
Understanding end-of-life multimorbidity: An analysis of Multiple Causes of Death in Denmark

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Sixth meeting of the MultiCause network – 17/10/2025

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Background: Challenges of mortality analysis

- Death involves numerous health risks and diseases throughout the lifespan
- Traditional mortality analysis focuses on single underlying cause of death
 - This approach misses the complex morbidity process leading to death
- Misreporting or misclassification of underlying cause is a persistent issue (Bishop et al., 2023)

Background: Growing Complexity of Mortality

- Average number of contributing causes has been increasing over time (Cheng et al., 2012; Jetté et al., 2010)
- Older individuals typically present more complex combinations of causes
- When multiple conditions interact, determining a single cause becomes problematic
 - Need for data and methods that capture multimorbidity at end of life

Background: Multiple Causes of Death (MCoD)

- MCoD data and analysis provides a more comprehensive view of mortality (Janssen, 1940):
 - Records all conditions that contributed to an individual's death
 - Provides insights into mortality risks and interactions
 - Highlights chronic conditions often relegated to secondary roles
 - Often used as a proxy for multimorbidity patterns at end of life
- **MCoD data are subject to biases: misreporting, underreporting, etc.**

1. Are the MCoD data representative of end of life health conditions?

NO!

2. Do they better represent the chain of events leading to death, given known disease histories?

MAYBE!

Data: Danish registers

→ Cause of death register

→ Including all information on underlying, intermediate, immediate, and contributing cause of death

→ Register of chronic diseases

→ Including individuals diagnosed with: **COPD**, dementia, and diabetes

→ Cancer register

→ Including all individuals diagnosed with cancer: both any cancer or specifically lung, breast, prostate, colorectal, and pancreatic cancers

Data: Study population

Danish population diagnosed with a chronic condition or cancer from 2010 to 2019 who are at least 50 years old:

- Sex
- Birth date
- Date (and age) at diagnosis
- Date (and age) at death
- Cause of death (1.a-1.d, 2.1-2.4)
- Educational attainment

Analysis: Descriptive statistics

Exploratory analysis to investigate:

- Number of times (%) each disease appears on the death certificate (in any position)
- Location of the chronic disease on the death certificate (%)

Descriptive results COPD

Population with COPD		
Has disease reported on death certificate	n	%
No	15739	64,9
Yes	8496	35,1

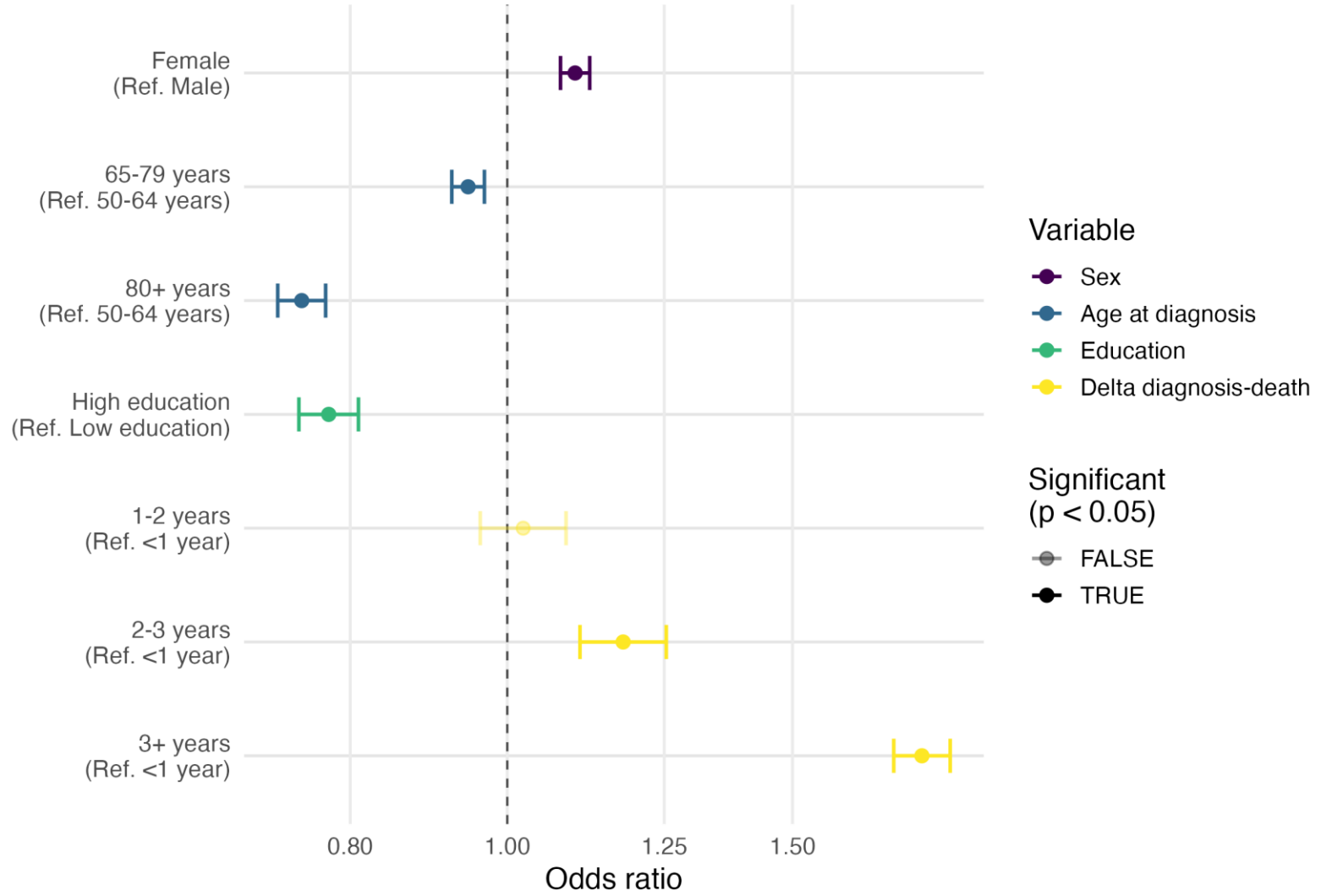
Placement on death certificate	n	%
1.a	645	7,6
1.b	1347	15,9
1.c	518	6,1
1.d	1488	17,5
2.1	2929	34,5
2.2	1075	12,7
2.3	356	4,2
2.4	133	1,6

Analysis: Logistic regression

→ Logistic regression model:

appearance on death certificate ~ sex +
age at diagnosis +
time elapsed between diagnosis and death +
educational attainment

Factors associated with COPD appearing on death certificates



Analysis: Multiple decrement life tables

Multiple decrement life tables computed by:

- Sex
- Period: 2010-11 to 2018-19
- Disease: COPD, dementia, diabetes, and cancer(s)
- Disease appearance on the death certificate
- Cause of death: Human Cause of Death Database (HCD), 17 categories

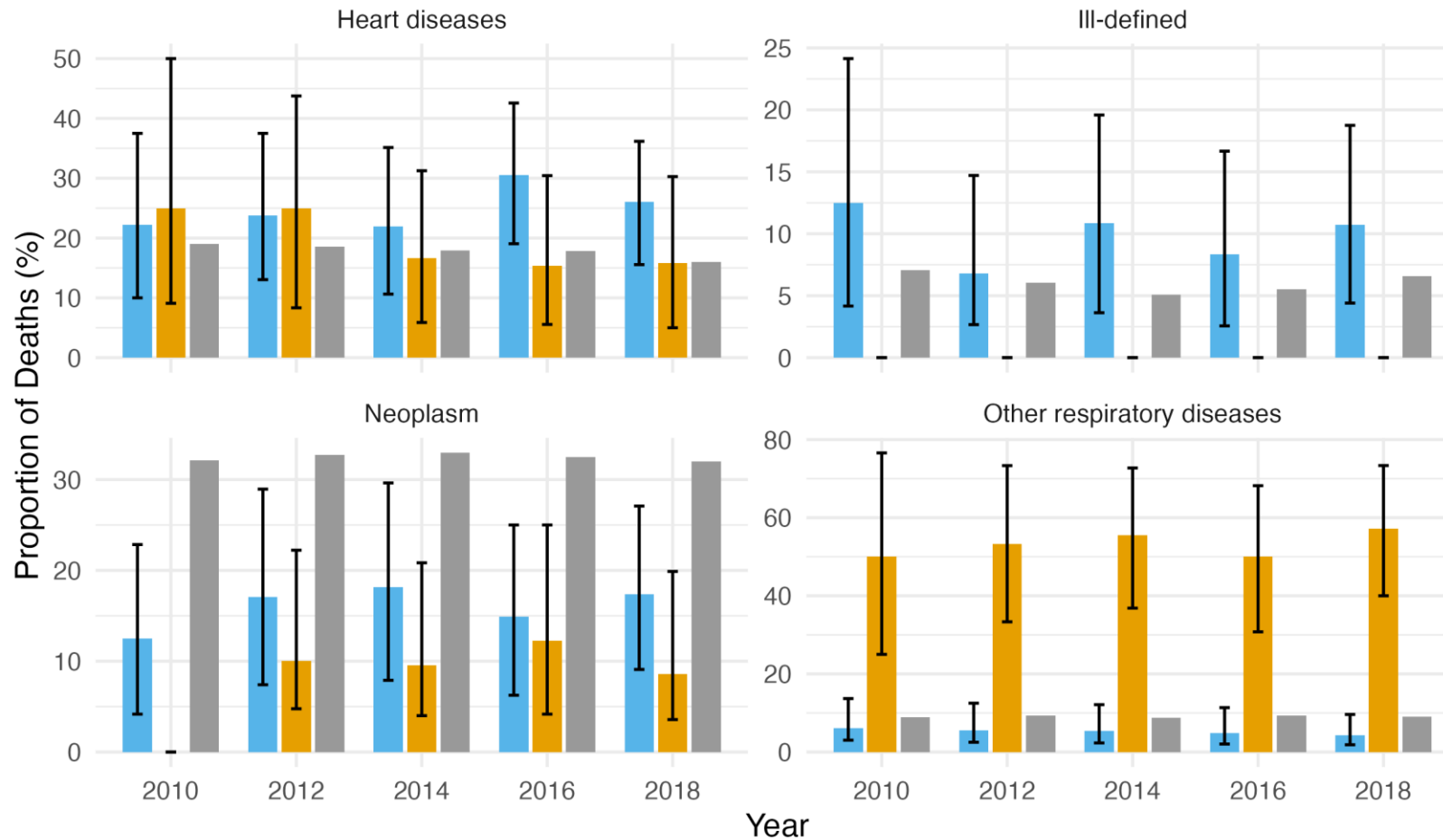
$${}_nq_x^i = {}_nq_x * \frac{{}_nD_x^i}{{}_nD_x}$$

$${}_nd_x^i = {}_nq_x^i * l_x$$

$$ratio_x^i = \frac{\sum_x {}_nd_x^i}{\sum_i \sum_x {}_nd_x^i}$$

Confidence intervals are computed with bootstrapping

Proportion of deaths among **men** with COPD by four leading causes of death and year



Analysis: CoD association

→ Cause of Death Association Indicator (CDAI): measure the association between different diseases reported on the death certificate (Désesquelles et al. 2010)

$$CDAI = \frac{\sum_x \frac{d_{uc,x}}{d_{u,x}} \cdot \frac{\bar{d}_x}{\sum_x \bar{d}_x}}{\sum_x \frac{d_{c,x}}{d_x} \cdot \frac{\bar{d}_x}{\sum_x \bar{d}_x}},$$

$d_{uc,x}$: Deaths at age x from cause u with chronic disease c

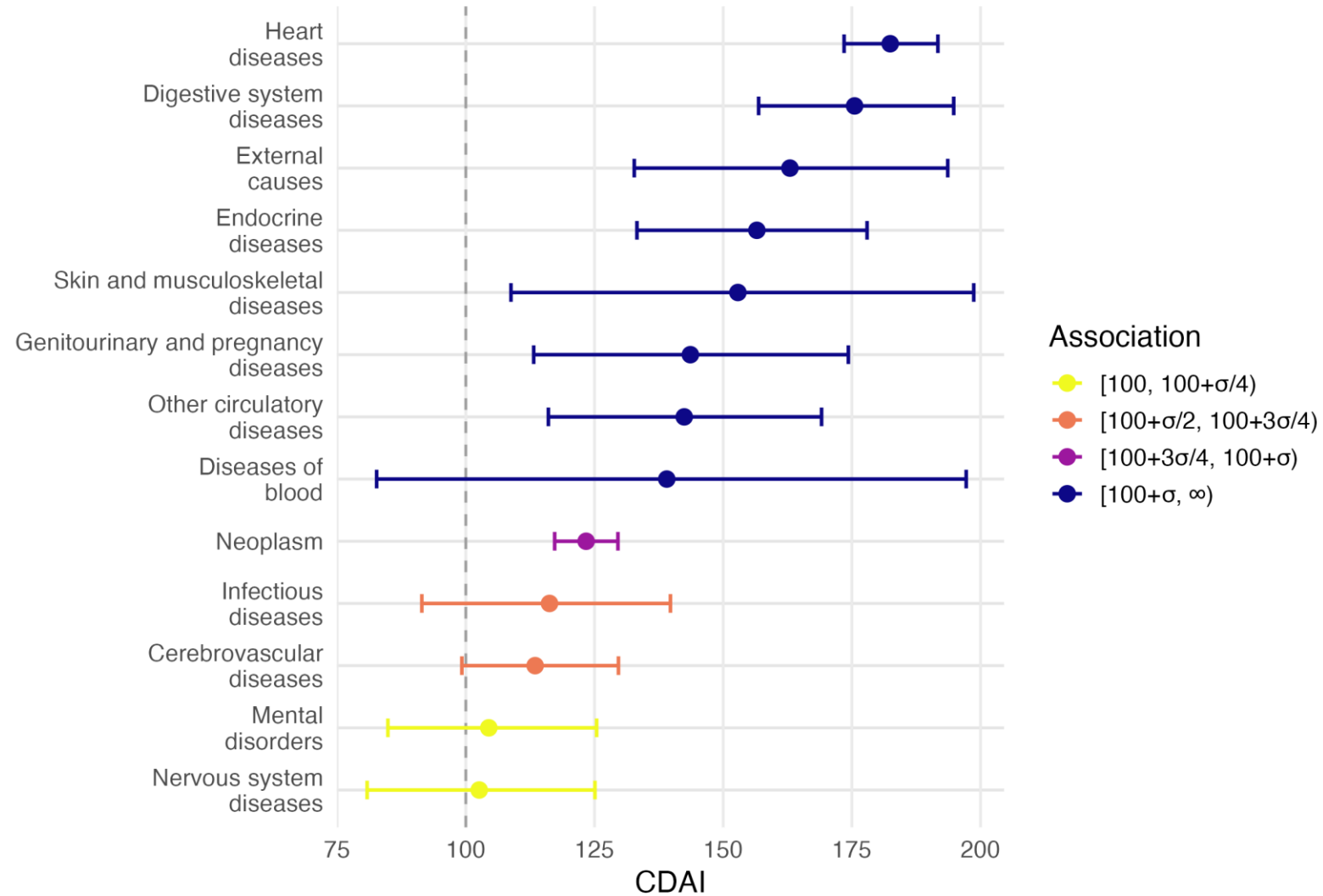
$d_{u,x}$: Deaths at age x from cause u (total population)

$d_{c,x}$: Deaths at age x with chronic disease c

d_x : Deaths at age x

\bar{d}_x : Deaths of standard population at age x

Association of CoD in COPD population



WRAPPING UP

Discussion:

→ MCoD data cannot be used as a proxy of individuals' health conditions at the end of life

- Only one out of every three times COPD does appear somewhere in the death certificate
- The odds increase the longer the time since diagnosis, while they decrease if the diagnosis is at older ages
- Over half of deaths for those with COPD on the death certificate are due to other respiratory causes, while ill-defined causes are quite prevalent when COPD is not reported

→ MCoD data seem suitable for better understanding the chain of events leading to death

- COPD is more often reported alongside heart and digestive system diseases and external causes of death

Thank you for attention!

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References

- Bishop, K., Balogun, S., Eynstone-Hinkins, J., Moran, L., Martin, M., Banks, E., Rao, C., & Joshy, G. (2023). Analysis of Multiple Causes of Death: A Review of Methods and Practices. *Epidemiology*, 34(3), 333–344
- Cheng, T.-J., Lin, C.-Y., Lu, T.-H., & Kawachi, I. (2012). Reporting of incorrect cause-of-death causal sequence on death certificates in the USA: Using hypertension and diabetes as an educational illustration. *Postgraduate Medical Journal*, 88(1046), 690–693
- Désesquelles, A., Salvatore, M. A., Frova, L., Pace, M., Pappagallo, M., Meslé, F., & Egidi, V. (2010). Revisiting the mortality of France and Italy with the multiple-cause-of-death approach. *Demographic research*, 23, 771-806
- Janssen, T. A. (1940). Importance of Tabulating Multiple Causes of Death. *American Journal of Public Health and the Nations Health*, 30(8), 871–879
- Jetté, N., Quan, H., Hemmelgarn, B., Drosler, S., Maass, C., Moskal, L., Poin, W., Sundararajan, V., Gao, S., Jakob, R., Üstün, B., Ghali, W. A., & Investigators, for the I. (2010). The Development, Evolution, and Modifications of ICD-10: Challenges to the International Comparability of Morbidity Data. *Medical Care*, 48(12), 1105