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Erik H. Nymoen

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Abstract:
Mortality of cerebrovascular disease show regional differences that may be associated with characteristics of place of residence at the time of death. Nevertheless, such differences may be misinterpreted if the impact of migrants is not considered. This study estimates, for the first time, the impact of migrants on Norwegian regional mortality rates of cerebrovascular disease. For the period 1991-1994 age-standardized mortality rates were estimated for men and women born in Norway during 1907-1946 separately for total population, migrants, and non-migrants at the geographical scales of county and main region. Overall, the migrants experience the same cerebrovascular mortality level as the non-migrants, but there are great regional differences and ratios are observed both well below and well above unity. The impact of migrants on a county's cerebrovascular mortality level in some cases result in the rank of the county being substantially altered compared with its rank based on the non-migrant population only.

Keywords: Cerebrovascular disease, mortality, regional variation, migration, Norway.

Address: Erik H. Nymoen, Division for Social and Demographic Research, Statistics Norway, P.O. Box 8131 Dep., N-0033 Oslo, Norway. E-mail: ehn@ssb.no

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Introduction

Mortality from cerebrovascular disease, commonly known as stroke, among both males and females in Norway has been characterized by marked regional differences. The highest mortality rates in the early 1970s were found in industrialized parts of the Oslo-fjord area, the inner regions of Trøndelag, Southern Troms/Northern Nordland and in Eastern Finnmark (Aase 1996). Before that mortality rates of cerebrovascular disease started to decline and regional differences are now reduced, even though ex. g. parts of Eastern Norway still have higher rates than the rest of the country. The decline is observed in both sexes and all age groups (Bjartveit 1983, Statistics Norway 1965, 1974, 1988, 1995). In the early 1990s cerebrovascular disease accounted for approximately 10% of male and 15% of female deaths.

Cerebrovascular disease comprise any disorder of the supply of blood to the brain. Nerve cells in the affected part of the brain die within minutes after a burst in or clogging of a brain artery, resulting in neurological disability, - a stroke. A stroke can vary in severity from a temporary weakness in a limb to an extensive paralysis, coma, and death. Hence, the primary disease is in the blood vessels and the effect on the brain is secondary (Smith and Pratt 1993).

Cerebrovascular disease and ischaemic heart disease share several risk factors, for example high blood pressure and tobacco smoking (Smith and Pratt 1993). Nevertheless, the decline in cerebrovascular mortality started earlier than for ischaemic heart disease and was in fact declining when ischaemic heart disease mortality was increasing sharply during the 1950s and 1960s (Aase 1992, Bjartveit 1983). Compared to ischaemic heart disease and the aggregate of total cardiovascular disease there has been relative few studies focusing on geographical aspects of cerebrovascular disease in Norway.

Geographical studies may provide insights into disease aetiology by identifying and exploring regional patterns of mortality risks and their relations to individual and contextual factors of the physical and social environment. In regional studies migration may cause misinterpretations of the relations between disease and the natural or man-made human habitat. In some situations the effect will be to hide real environmental determinants of disease. In other situations spurious associations will be produced (Bentham 1988). Nevertheless, careful geographical studies of migration and health may yield important insight into the relation between environment and health (MacMahon and Pugh 1970). The migrant population approach has been applied in several studies, but with some difficulties of interpretation and most often examining international migration only (Mayer 1980).

People who are resettled in a new place have been exposed to social circumstances and other environmental conditions not only in their current place of residence, but also in their former place(s) of residence. Some life style elements may be adopted early in life, have long lasting effects, and only slightly or very slowly be altered after resettlement in a different geographical context. Hence, migrants may have mortality risks different from the mortality risk of the non-migrants, and in regions of high migration they may have a considerable effect on spatial patterns of mortality. The geography of cerebrovascular disease may reflect differences in susceptibility related to adverse maternal and early postnatal influences it has been postulated. It is suggested that both the geographical differentials and the decrease in mortality from cerebrovascular diseases during the past 50 years reflect a dominant effect of early influences on the constitution of the individual organism (Barker 1994).

The present study examines, possibly for the first time, the influence of migrants on regional differentials of cerebrovascular mortality in Norway. Age-adjusted death rates for the period 1991-1994 for men and for women born in the country during 1907-1946 are estimated separately for total population, migrants, and non-migrants of each county and main region, respectively, and presented as a relative rate to the national rate.

Data

This paper is based on a historical follow-up study where the study cohorts comprises persons born in Norway during 1907-1946 who were residents in the country at the end of 1990. The observation period used in this study is 1991-1994.

Data from the population censuses, the central population register, and the cause-of-death register based on the death certificates were compiled by Statistics Norway. County of residence at the time of the 1990 population census were included in the record linkage with, where applicable, information from death certificate or record of emigration. Information on county of birth originates from the 1960 population census, which was the basis for the establishment of the Central Population Register in 1964.

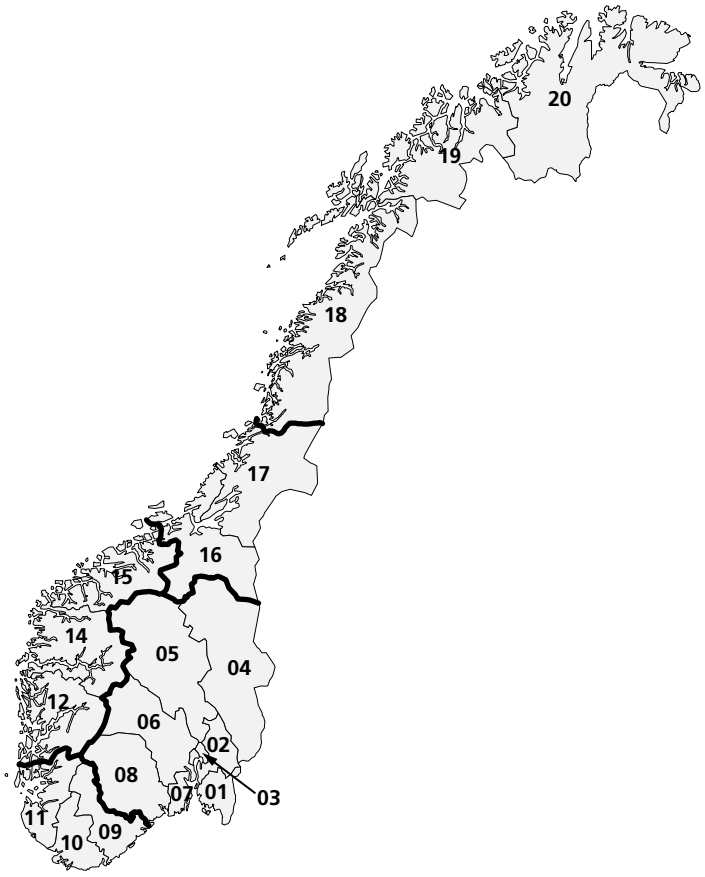
At the population census of 3 November 1990, Norway had a population of 4 247 546. During the record linkage on which this study is based 6 498 (0.2 %) of these men and women were not included due to some sort of mismatch or missing information. Of the 1 518 645 born 1907-1946 (and included from the 1990 census) there were 5 428 who died or left the country between 3 November 1990 and the beginning of 1991 when the observation period for this study started. Excluded from the study cohorts was 40 919 (2.7%) with no information on place of birth and 52 700 (3.5%) foreign born. The study population as defined above comprises 1 419 598 persons born in Norway 1907-1946 (age 44-83 at the end of 1990).

The study population was observed throughout 1991-1994 and deaths, emigrations, and person-years at risk (of dying and emigration) were recorded for one-year age groups. New inhabitants were not allowed to enter the study population, but persons were not excluded if they were temporary residents of a foreign country for some time during 1991-1994 and returned or never registered out (very few persons). Underlying cause of death was coded according to the International Classification of Diseases 9th Revision (ICD-9), codes 430 through 438 for cerebrovascular diseases (Statistics Norway 1993).

Methods

The study population were observed during 1991-1994 and the number of deaths from the study cohorts and the corresponding person-years at risk during the four-year period 1991-1994 for each age and region were registered. Place of residence at the 1990 census is used as place of residence throughout 1991-1994. Age-adjusted mortality rates are obtained by using the direct method of standardization (Lilienfeld and Lilienfeld 1980) and the European standard population (Waterhouse et al. 1976, WHO 1984) applied to one-year age groups as a uniform distribution over five-year intervals. The age-adjusted mortality rate for cerebrovascular disease observed for the total study population of the same sex is used as the baseline when computing standardized rate ratios (SRR_1) for regional mortality levels and the corresponding p-values (p_1) for testing of statistical significance. In comparations of migrants and non-migrants, SRR_2 is the ratio of the age-adjusted rate for migrants over the rate for non-migrants, and the level of significance is denoted p_2. The test for rate difference is based on a normal approximation (Lilienfeld and Lilienfeld 1980). Spatial patterns are evaluated by means of choroplete maps as well as tables. Figure 1 shows the Norwegian counties and main regions.

Figure 1. The 19 Norwegian counties and 5 main regions



Eastern Norway
01 Østfold
02 Akershus
03 Oslo
04 Hedmark
05 Oppland
06 Buskerud
07 Vestfold
08 Telemark
Agder and Rogaland
09 Aust-Agder
10 Vest-Agder
11 Rogaland
Western Norway
12 Hordaland
14 Sogn og Fjordane
15 Møre og Romsdal
Trøndelag
16 Sør-Trøndelag
17 Nord-Trøndelag
Northern Norway
18 Nordland
19 Troms
20 Finnmark

Data source: Statistics Norway.
Map data: Norwegian Mapping Autority.

Results

During 1991 - 1994 we observed altogether 67 826 male and 52 927 female deaths from the initial study population of 670 819 men and 748 779 women while 1 212 men and 742 women left the country for the rest of the study period. Altogether, the total number of person-years at risk over the age span 45 - 87 (one-year age groups) amounted to 2 546 925 for men and 2 891 553 for women. The proportion of all deaths caused by cerebrovascular disease was 10% (6 456) for men and 14% (7 227) for women.

The age-adjusted mortality rate from cerebrovascular disease observed for the male study population was 174 per 100 000 person-years, with a 95% confidence interval of ±5, the corresponding rate for women was 126 with a confidence interval of ±3. These two rates are used as baseline when calculating standardized rate ratios (SRR_1) for regional mortality levels. Hence, the overall rate for males is 1.38 times the rate for females.

Main regions

Among Norway's five main regions, Trøndelag and Northern Norway show male cerebrovascular mortality levels similar to the national level (Table 1), whereas the populous Eastern region has a mortality level slightly but significantly above the national level. The mortality level in Agder and Rogaland is slightly below the national level, whereas Western Norway is well (12%) below the national level.

Table 1. Cerebrovascular disease mortality in Norway 1991-1994 by main region, males born in Norway 1907-1946

Region	Residents 1990							
	Total		Non-migrants		Migrants			
	Deaths	SRR_1 p_1	Deaths	SRR_1 p_1	Pct	Deaths	SRR_1 p_1	SRR_2 p_2
Total	6 456	1.00	5 825	1.00	13	631	0.98	0.98
Eastern Norway	3 401	1.06 *	3 065	1.08 **	15	336	0.95	0.88 *
Agder and Rogaland	725	0.94	623	0.94	18	102	0.91	0.97
Western Norway	1 042	0.88 ***	945	0.86 ***	10	97	1.18	1.38 *
Trøndelag	604	0.99	539	0.98	14	65	1.04	1.06
Northern Norway	684	1.03	653	1.03	7	31	0.94	0.91

Region refers to place of residence 1990. Migrants are residents of a region in 1990 different from where they were born. The columns show number of deaths, age-standardized rate ratio (SRR_1), level of statistical significance (p_1) for test against national male rate (174 per 100 000 person-years), percentage migrants (Pct), relative rate (SRR_2) and test (p_2) for migrants versus non-migrants within each region. Significance levels: * $p<0.050$, ** $p<0.010$, *** $p<0.001$. Source: Statistics Norway.

According to the 1990 census 13% of the males who entered this study were residents of a main region different from where they were born. Over the main regions the proportion of migrants among the males varied from 7% in Northern Norway to 18% in the region of Agder and Rogaland. Overall, the migrant males had a cerebrovascular mortality rate 2% lower than the non-migrant males (Table 1). This relatively modest difference observed at the national level hides substantial regional inequalities, where Eastern Norway is the low extreme (relative rate for migrants 0.88) whereas Western Norway is the high extreme (relative rate for migrants 1.38). It is noteworthy that at this level of regionalization male cerebrovascular mortality is lowest among non-migrants of Western Norway and highest among migrants to Western Norway. The maximum influence on the regional mortality rate from the presence of migrants was 2 percentage points.

Females in Northern Norway had a cerebrovascular mortality level exactly equal to the national level for women whereas a slightly higher level was observed in Eastern Norway (Table 2). The regions to the west and to the south clearly has a lower level (relative rates 0.87 and 0.89 respectively), whereas Trøndelag has a cerebrovascular mortality level 21% above the national level and 39% above the region with the lowest rate.

Table 2. Cerebrovascular disease mortality in Norway 1991-1994 by main region, females born in Norway 1907-1946

Region	Residents 1990									
	Total			Non-migrants			Migrants			
	Deaths	SRR_1	p_1	Deaths	SRR_1	p_1	Pct	Deaths	SRR_1	p_1	SRR_2	p_2
Total	7 227	1.00		6 407	1.00		15	820	0.98		0.98	
Eastern Norway	3 825	1.04		3 365	1.05		17	460	0.97		0.92	
Agder and Rogaland	762	0.89	**	640	0.87	**	19	122	0.98		1.12	
Western Norway	1 154	0.87	***	1 039	0.86	***	12	115	0.92		1.07	
Trøndelag	758	1.21	***	653	1.20	***	16	105	1.27	*	1.06	
Northern Norway	728	1.00		710	1.02		7	18	0.81		0.80	

Region refers to place of residence 1990. Migrants are residents of a region in 1990 different from where they were born. The columns show number of deaths, age-standardized rate ratio (SRR_1), level of statistical significance (p_1) for test against national female rate (126 per 100 000 person-years), percentage migrants (Pct), relative rate (SRR_2) and test (p_2) for migrants versus non-migrants within each region. Significance levels: * $p<0.050$, ** $p<0.010$, *** $p<0.001$. Source: Statistics Norway.

At the time of the 1990 census 15% of the women in this study were residents of a main region different from their region of birth, with a minimum of 7% in Northern Norway and a maximum of 19% in the region of Agder and Rogaland (Table 2). Generally, the migrant women had a cerebrovascular mortality rate 2% lower than the non-migrant women (which is exactly the same as for men).

Regional differences among females between migrants and non-migrants are larger than for males, the relative rate ranging from 0.80 in Northern Norway to 1.12 in Agder and Rogaland. Nevertheless, these ratios did not influence the regional overall rates significantly.

Counties - men

Male mortality due to cerebrovascular disease at the county level is shown in Table 3. As indicated from the rates computed for main regions, low mortality rates were found in western and some of the southern counties, whereas high mortality rates was found among several counties of the south east. The highest rates are found in Hedmark (SRR_1=1.23) and Finnmark (SRR_1=1.22), which is approximately 45 % above the most favourable county. Østfold and Aust-Agder also have mortality rates clearly higher than the national rate for males (both 1.11). The lowest mortality level for men is observed in Hordaland (0.85) and Rogaland (0.87), followed by Møre og Romsdal and Sogn og Fjordane (both 0.90). In the remaining 11 counties we observed mortality levels close to the overall male rate.

Table 3. Cerebrovascular disease mortality in Norway 1991-1994 by county, males born in Norway 1907-1946

	Residents 1990										
Region	Total			Non-migrants			Migrants				
	Deaths	SRR_1	p_1	Deaths	SRR_1	p_1	Pct	Deaths	SRR_1	p_1	SRR_2 p_2
Total	6 456	1.00		4 931	1.00		29	1 525	1.00		0.99
Østfold	430	1.11		326	1.07		26	104	1.28	*	1.20
Akershus	463	0.96		210	1.07		65	253	0.89		0.83
Oslo	689	1.04		362	1.10		51	327	1.00		0.92
Hedmark	451	1.23	***	383	1.22	**	19	68	1.28		1.05
Oppland	352	1.01		299	1.03		19	53	0.90		0.87
Buskerud	412	1.09		309	1.14	*	37	103	0.98		0.86
Vestfold	319	1.08		208	1.09		37	111	1.04		0.95
Telemark	285	0.97		231	0.97		24	54	1.06		1.09
Aust-Agder	163	1.11		139	1.17		28	24	0.87		0.74
Vest-Agder	191	0.95		140	1.00		33	51	0.85		0.84
Rogaland	371	0.87	**	314	0.85	**	18	57	0.97		1.14
Hordaland	497	0.85	**	422	0.82	***	16	75	1.02		1.24
Sogn og Fjordane	189	0.90		171	0.88		13	18	1.09		1.23
Møre og Romsdal	356	0.90	*	307	0.87	*	14	49	1.19		1.37
Sør-Trøndelag	383	0.99		318	1.00		22	65	0.92		0.92
Nord-Trøndelag	221	0.97		178	0.92		18	43	1.27		1.38
Nordland	384	1.02		346	1.02		12	38	0.94		0.91
Troms	197	0.96		181	1.00		18	16	0.62	*	0.62 *
Finnmark	103	1.22		87	1.27		20	16	1.03		0.81

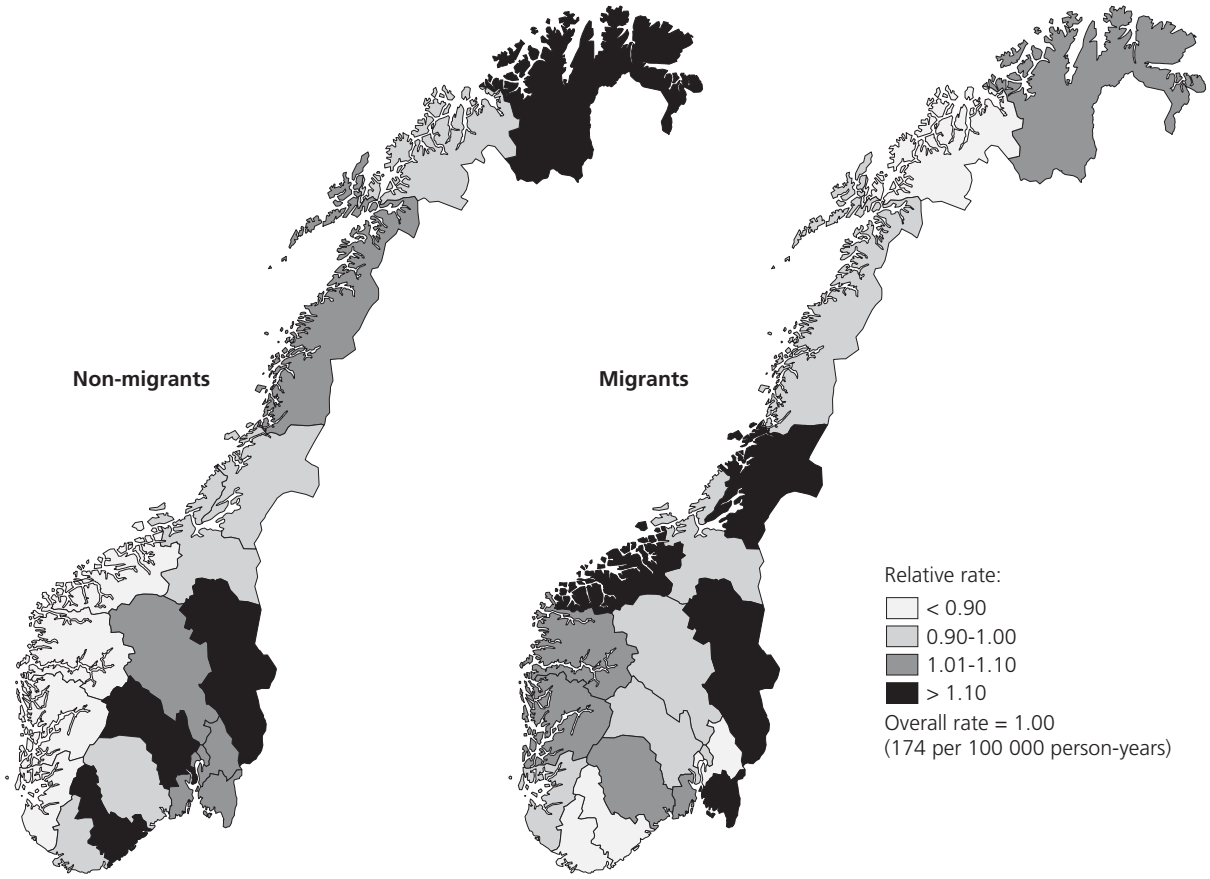
Region refers to place of residence 1990. Migrants are residents of a region in 1990 different from where they were born. The columns show number of deaths, age-standardized rate ratio (SRR_1), level of statistical significance (p_1) for test against national male rate (174 per 100 000 person-years), percentage migrants (Pct), relative rate (SRR_2) and test (p_2) for migrants versus non-migrants within each region. Significance levels: * $p<0.050$, ** $p<0.010$, *** $p<0.001$. Source: Statistics Norway.

In the 1990 census 29% of the male study population were residents in a county different from their county of birth (Table 3), ranging from 12% in Nordland to 65% in Akershus.

Overall, the migrant males at the county level had a cerebrovascular mortality rate equal to the non-migrant males (Table 3), but there are considerable regional variations (Figure 2). The range in SRRs among men was greater for migrants (approximately 2.0) than for non-migrants (approximately 1.5). This is considered only partially to be counted for by smaller numbers causing more random fluctuation in migrant rates.

Mortality from cerebrovascular disease was remarkably low among migrants compared to non-migrants in Troms (0.62) and Aust-Agder (0.74), and the same tendency was obvious in Finnmark, Akershus, and Vest-Agder as well. Counties where migrants had much higher mortality levels than non-migrants include Nord-Trøndelag (1.38), Møre og Romsdal (1.37), Hordaland (1.24), Sogn og Fjordane (1.23), and Østfold (1.20).

Figure 2. Male cerebrovascular disease mortality in Norway 1991-1994 by county, cohorts born in Norway 1907-1946. Age-standardized rate ratios for migrants and non-migrants



Data source: Statistics Norway.
Map data: Norwegian Mapping Authority.

In several counties did the presence of a migrant population influenced the regional mortality rate, most clearly in Akershus were the rate was lowered by 11 percentage points. In Hedmark and Østfold, two of the counties with very unfavourable rates the migrant population had even higher rates than the non-migrant population. In the four counties with the lowest mortality levels, the presence of a migrant population had the effect of increasing the county total level.

The effect on the total county cerebrovascular mortality of the migrant population take different forms, since there are different combinations of high and low rates for migrants and non-migrants. For example in Møre og Romsdal low mortality for non-migrants are drawn upwards of a high level among migrants. In Hedmark a high rate for non-migrants is increased by an even higher rate for migrants. Aust-Agder has a high rate for non-migrants that is modified by the low rate for migrants. There is no county combining low levels for both migrants and non-migrant males.

The map analysis of male cerebrovascular mortality is shown in Figure 2. The map shows different spatial distributions of mortality risks for migrants and non-migrants. Non-migrants show a clear demarcation between high- and low-risk areas, with the higher risks occurring in southeast and in the north. A different pattern emerged for migrants where areas of high and low rates are more scattered. The Spearman rank correlation coefficient for male mortality levels of non-migrants versus migrants at the county level was -0.07 (p=0.79).

Counties - women

Female cerebrovascular mortality at the county level is shown in Table 4. Highest mortality ratios are observed in Sør-Trøndelag (1.22) and Aust-Agder (1.21), which is about 50 % above the most favourable county. The lowest ratios among females are found in Rogaland (0.79), Hordaland and Sogn og Fjordane (both 0.83).

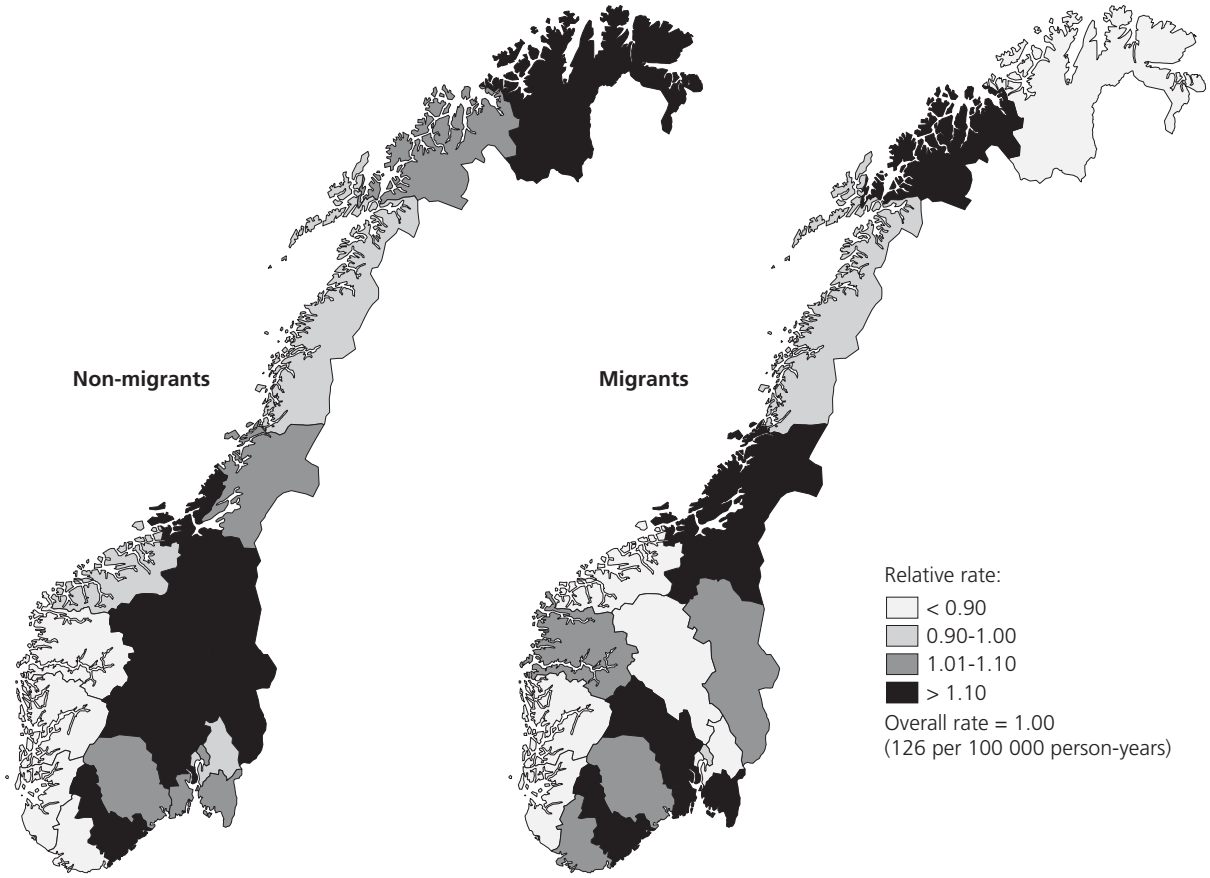
Table 4. Cerebrovascular disease mortality in Norway 1991-1994 by county, females born in Norway 1907-1946

	Residents 1990										
Region	Total			Non-migrants			Migrants				
	Deaths	SRR_1	p_1	Deaths	SRR_1	p_1	Pct	Deaths	SRR_1	p_1	SRR_2 p_2
Total	7 227	1.00		5 222	1.00		32	2 005	0.99		0.98
Østfold	541	1.16	**	398	1.09		29	143	1.34	**	1.23
Akershus	432	0.87	**	182	0.94		68	250	0.83	**	0.88
Oslo	956	0.97		457	1.05		55	499	0.90	*	0.85
Hedmark	396	1.13	*	325	1.15	*	24	71	1.02		0.89
Oppland	380	1.06		313	1.12		25	67	0.86		0.76 *
Buskerud	447	1.17	**	306	1.17	*	39	141	1.17		1.00
Vestfold	361	1.08		217	1.03		39	144	1.17		1.13
Telemark	312	1.04		247	1.04		26	65	1.01		0.97
Aust-Agder	195	1.21	*	142	1.14		30	53	1.41		1.24
Vest-Agder	189	0.86	*	120	0.76	**	36	69	1.05		1.38
Rogaland	378	0.79	***	320	0.81	***	20	58	0.72	**	0.89
Hordaland	580	0.83	***	482	0.84	***	20	98	0.82	*	0.98
Sogn og Fjordane	176	0.83	*	146	0.77	**	19	30	1.09		1.40
Møre og Romsdal	398	0.93		352	0.97		19	46	0.72	*	0.74
Sør-Trøndelag	500	1.22	**	382	1.20	**	26	118	1.28	*	1.07
Nord-Trøndelag	258	1.19	*	201	1.09		23	57	1.51	*	1.39
Nordland	408	0.96		360	0.96		16	48	0.97		1.01
Troms	223	1.07		187	1.04		20	36	1.23		1.18
Finnmark	97	1.01		85	1.11		21	12	0.61	*	0.55 *

Region refers to place of residence 1990. Migrants are residents of a region in 1990 different from where they were born. The columns show number of deaths, age-standardized rate ratio (SRR_1), level of statistical significance (p_1) for test against national female rate (126 per 100 000 person-years), percentage migrants (Pct), relative rate (SRR_2) and test (p_2) for migrants versus non-migrants within each region. Significance levels: * p<0.050, ** p<0.010, *** p<0.001. Source: Statistics Norway.

Of the female study population 32% were residents in a county different from their county of birth at the time of the 1990 census (Table 4), ranging from 16% in Nordland to 68% in Akershus. Hence, women follow the same pattern as men with just slightly higher proportions.

Figure 3. Female cerebrovascular disease mortality in Norway 1991-1994 by county, cohorts born in Norway 1907-1946. Age-standardized rate ratios for migrants and non-migrants



Data source: Statistics Norway.
Map data: Norwegian Mapping Authority.

Overall, the female cerebrovascular mortality in migrants showed the same level as the mortality among the non-migrants (Table 4), but there are wide geographical differences. The range in SRRs for women was much wider for migrants (approximately 2.5) than for non-migrants (approximately 1.5), and this is not likely to be caused only by smaller numbers increasing random variation.

The spatial pattern of female cerebrovascular mortality is examined in Figure 3. For non-migrants the map shows a spatial gradient with high mortality levels in the counties of East- and Mid-Norway and to the far north. These contrasts can also be observed for migrants, but it is less clear since high and low mortality counties are more scattered. The Spearman rank correlation coefficient for female mortality levels of non-migrants versus migrants at the county level was 0.40 (p=0.09).

High mortality ratios between migrants and non-migrants were observed in Sogn og Fjordane (1.40), Nord-Trøndelag (1.39), Vest-Agder (1.38), Aust-Agder (1.24), and Østfold (1.23). A very low ratio was observed in Finnmark (0.55), and low ratios were also found in Møre og Romsdal (0.74) and Oppland (0.76).

The total rate for Finnmark and Oslo was lowered by the presence of the migrant population by 10 and 8 percentage points, respectively. Both Vest-Agder and Nord-Trøndelag experienced an increase of 10 percentage points due to the presence of migrants.

Discussion and conclusions

Main findings summarized

The impact of migrants on regional levels of cerebrovascular mortality varies considerably by county and gender. Overall, the migrants experience the same cerebrovascular mortality level as the non-migrants, but there are great regional differences and ratios are observed both well below and well above unity. For example, in Akershus the level of cerebrovascular disease mortality for non-migrant males was higher than the national level, whereas the total county level for males was a little lower than the national level. Hence, due to their large number and low mortality level, the migrants masked the higher mortality risk of the non-migrants in Akershus.

Migrant males show a wider range in regional mortality levels than non-migrant males and the migrant females have a wider range than migrant males. The spatial pattern of high and low mortality levels for migrant males is quite different from the pattern for non-migrants, whereas the spatial pattern for migrant females differ less from the pattern observed for non-migrant females.

In about half of the counties the impact of migrants on the county total rate was in the opposite direction for males and females. This is e.g. obvious in Aust-Agder and Troms were female migrants have high mortality levels whereas male migrants have low levels.

The differential impact of migrants on a county's cerebrovascular mortality level in some cases resulted in the rank of a county, based on the rate ratio of the total study cohort of men or women, varying substantially from its rank based on the rate ratio of the non-migrant population. Furthermore, the cerebrovascular mortality difference between two counties may change direction when including or excluding the migrant population (e.g. for females in Østfold and Oppland). Migrant females in Finnmark showed the lowest cerebrovascular mortality level observed in this study (SRR_1=0.61), whereas the highest mortality level was observed among migrant females of Nord-Trøndelag (SRR_1=1.51). It is somewhat surprising that Hedmark differ that much from the neighbouring county Oppland, since they share many demographic and socio-economic characteristics. It is also intriguing that males in Trøndelag have average mortality levels (except migrants in Nord-Trøndelag), whereas females has high rates and even more so among migrant females.

A similar analysis of the influence of migrants on regional variations of ischaemic heart disease mortality in Norway has recently been reported (Nymoen 2002). Overall, cerebrovascular mortality and ischaemic heart disease mortality show county differences of the same magnitude, whereas cerebrovascular mortality shows greater variation between non-migrants and migrants.

Limitations of this study

The accuracy of information from registration of deaths and the population-at-risk estimates using the registry-based population census of 1990 is generally considered to be of high quality, and is not thought to represent important problems to this study. There can hardly be any inclusion bias in this study, but selective mortality or emigration before the start of this study may have an influence on the results reported here.

The random error associated with the SRR especially for small migrant populations in some counties are large, so these results should be interpreted with caution, and a longer follow-up period would be useful.

This study applies a rather crude measure of residential history. Migrants are defined as those people whose region/county of birth differed from their region/county of residence in 1990. Individuals could have migrated at any point of time after birth and could also have made multiple moves. Migration rates are

highly age dependent, and during the last decades the age pattern of Norwegian migrants has been highest in ages 15-29, intermediate for ages under 15 and 30-44, and low for ages 45-59 and very low for age 60 and above (see for instance Statistics Norway 1987).

Non-migrants are defined as those whose region/county of residence in 1990 was the same as their place of birth. This group will therefore include some migrants who moved back to their place of birth as well as migrants who moved shorter distances, for example between municipalities in the same county. Hence, this study neglects spatial aspects of cerebrovascular mortality related to the local geographical level as well as to a more complete residential history including places of birth and adolescence.

Social inequalities in regional mortality rates in Norway have been reported earlier (Borgan and Kristofersen 1986, Kristofersen 1990). Socio-economic factors are potential confounders in this study, since they might influence migration rates (Sørlie 1993) as well as cerebrovascular diseases mortality.

Future research

The useful contributions from regionalizing mortality data for population subgroups is demonstrated by the finding that from overall figures migrants seem to have the same risk of cerebrovascular mortality as non-migrants. Nevertheless, regionalized mortality figures for migrants show that considerable mortality differentials are covered up at the aggregate level. Further investigation of the influence of place of birth and selective patterns of migration for instance related to education needs to be done.

The relevance of geographical and individual data for more than the place of residence and period just before death is enhanced by etiological hypothesis emphasizing the long-term effects of different nutritional and other welfare conditions throughout the life course. For example poor living conditions very early in life is thought to increase the risk of suffering from cerebrovascular diseases in later life (Barker 1994). While the present study cannot dismiss that hypothesis, the observed results may also partly be due to selective migration. Further investigations of the role of age at migration and later mortality levels may contribute to a closer evaluation of early life experiences.

Reasons for migration as well as consequences of migration may be related to health. Both high and low relative mortality rates where observed among migrants and the migration itself is not likely to be the only factor behind the results of this study. Due to the considerable regional variations in the influence of migrants on regional mortality levels, the possibility of a healthy migrant selection effect is especially intriguing, and need to be investigated in depth. Gender differentials of residential history and cerebrovascular mortality should be explored further.

Conclusions

This is the first study that relates Norwegian data on mortality of cerebrovascular disease to the migratory status of individuals in the regional population at risk. In spite of the limitations of this study, the results indicate that even the crude definition of migration applied here add significant nuances to the understanding of regional mortality patterns. The findings of this study show that the regional distribution of cerebrovascular disease mortality in Norwegian counties and main regions for the period 1991-1994 was influenced by but not dominated by the mortality of the migrant populations. Failure to take into account migration status may lead to erroneous causal interpretations and inefficient recommendations for health care planning and interventions. This is new knowledge concerning regional mortality of cerebrovascular disease in Norway and may inform future interpretation of regional mortality patterns.

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