Cancer incidence in non-immigrants and immigrants in Norway

[AQ0]

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ABSTRACT

Background: Major cancers are associated with lifestyle, and previous studies have found that the non-immigrant populations in the Nordic countries have higher incidence rates of most cancers than the immigrant populations. However, rates are changing worldwide – so these differences may disappear with time. Here we present recent cancer incidence rates among immigrant and non-immigrant men and women in Norway and investigate whether previous differences still exist.**Material and methods:** We took advantage of a recent change in the Norwegian Cancer Registry regulations that allow for the registry to have information on country of birth. The number of person years for 2014–2018 was aggregated for every combination of sex, five-year age-group and country of birth, by summing up each year's population in these groups. The number of cancer cases was then counted for the same groups, and age-standardised incidence rates calculated by weighing the age-specific incidence rates by the Nordic and World standard populations. Further, we calculated incidence rate ratios using the non-immigrant population as a reference.**Results:** Immigrants from Eastern Europe, the Middle East, Africa and Asia had lower incidence of total cancer compared to the non-immigrant population in Norway and immigrants born in the other Nordic or high-income countries. However, some cancers were more common in certain immigrant groups. Asian men and women had threefold the incidence of liver cancer than non-immigrant men and women. Men from the other Nordic countries and from Eastern Europe had higher lung cancer rates than non-immigrant men.**Conclusion:** National registries should continuously monitor and present cancer incidence stratified on important population subgroups such as country of birth. This can help assess population subgroup specific needs for cancer prevention and treatment, and could eventually help reduce the morbidity and mortality of cancer.

Keywords: Cancer incidence ; immigrants ; age-standardised rates [AQ3]

Background

The change in demography of the Nordic countries over the past decades has been substantial. From being a homogeneous Caucasian population, the countries have attained a more diverse population that consists of around 15.7% immigrants and children of immigrants (2017) [1]. The immigrant population itself is diverse; Norway, Sweden, Denmark and to some extent Finland have a large number of immigrants with a European or Asian background, in addition to refugees from countries such as Syria, Iraq, Somalia and Eritrea. Iceland has mostly European immigrants (from Poland, Lithuania and Germany). The immigrant population is younger than the non-immigrant or total population, e.g., in Norway, 57% of the total population and 72% of the immigrant population are below the age of 44 years [2].

There are significant variations in risk factors for cancer across immigrant groups, and some cancer types have been found to be less common among certain immigrant groups compared to non-immigrants, and vice versa [3,4].

Length of stay and age distribution are factors that can influence the prevalence of risk factors [3]. Country of birth and reason for immigration may define specific subpopulations of immigrants, such as construction workers, refugees etc. An association between country of birth/reason for immigration and socioeconomic status (SES) can also be a factor contributing to the differences [5].

Both we and others have previously found differences between non-immigrants and immigrants with respect to cancer rates [6–9]. In general, cancer rates are higher in the non-immigrant populations than in the immigrant groups, with some exceptions. In Sweden, a higher incidence was observed for liver, stomach, oesophageal and nasopharyngeal cancers in immigrants from low-income countries [7,8] and in Denmark, a higher incidence was observed for lung cancer in immigrant men from Eastern Europe [9].

In Norway, including data from the years 1990–2012, we found that most cancers were more common in the non-immigrant population, and, similarly to the findings from Sweden and Denmark, we found more lung cancer in Eastern European men and more liver cancer in men and women from Asia and Africa [6]. However, rates can change as immigrants age and as new immigrants with different risk profiles enter the country. The aim of the current study was to investigate if these differences still persisted. We therefore took advantage of a recent change in Norwegian regulations to focus on the incidence rates the past five years (2014–2018). Here we present overall and site-specific age-standardised cancer incidence rates (ASRs) and incidence rate ratios (IRRs) among immigrant and non-immigrant men and women in Norway and investigate whether previous differences still exist.

Material and methods

The Cancer Registry of Norway has monitored cancer incidence in the Norwegian total population since 1953, and the registry has been found to be more than 95% complete [10]. The registry reports rates on solid and non-solid tumours and have information on localisation, the extent of the disease and treatment. In addition, the registry manages clinical registries with more site-specific pathology and clinical information on eight main cancers (prostate, breast, lung, colorectal, melanoma, lymphoid cancers, ovary and paediatric cancers). Data from the registry are continuously linked with data from the population and death registries to obtain information on vital status and cause of death. The registry can also be linked to other national registries through a unique 11-digit personal identification number assigned all newborns and people residing in Norway [10]. Country of birth became available when the Cancer Registry regulations were changed in 2018 [11].

Design and population

We conducted a cohort analysis on the population of Norway from 2014–2018. Individuals born in Norway or abroad with Norwegian-born parents were defined as non-immigrants. Included in this group are individuals born in Norway with foreign-born parents. Individuals born outside of Norway with foreign-born parents were defined as immigrants.

Data collection and country categorisation

The Cancer Registry of Norway reports on annual numbers and ASRs the past five years on a regular basis. This article is an expansion of the annual statistical analyses of the data from 2014–2018 [12]. Total cancer is defined as incident cases of all malignant neoplasms (ICD-10 C00-96) and includes the following D-diagnoses: D32-33, D35.2-35.4, D42-43, D44.3-44.5 and D45-47, but excludes all basal cell carcinomas from all topographies. For further details on multiple primary rules and detailed ICD definitions for each site, please see the Cancer in Norway report [12].

The dataset analysed included number of cases and person years, five-year age groups, gender and country of birth. Countries of birth were further collapsed into regions, because of small numbers of cancer cases in some countries of birth. We used the following regions: other Nordic countries, other high-income countries (the rest of Western Europe, North America and Oceania), Eastern Europe, Baltics and Balkans, the Middle East and Africa, and Asia (Supplementary Table 1).

Statistical analyses

The number of person years for 2014–2018 was aggregated for every combination of sex, five-year age-group and region of birth, by summing up each year's population in these groups. The number of cancer cases was then counted for the same groups, and ASRs calculated by weighing the age-specific incidence rates by the Nordic standard population [13]. Supplementary Figure 1 shows the age distribution among non-immigrants and immigrants.

In additional analyses we calculated ASRs standardised by the World standard population as proposed by Segi [14] and modified by Doll et al. [15]. For ASRs calculated over the past five years with the Norwegian population as the standard, we refer to the annual publication Cancer in Norway [16].

The rates are presented per 100,000 person years in the five-year time period 2014–2018. ASRs should then be independent of the age effect, thus permitting a comparison of cancer incidence between groups with a different age composition over time. We estimated 95% confidence intervals (CI) for the age-adjusted rates and assumed that the incidence followed the Poisson distribution.

Additionally, we calculated incidence rate ratios IRRs with the non-immigrant population as reference (Supplementary Table 2).

The statistical analyses were undertaken with Stata, version 16 (Statacorp. 2018, College Station, TX, USA).

Results

During the follow-up from 2014–2018, the average number of individuals living in Norway was 5,284,571 (2,664,212 men and 2,620,359 women), of which 821,922 individuals were defined as immigrants (428,453 men and 393,469 women). The study included 90,670 cancer cases among men and 77,730 cases among women, where 6795 (7.5%) had been diagnosed among immigrant men and 6320 (8.1%) among immigrant women. This is equivalent to an average of 16,775 non-immigrant men and 14,282 non-immigrant women, and 1359 immigrant men and 1264 immigrant women, being diagnosed with cancer each year. The population of immigrants is substantially younger than the non-immigrant population (Supplementary Figure 1).

Figure 1 shows the ASRs for total cancer by region of birth among men and women. The ASRs for non-immigrants (732.5 in men and 561.8 in women) exceeded the ASRs for all the immigrant groups. Immigrants from the other Nordic countries and from other high-income countries had ASRs similar to non-immigrants, whereas immigrants from Eastern Europe, Baltics and Balkans (hereafter called Eastern Europe), the Middle East, Africa and Asia had lower ASRs.

Figure 1. Age-standardised rates (ASRs) per 100,000 personyears for total cancer (C00-96) by birth region, 2014–2018. Standardised by the Nordic standard population. Adjusted for age in five-year categories. CI: confidence interval.

	Cases	Personyears	ASR (95% CI)
Total cancer, men			
Non-immigrants	83 875	11 178 792	732.5 (727.5-737.6)
Other Nordic countries	1 319	223 437	694.7 (652.9-738.5)
Western Europe, North America and Oceania	1 461	298 835	677.8 (638.1-719.1)
Eastern Europe, Baltics and Balkans	1 247	742 508	482.1 (440.1-526.5)
Middle East and Africa	824	450 534	441.7 (393.1-494.1)
Asia	624	302 076	407.9 (367.2-451.4)
Total cancer, women			
Non-immigrants	71 410	11 134 451	561.8 (557.6-566.0)
Other Nordic countries	1 193	218 442	497.3 (469.1-527.0)
Western Europe, North America and Oceania	1 147	246 236	508.1 (478.1-539.5)
Eastern Europe, Baltics and Balkans	1 361	565 629	432.0 (400.7-464.8)
Middle East and Africa	605	355 184	333.0 (293.8-375.6)
Asia	1 068	440 252	336.0 (307.7-366.1)

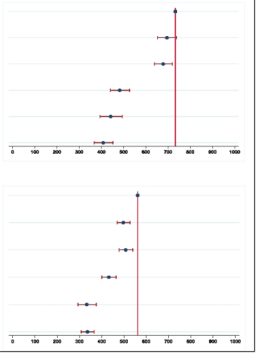
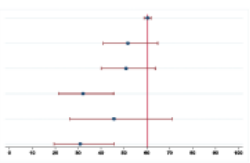


Figure 2 shows that the ASR for colon cancer was high among non-immigrant men (ASR 60.3) and somewhat lower among other Nordic men (ASR 51.7) and men from other high-income countries (ASR 50.9). Men from the Middle East and Africa had an ASR of 45.6, while men from Eastern Europe and Asia had even lower ASRs of 32.1 and 30.9, respectively. Among women, colon cancer was also most common in the Nordic countries (ASR 52.3) and especially among non-immigrant women (ASR 55.7). Women from other high-income countries had somewhat lower ASR (43.3). Incidence rates were substantially lower among women from Eastern Europe (ASR 28.8), Asia (ASR 20.5) and especially the Middle East and Africa (ASR 15.4). Figure 2 also shows that non-immigrant men had the

highest ASR for cancer of the rectum (33.1), and that rates for other Nordic men (ASR 30.0) and men from other high-income countries (ASR 29.0) were similar. ASRs for Eastern European (11.6), Middle Eastern and African (15.1) and Asian (16.2) men were substantially lower. Non-immigrant women had the highest ASR of cancer of the rectum (20.0), compared to all immigrant groups, about double the ASR compared to other Western (10.7) as well as Asian (9.5) women.

Figure 2. Age-standardised rates (ASRs) per 100,000 personyears for colon (C18) and rectal (C19-20) cancer by birth region, 2014–2018. Standardised by the Nordic standard population. Adjusted for age in five-year categories. CI: confidence interval.

	Cases	Personyears	ASR (95% CI)
Colon cancer, men			
Non-immigrants	6 748	11 178 792	60.3 (58.8-61.8)
Other Nordic countries	99	223 437	51.7 (40.9-64.7)
Western Europe, North America and Oceania	97	298 835	50.9 (40.0-63.7)
Eastern Europe, Baltics and Balkans	69	742 508	32.1 (21.5-45.5)
Middle East and Africa	49	450 534	45.6 (26.4-71.0)
Asia	34	302 076	30.9 (19.4-45.8)
Colon cancer, women			
Non-immigrants	7 404	11 134 451	55.7 (54.4-57.0)
Other Nordic countries	121	218 442	52.3 (43.3-62.9)
Western Europe, North America and Oceania	88	246 236	43.3 (34.4-53.6)
Eastern Europe, Baltics and Balkans	67	565 629	28.8 (20.3-39.3)
Middle East and Africa	27	355 184	15.4 (8.4-25.6)
Asia	49	440 252	20.5 (13.2-30.1)

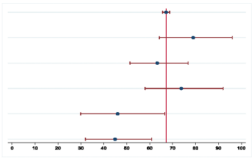


	Cases	Personyears	ASR (95% CI)
Rectal cancer, men			
Non-immigrants	3 805	11 178 792	33.1 (32.1-34.2)
Other Nordic countries	58	223 437	30.0 (21.9-40.2)
Western Europe, North America and Oceania	58	298 835	29.0 (21.0-38.8)
Eastern Europe, Baltics and Balkans	43	742 508	11.9 (6.8-19.1)
Middle East and Africa	39	450 534	15.1 (8.6-24.8)
Asia	31	302 076	16.2 (9.9-24.8)
Rectal cancer, women			
Non-immigrants	2 581	11 134 451	20.0 (19.3-20.8)
Other Nordic countries	35	218 442	14.3 (9.9-20.3)
Western Europe, North America and Oceania	24	246 236	10.7 (6.8-16.2)
Eastern Europe, Baltics and Balkans	31	565 629	13.6 (8.3-20.7)
Middle East and Africa	16	355 184	13.1 (4.9-26.3)
Asia	30	440 252	9.5 (5.6-15.3)

Figure 3 shows that non-immigrant men ~~from Norway~~ (ASR 67.2), men from the other Nordic countries (ASR 79.0) and other high-income countries (ASR 63.3), as well as Eastern Europe (ASR 73.8), had similar incidence of lung cancer. Men from the Middle East and Africa (ASR 46.0) and Asia (ASR 44.9) had lower ~~ASR~~rates. Non-immigrant women had an ASR of 55.0, higher than women from other high-income countries (ASR 47.2), Eastern Europe~~an~~ (ASR 44.7) and other Nordic countries (ASR 41.0). Women from Asia had a lower ASR (31.4), and women from the Middle East and Africa had around 70% lower incidence of lung cancer compared to non-immigrant women (ASR 17.3).

Figure 3. Age-standardised rates (ASRs) per 100,000 personyears for lung cancer (C33-34) by birth region, 2014–2018. Standardised by the Nordic standard population. Adjusted for age in five-year categories. CI: confidence interval.

	Cases	Personyears	ASR (95% CI)
Lung cancer, men			
Non-immigrants	7 743	11 178 792	67.2 (65.6-68.7)
Other Nordic countries	126	223 437	79.0 (64.2-96.0)
Western Europe, North America and Oceania	130	298 835	63.3 (51.4-76.8)
Eastern Europe, Baltics and Balkans	160	742 508	73.8 (58.0-92.0)
Middle East and Africa	59	450 534	46.0 (29.9-66.6)
Asia	63	302 076	44.9 (32.0-60.8)
Lung cancer, women			
Non-immigrants	7 266	11 134 451	55.0 (53.8-56.3)
Other Nordic countries	96	218 442	41.0 (33.1-50.4)
Western Europe, North America and Oceania	97	246 236	47.2 (38.1-57.9)
Eastern Europe, Baltics and Balkans	94	565 629	44.7 (34.2-56.9)
Middle East and Africa	23	355 184	17.3 (9.2-29.1)
Asia	59	440 252	31.4 (21.5-43.9)

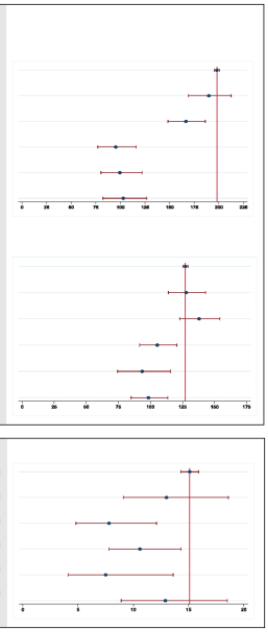


For melanoma of the skin, ASRs varied considerably, from 46.0 in non-immigrant men to 1.8 in men from Asia (Supplementary Figure 2). For women, non-immigrants had the highest ASR (41.7), followed by other Nordic women (ASR 34.6) and women from other high-income countries (ASR 29.2). Women from the Middle East and Africa had an ASR of 4.8 and from Asia 0.3.

Cancer of the prostate was the most common cancer type among non-immigrant men, with an ASR of 197.9 (Figure 4). Men from the other Nordic countries had an ASR of 189.7 and men from other high-income countries 166.4. Immigrant men from other countries had considerably lower ASRs of prostate cancer; 95.2 in men from Eastern Europe, 99.3 in men from the Middle East and Africa and 102.8 in men from Asia.

Figure 4. Age-standardised rates (ASRs) per 100,000 personyears for prostate (C61), breast (C50), and cervical (C53) cancer by birth region, 2014–2018. Standardised by the Nordic standard population. Adjusted for age in five-year categories. CI: confidence interval.

	Cases	Personyears	IR (95% CI)
Prostate cancer			
Non-immigrants	23 712	11 178 792	197.9 (195.3-200.5)
Other Nordic countries	380	223 437	189.7 (169.1-212.3)
Western Europe, North America and Oceania	378	298 835	166.4 (148.2-186.2)
Eastern Europe, Baltics and Balkans	176	742 508	95.2 (76.9-115.9)
Middle East and Africa	158	450 534	99.3 (80.1-121.7)
Asia	130	302 076	102.8 (82.1-126.6)
Breast cancer, women			
Non-immigrants	15 499	11 134 451	127.2 (125.2-129.3)
Other Nordic countries	317	218 442	127.8 (114.0-143.0)
Western Europe, North America and Oceania	332	246 236	137.9 (122.9-154.1)
Eastern Europe, Baltics and Balkans	394	565 629	105.3 (91.5-120.5)
Middle East and Africa	192	355 184	93.5 (74.4-115.7)
Asia	357	440 252	98.4 (84.9-113.5)
Cervical cancer			
Non-immigrants	1 566	11 134 451	15.1 (14.3-15.9)
Other Nordic countries	35	218 442	13.0 (9.1-18.6)
Western Europe, North America and Oceania	22	246 236	7.8 (4.8-12.1)
Eastern Europe, Baltics and Balkans	71	565 629	10.6 (7.8-14.3)
Middle East and Africa	23	355 184	7.5 (4.1-13.6)
Asia	67	440 252	12.9 (8.9-18.5)



Breast cancer was the most common cancer type among non-immigrant women (ASR 127.2), women from the other Nordic countries (ASR 127.8) and women from other high-income countries (ASR 137.9) (Figure 4). Women from other countries had lower incidence of breast cancer; women from Eastern Europe had an ASR of 105.3, from Asia 98.4 and from the Middle East and Africa 93.5.

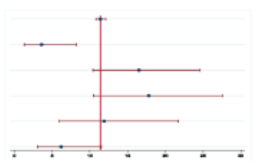
Non-immigrant women had the highest ASR of cervical cancer (15.1), followed by women from the other Nordic countries (13.0) and from Asia (12.9) (Figure 4). Women from Eastern Europe had an ASR of 10.6, while women

from other high-income countries, and the Middle East and Africa had around 50% lower incidence than non-immigrant women, with ASRs of 7.8 and 7.5 respectively.

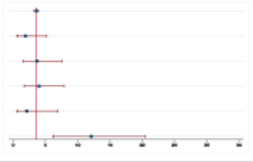
Stomach and liver cancer (Figure 5) displayed somewhat different trends. Eastern European men and women had high incidence of stomach cancer, with ASRs of 17.8 and 9.6, respectively. Men from other high-income countries also had high incidence (ASR 16.5), as did Asian women (ASR 9.9). In comparison, non-immigrant men and men from the Middle East and Africa had about the same ASRs (11.4 and 11.9, respectively) and men from the other Nordic countries and Asia had lower ASRs (3.6 and 6.2, respectively). Non-immigrant women and women from the other immigrant groups had similar ASRs, ranging from 5.0 to 6.0. Men and women from Asia had high incidence of liver cancer (ASRs 18.4 in men and 12.1 in women), as did men from the Middle-East and Africa (ASR 16.4). Non-immigrant men and women, and men and women from the other immigrant groups, had lower ASRs, ranging from 4.0 to 7.2 in men and from 1.9 to 4.0 in women.

Figure 5. Age-standardised rates (ASRs) per 100,000 personyears for stomach (C16) and liver (C22) cancer by birth region, 2014–2018. Standardised by the Nordic standard population. Adjusted for age in five-year categories. CI: confidence interval.

	Cases	Personyears	ASR (95% CI)
Stomach, men			
Non-immigrants	1277	11 178 792	11.4 (10.8-12.1)
Other Nordic countries	7	223 437	3.6 (1.3-8.2)
Western Europe, North America and Oceania	28	298 835	16.5 (10.4-24.6)
Eastern Europe, Baltics and Balkans	44	742 508	17.8 (10.5-27.6)
Middle East and Africa	29	450 534	11.9 (5.9-21.7)
Asia	15	302 076	6.2 (3.1-11.5)
Stomach, women			
Non-immigrants	765	11 134 451	5.7 (5.3-6.1)
Other Nordic countries	12	218 442	5.0 (2.6-9.3)
Western Europe, North America and Oceania	12	246 236	5.3 (2.6-9.5)
Eastern Europe, Baltics and Balkans	29	565 629	9.6 (5.2-15.9)
Middle East and Africa	11	355 184	6.0 (1.6-14.7)
Asia	16	440 252	9.9 (4.4-18.2)



	Cases	Personyears	ASR (95% CI)
Liver, men			
Non-immigrants	797	11 178 792	7.0 (6.5-7.5)
Other Nordic countries	9	223 437	4.0 (1.7-8.6)
Western Europe, North America and Oceania	17	298 835	7.2 (3.8-12.3)
Eastern Europe, Baltics and Balkans	20	742 508	6.5 (2.6-13.1)
Middle East and Africa	22	450 534	16.4 (7.4-30.2)
Asia	33	302 076	18.4 (11.0-28.6)
Liver, women			
Non-immigrants	472	11 134 451	3.6 (3.2-3.9)
Other Nordic countries	5	218 442	1.9 (0.6-5.2)
Western Europe, North America and Oceania	7	246 236	3.7 (1.5-7.6)
Eastern Europe, Baltics and Balkans	12	565 629	4.0 (1.7-7.9)
Middle East and Africa	4	355 184	2.1 (0.6-6.9)
Asia	19	440 252	12.1 (6.2-20.5)



Additional analyses standardised with the World standard population are shown in Supplementary Figures 3–8. Cancers that have the highest incidence rates in the oldest age groups were more affected by changes to this standard, i.e., the World standard has lower weights for the oldest age groups, and we observed the largest differences between standard populations in ASRs for lung, colorectal and prostate cancer.

Additional analyses presenting IRRs showed lower rates for total cancer in immigrants from Eastern Europe (IRR 0.62, 95% CI 0.59–0.66 for men and IRR 0.76, 95% CI 0.72–0.81 for women), the Middle East and Africa (IRR 0.68, 95% CI 0.64–0.73 for men and IRR 0.64, 95% CI 0.59–0.70 for women) and Asia (IRR 0.54, 95% CI 0.50–0.59 for men and IRR 0.68, 95% CI 0.64–0.72 for women) compared to the non-immigrant population. Men from Eastern Europe had a higher rate of lung cancer (IRR 1.32, 95% CI 1.13–1.54), and immigrants from all regions had higher

rates of stomach and liver cancer compared to non-immigrants (e.g., for stomach cancer; immigrants from Asia had IRRs of 3.85, 95% CI 2.71–5.48 for men and IRR 3.29, 95% CI 2.10–5.24 for women) (Supplementary Table 2).

Discussion

In this paper, we have reported that immigrants from Eastern Europe, the Middle East, Africa and Asia have lower incidence of total cancer compared to the non-immigrant population in Norway, as well as immigrants born in the other Nordic or other high-income countries. This is because of lower incidence of some of the major lifestyle-related cancer types, such as colon, rectal, melanoma and breast. On the other hand, some cancers are more common in certain immigrant groups than in non-immigrants, such as liver cancer, where Asian men and women have threefold the incidence of non-immigrant men and women, and lung cancer, where men from the other Nordic countries and from Eastern Europe have higher ASRs than non-immigrant men.

We have previously examined differences between immigrants and non-immigrants using data from 1990–2012, where an average of 11,449 non-immigrant men and 10,218 non-immigrant women, and 398 immigrant men and 449 immigrant women, were diagnosed with cancer every year [6]. Our current results show that differences in incidence between the non-immigrant and immigrant population in general persist, however the high incidence of lung cancer among Eastern European men and men from the other Nordic countries is not as prominent.

Differences in incidence between non-immigrants and immigrants have also been shown by others, both in Sweden [7,8] and Denmark [9]. Results from studies on survival points towards similar or better survival in immigrants compared to the non-immigrant populations in Norway, Sweden and Denmark [17–20], with some exceptions in breast cancer and melanoma [7,19,20].

It has been argued that some of the difference in incidence could be due to lower participation in screening programs. In Norway, studies have found that immigrants have lower attendance to screening than non-immigrants [21–23]. Among women who are not yet in screening-age (under 50 years of age), more advanced stage of breast cancer have been found among women from low-income countries [24].

Existing knowledge on cancer incidence among immigrant groups is based on stand-alone studies, because country of birth has not been registered as a variable in the Nordic cancer registries. As long as Nordic countries, as well as Nordcan [13] and Globocan [25], publish cancer incidence rates for the total population, without stratifying on country of birth, we may mask important changes over time, or over interpret changes in rates that are truly due to changing demographics.

When only one set of rates is presented, large groups of immigrants with low risk of cancer could artificially reduce the country's incidence rates. Similarly, an increase in the number of immigrants with a higher incidence of a certain type of cancer compared to the non-immigrant population could result in an apparent increase in the country's incidence rate for that cancer. One example is the increasing incidence of liver cancer in the Nordic countries [13]. Could this be attributed to an increasing proportion of immigrants from countries with a high incidence of this type of cancer, i.e., countries in Asia and Africa? A study from Sweden found that immigration increases the incidence of and need for treatment for liver cancer [26]. However, in Norway, we concluded that the overall increase in liver cancer was also found in non-immigrants [27].

Lung cancer is another example of a type of cancer with high mortality that should be monitored closely. While the incidence of lung cancer in Nordic men is decreasing, this is not yet visible in women [13]. We have hoped this is because of a fall in the proportion of men who are smokers, however the marked decline could also be partially caused by an increase in the proportion of non-smoking immigrants [28]. In our previous study [6] we found lung cancer to be significantly higher among Eastern European men and men from the other Nordic countries; however, in this study the differences are not as prominent. One reason could be that the type of immigrant workers from Eastern European countries has changed over time, and that more recent immigrants are less likely to smoke. Another reason could be that smoking prevalence in their countries of birth has declined, and the more recent immigrants reflect the current lower smoking rates. Also, due to changes in the immigrant population, the current definition of Eastern Europe was expanded to the North-West to include the Baltic countries and to the South-West by including the Balkan countries.

Incidence of prostate cancer is also slowly decreasing in the Nordic countries [13]. This could be attributed to a higher proportion of immigrants in the populations, but could also be explained by lower rates of detection, i.e., we

could be past the incidence peak following the introduction of prostate-specific antigen (PSA) testing. One example of this is the county of Oslo in Norway, where rates of prostate cancer have been decreasing significantly [29] while the city has accumulated a large population of immigrants with around half the incidence of prostate cancer compared to non-immigrants. Thus interpreting both increases and declines in cancer rates over time can become meaningless without examining rates by population subgroup, e.g., country of birth.

As the relatively young immigrant population grows older, more cases of cancer will most likely occur~~present themselves~~. Differences between immigrants and non-immigrants may remain, but will most likely become smaller. Immigrants tend to change their cancer incidence as they adapt to the culture and lifestyle of the population in their new home country, dependent on age at immigration and length of stay [30]. Thus with time, as immigrants adapt their culture to that of the new country, one expects the incidence of the immigrant population to approach that of the new country. However, rates are unlikely to become identical for several reasons. Some habits or dietary preferences may not change. Further, immigrants might have less access to health services because of language barriers or low degree of integration [31]. Low income and socioeconomic status is associated with less participation in cancer screening, later stage at detection and poorer cancer survival [32–34]. Immigrants, especially from Africa and Asia, tend to have lower income [35] and education [36] than the general population. Differences in cancer incidence also depend on lifestyle; i.e., diet, smoking, alcohol use or physical activity level, and depending on the level of acculturation, lifestyle factors could differ between immigrants and non-immigrants. In Norway diets are healthier and alcohol consumption lower in certain immigrant groups, while physical inactivity and smoking prevalence is higher in immigrants from certain countries [3,4]. Other factors to be taken into consideration when assessing cancer risk among immigrants are reasons for immigration, which may vary across immigrant groups [37]. In general, those who migrate for employment, family or~~and~~ study reasons report better health outcomes than non-immigrants, while those who migrate to seek asylum report worse health outcomes than non-immigrants [38].

There are differences in cancer incidence across geographic regions and populations in the world, however the cancer rates in the immigrants' countries of birth cannot directly be used as a description of their disease risk, if overall health of immigrants is better than in the general population in the country of which they emigrated. This 'healthy migrant effect' has been well described previously [39].

A strength of this study is the large study population, which constitutes the population of~~in~~ Norway in total, over a given period of time. Data from the Cancer Registry of Norway have shown to be near to complete and have a high validity [10], providing a reliable picture of cancer incidence among both the non-immigrant and the immigrant population.

A limitation of the study is that the broad geographic groups we used of immigrants are possibly very heterogeneous, and thereby may have masked important variations by country of birth. However investigating group differences still have empirical value. Additionally, immigration patterns to Norway have shifted over time, and older and younger immigrants, with different reason for immigration, originate from different countries. Another limitation is that the immigrant population in Norway is relatively young and has not yet reached the age groups characterised with high lung, colorectal and prostate cancer rates. If immigrants adapt to the Norwegian lifestyle, then rates of some cancer may increase as the immigrants age, and with time since immigration. However, the estimates presented should not be affected by the different age-distributions. The ASRs are standardised, i.e., adjusted for the effect of differences in age-distribution across populations. It should be noted that ASRs with the Nordic standard result in rates that are about twice the size of ASRs with the World standard, since the World standard has lower weights for the oldest age groups.

Immigrants have greater emigration rates than non-immigrants [40], and some immigrants may emigrate back to their country of birth without notifying the Norwegian population registry. The 'salmon bias' hypothesis suggests that as immigrants age or fall ill they migrate back to their country of birth [41]. The extent to which missing or incorrect emigration data may have influenced our results could not be examined. We included individuals born in Norway of immigrant parents in the non-immigrant population, but if they have rates in between immigrants and Norwegian-born with Norwegian-born parents, then the differences may have been underestimated. However, this was a small group, consisting of young individuals not yet reached the age where cancer normally occurs.

Conclusion

Given the substantial and persisting differences in cancer incidence between non-immigrants and immigrants, and between the immigrant groups, it is likely that population cancer rates will be affected. Simply reporting overall rates of the general population does mask the diversities arising from country of birth.

It is important that both health authorities and health care personnel are attentive of cancer incidence in subgroups of the population. To ensure our health care systems cater to everyone, all national registries must start monitoring and presenting cancer incidence stratified on important population subgroups such as country or larger geographic regions of birth. This would also help assess population subgroup specific needs for cancer prevention and treatment, and could eventually help reduce the morbidity and mortality of cancer.

Disclosure statement

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