MEASURING GLOBAL HEALTH: AN INTRODUCTION TO THE ASSESSMENT OF THE BURDEN OF DISEASE

Tim Driscoll

Sydney School of Public Health

Outline for today

- Background and history
- DALYs and Population Attributable Fractions
- Overview of methods
- Overview of results for GBD and Australian Burden of Disease study
- How to use Burden of Disease information

- (Consideration of some of the major challenges)
- (Behind the scenes of the GBD)
- Thanks to Michael Dibley and Yasir Bin Nisar for some of the slides!

A Fundamental Question in International Health

What are the most important health problems in the world?

The GBD study: Background and history

What is the burden of disease?

An estimate of the total amount of ill health in a community

May focus on or compare particular population sub-groups

Includes injuries!

Looks at outcomes (burden) and the causes of those outcomes (risk factors)

Why measure burden of disease?

- Establish health care priorities
  - To make best investments in health
  - To ensure greatest impact from health care
- Monitor health care system performance
- Assuming……
  - Something can be done to change the disease burden
  - There are cost effective interventions

Other relevance of global estimates

Demonstrate contribution to global burden of disease

Attract attention of policy makers

Provide guidance to policy makers

Encourage steps to reduce risks

Limited resources means funding should be determined by evidence-based priorities!

Why can't the cases just be counted?

Incomplete reporting systems

Rudimentary reporting systems

Absent reporting systems

Some injury and disease difficult because of lack of coverage and under-reporting of known cases

Some disease extremely difficult to link to exposures due to long latency

Why bother using standard methods?

GLOBAL, COMPARABLE, EVIDENCE-BASED information on injuries and diseases and associated risk factors

"A response to the need for comprehensive, consistent and comparable information on diseases and injuries at global, regional and national levels" (WHO)

The history of the GBD

GBD 1990

- Commissioned in 1991 by World Bank
- Run by Chris Murray and Alan Lopez
- Focussed on 1990
- Released in 1996
- Involved collaborators from many countries
- Primarily looked at outcomes (overall burden)
- *- "107 diseases and injuries and ten risk factors"*
- Several minor modifications followed

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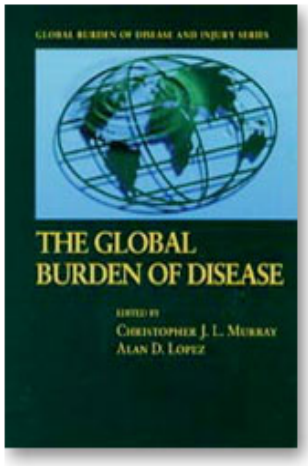


GLOBAL BURDEN OF DISEASE

A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020

EDITOR CHRISTOPHER J. L. MURRAY

EDITOR ALAN D. LOPEZ

The Global Burden of Disease and Injury Series details and analyzes global patterns of death and disability, providing a bold, comprehensive examination of the state of the world's health.

The Comparative Risk Assessment project

- Looked at risk factors
- Ran from 2000 to 2004
- Looked at burden in 2000
- Involved working groups for specific areas
- Involved collaborators from many countries

Establishing the GBD 2010

- Originally GBD 2005 rather than GBD 2010
- Funded by Bill and Melinda Gates Foundation
- Call for collaborators in July 2007 (Lancet)
- Expert Group leaders appointed mid 2007

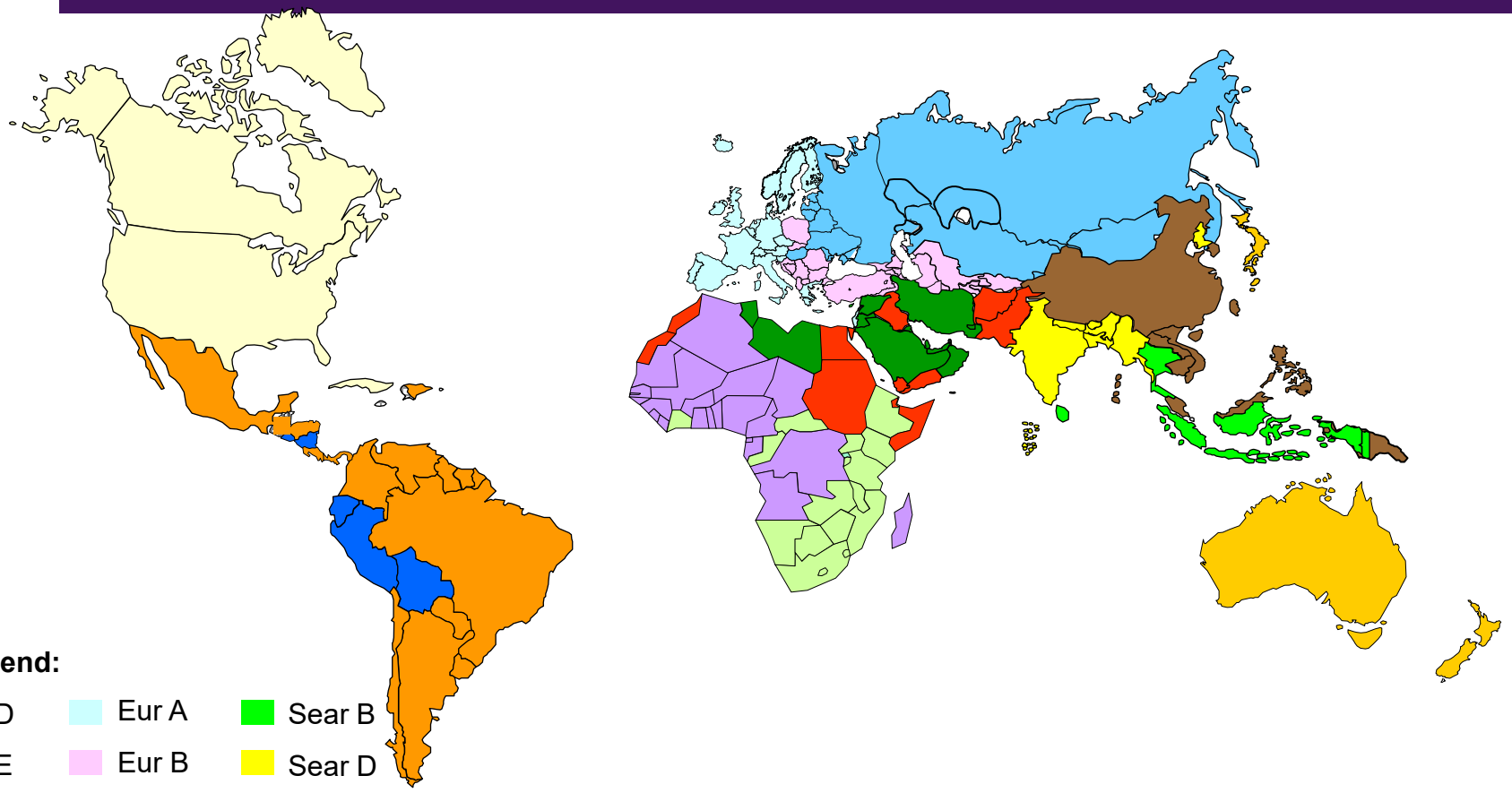
GBD 2010: meetings and deadlines

- Study meetings in Seattle in September 2007 and May 2010
- Group meetings at the Gold Coast (August 2008) and Sydney (mid-2010)
- Original due date for information was mid-2009
- Revised due date was mid 2011
- Actual due date was early 2012
- Data first released in December 2012

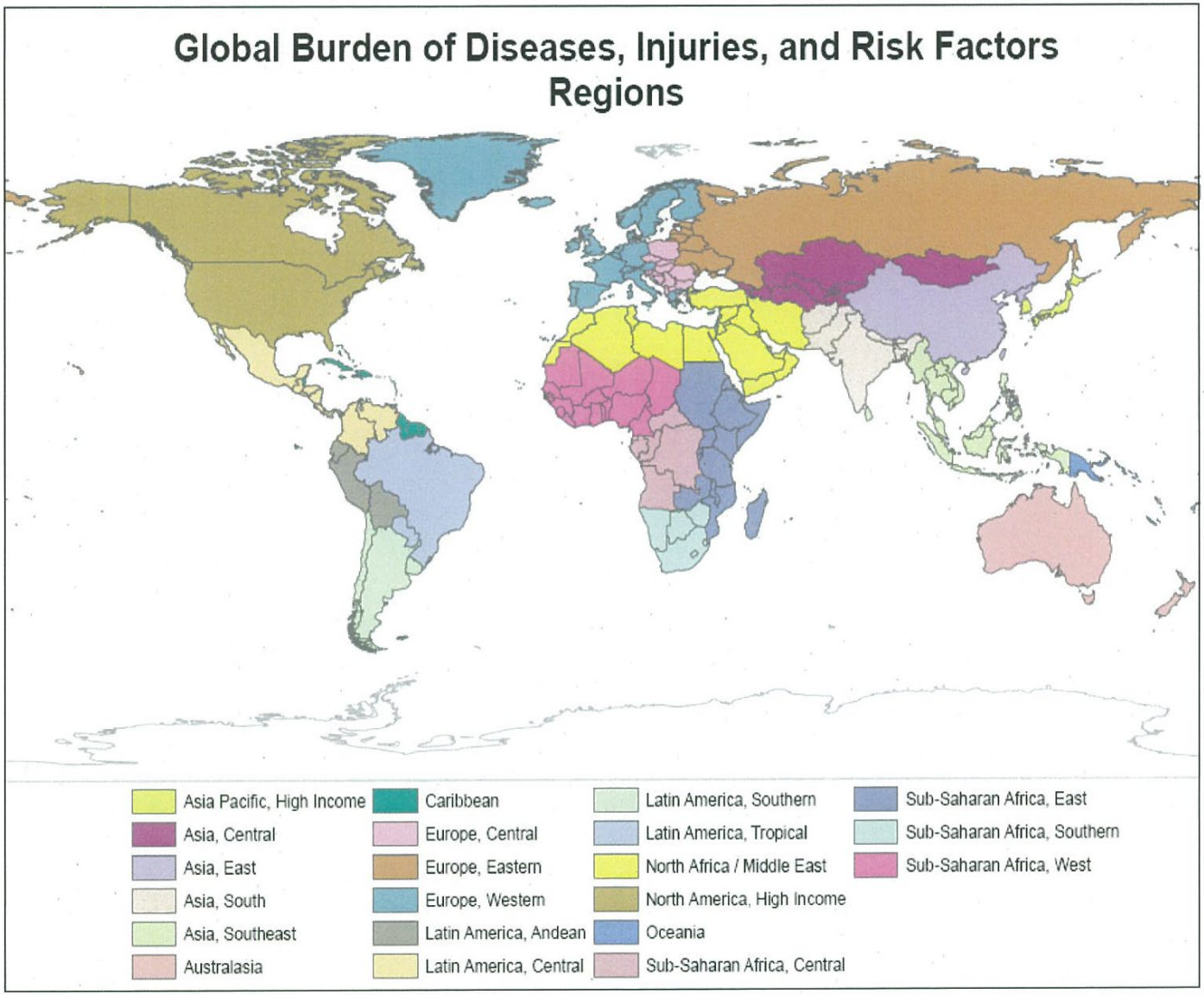
GBD data and publications

- Regular updates undertaken (GBD 2013, GBD 2015, GBD 2016, GBD 2017, GBD 2019) and planned
- Lots of publications on specific aspects
- Each update incorporates new information and methods

GBD1990 – 14 regions

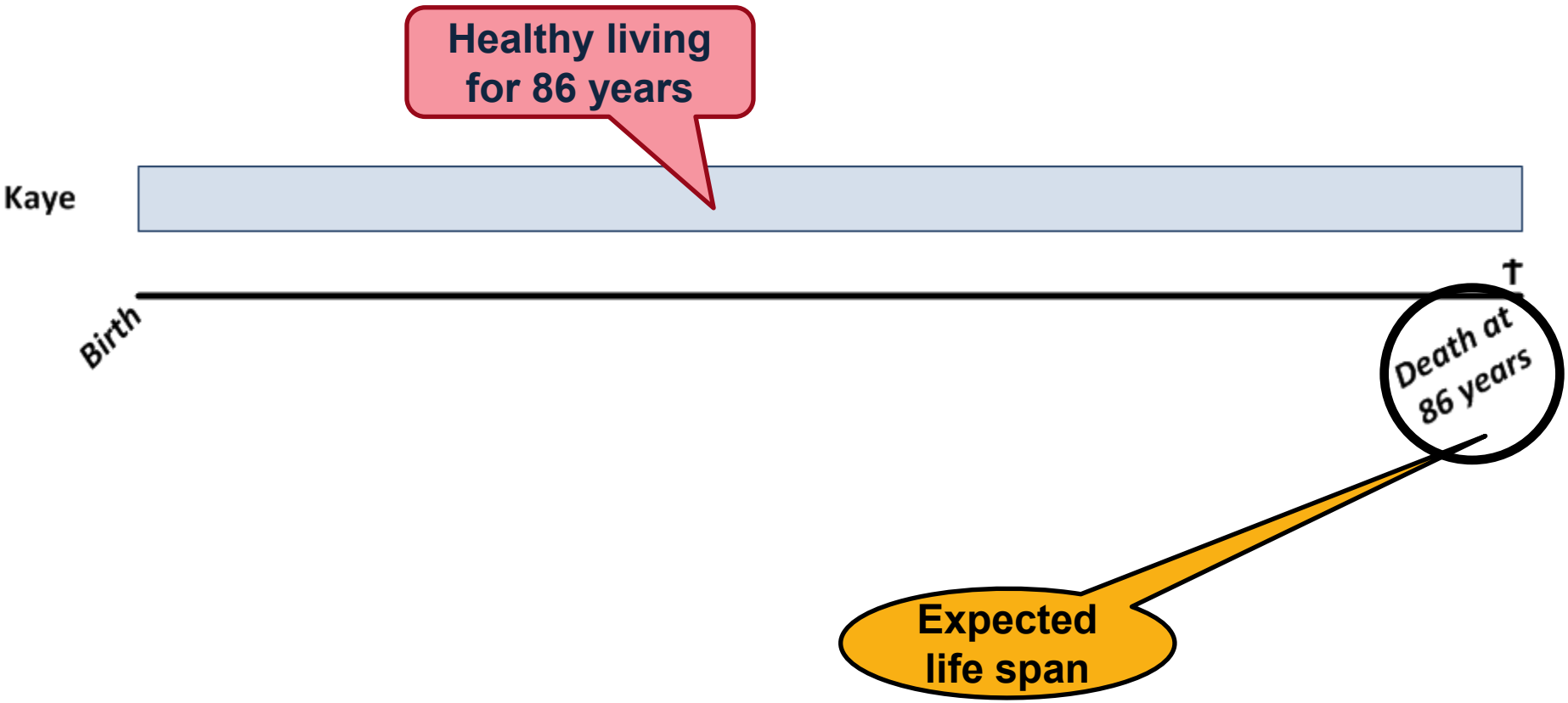


GBD2010 – 21 regions

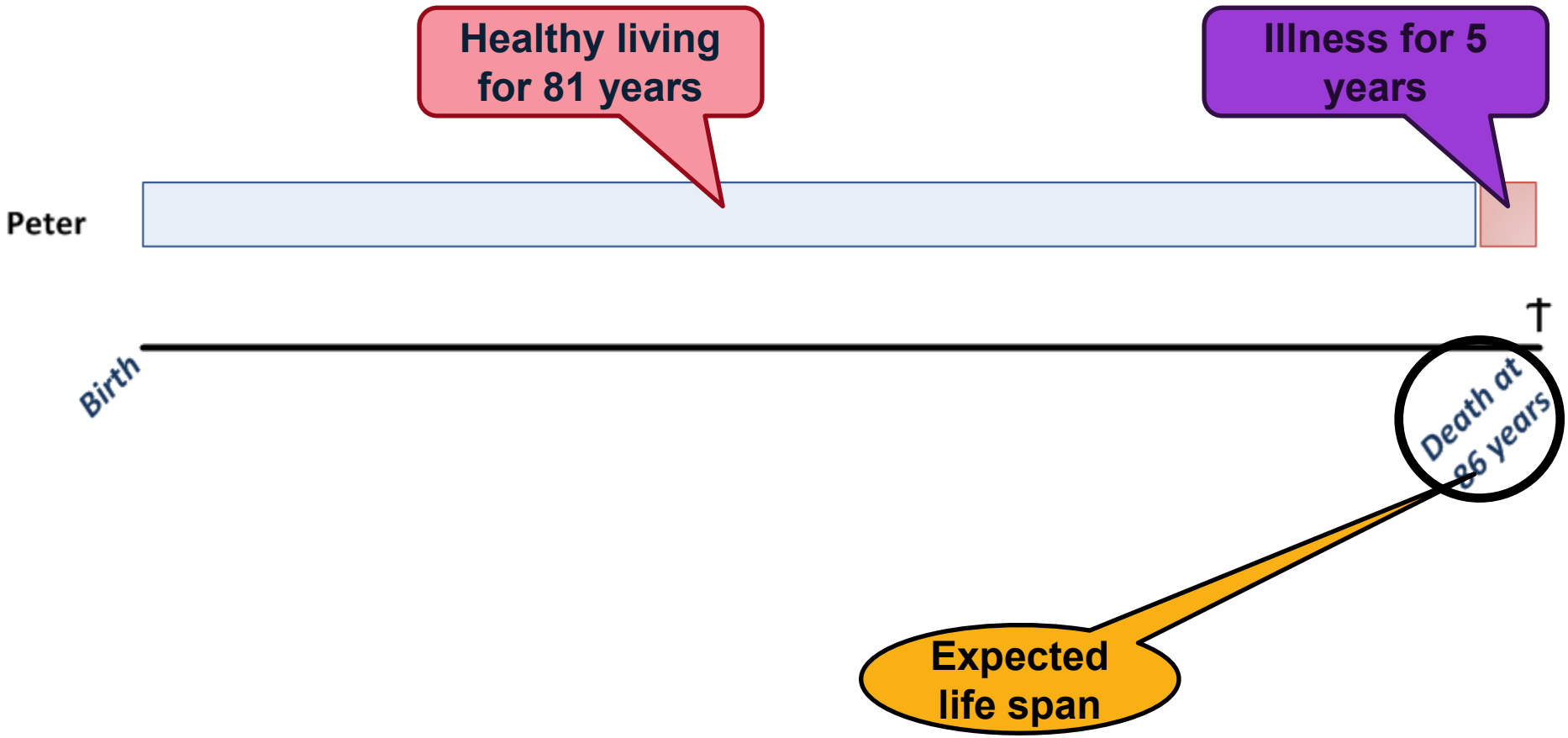


How should the burden of disease be measured?

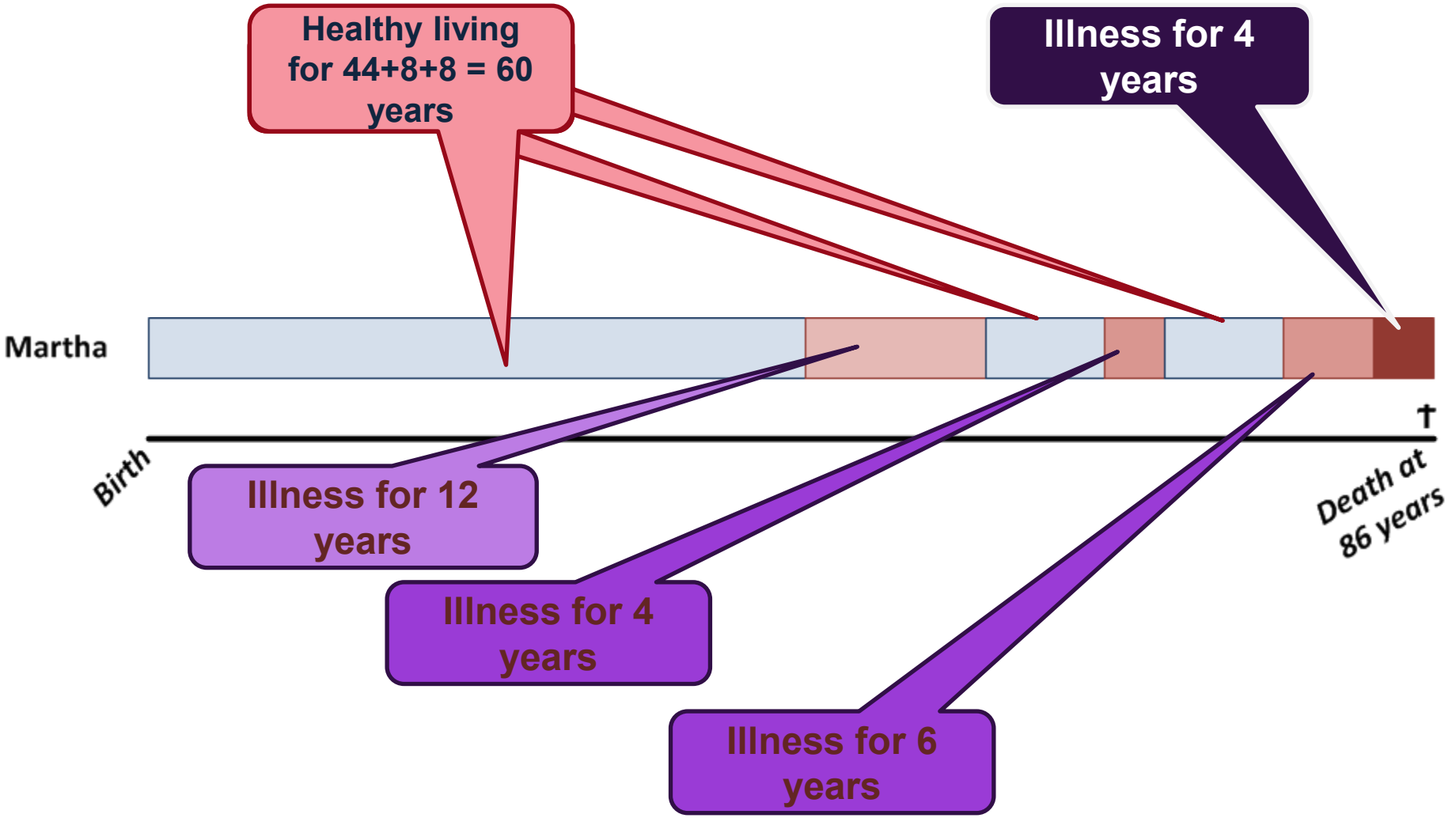
Individual Life Histories: a long healthy life



Individual Life Histories: illness at the end



Individual Life Histories: mid-life chronic illness



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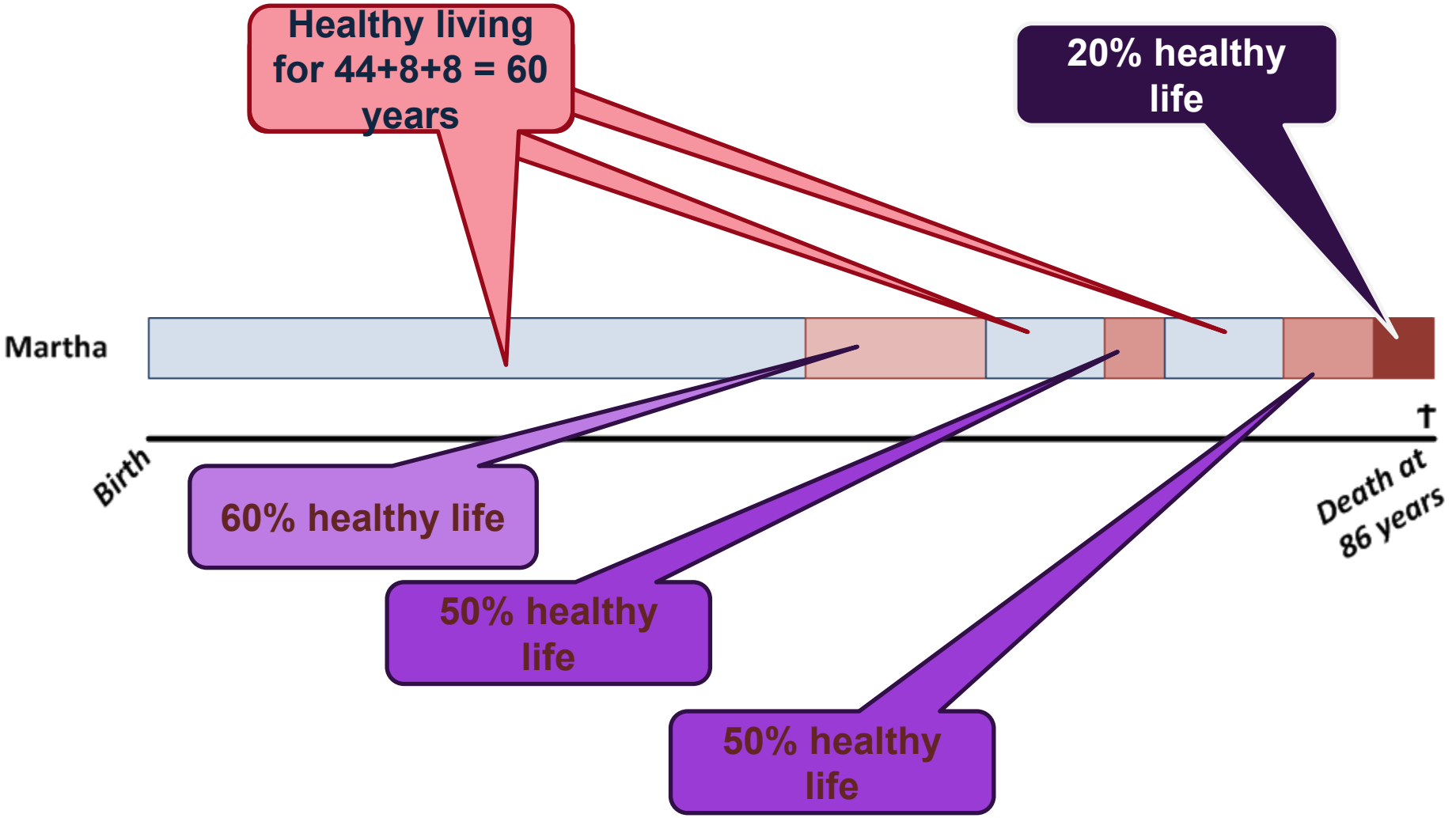

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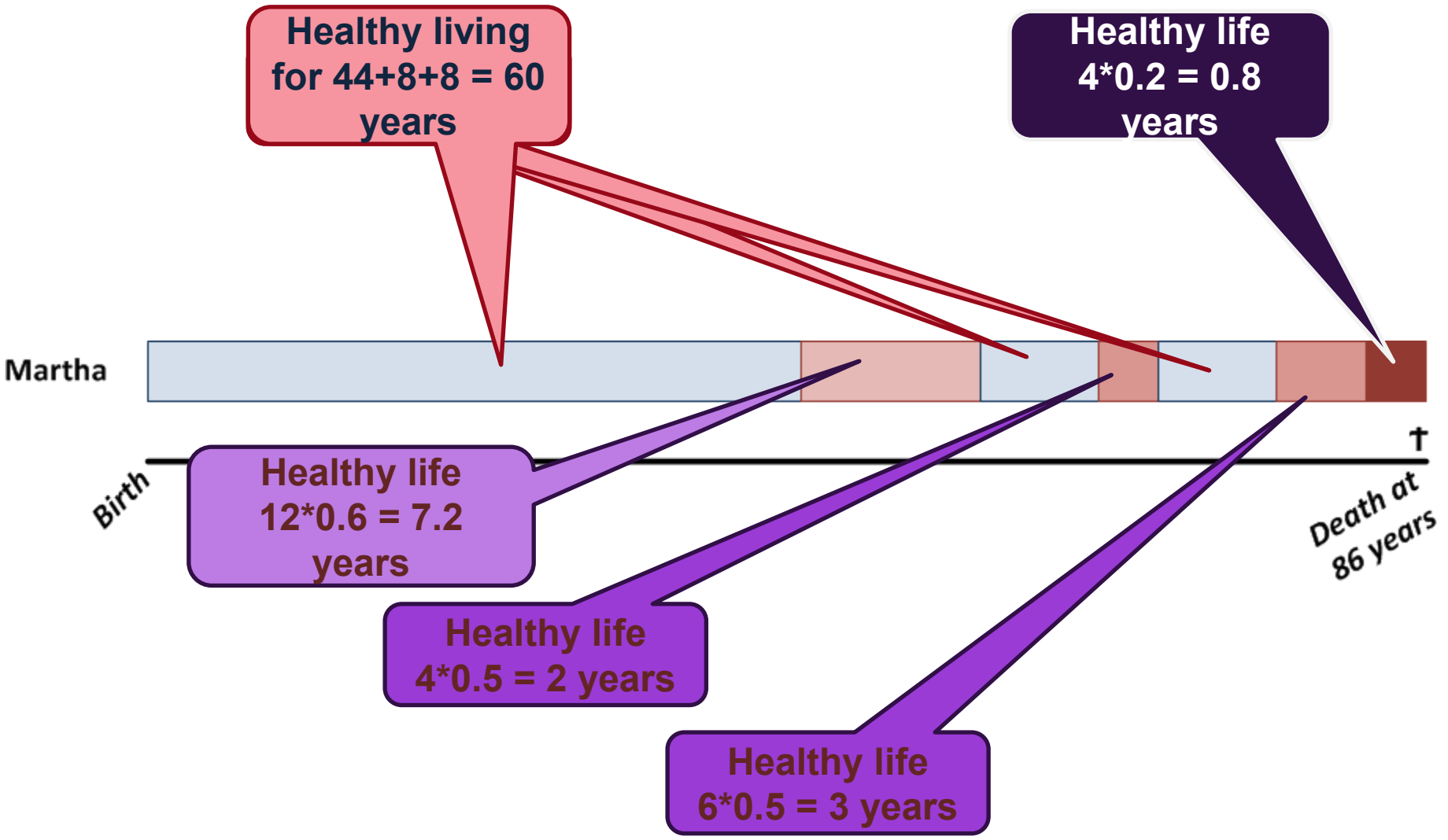

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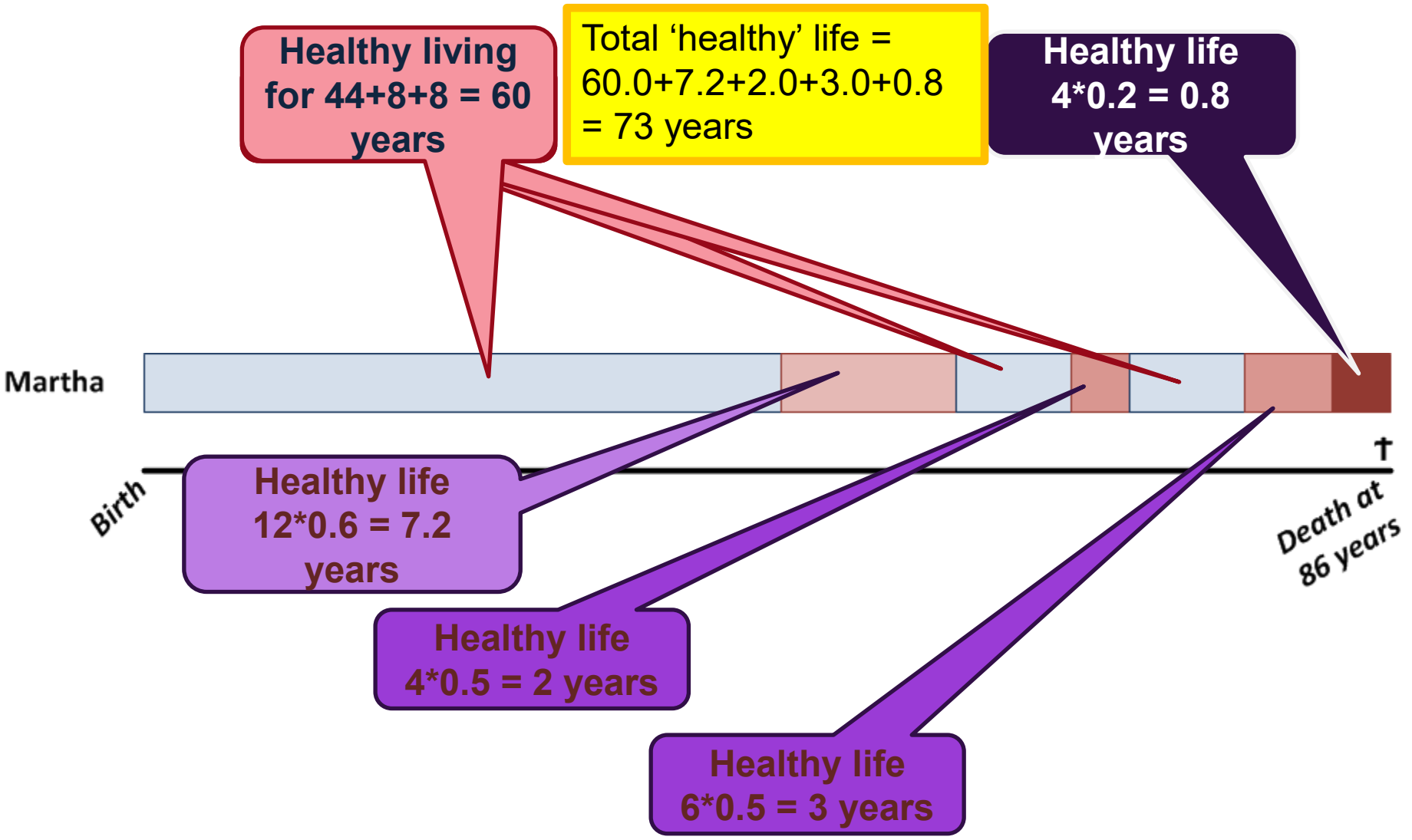
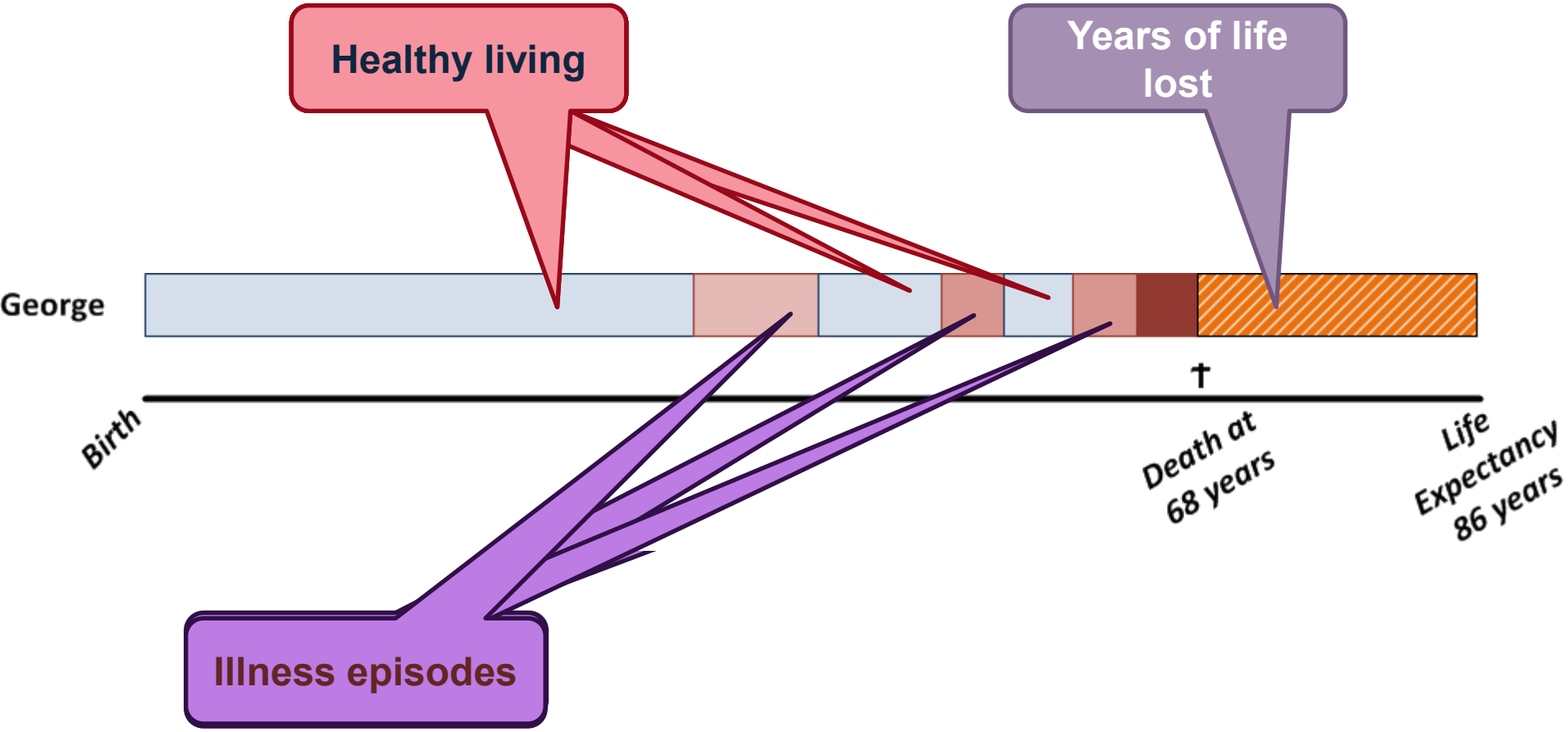
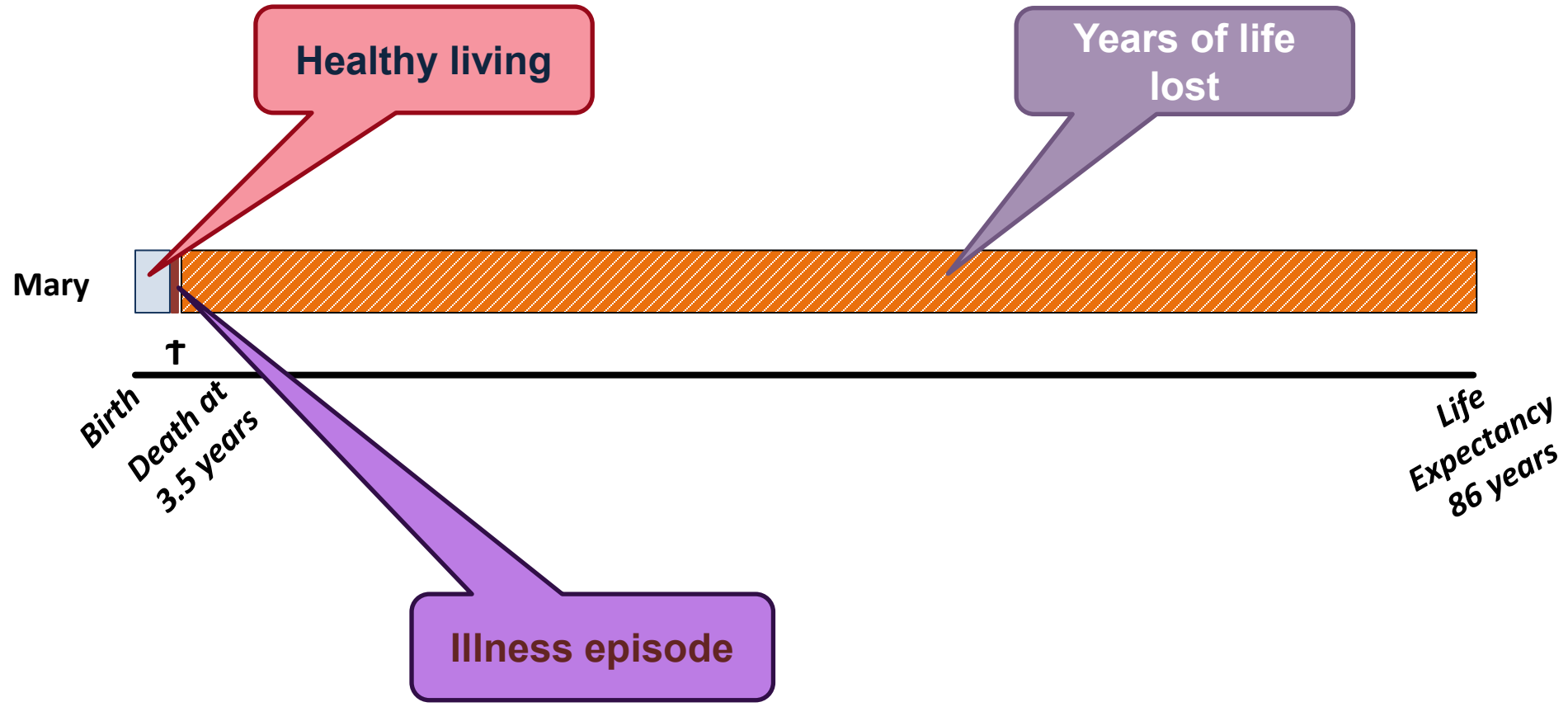


Individual Life Histories: a chronic illness & premature death



Individual Life Histories: early premature death



Exercise

Marjorie

- *Well until age 50*
- *Diagnosed with chronic obstructive airways disease (COPD)*
  - *Aged 50 to just before 65th birthday: loss of 20% of usual function*
  - *Aged 65 to just before 75th birthday: loss of 40% usual function*
  - *Aged 75: died*
    - *(Would have expected to live until age 87).*

How many equivalent years of healthy life did Marjorie lose?

DALYs

DALY *(Disability Adjusted Life Year)*

Incorporate mortality and disability

DALY = Σ (YLL + YLD)

- **YLL = years of life lost due to premature mortality**
- **YLD = the (weighted) years lived with a disability**

Does it matter at what age death occurs?

Years of life lost (YLL)

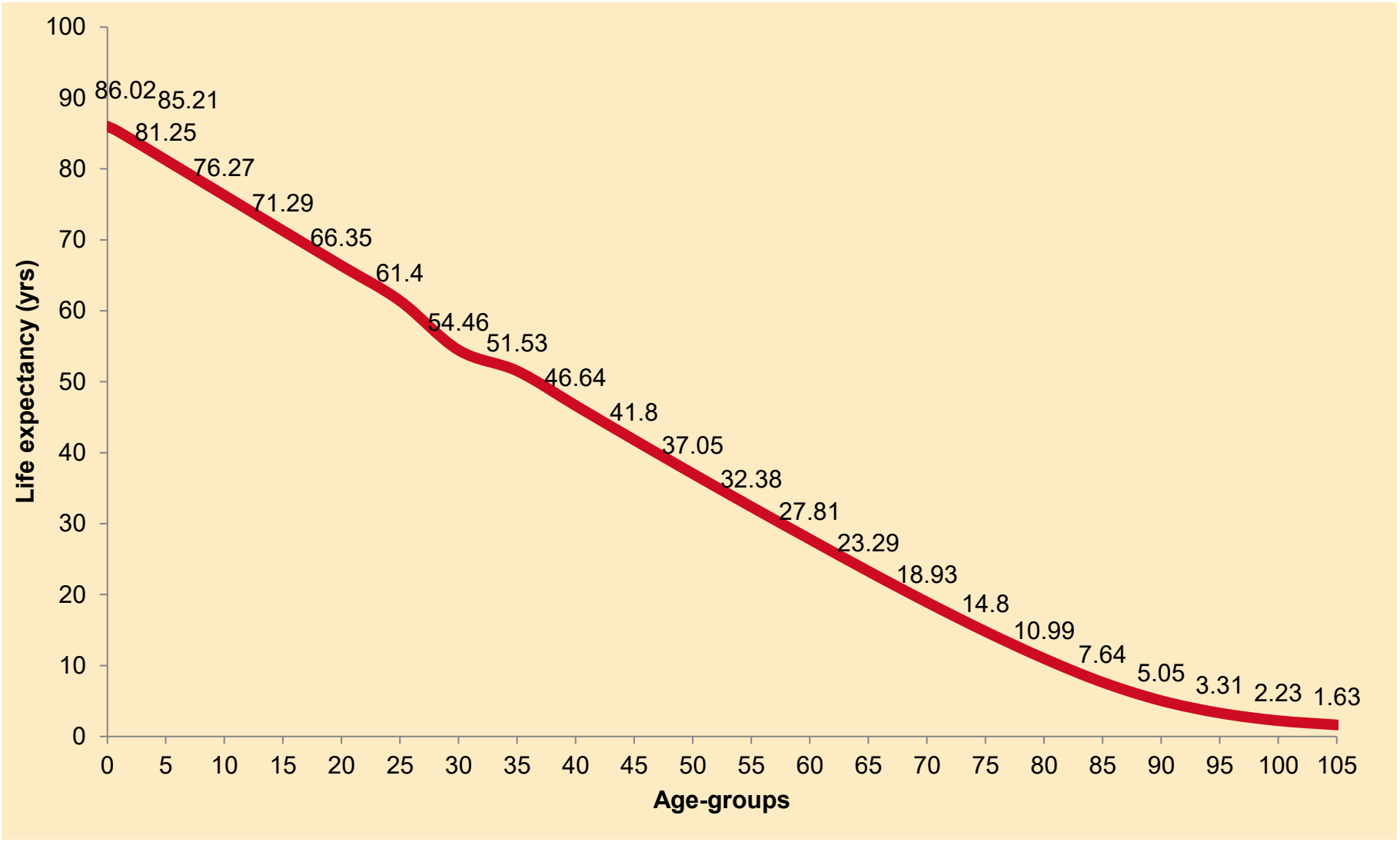
How long should we expect people to live?

- WHO GBD 2004 study used life expectancy from Japan

  82.5 years females / 80.0 years males

- GBD study 2010 developed a new reference standard life.
  - Set life expectancy at birth of 86.0 years for males and females.

Life expectancy values at each age-group



Source: Murray CJL, Ezzati M, Flaxman AD, et al. GBD 2010: design, definitions, and metrics. *Lancet 2012;* ***380: 2063–66.***

Years of life lost (YLL)

YLL is the sum of the years of life lost due to premature mortality in the population

$$YLL = N \times L$$

Where

YLL: Years of life lost

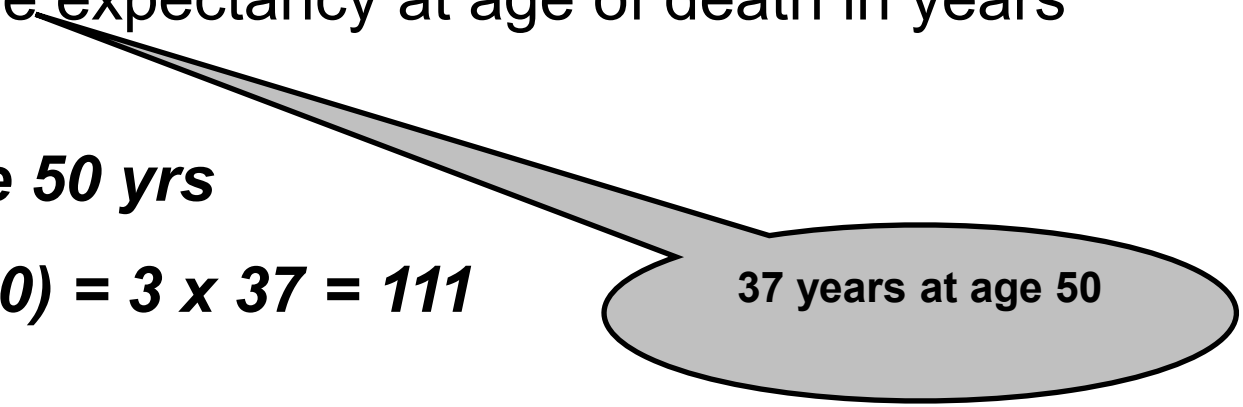
N = number of deaths

L = standard life expectancy at age of death in years

Example:

3 deaths at age 50 yrs

YLL= 3 x (87-50) = 3 x 37 = 111



Source: Murray CJL, Ezzati M, Flaxman AD, et al. GBD 2010: design, definitions, and metrics. *Lancet 2012;* ***380: 2063–66.***

DALYs

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Does disability matter?

THE UNIVERSITY OF SYDNEY

Healthy life lost due to disability (YLD)

- How to estimate?
  - Estimate prevalence of condition
  - Multiply average duration for each case by severity weight
  - Severity weight quantifies equivalent loss of healthy life lost due to condition
- Severity weights represent social preferences about the severity of different types of disability

Years Lived with Disability (YLD)

$$YLD = P \times DW \times d$$

Where

YLD = Years of life lived with disability

P = Prevalence of cases in the population

DW = Disability weight

D = Duration of disability [years]

Example:

4 cases of mild mental retardation due to birth trauma (death at age 80 years):

YLD = 4 x 0.36 x 80 years
= 115 YLD

Disability Weights (DW)

- Quantify preferences for health states in terms of a single number on an interval level scale
  - 0 = full health
  - 1 = health state equivalent to death
- DW quantify preferences for health states
  - (bigger weight -> more lost health)
- DW say nothing about
  - the value of the person
  - their quality of life
  - their utility in society

DW valuation in GBD study

- GBD 2010 Study
  - General public view considered
  - 220 unique health states across the 1,160 disease and injury sequelae
  - General population surveys in 5 countries (Bangladesh, Indonesia, Peru, Tanzania, United States) and through an internet survey
  - Respondents aged 18 years and above
  - DW elicited using pair-wise comparisons
  - Expanded and updated survey information for GBD 2015 and thereafter

Disability weights estimation

Disability weights estimation

- Spinal cord lesion at neck level (treated)
- Gout, acute
- Hearing loss, complete
- Major depressive disorder, moderate episode
- Asthma, uncontrolled
- Heart failure, severe
- HIV/AIDS cases, receiving ARV treatment
- AIDS cases, not receiving ARV treatment
- Back pain, chronic, without leg pain
- Diarrhea, mild
- Fracture of pelvis (short term)

Disability Weights

Options to respond:

1. Vote using this direct link: https://www.menti.com/alzhjesxtyhx
2. Go to www.menti.com and enter code **47 53 00 3**
3. Scan the QR code on this screen

DALYs

DALY *(Disability Adjusted Life Year)*

Incorporate mortality and disability

DALY = Σ (YLL + YLD)

- **YLL = years of life lost due to premature mortality**
- **YLD = the (weighted) years lived with a disability**

GBD burden estimates made easy

Estimate how many people died of a particular disorder (DEATHS)

Estimate what proportion of people die due to a particular risk factor (PAF)

Multiply the DEATHS by the PAF

This gives the number of deaths due to exposure to the risk factor!

Essentially do the same with DALYs

Assessment of risk factors

Population attributable fraction

Population attributable fraction

The proportion of cases that would not occur if the risk factor was eliminated.

Population attributable fraction

The population attributable fraction (PAF) is based on:

- exposure prevalence
- relative risk

$$PAF = \frac{\sum Pi*RRi - 1}{\sum Pi*RRi}$$

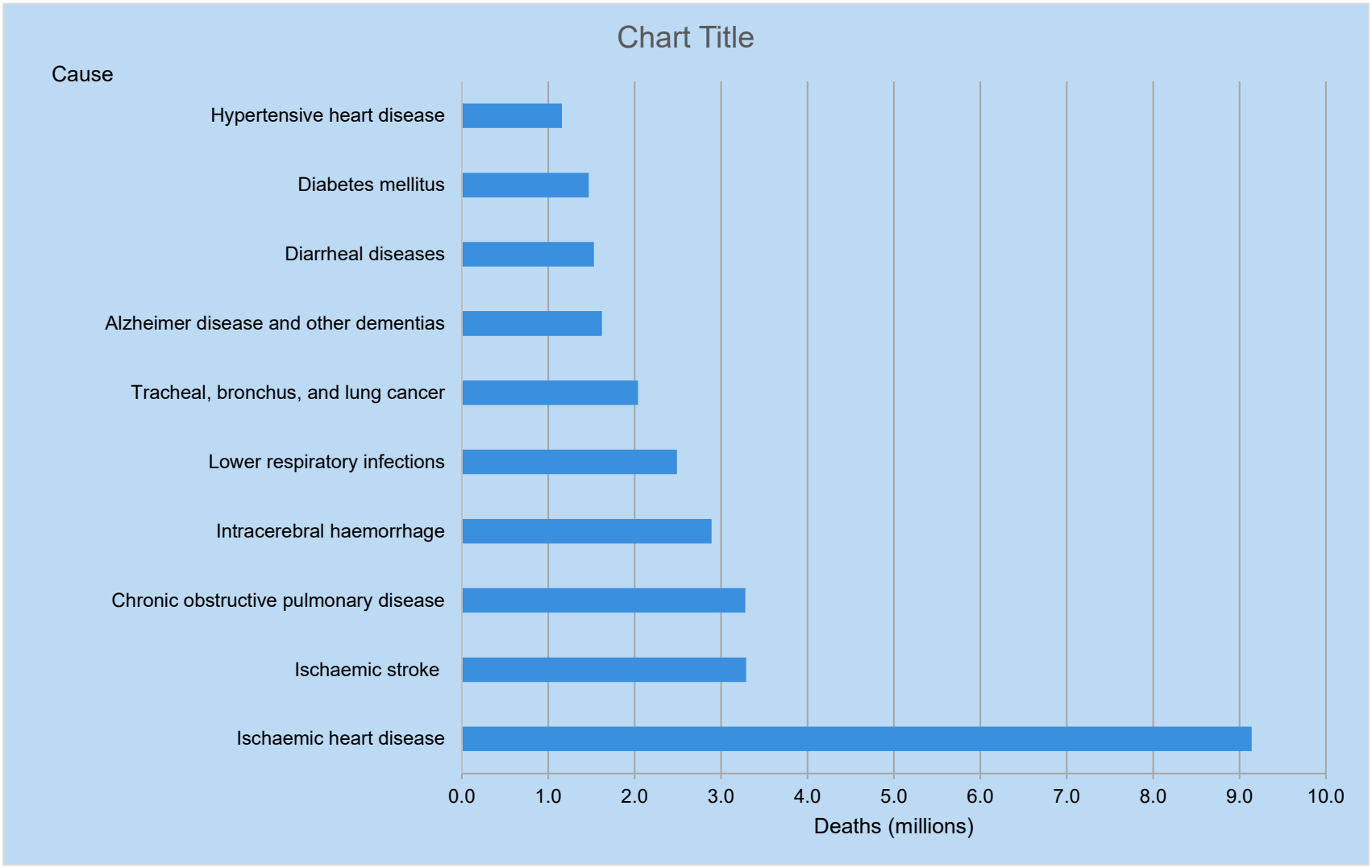
GBD 2019

- 369 disease and injury causes
  - 286 causes of death
- 87 risk factors and clusters of risk factors
  - 560 risk-outcome pairs
- 204 countries and territories (in 21 regions and seven “GBD super-regions”)
  - Separate information for sub-national areas in 21 countries
- 23 age groups
- Males, females and both sexes combined
- 1990 and 2019

Source: Lancet 2020; 392(10258):1129-1306

Results

Global causes of mortality, World, 2019

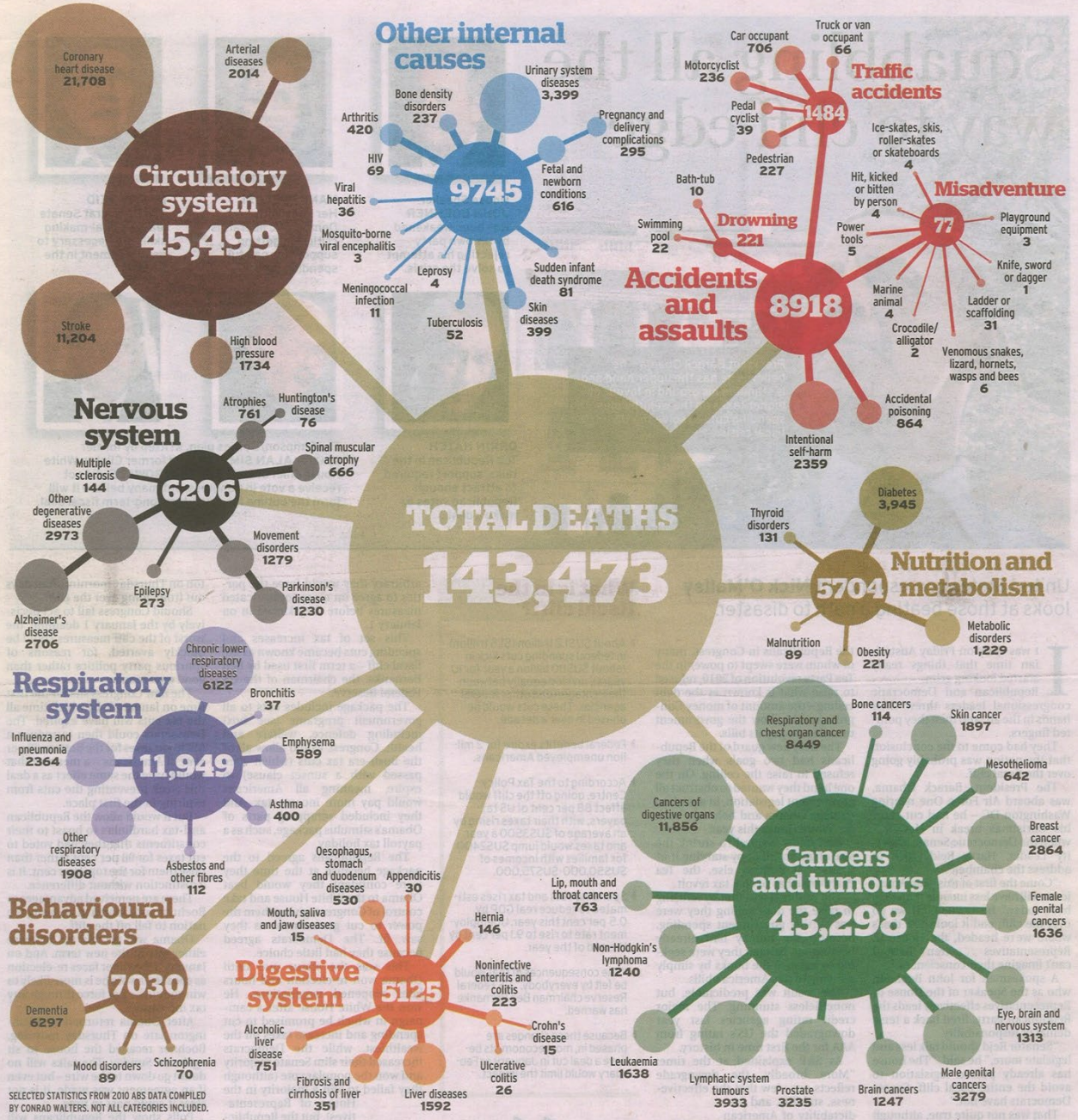


Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Global Causes of Mortality, World, 2019

Rank	Cause	Number (millions)
1	Ischaemic heart disease	9.14
2	Ischaemic stroke	3.29
3	Chronic obstructive pulmonary disease	3.28
4	Intracerebral haemorrhage	2.89
5	Lower respiratory infections	2.49
6	Tracheal, bronchus, and lung cancer	2.04
7	Alzheimer disease and other dementias	1.62
8	Diarrheal diseases	1.53
9	Diabetes mellitus	1.47
10	Hypertensive heart disease	1.16

Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

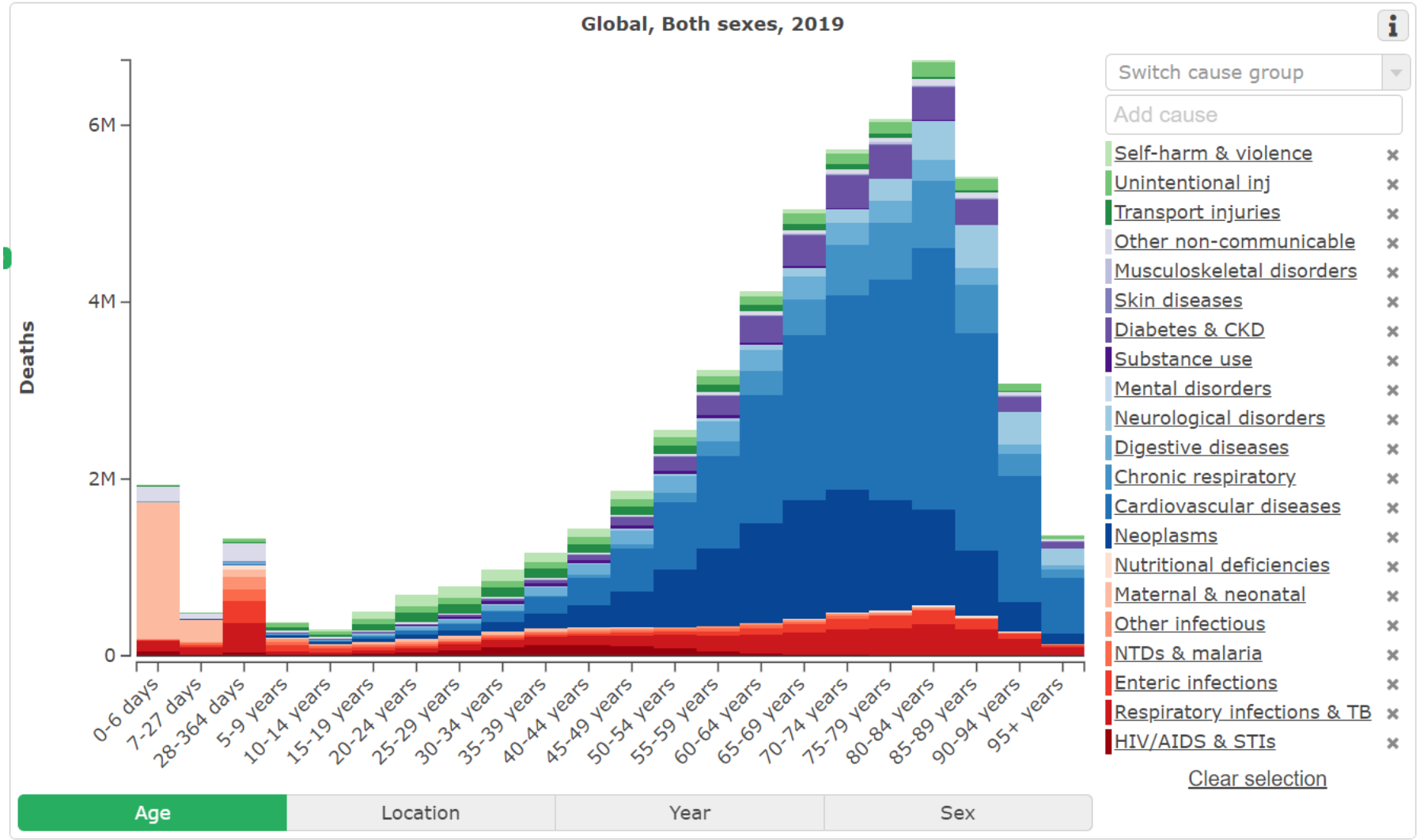


SELECTED STATISTICS FROM 2010 ABS DATA COMPILED BY CONRAD WALTERS. NOT ALL CATEGORIES INCLUDED.

Annual loss recorded: a year in the life of death

SMH 29 Dec 2012

Global deaths by age, World, 2019



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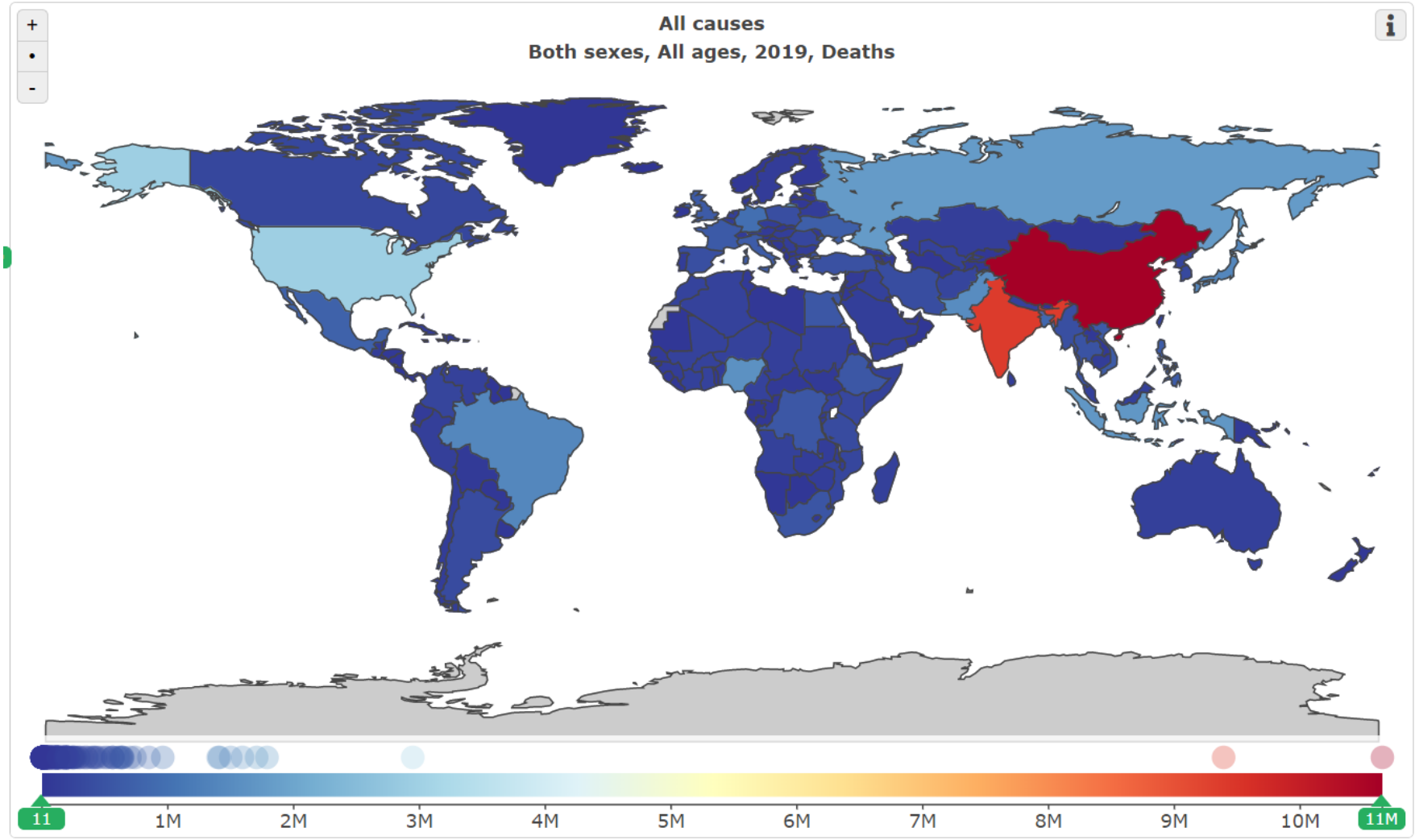
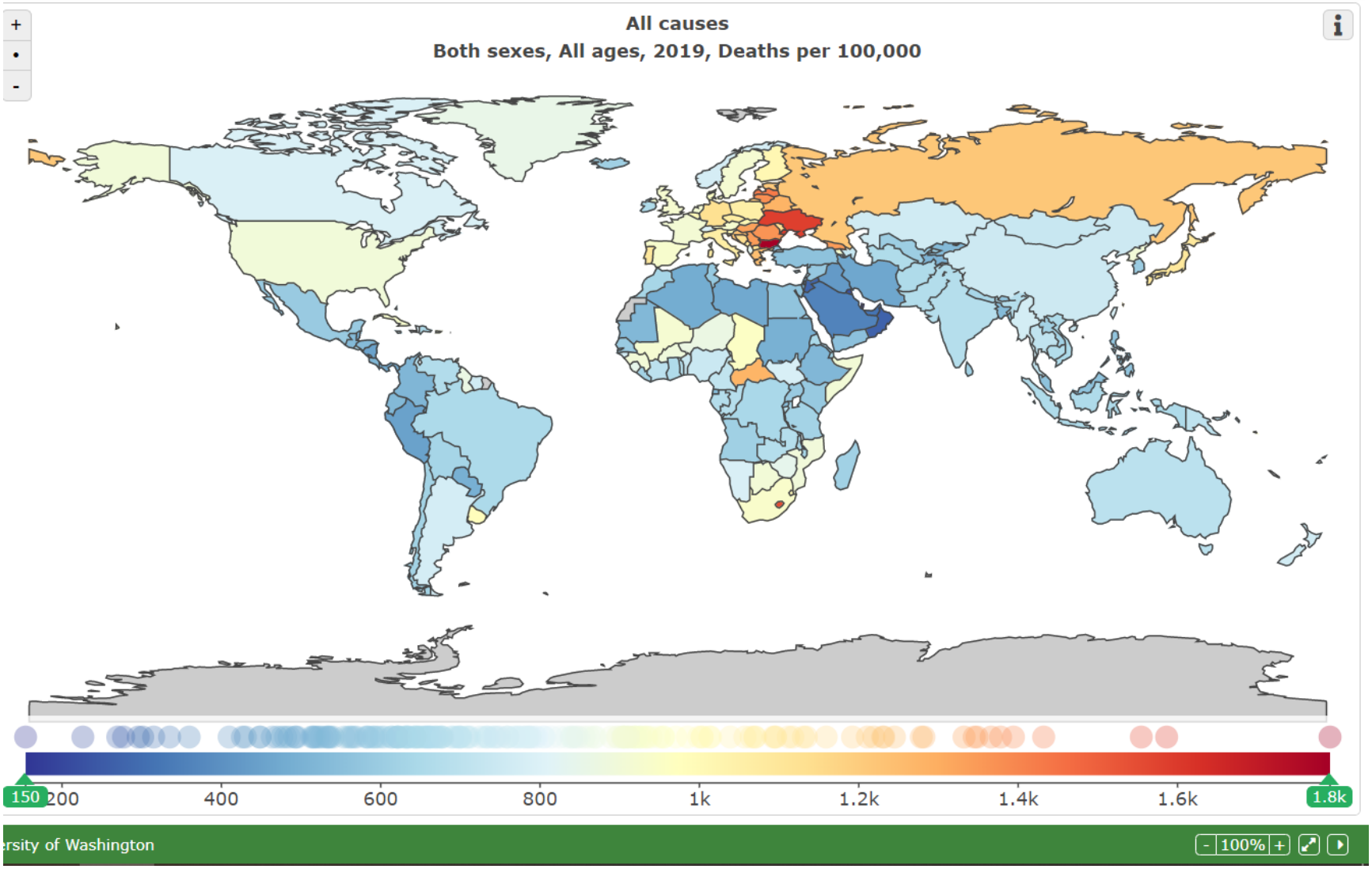
Global deaths by region in 2019 - number



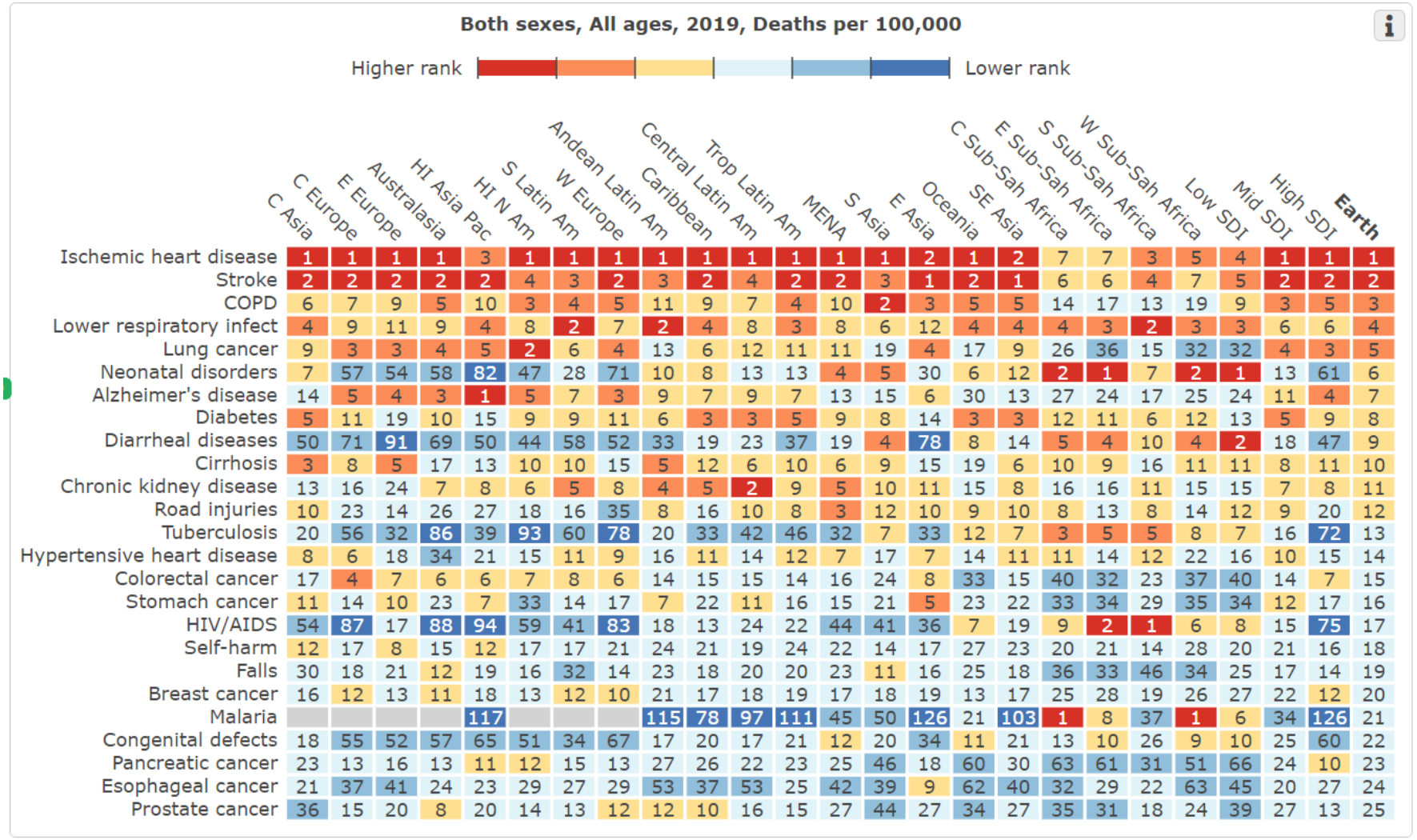
Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Global deaths by region in 2019 – per 100,000



Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Cause of death * region – 2019 – Global rank



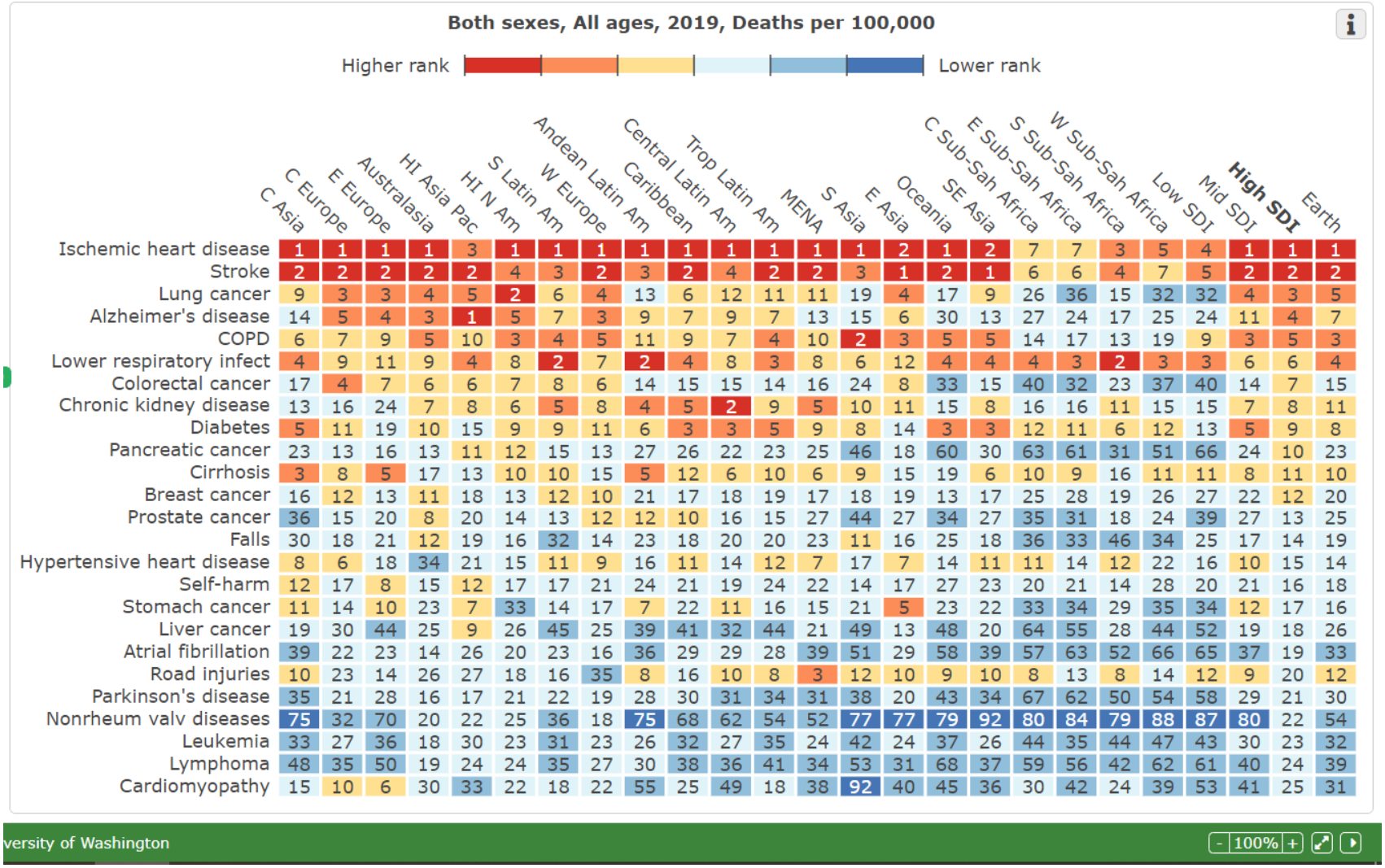
	C Asia	C Europe	E Europe	Australasia	HI Asia Pac	HI N Am	S Latin Am	W Europe	Andean Latin Am	Caribbean	Central Latin Am	Trop Latin Am	MENA	S Asia	E Asia	Oceania	C Sub-Sah Africa	SE Asia	E Sub-Sah Africa	S Sub-Sah Africa	W Sub-Sah Africa	Low SDI	Mid SDI	High SDI	Earth
Ischemic heart disease	1	1	1	1	3	1	1	1	1	1	1	1	1	1	2	1	2	7	7	3	5	4	1	1	1
Stroke	2	2	2	2	2	4	3	2	3	2	4	2	2	3	1	2	1	6	6	4	7	5	2	2	2
COPD	6	7	9	5	10	3	4	5	11	9	7	4	10	2	3	5	5	14	17	13	19	9	3	5	3
Lower respiratory infect	4	9	11	9	4	8	2	7	2	4	8	3	8	6	12	4	4	4	3	2	3	3	6	6	4
Lung cancer	9	3	3	4	5	2	6	4	13	6	12	11	11	19	4	17	9	26	36	15	32	32	4	3	5
Neonatal disorders	7	57	54	58	82	47	28	71	10	8	13	13	4	5	30	6	12	2	1	7	2	1	13	61	6
Alzheimer's disease	14	5	4	3	1	5	7	3	9	7	9	7	13	15	6	30	13	27	24	17	25	24	11	4	7
Diabetes	5	11	19	10	15	9	9	11	6	3	3	5	9	8	14	3	3	12	11	6	12	13	5	9	8
Diarrheal diseases	50	71	91	69	50	44	58	52	33	19	23	37	19	4	78	8	14	5	4	10	4	2	18	47	9
Cirrhosis	3	8	5	17	13	10	10	15	5	12	6	10	6	9	15	19	6	10	9	16	11	11	8	11	10
Chronic kidney disease	13	16	24	7	8	6	5	8	4	5	2	9	5	10	11	15	8	16	16	11	15	15	7	8	11
Road injuries	10	23	14	26	27	18	16	35	8	16	10	8	3	12	10	9	10	8	13	8	14	12	9	20	12
Tuberculosis	20	56	32	86	39	93	60	78	20	33	42	46	32	7	33	12	7	3	5	5	8	7	16	72	13
Hypertensive heart disease	8	6	18	34	21	15	11	9	16	11	14	12	7	17	7	14	11	11	14	12	22	16	10	15	14
Colorectal cancer	17	4	7	6	6	7	8	6	14	15	15	14	16	24	8	33	15	40	32	23	37	40	14	7	15
Stomach cancer	11	14	10	23	7	33	14	17	7	22	11	16	15	21	5	23	22	33	34	29	35	34	12	17	16
HIV/AIDS	54	87	17	88	94	59	41	83	18	13	24	22	44	41	36	7	19	9	2	1	6	8	15	75	17
Self-harm	12	17	8	15	12	17	17	21	24	21	19	24	22	14	17	27	23	20	21	14	28	20	21	16	18
Falls	30	18	21	12	19	16	32	14	23	18	20	20	23	11	16	25	18	36	33	46	34	25	17	14	19
Breast cancer	16	12	13	11	18	13	12	10	21	17	18	19	17	18	19	13	17	25	28	19	26	27	22	12	20
Malaria					117				115	78	97	111	45	50	126	21	103	1	8	37	1	6	34	126	21
Congenital defects	18	55	52	57	65	51	34	67	17	20	17	21	12	20	34	11	21	13	10	26	9	10	25	60	22
Pancreatic cancer	23	13	16	13	11	12	15	13	27	26	22	23	25	46	18	60	30	63	61	31	51	66	24	10	23
Esophageal cancer	21	37	41	24	23	29	27	29	53	37	53	25	42	39	9	62	40	32	29	22	63	45	20	27	24
Prostate cancer	36	15	20	8	20	14	13	12	12	10	16	15	27	44	27	34	27	35	31	18	24	39	27	13	25

versity of Washington

- 100% +

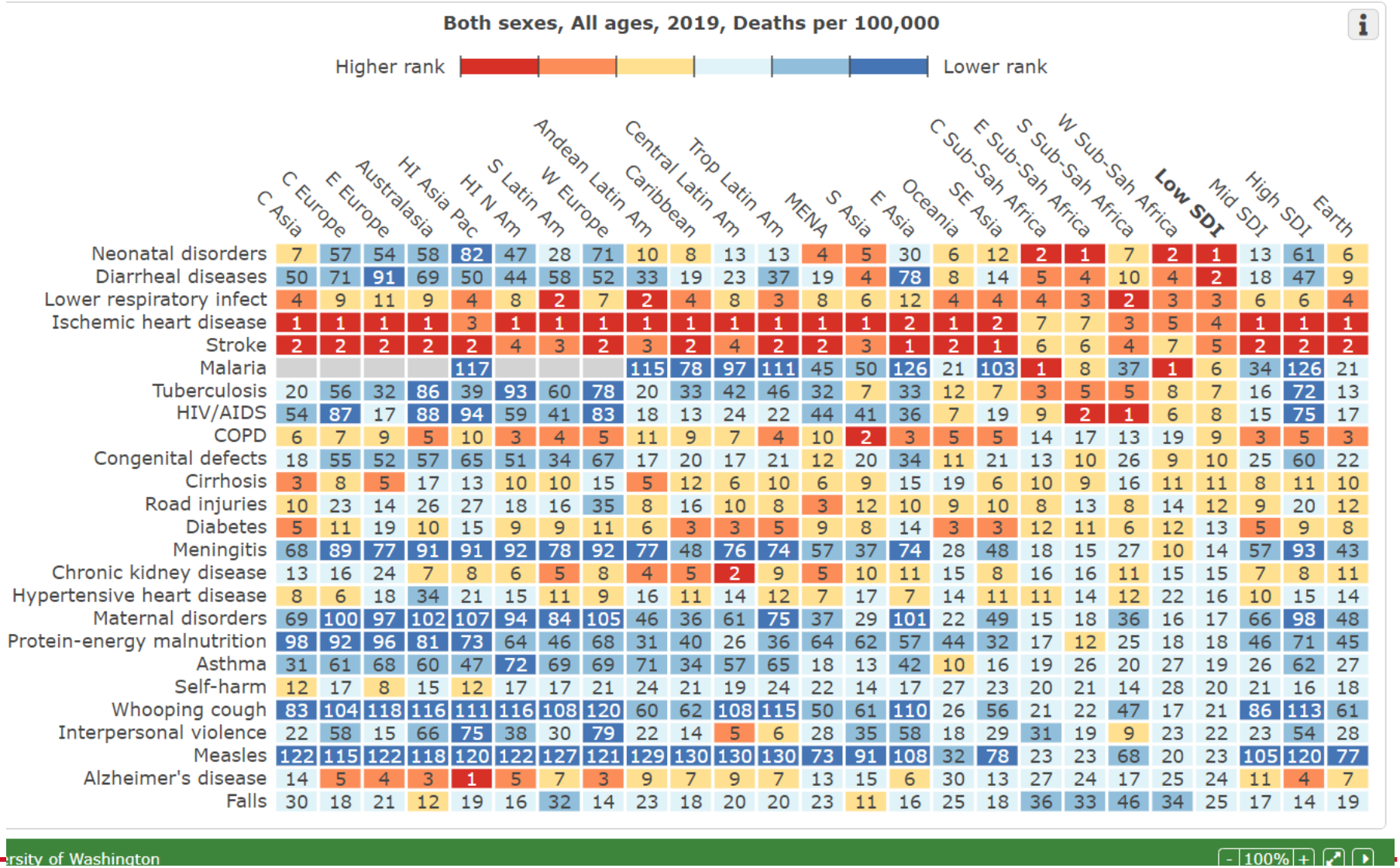
Source: GBD Compare Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Cause of death * region – 2019 – High SDI rank



Source: GBD Compare Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Cause of death * region – 2019 – Low SDI rank



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Ischemic heart disease	1	1	1	1	3	1	1	1	1	1	1	1	1	1	2	1	2	7	7	3	5	4	1	1	1
Stroke	2	2	2	2	2	4	3	2	3	2	4	2	2	3	1	2	1	6	6	4	7	5	2	2	2
Malaria					117				115	78	97	111	45	50	126	21	103	1	8	37	1	6	34	126	21
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HIV/AIDS	54	87	17	88	94	59	41	83	18	13	24	22	44	41	36	7	19	9	2	1	6	8	15	75	17
COPD	6	7	9	5	10	3	4	5	11	9	7	4	10	2	3	5	5	14	17	13	19	9	3	5	3
Congenital defects	18	55	52	57	65	51	34	67	17	20	17	21	12	20	34	11	21	13	10	26	9	10	25	60	22
Cirrhosis	3	8	5	17	13	10	10	15	5	12	6	10	6	9	15	19	6	10	9	16	11	11	8	11	10
Road injuries	10	23	14	26	27	18	16	35	8	16	10	8	3	12	10	9	10	8	13	8	14	12	9	20	12
Diabetes	5	11	19	10	15	9	9	11	6	3	3	5	9	8	14	3	3	12	11	6	12	13	5	9	8
Meningitis	68	89	77	91	91	92	78	92	77	48	76	74	57	37	74	28	48	18	15	27	10	14	57	93	43
Chronic kidney disease	13	16	24	7	8	6	5	8	4	5	2	9	5	10	11	15	8	16	16	11	15	15	7	8	11
Hypertensive heart disease	8	6	18	34	21	15	11	9	16	11	14	12	7	17	7	14	11	11	14	12	22	16	10	15	14
Maternal disorders	69	100	97	102	107	94	84	105	46	36	61	75	37	29	101	22	49	15	18	36	16	17	66	98	48
Protein-energy malnutrition	98	92	96	81	73	64	46	68	31	40	26	36	64	62	57	44	32	17	12	25	18	18	46	71	45
Asthma	31	61	68	60	47	72	69	69	71	34	57	65	18	13	42	10	16	19	26	20	27	19	26	62	27
Self-harm	12	17	8	15	12	17	17	21	24	21	19	24	22	14	17	27	23	20	21	14	28	20	21	16	18
Whooping cough	83	104	118	116	111	116	108	120	60	62	108	115	50	61	110	26	56	21	22	47	17	21	86	113	61
Interpersonal violence	22	58	15	66	75	38	30	79	22	14	5	6	28	35	58	18	29	31	19	9	23	22	23	54	28
Measles	122	115	122	118	120	122	127	121	129	130	130	130	73	91	108	32	78	23	23	68	20	23	105	120	77
Alzheimer's disease	14	5	4	3	1	5	7	3	9	7	9	7	13	15	6	30	13	27	24	17	25	24	11	4	7
Falls	30	18	21	12	19	16	32	14	23	18	20	20	23	11	16	25	18	36	33	46	34	25	17	14	19

Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

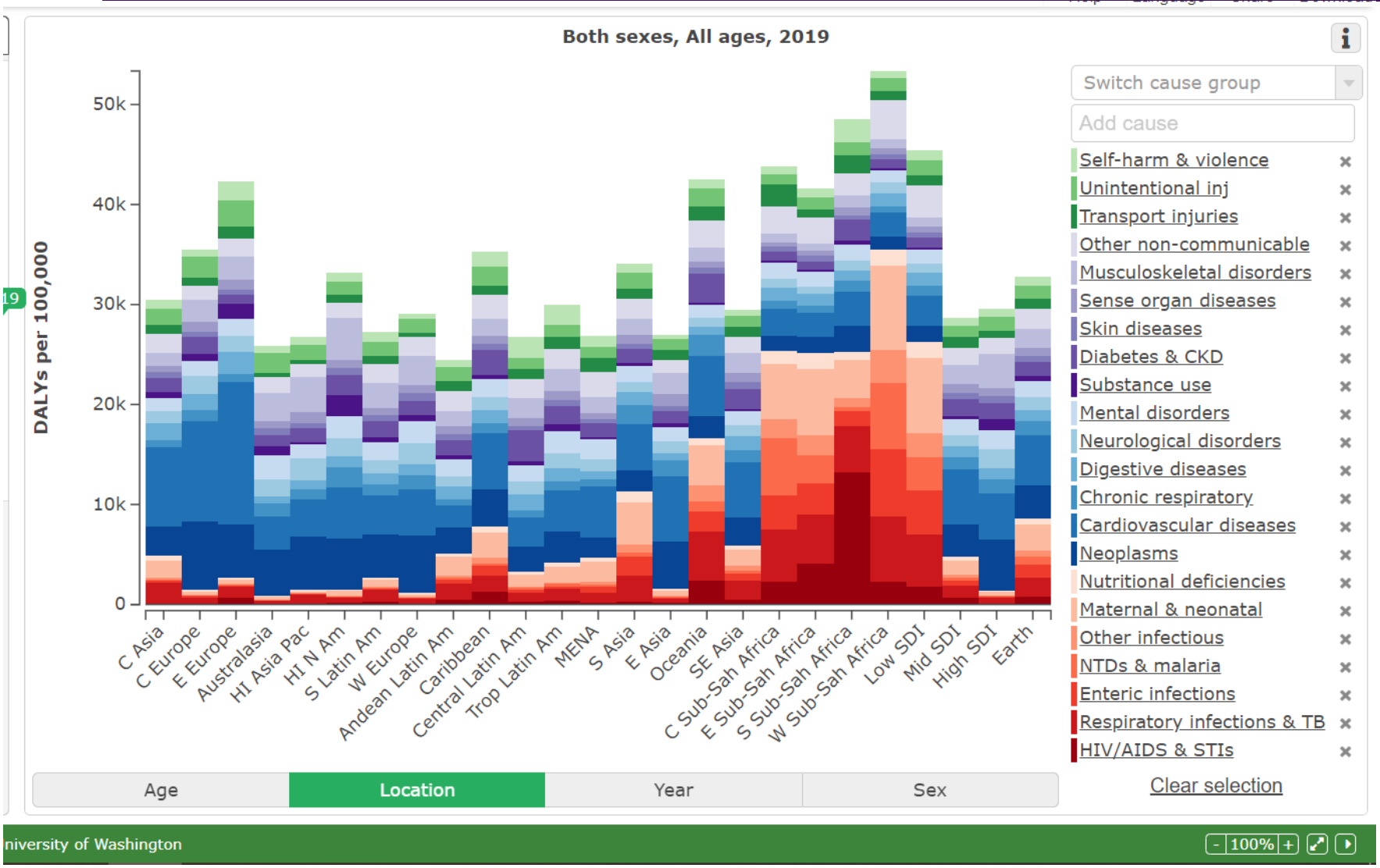
Leading Global Causes of Mortality and Disability, World, 2019

Rank	Cause (deaths)
1	Ischaemic heart disease
2	Ischaemic stroke
3	Chronic obstructive pulmonary disease
4	Intracerebral haemorrhage
5	Lower respiratory infections
6	Tracheal, bronchus, and lung cancer
7	Alzheimer disease and other dementias
8	Diarrheal diseases
9	Diabetes mellitus
10	Hypertensive heart disease

Rank	Cause (DALYs)
1	Ischemic heart disease
2	Lower respiratory infections
3	Diarrheal diseases
4	Chronic obstructive pulmonary disease
5	Pre-term birth complications
6	Intracerebral haemorrhage
7	Diabetes (Type 2)
8	Low back pain
9	Ischaemic stroke
10	Neonatal encephalopathy

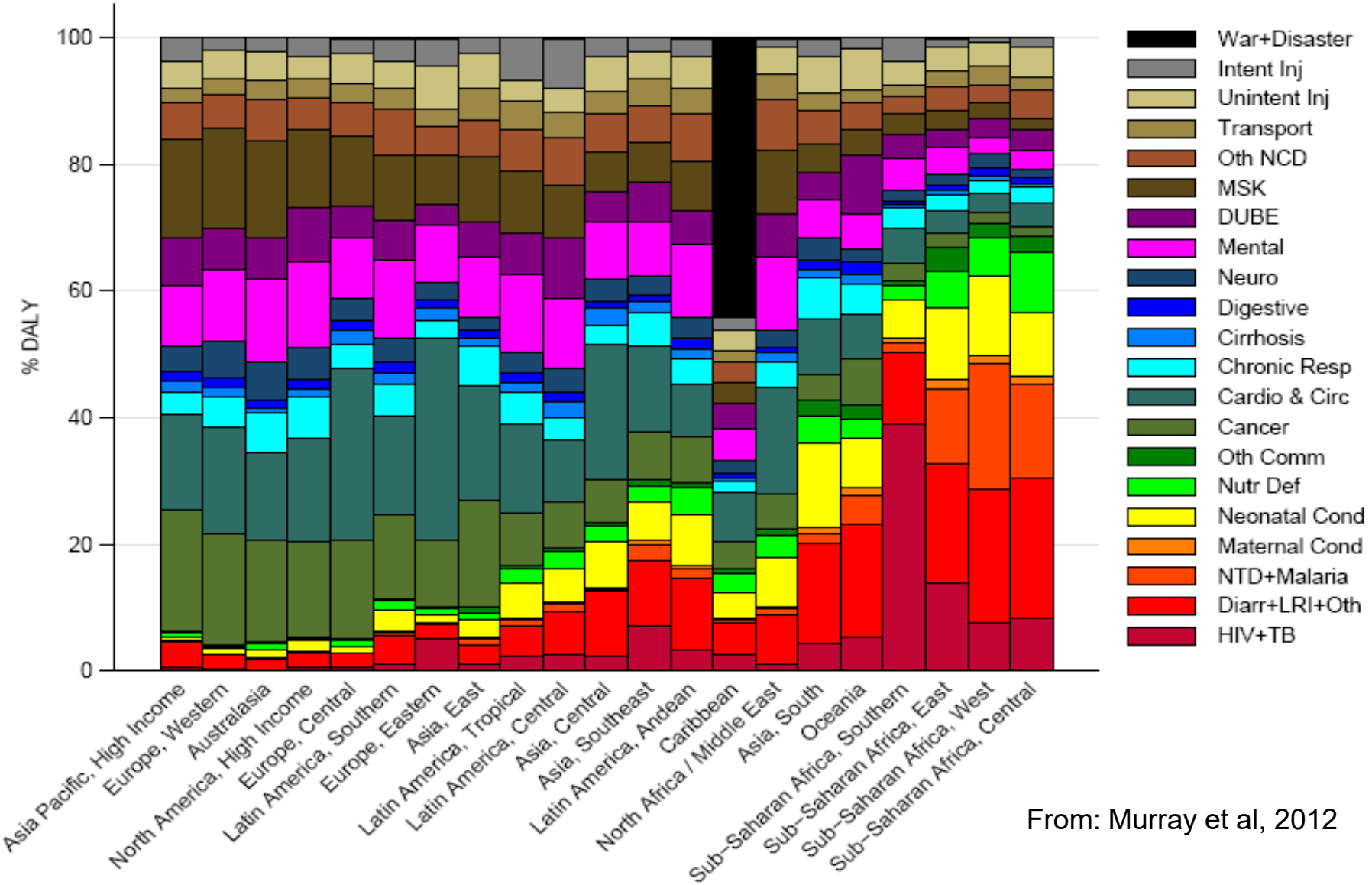
Source: GBD Compare Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

DALY rates by Cause and Region (2019)



Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

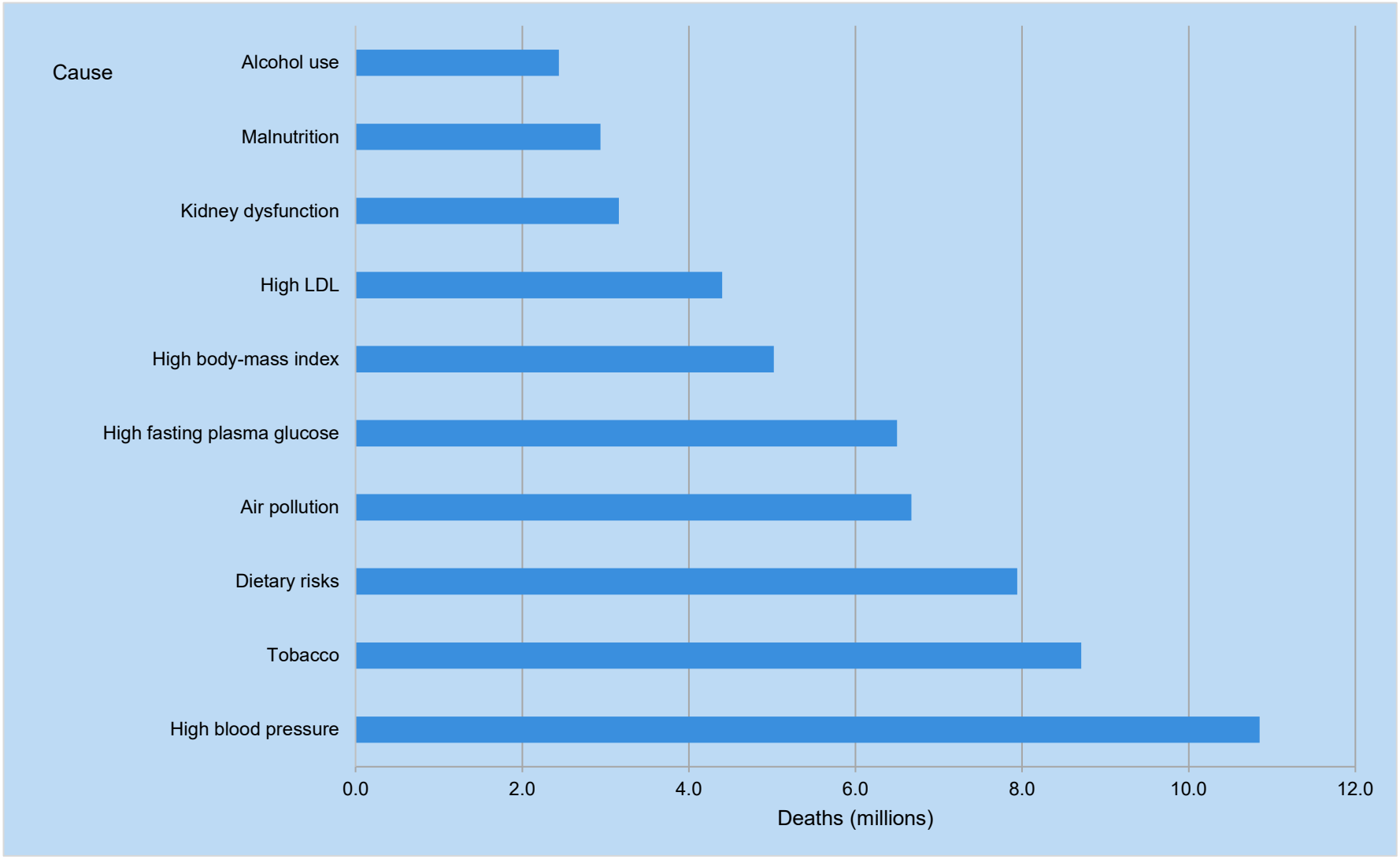
% DALYs by Cause and Region (2010)



From: Murray et al, 2012

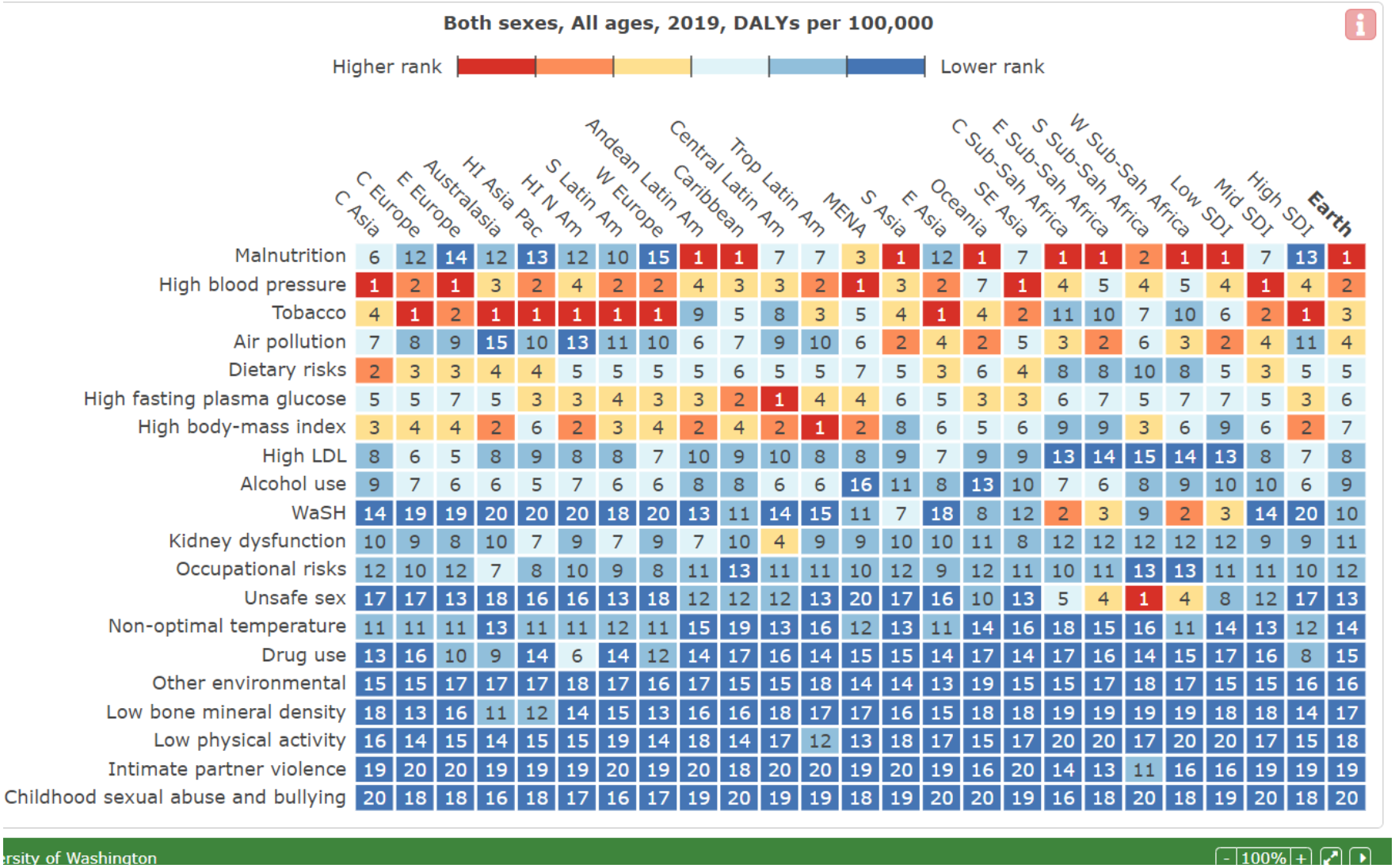
Leading global risks of mortality, 2019

Leading global risks of mortality, 2019



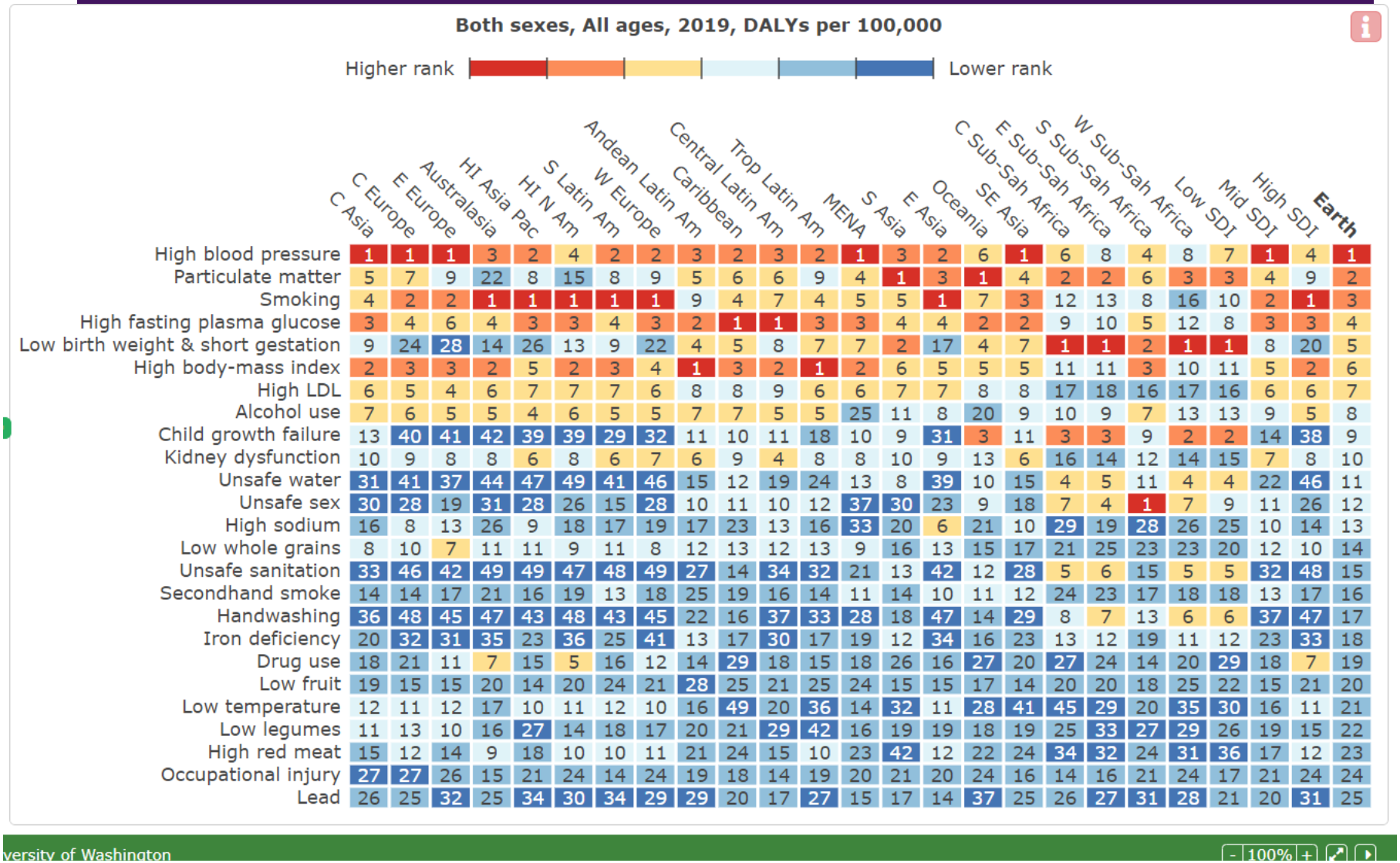
Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Risk factors - DALYs * region – 2019 – Global rank



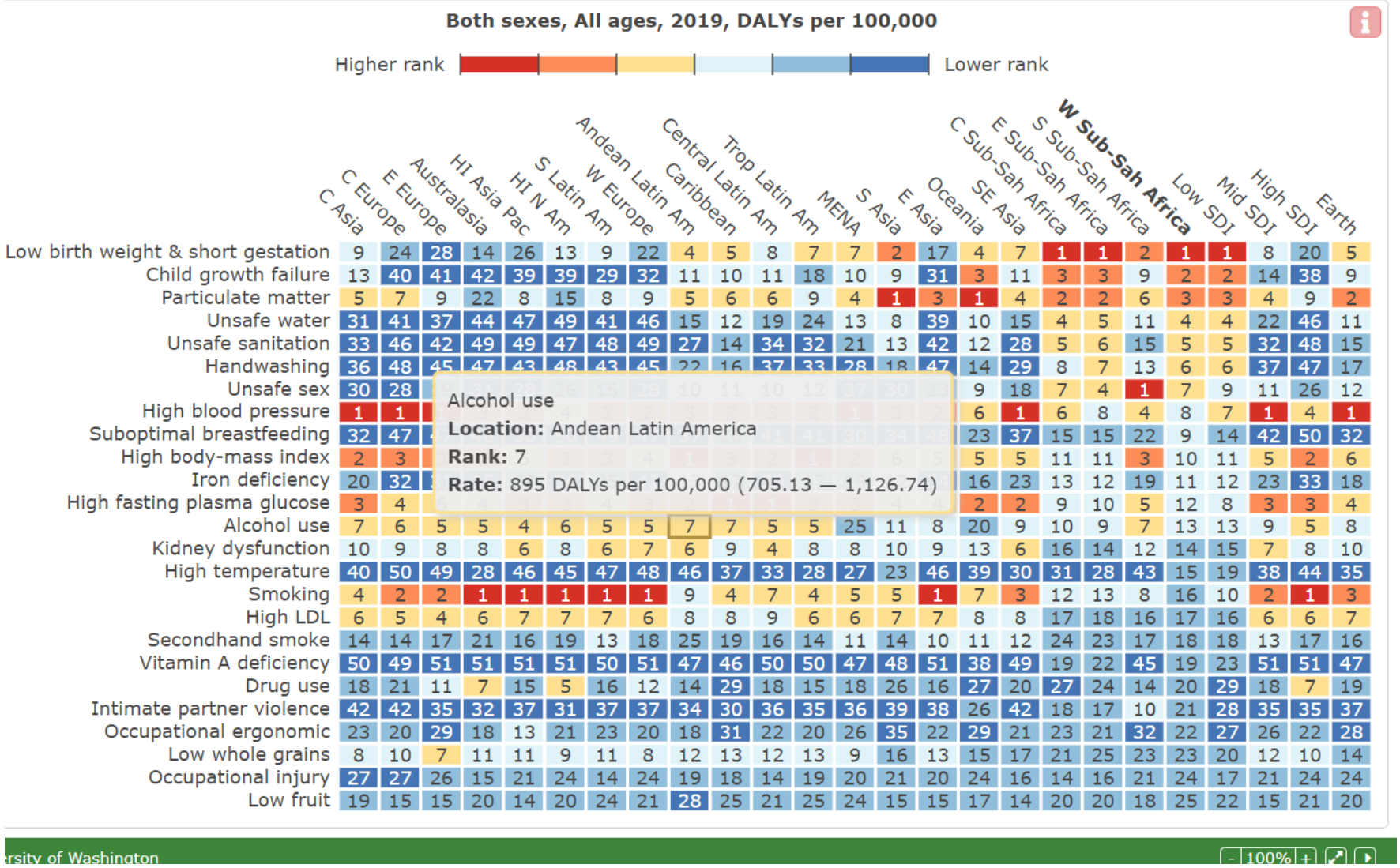
Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Risk factors - DALYs * region – 2019 – Global rank (Detailed)



Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Risk factors - DALYs * region – 2019 – Western SSA)



Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

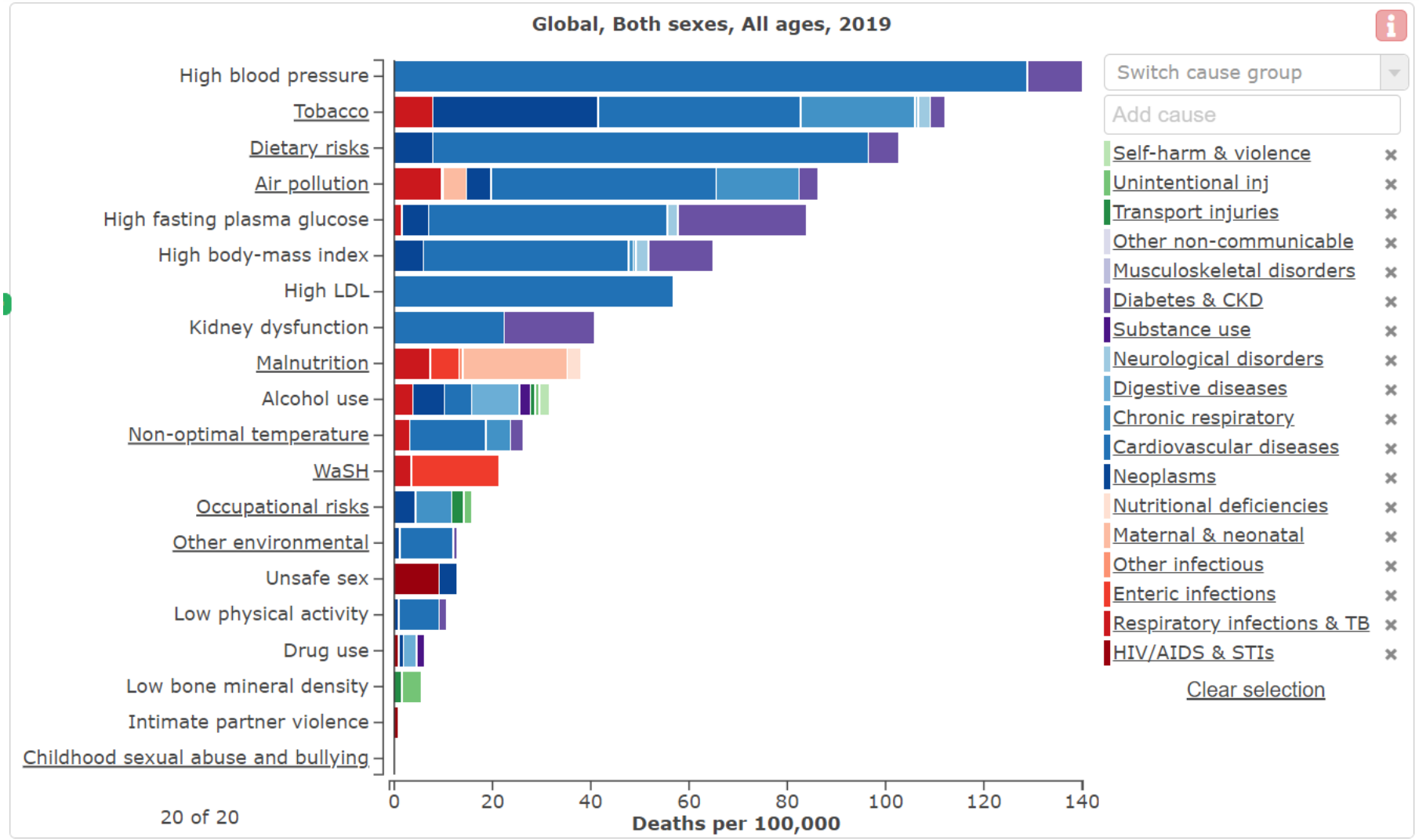
Leading Global Risk factors of Mortality and Disability, World, 2019

Rank	Cause (deaths)
1	High systolic blood pressure
2	Tobacco smoke
3	Dietary risks
4	Air pollution
5	High fasting plasma glucose
6	High body-mass index
7	High LDL
8	Kidney dysfunction
9	Malnutrition
10	Alcohol use

Rank	Cause (DALYs)
1	Malnutrition
2	High systolic blood pressure
3	Tobacco smoke
4	Air pollution
5	Dietary risks
6	High fasting plasma glucose
7	High body-mass index
8	High LDL
9	Alcohol and drug use
10	Unsafe water, sanitation and hand washing

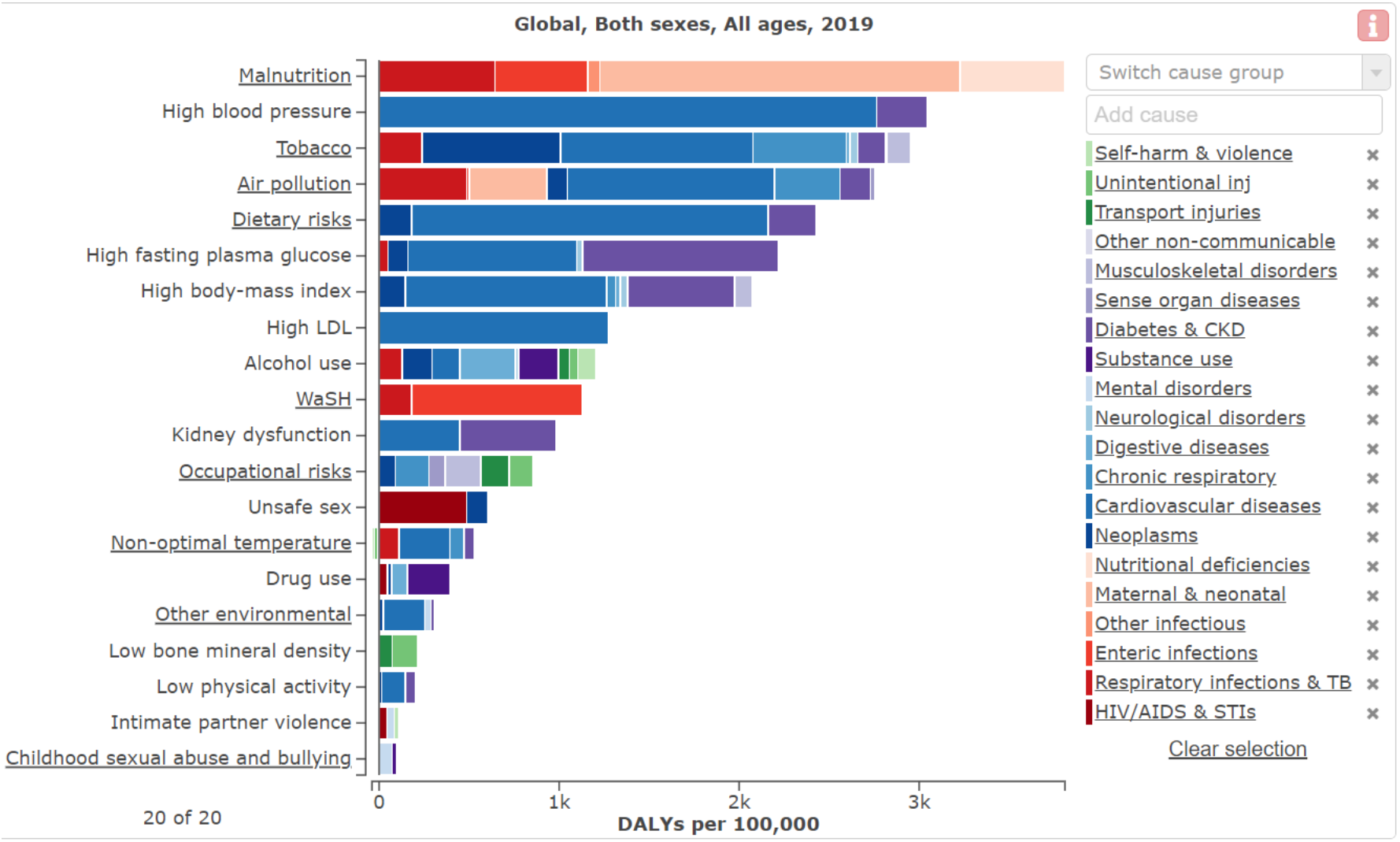
Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Burden of disease (deaths) attributable to leading risk factors in 2019



Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

Burden of disease (DALYs) attributable to leading risk factors in 2019



Source: GBD Compare - Available from http://vizhub.healthdata.org/gbd-compare. (Accessed 27/2/2023)

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Conclusions

Conclusions

Burden of disease approaches provide useful information for public health

Various measures can be used (e.g. deaths, DALYs)

Can focus on outcomes or exposures

Focus on exposure is potentially more useful for planning and evaluation

The burden of disease is not shared equitably.

Use the available GBD data and resources (e.g. GBD Compare)