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Changes in hospitalisation and surgical procedures among the oldest-old: a follow-up study of the entire Danish 1895 and 1905 cohorts from ages 85 to 99 years

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Abstract

Objective: to examine whether the Danish 1905 cohort members had more active hospital treatment than the 1895 cohort members from ages 85 to 99 years and whether it results in higher in-hospital and post-operative mortality.
Methods: in the present register-based follow-up study the complete Danish birth cohorts born in 1895 ($n = 12{,}326$) and 1905 ($n = 15{,}477$) alive and residing in Denmark at the age of 85 were followed from ages 85 to 99 years with regard to hospitalisations and all-cause and cause-specific surgical procedures, as well as in-hospital and post-operative mortality.
Results: the 1905 cohort members had more frequent hospital admissions and operations, but they had a shorter length of hospital stay than the 1895 cohort at all ages from 85 to 99 years. The increase in primary prosthetic replacements of hip joint was observed even within the 1895 cohort: no patients were operated at ages 85–89 years versus 2.2–3.6% at ages 95–99 years. Despite increased hospitalisation and operation rates, there was no increase in post-operative and in-hospital mortality rates in the 1905 cohort. These patterns were similar among men and women.
Conclusions: the observed patterns are compatible with more active treatment of the recent cohorts of old-aged persons and reduced age inequalities in the Danish healthcare system. No increase in post-operative mortality suggests that the selection of older patients eligible for a surgical treatment is likely to be based on the health status of old-aged persons and the safety of surgical procedures rather than chronological age.

Keywords: *cohort comparison, hospitalisation, surgical procedure, old age, post-operative mortality, in-hospital mortality, register study, Denmark, older people*

Background

Since the 1950s most developed countries have experienced substantial improvements in old-age survival resulting in a growing proportion of elderly individuals [1–5]. The probability of survival from age 80 to 90 years has almost doubled from 1950 to 2002 for both men and women in most developed countries. Population forecasts suggest that in low-mortality countries most babies born since 2000 will live to 100 years assuming the pace of life expectancy improvements over the twentieth century continues through the twenty-first century [4].

The picture is more complex with regard to health trends in the elderly populations [6–9]. A recent review paper suggests that generally people younger than 85 years enjoy longer lives and have less limitations in daily activities [4], although increasing trends have been observed for some diseases and symptoms [4, 6]. However, current evidence about health trends in the populations over 85 years is limited and contradictory. Some data show an increase in disability levels over cohorts [10], whereas other studies suggest that the postponement of mortality does not result in an increasing proportion of disabled and cognitively impaired individuals [11–13].

Possibly, the more active surgical treatment of the old-aged population has partially contributed to better survival and a growing number of very old individuals observed since 1950s in developed countries. The present study was conducted to investigate changes in hospital treatment of the Danish older population by comparing hospitalisation patterns and surgical procedures for the entire Danish 1895 and 1905 cohort members from ages 85 to 99 years. We expected to see a higher frequency of hospitalisation and surgical procedures in the 1905 cohort than in the 1895 cohort at ages 85–99 years, which could be due to reduced age inequalities for surgical treatment, better health at old ages in more recent cohorts, and improved anaesthetic and surgical procedures enabling more operations among older persons. The study also investigated whether more active treatment of old-aged persons resulted in higher in-hospital mortality and post-operative mortality.

Methods

In the present register-based study, all individuals born in 1895 ($n = 12{,}326$) and 1905 ($n = 15{,}477$), alive and residing in Denmark at the age of 85 were followed from ages 85 to 99 years with regard to hospitalisations and surgical procedures, as well as in-hospital and post-operative mortality. The study utilised data from the Central Personal Register (CPR, since 1968), Danish Demographic Database (since 1968), the Danish National Patient Register (NPR, since 1977) and the Building and Residence Register (since 1981) and the National Cause of Death Register (since 1943). The linkage across different registers was done using a unique 10-digit identifier, CPR number.

Hospitalisation was assessed as the percentage of persons hospitalised at least once within a 5-year period. The mean annual length of hospital stay (LOS) was estimated as the average of the total number of days within the 5-year period. The percentage of individuals operated annually for each cohort was calculated for all-cause and selected specific surgical procedures.

To investigate how changes in hospitalisations and surgical procedures are reflected in post-operative and in-hospital mortality, we estimated the percentage of individuals deceased within 30 days after surgery among all operated irrespective of place of death and the percentage of persons dying in the hospital in the total sample independent of LOS, respectively. Sub-analyses were performed for home-dwellers, persons living at their own homes during the whole observation period.

Prior studies have shown that the Danish registers are reliable and valid source of information for research purposes with no linkage problems among registers [14]. Since private sector in Denmark was introduced in the 2000s and only 5% of surgical procedures, largely accounted by services paid by private insurance companies or private persons, were missing from the NPR in 2008 [15], the completeness of NPR in terms of state-paid and privately paid hospital services should be of minor concern in the present study. Please see more details in the Supplementary data available in *Age and Ageing* online, Appendix 1.

Results

The study population included 12,326 individuals (7,853 women, 64%) born in 1895 and 15,477 persons (10,352 women, 67%) born in 1905 and alive at age 85. Analysis of hospitalisation showed that the percent of hospitalised persons was consistently higher in the 1905 cohort compared with the 1895 cohort in all age groups (Table 1). The size of the difference varied from 2.0% (95% CI: −0.3, 7.3) to 17.2% (95% CI: 10.3, 24.0) among men and from 4.2% (95% CI: 1.9, 6.6) to 13.1% (95% CI: 9.1, 17.0) among women. Although these patterns were similar in both genders, men were hospitalised more often than the same-aged women prior to death in both cohorts (diagonals in Table 1).

Despite a higher frequency of hospitalisation, the 1905 cohort members had shorter LOS than their counterparts from the 1895 cohort in all age groups (Table 1). The 1905 cohort members shorter LOS compared with the same-sex counterparts from 1895 cohort ranging from 1.6 days (95% CI: 0.3; 3.4) to 3.6 (95% CI: 2.2, 5.1) among men and from 1.9 days (95% CI: 0.9, 2.9) to 5.3 (95% CI: 3.5, 7.1) among women. There was a tendency towards longer hospital stay among women compared with the same-aged men in both cohorts. All patterns remained unchanged when the mean LOS was estimated in the total samples including non-hospitalised persons and when the analysis was performed using the median LOS (results not shown).

The percentage of individuals with surgical procedures was consistently higher among 1905 cohort members than in the 1895 cohort at all ages (Table 1). The absolute increase in the proportion of operated men in the 1905 cohort versus 1895 cohort men was ranging from 7.3% (95% CI: 3.7, 10.8) to 18.5% (95% CI: 12.0, 25.0), whereas the increase in the female samples was ranging from 8.2% (95% CI: 6.2, 10.2) to 14.4% (95% CI: 10.5, 18.4). The frequencies of surgical procedures and their difference between the two cohorts were similar in both sexes.

Despite substantial increase in hospitalisation rates, in-hospital mortality was similar in the 1895 and 1905 cohort men and women (Table 2). Although in-hospital mortality among 95–99 years old men born in 1905 was by 5.7% higher than among same-aged men from 1895 cohort, the difference was not statistically significant. Within each cohort more men died in the hospital compared with women at all ages. Post-operative mortality for all-cause surgical procedures

Table 1. Frequency of hospitalisations and surgical procedures and length of hospital stay by age at hospitalisation and age at death in the Danish 1895 and 1905 cohorts

Age at death	Age at hospitalisation							
	n total	85–89, % (*n*)	90–94, % (*n*)	95–99, % (*n*)	*n* total	85–89, % (*n*)	90–94, % (*n*)	95–99, % (*n*)
Number and percent of hospitalised								
1895 cohort men (*n* = 4,473)					1905 cohort men (*n* = 5,125)			
85–89	2,765	76.6 (2,119)			3,196	81.9 (2,618)		
90–94	1,346	60.8 (818)	71.0 (956)		1,533	64.4 (987)	73.0 (1,119)	
95–99	362	42.3 (153)	59.9 (217)	52.8 (191)	396	53.8 (213)	64.1 (254)	69.9 (277)
1895 cohort women (*n* = 7,853)					1905 cohort women (*n* = 10,352)			
85–89	4,129	74.1 (3,059)			5,240	78.8 (4,127)		
90–94	2,710	62.4 (1,692)	63.7 (1,726)		3,690	66.7 (2,460)	68.5 (2,528)	
95–99	1,014	48.1 (488)	63.5 (644)	50.8 (515)	1,422	55.7 (792)	67.0 (953)	63.9 (908)
Age at death	Age at hospitalisation							
	n total	85–89 Mean (SE)	90–94 Mean (SE)	95–99 Mean (SE)	*n* total	85–89 Mean (SE)	90–94 Mean (SE)	95–99 Mean (SE)
Length of hospital stay								
1895 cohort men (*n* = 4,473)					1905 cohort men (*n* = 5,125)			
85–89	2,765	0.5 (16.2)			3,196	0.3 (13.0)		
90–94	1,346	0.4 (8.3)	0.6 (14.0)		1,533	0.3 (6.3)	0.5 (10.4)	
95–99	362	0.6 (5.8)	0.6 (7.1)	0.8 (8.4)	396	0.3 (3.5)	0.3 (4.2)	0.5 (6.8)
1895 cohort women (*n* = 7,853)					1905 cohort women (*n* = 10,352)			
85–89	4,129	0.5 (18.4)			5,240	0.3 (15.2)		
90–94	2,710	0.4 (12.1)	0.5 (14.5)		3,690	0.2 (8.3)	0.3 (10.3)	
95–99	1,014	0.4 (7.7)	0.4 (9.4)	0.8 (12.9)	1,422	0.3 (5.8)	0.3 (6.2)	0.4 (7.5)
Age at death	Age at operation							
	n total	85–89, % (*n*)	90–94, % (*n*)	95–99, % (*n*)	*n* total	85–89, % (*n*)	90–94, % (*n*)	95–99, % (*n*)
Number and percent with surgical procedures								
1895 cohort men (*n* = 4,473)					1905 cohort men (*n* = 5,125)			
85–89	2,765	34.6 (958)			3,196	42.6 (1,360)		
90–94	1,346	35.5 (478)	32.3 (435)		1,533	40.8 (626)	35.2 (540)	
95–99	362	22.9 (83)	35.9 (130)	25.7 (93)	396	38.4 (152)	39.1 (155)	29.3 (116)
1895 cohort women (*n* = 7,853)					1905 cohort women (n = 10,352)			
85–89	4,129	34.4 (1,422)			5,240	42.2 (2,209)		
90–94	2,710	34.1 (923)	30.4 (825)		3,690	40.9 (1,511)	32.8 (1,211)	
95–99	1,014	26.4 (268)	34.2 (347)	24.7 (250)	1,422	34.8 (495)	36.9 (525)	27.5 (391)

Table 2. In-hospital mortality[a] in the Danish 1895 and 1905 cohorts

Age at death	Men					Women					M:F ratio
	n total	*n* hosp.	% hosp.	*n* died	% died	*n* total	*n* hosp.	% hosp.	*n* died	% died	
1895 cohort											
85–89	2,765	2,119	76.6	1,170	42.3	4,129	3,059	74.1	1,482	35.9	1.18
90–94	1,346	956	71.0	423	31.4	2,710	1,726	63.7	644	23.8	1.32
95–99	362	191	52.8	68	18.8	1,014	515	50.8	155	15.3	1.23
Total	4,473	3,266	73.0	1,661	37.1	7,853	5,300	67.5	2,281	29.0	1.28
1905 cohort											
85–89	3,196	2,618	81.9	1,365	42.7	5,240	4,127	78.8	1,904	36.3	1.18
90–94	1,533	1,119	73.0	453	29.5	3,690	2,528	68.5	909	24.6	1.20
95–99	396	277	69.9	97	24.5	1,422	908	63.9	254	17.9	1.37
Total	5,125	4,014	78.3	1,915	37.4	10,352	7,563	73.1	3,067	29.6	1.26

[a]In-hospital mortality indicates the percent of elderly who died in the hospital irrespective of length of hospital stay in the total sample.

was also similar in the 1895 and 1905 cohorts (Table 3) and in both genders.

Additional analysis of all-cause surgical procedures excluding transluminal endoscopies and cause-specific operations showed the same patterns (Supplementary data are available in *Age and Ageing* online, Appendix 2). The 1905 cohort men and women underwent more frequently operations on lens, primary prosthetic replacements of hip joint and transluminal endoscopies compared with the same-sex counterparts in the 1895 cohort at all ages (Supplementary data are available in *Age and Ageing* online, Appendix 2). Remarkably, the increase in primary prosthetic replacements of hip joint was observed even within the 1895 cohort: no patients from this cohort were operated at ages

Table 3. Post-operative mortality[a] with and without transluminal endoscopic procedures in the Danish 1895 and 1905 cohorts

Age at death	*n* total	Operated, % (*n*)	Died, % (*n*)	*n* total	Operated, % (*n*)	Died, % (*n*)	M:F ratio
All surgical procedures							
1895 cohort men				1895 cohort women			
85–89	2,765	34.6 (958)	24.4 (234)	4,129	34.4 (1,422)	26.4 (376)	0.92
90–94	1,346	35.5 (478)	22.6 (108)	2,710	34.1 (923)	19.9 (184)	1.13
95–99	362	22.9 (83)	20.5 (17)	1,014	26.4 (268)	22.0 (59)	0.93
Total	4,473	34.0 (1,519)	23.6 (359)	7,853	33.3 (2,613)	23.7 (619)	1.00
1905 cohort men				1905 cohort women			
85–89	3,196	42.6 (1,360)	22.9 (312)	5,240	42.2 (2,209)	23.0 (509)	1.00
90–94	1,533	40.8 (626)	23.5 (147)	3,690	40.9 (1,511)	20.2 (305)	1.16
95–99	396	38.4 (152)	23.7 (36)	1,422	34.8 (495)	19.0 (94)	1.25
Total	5,125	41.7 (2,138)	23.2 (495)	10,352	40.7 (4,215)	21.5 (908)	1.07
All surgical procedures except endoscopies							
1895 cohort men				1895 cohort women			
85–89	2,765	30.2 (834)	26.1 (218)	4,129	31.6 (1,305)	26.1 (340)	1.00
90–94	1,346	28.2 (380)	24.5 (93)	2,710	28.6 (774)	22.6 (175)	1.08
95–99	362	23.2 (84)	20.2 (17)	1,014	23.6 (239)	23.4 (56)	0.86
Total	4,473	29.0 (1,298)	25.3 (328)	7,853	29.5 (2,318)	24.6 (571)	1.03
1905 cohort men				1905 cohort women			
85–89	3,196	36.1 (1,154)	23.5 (271)	5,240	38.2 (2,001)	23.4 (469)	1.00
90–94	1,533	30.0 (460)	28.7 (132)	3,690	27.8 (1,026)	24.8 (254)	1.16
95–99	396	24.7 (98)	34.7 (34)	1,422	23.8 (338)	26.0 (88)	1.33
Total	5,125	33.4 (1,712)	25.5 (437)	10,352	32.5 (3,365)	24.1 (811)	1.06

[a]Post-operative mortality indicates the percent of elderly with surgical procedures who died within 30 days after surgery.

85–89 years, whereas 2.2% of men and 3.6% of women born in 1895 underwent hip replacements at ages 95–99 years. The frequency of primary hip replacements was higher among women than among men in the 1905 cohort.

Further, as in the total sample, the frequencies of hospitalisations and surgical procedures were higher (Supplementary data are available in *Age and Ageing* online, Appendix 3), and the LOS was shorter in the 1905 than in 1895 cohort at all ages among home-dwellers. Post-operative mortality among home-dwellers was also similar in the two cohorts. The percentage of people living at home from ages 86 until 99 years or until death was higher in the 1905 than in the 1895 cohort, for both men and women.

To investigate changes in the proportion of survivors to the oldest ages over the cohorts, we estimated percent survivors from ages 75–79 years to age 100+ years for each sex separately (Supplementary data are available in *Age and Ageing* online, Appendix 4). Survival was consistently better among women from the 1905 cohort than among their female counterparts from the 1895 cohort, but there were no survival improvements among men from the 1905 cohort compared with men born in 1895 from ages 75–79 to 100+ years.

To investigate whether sex differences in smoking prevalence in these cohorts could explain different patterns of sex-specific survival trajectories over the cohorts, lung cancer death rates were estimated. Lung cancer death rates were higher among men than among women in both cohorts and increased from the 1895 cohort to the 1905 cohort at all ages. The cohort difference was small before age 65 among women, increased at the ages 70–80 years, and declined afterwards (Supplementary data are available in *Age and Ageing* online, Appendix 5). Both relative and absolute increases in lung cancer mortality rates over the two cohorts were higher among men than among women (Supplementary data are available in *Age and Ageing* online, Appendixes 5 and 6).

Discussion

The present study revealed that the proportion of hospitalised persons and the proportion of individuals treated surgically were higher and the LOS was shorter in the 1905 cohort than in the 1895 cohort at all ages from 85 to 99 years. Despite increased hospitalisation rates, the proportion of a cohort dying in the hospital and the proportion of old-aged dying after surgical treatment within the same age interval remained unchanged. These patterns were similar among men and women, although men had higher in-hospital mortality rates than the same-aged women in both cohorts.

The patterns of more hospitalisations and surgical procedures in the 1905 cohort than in the 1895 cohort are compatible with active hospital treatment of old-aged people and reduced age inequalities for surgical treatment in the Danish healthcare system in recent years. These changes are likely to be due to improved health of recent cohorts of old-aged persons [11, 12], development of better anaesthetic and surgical procedures that make it possible to perform more operations among old people, and reorganisation of the Danish healthcare system facilitating earlier discharge from hospital and shortening of LOS [16]. Improved homecare and institutional care provided by Danish municipalities can also contribute to the explanation of a shorter LOS in the 1905 cohort than in the 1895 cohort. Furthermore, in many countries hospitals are a common place to die among old-aged people. However, our study found similar in-hospital mortality rates in the 1895 and 1905 cohorts despite increased hospitalisations in the recent cohort. It suggests that the admission to the hospital to die is unlikely to explain increased hospitalisation rates in the 1905 cohort. Advances in medical research and technology have made it possible to perform more safely complicated surgical procedures in the oldest populations. The major question to be considered by medical communities and individuals is whether treating very old persons more actively is beneficial? Data on post-operative and overall survival, functional status and other health outcomes after surgical treatment of very old patients are still sparse and conflicting [17, 18]. Some research studies have demonstrated that open-heart surgeries and hip arthroplasty can be safely performed on oldest-old persons [19–22]. Mandawat *et al.* found that hospitalisation among the US centenarians increased by 18% over a 5-year period with almost 90% survival suggesting that hospital treatment may be beneficial even for the oldest-old [23]. Nevertheless, advanced age was found to be associated with lower odds of surgical treatment among cancer patients and lower referral rates from primary to secondary care for some diseases and conditions [24, 25]. This insufficient evidence can be due to the exclusion of old-aged persons from clinical trials, prejudiced attitudes towards old-aged as frail, and patient preferences for low-risk treatments [26, 27]. Our findings of similar post-operative mortality in the 1895 and 1905 cohorts, despite increased proportion of operated persons over time, suggest that patients are found eligible to undergo a surgical treatment based on their health status and safety of surgical procedures rather than on chronological age.

The present study also showed that survival improvements over these two cohorts at ages 75–99 years were observed in the female population, whereas no survival progress was seen for men. No survival improvements in the 1905 cohort men compared with their counterparts born in 1895 are not surprising considering the evolution of death rates in Denmark during the twentieth century [28]. There were no improvements in old-age male mortality from 1950 to 1980, whereas the female mortality continued to decline. Little improvements were seen in both genders from 1980 to 1995 and only from 1995 have death rates at older ages declined steadily until present [28].

Since the World Wars did not affect mortality in Denmark to a notable degree, the major historical events cannot explain no survival improvements among men. Another possible explanation for sex-specific survival trajectories over time may be differences in smoking behaviour. Since the data on secular trends in smoking behaviour in these cohorts are unavailable, sex-specific lung cancer death rates were estimated. The comparison of lung cancer mortality rates in the 1890–1899 and 1900–1909 cohorts from ages 50 to 90+ years showed that they increased over time in both genders, but the increase was much higher among men than among women. These findings suggest that smoking may partially explain no survival progress at old ages in the 1905 male cohort compared with the 1895 cohort men. The finding that men had substantially higher lung cancer mortality rates than the same-aged women in all cohorts is in agreement with previous studies on sex differences in smoking behaviour in Denmark from the 1950s [29, 30].

A major strength of this study is the size and completeness of the Danish register data and its longitudinal nature which enabled us to compare hospitalisation patterns in the complete cohorts of Danes born in 1895 and 1905 from ages 85 to 99 years. Social welfare provision enables equal access to free healthcare services for each resident in the country making healthcare data less confounded by the socio-economic status than in some countries. The hospitalisation data were obtained for all cohort members, thus, there was virtually no room for selection bias due to non-participation or loss to follow-up inherent in longitudinal surveys.

A potential study limitation is that the cohort difference in the frequency of surgical procedures could be due to changes in the ICD codes rather than to the changes in treatment activity. However, the analysis of several cause-specific surgical procedures, for which the ICD-8 and ICD-10 codes were identified by specialists, showed the same patterns as all-cause hospitalisations. Another potential limitation is that register data on migration status were available until February 2003, whereas hospitalisation in the 1905 cohort was followed through 2004. However, migration rates at very old ages are very low and, thus, unlikely to influence our findings. Finally, our findings may be country-specific and may not be generalisable to other settings.

In conclusion, the findings of more hospitalisations and surgical procedures, but shorter LOS and no increase in post-operative and in-hospital mortality in the 1905 cohort compared with the 1895 cohort at the ages from 85 to 99 years point towards provision of less care but more treatment in hospitals. No increase in post-operative mortality suggests that eligibility for a surgical treatment is likely to be based on the health status of old-aged persons and safety of surgical procedures rather than chronological age.

Key points

- The proportion of hospitalised and surgically treated persons was higher in the 1905 cohort than in the 1895 cohort.
- The LOS was shorter in the 1905 cohort than in the 1895 cohort.
- No increase in post-operative and in-hospital mortality rates over time was observed.
- Eligibility for a surgical treatment is likely to be based on the health of old-aged persons and safety of surgical procedures.

Conflicts of interest

None declared.

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Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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