

Mortality and Morbidity Inequality Dynamics: Towards an Integration

Exploring Population Heterogeneities

WITTGENSTEIN CENTRE CONFERENCE 2023

Vienna, 6th of December

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MOTIVATION

- Longevity is increasing worldwide (Oeppen and Vaupel 2002, Riley 2005, 2015). Unprecedented landmark in human history.
- Living long *and* healthy lives?
 - Compression vs Expansion of Morbidity debate

MOTIVATION

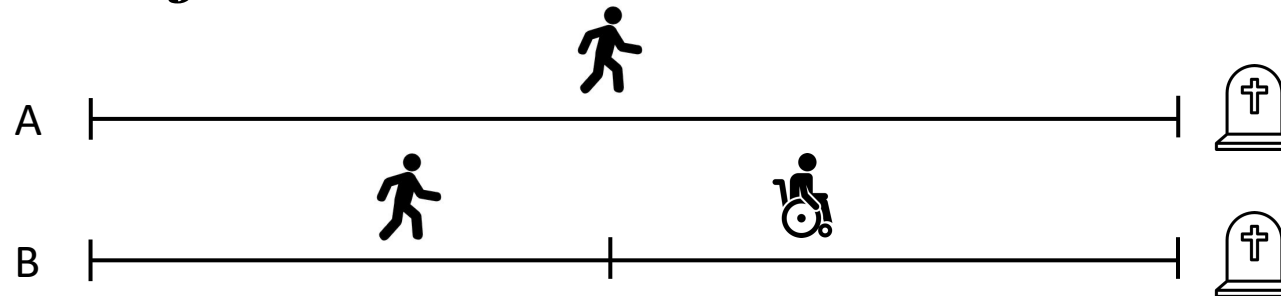
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 - Health policies are increasingly concerned with *health inequalities*, and go beyond increasing average/overall attainments (e.g., life expectancy).

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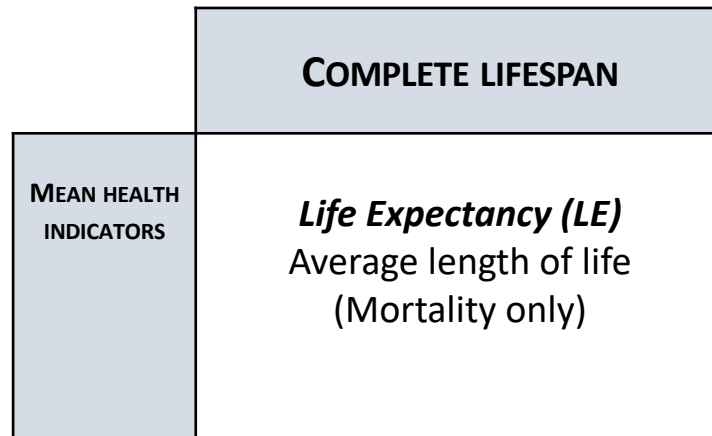
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 - Health policies are increasingly concerned with **health inequalities**, and go beyond increasing average/overall attainments (e.g., life expectancy).
- “Inequality in length of life is the most fundamental of all inequalities; every other type of inequality is conditional upon being alive” (van Raalte et al 2018).

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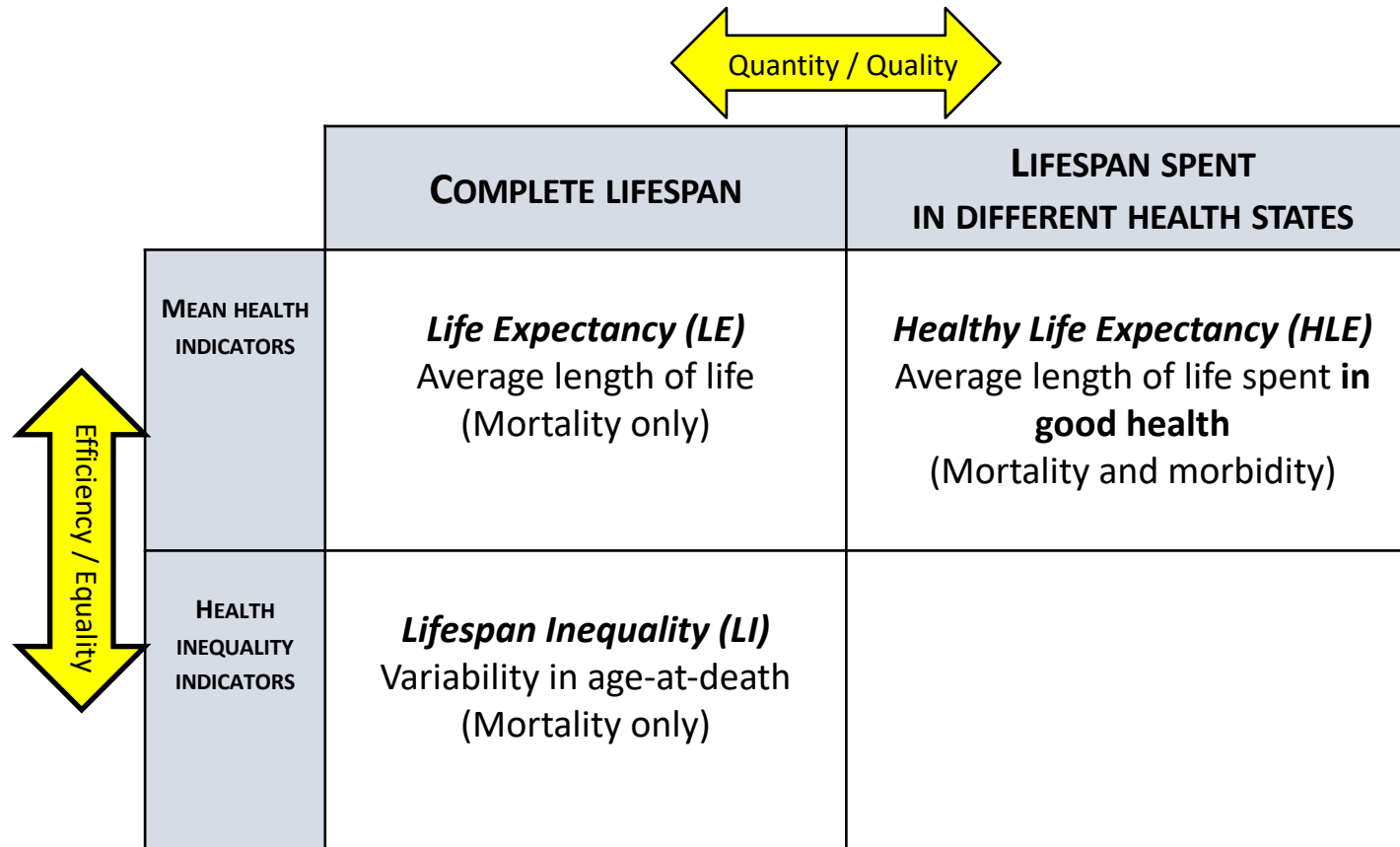
MEASURES OF POPULATION HEALTH



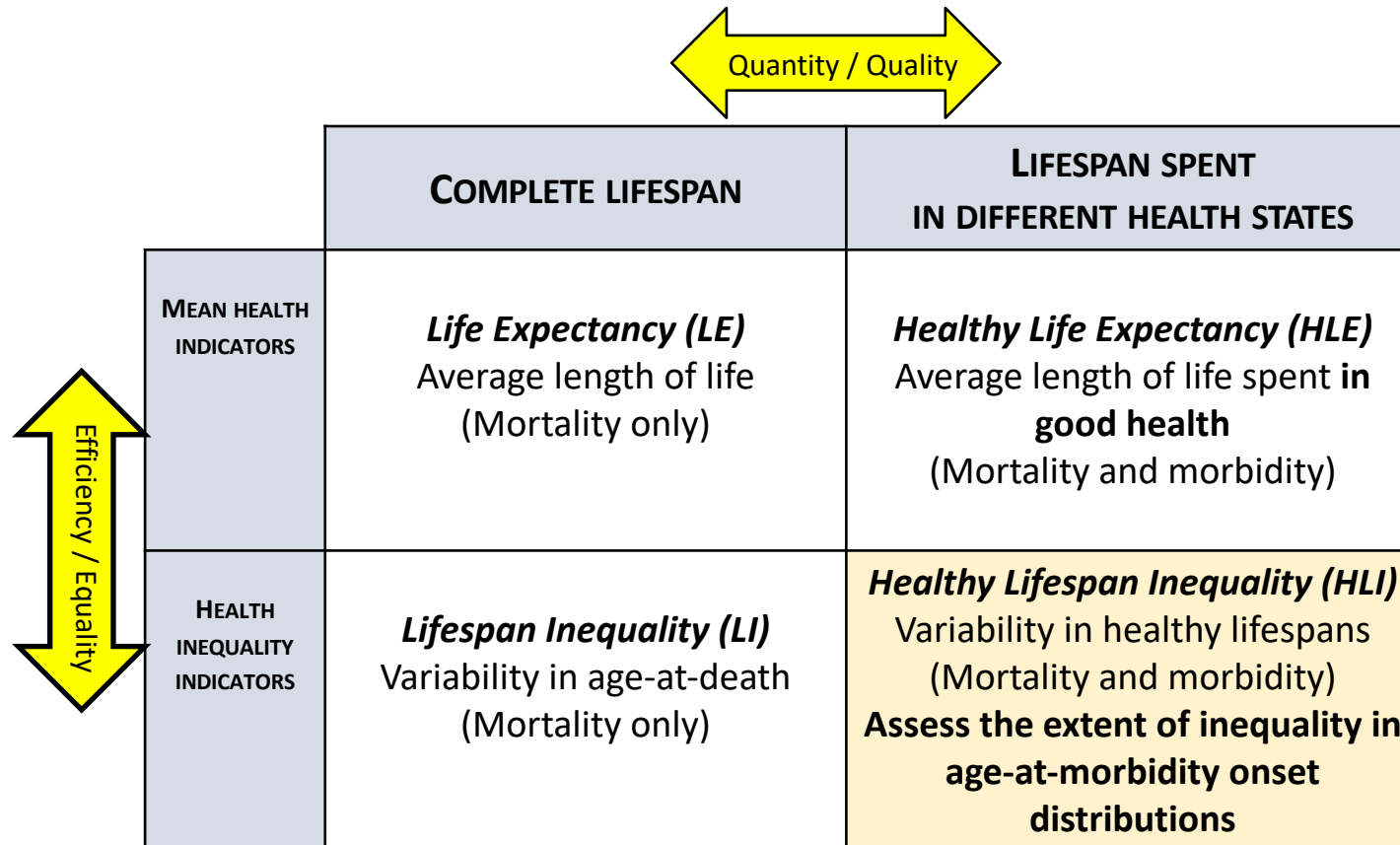
MEASURES OF POPULATION HEALTH

	COMPLETE LIFESPAN	LIFESPAN SPENT IN DIFFERENT HEALTH STATES
MEAN HEALTH INDICATORS	<i>Life Expectancy (LE)</i> Average length of life (Mortality only)	<i>Healthy Life Expectancy (HLE)</i> Average length of life spent in good health (Mortality and morbidity)

MEASURES OF POPULATION HEALTH



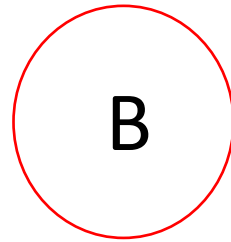
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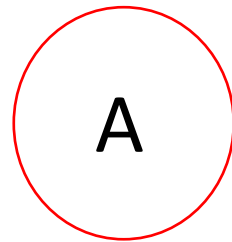
HEALTHY LIFESPAN INEQUALITY (HLI)

- HLI measures the variability in **healthy** lifespans, or in the ages at which individuals cease to be in “good” health.
- HLI indicators show whether the **age at morbidity onset** is un/equally distributed across individuals.
- Healthy lifespans are **normatively desirable** (everyone wants to live more years in good health). Unhealthy lifespans (years spent in “less-than-good” health) are **controversial** because of the personal, social, and economic costs often associated with the presence of disease or disability.

“Quality”



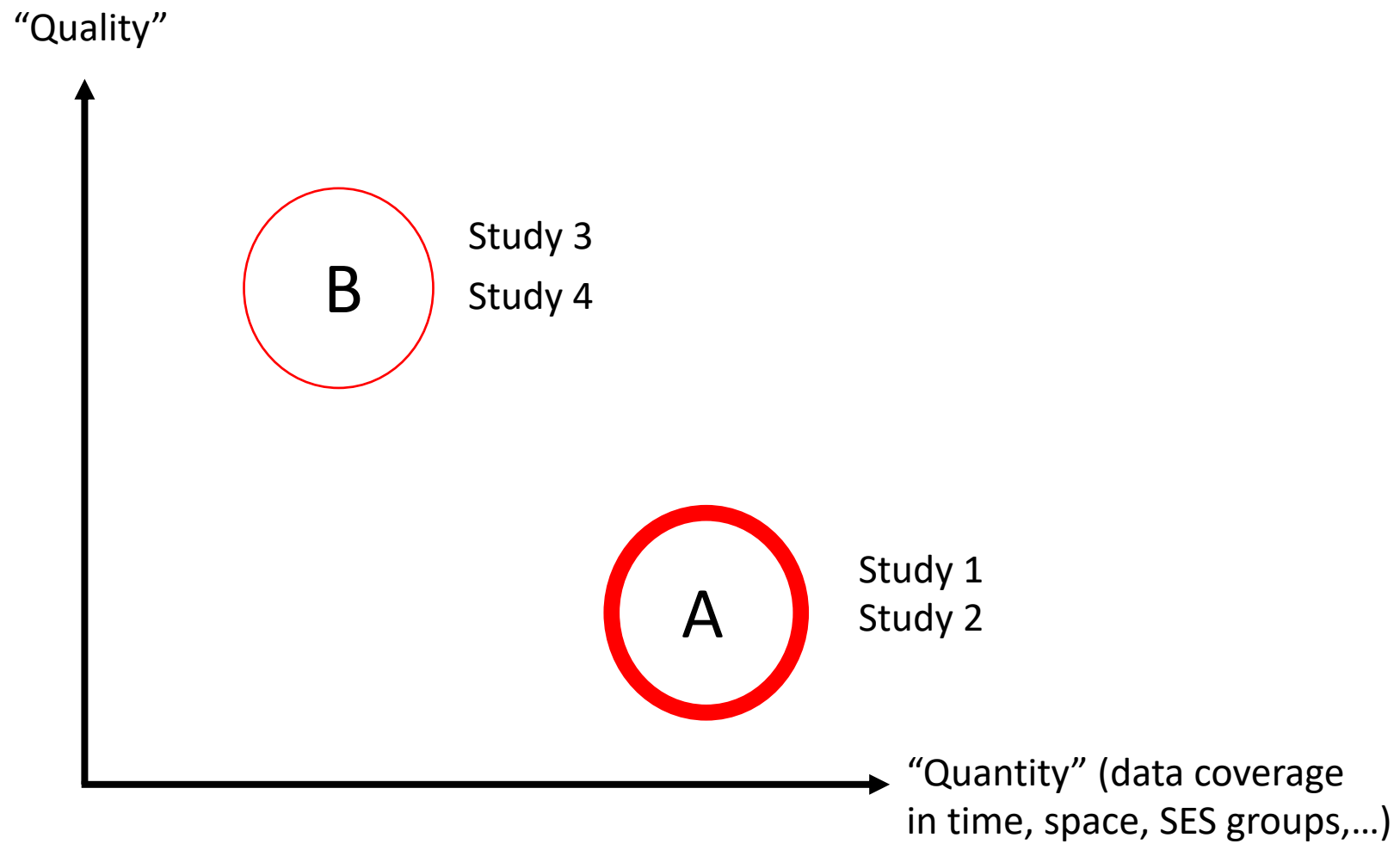
Study 3
Study 4



Study 1
Study 2



“Quantity” (data coverage
in time, space, SES groups,...)

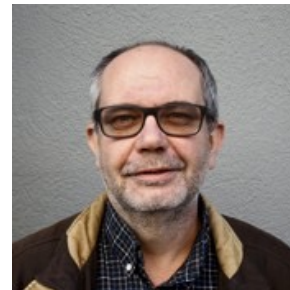


Study 1

Healthy lifespan inequality by educational attainment Spain 2015



Jeroen Spijker



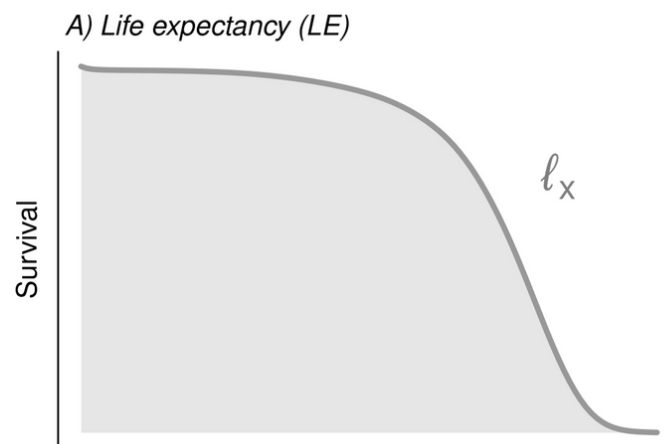
Amand Blanes

DATA SOURCES

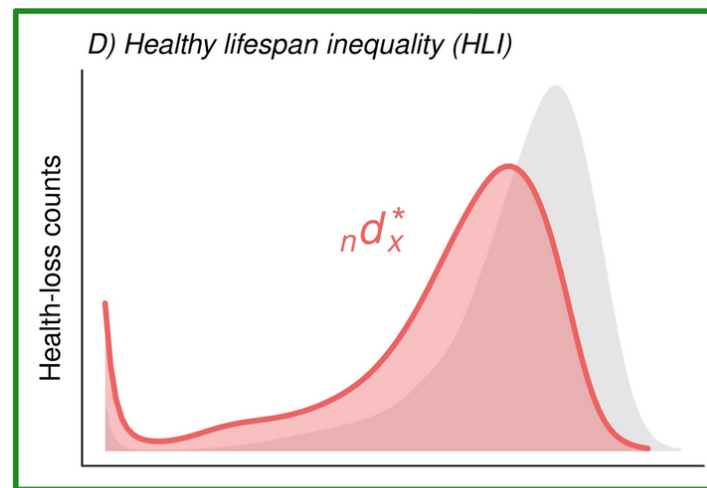
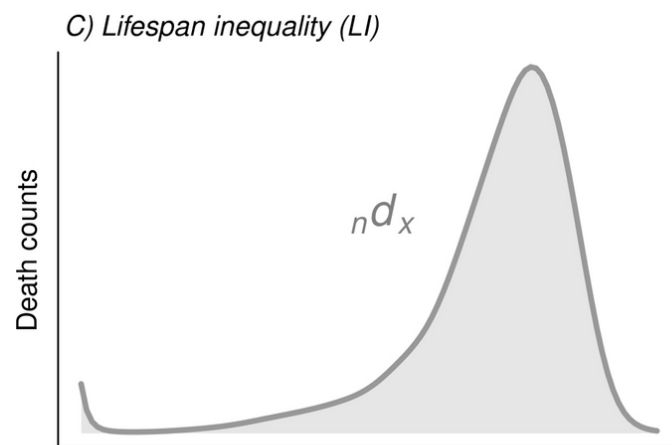
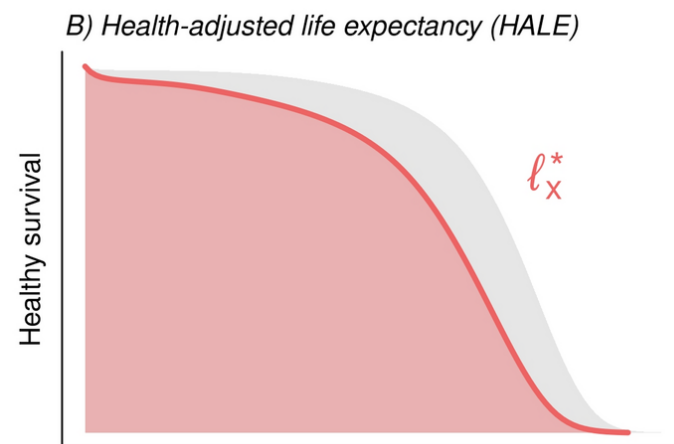
- Recently, the Spanish Statistical Office (INE) has linked mortality with education data.
 - Sex-specific life tables by educational attainment for those with *'less than Primary education', 'Primary education' and 'Secondary and above'*.
 - Ages are bottom truncated at 35 to allow all individuals completing their formal education
- Spanish National Health Surveys (2014, 2017)
 - Used to obtain the sex-, education- and age- specific prevalence rates associated to **the GALI indicator**.
 - Because of small sample sizes, ages were top truncated at 85.

METHODS

MORTALITY



MORBIDITY



Age

MAIN RESULTS

	Mean health indicators							
	Life expectancy (LE): e_{35-85}				Healthy life expectancy (HE): e_{35-85}^h			
	Low	Mid	High	Total	Low	Mid	High	Total
Women	44.5	46.3	46.9	46.4	22.4	29.3	34.0	29.7
Men	40.4	42.5	44.3	43.1	24.0	30.0	33.5	30.8
	Health inequality indicators							
	Lifespan inequality (LI): I_{35-85}				Healthy lifespan inequality (HLI): I_{35-85}^h			
	Low	Mid	High	Total	Low	Mid	High	Total
Women	0.081	0.075	0.068	0.069	0.129	0.119	0.106	0.113
Men	0.086	0.085	0.072	0.077	0.121	0.114	0.104	0.112

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- HLI levels are **substantially larger** than LI
- The low-educated have worse outcomes in the four health indicators.

Study 2

Healthy lifespan inequality around the globe 1990-2019



Sergi Trias-Llimós



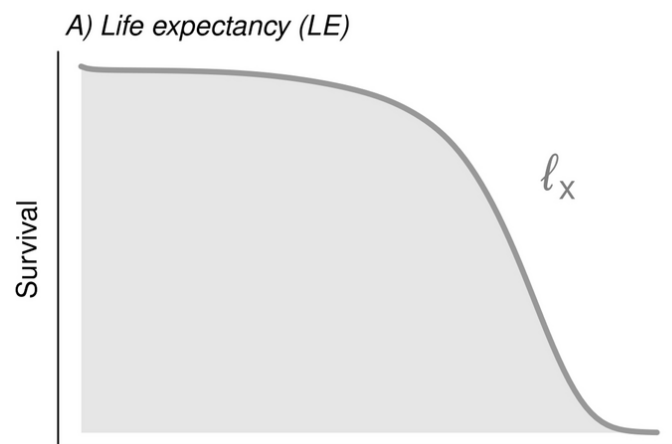
Francisco Villavicencio

DATA

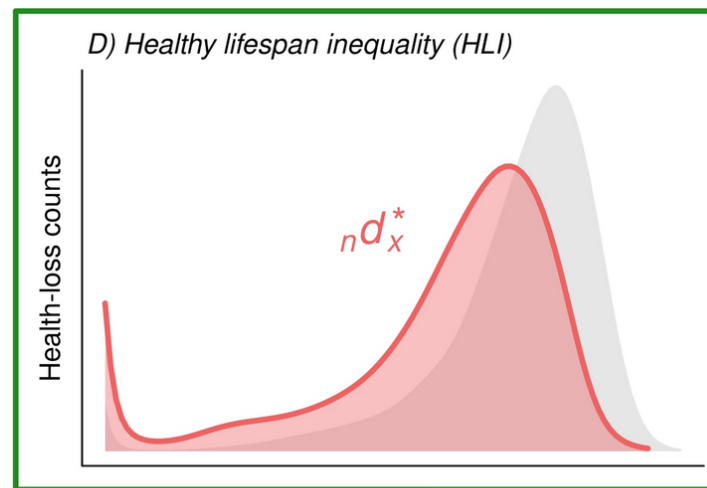
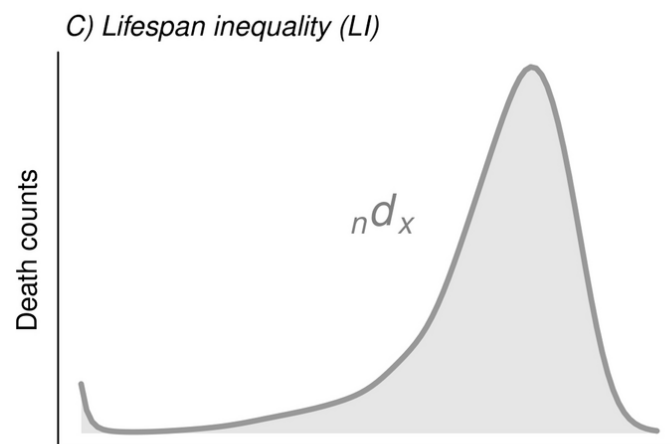
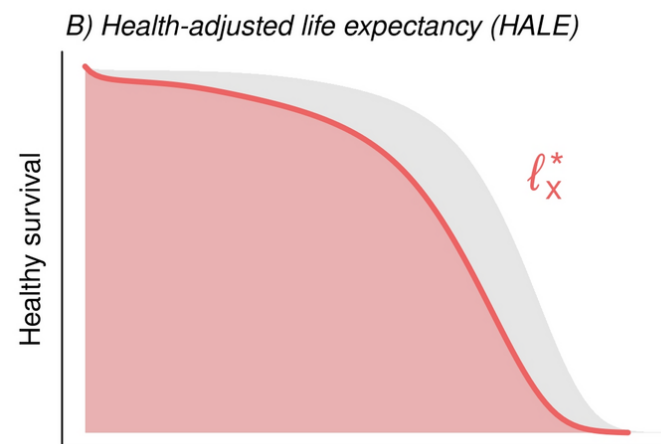
- Global Burden of Disease (GBD) project
- All years between 1990 and 2019
- Disaggregated by sex
- Information available for 204 countries & territories all over the world
- Results aggregated by super-region (7 in total)
- Values of $HALE_x$ available for all x .
 - Used to reconstruct morbidity (i.e., “healthy survivorship”) curves

METHODS

MORTALITY

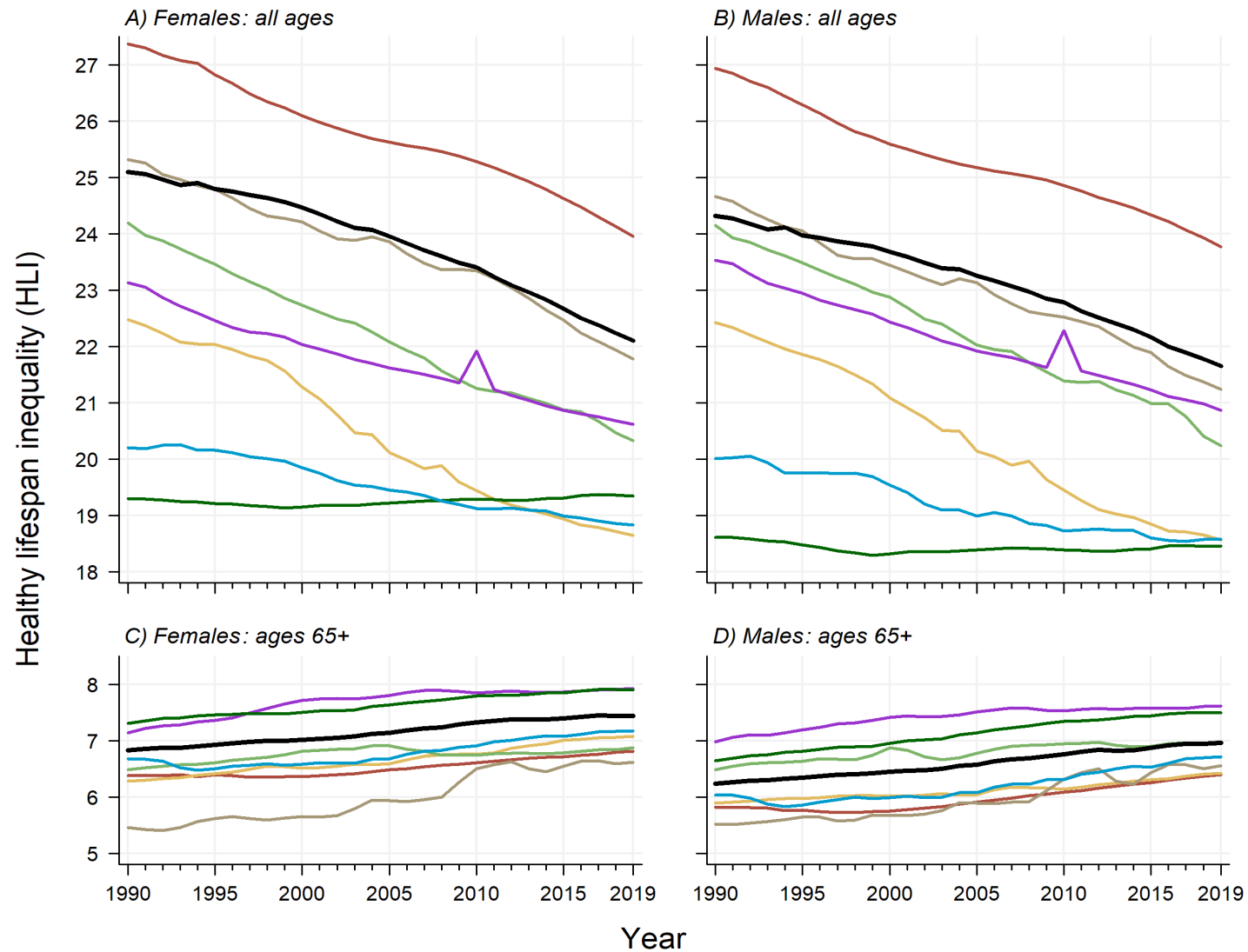


MORBIDITY



Age

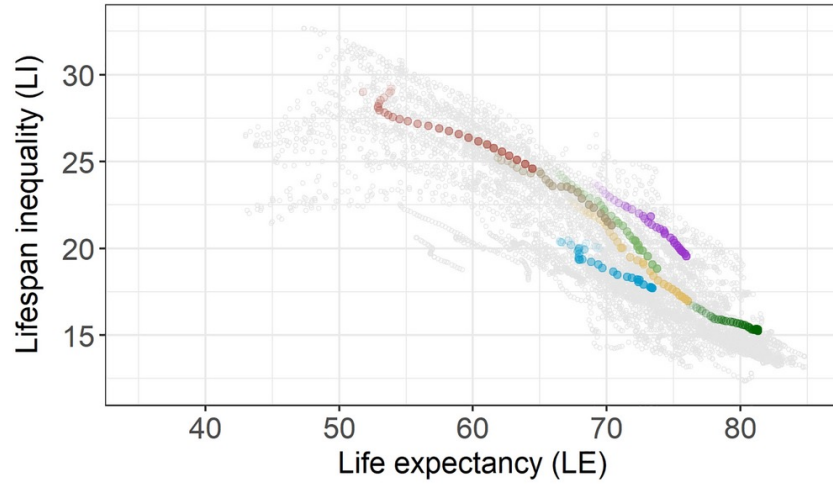
HLI LEVELS AND TRENDS: 1990-2019



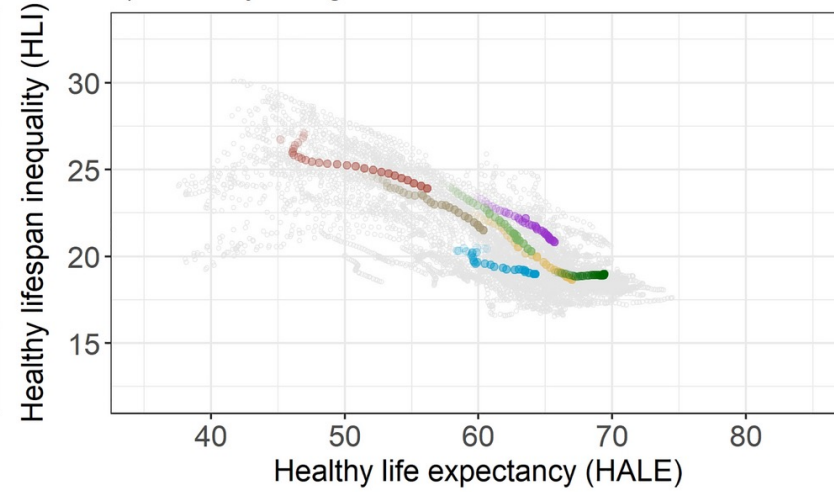
- World
- High-income countries
- Latin America and Caribbean
- Central Europe, eastern Europe and central Asia
- South Asia
- Sub-Saharan Africa
- North Africa and Middle East
- Southeast Asia, east Asia and Oceania

EFFICIENCY VS EQUALITY

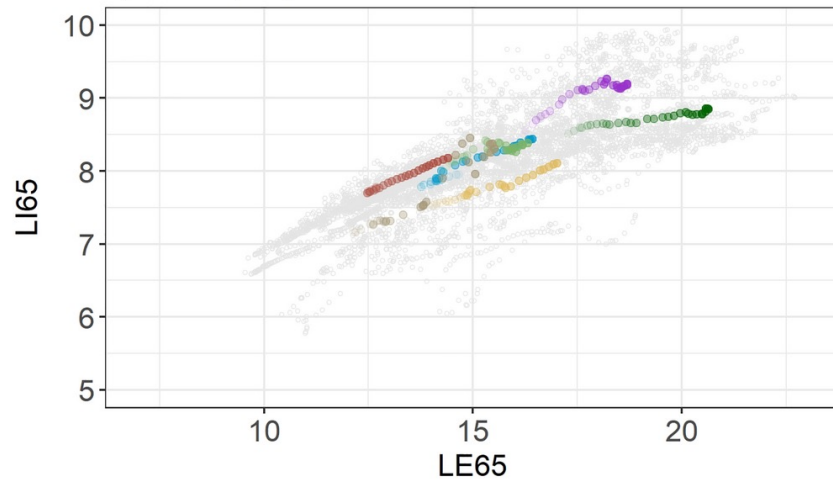
A) Mortality: all ages



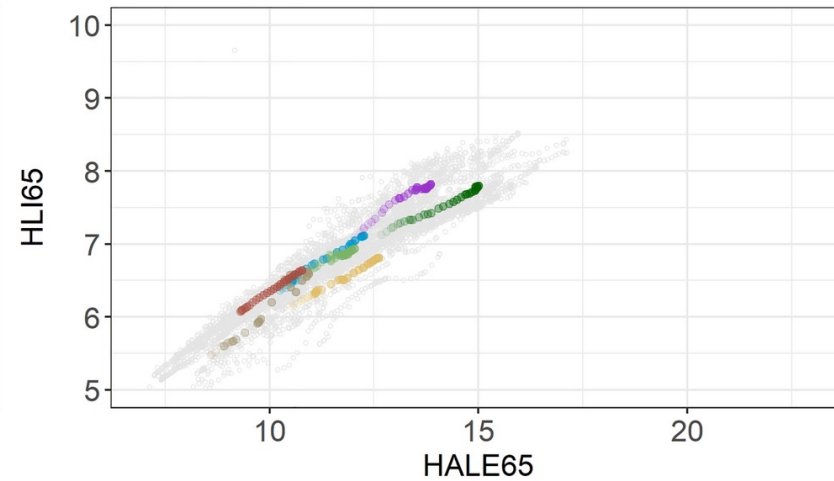
B) Morbidity: all ages



C) Mortality: ages 65+



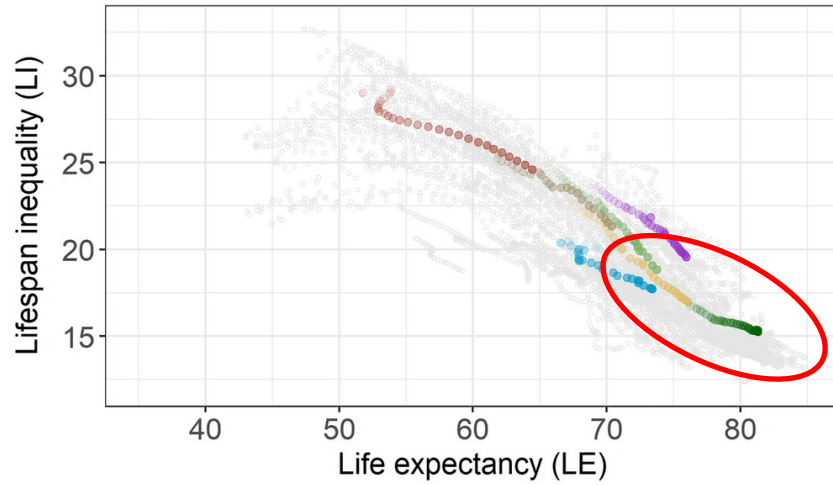
D) Morbidity: ages 65+



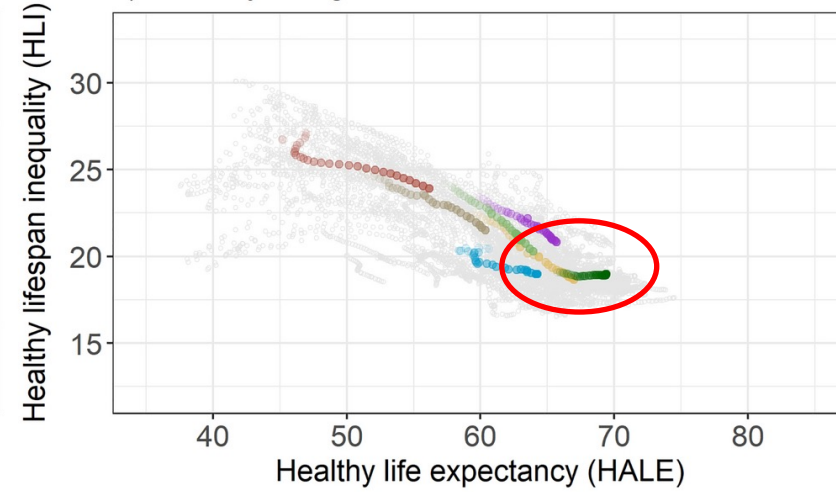
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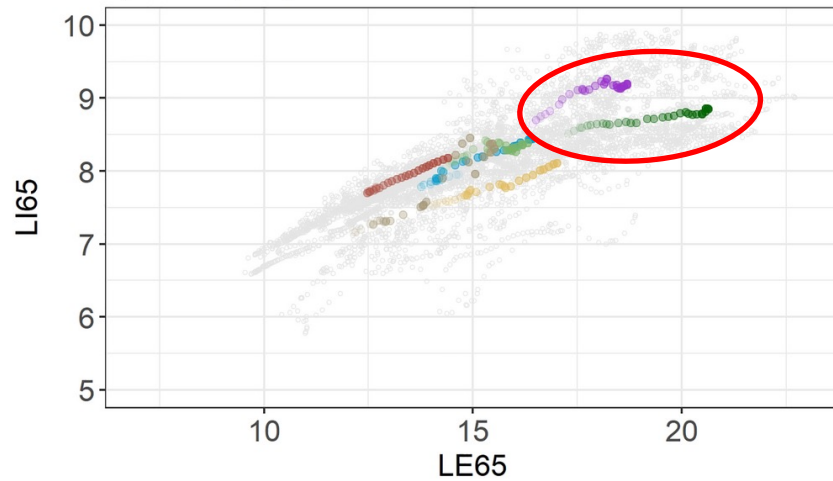
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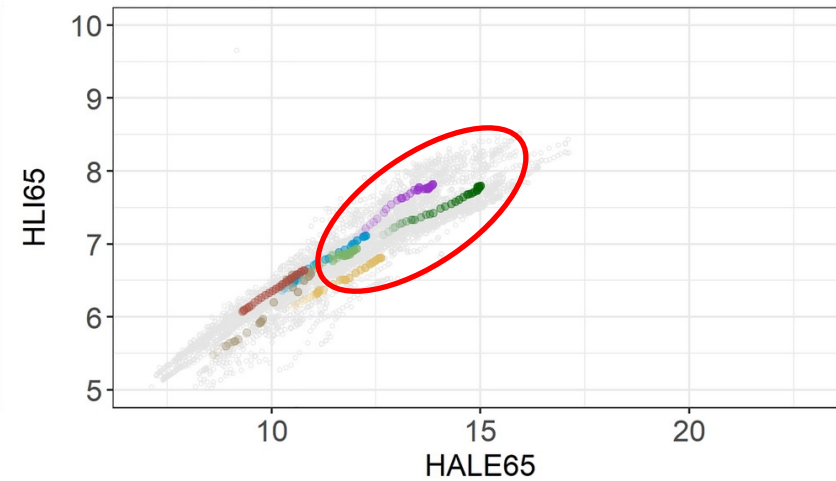
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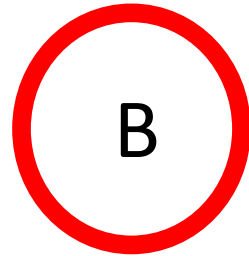


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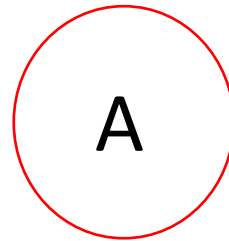
LIMITATIONS

- Strong assumptions underlying the Sullivan method
 - Mortality rates are assumed to be the same for healthy and unhealthy individuals.
 - Reliance on prevalence rather than incidence data
- Health state indicators reversible (i.e., not necessarily measuring “morbidity onset”)
 - Easier if we monitor *chronic* (i.e., non-reversible) conditions
- We are ignoring the relationship between “length of healthy life” and “length of unhealthy life”.

“Quality”



Study 3
Study 4



Study 1
Study 2



“Quantity” (data coverage
in time, space, SES groups,...)

Studies 3 & 4

The triangular life table



Tim Riffe



Chiara Micheletti



Cosmo Strozza

Serena Vigezzi

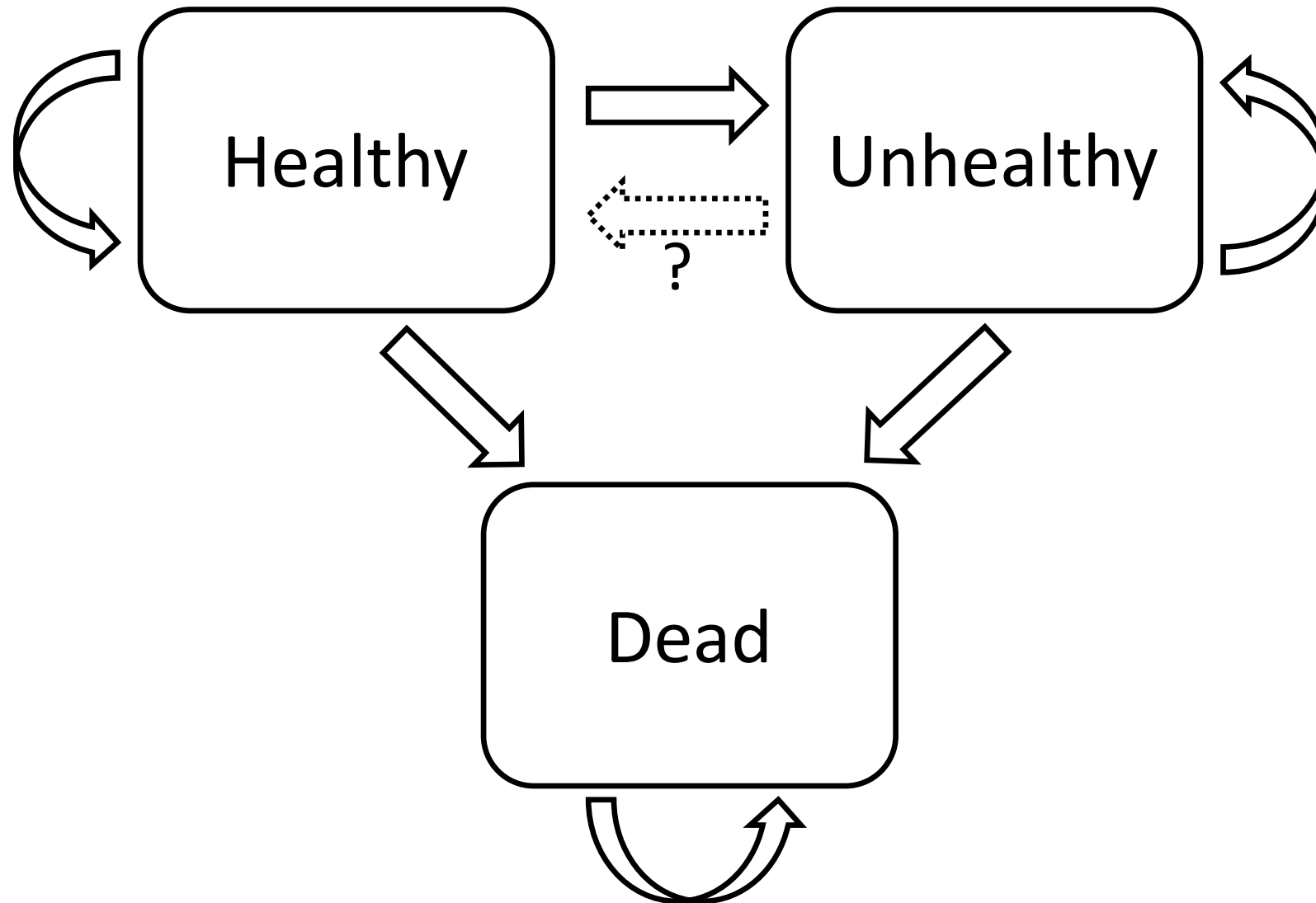
MAIN GOAL

- Break down individuals' length of life (x) in “healthy” (h) and “unhealthy” (u) years, in such a way that

$$x = h + u$$

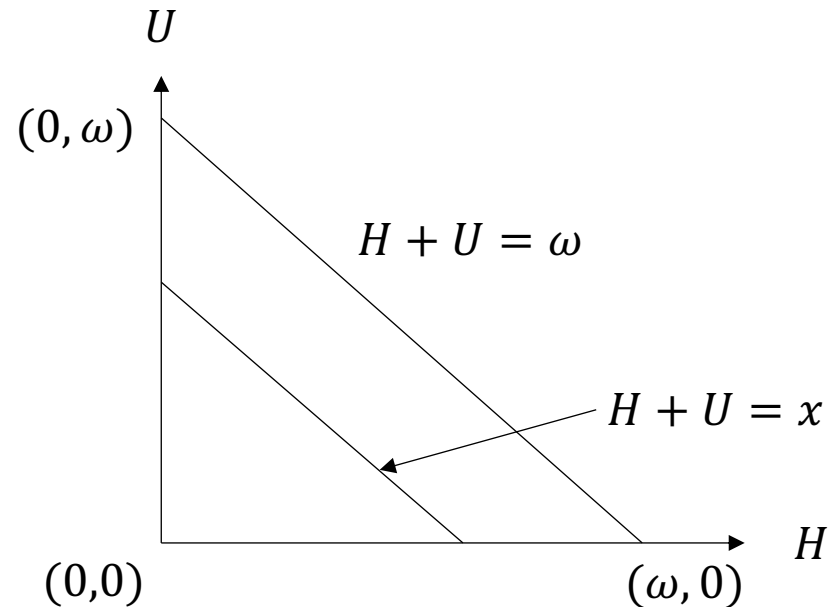
- h is normatively desirable (“more is better”).
- The normative desirability of u might be *unclear* (depending on how “unhealthy” is defined).
 - Quantity vs Quality trade-offs

HEALTH TRANSITIONS



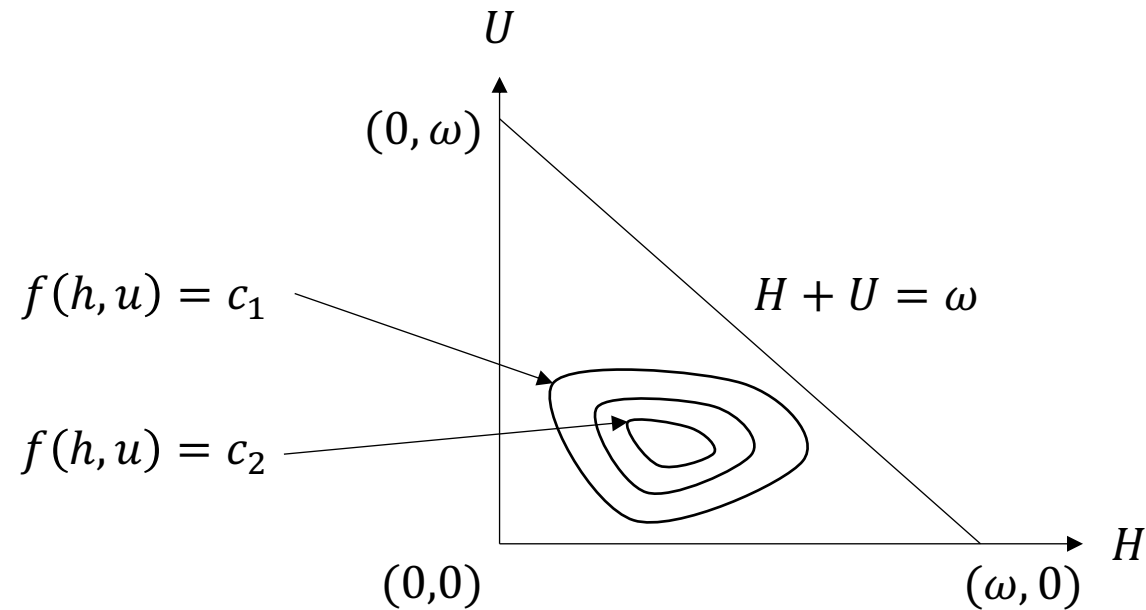
A NEW DOMAIN

- Let $\mathcal{L} = (H, U)$ be a bi-variate random variable capturing the number of years individuals have lived in “healthy” and “unhealthy” states at time at death, and let ω denote the maximal lifespan.



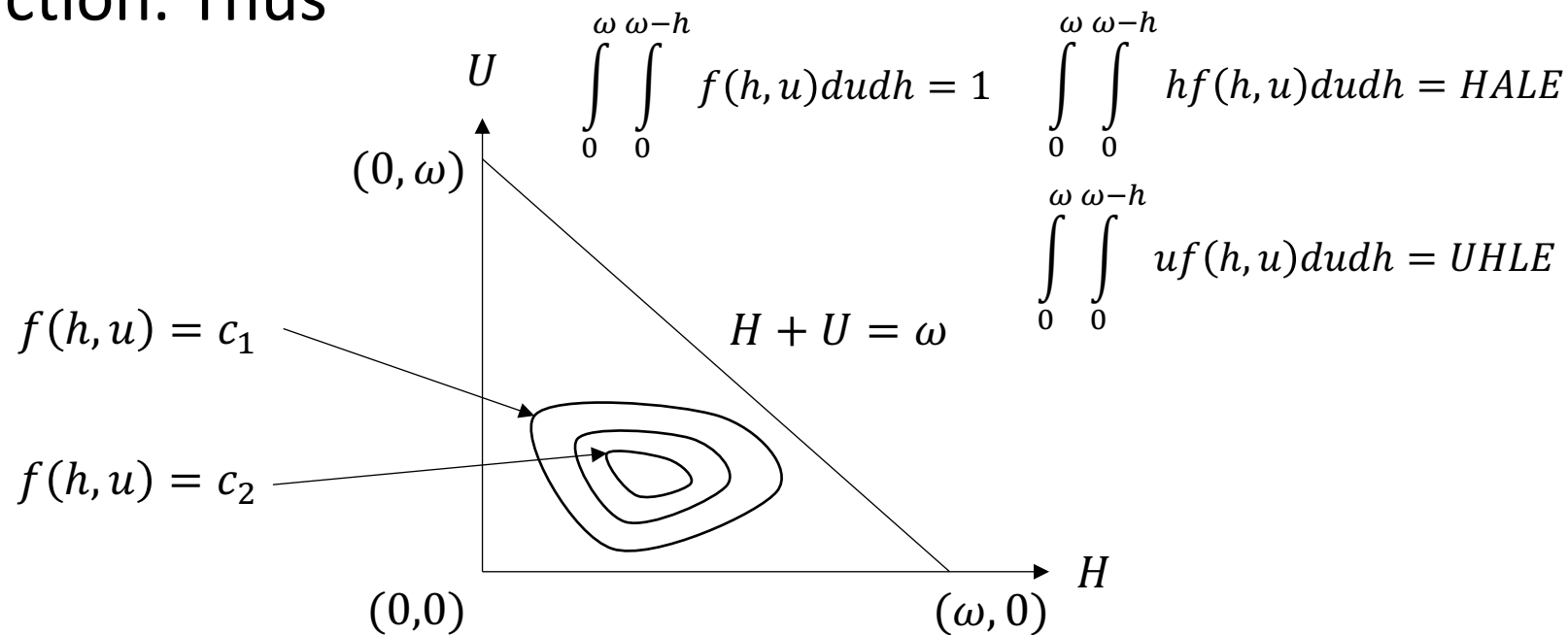
A BIVARIATE AGE-AT-DEATH DISTRIBUTION

- Let $f(h, u)$ be the corresponding joint density function. Thus



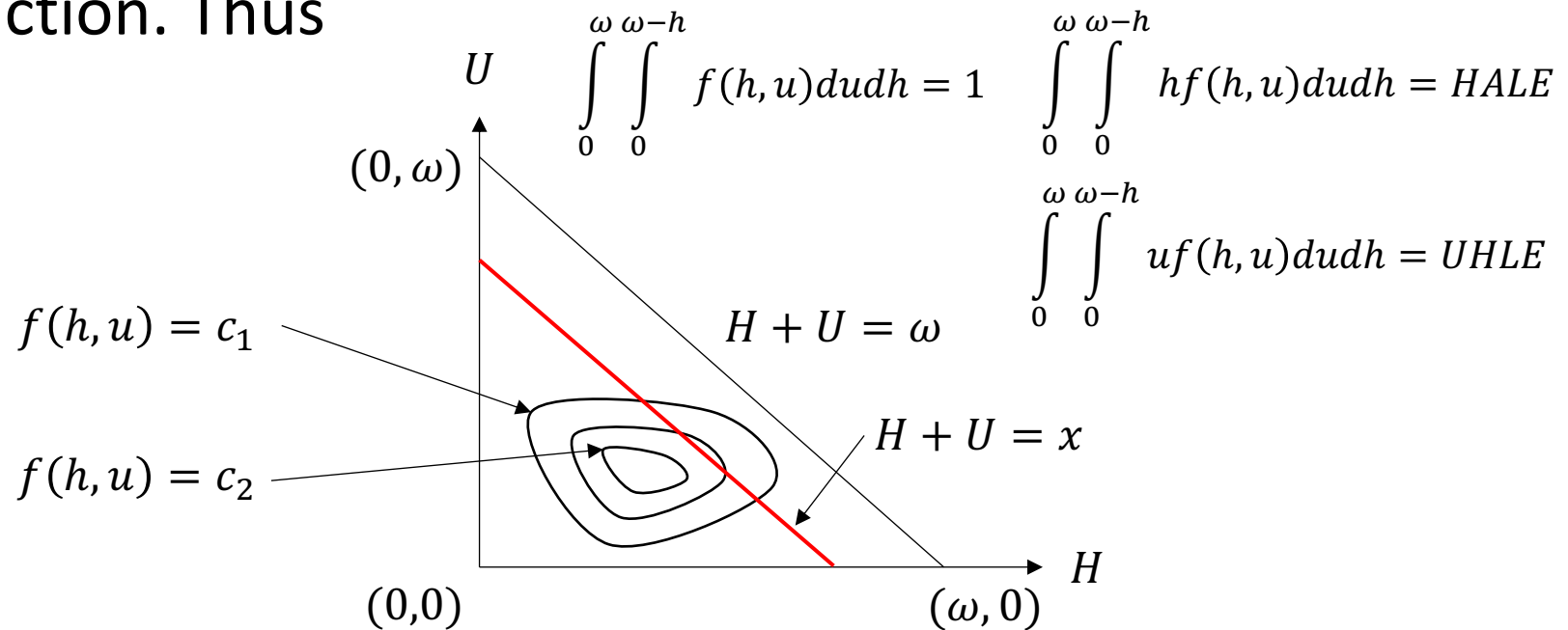
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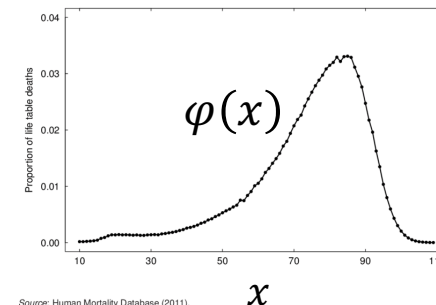
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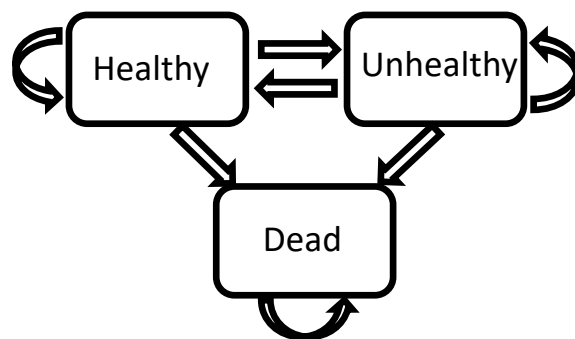
- For a given age-at-death $x \in [0, \omega]$, let

$$\varphi(x) = \int_0^x f(h, x-h) dh$$



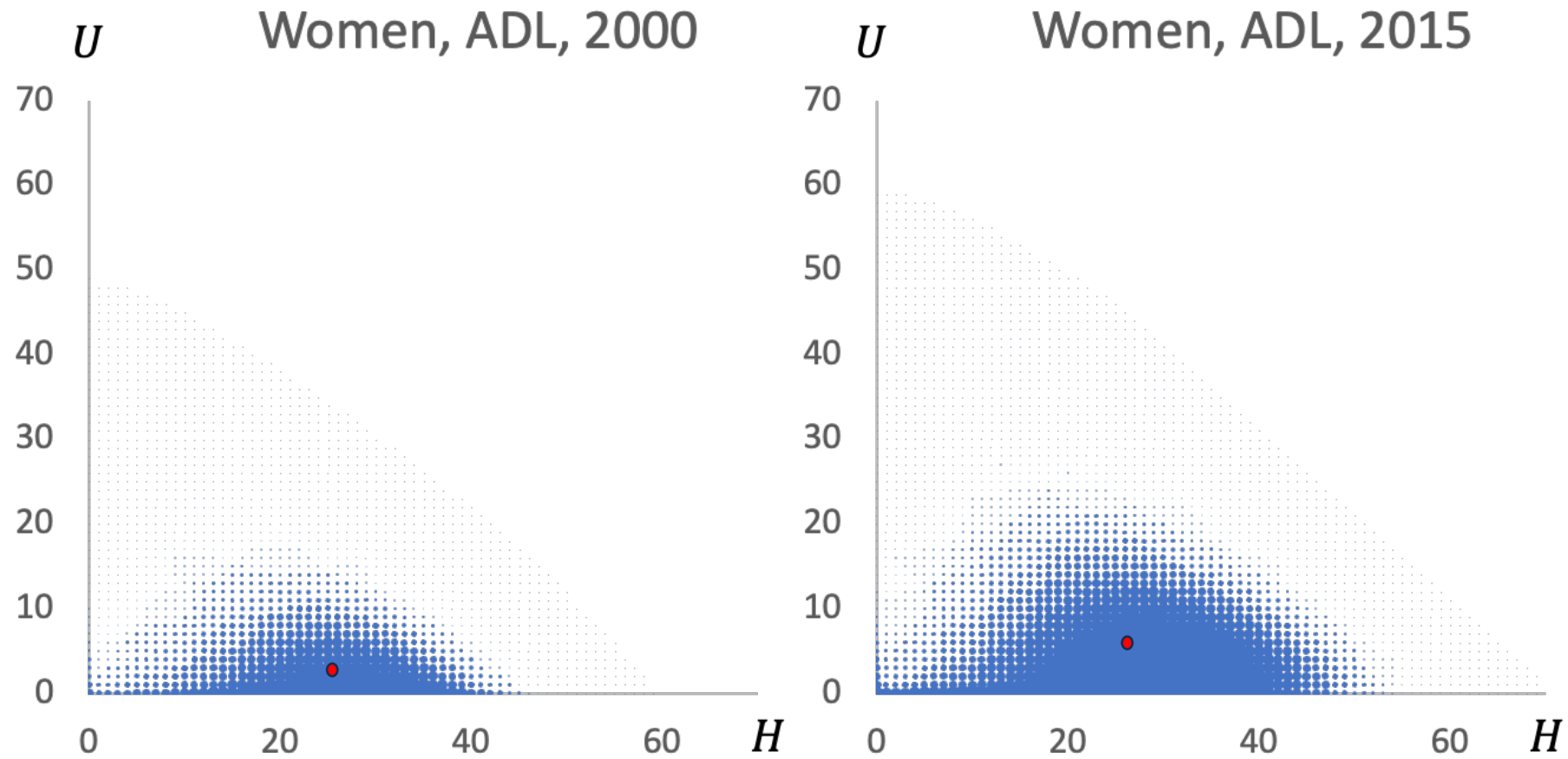
EMPIRICAL EXAMPLE 1

- Health and Retirement Study (HRS)
- Health measure: ADL.
 - “Less-than-good health” whenever someone reports at least one ADL.
- Values of h and u estimated by **cumulating time spent in different health states (via transition probabilities)**

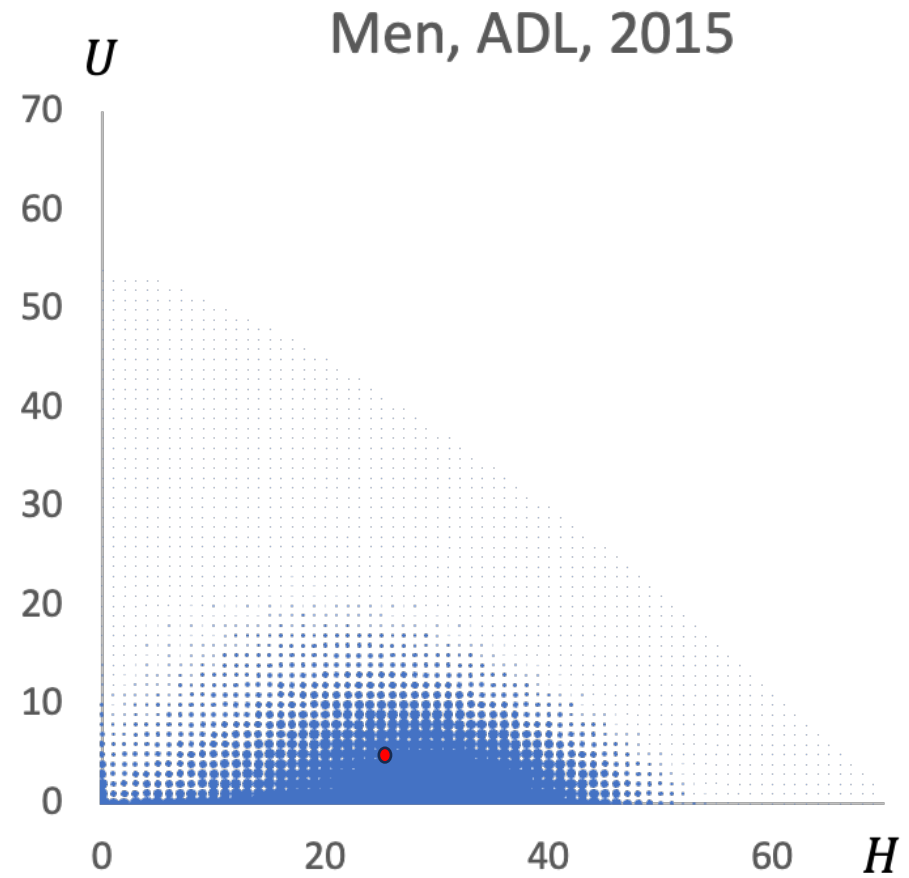
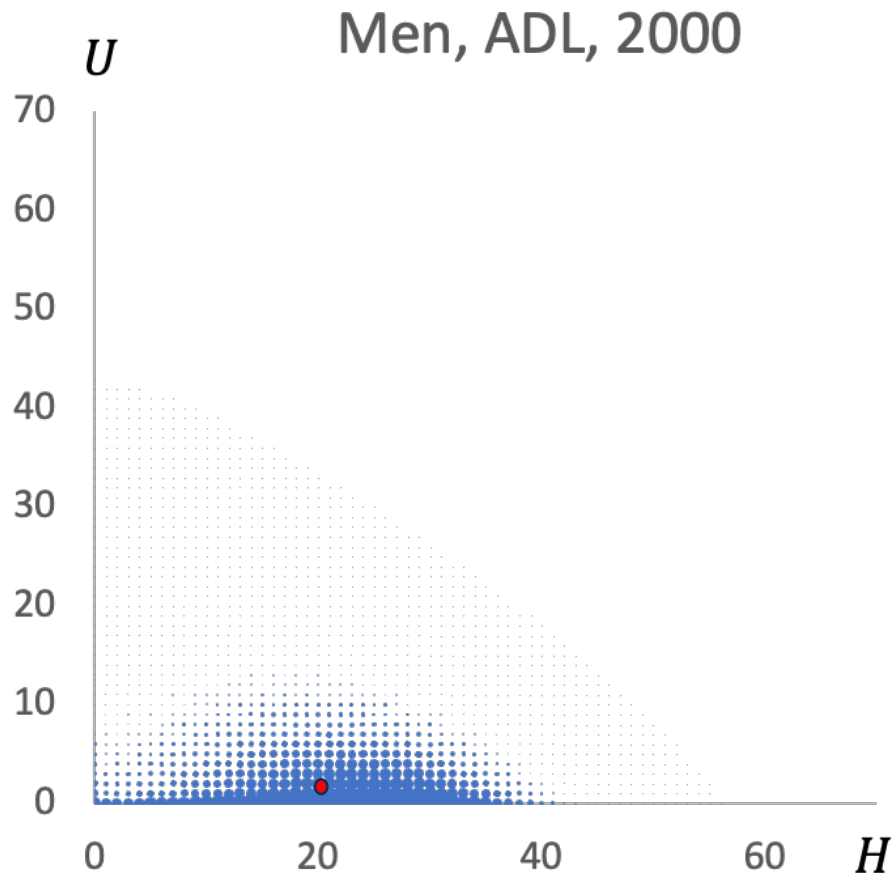


- Results reported for women and men separately
- Years: 2000, 2005, 2010, 2015

JOINT DENSITY FUNCTIONS (WOMEN)

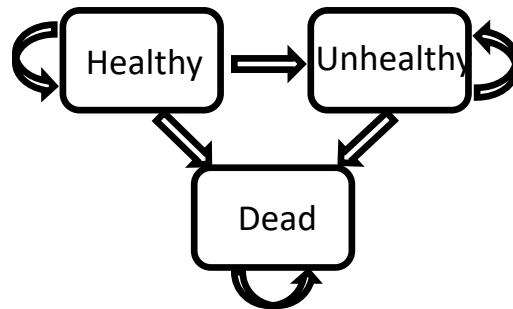


JOINT DENSITY FUNCTIONS (MEN)

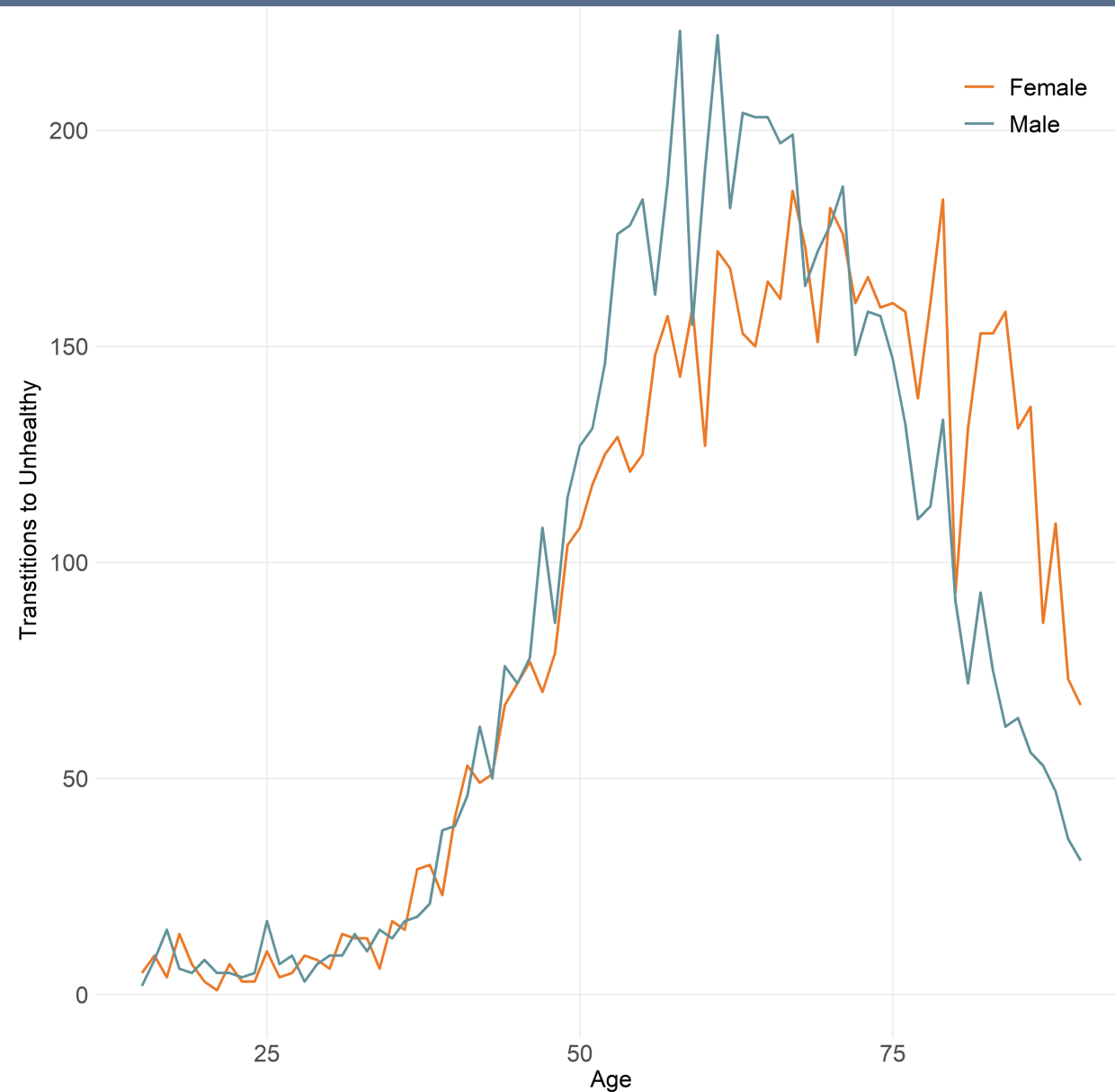


EMPIRICAL EXAMPLE 2

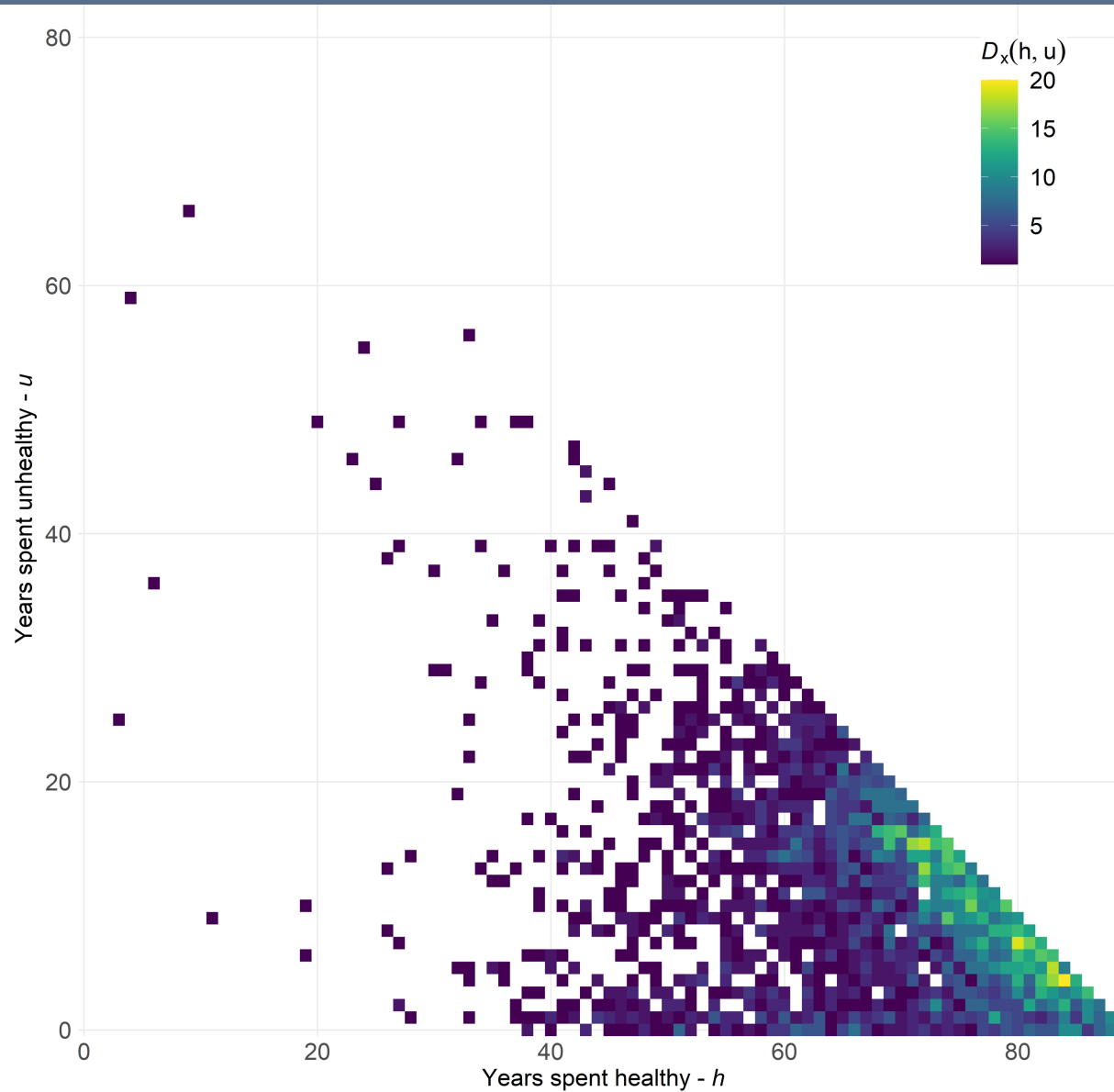
- Health Registers from Catalonia (PADRIS)
 - Cohort design: From 2005 onwards
- We document age-at-first-diagnosis for major chronic diseases (*no recovery from unhealthy state admissible*)
 - Diabetes; Myocardial infarction; Angina pectoris; Other diseases of the heart; Stroke; Chronic bronchitis/Chronic obstructive pulmonary disease/Emphysema; Cirrhosis of the liver; Malignant tumor; Parkinsonism; Alzheimer's disease; Chronic renal failure
- Values of h and u **estimated through age-at-diagnosis of the previous chronic diseases and age-at-death.**



TRANSITIONS HEALTHY → UNHEALTHY (2019)



DEATH COUNTS (CATALAN WOMEN 2019)



CONCLUSIONS AND WORK AHEAD

- HLI is an important marker of population health heterogeneity, *integrating mortality and morbidity dynamics into a coherent whole*.
 - HLI higher than LI (new layer of health inequalities)
 - HLI higher among low-educated individuals
 - HLI higher among women (as opposed to LI)
 - HLI declines have stagnated in low-mortality countries during the last 30 years
- As longevity increases worldwide, the locus of health inequality is gradually moving from death-related inequalities to disease- and disability-centered ones – a **compositional shift in health inequality** .
- **Future work:**
 - Expand multi-state analyses to Catalonia, Denmark, ...
 - Contribution of healthy/unhealthy years to lifespan inequality?
 - Revisit compression vs expansion of morbidity debate
- Many of the determinants of “less-than-good” health are **avoidable**. Policies must be put in place.

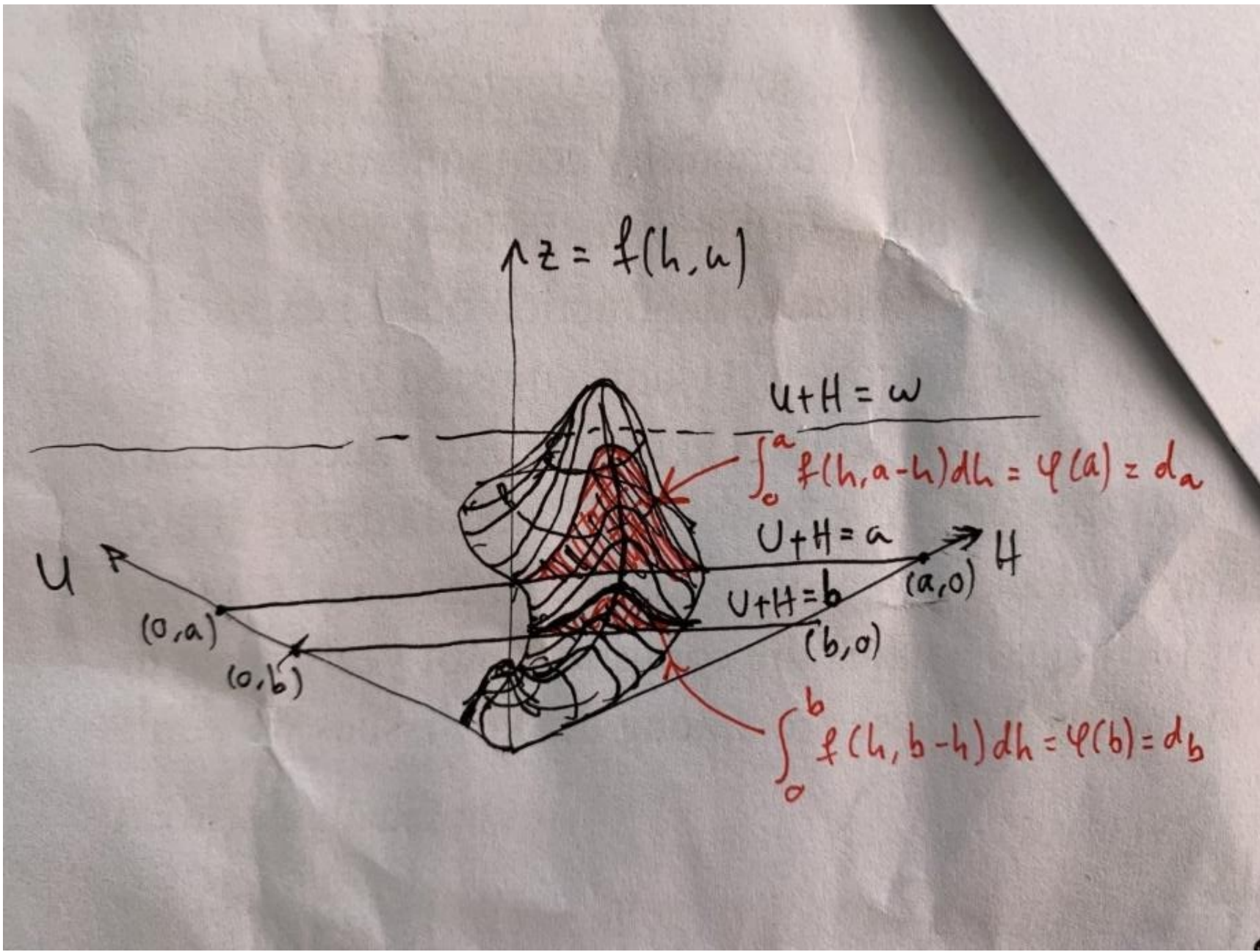
Thank you

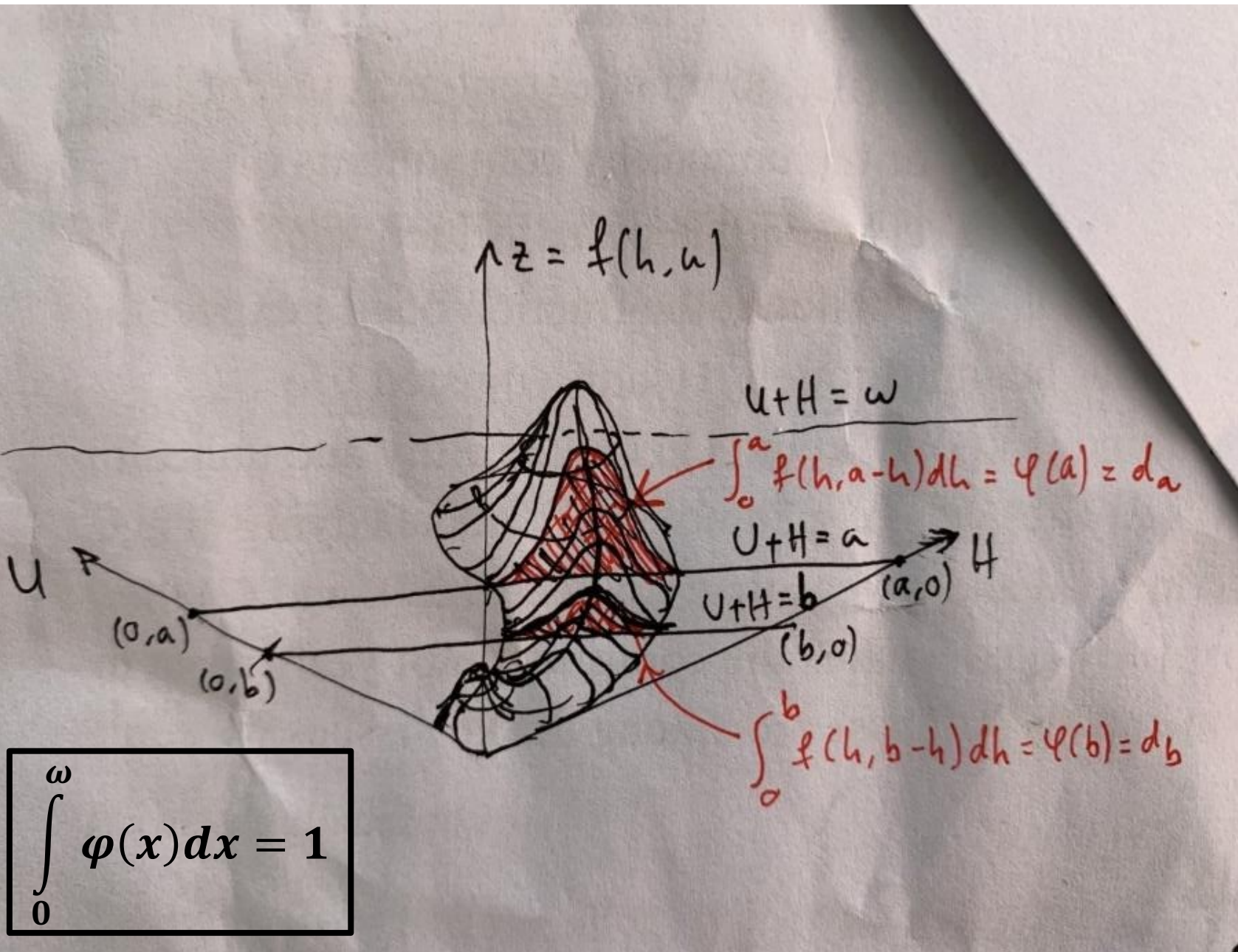
Iñaki Permanyer
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$$\int_0^{\omega} \varphi(x) dx = 1$$