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Cancer mortality rates among first and second generation migrants in the Netherlands: Convergence toward the rates of the native Dutch population

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This study investigates the difference in cancer mortality rates between migrant groups and the native Dutch population, and determines the extent of convergence of cancer mortality rates according to migrants' generation, age at migration and duration of residence. Data were obtained from the national cause of death and population registries in the period 1995–2000. We used Poisson regression to compare the cancer mortality rates of migrants originating from Turkey, Morocco, Surinam, Netherlands Antilles and Aruba to the rates for the native Dutch. All-cancer mortality among all migrant groups combined was significantly lower when compared to that of the native Dutch population (RR = 0.55, CI: 0.52–0.58). For a large number of cancers, migrants had more than 50% lower risk of death, while elevated risks were found for stomach and liver cancers. Mortality rates for all cancers combined were higher among second generation migrants, among those with younger age at migration, and those with longer duration of residence.

This effect was particularly pronounced in lung cancer and colorectal cancer. For most cancers, mortality among second generation migrants remained lower compared to the native Dutch population.

Surinamese migrants showed the most consistent pattern of convergence of cancer mortality. The generally low cancer mortality rates among migrants showed some degree of convergence but did not yet reach the levels of the native Dutch population. This convergence implies that current levels of cancer

mortality among migrants will gradually increase in future years if no specific preventive measurements are taken.

While molecular epidemiology has identified several examples of genetically determined differences between races, classical epidemiology has shown that the environment and lifestyle predominates in determining cancer incidence.[1,2] The role of the environment and behavior is particularly visible in the changing incidence and mortality rates of cancer among migrant populations. Many migrant studies on cancer have shown that the initially different levels of cancer incidence and mortality of migrant groups gradually converge toward the levels of the new host population.[3–16] At present, it is still not known how quickly the convergence develops, and how the pace of convergence may differ according to migrant group and type of cancer. This information would better position the role of environmental factors as well as provide knowledge for more rational planning of specific preventive and curative health services for migrant populations.

About 10% of the population of the Netherlands is currently of nonwestern foreign origin.[17] The largest migrant groups originate from Turkey, Morocco, and the former Dutch colonies in South America and the Caribbean (Surinam and Netherlands Antilles/ Aruba). Turkish and Moroccans are mostly labor migrants followed by their immediate family and descendants for family reunification. Surinamese came to the Netherlands more recently with the independence of Surinam as a Dutch colony.

Existing cancer registries in the countries of origin of these migrant groups provide indication for lower cancer incidence and mortality for most cancers compared to the European population.[18,19] In the Netherlands and other European countries, the overall cancer incidence and mortality among Turkish and Moroccan migrants was reported to be lower when compared to those among the native population in the destination countries,[5,6,20] although some variations depending on cancer type and country of origin were observed.[21,22] Previous Dutch studies covered only a few types of cancer and were restricted to the first generation migrants living in specific regions. In addition, no information was available on the migrants' age at immigration. As a result, little is known about the rate of convergence of cancer mortality of migrants compared to the native Dutch population.

This knowledge is of particular importance in view of the increasing number of ageing migrant populations in the Netherlands in the forthcoming decades. Rapid and persistent convergence would imply that migrant populations would require a greater share in the use of the cancer care services. Therefore, information on the rate of convergence of cancer incidence is important to better estimate future developments in the burden of cancer mortality and morbidity and demand for specific oncologic care among migrant groups.

The objective of the study was to determine the extent and the rate of convergence of cancer mortality rates among second and second generation immigrant population toward the rates of the native Dutch population. We use national level data on the mortality from the major cancer types according to migrants' generation, their age at migration and their duration of residence in the Netherlands.

DATA AND METHODS

We used data for the years 1995 through 2000. By means of personal identification numbers, we linked data from the cause of death registry to data of the municipal population registers. These data sources include all legal residents of the Netherlands. The population register in the Netherlands is based on an ongoing process of data update of population numbers by recording all births, deaths (regardless whether occurred in the Netherlands or abroad), immigrations, emigrations and remigrations. Deaths and corresponding population numbers are from the same source.

[TABLE 1]

The causes of death were coded according to the ICD-9 for 1995, and according to ICD-10 for 1996–2000. We selected all major types of cancer from which the total number of deaths in the study period was close to or exceeded 2,000 cases. The cancer types selected for the study and their ICD codes are given in Table II.

Legal residents entered the study throughout the study period (open cohort design). For each legal resident, the amount of person time was calculated. All data on deaths and persons-years at risk were tabulated according to sex, date of birth (classified in 5 age groups), country of origin, 6-digit postal code and marital status.

These sociodemographic indicators were previously shown to be related to cause-specific mortality.[22] All immigrants, in addition, were classified by generation and date of immigration, based on which we calculated age at immigration and duration of residence.

We used country of birth to identify ethnic groups. Residents were categorized as nonnative if they or one of their parents was born abroad. We thus followed a definition used by Statistics Netherlands widely accepted among health researchers in the Netherlands.[17] According to this definition, in mixed ethnic minority families, the country of birth of the mother predominated.

Age at immigration and duration of residence were established on the basis of the latest known date of immigration into the Netherlands.

If a person immigrated to the Netherlands, emigrated consecutively, and immigrated again to the Netherlands, the most recent date of immigration determined the year of immigration.

We classified year of immigration in such a manner that there was a substantive variation in duration of residence between the 3 groups (prior to 1980, 1980–89 and 1990 or later) while maintaining sufficiently large numbers of residents in each group.

Data included characteristics of neighborhood of each person's place of residence that was based on the 6-digit postal code. For our study, we used information on degree of urbanization (addressdensity per square kilometer, classified into 5 categories) and mean household equivalent income of all households in the neighborhood (classified into the 10 deciles for the total population).[23] The size of the difference in cancer mortality rates between migrant groups and the native Dutch population was calculated using Poisson regression (in Stata software, version 7). All relative risks (RRs) were adjusted for age, sex, marital status, urbanization level and area income.

To estimate the rate of change of cancer mortality, we examined the difference in mortality rates according to generation, age at migration, and duration of residence within migrant groups. To determine the extent to which migrant groups have approached the cancer mortality rates of the native Dutch population, we compared the cancer mortality rates between Dutch and immigrant groups.

RESULTS

Compared to the native Dutch, all migrant groups were much younger and lived in more urbanized and lower income areas (Table I).

More migrants belonged to the first generation and migrated at the age of 15–30 years. About 50% of Turkish and Moroccan migrants arrived before 1985. This percentage was slightly higher for Surinamese, but lower for Antilleans and Arubans.

Most deaths from malignant conditions occurred among the native Dutch people (172,007 deaths, Table II and Appendix Table I).

Among migrants, Surinamese had the largest numbers of death (708), followed by Turkish (350 deaths), Moroccans (211 deaths), and Antillean/Aruban populations (185 deaths). Lung cancer was the most frequent cause of death for all population groups, with the exception of Antilleans/Arubans, among whom breast cancer caused most deaths.

The mortality rate from all cancers combined and for all migrant groups combined was significantly and substantially lower than the rate of the native Dutch population (RR = 0.55,

CI: 0.52–0.58). Relative risks varied between 0.40 for Moroccans and 0.78 for Antilleans/ Arubans. For a large number of cancers, migrants had 50% or lower risk of death compared to the native Dutch population. This included lung cancer (RR = 0.33, CI: 0.36–0.45), colorectal cancer (RR = 0.54, CI: 0.45–0.64) and breast cancer (RR = 0.53, CI: 0.46–0.62). Similarly, low levels were found for cancers of esophagus, pancreas, cervix uteri, ovary, testis, urinary, hematopoietic and lymphoid tissue, and central nervous system. Patterns for migrant men and women were similar for all cancer types except lung cancer, for which women had a significantly lower mortality (RR = 0.21) when compared to men (RR = 0.52).

In contrast, some cancers had elevated risks of death among migrants when compared to the native Dutch population. Liver cancer was significantly elevated among Turkish and Surinamese migrants (RR in both migrant groups above 2.20). Stomach cancer was significantly elevated among Antilleans/Arubans (RR = 2.06, CI: 1.28–3.33) and among Turkish and Surinamese migrants (but not with statistical significance).

For all migrant groups combined, the total mortality from all cancers was lower among first generation when compared to the second generation migrants (RR = 0.80, CI: 0.63–1.02, Table III).

[TABLE 2]

[TABLE 3]

[FIGURE 1]

This pattern differed depending on country of origin. First generation Turkish migrants had a 30% higher risk of death from all cancers combined, while first generation Surinamese migrants had a lower risk of about 30%. Cancer mortality rate of Moroccan and Antillean migrants were similar for both generations. Migrant groups, both individually and combined, had a lower death rate from cancer if they migrated at older age (RR at 30+ age between 0.52 and 0.95). Similarly, migrants had a lower mortality rate if they had a shorter duration of residence (RR at less than 10 years of residence between 0.64 and 0.95). Especially clear pattern of increasing death rates with younger age at arrival and longer duration of residence was observed among Surinamese migrants, while for other migrant groups the picture was more discordant.

The RRs of death from all cancers combined increased with younger age at migration among all migrant groups, approaching the cancer death rates of the native Dutch population (Fig. 1). The mortality rates for the second generation migrants were in between the mortality rates of the first generation migrants and the native Dutch population. At the same time, the risk of death for both generations remained lower when compared to the native Dutch population.

The RRs of death for migrants by type of cancer are shown in Table IV (in reference to the native Dutch population) and Appendix Table II (comparisons within migrant groups). For the majority of the cancers, mortality rates tended to be lowest observed among migrants of first generation, those who migrated at older ages and migrants with a shorter duration of residence. For lung cancer and colorectal cancer we observed a consistent pattern of increasing mortality for second generation migrants, those with younger age at migration and migrants with longer duration of residence. The high level of mortality from liver cancer, on the other side, had a tendency to decrease among the second generation migrants and among those who resided longer in the Netherlands. For many specific types of cancers, the number of deaths was too small to estimate the effect of generation, age at migration or duration of residence.

DISCUSSION

All-cancer mortality among all migrant groups combined was significantly lower when compared to the native Dutch population.

For a large number of cancers, migrants had more than 50% lower risk of death, while elevated risks were found for stomach and liver cancers. Within migrant groups, mortality risks for all cancers combined were the highest among second generation migrants, those with younger age at migration and those with longer duration of residence. This effect was particularly pronounced in lung cancer and colorectal cancer. Although cancer mortality rates among second generation migrants approached the levels of the native Dutch population, they remained lower than the rates of the native Dutch population. Among all migrant groups, Surinamese population showed the most consistent pattern of convergence toward native cancer mortality rates.

Some limitations of the data deserve consideration. First, because the migrant populations are younger than the native Dutch population and, in addition, they have low cancer mortality rates, the statistical power was sometimes too limited to allow a detailed study of cancer mortality rates in relation to generation, age at migration or duration of residence. Second, comparison within migrant populations in relationship to generation is somewhat problematic because of highly different age structures of the groups that are compared. While age standardization of rates should solve this problem, first and second generations have limited overlap in age groups, and therefore, the statistical power of the within-group comparisons was limited. The same applies, although to a lesser extent, to direct comparisons between groups with different age at immigration or duration of residence. Third, a higher rate of death occurring abroad would lead to underestimation of migrant's cancer mortality in the Netherlands and, thus, potentially could have biased our results. Statistics Netherlands through various mechanisms ensures the registration of virtually all deaths, including the ones that occurred abroad. Although the cause of death abroad is rarely known, special inquiry showed that about 50% of deaths that occurred abroad were because of injuries.

The number of cancer deaths that occurred abroad is low.

Therefore, we do not believe that our results of cancer mortality among migrants might have been largely influenced by the deaths that occurred abroad.

[TABLE 4]

The ''healthy migrant'' and ''unhealthy remigrant'' selection effects could play a larger role in case of cancer mortality when compared to the overall mortality.[24,25] Selection of healthier migrants might have explained the initially lower cancer mortality.

However, this advantage wears off over time.[26,27] Reduction of the healthy migrant selection effect would lead to a higher cancer mortality among migrants with long duration of stay, compared to those with a shorter duration of stay. This could partly contribute to the convergence of cancer mortality rates observed in our study.

The remigration of critically ill patients was observed in other countries[5,28] and cannot be completely ruled out in the Netherlands.

Remigration of patients dying from cancer would have underestimated cancer mortality rates observed in our study. This ''salmon bias'' is unlikely to be large and explain the patterns of convergence that we found in our study, since remigration generally is a rare event among migrants in the Netherlands.[29] In addition, a higher quality of cancer services in the Netherlands than in the country of origin may provide a reason for cancer patients to stay.

The transition of the initially lower cancer mortality among migrants to the higher rates of the host population is not a surprise as it has been described worldwide.[5,10,11,13,30] Our study adds to this knowledge by comprehensively describing the changes that occur in cancer mortality among migrants according to generation, age at migration and duration of

residence. Several explanations can be offered for this convergence, including the uptake of smoking by migrants, changes in their traditional diet and changes in reproductive behavior. Converging rates of cancer mortality among migrants could, in theory, also be the consequence of lower quality of medical care provided to migrant cancer patients, leading to higher mortality. However, this mechanism would not explain the increase in cancer mortality with increasing length of residence in the Netherlands. In addition, studies in the Netherlands did not find gross inequalities in the medical care provided to migrant patients in comparison to the native Dutch patients.[31–33] Therefore, we will focus mostly on the role of behavioral factors.

In our study, lung cancer was the most frequent cause of death among all migrants with exception of Antilleans/Arubans. Our results indicate that the mortality rates from lung cancer were increasing among second generation migrants and among migrants with longer duration of residence, although they remain lower when compared to that in the native Dutch.Without doubt this is the result of trends in smoking among immigrants in the Netherlands, who have delayed their uptake of smoking and currently have a higher consumption of tobacco products.[34,35] Similar results were found in Germany, which hosts a large Turkish population,[5] and in France, which hosts a large migrant group from North Africa, including Morocco.[28] Although the level of lung cancer mortality still remains lower when compared to the native Dutch, the increasing mortality trend indicates a growing contribution of lung cancer to the total cancer burden among migrant groups.

Colorectal cancer is the second leading cause of death from neoplasms among the Dutch population. It occupies only the fourth or lower position among migrants. We observed, however, a rather rapid convergence toward native levels of colorectal cancer mortality. Such a convergence was also found in other countries, including migrants originating from the Mediterranean region.[14,15,36,37] Although there is no agreement yet on the most important causes of colorectal cancer,[38] higher consumption of red meat and alcohol, lower consumption of vegetables, fruits, and micronutrients, and lower physical activity are likely to play an important role in the observed increase in incidence and mortality risks.[39–42] The traditional diet of migrants, rich in fruits and vegetables and with generally lower red meat consumption,[34,43] is likely to have had a persistent protective effect against colorectal cancer among migrants in the Netherlands. It is likely, however, that migrant groups gradually change their traditional diet influenced by western habits, with a much higher red meat and other animal fat consumption, and lower vegetable and fruit consumption.

Higher BMI among migrants when compared to Dutch may be another factor contributing to the increase in colorectal cancer with increasing duration of residence and younger age at migration.

[34] Comparison of the results between generations, age at migration and duration of residence suggests that earlier years of life play an important role in setting the pattern for colorectal cancer risks in later life. This effect is likely to be the consequence of higher adaptability to the host culture and greater life style changes among migrants who arrived at younger age or were born in the host country.[44] Detailed empirical evidence on this issue is, however, still lacking.

Breast cancer mortality among women of all migrant groups combined was significantly lower when compared to the native Dutch women, but increased with younger age at migration and among second generation migrants. Lower breast cancer incidence and mortality among migrant populations from southern Europe and the Mediterranean basin were shown in Australia,[4,10,14] Germany,[5,45] France,[6] Canada[37] and the Netherlands.[46] Similar to our results, most of these studies reported that breast cancer mortality rates in the immigrant groups shifted toward the rate of the native-born population of the destination country. A higher parity, lower age at first birth and longer breastfeeding practice was shown to play a protective role for immigrant women.[47,48] Other studies also indicated that dietary factors, alcohol consumption and smoking (often increasing after migration) could partly contribute to the increased risk of breast cancer.[49] Breast cancer was the most frequent cause

of death among Antilleans/Arubans. Higher breast cancer mortality among this migrant group is likely to be the result of a higher incidence of breast cancer in the Antillean islands and Aruba.[50] An additional factor may be selective migration of higher educated women who might have had a higher incidence of breast cancer.[46] Increasing rates of breast cancer among migrant populations call for more attention for programs to increase the compliance to breast cancer screening, which was shown to be lower among migrants in the Netherlands when compared to native Dutch.[51] The increased rates of hepatic cancer in migrants are consistent with other studies[14,37] and are in accordance with the higher prevalence of liver cancer in migrants' countries of origin.[52] Evidence from Germany,[53] France[54] and the Netherlands[55,56] point to a higher prevalence of Hepatitis B surface antigen (HBsAg) among immigrant populations residing in these countries. The mortality rates remained high even in the groups of migrants who immigrated at younger ages, indicating that the infection occurred early in life. Hepatic cancer mortality rates are high as well among second generation migrants possibly because of the vertical (mother to child) transmission of HBsAg.

We observed the most consistent pattern of convergence in cancer mortality by generation, age at migration, and duration of residence among Surinamese migrants. This may be because Surinamese immigrants were generally older and provided the largest number of cancer deaths (702 deaths, 2–4 times more than other migrant groups). This may have increased the statistical power to detect patterns of convergence. In addition, this might be related to a stronger integration of the Surinamese into the Dutch society.

With increasing length of stay, Surinamese migrant groups integrate more fully compared to the Turkish and Moroccan groups.

The consistent convergence observed for Surinamese migrants might indicate the direction that cancer mortality will take in due time among other migrant groups when these groups will age and get more integrated into Dutch society.

CONCLUSION

The greater part of our findings supports the idea of ongoing transition of cancer incidence and mortality among migrant residents in the Netherlands. Our findings show that cancer is increasingly becoming an important cause of death in migrant groups.

This has implications for both research and practice. The next step for research is to pinpoint specific environmental factors that cause change in cancer incidence (increase or decrease) upon migration, especially in cancers with particular public health concern such as lung, colorectal and breast cancer. There is also a need for research from a life course perspective, in which critical ages of immigration and associated risk factors are identified more accurately.

Convergence of cancer mortality among migrants is important for future developments in the burden of cancer morbidity and demand for oncologic care. The ageing of migrant populations will lead to gradual increase in the absolute number of migrant cancer patients and thus a greater demand for oncologic services. Yet, the total share of oncologic services used by migrants in the Netherlands is currently low (about 1%) and the process of cancer convergence is relatively slow.[19] This implies that there is no immediate demographic pressure to increase and diversify facilities and expertise within oncology care. At the shorter term, most needed are measures to prevent an increase in cancer incidence in migrant populations, such as health promotion campaigns to preserve native diets, reinforced antismoking policies, and measures to improve screening compliance.

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[APPENDIX TABLE 1]

[APPENDIX TABLE 2]

TABLES, FIGURE AND APPENDIX TABLES.

TABLE I – BACKGROUND CHARACTERISTICS BY ETHNIC GROUP AND GENDER

	Dutch	Turkish	Moroccans	Surinamese	Antillean/ Aruban
Person years (1000[1])					
Men	31,931	693	595	668	208
Women	39,262	753	628	865	258
Gender distribution					
% Men[1]	45	48	49	44	45
Age distribution					
% Men					
Younger than 15 years	18.2	35.1	36.8	29.3	33.8
50+ years	28.9	8.3	9.2	10.3	6.6
Women					
% Younger than 15 years	17.0	36.7	40.6	26.4	31.7
% 50+ years	33.5	7.5	5.9	12.1	9.4
Distribution by generation					
% First generation men	NA	56.9	59.4	58.9	58.6
% First generation women	NA	54.8	54.5	62.3	61.0
Distribution by age at immigration					
% Men arrived at age					
<14 years	NA	34.4	35.8	37.9	31.3
15–29 years		51.7	46.8	42.3	48.8
30+ years		14.0	17.5	19.8	19.9
% Women arrived at age					
<14 years	NA	33.8	40.1	34.6	29.4
15–29 years		50.3	42.0	44.4	47.0
30+ years		159	17.9	21.0	23.6
Duration of stay in the Netherlands					
% Men arrived					
Before 1976 (20+ years)	NA	23.2	19.9	38.1	10.2
Between 1976–85 (10–19 years)		32.7	32.5	29.3	20.7
After 1985 (0–9 years)		44.1	47.6	32.6	69.1
% Women arrived					
Before 1976 (20+ years)	NA	15.7	7.6	38.0	9.6
Between 1976–85 (10–19 years)		36.9	42.8	29.8	21.3
After 1985 (0–9 years)		47.4	49.5	32.2	69.1

[1] All % are based on the total number of person years in the respective group.

Stirbu, I., Kunst, A.E., Vlems, F.A., Devillé, W., Nijhuis, H.G.J., Coebergh, J.W. Cancer mortality rates among first and second generation migrants in the Netherlands: convergence toward the rates of the native Dutch population. International Journal of Cancer: 2006, 119(11), 2665-2672

TABLE II – ABSOLUTE NUMBERS AND RELATIVE RISKS OF DEATH BY TYPE OF CANCER FOR FIRST GENERATION ETHNIC MINORITIES

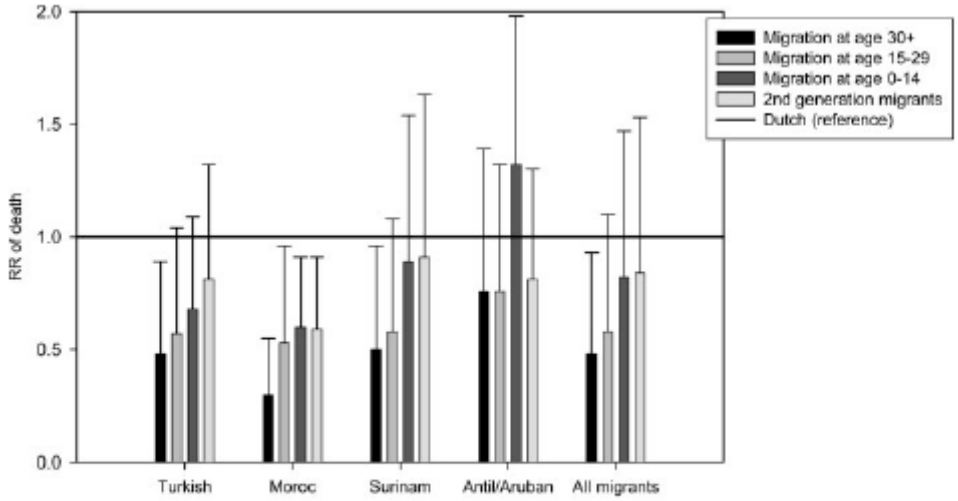
	Absolute numbers				Relative risks[1]		
	Dutch		All migrants		All migrants combined		
	Men	Women	Men	Women	Men	Women	Men and women
Total mortality	*29,8769*	*351,619*	*4,025*	*3,229*	*1.02 (0.99–1.05)*[2]	*0.95 (0.91–0.98)*	*0.98 (0.96–1.01)*
Total mortality malignant conditions	*90,298*	*81,709*	*707*	*629*	*0.59 (0.55–0.63)*	*0.51 (0.47–0.55)*	*0.55 (0.52–0.58)*
Lung, bronchus, trachea (C33, C34[3])	30,118	10,188	220	57	0.52 (0.45–0.59)	0.21 (0.16–0.27)	0.40 (0.36–0.45)
Oesophagus (C15)	3,341	1,796	20	5	0.33 (0.21–0.51)	0.21 (0.09–0.50)	0.29 (0.20–0.44)
Stomach (C16)	4,852	3,560	65	49	1.05 (0.82–1.35)	1.35 (1.01–1.80)	1.16 (0.96—1.40)
Colorectal (C18–C21)	9,375	11,378	72	52	0.63 (0.50–0.79)	0.45 (0.34–0.59)	0.54 (0.45–0.64)
Liver (C22)	1,015	908	33	28	1.95 (1.36–2.80)	2.49 (1.68–3.69)	2.19 (1.67–2.85)
Pancreas (C25)	3,625	4,836	43	27	0.80 (0.59–1.09)	0.48 (0.33–0.70)	0.63 (0.50–0.81)
Breast (C50)	125	18,455	0	171	0	0.54 (0.46–0.62)	0.54 (0.46–0.62)
Uterus (C54, C55)	NA	1,981	NA	21	–	1.02 (0.66–1.58)	1.02 (0.66–1.58)
Cervix uteri (C53)	NA	2,922	NA	35	–	0.61 (0.44–0.87)	0.61 (0.44–0.87)
Ovary (C56)	NA	5,161	NA	36	–	0.53 (0.38–0.74)	0.53 (0.38–0.74)
Prostate (C61)	10,747	NA	55	NA	0.78 (0.60–1.02)	–	0.78 (0.60–1.02)
Testis (C62)	2,104	NA	6	NA	0.32 (0.14–0.72)	–	0.32 (0.14–0.72)
Cancer of urinary system (C64-68)	6,205	3,753	24	8	0.31 (0.20–0.46)	0.20 (0.10–0.40)	0.27 (0.19–0.38)
Cancer of HLT[4] (C81-C85, C88, C90-96)	6,820	7,286	84	83	0.79 (0.64–0.99)	0.89 (0.72–1.12)	0.84 (0.72–0.98)
Skin, melanoma (C43)	1,092	1,104	2	1	0.07 (0.02–0.29)	0.04 (0.01–0.25)	0.05 (0.02–0.16)
Central nervous system (C70-C72)	2,013	1,823	27	12	0.49 (0.33–0.72)	0.30 (0.17–0.54)	0.42 (0.30–0.57)
Ill-defined cancer sites (C76, C80)	5,668	6,558	49	44	0.60 (0.45–0.80)	0.58 (0.43–0.79)	0.59 (0.48–0.73)

[1]All migrants combined compared to the native Dutch population (reference group).–[2]Values in parentheses are 95% confidence intervals.–[3]Corresponding ICD-10 code.–[4]Hematopoietic and lymphoid tissue.

TABLE III – RELATIVE RISKS OF DEATH BY MIGRANT'S GENERATION, AGE AT IMMIGRATION, DURATION OF RESIDENCE AND ETHNICITY (ALL TYPES OF CANCER COMBINED)

	Relative risk[1,2]				
	Turkish	Moroccans	Surinamese	Antillean/Aruban	All migrants
First generation M and W	1.34 (0.54–3.31)[3]	1.04 (0.36–3.01)	0.76 (0.57–1.02)	0.97 (0.58–1.62)	0.80 (0.63–1.02)
First generation men	0.87 (0.25–3.01)	1.64 (0.32–8.35)	0.75 (0.49–1.14)	1.22 (0.54–2.74)	0.83 (0.58–1.17)
First generation women	2.09 (0.59–7.45)	0.81 (0.21–3.15)	0.77 (0.51–1.16)	0.82 (0.43–1.58)	0.79 (0.57–1.10)
Second generation	1.00	1.00	1.00	1.00	1.00
Age at immigration					
M and W					
0–14 years	1.00	1.00	1.00	1.00	1.00
15–29 years	1.07 (0.56–2.07)	1.26 (0.51–3.08)	0.81 (0.54–1.21)	0.58 (0.24–1.37)	0.85 (0.63–1.14)
30+ years	0.95 (0.47–1.92)	0.84 (0.32–2.17)	0.73 (0.48–1.11)	0.52 (0.22–1.25)	0.72 (0.53–0.99)
Men					
15–29 years	1.34 (0.49–3.64)	0.89 (0.22–3.60)	0.63 (0.34–1.17)	0.75 (0.18–3.06)	0.76 (0.48–1.20)
30+ years	1.26 (0.44–3.60)	0.57 (0.13–2.44)	0.59 (0.31–1.12)	0.63 (0.15–2.65)	0.66 (0.41–1.05)
Women					
15–29 years	0.93 (0.39–2.21)	1.64 (0.50–5.42)	0.94 (0.55–1.60)	0.45 (0.15–1.33)	0.94 (0.63–1.38)
30+ years	0.89 (0.32–2.44)	2.00 (0.53–7.57)	0.85 (0.48–1.50)	0.45 (0.15–1.33)	0.85 (0.56–1.31)
Duration of residence					
M and W					
0–9 years	0.95 (0.65–1.26)	0.64 (0.41–1.00)	0.83 (0.67–1.03)	0.77 (0.52–1.15)	0.85 (0.74–0.99)
10–19 years	1.03 (0.78–1.38)	0.72 (0.49–1.07)	0.94 (0.77–1.16)	0.98 (0.65–1.50)	0.95 (0.82–1.09)
Men					
0–9 years	1.12 (0.71–1.75)	0.86 (0.46–1.60)	1.03 (0.77–1.38)	0.75 (0.41–1.39)	1.03 (0.84–1.27)
10–19 years	1.06 (0.69–1.63)	0.82 (0.48–1.43)	0.95 (0.71–1.29)	1.45 (0.79–2.65)	1.05 (0.86–1.29)
Women					
0–9 years	0.92 (0.55–1.54)	1.03 (0.45–2.34)	0.65 (0.47–0.90)	0.78 (0.46–1.32)	0.78 (0.63–0.96)
10–19 years	1.24 (0.81–1.90)	1.24 (0.57–2.68)	0.92 (0.70–1.21)	0.73 (0.41–1.32)	0.93 (0.77–1.12)
20+ years	1.00	1.00	1.00	1.00	1.00

M, men; W, women.
[1]Adjustment for age, sex, marital status, urbanization level and area income.–[2]Migrants compared to the native Dutch population (reference group).–[3]Values in parentheses are 95% confidence intervals.



Migrants compared to the native Dutch population (reference group).
Adjustment for age, gender, marital status, urbanization level, and area income.

FIGURE 1 – Relative risks of death by migrant's age at immigration for all types of cancer combined (men and women combined).

TABLE IV – RELATIVE RISKS OF DEATH FOR MIGRANTS BY AGE AT MIGRATION, DURATION OF RESIDENCE AND TYPE OF CANCER (MEN AND WOMEN COMBINED)

	Relative risk[1]						
	Age at migration			Reference (Dutch)	Duration of residence		
	30+	15–29	0–14		20+	10–19	0–9
Total mortality	0.94 (0.91–0.96)[2]	1.00 (0.95–1.04)	1.31 (1.20–1.42)	1.00	0.93 (0.90–0.96)	1.05 (1.00–1.10)	0.99 (0.95–1.04)
Total mortality malignant	0.50 (0.47–0.54)	0.59 (0.53–0.65)	0.82 (0.65–1.03)	1.00	0.54 (0.50–0.58)	0.54 (0.49–0.61)	0.51 (0.45–0.57)
Lung, bronchus, trachea	0.33 (0.28–0.39)	0.57 (0.47–0.68)	0.55 (0.23–1.32)	1.00	0.43 (0.37–0.50)	0.37 (0.28–0.49)	0.35 (0.26–0.47)
Oesophagus	0.35 (0.23–0.55)	0.19 (0.08–0.46)	0[3]	1.00	0.28 (0.17–0.47)	0.33 (0.15–0.74)	0.30 (0.13–0.73)
Stomach	1.07 (0.54–1.35)	1.22 (0.86–1.73)	2.79 (1.23–6.31)	1.00	1.02 (0.78–1.33)	1.59 (1.14–2.22)	1.02 (0.66–1.57)
Colorectal	0.45 (0.35–0.56)	0.67 (0.49–0.92)	1.51 (0.72–3.20)	1.00	0.56 (0.44–0.70)	0.59 (0.41–0.83)	0.37 (0.23–0.59)
Liver	2.37 (1.75–3.22)	1.67 (0.96–2.92)	3.14 (0.98–10.09)	1.00	2.25 (1.59–3.19)	2.50 (1.51–4.53)	1.80 (0.99–3.28)
Pancreas	0.69 (0.53–0.90)	0.47 (0.27–0.81)	0.55 (0.08–3.92)	1.00	0.62 (0.45–0.85)	0.76 (0.49–1.19)	0.52 (0.29–0.91)
Breast	0.45 (0.37–0.56)	0.66 (0.51–0.83)	0.62 (0.31–1.24)	1.00	0.57 (0.46–0.72)	0.47 (0.36–0.62)	0.53 (0.39–0.72)
Uterus	1.20 (0.77–1.88)	0[3]	0[3]	1.00	1.62 (0.97–2.71)	0.50 (0.16–1.56)	0.37 (0.09–1.49)
Cervix uteri	0.52 (0.36–0.76)	0.38 (0.20–0.71)	0.49 (0.12–1.96)	1.00	0.35 (0.21–0.58)	0.81 (0.50–1.30)	0.40 (0.20–0.81)
Ovary	0[3]	0.66 (0.36–1.19)	0.39 (0.05–2.76)	1.00	0[3]	0.57 (0.32–1.01)	0.45 (0.22–0.90)
Prostate	0.68 (0.50–0.93)	1.08 (0.59–1.95)	4.89 (1.21–19.72)	1.00	0.67 (0.47–0.95)	0.75 (0.38–1.51)	1.15 (0.68–1.95)
Testis	0.40 (0.17–0.97)	0[3]	0.71 (0.10–5.15)	1.00	0.38 (0.14–1.02)	0.28 (0.04–1.96)	0.23 (0.03–1.67)
Cancer of urinary system	0.20 (0.12–0.32)	0.43 (0.25–0.74)	0.99 (0.25–3.99)	1.00	0.26 (0.16–0.41)	0.28 (0.14–0.60)	0.30 (0.14–0.63)
Cancer of HLT[4]	0.71 (0.55–0.87)	0.87 (0.65–1.17)	1.35 (0.90–2.51)	1.00	0.77 (0.61–0.98)	0.85 (0.63–1.14)	0.91 (0.68–1.21)
Skin, melanoma	0.08 (0.02–0.33)	0.04 (0.01–0.28)	0[3]	1.00	0.04 (0.01–0.30)	0[3]	0.13 (0.03–0.51)
Central nervous system	0.37 (0.22–0.61)	0.48 (0.30–0.75)	0.32 (0.12–0.86)	1.00	0.58 (0.39–0.88)	0.11 (0.04–0.35)	0.45 (0.15–0.79)
Ill-defined cancer sites	0.59 (0.46–0.75)	0.52 (0.34–0.80)	1.49 (0.66–3.36)	1.00	0.51 (0.38–0.69)	0.66 (0.44–0.98)	0.72 (0.49–1.07)

[1]Migrants compared to the native Dutch population (reference group). Adjustment for age, sex, marital status, urbanization level, and area income.–[2]Values in parentheses are 95% confidence intervals.–[3]No cases.–[4]Hematopoietic and lymphoid tissue.

APPENDIX TABLE I – ABSOLUTE NUMBER OF DEATH (AN) AND RELATIVE RISK (RR) BY ETHNICITY AND TYPE OF CANCER FOR 1ST GENERATION MIGRANTS (MEN AND WOMEN COMBINED)

	Dutch		Turkish		Moroccan		Surinamese		Antillean/Aruban	
	AN	RR	AN	RR[1]	AN	RR[1]	AN	RR[1]	AN	RR[1]
Total mortality	*65,0388*	*1.00*	*2,188*	*1.04 (0.99–1.09)*[2]	*1477*	*0.81 (0.76–0.86)*	*4302*	*1.01 (0.98–1.05)*	*886*	*1.02 (0.95–1.10)*
Total mortality malignant cond.	*17,2007*	*1.00*	*350*	*0.55 (0.50–0.61)*	*211*	*0.41 (0.35–0.46)*	*708*	*0.57 (0.53–0.62)*	*185*	*0.78 (0.68–0.91)*
Lung, bronchus, trachea	40,306	1.00	98	0.55 (0.45–0.67)	55	0.35 (0.27–0.46)	110	0.33 (0.27–0.41)	26	0.46 (0.31–0.69)
Oesophagus	5,137	1.00	3	0.14 (0.05–0.44)	3	0.17 (0.05–0.51)	15	0.34 (0.20–0.59)	6	0.83 (0.37–1.86)
Stomach	8,412	1.00	29	1.17 (0.81–1.69)	16	0.79 (0.48–1.30)	53	1.15 (0.87–1.51)	17	2.06 (1.28–3.33)
Colorectal	20,753	1.00	16	0.28 (0.17–0.46)	15	0.33 (0.20–0.55)	84	0.70 (0.56–0.88)	16	0.78 (0.48–1.28)
Liver	1,923	1.00	15	2.20 (1.32–3.69)	8	1.43 (0.71–2.88)	37	2.76 (1.97–3.88)	3	0.81 (0.20–3.26)
Pancreas	8,461	1.00	21	0.79 (0.51–1.21)	11	0.52 (0.29–0.94)	34	0.60 (0.42–0.85)	8	0.72 (0.34–1.52)
Breast	18,580	1.00	35	0.46 (0.33–0.64)	23	0.44 (0.29–0.66)	90	0.51 (0.41–0.63)	34	0.93 (0.66–1.31)
Uterus	1,981	1.00	2	0.47 (0.12–1.87)	0	0[3]	16	1.32 (0.79–2.20)	6	1.74 (0.65–4.66)
Cervix uteri	6,120	1.00	5	0.19 (0.07–0.52)	6	0.36 (0.16–0.81)	28	0.67 (0.46–0.98)	6	0.53 (0.20–1.41)
Ovary	5,161	1.00	9	0.59 (0.31–1.14)	5	0.49 (0.20–1.18)	19	0.46 (0.28–0.75)	6	0.75 (0.34–1.67)
Prostate	10,747	1.00	8	0.54 (0.27–1.09)	6	0.44 (0.20–0.99)	37	0.94 (0.68–1.32)	7	1.25 (0.56–2.79)
Testis	2,104	1.00	0	0[3]	1	0.25 (0.03–1.76)	5	0.58 (0.24–1.39)	0	0[3]
Cancer of urinary system	9,958	1.00	7	0.24 (0.11–0.51)	7	0.29 (0.14–0.60)	15	0.20 (0.11–0.36)	8	0.72 (0.34–1.51)
Cancer HLT	14,106	1.00	56	0.88 (0.65–1.18)	27	0.52 (0.34–0.79)	90	0.92 (0.74–1.15)	24	1.11 (0.72–1.73)
Skin, melanoma	2,196	1.00	1	0.06 (0.01–0.46)	2	0.16 (0.04–0.63)	0	0[3]	1	0[3]
Central nervous system	3,836	1.00	21	0.56 (0.33–0.93)	13	0.41 (0.21–0.78)	26	0.33 (0.19–0.59)	6	0.35 (0.11–1.10)
Ill-defined cancer sites	12,226	1.00	24	0.65 (0.44–0.97)	13	0.41 (0.23–0.72)	49	0.61 (0.46–0.82)	11	0.72 (0.39–1.35)

Migrants compared to the native Dutch population (reference group).
[1]Adjustment for age, sex, marital status, urbanization level, and area income.–[2]Values in parentheses are 95% confidence intervals.–[3]No cases.

APPENDIX TABLE II – RELATIVE RISKS OF DEATH FOR MIGRANTS BY AGE AT MIGRATION AND DURATION OF RESIDENCE BY TYPE OF CANCER (4 ETHNIC MINORITY GROUPS COMBINED, MEN AND WOMEN COMBINED)

	Relative risk[1]							
	Generation		Age at migration			Duration of residence		
	1st	2nd	30+	15–29	0–14	0–9	10–19	20+
Total mortality	*1.07 (0.97–1.18)*[2]	*1.00*	*1.06 (0.84–1.05)*	*0.94 (0.84–1.05)*	*1.00*	*0.98 (0.92–1.04)*	*1.06 (1.00–1.12)*	*1.00*
Total mortality malignant cond.	*0.80 (0.63–1.02)*	*1.00*	*0.72 (0.53–0.99)*	*0.85 (0.63–1.14)*	*1.00*	*0.85 (0.74–0.99)*	*0.95 (0.82–1.09)*	*1.00*
Lung, bronchus, trachea	0.63 (0.35–1.15)	1.00	0.89 (0.34–2.30)	1.30 (0.51–3.31)	1.00	0.75 (0.53–1.05)	0.80 (0.58–1.10)	1.00
Oesophagus	0.43 (0.10–1.91)	1.00	0	0.37 (0.24–0.57)	1.00	1.21 (0.42–3.44)	1.58 (0.60–4.21)	1.00
Stomach	4.82 (0.66–35.17)	1.00	0.44 (0.16–1.22)	0.48 (0.18–1.29)	1.00	0.96 (0.57–1.61)	1.46 (0.93–2.27)	1.00
Colorectal	0.72 (0.33–1.58)	1.00	0.33 (0.13–0.81)	0.44 (0.18–1.08)	1.00	0.63 (0.37–1.07)	1.01 (0.65–1.57)	1.00
Liver	1.16 (0.25–5.49)	1.00	0.72 (0.17—3.05)	0.57 (0.15–2.26)	1.00	2.09 (0.82–4.09)	1.48 (0.65–3.11)	1.00
Pancreas	0.61 (0.21–1.73)	1.00	2.03 (0.22–18.70)	1.06 (0.12–9.53)	1.00	0.91 (0.46–1.79)	1.41 (0.80–2.49)	1.00
Breast	0.69 (0.37–1.29)	1.00	1.46 (0.63–3.39)	1.71 (0.79–3.70)	1.00	0.85 (0.58–1.24)	0.79 (0.55–1.15)	1.00
Uterus	0.36 (0.10–1.26)	1.00	0	0	1.00	0.19 (0.04–0.83)	0.41 (0.12–1.44)	1.00
Cervix uteri	0.69 (0.19–2.58)	1.00	0.89 (0.15–5.28)	0.87 (0.17–4.55)	1.00	0.89 (0.37–2.13)	1.92 (0.93–3.97)	1.00
Ovary	0.68 (0.18–2.55)	1.00	1.63 (0.17–15.72)	2.16 (0.25–18.47)	1.00	0.83 (0.35–1.99)	1.09 (0.50–2.40)	1.00
Prostate	0.88 (0.26–2.92)	1.00	0.10 (0.02–0.44)	0.18 (0.04–0.86)	1.00	1.54 (0.80–2.97)	1.04 (0.48–2.29)	1.00
Testis	0[3]	1.00	0	0	1.00	0	0	1.00
Cancer of urinary system	0.27 (0.09–0.82)	1.00	0.16 (0.03–0.87)	0.30 (0.06–1.51)	1.00	1.39 (0.56–3.50)	1.09 (0.44–2.76)	1.00
Cancer of HLT	1.44 (0.79–2.61)	1.00	0.69 (0.34–1.40)	0.77 (0.42–1.42)	1.00	0.90 (0.60–1.36)	0.91 (0.61–1.36)	1.00
Skin, melanoma	0.34 (0.02–4.71)	1.00	0	0	1.00	1.58 (0.11–21.71)	0	1.00
Central nervous system	0.39 (0.17–0.91)	1.00	1.30 (0.22–7.77)	2.19 (0.44–10.86)	1.00	0.69 (0.31–1.57)	0.19 (0.06–0.67)	1.00
Ill-defined cancer sites	1.60 (0.48–5.33)	1.00	0.82 (0.26–2.58)	0.50 (0.17–1.52)	1.00	1.34 (0.79–2.25)	1.21 (0.72–2.03)	1.00

[1]Adjustment for age, sex, marital status, urbanization level and area income.–[2]Values in parentheses are 95% confidence intervals.–[3]No cases.