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MORTALITY

Trends in life expectancy by education in Norway 1961–2009

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Abstract Educational attainment and longevity are strongly related. Large population studies covering long periods to provide evidence of trends in educational inequalities regarding life expectancy are scarce though, especially prior to the 1980s. Our objective was to document changes in life expectancy by education in Norway in the period 1961–2009, and to determine whether the patterns differ between sexes. This is a register-based population study of all Norwegian residents over 34 years, with data from the National Central Population Registry and the National Education Database. For each calendar year during 1961–2009, death rates by 1 year age groups were calculated separately for each sex and three educational categories (primary, secondary and tertiary). Annual life tables were used to calculate life expectancy at age 35 (e_{35}) and survival probability for the three age-intervals 35–44, 45–64, and 65–90. All education groups increased their e_{35} over time, but inequalities in e_{35} between tertiary and primary educational categories widened 5.3 years for men and 3.2 years for women during the study period. The probability for women with primary education to survive to age 64 did not improve from 1961 to 2009. The gain in life expectancy lagged about 10 years in lower compared to higher education groups which might suggest that improvements in life sustaining factors reach different segments of the population at different times. The widening of the gap seems to have partly tapered off over the last two decades, and the changes in life expectancy should be followed carefully in the future to document the development.

Keywords Trend · Life expectancy · Survival probability · Education · Inequalities

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Introduction

Education is frequently coming up as a major determinant for longevity. A strategic review of post-2010 health inequalities in England indicates that around 200,000 fewer premature deaths would occur in people aged 30 and above each year if everyone had the same death rate as those with tertiary degrees [1]. Data from the last two to three decades of the twentieth century show that those with higher educational attainment have enjoyed a more rapid increase in life expectancy [2–5]. This also applies to welfare states with universal and equitable access to health care services, comprehensive social security benefits and redistributive economic policies as a fundament [6]. Large population studies covering long periods to provide evidence for extended trends in educational inequalities in life expectancy are scarce though, especially those that go further back than the 1980s. This is unfortunate since the decades after the Second World War, when major social changes occurred, are important for understanding recent and current trends in life expectancy.

Using register-based data on mortality and educational attainment linked by unique personal identification numbers, we followed temporal changes in educational inequalities in

life expectancy over half a century of large welfare adjustments. Our objective was to document changes in life expectancy by education for all Norwegians aged 35 years and older in the period 1961–2009, and to determine whether patterns differed by sex.

Materials and methods

Data retrieval and educational levels

Unique personal identification numbers were used to link the Norwegian Central Population Registry, the National Education Database, and the 1960 National Census. From 1970 onwards information about educational attainment was annual and gathered from the National Education Database, while the attainment reported in 1960 census was used for the period 1961–1969. From 1967 we were able to measure time under exposure with full control of migration in and out of the country. Data were compiled by Statistics Norway [7] and contain information about all residents of Norway at any point in time between 1961 and 2009.

Education scales follow directly from the Norwegian NUS-2000 standard (see Statistics Norway) [7] coding scheme, which recently has been harmonised with the International standard classification of education (ISCED-97) [7, 8]. In the present study we employed a three level scale: primary education, secondary education and tertiary education. Primary education refers to levels 0–2 in ISCED-97 [ISCED-level 1 = primary education or first stage of basic education, ISCED-level 2 = lower secondary or second stage of basic education], secondary education refers to levels 3–4 in ISCED-97 [ISCED-level 3 = (upper) secondary education, ISCED-level 4 = post-secondary non-tertiary education], and tertiary education refers to levels 5–6 in ISCED-97 [ISCED-level 5 = first stage of tertiary education, ISCED-level 6 = second stage of tertiary education].

The educational data from the 1960 Census are coded differently from data in the National Education Database and therefore somewhat less comparable to later figures. We were, however, able to make a quite reliable conversion to our categories of primary, secondary and tertiary education by comparing frequency tables of education codes in 1960 and 1970 for the older population whose education level was unlikely to have changed in this period.

Inclusion and classification

We used a lower age limit of 35 years (Table 1) to ensure that the majority of the study population had attained their highest education prior to inclusion. Note that for those aged 35 in 1969 the education level pertains to the situation at age 26 at the 1960 census. Raising the lower age limit to 40 years did not alter our results substantially.

Data analysis

Life tables were constructed for each calendar year from 1961 to 2009 where death rates by 1 year age groups were calculated separately for each of the six subpopulations defined by sex and the three educational categories. For each life table we then calculated life expectancy at age 35, later referred to as e_{35}. In these calculations mortality was assumed constant beyond age 95, and set equal to the crude rate for the age-group 95 years and over [9]. Yearly increase in e_{35} by period (1961–70, …., 2001–2009), sex and educational level is given as the slope coefficient of a linear regression line. Additionally, we used life tables to calculate the probability of a 35 year old surviving to age 44 (9q35), a 45 year old surviving to age 64 (19q45), and a 65 year old surviving to age 90 (25q65) [9]. Year to year fluctuations in life expectancy serve as indications of the level of uncertainty.

Results

There was a large shift towards a higher education level in the population during the observation period (Table 1). The group with primary educational attainment was reduced from 71% of the study population in 1961 to 33% in 2001. The tertiary educational group increased from 5% in 1961 to 21% in 2001. Women had a lower educational level than men in all five decades (Table 1).

At the beginning of the observation period, e_{35} for the primary educational group was 40.3 years for men and 44.1 years for women (Table 1). Corresponding figures for the secondary and tertiary educational categories were about 1–3 years higher. In the tertiary educational group, e_{35} increased 6.4 years for men and 6.1 years for women during the observation period, giving 48.6 remaining life years among men and 51.7 among women in 2009. The group with secondary educational attainment increased their e_{35} by 4.2 years (men) and 4.3 years (women), whereas the group with primary educational attainment increased their e_{35} by 2.1 years for men and 2.9 years for women. Thus, the e_{35} inequalities between the tertiary and primary educational categories increased from 1.9 years for men and 1.5 years for women in 1961 to 6.2 years for men and 4.7 years for women in 2009.

For both sexes, the tertiary educational group increased their e_{35} throughout the whole study period (Fig. 1). There seems to be about a 10-year lag in the e_{35}-gain between the different educational groups, with e_{35} in the secondary group beginning to increase around 10–20 years later than

Table 1 Person years (35 years and older) and life expectancy at age 35 (e_{35}), by sex and educational level

Time	Level of education	Men			Women		
		Person years	%	e_{35}	Person years	%	e_{35}
1961	Primary	562,043	65.7	40.3	689,668	75.6	44.1
	Secondary	242,256	28.3	41.6	190,108	20.9	45.9
	Tertiary	50,778	5.9	42.2	31,720	3.5	45.6
	Missing	226	<0.01		272	<0.01	
	All levels	855,693	100.0	40.5	911,768	100.0	44.2
1971	Primary	502,249	56.0	38.6	631,877	64.9	43.9
	Secondary	313,096	34.9	40.4	287,765	29.5	46.6
	Tertiary	76,440	8.5	42.1	48,640	5.0	47.5
	Missing	5,843	0.6		5,510	0.6	
	All levels	897,628	100.0	39.4	973,792	100.0	44.5
1981	Primary	437,711	46.0	39.1	578,140	55.4	45.4
	Secondary	381,015	40.1	40.6	373,291	35.8	46.9
	Tertiary	121,112	12.7	42.9	82,591	7.9	47.2
	Missing	10,949	1.2		9,364	0.9	
	All levels	950,787	100.0	40.0	1,043,386	100.0	45.9
1991	Primary	372,198	35.5	39.7	514,754	44.9	46.0
	Secondary	470,589	44.9	41.6	472,146	41.2	47.6
	Tertiary	191,142	18.3	44.4	149,426	13.0	49.2
	Missing	13,826	1.3		10,845	0.9	
	All levels	1,047,755	100.0	41.1	1,147,171	100.0	46.7
2001	Primary	334,993	28.6	40.5	458,090	36.4	46.3
	Secondary	553,019	47.2	43.7	535,475	42.6	48.7
	Tertiary	268,285	22.9	46.6	250,914	19.9	50.3
	Missing	15,577	1.3		13,444	1.1	
	All levels	1,171,874	100.0	43.1	1,257,923	100.0	47.8

Primary education = levels 0–2 in ISCED-97; secondary education = levels 3–4 in ISCED-97; tertiary education = levels 5–6 in ISCED-97. ISCED-97 = International Standard Classification of Education 1997

for the tertiary group, and the primary group about 10 years later than the secondary group (Fig. 1, Table 2). Men with tertiary educational attainment experienced a steeper increase in e_{35} from the period 1971–1980 (Table 2). Those with secondary educational attainment experienced the increase from the period 1991–2000 and the group with primary educational attainment in the period 2001–2009 (Table 2). A similar pattern is seen among women, except that an increase in e_{35} in the group with tertiary education started around 10 years later than among men (Table 2). Also noteworthy is that the primary and the secondary educational groups had a substantial decrease in e_{35} among men during the 1960s. It was not until the late 1990s that men in the primary educational group again reached the e_{35} they had in the beginning of the 1960s. Women in the primary educational group had an increase in e_{35} in the 1970s, but otherwise they had small gain in e_{35} until the last decade of the observation period.

Figure 2 shows that among men the differences in e_{35} between the secondary and primary educational groups and between the tertiary and secondary educational groups increased approximately equally in the period 1970–1990. Then the widening of the gap between tertiary and secondary educational groups started tapering off, whereas the widening of the gap between secondary and primary educational groups started tapering off around 10 years later. Among women, a similar pattern of tapering off between the tertiary and secondary educational groups is found from around year 2000.

During the whole observation period, all educational groups and both sexes had at age 35 more than 97% probability of surviving to at least 44 years old (Fig. 3a). Unlike the secondary and tertiary groups, the primary educational group did not increase their probability of living nine more years between 1961 and 2009 (Fig. 3a). Similarly, the probability for a 45 year old woman with primary educational attainment to live to age 64 did not increase from 1961 to 2009 (Fig. 3b). The 45 year old men with primary educational attainment have since the 1990s increased their probability to live 19 more years, but this

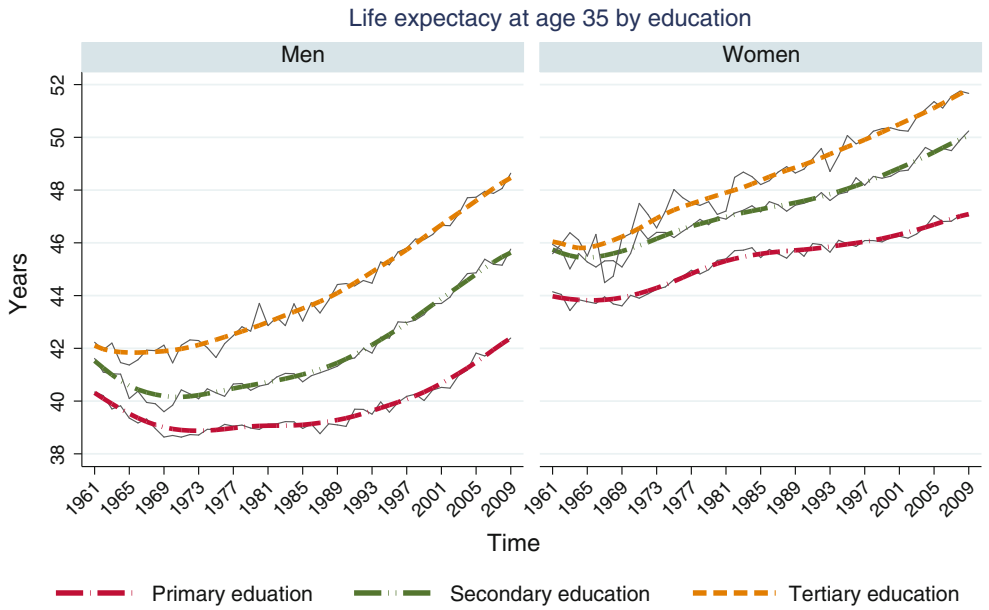

Fig. 1 Trends in educational inequalities in life expectancy in men and women aged 35 (e_{35}), 1961–2009. *Broken lines* represent a Lowess smooth (bandwidth = 0.4). Primary education = levels 0–2 in ISCED-97; secondary education = levels 3–4 in ISCED-97; tertiary education = levels 5–6 in ISCED-97. ISCED-97 = International Standard Classification of Education 1997

Table 2 Yearly increase in life expectancy at age 35 (e_{35}) by period, sex and educational level presented as linear slope coefficients

Time	Men			Women		
	Primary education	Secondary education	Tertiary education	Primary education	Secondary education	Tertiary education
1961–1970	−0.19	−0.21	−0.03	−0.02	−0.04	−0.02
1971–1980	0.04	0.03	0.13	0.15	0.07	0.03
1981–1990	−0.02	0.07	0.17	0.01	0.05	0.10
1991–2000	0.08	0.22	0.24	0.03	0.11	0.15
2001–2009	0.19	0.23	0.23	0.11	0.17	0.20

Primary education = levels 0–2 in ISCED-97; secondary education = levels 3–4 in ISCED-97; tertiary education = levels 5–6 in ISCED-97. ISCED-97 = International Standard Classification of Education 1997

follows approximately 30 years of reductions in survival probability (Fig. 3b). For 65 year old women, the probability of surviving until age 90 has increased substantially since 1961 in all educational groups, but somewhat less for men in the lower educational groups (Fig. 3c).

Discussion

The educational gap in life expectancy at 35 years (e_{35}) widened more than threefold among both sexes between 1961 and 2009. This widening trend seems to have abated between all educational groups among men and between the tertiary and secondary educational groups among women during the last 10–20 years of observation. All groups increased their e_{35} over the five decades studied, but the gain lagged about 10 years between educational categories.

The main strengths of this study are the size and quality of the dataset and the length of the observation period. Inclusion of an entire population by linked registers should strengthen data validity, and data from the Norwegian administrative registers are known to be of high quality. The reliability of our data for the period 1960–1969 might be influenced by the different coding scheme for educational attainment and the missing information about migrations in and out of Norway prior to 1967.

Men in the primary education category experienced a declining e_{35} during the first decade studied, reaching a minimum in 1971, a year coinciding with the summit of coronary heart disease mortality rates in Norway [10]. A declining e_{35} during this period was also observed in the secondary education category, but not in the tertiary. This might indicate that the coronary heart disease epidemic had lesser impact on those with higher educational attainment, or occurred prior to the 1960s. That would be compatible

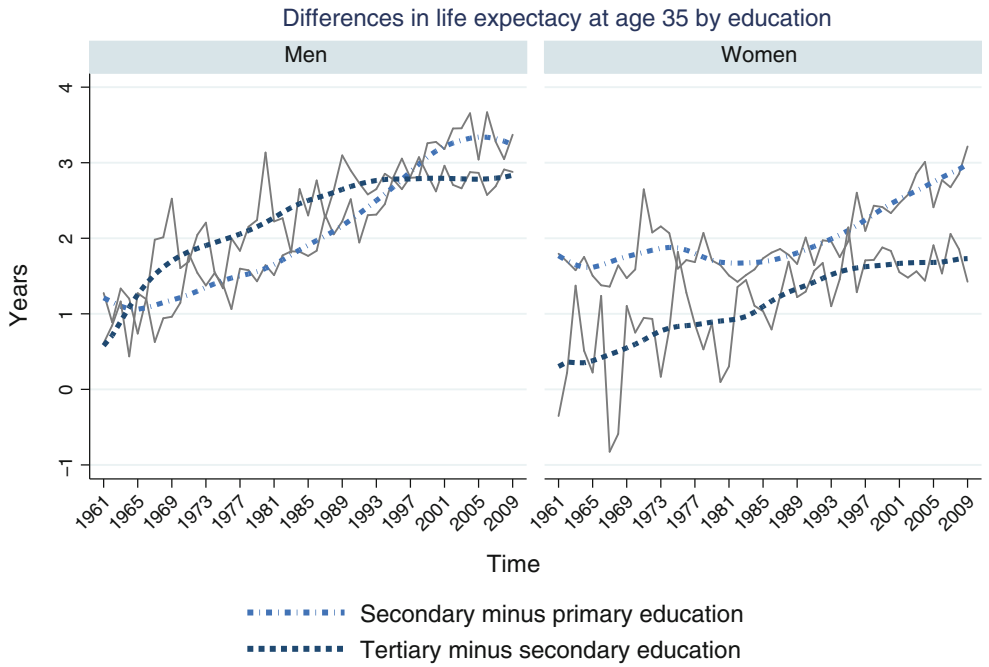

Fig. 2 Differences in life expectancy at age 35 (e_{35}) by education, 1961–2009. *Broken lines* represent a Lowess smooth (bandwidth = 0.4). Primary education = levels 0–2 in ISCED-97; secondary education = levels 3–4 in ISCED-97; tertiary education = levels 5–6 in ISCED-97. ISCED-97 = International Standard Classification of Education 1997

with our results of lagging of the secondary category behind the tertiary, and the primary category behind the secondary in terms of life expectancy gain. This lagging structure is likely to reflect different timing in adoptions of health promoting and preventative behaviour as well as inequalities regarding use and quality of health care.

Our observation period represents a time with increasing focus on health promotion strategies in Norway. One of the earliest interventions against smoking was already implemented in 1964 when the Norwegian health authorities published a statement about the harmful health effects of smoking that were described in an American report [11]. In 1975, all tobacco advertising was banned and warnings were printed on all products [12, 13]. One year later, the Norwegian government's first report on official nutrition policy was published [14], which was followed by a marked reduction in saturated fat and trans-fatty acids intake in Norway [15] and further declines in coronary heart disease mortality [10]. Other preventive strategies were also adopted in the decades to come, such as measures against physical inactivity, drugs and alcohol use. The observed lagging of life expectancy gain in the primary and secondary educational categories over the last half a century might support the fundamental causes theory of health inequalities, which states that advantaged people have a better position to avoid health risks irrespective of what the current important health determinants are [16]. Population-level structural interventions might, however, help health enhancing changes reach broader segments of the population simultaneously. In Norway, banning smoking in public places and on public transport in 1989 and in bars and restaurants from 2004 [12] are examples of such interventions.

Socioeconomic differences in the allocation of medical treatment are documented in several countries that provide universal or close to universal health-care coverage [17]. This also applies to Norway [18, 19]. Despite the egalitarian strategy after the Second World War, the quality of the service and access to the best available treatment may have varied between segments of the population. Some groups may therefore have benefited less from the huge improvements in medical care from the 1980s and onwards. For example, the lower educated have had less visits to private specialist services [18] and elderly and women are overrepresented among diagnostic groups without priority access to treatment at hospitals [19]. Evaluation of the implementation of the Norwegian Patient Rights Act in 1999 and their amendments in 2004 also suggests educational differences in priority access to health care [19]. Changes in the Norwegian priority strategies may therefore influence the pattern of educational inequalities in health and health related factors which might affect life expectancy.

As part of the welfare model, several school reforms have been implemented in Norway since the early twentieth century. This has resulted in large shifts in the general

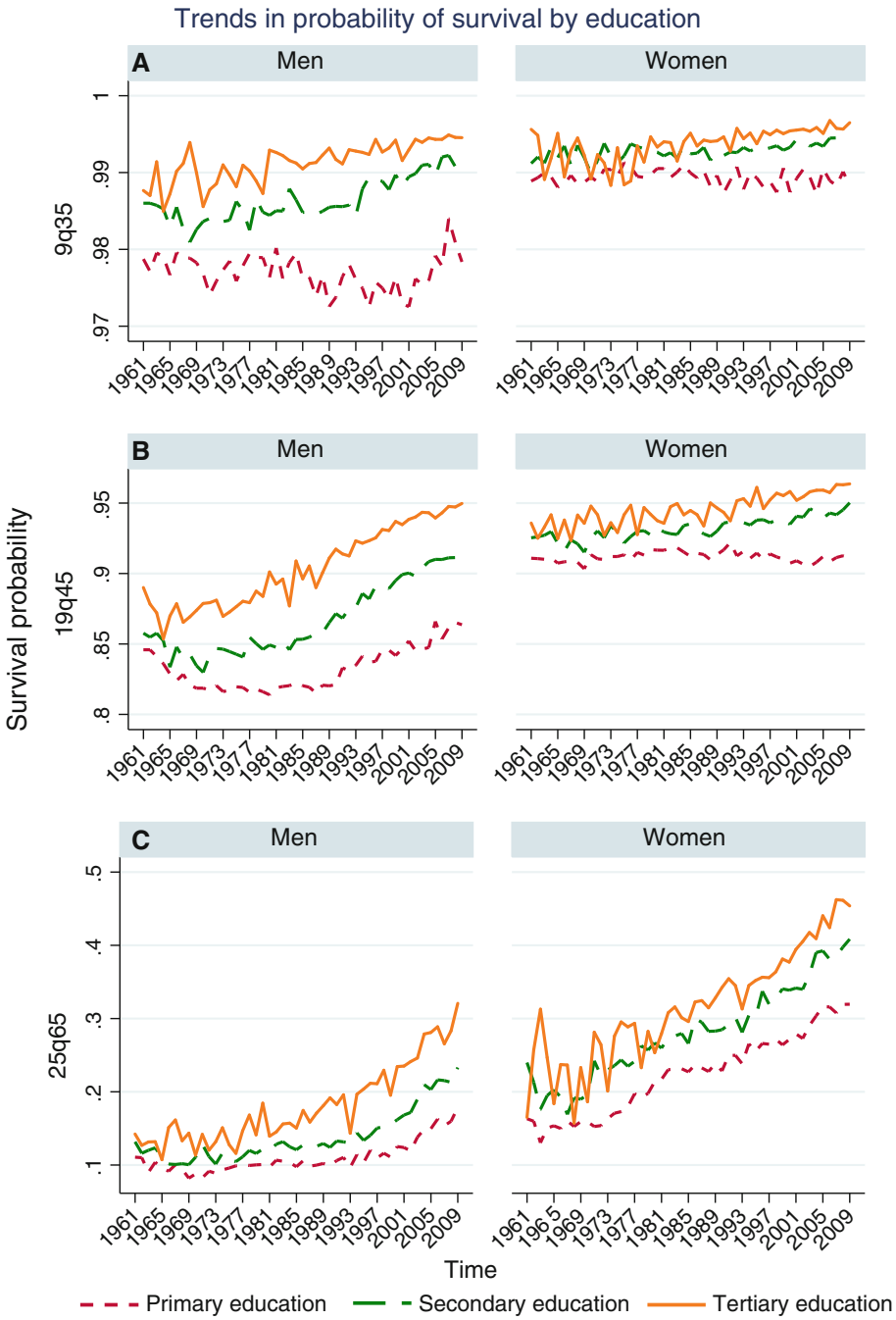

Fig. 3 Survival probability by education, 1961–2009. Note dissimilar scale on the vertical axis. 9q35 represents the probability of a 35 year old surviving 9 years (to age 44), 19q45 represents the probability of a 45 year old surviving 19 years and 25q65 represents the probability of a 65 year old surviving 25 years. Primary education = levels 0–2 in ISCED-97; secondary education = levels 3–4 in ISCED-97; tertiary education = levels 5–6 in ISCED-97. ISCED-97 = International Standard Classification of Education 1997

educational level throughout the decades under observation, reflected by the changing composition of our study population. The effect of these changes on differences in life expectancy is not clear. On the one hand, educational attainment among Norwegians today is likely to be more dependent on cognitive abilities and interests than capital. The tertiary educational category used in this study has therefore most likely changed over the observation time from a subgroup of highly materially privileged to a group of people with different socioeconomic background. This may result in abating differences between those with tertiary and secondary educational attainment. On the other

hand, the shift towards higher education might over time result in a proportionally larger marginalised subgroup among those in the primary education category. This may lead to increased inequalities between those with primary and secondary educational attainment. Our data show possible stabilizing of trends in educational inequalities in e_{35} among men of all educational groups and among women with higher levels of educational attainment. This might indicate that the educational groups have become more homogenous during our observation period. The widening in inequalities between tertiary and secondary educational groups began tapering off around 1990 in men and about 10 years later in women. The widening in inequalities between the secondary and 1al groups also began tapering off around 2000 in men. Educational opportunities opened up later among women than men, which may partly explain why the abating effect between the lower educational groups at present is not found in both sexes.

At the same time that educational inequalities have widened, sex differences in life expectancy have declined in many countries [20]. In Norway, the differences have gradually decreased since the late 1980s [7]. Our results from the most recent decades show that women with primary educational attainment have had the least gain in e_{35}, which is in agreement with results from Denmark and Belgium [4, 5]. We also find reduced survival probability for women with primary educational attainment compared to the other groups when we analyze subgroups of age. Actually, the probability for women with primary education to survive from age 35 to age 64 has not improved during the last half a century. In a previous study we found that the widening of absolute educational differences in mortality among middle aged men and women in the period 1960–2000 was largely driven by smoking related causes of death, such as lung cancer and lower respiratory tract diseases [21]. One of the reasons for decreased sex differences in life expectancy is therefore likely to be dissimilar changes in smoking habits and related death rate. Annual tobacco use reached a maximum level among Norwegian women in the 1990s, compared with about 20 years earlier among men [22]. The proportion of women that smoked increased gradually from less than 5% in the 1930s to 42% in 1970, while the proportion of male smokers was stable at 60–70% until the mid-1950s then started to decrease [22, 23]. About 25% of both sexes smoked in the early 2000s [22] and around half of the daily smokers in the age group 25–64 years had at that time only primary educational attainment [10, 23]. The decline in smoking has the last decades been largest among those with higher educational level [22, 23] which resembles theories about the process of the smoking epidemic [24]. While mortality from lung cancer (including larynx, bronchus, trachea) among the middle aged with primary educational level increased in men from 96 to 115 deaths per 100,000 persons per year in the periods 1980–1985 to 2001–2005, the increase was from 26 to 83 deaths per 100,000 persons per year in women [10]. During the same period lung cancer mortality among the middle aged was reduced by 13–14 deaths per 100,000 persons per year in men with secondary or tertiary educational level, but increased from 20 to 37 deaths per 100,000 per year in women with secondary educational attainment and was stable among women with tertiary educational attainment [10]. Lung cancer mortality among Norwegians older than 64 years increased for both sexes and all educational groups from the early 1980s to early 2000s, but the increase was largest among those with primary educational level [10]. A recent Norwegian study of trends in educational differences in lung cancer deaths among 45–74 year olds during the last three decades of the twentieth century shows that the odds ratio increased from 1.37 to 2.02 among men and from 1.12 to 2.17 among women with primary compared to tertiary educational attainment [25]. Also the Relative Index of Inequality (RII) increased more among women (0.76–3.18) than men (1.17–2.78) [25].

Much of the earlier findings about inequalities in life expectancy in the European countries, especially those from the pre-1980s, are based on occupation or income as a measure of socioeconomic position [26, 27]. Although these measures seem to be closely related to educational level, they are not interchangeable [28]. Many of these earlier studies also concern only men. If women were included, they were often classified according to their husband's occupation. Our data show that inequalities in e_{35} in Norway increased between the highest and lowest educational group from the beginning of the 1960s and throughout the twentieth century. This is in agreement with several other findings from Western countries over the last two to three decades of the twentieth century, where education or other measures were used as a proxy of socioeconomic position [2–5, 29–31] One study from Austria showed a decreased difference in life expectancy among women between 1981 and 2006 [32]. Another report from Barcelona showed that absolute educational inequalities in mortality tended to decrease over a study period of 12 years (1992–2003) [33]. Narrowing inequalities in life expectancy were also found between blacks and whites in the US from 1994 to 2003, but it followed a sharp increase in inequalities in the period 1983–1993 [34]. We are not aware of any studies that show a 10-year lagging structure similar to ours or a tapering off of the widening in inequalities in life expectancy in the late twentieth and early twentyfirst century. Our findings should be followed up closely in the coming years to document whether the abating effects are the ending of the widening gap in educational inequalities in life expectancy or merely random fluctuation.

Conclusions

Although widening of inequalities in life expectancy have in part flattened out the last two decades, Norway has experienced a steep increase in inequalities between 1961 and 2009. The finding of a lag structure of approximately 10 years may indicate that improvements in life sustaining factors reach different segments of the population at different times. Trends in life expectancy should be monitored closely in the coming years to see if the abating effect seen among men and the higher educational groups among women is due to random fluctuations or due to changed trends in educational inequalities in life expectancy.

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Conflict of interest We declare that we have no conflict of interest.

Ethical approval Data linkage was approved by the Norwegian Data Inspectorate and data handling was approved by the Norwegian Directorate of Health.

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