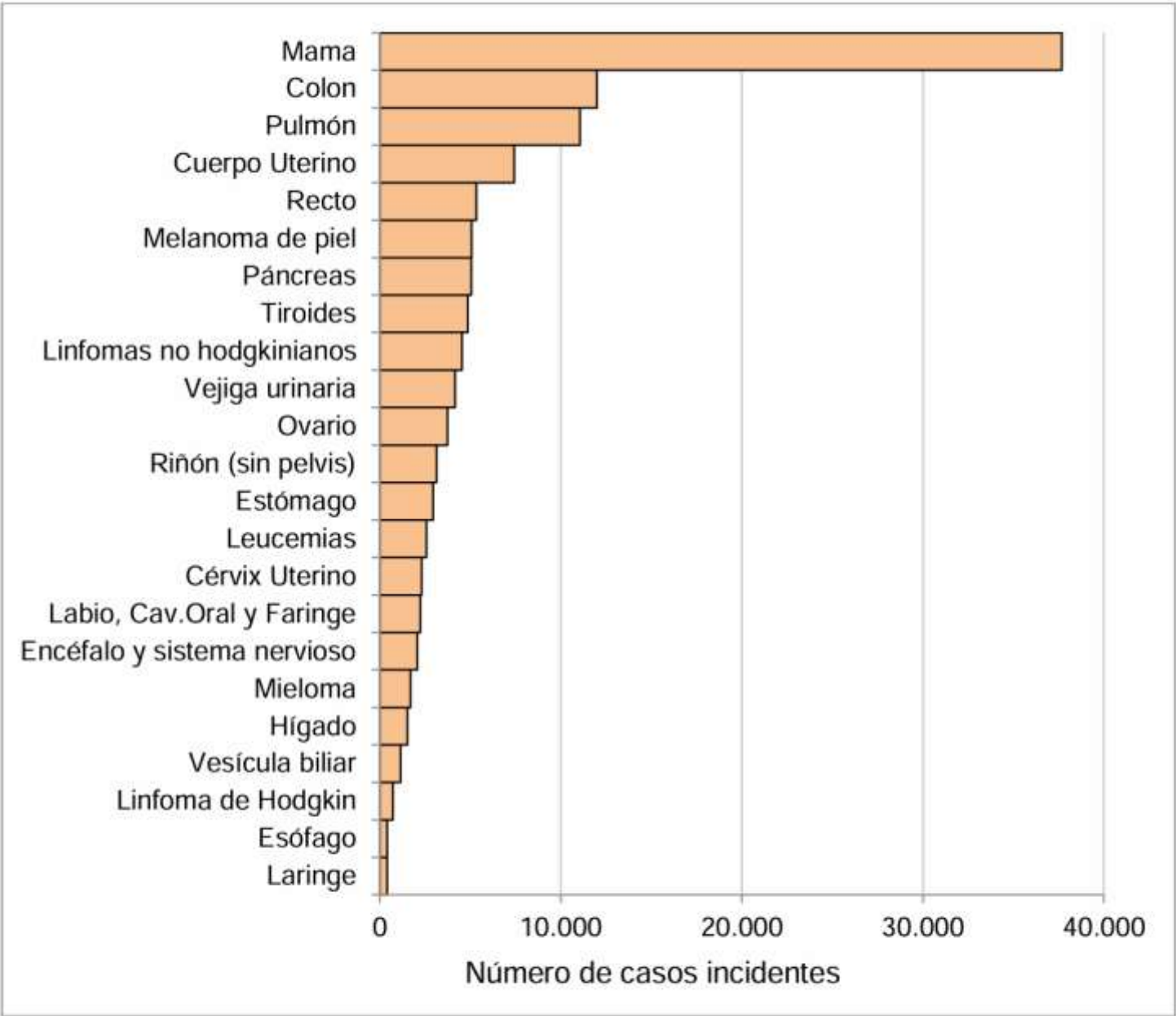
- Cancer is a major cause of morbidity and mortality in Spain.
- In 2025, an increase of **3.3%** cancer cases compared to 2024 is expected.
- A total of **296,103** cancer cases are expected in Spain, according to projections from the Spanish Society of Medical Oncology (SEOM) and the Spanish Network of Cancer Registries (REDECAN).
- Cancer has become the leading cause of death for the first time in Spain, according to 2023 mortality figures (National Institute of Statistics).
- Significant improvement in detection
 - AI-assisted mammograms and blood tests

Figura 2. Número estimado de casos incidentes de cáncer en España por tipo tumoral, 2025. Hombre



Fuente: Red Española de Registros de Cáncer

Figura 3. Número estimado de casos incidentes de cáncer en España por tipo tumoral, 2025. Mujeres



Fuente: Red Española de Registros de Cáncer

Population Health: Lung Cancer in Spain

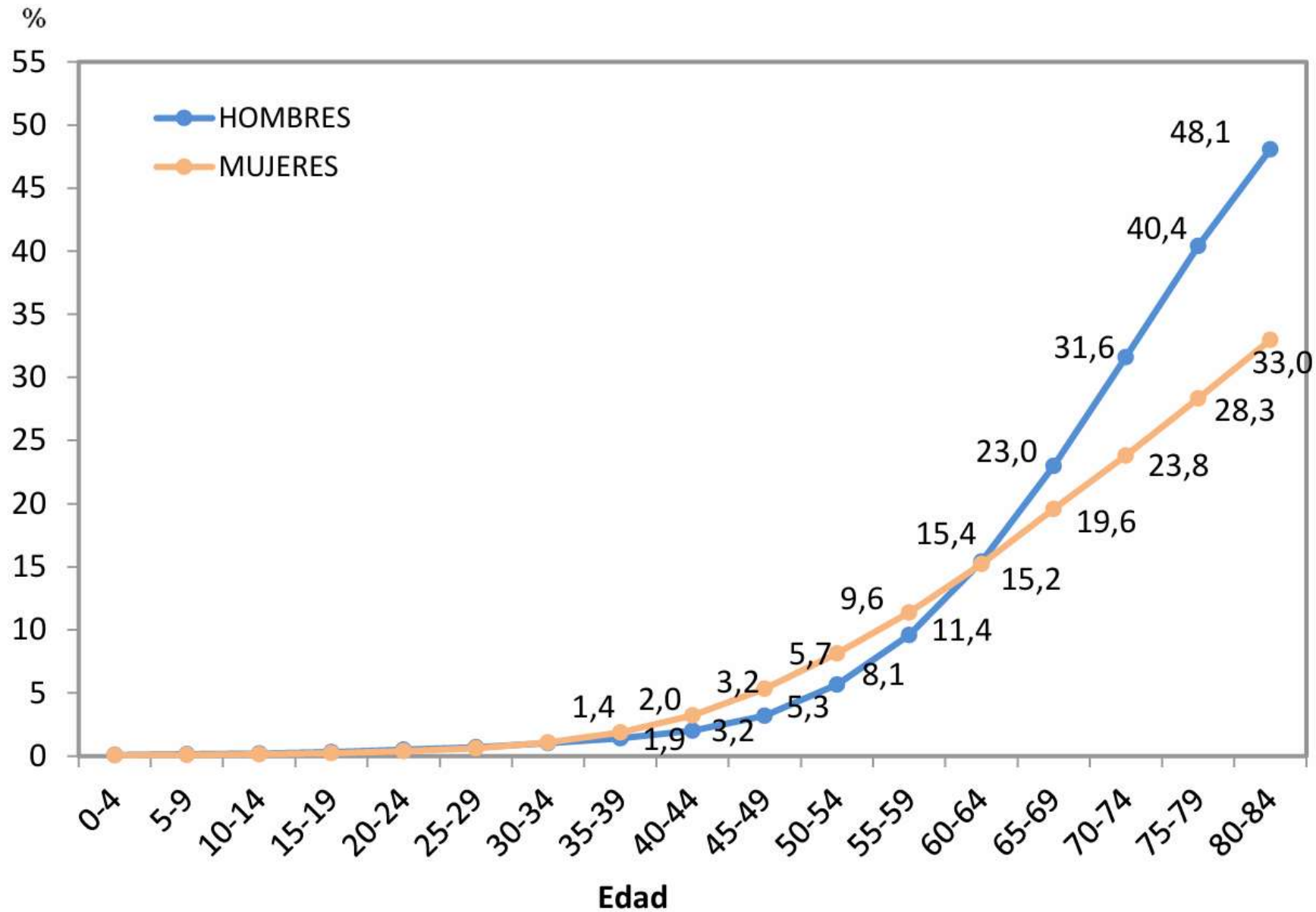
- Primary cause of lung cancer is tobacco consumption
- Responsible for approximately 90% of all cases.
- Despite public health efforts, 20% of the Spanish population continues to smoke daily.
- Reducing tobacco use is a major challenge .



Breast cancer
mortality in Spain
by community, 2019



Figura 11. Probabilidad (%) de desarrollar un cáncer (excluidos los tumores cutáneos no melanoma) según la edad por sexo en España el año 2025



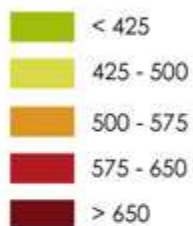
Population Health: Cancer in Spain

- According to the World Health Organization (WHO), predisposing factors related to cancer deaths in Spain are tobacco, alcohol, infections, obesity, sedentarism, and inadequate diet.



Mortalidad en Europa

Tasa de mortalidad por cáncer
por cada 100.000 habitantes



Cartografía:
Abel Gil Lobo (2019)
Fuentes:
Eurostat (2015-2016)

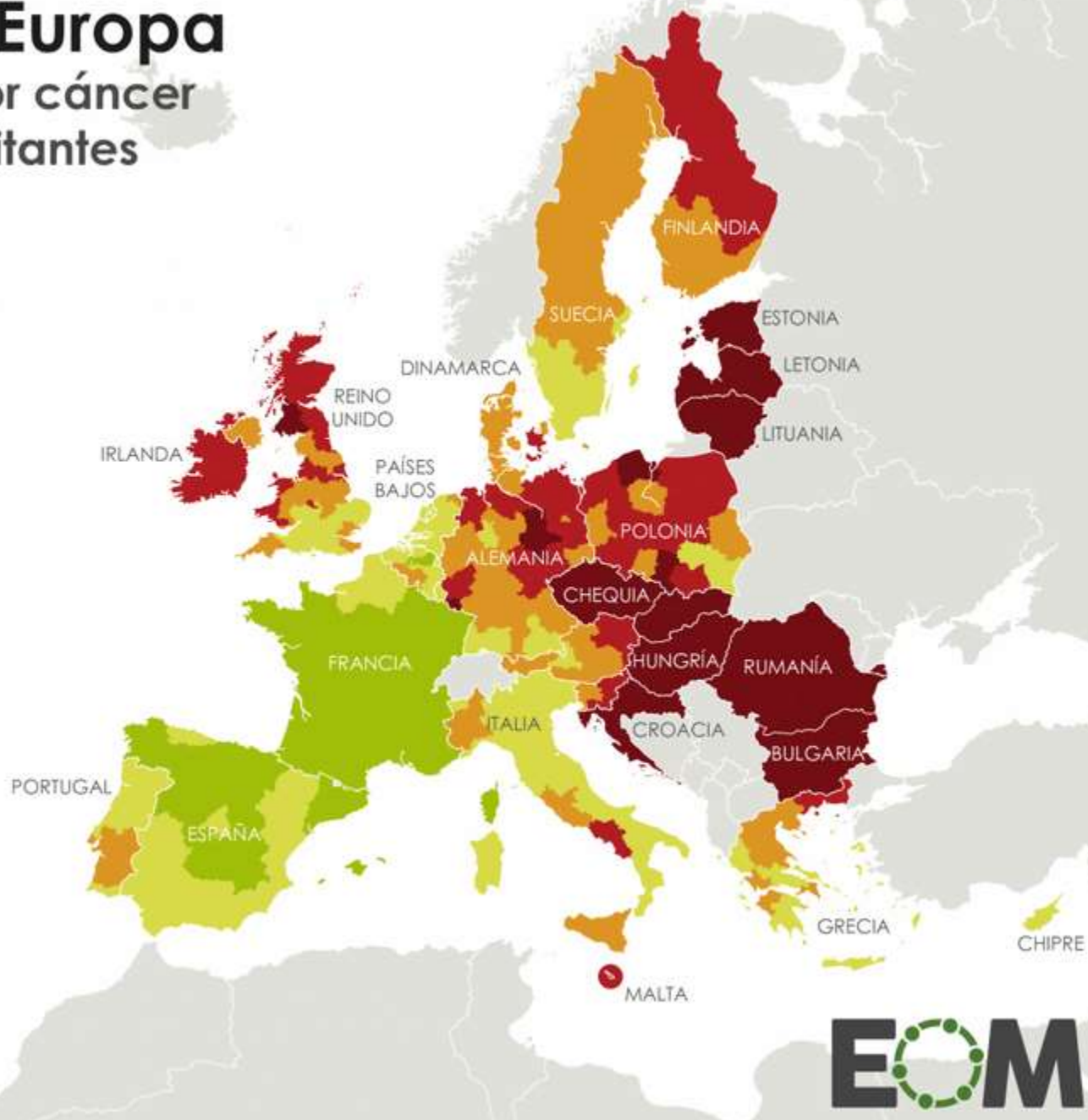


Azores (Pt)

Regiones ultraperiféricas

Madeira (Pt)

Canarias (Es)



Population Health: Cancer in Spain

- Redecan has prepared estimates of the incidence of cancer annually in Spain. How is this information helpful?
- With this big data, what questions could be answered to help advance diagnosis and treatment of cancer?
 - What would you analyze?
 - What research questions could be answered with machine learning methods?
- Knowing this data about cancer in Spain, what actions could be taken to improve the health of the population?

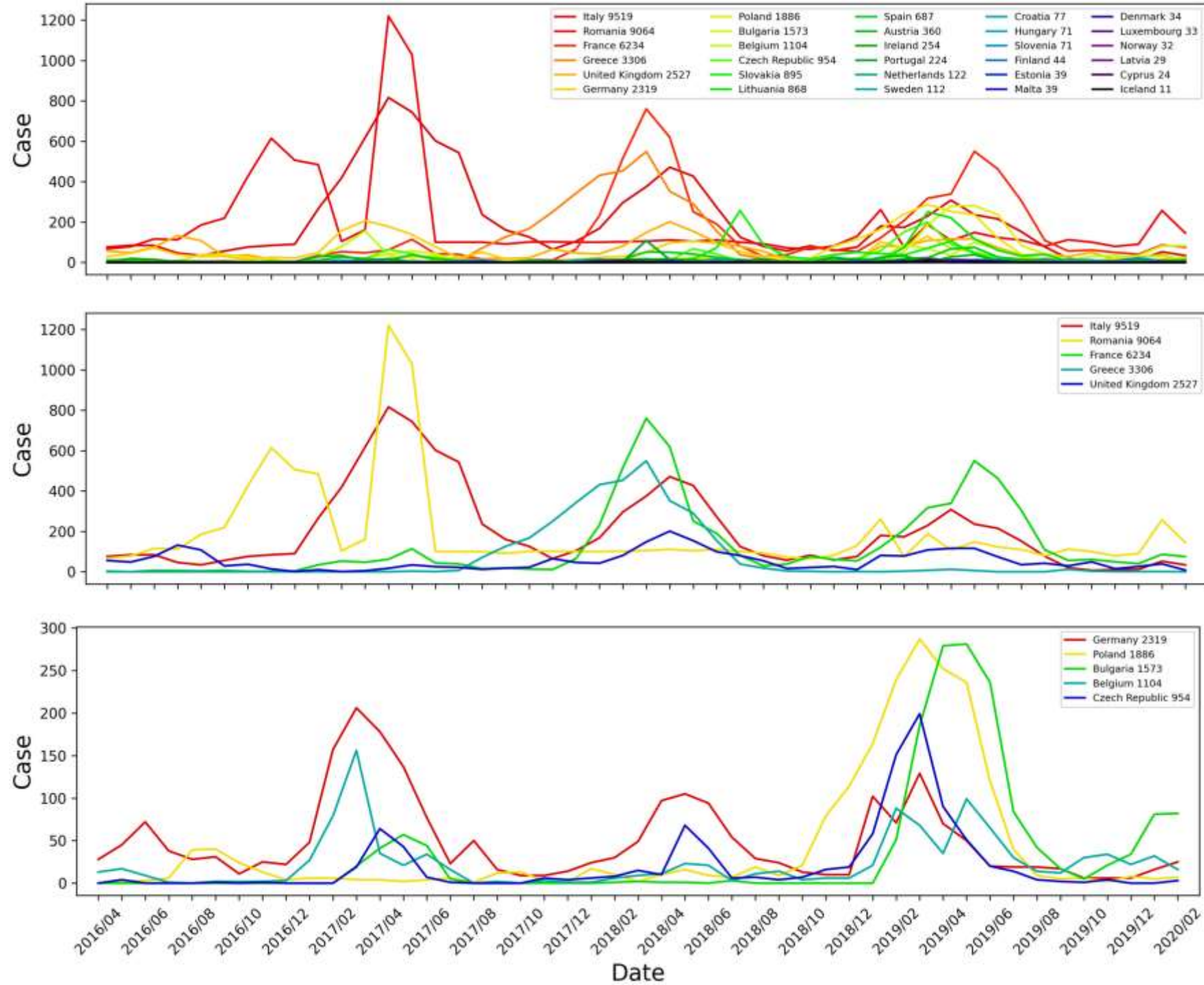
Population Health: Cancer in Spain

- Institute for Research in Biomedicine (IRB Barcelona) pursues a society free of disease.
- Read: Big Data analysis identifies new cancer risk genes
- <https://www.irbbarcelona.org/en/news/big-data-analysis-identifies-new-cancer-risk-genes>
- What did researchers there develop?
- What are cancer predisposition genes?
- What are the advantages of having a uniform cancer data set for all in a population of Spain? How clean is the data?
- What are the practical uses of the information and the ethics of the results?
- Can we conquer cancer with a great data set? How?

Population Health: Measles



Monthly number of measles cases for 29 EU/EEA member states and the UK from 2016 to 2020.



Population Health: Measles

- Read: Santangelo, O.E. (2019). Digital epidemiology: assessment of measles infection through Google Trends mechanism in Italy. *Ann Ig* 2019; 31: 385-391
doi:10.7416/ai.2019.2300
- [Can Google Trends and Wikipedia help traditional surveillance? A pilot study on Measles - PMC](#)
- What did they learn?
- Is there a correlation between search terms and the real number of cases of measles?
- Does the media influence the population's search terms?
- Can Google search terms be used as an additional disease surveillance tool?
- What other diseases would this approach be helpful for?
- What can be the negative consequences of using information for public health?

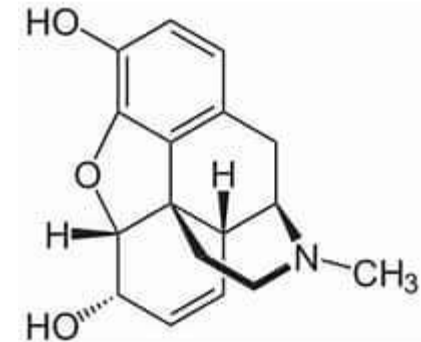
Population Health: Measles

- Google Trends was suitable for monitoring acute disease outbreaks of measles in high income countries even when there are only a few weekly cases.
 - <https://www.nature.com/articles/s41598-024-60120-8>
- Google Trends have a potential role in public health in order to provide near real-time indicators of the spread of infectious diseases.

Population Health: Opioid Dependence

Opioid dependence simply refers to the **development of tolerance**. Tolerance is needing higher doses to produce the same effect or getting less benefit from the same dose over time.

Opioids have high addiction potential because they trigger your brain to release endorphins. Examples: post surgical use of morphine, heroin addiction



Population Health: Opioid Dependence

- Opioid360 from Google and Deloitte
 - Machine learning platform aiming to assess social, lifestyle, and behavioural risks associated with drug dependence.
 - Automates risk calculation to identify persons at risk of opioid dependence using browser histories, credit, insurance, social media and traditional survey data.
 - Marketed to health and human services at information technology conferences as a tool to help support over-worked clinicians to see invisible signs of potential addiction, and to act swiftly on these signs.
- https://orcid.org/0000-0003-3088-9501_rachel.s.rowe@gmail.com View all authors and affiliations. <https://doi.org/10.1177/20539517211062881>

The power of insight

A persistent "360" view

Analytics & Ads Data

- Targeted ad keyword searches indicating interest in opioids
- Data enrichment with google analytic and public data sets



Public Sector Data

- 30 data sets
- Up to 5,000 data elements
- Medical Claims, ED visits, Prescription Monitoring Programs



Lifestyle Data

- Personal indicators (i.e. exercises regularly)
- Financial (i.e. owns home)
- Regional economic growth indicators

1. De-identified with



Population Health: Opioid Dependence

- Using big data models to identify health risks using social determinants of health (economic stability, social and community environments, access to quality healthcare, and education).
- Is this a more efficient, accurate, and actionable way of understanding and acting on the complex social factors that shape the health of populations?
- What could go wrong with this approach?

Population Health: AIDS in Africa

- **HIV/AIDS is a major public health concern in Africa.**
- The continent is home to about **15.2%** of the world's population but more than **two-thirds** of total HIV infections worldwide, affecting roughly 35 million people.
- Ghana: In 2023, **334,095 people were living with HIV**, including 115,891 males and 218,204 females. Additionally, 17,774 people became newly infected with HIV in that year.



Population Health: AIDS in Africa

- Ghana: Significant health efforts against AIDS

HIV testing and treatment services are free in all government health facilities; health care workers have been trained; prevention services such as self-testing and pre-exposure prophylaxis are free.

Resulting in a 38% reduction in new HIV infections since 2010

[Strengthening the fight against HIV in Ghana | WHO | Regional Office for Africa](#)

- Watch: <https://www.gatesfoundation.org/video/darlington-akogo> (1 min)
- What types of data sets would be helpful for the health of the people of Ghana?
- How could AI be used to help the health of people in Ghana especially against AIDS?

Population Health: Datasets

Total Retrieved Images	Positive In Final Result	Negative In Final Result	Precision	Recall	Computation Time	Matching Time	Total Time
21	16	5	0.76	0.80	16.01	22.74	38.75
32	28	4	0.88	0.93	63.46	76.61	140.07
42	30	12	0.71	1.00	71.62	114.75	186.37
45	28	17	0.62	0.93	58.89	83.61	142.50
24	20	4	0.83	1.00	38.65	72.51	111.17
32	27	5	0.84	0.90	39.09	79.24	118.33
36	21	15	0.58	0.70	44.17	64.35	108.51
45	24	21	0.53	0.96	72.45	124.04	196.49
22	17	5	0.77	0.85	38.22	65.69	103.90
30	26	4	0.87	0.87	40.49	84.37	124.86

- In UK: 100,000 genome repository – British initiative **sequencing whole genomes from NHS patients, focusing on rare diseases, some common types of cancer, and infectious diseases.**
- Phenotype Knowledge Base – PheKB.org
- Publicly available: kids data, air data, behavioral risk data, injury, risk, nutrition, census, gerontology, pharmacoeconomics

Population Health: AI Tools

- Read: Opportunities and Limits: The role of AI in population health
- <https://www.linkedin.com/pulse/opportunities-limits-what-role-ai-population-health-rz8re/>
- What were the recommendations from this report?
- How would you propose sharing the information globally?
- Will AI regulations be helpful or stall progress?



Population Health: AI Tools

- Uses :
 - **Detect signs, patterns, anomalies, and risks in populations**
 - Identify people at risk of chronic diseases
 - Understand the impact of interventions
 - Predict high use and high cost patients
 - Accelerate medical discoveries especially drug development
 - Improve screenings in radiology interpretation
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10960211/#:~:text=Generative%20AI%20has%20the%20potential,decision%2Dmaking%20%5B4%5D> .

Population Health

- Benefits: Focus on wellness instead of sick care, improve patient outcomes and save lives, lower costs.
- Challenges: Privacy violations, security risks, job displacement, misdiagnosis or mistreatment, legal or regulatory
- High interest and generous funding
 - By some estimates, population data analytics funding surpasses investment in apps, wearables, and clinical decision support tools.
- Accelerate the application of large language models and generative AI to difficult grand challenges in population health
- <https://www.washington.edu/populationhealth/resources/funding-and-awards/application-of-ai-to-grand-challenges-in-population-health/>

Bioethics Definition

- A **branch of applied ethics** that studies the philosophical, social, and legal issues arising in medicine and the life sciences.
- Covers topics such as health care, research, reproduction, death, and human well-being.



Bioethical Challenges in Population Health

- Focus on dilemmas that arise at the population health level
 - Evaluate disease severity
 - Prioritize scarce resources
 - Involve communities so they advance their needs and interests
 - Consider the impact of large-scale events, like climate change and disasters and pandemics
 - Consider the impact of politics on health such as war

Bioethics

- Sometimes differences in values and beliefs arise between groups, populations, or institutions.
 - For example, during the COVID-19 pandemic, public health decision makers sometimes failed to be transparent with the public about their reasoning and the use of masks became a political issue in the U.S.
- The four pillars of bioethics: patient autonomy (**respect**), beneficence (**benefit others**), nonmaleficence (**do no harm**), and social justice (**fairness** in process and outcomes).

Bioethical Challenges: Discussion Questions

- In a pandemic, who gets diagnostic kits or treatments?
- Why are women and minorities not included in research studies at the same rate as white males?
- Can we use machine learning models to predict the most at risk or the most benefit?
- With misinformation and disinformation on the Internet, how is one to believe any results of population health studies?

Summary: Biomedical informatics and Bioethics: Tools for Population Health

Definitions of population health and bioethics

Benefits and limitations of large data sets and AI tools in population health

Examples of population health studies and the role of big data



summary

Next session

- Biotech, diagnostics, pharma, medical devices, clinical research
- Homework: Midterm exam