Title: Trends in hospital deaths in Denmark from 1980 to 2014, at ages 50 and over

Short running title: Trends in hospital deaths in Denmark

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IMPACT statement:

We certify that this work is novel. It provides important insights about the share of the population dying in hospitals and determinants of hospital deaths. In light of the growing population of older people in high-income countries, our findings are relevant for policy makers and healthcare professionals in planning and developing end-of-life care programs, as well as to individuals, who, generally, wish to die at home not only in Denmark, but also across other European and North American countries. In Denmark from 1980 to 2014 for both sexes, we find that the proportion of hospital deaths substantially declines for ages 50-79, remains almost unchanged at ages 80-89 and increases after age 90. We found increasing trends for hospital deaths from respiratory diseases and with terminal hospitalizations lasting 1-3 days. Married individuals, middle- and high-income groups, and individuals who died of respiratory diseases were more likely to die in hospital. Further research is needed to understand structural determinants of place of death in Denmark.

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Author contributions: AO, NCV, AC, and JMH designed the study. AC, RLJ and AO had access to the data. AC performed all statistical analyses. NCV, AC, AO, and JMH wrote the first draft. RLJ helped to acquire data and to clarify content, quality, and comparability over time of some variables in the register data. KAR provided insights into the healthcare and social care systems in Denmark. All authors interpreted the results and revised earlier versions of the paper critically for important intellectual content and approved the final version. Sponsors had no role in the design, methods, subject recruitment, data collections, analysis or preparation of the paper.

Abstract

OBJECTIVES: To explore temporal trends and individual-level determinants of hospital deaths at ages 50 and over in Denmark, from 1980 to 2014.

DESIGN: Individual-level, register-based retrospective study.

SETTING: Denmark, 1980-2014.

PARTICIPANTS: All deaths that occurred in Denmark from 1980 to 2014 among individuals aged 50 years or older (N = 1,834,437), extracted from population registers.

MEASUREMENTS: A death was defined as a hospital death if the individual was admitted to the hospital as an inpatient, and the date of discharge from the hospital is equal to the date of death.

RESULTS: The percentage of hospital deaths decreased in both sexes (all ages combined, men: 56% to 44%; women: 49% to 39%) and at ages 50-79, remained almost unchanged at ages 80-89 and increased in the oldest age group (90+ men: 27% to 32%; women: 18% to 24%). We observed increasing trends of hospital deaths for three groups, people: age 90 years and older, dying from respiratory diseases, and who had terminal hospitalizations lasting 1-3 days. Sub-analysis of all hospital deaths according to length of the terminal hospitalizations suggests that the overall reduction of hospital deaths might be driven by a reduction in hospitalizations that were longer than one week. Persons who are married, have middle or high income, have a history of hospitalizations in the year before death, or die because of respiratory diseases have higher odds of dying in a hospital.

CONCLUSION: Results provide evidence that Danes age 50 years and older are increasingly dying outside the hospital context. We find three age-specific patterns in the proportion of hospital deaths. Changes in healthcare and social systems implemented in Denmark during the observation period may underlie the broader reduction in hospital deaths in the country.

Keywords: place of death, end-of-life, hospital deaths

Introduction

Remarkable improvements in life expectancy over the last two centuries in high-income countries have resulted in a rapidly growing population of old-aged individuals [1]. This has led to new areas of research studying how older people live, including general trends in morbidity and disability, as well as socioeconomic and gender disparities in health outcomes [2]. In the last decade more research has been initiated to study health patterns, healthcare needs, and quality of care at the end of life [3,4]. Older people often have multiple health problems and are at higher risk of functional declines, and thus have special needs for treatments and symptom management. Ensuring continuity of care at older ages and improving end-of-life care have both been recognized as global public health priority issues by the World Health Organization [5] and the United Nations General Assembly [6].

Central to planning policies for end-of-life care is measuring the share of the population dying in different contexts. There are several components that determine place of death, including socio-demographic factors, cause of death, other illness-related factors [7], structural factors, and social trends that change over time. Studies have shown that many high-income countries have worked toward shifting the place of death from hospital to home or long-term care institutions to reduce healthcare costs, iatrogenic conditions, and hospital-acquired infections, as well as to meet patients' and caregivers' preferences [8,9]. There is evidence that quality of death is highest at home, lowest in the hospital, and intermediate in palliative care units [10,11]. Furthermore, hospital admissions at the end-of-life can substantially increase total healthcare expenditures [12].

Individual factors include demographic characteristics (e.g., age, gender, race, marital status, number of children), socioeconomic status (SES) (e.g. education, family income, social

class) and cause of death. Population-level studies have demonstrated that increasing age is associated with decreasing probability of dying in hospital [13,14]. However, this relationship is less consistent in the studies that focus on specific population groups, such as cancer patients [7,15]. Women die in hospital more often than men do [16-18], which likely has multiple causes, including women having no partner to provide caregiving at home [19]. People who do not have relatives to care for them have increased probability of dying in a hospital [20], as do those of lower SES [21]. The most frequent causes of hospital death are cancer, stroke, and respiratory diseases [17,20]. Previous studies suggest that people with advanced chronic diseases prefer to die at home [4], as it offers greater physical and psychological comfort and more time with family without additional caregiver psychological and economic burden [10,11].

In Denmark, there is little research on place of death, and, to our knowledge, the published research has focused mainly on preferred place of care and death and the association of GP visits with home death among terminally-ill cancer patients [22,23]. Using high-quality register data on the total Danish population, this study examines trends in hospital deaths at ages 50 and over and how trends vary by age, gender, and causes of death over a 35-year period from 1980 to 2014. We also investigate individual-level determinants of hospital deaths in the Danish population.

Data and Methods

This study is based on register data which cover the total population of Denmark. The study involves secondary data analysis of de-identified micro-data, for which a formal consent is not required. The initial application for a broader project has been approved by Statistics Denmark (Project No. 5935).

The study population includes all deaths that occurred in Denmark from 1980 to 2014 among individuals aged 50 years or older, as this is the approximate age at which individuals start accumulating diseases and disabilities and at which the incidence of most common causes of death in Denmark increases substantially [24].

A death was defined as a hospital death if the individual was admitted to the hospital as inpatient and the date of discharge from the hospital was the same as the date of death.

We first present temporal trends in the proportions of hospital deaths, and then we discuss results of sex-specific multivariate logistic regression models. Details about data and method are presented in the Supplementary Text S1.

Results

From 1980 to 2014, 47.5% (870,776) of deaths at ages 50 and older were defined as hospital deaths out of a total of 1,834,437 deaths. The percentage of hospital deaths decreased from 1980 to 2014 for both sexes, men: 56% to 44% and women: 49% to 39%, and shows three age-specific trends (Supplementary Table S2). The percentage of hospital deaths decreased with increasing age (all years combined, men: 53% to 30% and women: 60% to 23%). The percentage of hospital deaths was higher among married (men 56%, women 57%) than among non-married counterparts in all years combined. For both sexes, the highest percentage of hospital deaths was recorded for neoplasms in 1980 (men 70%, women 68%) and respiratory diseases in 2014 (men 58%, women 54%), whereas deaths due to mental and behavioral disorders accounted for the lowest percentages. High-income men and women had the lowest percentage of hospital deaths in 1980 (54% and 44% respectively), while the lowest proportion of hospital deaths was observed for middle-income groups in 2014 (men 43%, women 37%).

Trends in hospital deaths

Figure 1 shows time trends (1980-2014) of the proportion of hospital deaths by age groups (panel A) and causes of death (panel B). The proportion of deaths occurring in a hospital declines for individuals aged 50 to 79. The proportion of hospital deaths at ages 80-89 years remains almost unchanged over the observation period, while it increases slightly in the oldest age category (90+). Decreasing trends were observed for all causes of death, except for deaths due to diseases of the respiratory system and "other" causes. The highest proportion of hospital deaths was due to neoplasms until 2005; this category had the steepest decline (Figure 1, panel B).

Figure 1 (panel C) illustrates the trends of hospital deaths by age and sex for the complete study population (All) and for all deaths excluding terminal hospitalizations with a hospital stay between 1 and 3 days (Hosp > 3 days). This is to exclude hospitalizations that were mainly due to adverse health deteriorations shortly before death. For those aged 50-59 and 60-69, the proportion of hospital deaths is consistently higher for women than men across all years, but no gender difference is observed in the age group 70-79. In contrast, at ages 80 years and older, men have higher proportions of hospital deaths compared with their women counterparts during the whole observation period. In the subpopulation that excludes terminal hospitalizations with a hospital stay between 1 and 3 days, the proportion of hospital deaths declines across all ages, except for the 90+ age group. A possible explanation for the sex- and age-specific patterns is provided in Supplementary Analysis S3.

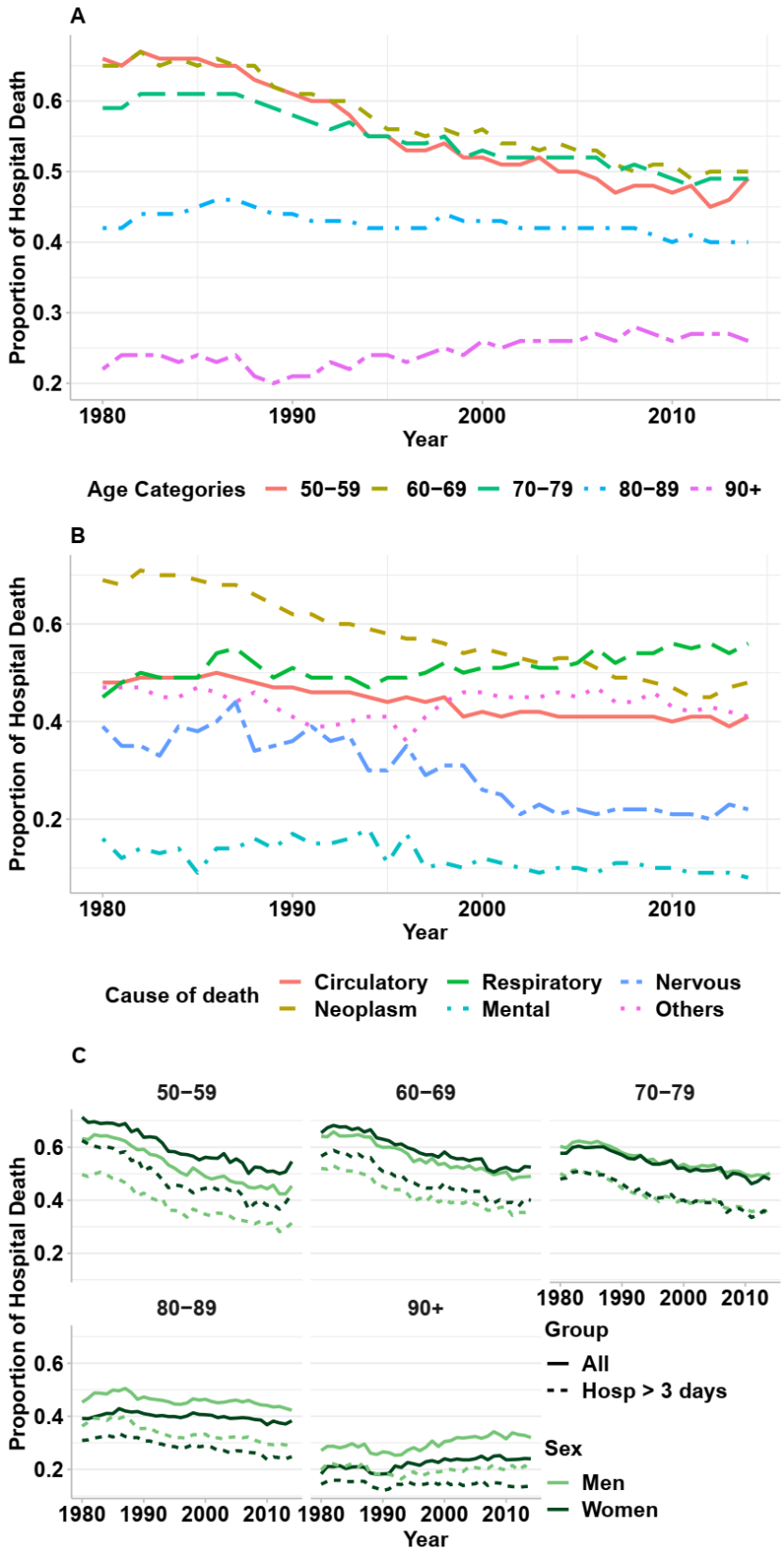

Figure 1 A, Time trends (1980-2014) in the proportion of hospital deaths by age. B, Cause of death. C, Cause of death by age and sex in the complete data (solid lines) and excluding deaths with terminal hospitalizations lasting less than 4 days (broken lines).

Figure 3 shows that the proportion of hospital deaths due circulatory diseases decreases in the youngest age categories, while the trends are stable or are slightly increasing in the age 80-89 and 90+ age groups, respectively. The proportion of hospital deaths due to neoplasms declined over time for all age categories, except for the two youngest age groups, which peak in in 2013-2014. There is an increase in the proportion of hospital deaths due to diseases of the respiratory system among those aged 70 and over. This was even steeper for people aged 80 and over than among their younger counterparts.

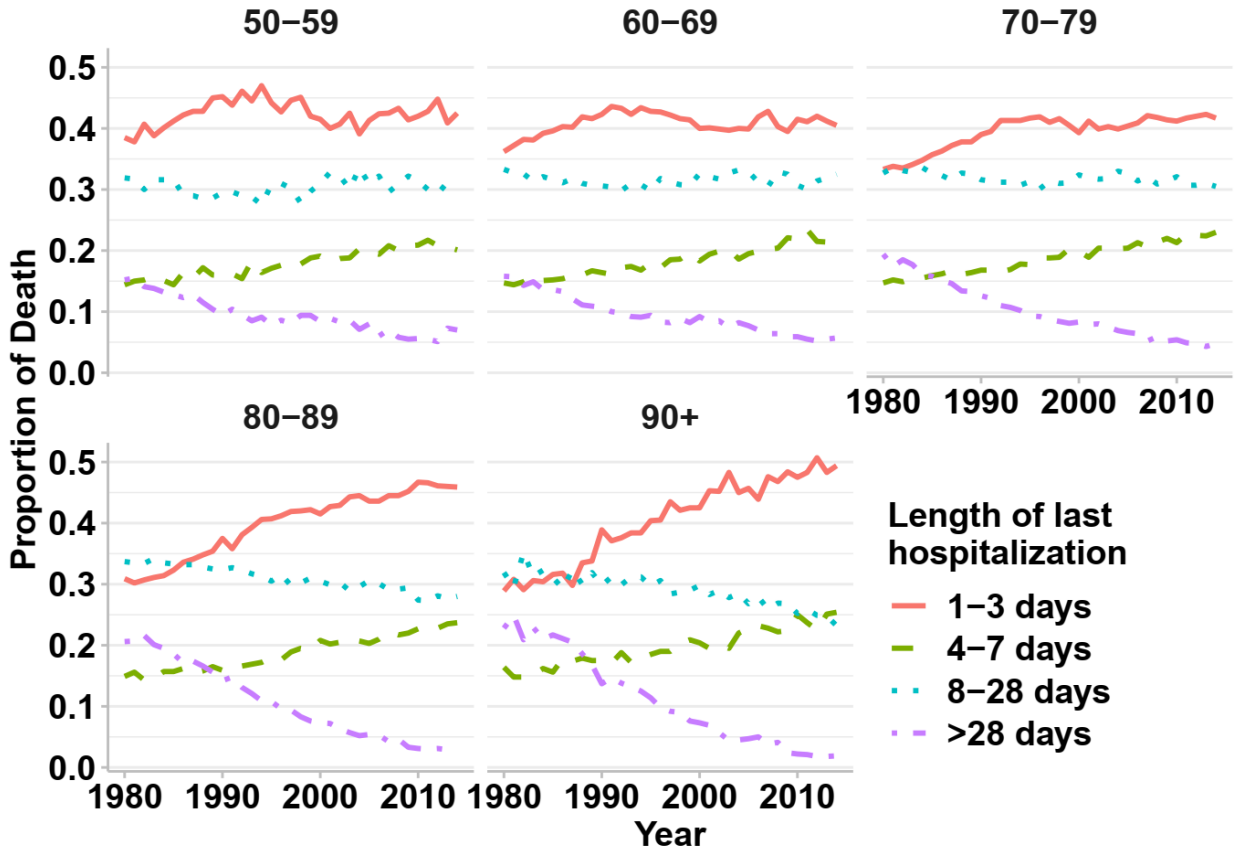

Figure 2 Time trends (1980-2014) in the proportion of deaths by age groups and length of last hospitalization before death (hospital deaths only).

Determinants of hospital deaths

For both sexes, whereas the odds of dying in the hospital were higher at ages 60-79 compared to the 50-59 age group, they were lower for those aged 80 and older (Table 1). Married individuals had a higher risk of dying in hospital when compared to their non-partnered counterparts. The odds of dying in a hospital for both sexes were higher for middle- and high-income groups than low-income groups (Table 1). In comparison with circulatory diseases, the risk of dying in a hospital was lower for all causes of death except deaths due to diseases of the respiratory system. Finally, each additional hospitalization in the year prior to death increased the odds of dying in the hospital for both genders. Despite controlling for these social covariates and causes of death, there is still a significant decline in the odds of dying in a hospital over the period for both sexes.

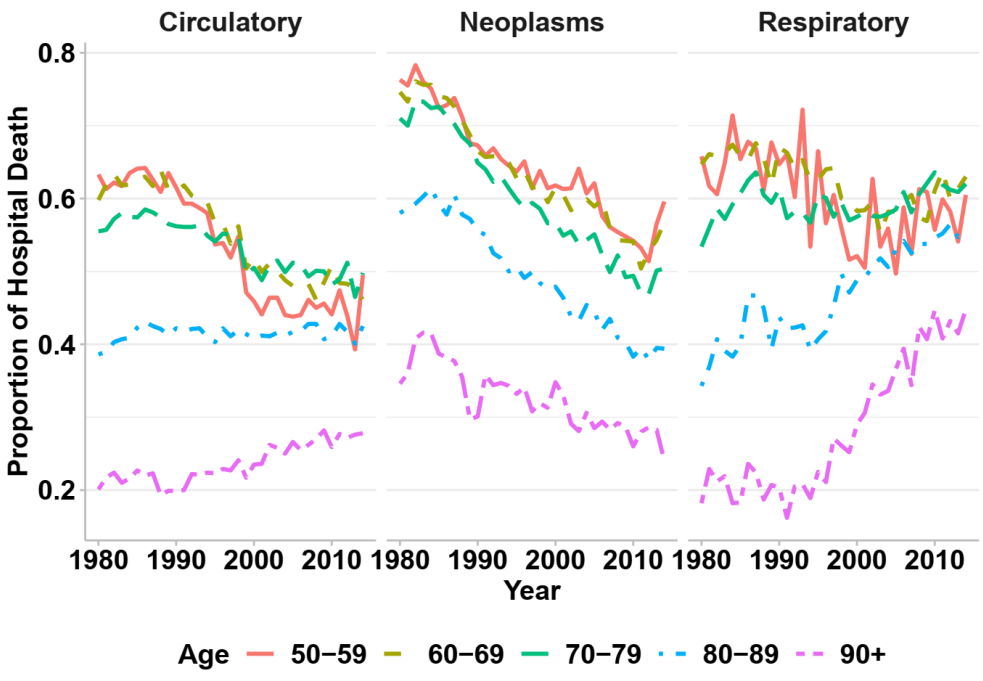

Figure 3 Time trends (1980-2014) in the proportion of hospital deaths by age and cause of death.

Table 1. – Multivariate logistic regression models for the odds of dying in a hospital [a]

Coefficients	Men	Women
Period (ref.: 1980-1984)		
1985-1989	0.94 (0.92, 0.95)	0.97 (0.95, 0.98)
1990-1994	0.77 (0.76, 0.78)	0.82 (0.80, 0.83)
1995-1999	0.68 (0.67, 0.69)	0.74 (0.73, 0.75)
2000-2004	0.61 (0.60, 0.62)	0.66 (0.65, 0.67)
2005-2009	0.55 (0.54, 0.56)	0.60 (0.59, 0.61)
2010-2014	0.45 (0.45, 0.46)	0.49 (0.48, 0.50)
Age (ref.: 50-59)		
60-69	1.08 (1.06, 1.10)	1.13 (1.11, 1.16)
70-79	1.08 (1.06, 1.10)	1.14 (1.12, 1.16)
80-89	0.86 (0.85, 0.87)	0.79 (0.78, 0.81)
90 +	0.54 (0.52, 0.55)	0.43 (0.42, 0.45)
Cause of death (ref.: Circulatory disease)		
Neoplasms	0.94 (0.93, 0.95)	0.91 (0.90, 0.92)
Respiratory diseases	1.25 (1.23, 1.27)	1.16 (1.15, 1.18)
Mental and behavioral diseases	0.26 (0.25, 0.27)	0.15 (0.14, 0.16)
Nervous diseases	0.50 (0.48, 0.51)	0.39 (0.37, 0.40)
Other	0.90 (0.89, 0.91)	1.01 (1.00, 1.03)
No. of hospitalizations [b]	1.29 (1.28, 1.29)	1.32 (1.32, 1.32)
Civil status (ref.: Married)		
Never married	0.74 (0.72, 0.75)	0.66 (0.65, 0.68)
Widowed/divorced	0.82 (0.81, 0.82)	0.72 (0.71, 0.72)
Income (ref.: Low)		
Middle	1.29 (1.28, 1.31)	1.54 (1.52, 1.56)
High	1.27 (1.26, 1.29)	1.43 (1.41, 1.45)

[a] Data expressed as odds ratio (95% confidence interval)
[b] Total number of hospitalizations in the year before death.

Discussion

In this contemporary nationwide study on long-term trends in hospital deaths in Denmark we found a decline in hospital deaths from 1980 to 2014 for ages 50-79, and for all causes of death, except for diseases of the respiratory system and "other" causes of death. Stable trends were observed for ages 80-89. Individuals 90+ experienced increased hospital deaths. Our additional analyses of trends in hospital deaths by length of the terminal hospitalization prior to

death (Figure 2) provide some insights into the increasing hospital deaths in the oldest age group. A steep increase in hospital deaths with the duration of a 1-3 day terminal hospitalization among the oldest old individuals suggests that these individuals may spend most of the time leading to death at home or in a long-term care facility, and are then transferred to a hospital shortly before death. Focusing on deaths that do not involve 1-3 day terminal hospitalizations shows constant trends in hospital deaths among age 90+ men and women. Although our data do not allow us to investigate the qualitative context surrounding these short-term terminal hospitalizations, other scholars have found that potential avoidable hospitalizations among residents of nursing homes in the U.S. were significantly more likely when patients developed respiratory symptoms [25]. Also in England, individuals dying from respiratory diseases were found twice as likely to be transferred to a hospital shortly before death than those dying from cancer [26].

A hospitalization prior to death can be unavoidable because of acute health deterioration, for which home care is likely to be insufficient [27,28]. It is also possible that caregivers are feeling overwhelmed by worsening of health status, and therefore choose to transfer the patient to the hospital. This evidence contextualizes our findings of increasing trends for specific causes of death and shorter terminal hospitalizations – i.e., these trends may be driven by intensified needs for proficient clinical care. These study findings also raise the question of whether more education on end-of-life symptom management should be incorporated in training for healthcare professionals [29] and reemphasize the need for better health care delivery models that allow patients to have a "good death" [30].

Prior work has suggested that there is more active hospital treatment in Danes of the 1905 cohort compared to the 1895 cohort, based on the higher proportions of hospitalizations and surgical procedures performed, without an increase in in-hospital mortality (within 30 days after surgery among all operated) [31]. In contrast, we find increasing trends in hospital deaths for

respiratory diseases and circulatory diseases (to a smaller extent) in the oldest age group (Figure 3), which could be due to different definitions of (in-)hospital deaths used in these studies. Upon data availability, more rigorous analyses are needed to investigate the reasons for increasing tendency of hospital deaths among oldest old in Denmark.

We find the percentage of hospital deaths to be higher among married than among all non-married counterparts. To some extent this is an unexpected finding, as some research finds living with a spouse or another person is associated with higher odds of home death [19]. However, being married was also associated with a higher risk of a hospital death in Stockholm County and in Portugal [32,33]. Possible explanations could include differences in treatment-seeking behavior by marital status and/or that spouses become overwhelmed by the symptoms related to substantial health deterioration prior to their partners' death and, thus, are more likely to transfer them to a hospital. That said, marital status is based on the civil status recorded in the register, which may not reflect actual living arrangements. The data available to the researchers do not allow identifying persons living in long-term care facilities, making more detailed analysis of living arrangements and place of death impossible. Therefore, the above explanations are speculative and should be addressed in future research.

The odds of dying in a hospital are higher for middle- and high-income than low-income men and women. Although in Denmark access to health care services, including hospital care and prescription drugs administered through hospitals [34], is universal and free to all residents, research shows that income disparities in life expectancy [35] and social disparities in delays in diagnosis of cancer and asthma do exist in Denmark [36,37].

A Swedish study found higher odds of dying in the hospital for higher educated individuals residing at home, compared to lower educated [14]. In Sweden, individuals with higher education are more likely to live in the community until the end of their lives, and are more

likely to be transferred to the hospital shortly before death than those with primary education [38]. Although another Swedish study found no association between hospital deaths and socioeconomic status, the study population was limited to persons in Stockholm County who had at least one contact with health system in the previous three years [32].

It is likely that the income measure partially captures the effect of education. People with higher education are more likely to live in cities or nearby where hospitals are available, and thus can more easily be transferred to a hospital than their lower-educated counterparts. Additionally, higher-educated people may have more knowledge about pathological signs, leading them to seek hospital treatment earlier in the health deterioration process. We are unable to test these hypotheses with the available data, but encourage future researchers to investigate whether lower-income individuals are dying more often outside the hospital due to preference, economic constraints, or other factors.

Changes in healthcare and social systems implemented in Denmark during the observation period may drive the broader reduction in hospital deaths. First, changes in healthcare policies might have altered the length of hospital stay in the period from 1980 to 2014. However, inpatient admissions with at least one day of hospital stay are likely to be less sensitive to policy changes than longer admissions. Second, changes in the admission strategies for specific causes or treatments are likely to have changed as well. Finally, in Denmark the total number of hospital beds was reduced from 4.64 per 1,000 inhabitants in 1997 to 2.64 in 2014 [39]. These reductions were motivated by various financial incentives, especially for those needing long-term care. In the 1990s, municipalities were forced to pay a daily fee to hospitals for the patients waiting for a vacant place in a long-term care facility or to proper home care being established. Currently, a similar principle of financial incentives applies to all municipalities, which have to pay a co-financing contribution to the hospitals when any citizen is hospitalized.

This prompted the municipalities to extend in-home care, including palliative care, and to construct intermediary nursing care homes [40], giving the citizens the opportunity to stay at home or in a care home until death, even with advanced palliative treatment.

There are several limitations of the study. Due to data availability, it was impossible to differentiate across place of death outside of hospitals, i.e., long-term care facilities and home, or to investigate geographical variation in hospital deaths. Previous research shows that even in Sweden, a country which aims to provide egalitarian healthcare and social support, there is substantial variation in the coverage of home help for older populations across municipalities [41]. It is possible that differential provision of home help and care across Danish municipalities may also influence the proportion of hospital deaths. However, as a small country, Denmark may be less likely to face Sweden's challenges of providing home care in less populated areas across large distances.

Despite these limitations, one strength of this study is that it utilized high-quality register data covering the total Danish population to examine trends in hospital deaths over 35 years of observation from 1980 to 2014. These high-quality data comprise nearly complete registration of all hospital admissions from 1977, as well as complete survival follow-up. However, changes in ICD codes and in coding practices limit a more detailed analysis by cause of death [42]. In contrast to previous research in Denmark, our study is not restricted to cancer patients, instead including all causes of death among individuals aged 50 years or older.

Our findings of declining trends in hospital deaths for most groups are informative to policy makers and healthcare professionals in Denmark, as the trends highlight the importance of planning and developing end-of-life care programs that can accommodate dying individuals outside of the hospital context. The findings also have broader relevance across high-income countries for several reasons. First, population ageing is a global phenomenon. Second and

relatedly, many high-income countries are experiencing a reduction in hospital beds despite the growing proportion of old-aged persons and the increasing prevalence of chronic conditions [2] . Third, international qualitative work shows individuals exhibit preferences to be cared for and die at home at terminal stages of their lives [23]. Our use of high quality register data, unavailable in most other high-income countries, provides clear quantitative evidence of the need to expand other end-of-life care settings in Denmark. This, for the reasons stated above, is likely also true of other high income countries.

In conclusion, our results show a substantial reduction in the proportions of hospital deaths versus all the other deaths in Denmark for both sexes and all age groups, except the oldest old, where a slight increase in hospital deaths is observed. Married individuals, as well as middle- and high-income groups and individuals who died of respiratory diseases were more likely to die in hospital. Finally, increasing numbers of hospitalizations in the year before death were linked with higher odds of dying in hospital with respect to dying elsewhere.

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Supplemental Material:

Supplementary Text S1 – Detailed Data and Methods.

Supplementary Table S2 – Socio-demographic characteristics of individuals who died in hospital, N (%): 1980 – 2014 (first and second column), 1980 (third and fourth column) and 2014 (fifth and sixth column), men and women respectively. The percentages refer to all deaths in each respective category.

Supplementary Analysis S3 – Sub-analysis of trends in the proportion of hospital deaths by age and sex for the two major causes of death in Denmark, Neoplasms and Circulatory diseases.

Supplementary Text S1 – Detailed Data and Methods

This study is based on data from the Civil Registration System (CRS) [1], the National Patient Register [2], the Register of Causes of Death [3], and the Income Statistics Register [4], each of which covers the total population of Denmark. Information from the registers were linked by a personal 10-digit identification number (CPR number) unique to each resident in Denmark.

The study population was selected from all deaths of Danish residents that occurred in Denmark from 1980 to 2014 that were registered in the Register of Causes of Death. We then restricted the data to consider only individuals with age at death greater or equal to 50. After we identified the main study population, we linked the other registers through the CPR number. Regular validation studies ensure the high quality of the linkage between the Danish registers [5].

The information on date of birth, sex, vital status, civil status, and dates of any changes was obtained from the CRS register [1]. The date and primary cause of all deaths that occurred in Denmark between 1980 and 2014 were extracted from the Register of Causes of Death, existing in Denmark since 1943 [3]. The information on disposable income in the year before death was extracted from the Danish Register on Personal Income [4].

The National Patient Register (NPR) contains information on every hospitalization since 1977 including dates of admission to the hospital, date of discharge, type of patient (e.g., in-patient, out-patient, and emergency room patient), and diagnosis at discharge with International Classification of Disease (ICD) codes [2]. Prior studies have shown that the Danish registers are reliable and valid sources of information for research purposes, although more caution should be paid to the linkage of the NPR and clinical databases to avoid potential fallacies [6,7].

Using the ICD codes, we categorized the causes of death in six broad categories: neoplasms, diseases of the circulatory system, diseases of the respiratory system, mental and behavioral disorders, diseases of the nervous system and others (which includes all the other

categories). During the study period, the coding for causes of death changed from ICD-8 (1977-1994) to ICD-10 (1995 onwards). Although previous research has shown that change in the ICD versions may be problematic when studying trends of specific causes of death, this issue is of less concern when broader categories of causes of death are used [8].

Age at death was grouped in 10-year categories, 50-59 years, 60-69, 70-79, 80-89 and 90 or older. Alternative age specifications yielded consistent results. Marital status was categorized as married (including same-sex partnerships starting in 1989), divorced and widowed, and never married. Disposable income is defined as total income net of taxes and interest and is used as a measure of socioeconomic status. We classify disposable income in three categories, according to the distribution of the variable in each year (low, middle, and high). The final study population includes only individuals with complete information for each of the variables considered.

Analytic Strategy

The initial analysis included a description of temporal trends in the proportion of hospital deaths in the period 1980-2014 by sex, age, and causes of death. Additionally, we examined the trends of hospital deaths by length of the latest hospital stay prior to death to investigate whether the observed trends are driven by hospitalizations that occurred due to adverse health deterioration shortly before death [9]. The length of hospital stay was categorized into 1-3 days, 4-7 days, 8-28 days, and 29 days or more.

To quantify the changes in the odds of dying in a hospital over the period 1980 to 2014 and to identify the main factors that determine the probability of dying in a hospital, we performed multivariate sex-specific logistic regression models. The models include age at death

and period of death (in 5-year intervals), adjusted for marital status, disposable income, cause of death, and total number of hospitalizations in the year prior to death.

All analyses were performed separately for men and women using R, version 3.3.2 and R-studio, version 1.0.136 [10].

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Supplementary Table S2. Socio-demographic characteristics of individuals who died in hospital, N (%): 1980 – 2014 (first and second column), 1980 (third and fourth column) and 2014 (fifth and sixth column), men and women respectively. The percentages refer to all deaths in each respective category.

	All years		**1980**		**2014**	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Age						
50-59	46 976 (53)	34 508 (60)	1 686 (63)	1 194 (71)	939 (45)	684 (55)
60-69	105 170 (57)	72 585 (59)	4 003 (64)	2 353 (65)	2 344 (49)	1 671 (52)
70-79	164 200 (56)	128 120 (54)	5 708 (60)	4 071 (58)	3 433 (50)	2 555 (48)
80-89	122 157 (46)	137 552 (40)	2 898 (45)	3 185 (39)	3 196 (42)	3 251 (38)
90+	21 281 (30)	38 227 (23)	381 (27)	449 (18)	891 (32)	1 546 (24)
Civil status						
Married	276 829 (56)	126 384 (57)	9 834 (61)	4 000 (63)	5 905 (50)	2 836 (49)
Widowed/divorced	144 083 (45)	252 309 (40)	3 723 (47)	6 039 (44)	3 727 (41)	6 255 (36)
Never Married	28 872 (43)	32 299 (39)	1 119 (49)	1 213 (44)	1 171 (39)	616 (37)
Cause of Death						
Circulatory diseases	178 901 (49)	153 845 (41)	7 164 (52)	5 225 (43)	2 597 (44)	2 288 (39)
Neoplasms	155 499 (59)	136 784 (56)	4 875 (70)	4 150 (68)	3 991 (50)	3 271 (46)
Respiratory diseases	47 811 (55)	41 876 (48)	1 190 (52)	617 (36)	1 522 (58)	1 544 (54)
Mental + behavioral disorders	3 370 (16)	2 045 (7)	29 (31)	5 (4)	127 (10)	108 (6)
Nervous diseases	4 785 (31)	4 005 (22)	92 (42)	66 (35)	255 (29)	182 (17)
Others	69 418 (46)	72 437 (42)	1 326 (49)	1 189 (45)	2 311 (43)	2 314 (39)
Income						
Low	80 733 (44)	107 330 (39)	3 917 (61)	3 263 (56)	2 900 (47)	2 747 (46)
Middle	222 471 (52)	215 351 (46)	1 733 (58)	2 290 (57)	4 661 (43)	4 985 (37)
High	156 580 (54)	88 311 (47)	9 026 (54)	5 699 (44)	3 242 (46)	1 975 (38)
Total	**459 784 (51)**	**410 992 (44)**	**14 676 (56)**	**11 252 (49)**	**10 803 (44)**	**9 707 (39)**

Supplementary Analysis S3 – Sub-analysis of trends in the proportions of hospital deaths by age and sex for the two major causes of death in Denmark, Neoplasms and Circulatory diseases.

This sub-analysis investigates possible explanations for the sex- and age-specific patterns of hospital deaths from all causes shown by Figure 1, panel C.

Figure S3 shows sex specific trends in the proportion of hospital deaths for circulatory diseases and neoplasms only, the two most common causes of death in Denmark. No age- and sex-specific pattern appears for hospital deaths of individuals dying from neoplasms. However, in younger age groups, the proportion of hospital deaths due to circulatory diseases are consistently higher among women than among men. This pattern disappears at the ages 70-79 and reverses after age 80.

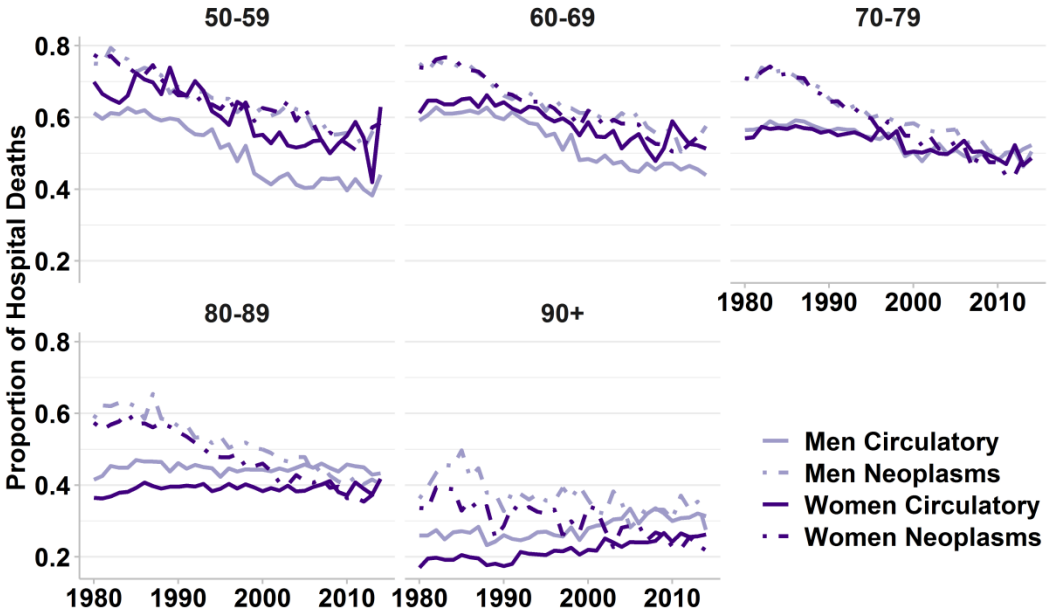

Figure S3 – Time trends (1980-2014) in the proportion of hospital deaths by age, sex and the two main causes of death in Denmark, Circulatory diseases and Neoplasms.

The higher proportion of hospital deaths among younger women dying from circulatory diseases indicates that the sex- and age-specific patterns for hospital deaths from circulatory diseases are likely to drive the sex- and age-specific patterns for hospital deaths from all causes. However, with our data we are not able to explain this gender difference among younger individuals. Although research findings of gender differences in post-myocardial infarction (MI) and post-stroke survival are inconclusive, some prior works suggest that hospital mortality due to MI [1], especially in younger women [2], and stroke case-fatalities are higher in women than in men [3]. Differences in comorbid conditions, the severity of the disease, and early treatment are suggested to account for the female disadvantage in post-MI and post-stroke mortality rates. It is also possible than more men die from circulatory diseases before they reach hospital. A register-based study in Finland found that pre-hospital case-fatality tended to be higher among men than among women [4].

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