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Regional Inequalities in Physical Aging in Denmark, 2010-2021

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Abstract

Regional health inequalities persist across high-income countries, including Denmark. Using data from The Danish National Health Survey (2010-2021) linked to Danish registry data, we examine regional disparities in physical health among adults aged 50 and older across Denmark's five regions. Physical health is measured using the Physical Component Summary (PCS) from the SF-12 questionnaire, with respondents categorized as healthy (PCS ≥35) or unhealthy (PCS <35). We apply the Sullivan method to calculate healthy life expectancy (HLE) and health ratios with confidence intervals.

Between 2010 and 2021, HLE at age 65 increased from 9.4 to 12.7 years for women and from 10.5 to 12.9 years for men, nearly closing the gender gap in absolute years of healthy life. However, men continued to spend a higher proportion of their remaining life in good health (70% versus 61% in 2021). Regional patterns revealed both convergence and persistent disparities. The Capital Region, Region Zealand, and the Region of Southern Denmark demonstrated consistent improvements throughout the study period, whilst Central Denmark Region experienced steady progress until 2017 followed by a modest decline. Most concerning, North Denmark Region consistently recorded the lowest HLE and health ratios, with both sexes falling approximately 5 percentage points below other regions by 2021. Life expectancy at age 65 increased similarly for both sexes between 2010 and 2021, reaching 21.1 years for women and 18.5 years for men, with regional values remaining relatively close except for North Denmark. The increases in health ratios indicate that improvements in healthy years outpaced gains in total life expectancy, representing compression of morbidity. However, regions with lower life expectancy did not necessarily perform worse in HLE, revealing complex relationships between mortality and morbidity. These findings highlight the need for targeted health policies to address persistent regional inequalities, particularly in North Jutland, to ensure more equitable healthy ageing outcomes across Denmark.

Introduction

As in many high-income countries, more people in Denmark are reaching older ages than ever before. However, it remains unclear whether the additional years lived are in good or poor health, specifically, whether these additional years are characterized by an expansion or compression of physical disability (Fries, 1980; Gruenberg, 1977; Manton, 1982; Olshansky et al., 1991). Despite extensive research on the topic, findings remain mixed, varying by country, age group, and the specific disability indicators used (Robine et al., 2020). Physical functioning is a crucial aspect of individual well-being, as it reflects an individual's ability to engage with their environment and maintain independence (Bergeron-Boucher et al., 2025). Understanding trends in physical disability is therefore essential for evaluating population health and planning interventions aimed at improving the quality of aging.

Denmark, while also experiencing significant population aging, lags behind other high-income countries in terms of life expectancy. This makes it a particularly interesting case for studying how physical disability evolves in older adults. Recent research has primarily focused on the persistent social gradient in disability-free life expectancy (e.g., Brønnum-Hansen et al., 2019, 2021), leaving trends in the onset and progression of physical disability less explored in more recent years. A study examining the first decade of the 2000s showed improvements in disability-free life expectancy in Denmark (Jeune et al., 2015), but a more recent study, using data up to 2015, suggested that these improvements slowed after 2010 (Brønnum-Hansen et al., 2024).

Beyond national trends, there is growing evidence of substantial regional variation in health and mortality outcomes across high income countries including Denmark (Sauerberg et al., 2024). The Danish National Health Survey 2021 report (Sundhedsstyrelsen, 2022) documented considerable geographical differences in physical health, with the Capital Region generally showing better health profiles whilst North Jutland consistently reported poorer outcomes. However, examining prevalence alone provides an incomplete picture of regional health inequalities, as it does not account for differences in mortality rates across regions. A region with lower disability prevalence but higher mortality may ultimately offer fewer years of healthy life than a region with higher prevalence but lower mortality. Healthy life expectancy, which combines both health and mortality information, offers a comprehensive measure of population health essential to assess the magnitude of regional disparities in physical ageing. Like life expectancy, this summary indicator is standardized

for population age structure, allowing for direct comparisons across regions regardless of differences in their age compositions.

The aim of this study is to provide new insights into trends in physical aging among older adults in Denmark, and to examine regional inequalities in healthy life expectancy. Specifically, we seek to understand how the healthy aging process has evolved differently across Denmark's five main regions and between men and women over the past decade. Using data from The Danish National Health Survey, a large national health survey linked to Danish registry data, we analyzed trends in the prevalence of good physical health and healthy life expectancy among individuals aged 50 and older between 2010 and 2021. By applying the Sullivan method to combine health survey data with official mortality statistics, we assessed whether improvements in physical health occurred uniformly across regions and genders or whether geographical and gender disparities persisted, narrowed, or widened over the study period. The findings offer policy-relevant insights into the patterns of recent healthy aging and their inequalities. By identifying regions facing persistent disadvantage (net of differences in age and sex composition), the study can help prioritize where interventions may be needed first, while regions with favorable outcomes may offer best practices that could be replicated elsewhere to reduce inequalities in healthy aging across Denmark.

Data and Methods

We used two complementary data sources for our analysis. Health data came from the Danish National Health Survey (DNHS) in 2010, 2013, 2017, and 2021. The DNHS is a comprehensive cross-sectional survey based on five regional stratified random samples and one national random sample drawn from the Danish Civil Registration System (Christensen et al., 2022). Sundhedsprofil includes detailed information on physical health and functioning across a large, nationally representative sample of the Danish adult population. We selected all respondents aged 50 and older for our study population.

Physical functioning was measured using responses from the SF-12 questionnaire, summarized in the Physical Component Summary (PCS) indicator, which assessed limitations in daily activities due to physical health (Ware et al., 1996). As a questionnaire-based measure, the PCS is a self-reported indicator of physical health. The indicator ranged from 0 to 100, with higher scores indicating better physical health. We categorized respondents into two levels: 1) those who scored 35 or above (healthy), and 2) those who scored below 35 (unhealthy). This threshold, used in the Danish National Health Survey 2021

report, distinguished the lowest 10% of the PCS distribution from the rest of the population in 2010 (Sundhedsstyrelsen, 2022).

For each survey year, we aggregated Danish registry data to compute life tables by sex and region, using five-year age groups with an open age interval at 85+. We considered Denmark's five main regions: the Capital Region, Zealand, Southern Denmark, Central Jutland, and North Jutland. We then computed healthy life expectancy at age 65 by year, sex, and region using the Sullivan method, which weights person-years lived at each age by the corresponding health prevalence calculated from the survey data (Sullivan, 1971). Additionally, we calculated the health ratio (HR) as the ratio between healthy life expectancy and total life expectancy, providing a measure of the proportion of remaining life expected to be spent in good health. We computed confidence intervals for both healthy life expectancy and the health ratio to account for uncertainty due to the sample size of the health estimates.

Results

Figure 1 presents the prevalence of good physical health by age, sex, and region over the study period. In panel a, we observed that both women and men experienced improvements in the prevalence of good physical health over time. Whilst men remained healthier than women, the latter showed the greatest improvement between 2010 and 2021. The gender gap in good physical health was therefore reduced, with the largest differences remaining at the oldest ages. For instance, in 2021, approximately 51% and 33% of women reported good physical health at ages 80–84 and 85+ respectively, compared with approximately 62% and 46% for men. We observed the greatest improvements for both sexes at older ages: 65 to 84 for women and 70 to 84 for men. Panel b presents the regional prevalence trends. Whilst all regions followed the age-specific improvements in physical health, there was heterogeneity in the magnitude of improvement across Denmark's regions. The Capital Region, Zealand, and Southern Denmark experienced substantial improvements in physical health, whilst Central Jutland and North Jutland experienced considerably less improvement over the study period.

Figure 2 presents life expectancy (LE) at age 65 by sex and region in Denmark across the study period. Denmark experienced similar gains in LE for both sexes between 2010 and 2021, with women and men reaching 21.1 and 18.5 years respectively by 2021. Regional patterns in LE trajectories revealed notable heterogeneity, though values remained relatively

close across most regions, with the exception of North Jutland. The Capital Region showed improvements until 2017, but experienced a decline in 2021, with LE falling to 21.0 years for women and 18.6 years for men. Southern Denmark followed a similar pattern, recording gains through 2017 before deteriorating in the final observation year. In contrast, Central Jutland demonstrated steady improvements across the entire study period, achieving LE values of 21.2 years for women and 18.4 years for men by 2021. North Jutland and Zealand exhibited more modest progress after 2013. In Zealand, the timing of improvements differed by sex: women experienced their greatest gains between 2010 and 2013, while men saw the most substantial increases between 2013 and 2017. North Jutland remained the region with the most limited advancement, with LE persistently lower than other regions at 20.6 years for women and 18.0 years for men in 2021.

Figure 3 presents healthy life expectancy (HLE) at age 65 by sex and region in Denmark for the four years under analysis. Overall, HLE increased for both women and men between 2010 and 2021, rising from 9.4 and 10.5 years respectively to 12.7 and 12.9 years. The gender gap in years spent in good physical health nearly closed due to sharper improvements for women. Whilst the improvement in HLE was steady for Denmark as a whole, we observed regional differences in HLE trends. Following the patterns described for prevalence, the Capital Region, Zealand, and Southern Denmark experienced improvements in HLE. However, whilst the Capital Region showed the steadiest improvement over the study period, the other two regions experienced their greatest improvements in the final year of analysis. For all three regions, HLE reached around or above 13 years for both sexes, approaching nearly 14 years in Zealand for men. Central Jutland had the highest HLE of all regions for both men and women in 2010, and whilst it continued improving steadily until 2017, it experienced a slight decline in 2021. North Jutland was the region with the lowest HLE in 2021, remaining below 12 years for both men and women: we observed improvement in 2013 but no further progress, or even a slight decline, thereafter.

Figure 1. Health prevalence by age and sex with values annotated (panel a) and by age, sex, and region (panel b). Years 2010-2021

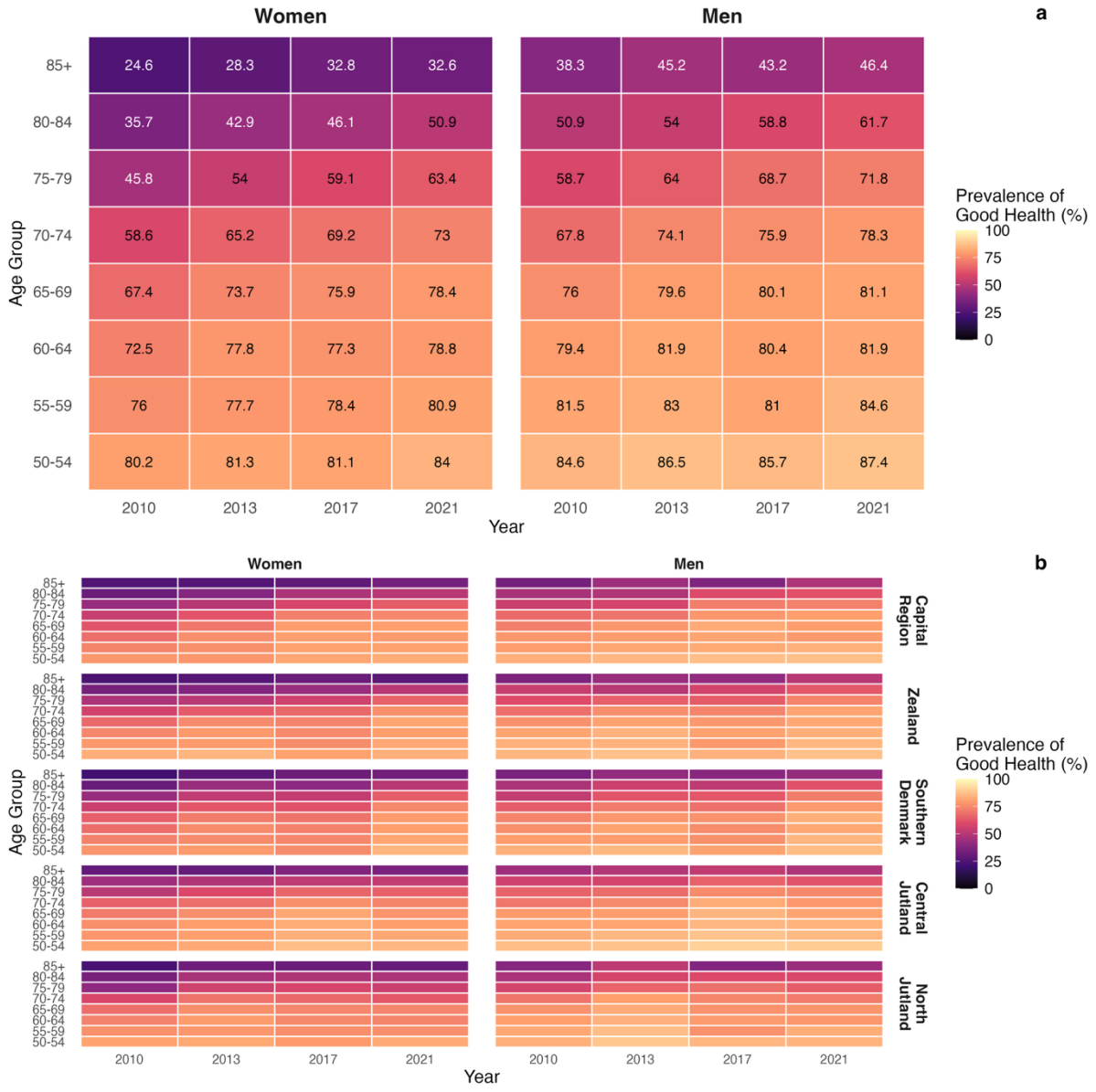


Figure 2. Life expectancy (LE) at age 65 by sex and region. Years 2010-2021

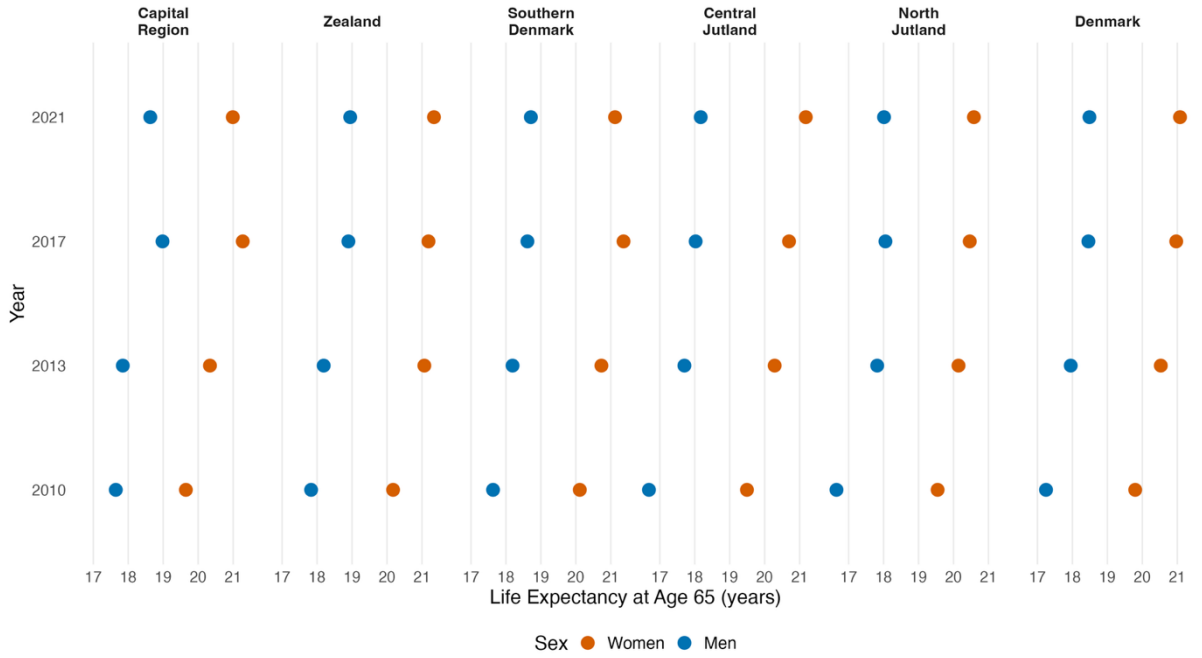


Figure 3. Healthy life expectancy (HLE) at age 65 by sex and region. Years 2010-2021

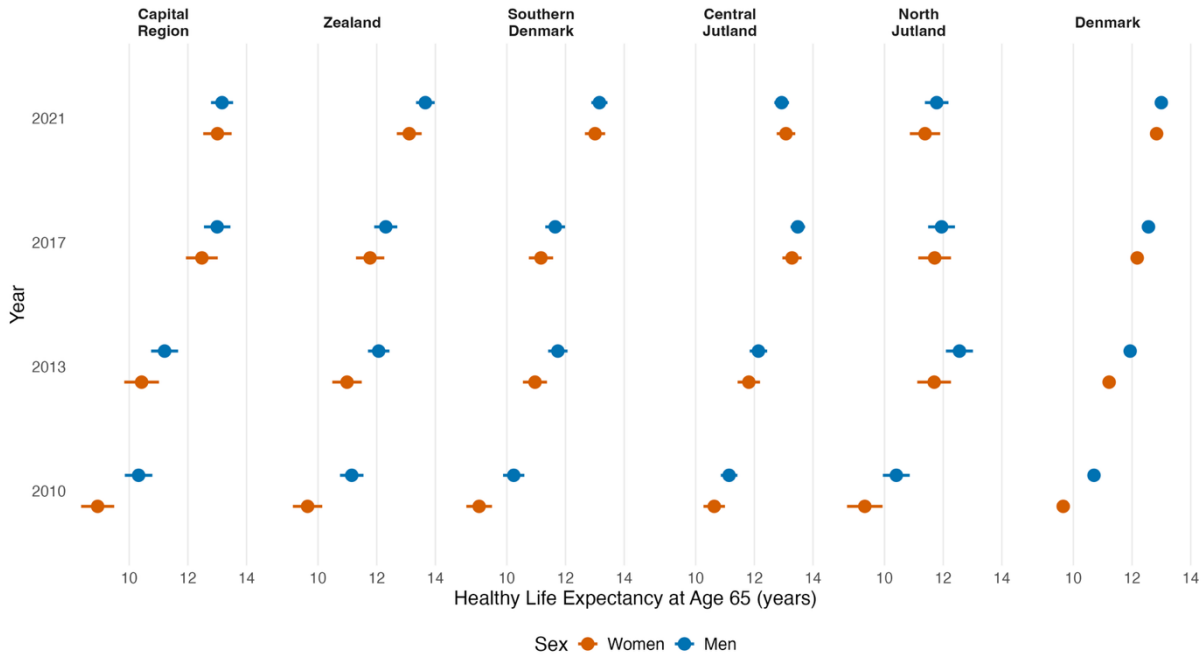
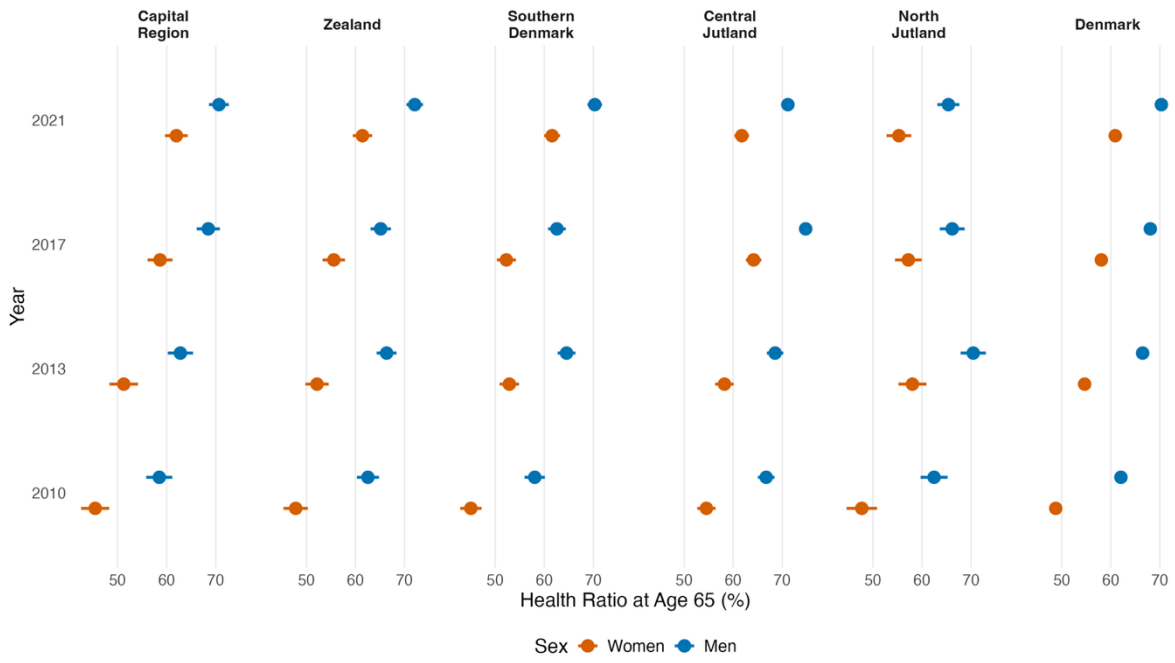


Figure 4 displays the health ratio (HR) at age 65 across Denmark's regions by sex for the four years under analysis. Between 2010 and 2021, HR improved for both sexes nationally, increasing from 49% to 61% for women and from 62% to 70% for men. Unlike the patterns observed for HLE, a notable gender gap in the proportion of remaining life spent in good physical health persisted, with men consistently spending a higher proportion of their lives in

good health than women. Regional variation in HR trajectories was evident throughout the study period. The Capital Region, Zealand, and Southern Denmark all showed upward trends in HR, mirroring the patterns observed for prevalence and HLE. The Capital Region and Zealand demonstrated consistent improvement across all four time points, whereas Southern Denmark saw particularly marked gains in 2021. In these three regions, HRs are close to the country levels. Central Jutland began the study period with the highest HR values for both sexes but, after steady increases through 2017, experienced a modest downturn in 2021, yet HRs are in line with the country level. North Jutland consistently recorded the lowest HR values, with both sexes falling 5% points below the other regions for both sexes in 2021. Whilst this region showed some improvement in 2013, subsequent years brought stagnation or slight reduction in the proportion of healthy years lived.

Figure 4. Health ratio (HR) at age 65 by sex and region. Years 2010-2021



Discussion

Our analysis of regional inequalities in physical aging across Denmark between 2010 and 2021 reveals several important findings that contribute to understanding healthy aging patterns in high-income countries. Using data from the DNHS linked to Danish registry data, we found a general improvement in healthy life expectancy at age 65 across all Danish regions during this period, contrary to recent findings by Brønnum-Hansen et al. (2024). This

divergence likely stems from the use of different underlying health indicators rather than other methodological differences (Robine et al., 2020). While our study employs the SF-12 Physical Component Summary to assess physical functioning, the Brønnum-Hansen study uses the Global Activity Limitation Indicator (GALI) from SHARE, which captures a broader dimension of activity limitations. Furthermore, our study draws on large, nationally representative cross-sectional data from DNHS, while the Brønnum-Hansen study relies on relatively small samples from SHARE. The comprehensive coverage and larger sample sizes in DNHS may provide more robust estimates of health prevalence, particularly at the regional level, which could explain the more optimistic trajectory we observe.

Notably, we observed a near-closure of the sex gap in HLE, driven by the sharper improvements in health among women, since we observed comparable improvements in life expectancy across genders. Between 2010 and 2021, women's HLE at age 65 increased from 9.4 to 12.7 years, while men's increased from 10.5 to 12.9 years. However, despite this convergence in absolute years of healthy life, men continue to spend a higher proportion of their remaining years in good physical health compared to women, as evidenced by the persistent gap in health ratios (70% for men versus 61% for women in 2021). This pattern reflects women's persistent advantage in total life expectancy combined with their higher prevalence of physical limitations, consistent with the well-documented paradox of women living longer but in poorer health (Oksuzyan et al., 2008; Van Oyen et al., 2013). It is worth noting that some of these sex differences may be influenced by differential reporting patterns, as women are often more likely than men to report health problems at similar underlying levels of health (Golini & Egidi, 2016).

Regional patterns reveal both encouraging convergence and persistent disparities. The Capital Region, Zealand, and Southern Denmark demonstrated consistent improvements in both Healthy Life Expectancy (HLE) and health ratios throughout the study period, with particularly marked gains in Southern Denmark in 2021. The increase in health ratios indicates that improvements in healthy years outpaced gains in total life expectancy in these regions—a pattern consistent with compression of morbidity. This reflects the critical interplay between longevity and health: even when both HLE and life expectancy increase, it is the relative pace of improvement that determines whether the proportion of life spent in good health is expanding or contracting (Kreft & Doblhammer, 2016). However, the favorable compression pattern observed in these leading regions must be considered alongside the overall modest improvements in life expectancy. While life expectancy

increased similarly for both sexes between 2010 and 2021, reaching 21.1 years for women and 18.5 years for men, regional variation in life expectancy trajectories showed notable heterogeneity. Some regions, including the Capital Region and Southern Denmark, experienced improvements until 2017 followed by declines in 2021, while Central Jutland demonstrated steady gains throughout the period. This suggests that the compression of morbidity observed in certain regions occurred against a backdrop of fluctuating mortality patterns, with health improvements sometimes outpacing longevity gains due to stagnating or declining life expectancy rather than solely through reduced morbidity. The divergent life expectancy trajectories—with values remaining relatively close across most regions except North Jutland—indicate that regional disparities in healthy aging are driven more by differences in health status than by mortality differentials alone. Notably, Zealand's strong performance represents a departure from the broader regional mortality patterns documented in Denmark, particularly given that the region includes Lolland-Falster in its southern and western areas—identified as the most disadvantaged area in the country with life expectancy almost six years lower than wealthy capital suburbs (Holmager et al., 2021). Central Jutland presents a unique trajectory: despite starting with the highest health ratios in 2010 and maintaining steady improvements through 2017, the region experienced a modest downturn in 2021, though its health outcomes remained aligned with national averages. Most concerning is the persistent disadvantage observed in North Jutland, which consistently recorded the lowest HLE and health ratio values across all time points. The mechanisms underlying these regional disparities likely reflect multiple factors, including differences in healthcare service delivery across Denmark's five administrative regions, socioeconomic composition, and health-related behaviors. Denmark's regions have substantial autonomy in healthcare administration, which may lead to variations in preventive care, treatment protocols, and resource allocation. Additionally, regional differences in industrial structure, employment patterns, and historical economic trajectories may contribute to the health disadvantages observed in areas like North Jutland, which has experienced industrial decline and population out-migration. Previous research has documented substantial socioeconomic inequalities in all-cause mortality among Northern Jutland residents (Ullits et al., 2015), which might be one of the explanations for the region to be lagging behind. By 2021, both men and women in North Jutland fell approximately 5 percentage points below other regions in the proportion of life spent in good health. While this region showed some improvement in 2013, subsequent years brought stagnation or slight declines, suggesting that national improvements in physical health have not reached all regions equally. These findings

underscore the need for targeted health policies to address the specific challenges facing North Jutland and ensure more equitable healthy aging outcomes across Denmark.

Our findings should be interpreted in light of several limitations. The Sullivan method is widely used due to its simplicity and good performance in assessing trends when mortality and health conditions are relatively stable over time (Mathers & Robine, 1997). However, as a prevalence-based approach, it assumes that current health and mortality conditions persist. It cannot capture cohort effects or dynamic transitions between health states over the life course. Additionally, our choice of the PCS cutoff point at 35, while aligned with the DNHS 2021 report methodology (Sundhedsstyrelsen, 2022), represents a somewhat arbitrary threshold distinguishing the lowest 10% of the population. However, sensitivity analyses using an alternative cutoff of 40 yielded consistent patterns, suggesting our main conclusions are robust to this methodological choice. Future research employing longitudinal data and multistate life table methods could provide deeper insights into the dynamics of physical health transitions and their relationship with mortality risks across Danish regions.

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