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Cancer risk diversity in non-western migrants to Europe: An overview of the literature

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ABSTRACT

Background: Cancer risk varies geographically and across ethnic groups that can be monitored in cancer control to respond to observed trends as well as ensure appropriate health care. The study of cancer risk in immigrant populations has great potential to contribute new insights into aetiology, diagnosis and treatment of cancer. Disparities in cancer risk patterns between immigrant and autochthonous populations have been reported many times, but up to now studies have been heterogeneous and may be discordant in their findings. The aim of this overview was to compile and compare studies on cancer occurrence in migrant populations from non-western countries residing in Western Europe in order to reflect current knowledge in this field and to appeal for further research and culturally sensitive prevention strategies.

Methods: We included 37 studies published in the English language between 1990 and April 2010 focussing on cancer in adult migrants from non-western countries, living in the industrialised countries of the European Union. Migrants were defined based on their country of birth, ethnicity and name-based approaches. We conducted a between-country comparison of age-adjusted cancer incidence and mortality in immigrant populations with those in autochthonous populations.

Findings: Across the board migrants from non-western countries showed a more favourable all-cancer morbidity and mortality compared with native populations of European host countries, but with considerable site-specific risk diversity: Migrants from non-western countries were more prone to cancers that are related to infections experienced in early life, such as liver, cervical and stomach cancer. In contrast, migrants of non-western origin were less likely to suffer from cancers related to a western lifestyle, e.g. colorectal, breast and prostate cancer.

Discussion: Confirming the great cancer risk diversity in non-western migrants in and between different European countries, this overview reaffirms the importance of exposures experienced during life course (before, during and after migration) for carcinogenesis. Culturally sensitive cancer prevention programmes should focus on individual risk patterns and specific health care needs. Therefore, continuously changing environments and subsequently changing risks in both migrant and autochthonous populations need to be observed carefully in the future.

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1. Background

Studies on cancer risk in migrant populations have recently gained increased recognition, but still have rather heterogeneous study populations and methods applied. However, insights into risk diversity deduced from such studies contribute to our understanding of carcinogenesis and might help answer unclear aetiology questions.

Migration has become an important phenomenon in Western Europe in terms of population changes and the composition of society during the past decades. In 2005, Western and Central Europe hosted 44.1 million migrants, defined as foreign-born persons.[1] Many of them originate from non-western countries, seeking social security, employment opportunities and a better future.

European societies characterised by an increasing degree of heterogeneity pose major challenges to health care systems and policies. Evidence-based research is therefore a prerequisite for appropriate and individual health care of high quality and effectiveness as well as the implementation of culturally sensitive measures of prevention.[2,3]

Health is closely related to global movements. The transition of disease and risk patterns over time and across countries have been the scope of many epidemiological research questions. Accordingly, infectious diseases become less important as populations advance in terms of westernisation and the role of chronic health conditions, such as cancer and cardio-vascular diseases, becomes predominant.[4]

Hence, migrants from non-western countries are equipped with a unique constellation of risk factors that are determined by exposure and disease patterns experienced in both their home as well as their host country.[5,6] This sudden change in the stage of epidemiological transition as well as environmental determinants has a major impact on an individual's lifetime disease risk.

Many theories have been developed to explain differences in mortality and morbidity between migrants and the population of their host and home countries, respectively, one of them being the healthy migrant effect. Thus, migrants are subject to selection processes that initially underlie good physical and mental health. Those health advantages after migration are thought likely to disappear with advancing duration of residence and generations. As suggested in some studies, no evidence of quickly diminishing health advantages could be observed, challenging this concept and allowing room for other explanations.[7] Nonetheless, the change in risk patterns over time is of special interest in epidemiological research.

Multi-causality and geographical variation make cancer in migrant populations highly suitable for research, especially in cancers whose main causes are still not attributable to either environmental ('nurture components') or genetic ('nature components') risk factors.[8] In this context, the individual life course and particularly early life experiences (as the first step in carcinogenesis) have a great impact and play a major role in the effects of exposure and their association with cancer risks.[9,10]

Investigating the occurrence of cancer in migrant populations may allow for a better understanding of cancer aetiology and of biological factors that can be integrated into prevention and treatment programmes.

The purpose of this article is to compile and compare results from studies conducted all over Europe dealing with cancer in non-western migrant populations. The resulting overview can serve as a guide, reflecting the present state of knowledge in this field, and as an appeal for further research and prevention.

2. Methods

2.1. *Inclusion criteria of studies*

We included studies focussing mainly or partly on cancer incidence and mortality in adult migrants from non-western countries, living in the industrialised countries of the European Union, published in English between 1990 and April 2010. Studies were identified by searching pubmed and other established scientific databases in combination with the following keywords: cancer + ethnicity/ethnic minority/(im)migrant(s)/foreign(ers)/country of birth. A further inclusion criterion was a comparison of the migrant population with the native population of the country of the study (no studies conducted within migrant populations).

2.2. *Study descriptions*

We identified 37 studies conducted in the following seven countries: Denmark (3), France (4), Germany (6), Spain (1), Sweden (7), The Netherlands (5) and the United Kingdom (11). In 51% of the studies (19/37) incidence data were analysed, in 41% (15/37) mortality data and in 8% (3/37) both. All studies were based on the retrospective cohort design.

Owing to the heterogeneous measures of association applied in the studies, we described tendencies instead of combined rate ratios (RRs) or odds ratios (ORs) to indicate differences in risks as follows: significantly elevated, elevated, no difference, decreased and significantly decreased. Age-adjustment procedures had been carried out in all the studies included. Other covariables are listed in Table 1.

In general 70% of the studies (26/37) involved all-cancer comparisons and 24% of the studies (9/37) focused on only one specific cancer site. The most commonly investigated sites were breast (28 studies) and lung cancer (26 studies) as well as stomach and colorectal cancer (24 studies each).

2.3. *Defining the migrant status, generations involved and pooling of migrant origins*

The indicator for defining the migrant population under study ranged from country of birth (of the patient or in combination with the parental country of birth) in 73% (27/37), name-based approaches in 14% (5/37), (self-assigned) ethnicity in 11% (4/37) and a combination in one study.

The applied indicator or proxy for ethnicity is highly dependent on the availability and completeness of potential variables in the particular host country. However, country of birth is the most widely used and accepted proxy although it has some validity limitations with regard to cultural and ethnic identity.[11]

Table 1 – Methodological features of the studies included.

Country, authors and year of study		Study aim: to explore	Data source	Period	Outcome/measure of association (*covariables*)	Cohort acquisition/In- and exclusion criteria	Methodological peculiarities	Definition of ethnicity	Reference population	Size and composition of study population	Discussed explanations for risk differences	Study limitations
Denmark	Myrup et al. (2008)[13]	The aetiology of testicular cancer risk	Study population: civil registration system linked to Danish Cancer Registry through unique personal identification number (population-based)	1968–2003	Incidence RR (*Age, calendar year, parental birthplace, duration of stay, age at immigration*)	Males born between 1930 and 2003; residents of Denmark between 2nd April 1968 and 31st December 2003, born between 1st January 1930 and 31st December 2003; known place of birth; exclusion of individuals born in Greenland	Adjustments for maternal and paternal birthplace in different strata; trend analyses for duration of stay and age at immigration	(Parental) Country of birth (collected by civil registration system from index cards in municipality registration offices)	Men born in Denmark of parents born in Denmark	Cohort: *n* = 2,109,459 Cancer cases in cohort: *n* = 4216 (1st generation migrants: *n* = 166 (3.9%), 2nd generation migrants: *n* = 13 (0.3%)	Early environmental exposures/period in uteri; salmon bias	Small number of cases in second-generation immigrants
	Norredam et al. (2008)[29]	Differences in cancer stage at diagnosis between migrant women and native Danish women	Study population: Statistical Department at The Danish Immigration Service; linkage of civil registration numbers of the study cohort with Danish Cancer Registry (population-/register-based cohort)	1993–1999 (cohort)/2002 (cases)	Incidence OR (matching procedure, age group, cancer type at first diagnosis)	Women aged 18+; migrants with residence permit as refugees or through family reunification in Denmark between 1st January 1993 and 31st December 1999; only first diagnosis cancers; only cancer types allowing categorisation of stage; exclusion criteria: missing civil registration number; duplicates; unclear or missing data on nationality	1:6 matching on age and sex on population level; 1:4 matching on an individual level on age and sex through a random sampling procedure; comparison of local with non-local stages of tumours; migrant status as proxy for pre- and post-migration circumstances	Nationality according to WHO's classification system	Danish-born residents with Danish-born parents (identified through Statistics DK)	Study cohort: Cases (1st generation Migrants) *n* = 62461; Controls (Danish-born) *n* = 249,839; Cancer cohort: Cases *n* = 269; Controls *n* = 1608	Differences in tumour biology between migrants and host populations; barriers in access to healthcare (language, culture, health care system); poor screening uptake; salmon bias	Small number of cases; high number of cases with unknown stage; nationality as poor bio-socio-cultural proxy of ethnicity; no SES adjustments possible
	Norredam et al. (2007)[30]	Incidence of cancer among 1st generation migrants compared with native Danes, including time trends	Statistical Department at The Danish Immigration Service; linkage of civil registration numbers of the study cohort with Danish Cancer Registry (population-/register-based cohort)	1993–2003	Incidence RR (age, region of origin, migrant type, duration of residence)	Men and women aged 30–80; residence permit as refugees or through family reunification in Denmark between 1st January 1993 and 31st December 1999; exclusion criteria: missing civil registration number; duplicates; unclear or missing data on nationality; non-melanoma skin cancers	1:6 matching on age and sex upon arrival in Denmark and 1:4 matching on an individual level on age and sex through a random sampling procedure in the study cohort; migrant status as proxy for pre- and post-migration circumstances	Nationality according to WHO's classification system	Danish-born residents with Danish-born parents (identified through Statistics DK)	Study cohort: cases (1st generation migrants) *n* = 62461; controls (Danish-born) *n* = 249,899; cancer cases *n* = 3366 (16% migrants)	Lifestyle patterns (breast and colorectal cancer), smoking; decline in incidence over time in migrant women related to increased cancer diagnostic activities such as screening and better access to healthcare services	Small number of cases; no SES adjustments possible; trend analysis irrespective of duration of stay which may dilute effects
France	Bouchardy et al. (1996)[31]	Cancer mortality in North African migrants to France	Population data: 'Institut National de la Statistique et des Etudes Economiques' (INSEE), derived from the French 1982 census; mortality data: 'Institut National de la santé et de la recherche médicale' (INSERM)	1979–1985	Mortality RR (age, gender, social class, area of residence)	Men and women of all ages; records of deaths in resident population of France from 1979 to 1985 (provided by INSERM)	Stratified analyses by socioeconomic subgroup	Country of birth	Individuals born in metropolitan France (native French)	Cancer deaths among migrants: *n* = 27,352 (3.4% of all cancer deaths)	Return of ill migrants to country of origin prior to death; healthy-migrant effect; lower consumption of alcohol and higher tobacco intake; dietary differences; reproductive behaviour; cultural factors related to Islam	Poor quality of French mortality data; small numbers of cancer deaths among Egyptian migrants; heterogeneity within migrant groups
	Bouchardy et al. (1995)[32]	Cancer mortality in sub-Saharan African migrants to France	Population data: 'Institut National de la Statistique et des Etudes Economiques' (INSEE), derived from the French 1982 census; mortality data: 'Institut National de la santé et de la recherche médicale' (INSERM)	1979–1985	Mortality RR (age group, gender, social class, area of residence)	Men and women of all ages; records of deaths in resident population of France from 1979 to 1985 (provided by INSERM)	Stratified analyses by socioeconomic subgroup	Country of birth	Individuals born in metropolitan France (native French)	Migrant study population: *n* = 288,060; Cancer deaths among migrants: *n* = 1126 (0.1%)	Return of ill migrants to country of origin; healthy migrant effect; protective lifestyle factors (tobacco, alcohol consumption, lower meat/fat intake, high fibre diets); infection with hepatitis B virus during childhood/chronic persistent hepatitis (liver cancer); Schistosoma haematobium infections (bladder cancer); Burkitt's lymphoma (NHL)	Poor data quality; heterogeneity within migrant groups
	Khlat (1995)[33]	The cancer profile of Maghrebian and Near Eastern migrants	Two large migrant studies	1979–1991	Mortality RR (age, area of residence, social class)	Men and women of all ages; French mortality data	Review of studies	Country of birth	Native French population	Cancer deaths among Moroccan migrants: *n* = 2062	Genetic factors, diet, alcohol consumption, childbearing patterns, cultural factors, viral causes	
	Bouchardy et al. (1994)[34]	cancer patterns in Chinese and South East Asian migrants to France	Population data: « Institut National de la Statistique et des Etudes Economiques » (INSEE), derived from the French 1982 census; mortality data: « Institut National de la santé et de la recherche médicale » (INSERM)	1979–1985	Mortality RR (age, social class, area of residence)	Men and women of all ages; records of deaths in resident population of France from 1979–1985 (provided by INSERM)	Computation of differences in risk between migrants using a case-control approach	Country of birth	Metropolitan-born population in France	Migrants in population data: 3.2%; Cancer deaths among migrants: *n* = 8708	Consumption of salted and preserved foods (nasopharyngeal cancer); genetic susceptibility; high and early exposure to infection with hepatitis-B virus and aflatoxin, chronic infection with liver flukes (liver cancer)	Poor quality of French mortality data; Small number of deaths in Chinese-born migrants

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Table 1 – *continued*

Country, authors and year of study		Study aim: to explore	Data source	Period	Outcome/measure of association (*covariables*)	Cohort acquisition/In- and exclusion criteria	Methodological peculiarities	Definition of ethnicity	Reference population	Size and composition of study population	Discussed explanations for risk differences	Study limitations
Germany	Spallek et al. (2009)[16]	Cancer incidence in Turkish immigrants in Hamburg	Study cohort: Hamburg Cancer Registry; Reference population: population registry	1990–2004	Incidence RR (year of birth)	Men and women of all ages; identification of cases of Turkish origin by use of name-based algorithm	Stratification by birth cohorts to adjust for age and to investigate the life course perspective	Name-based algorithm	Representative population sample of Hamburg	Cancer cases in Turkish migrants: $n = 1346$	Different nutritional patterns (cancer of digestive, urinary tract and prostate); early life experiences and infections (e.g. HPV and EBV); higher smoking prevalence among Turkish males; different reproductive behaviour	Misclassification and incomplete identification cannot be ruled out due to name-based approach; small number of Turkish cases; possible underestimation due to remigration
	Winkler et al. (2009)[35]	Cancer mortality and incidence in FSU migrants in Germany	Cancer mortality: sample of migrant cohort in North Rhine-Westphalia; cancer incidence: sample of migrant cohort in Saarland; Linkage with local population registries, local reception centres, Saarland Cancer Registry, NRW statistical office and local health offices	1990–2005	SMR, SIR (age, calendar year)	Cancer mortality: arrival in Germany between 1st January 1990 and 31st December 2001; aged 15+; cancer incidence: arrival between 1990 and 2005; exclusion: missing data, cancer diagnosis in country of origin	Date of arrival approximated by passport issue date; person-year estimation using German mortality rates	Resettlers from FSU of German ethnicity	The entire population of Germany	Mortality: Study (migrant) cohort: $n = 34,393$, Deaths in cohort: $n = 2580$, Cancer deaths: $n = 708$; Incidence: Study (migrant) cohort: $n = 18,619$, Cancer cases: $n = 586$	Similar SIR and SMR patterns (presumably no survival differences); big impact of smoking prevalence (similar to country of origin); *H. pylori* prevalence (stomach cancer); alcohol consumption and hepatitis infection (liver cancer); higher birth rates (breast cancer)	Slightly different populations used for standardisation; follow-up estimation
	Ronellenfitsch et al. (2009)[36]	Stomach cancer mortality in FSU migrants in Germany	Study population: sample of migrants from FSU to German federal state North Rhine Westphalia, identified in municipal population registries; linkage with mortality data (cause of death database) through sex, dates of birth and death, last residence as identifiers (registry-based)	1990–2005	SMR (age, calendar year)	Arrival in Germany between 1st January 1990 and 31st December 2001; aged 15+; successfully identified in electronic municipal population registries	Follow-up assurance through electronic record linkage with municipal population registries and a state cause of death database; vital status ascertainment; cause of death retrieval	Resettlers from FSU of German ethnicity	The entire population of Germany	Study (migrant) cohort: $n = 34,393$, deaths in cohort: $n = 2580$; stomach cancer deaths: $n = 68$	Long latency after exposure to risk factors in early life (e.g. HP infection; continuation of lifestyles and behaviours (e.g. dietary habits); change in hygiene conditions, earlier detection, better treatment options, improved access to healthcare	Restricted data availability; differences in study populations; no information on exact tumour location
	Ott et al. (2008)[37]	Mortality of cancers of possibly infectious origin in migrants from FSU to Germany	Study population: sample of migrants from FSU to German federal state North Rhine Westphalia, identified in municipal population registries; linkage with mortality data (cause of death database) through sex, dates of birth and death, last residence as identifiers (registry-based)	1990–2005	SMR (sex, 5-year age group, calendar year, length of stay, immigration period), mortality RR	Arrival in Germany between 1st January 1990 and 31st December 2001; aged 15+; successfully identified in electronic municipal population registries	Age-, sex-, cause- and calendar year specific mortality rates of the German population obtained using WHO's Mortality Database; Effect of length of residence analysis	Resettlers from FSU of German ethnicity	The entire population of Germany	Study cohort: $n = 34,393$, deaths in cohort: $n = 2580$	*H. pylori* and hepatitis virus infection, nutritional factors (low fruit/vegetable consumption, high intake of nitrite-containing foods), high alcohol consumption (gastric and liver cancer); living conditions; differences in health-seeking behaviour	Results not adjusted for prevalence of risk factors; only limited interpretation of results possible owing to absence of ethnic-specific mortality data in studies using administrative data
	Kyobutungi et al. (2006)[38]	Differences in cancer mortality between ethnic German immigrants and the native German population	Study population: sample of migrants from FSU to German federal state North Rhine Westphalia, identified in municipal population registries; linkage with mortality data (cause of death database) through sex, dates of birth and death, last residence as identifiers (registry based)	1990–2001/2002	SMR (age, calendar year, arrival period), Mortality RR	Arrival in Germany between 1st January 1990 and 31st December 2001; aged 15+; successfully identified in electronic municipal population registries	Age-, sex-, cause- and calendar year specific mortality rates of the German population obtained using WHO's Mortality Database; analysis of secular trends and effect of length of residence; directly standardises death rates calculated for all-cancers and lung cancer	Resettlers from FSU of German ethnicity	The entire population of Germany	Person-years of FU in migrant study cohort: $n = 247,143$; Cancer deaths in cohort: $n = 469$	Differences in risk factor distribution: smoking, alcohol consumption, diet, physical activity, reproductive history, health care utilisation, genetic factors, viral infections; cancer mortality mainly influenced by pre-migration risk factors (country of origin effect)	Assessment of current or pre-migration individual risk profiles of migrants impossible; incomplete FU for some cohort members
	Zeeb et al. (2002)[21]	The transition in cancer mortality patterns among Turkish migrants residing in Germany	Mortality data: death registration records (former) West Germany; incidence data: Saarland cancer registry	1970–1998 (Incidence) and 1980–1997 (Mortality)	ASMR, PCIR (age)	Men and women aged 0–64; use of name-based approach (based on Turkish first and surnames) as proxy for ethnicity	Time trends for ASMRs analysed in three equal intervals; missing information on ethnicity in incident denominator population remedied by calculation of PCIRs (nominator only), expected proportions obtained by use of stratified random sample of the entire registry	Nationality (mortality analysis); name-based algorithm (incidence analysis)	Native German population	Cancer deaths among migrants: $n = 6054$; incident cancer cases among migrants: $n = 163$	Potential risk factors: unfavourable living conditions in childhood, high prevalence of *H. pylori* infections among Turks (stomach cancer); high dietary energy intake (breast cancer); smoking trends; hepatitis B infection (liver cancer); healthy migrant effect; re-migration of ill migrants (salmon bias); lifestyle changes; socio-cultural barriers affecting uptake and quality of clinical treatment	Study restricted to persons below 65; small number of cases because of young age distribution of Turkish migrants in Germany; no generation assignment possible and subject to bias (e.g. intercultural marriages)

Spain	Regidor et al. (2008)[39]	Whether mortality in immigrants in the region of Madrid differs from mortality in Spanish in-country migrants	Mortality data: Mortality Register; population data: Municipal Population Register, census data (both sources provided by Madrid Institute of Statistics); unlinked study	2000–2004	Mortality RR (age, per capita income, area of residence)	Men aged 20–64	Per capita income estimated based on income tax returns for the year 2000, quartiles of distribution assigned to each individual based on census tract of residence	Country of birth	Spanish in-country migrants; population born in Madrid	Cancer deaths among migrants: $n = 335$	Healthy-migrant effect; differences in demographics; stage of smoking epidemic	Heterogeneity within migrant groups; information on population and deaths from different sources (numerator/ denominator information bias); no information on duration of residence
Sweden	Hemminki et al. (2010)[40]	Liver and gallbladder cancer in immigrants to Sweden	Study cohort: Swedish Family Cancer Database; linkage of administrative family register at Statistics Sweden to The Swedish Cancer Registry	1958–2006	SIR (5-year age group, sex, period)	Foreign-born men and women of all ages; primary liver cancer		Country of birth	Native Swedish population	Cancer cases in migrants: $n = 1428$	Chronic HBV infection, often transmitted at birth; liver fluke infections; poor living conditions; unavailability of medical care	
	Mousavi et al. (2010)[41]	Cancer incidence in Iranian immigrants to Sweden	Study cohort: Swedish Family Cancer Database (created by linkage of administrative family register at Statistics Sweden to The Swedish Cancer Registry	1958–2006	SIR (5-year age group, sex, region, time period)	Men and women of all ages		Country of birth	Native Swedish population	Cancer cases in migrants: $n = 1293$	Environmental, reproductive and socioeconomic factors; Hepatitis infection in country of origin; smoking (bladder cancer)	
	Mousavi et al. (2010)[42]	Nasopharyngeal and hypopharyngeal cancer risk in immigrants to Sweden	Study cohort: Swedish Family Cancer Database (created by linkage of administrative family register at Statistics Sweden to The Swedish Cancer Registry	1958–2006	SIR (5-year age group, sex, time period)	Men and women of all ages		Country of birth	Native Swedish population	Cancer cases in migrants: $n = 243$	EBV infection in early life; differences in smoking and dietary patterns; chewing tobacco	
	Azerkan et al. (2008)[43]	Risk of invasive cervical cancer among immigrant women	Study population: Swedish Total Population Register; linkage with Swedish Cancer, cause of death and migration registers through national registration numbers	1968–2004	Incidence ASR, RR (age, calendar period, SES)	Women aged 13–79; exclusion criteria: death, emigration, history of cervical cancer before entry into cohort; missing place of birth or migration date; women older than 100 years during FU	Categorisation of migrant origins into low-, medium- and high-risk areas for cervical cancer, accounting for inter-country variations; SES obtained from 1960, 1970, 1980 and 1990 censuses, categorised into five groups; effect of duration of stay (more or less than 10 years); stratification by age at immigration	Birth regions	Swedish-born women	Cervical cancer cases: $n = 19,542$, Cases among migrants: $n = 1991$ (10.2%)	Changes in lifestyle, sexual behaviour; establishment of cervical cancer screening programmes; healthy migrant effect; persistent HPV infection or precancerous lesions before immigration	Re-migration without recording, leading to underestimation of risks; young migrant populations; higher proportion of unclassified SES among immigrants
	Moradi et al. (2008)[44]	The occurrence of thyroid cancer among Swedish residents born in Iran compared with that of Swedish-born residents	Study cohort: total Population Register held by Statistics Sweden; reference cohort: National censuses 1960–1990, longitudinal integration database for health insurance and labour market studies 1990–2003; linkage with Cancer Register through national registration number	1969–2004	Incidence RR (age, calendar year, education)	Men and women of all ages; known date of immigration, free of thyroid cancer at start of FU	Data on parental place of birth through linkage with multigeneration register; stratification of results by age at immigration, duration of stay and calendar year of migration (before or after 1990)	Country of birth	Native Swedish population	Incident cancer cases: $n = 9826$; among migrants: $n = 50$ (0.5%)	Exposure to environmental risk factors during early life; iodine deficiency; hyperplastic lesions of the thyroid gland	No information on prevalence of risk factors; no information on histological classification
	Hemminki et al. (2002)[45]	Cancer risks in adult immigrants to Sweden	Study cohort: Swedish Family Cancer Database (created by linkage of administrative family register at Statistics Sweden to The Swedish Cancer Registry); mortality data: death notification data; additional population data: national censuses of 1960, 1970, 1980 and 1990; linkage through unique technical identification number	1961–1998	SIR (5-year age group, sex, region, period, tumour type)	Adult men and women; having children born in Sweden (member of Family Database)		Country of birth	Swedish natives	Cancer cases: $n = 673,424$, cancer cases among immigrants: $n = 32,722$ (4.9%)	Marital status; young age distribution of immigrants; tobacco consumption (lung, urinary bladder); pigmentation, behavioural differences (melanoma); reproductive histories (breast); diagnostic activity; medical services	Multiple comparison problem
	Hemminki and Li (2002)[12]	Cancer risks in Sweden-born descendants of immigrants from European and North American countries	Study cohort: Swedish Family Cancer Database (created by linkage of administrative family register at Statistics Sweden to The Swedish Cancer Registry through unique technical identification number)	1961–1998	SIR (5-year age group, sex, region, period, tumour type)	Men and women aged 0–66	Separate analysis by father's birth country, mother's birth country, for compatriot parents	Parental country of birth	Offspring of Swedish natives	Cancer cases by father's birth country: $n = 3460$, cancer cases by mother's birth country: $n = 4473$	Long-lasting environmental and heritable effects (e.g. skin pigmentation); immune response	Small number of cases; multiple comparisons

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Table 1 – *continued*

Country, authors and year of study		Study aim: to explore	Data source	Period	Outcome/measure of association (*covariables*)	Cohort acquisition/In- and exclusion criteria	Methodological peculiarities	Definition of ethnicity	Reference population	Size and composition of study population	Discussed explanations for risk differences	Study limitations
The Netherlands	Visser and van Leeuwen (2007)[46]	Cancer risk in first generation migrants	Population data: annual population data from Statistics Netherlands; linked with Study Cohort: Amsterdam Cancer Registry (covering the provinces North Holland and Flevoland); population-based	1995–2004	SIR (age, gender)	Men and women of all ages; primary invasive cancers; exclusion criterion: unknown country of birth	Country of birth (if possible) verified with information from national population network (e.g. screening participants)	Residents born outside the Netherlands	Native Dutch population of North Holland/Flevoand	Cancer cases: *n* = 106,415; cancer cases among migrants: *n* = 9271 (9%)	Exposure to infectious diseases before migration; healthy lifestyle habits protecting against cancer; genetic factors (e.g. higher prostate cancer risk in Surinamese males)	Selective (re-)migration
	Stirbu et al. 2006 (14)	Differences in cancer mortality between migrants and the native Dutch population	Population data: municipal population registers; linked through personal identification numbers to mortality data: cause of death registry (population-based)	1995–2000	Mortality RR (age, sex, marital status, urbanisation level, area income)	Men and women of all ages; legal residents of the Netherlands	Age at immigration and duration of residence based on latest known date of immigration; degree of urbanisation and mean household equivalent used to approximate SES calculated based on postal code	Residents or parents of residents born abroad (predominant role of country of birth of mother)	Native Dutch population	Cancer deaths: *n* = 173,461, deaths among migrants *n* = 1454 (0.8%)	Healthy-migrant/unhealthy-remigrant effect; uptake of western lifestyle (smoking, changes in diet and reproductive behaviour); hepatitis B surface antigens (risk factor for liver cancer); importance of life-course perspective	Limited statistical power owing to small numbers and relatively young (and highly different) age distributions of migrants
	Bos et al. (2004)[47]	Factors causing a higher or lower mortality in migrants compared with the native population	Population data: municipal population registers; linked through personal identification numbers to mortality data: cause of death registry (population-based)	1995–2000	Mortality RR (age, marital status, region, degree of urbanisation, SES by sex)	Men and women of all ages; legal residents of the Netherlands		Country of birth of subject and both parents (non-Dutch if at least one parent born abroad)	Native Dutch population	All deaths in Dutch population during study period: *n* = 750,148	Healthy-migrant/unhealthy-remigrant effect; smoking, dietary habits (adaptation of unhealthy western lifestyle)	No information on within-migrant group variations; risk underestimation in some groups; unregistered remigration
	Visser et al. (2004)[48]	Breast cancer incidence in migrants in the Netherlands	Population data: annual population data obtained from Statistics Netherlands; study cohort: Amsterdam Cancer Registry and Cancer Centre West (covering the provinces North Holland and The Hague) linked to screening data	1989–1998	SIR	Women of all ages	Validation of country of birth information with breast cancer screening programmes to Cancer registry data; if data in cancer registry discrepant or missing, country of birth information from screening data used	Country of birth	Native Dutch women	Cancer cases: *n* = 20,016 (among migrants: *n* = 1699 (8.5%)	Screening attendance; change in reproductive risk factors such as lower parity	
	Visser et al. (2003)[49]	Incidence of cervical cancer in North Holland by country of birth	Population data: annual population data obtained from Statistics Netherlands; study cohort: Amsterdam Cancer Registry (covering the provinces North Holland and Flevoland)	1988–1998	ASIR, O/E ratio (age)	Women of all ages with invasive cervical cancer		Dutch resident born abroad	Native Dutch women	Cancer cases: *n* = 1530 (among migrants: *n* = 232 (15.2%)	HPV infection; changes in lifestyle; screening programmes in host country; selection effects	Missing country of birth in 10% of cases; incompleteness of mortality registration; no information on prevalence of risk factors and differences in SES
United Kingdom	Harding et al. (2009)[28]	Trends in cancer mortality in migrants living in England and Wales	Anonymised death records; population data from the 1981, 1991 and 2001 censuses for England and Wales	1979–2003	Mortality RR (age)	Men and women aged 30–69; consistent country of birth definition in both deaths and census data	Trend analysis (changes in death rates among three time intervals)	Country of birth	English -and Welsh-born		Changes in risk behaviour (convergence in rates to those of England and Wales); rising smoking trends among immigrants; alcohol consumption; delayed uptake and poorer quality of clinical management; poor cancer awareness; co-morbidities; historic (viral) infections	Possible misclassification of country of birth between census data and death certificates; healthy-migrant effect (selection bias)
	Jack et al. (2009)[17]	Breast cancer incidence, stage, treatment and survival in ethnic groups in South East England	Study cohort: Thames Cancer Registry; National Health Service Central Register; population data: Office for National Statistics (matching on NHS number); registry- and population-based study	1998–2003	Incidence RR, HR (age, socioeconomic deprivation, stage at diagnosis, treatment)	Women of all ages; known ethnicity, complete registration information; exclusion criteria: patients registered by death certificate only excluded from analyses on stage, treatment and mortality	Socio-demographic deprivation based on income domain of Index of Multiple Deprivation 2000, divided into quintiles, assigned to records using postcode of residence at diagnosis	Self-assigned ethnicity (using codes from 1991 and 2001 censuses)	White women	Cancer cohort: *n* = 33,024	Screening uptake; treatment differences; reproductive, socioeconomic, anthropometric and dietary factors; differences in disease perception and resulting access to healthcare services	Ethnicity information not available for large portion of patients (36%); representativeness of ethnic groups; within ethnic group variation

Wild et al. (2006)[22]	Cancer mortality in England and Wales by country of birth	Population data: National Statistics, 2001 Census of England and Wales; mortality data: Office of National Statistics	2001–2003	SMR (age)	Men and women aged 20+		Country of birth	England and Wales as a whole	Cancer deaths: $n = 398,515$; among non-western migrants: $n = 13,161$ (3.3%)	Complex combination of genetic and environmental factors (diet, lifestyle, socioeconomic status); smoking habits (lung cancer); poor uptake of cancer screenings; unexplained high risks in West Africans	No information on environmental and demographic factors; limited reliability of country of birth as ethnicity proxy; numerator/denominator bias; accuracy of cause of death information; possible misclassification of country of birth
Smith et al. (2003)[18]	Recent trends in cancer incidence among UK South Asians	Population data: estimates from 1991 census of England and Wales; Study cohort: Trent Cancer Registry	1990–1999	Incidence RR (age, deprivation)	Men and women of all ages (for all-cancer)/aged 30+ (for site-specific analyses)	Level of deprivation of the patient's area of residence (SES proxy) using Townsend Index	Sur- and forename	English non-South Asians	Cancer cases: $n = 12,128$; among migrants ($n = 862$ (7.1%)		
Harding and Rosato (1999)[50]	Incidence of cancers among foreign-born residents of England and Wales	Study cohort: 1% sample of the population of England and Wales; linked to Cancer registrations: NHS Central Register	1971–1989	SIR (sex, age, year of diagnosis)	Men and women aged 15+	Classification of results by religion	Country of birth, enhanced by name analysis, classified by religion	All members of the study	Cancer cases among non-western migrants: $n = 167$	Differences in socioeconomic status; smoking and alcohol consumption; dietary habits; uptake of screening services; lifestyle; occupation	Unknown emigrations; higher loss of FU among migrants; self-selection processes; no information on social distribution of risk factors
Haworth et al. (1999)[51]	Mortality from cirrhosis of the liver and primary liver cancer in first-generation migrants to England and Wales	Population data: estimates from 1991 census of England and Wales; mortality data: Office for National Statistics	1988–1992	SMR (age, sex)	Men and women aged 20–69		Country of birth	Native population of England and Wales	Cancer deaths: $n = 3237$; Cancer deaths among migrants from non-western countries: $n = 238$ (7.4%)	Culture; Religion; Socioeconomic differences; Alcohol intake; Chronic hepatitis B and C infections; lifestyle	Small numbers of deaths (especially among females)
Winter et al. (1999)[20]	Cancer incidence in the South Asian population of England	Population data: estimates from 1991 census of England and Wales; study cohort: Cancer Registries of Thames, Trent, West Midlands and Yorkshire	1990–1992	ASIR (age)	Men and women of all ages	South Asian names identified using a computer programme; two comparisons: South Asian versus. non-South Asian (England) and South Asians in England versus data from the Indian subcontinent	Ethnic origin determined based on names	Non-South Asian English population of study region; Indian registry data	Incident cancer cases: $n = 356,555$; Cases among migrants: $n = 3845$ (1.1%)	Lifestyle; diet; access and uptake of health services (screenings); chewing of tobacco with betel-quid (risk factor for cancer of tongue, mouth and hypopharynx); hepatitis B infection (liver)	Within-group differences with regard to lifestyle, diet etc.; possible misclassification of names; very limited validity of comparison between English South Asian rates and Indian Asian rates
Swerdlow et al. (1995)[19]	Cancer risks in British ethnic and Indian ethnic migrants to England and Wales	Mortality data: Office of Population Censuses and Surveys	1973–1985	Mortality RR (MH OR) (age)	Men and women of all ages; exclusion criterion: unknown ethnicity	No suitable denominator information: calculation of odds ratios, risk of death from each cancer site in each migrant group/ risk of death from the same cancer site in English- and Welsh-born residents (relative risk of mortality); Information on social class, marital status and parity from 1971 census	Country of birth and ethnic group (determined on the basis of names)	Native English and Welsh natives	Cancer deaths among migrants: $n = 8282$	Differences in exposures (occupation); differences in social class; betel-quid chewing (oral and pharyngeal cancers); smoking and alcohol consumption (oesophageal and laryngeal cancer); hepatitis B infection (liver); obesity (gallbladder); reproductive factors (breast)	Numerator only measure; reliability of ethnic coding; misrecording of death certificates; no information on distribution of risk factors
Grulich et al. (1992)[23]	Site-specific cancer mortality in West African-, East African- and Caribbean-born immigrants	Population data: 1971 population census of England and Wales; mortality data: Office of Population Censuses and Surveys	1970–1985	Mortality RR (age, calendar period, social class)	Men and women of all ages	Social class recorded on death certificates (only available for subjects aged 15–64), only performed for Caribbean	Country of birth	England and Wales natives	Cancer deaths among migrants: $n = 5407$	Viral origins; differences in social class; western lifestyle; genetic disposition; hepatitis B infection (liver); diagnostic facilities; betel-chewing (oral cancer)	
Swerdlow (1991)[52]	Cancer incidence and mortality in Vietnamese refugees in England and Wales	Study population: National Health Service Central Register	1979–1989	SMR, SRR (age)	Male and female Vietnamese refugees born before 1950 and with NHS registrations from 24 May 1979 to 16 July 1985; exclusion criteria: unknown sex, death during FU	Observed mortality and cancer registrations compared with age-, sex-, and year-specific expectations derived from application of England and Wales national mortality and cancer registration rates to the person-years at risk	Refugees born abroad	Mortality and cancer incidence in England and Wales (cancer registration data)	Migrant study cohort: $n = 3327$; total mortality: $n = 187$; cancer incidence: $n = 49$	High prevalence of tuberculosis and hepatitis B	Incomplete death registration; selection bias
Barker and Baker (1990)[15]	Incidence of cancer in Asians living in Bradford, England	Population data: 1981 census (University of Leeds); study population: Yorkshire Regional Cancer Registry	1979–1984	Incidence SRR (age)	Men and women of all ages	Census data restricted to heads of households; Cancer risk among Asians in Bradford compared with non-Asians in Bradford and with cancer registry data from Bombay	Ethnic origin determined on the basis of name	Rates of non-Asian population/the Bombay cancer registries	Cancer cases among migrants: $n = 178$	Change in environmental and behavioural influencescing, heavy alcohol consumption, betel chewing, consumption of spiced foods (hypopharynx, pharynx); uptake of cancer screenings	Small number of cases; limited validity of comparison with Bombay rates; misclassification of ethnicity

ASMR, age-standardised mortality rate/ratio; ASIR, age-standardised incidence rate/ratio; ASR, age-standardised rate; EBV, Epstein–Barr virus; FSU, Former Soviet Union; FU, follow-up; HPV, Human Papilloma Virus; NHL, non-Hodgkin's lymphoma; NHS, National Health Service; O/E-ratio, observed/expected ratio; OR, odds ratio; PCIR, proportional cancer incidence ratio; RR, risk/rate ratio; SES, socioeconomic status; SIR, standardised incidence rate/ratio; SMR, standardised mortality rate/ratio; SRR, standardised registration rate/ratio.

Only one study focused entirely on second-generation migrants[12] (based on the patient's own and parental country of birth) and two other studies included this group explicitly in addition to first-generation migrants.[13,14] Seven studies included descendants indirectly, owing to the method used for identifying migrants.[15–21] For instance, the name-based approach does not allow a distinction between generations, which can only be estimated vaguely based on age. There were 27 studies that were aimed at first-generation migrants only.

For reasons of clarity, migrant origins have been pooled into the following categories: Eastern Europe [Former Soviet Union (FSU), Russia], Africa (North, West and East Africa), Middle East (most frequently referring to Iran, Iraq and adjacent countries), Southern Europe/Turkey, Asia [divided into general Asia (mostly China and Vietnam) and South Asia (including India, Bangladesh, Indonesia, Ceylon and Pakistan)] and Southern and Central America. Owing to inconsistent definitions between the studies, some overlap cannot be excluded.

2.4. *Applied methods*

Studies investigating cancer incidence used mainly cancer registry data (21/37). Studies assessing cancer mortality drew mostly on vital statistics such as mortality or cause of death registries and databases or surveys (17/37). Population data were obtained from population registers/statistical bureaux (17/37), census data (13/37) – which were primarily used in studies from France and the United Kingdom (UK) – or a population sample (7/37). Most studies were population-/registry-based. In many studies linkage procedures had been performed using a unique identifier such as the 'Personal Identity Number' in Sweden and the 'National Health Service (NHS) number' in the UK. Two studies used numerator-only analyses.

Some studies adjusted for a socioeconomic proxy and also took important covariables such as duration of stay, age at immigration and calendar year into account.

Table 1 summarises the methodological features, explanations and limitations of the studies included.

3. Findings

Table 2 provides an overview of all findings according to country of study, population of interest and cancer site, expressed in tendencies.

The all-cancer comparison of most studies showed in particular on average a lower cancer risk for first-generation migrants from non-western countries in terms of incidence and mortality, although there were some studies that did not reveal significant differences, sometimes obviously due to small study cohorts. However, male subjects originating from West Africa exhibited significantly elevated cancer mortality in two studies from the United Kingdom.[22,23] Ambiguous results were attained for migrants from Eastern Europe: Many studies revealed advantageous risks, although in several cases they were not significant.

Since all-cancer morbidity reflects a summary of site-specific results, the aim is to point out cancers with significantly elevated or lowered risks among migrants and to investigate these results according to migrant origin.

3.1. *Migrants from Southern Europe*

In 35% of all studies (13/37) included from five different countries, migrants from Southern Europe, mostly Turkey, were investigated. According to these studies, all malignant neoplasms together tended to occur significantly less often in this group compared with the general population of the host country.

Significantly elevated risks for this migrant group could be observed for cancers of the stomach, liver, lung among males and thyroid gland. In addition, increased risks were reported for Hodgkin's disease and lymphomas. In contrast, significantly lower risks were found for cancers of the oesophagus, colorectum, lung among females, skin, breast, prostate and testis and bladder.

3.2. *Migrants from Eastern Europe*

In 32% of studies from five countries (12/37) migrants came from the Eastern part of Europe, mostly parts of the former Soviet Union. Lower all-cancer morbidity and mortality were confirmed by the majority of these studies.

The site-specific results were ambiguous, but strongly concurred on the elevated risks for stomach and lung cancer in males, whereas consistently decreased risks could be observed for breast cancer in females and melanoma.

3.3. *Migrants from Africa*

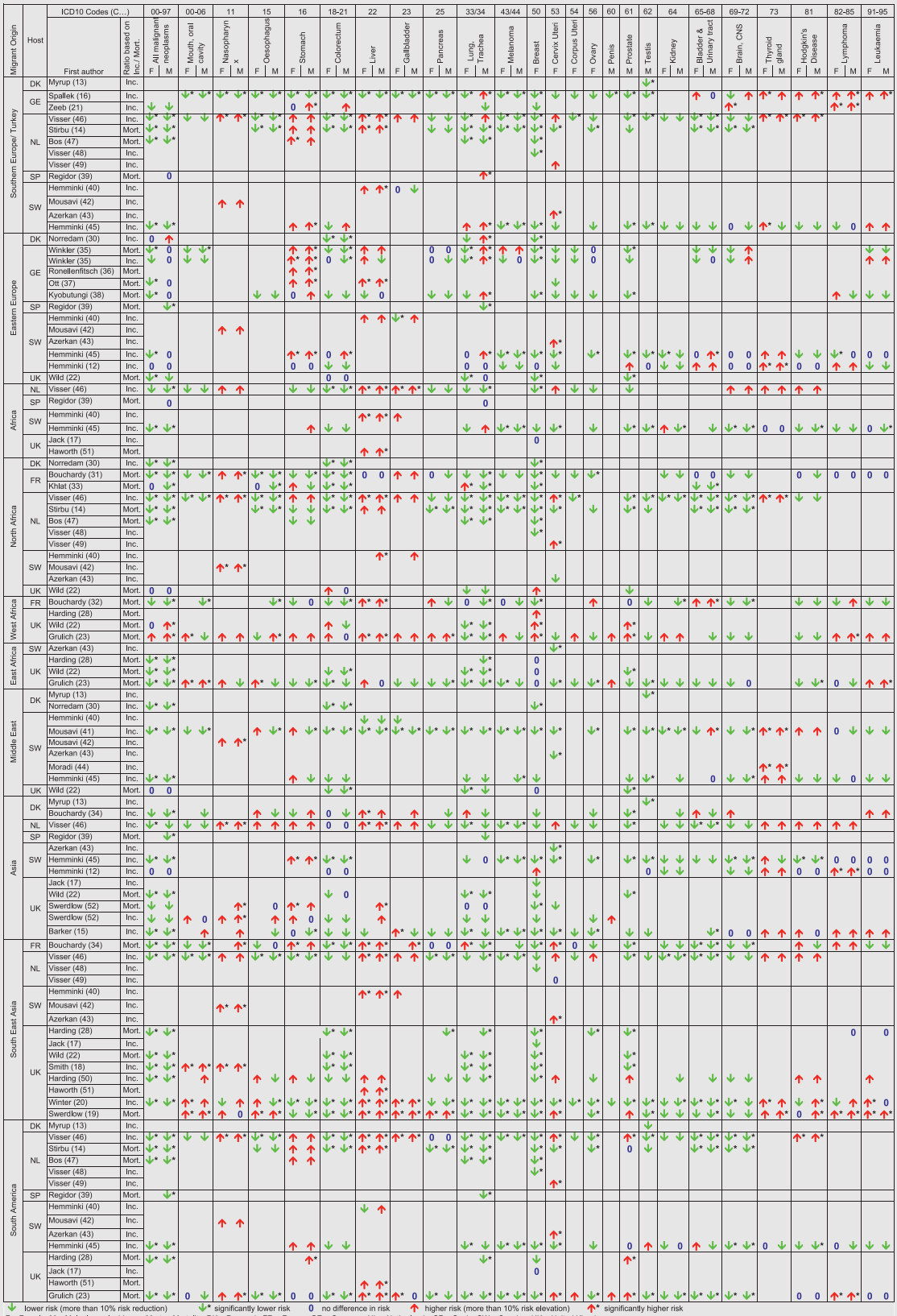
Migrants originating from the African continent had to be categorised into 'Africa' (if no subgroups were available), 'North Africa', 'West Africa' and 'East Africa'.

In 16% of studies from four countries (6/37) migrants from Africa without further regional classifications were investigated. However, only three studies covered all-cancer morbidity which resulted in advantageous risks for migrants. The most striking similarities in the study results could be observed for liver cancer due to strongly elevated risks and colorectal cancer as well as cancer of male and female genital organs due to decreased risks.

North African migrants were studied in 12 studies (32%) from five countries (Denmark, France, Sweden, Netherlands and the UK). All-cancer morbidity was lower or not significant in all studies. Elevated risks were observed for cancers of the nasopharynx, liver, gallbladder and cervix uteri. Significantly decreased risks were found for almost all other cancer sites, especially for colorectal, lung and breast cancer as well as melanoma.

Migrants from the western part of Africa represent an exceptional group among migrants from non-industrialised countries. Only 4 out of 37 studies (11%) from France and the UK looked at this group but all of them presented quite detailed results that allowed us to look at many possible parallels. All-cancer mortality was significantly elevated among males residing in the United Kingdom, but the opposite was the case for males living in France. The studies coincide in increased risks for cancers of the liver, pancreas and prostate as well as

Table 2 – Site-specific cancer occurrence in male and female migrants from different regions residing in selected European countries.*,#



↓ lower risk (more than 10% risk reduction) ↓* significantly lower risk 0 no difference in risk ↑ higher risk (more than 10% risk elevation) ↑* significantly higher risk

F = Female; M = Male; Inc. = Incidence; Mort. = Mortality; DK = Denmark; FR = France; GE = Germany; NL = Netherlands; SP = Spain; SW = Sweden; UK = United Kingdom

* If only a total risk was reported in studies (no distinction between males and females), the tendencies for F/M correspond to the total

If only combined diagnosis groups were provided in studies, the same results are repeated over the separate diagnoses

lymphomas. Other cancer sites showed ambiguous results, for example, significantly elevated mortality due to breast cancer in the studies from the UK as opposed to study results from France, which showed a significantly decreased risk among West African women. This implies important regional risk diversity in similar migrant groups across European countries and is certainly an interesting subject for further research.

Another four studies from Sweden and the UK focussed on East African migrants. The three British studies agreed on lower all-cancer mortality in this group and revealed elevated risks for cancer of the oral cavity and leukaemia. All other cancer sites showed continuously decreased risks, most remarkably for cancers of the colon and rectum, lung and genital organs. The Swedish study yielded a significantly decreased risk of cancer of the cervix uteri in this migrant group.

3.4. *Migrants from the Middle East*

In 24% of the studies (9/37) migrants originating from the Middle East were investigated, investigating only few cancer sites. All-cancer occurrence appeared to be significantly less frequent in three studies. Moreover, decreased risks could be observed for colorectal, lung, prostate, testis and breast cancer in studies carried out in Denmark, the United Kingdom and Sweden, where an increased risk of cancer of the thyroid gland was also revealed.

3.5. *Migrants from Asia*

Many studies took migrants from Asia into account. With regard to the vastness of this continent, it made sense to distinguish between Asia in general, mostly referring to China and Vietnam, and South East Asia, which included India, Ceylon, Bangladesh, Indonesia and sometimes Pakistan (depending on the definition).

Cancer risks among migrants from Asia in general were examined in 30% of the studies from six different European countries (11/37), all of them exhibiting lower all-cancer mortality and morbidity rates. Consistent findings of elevated risks were found for cancers of the nasopharynx, stomach, liver and endocrine glands as well as lymphomas. Parallel, decreased risks could in particular be observed for colorectal, lung, breast and bladder cancer as well as for melanoma and cancers of the cervix, ovary, prostate and testis.

Migrants from South East Asia showed surprisingly similar results between the studies for many cancers. In total, 41% of all studies included (15/37), performed in France, Sweden, The Netherlands and the UK focused on this migrant group, varying little in the definition of South East Asian countries. All-cancer mortality and morbidity risks appeared to be consistently lower in all studies that covered this general comparison. Uniformly elevated risks were revealed for migrants with cancers of the oral cavity, nasopharynx, liver, gallbladder and thyroid gland. Moreover, a higher risk of lymphomas and leukaemia was observed in several studies, whereas lowered risks were found for stomach, colorectal, lung, breast, ovary, prostate, testis, kidney and bladder cancer as well as melanoma.

3.6. *Migrants from South and Central America*

In 41% of all studies included in this overview (15/37) cancer risks were determined for migrants coming from South and Central American countries, most frequently Caribbean countries that used to be European colonies. All-cancer mortality and morbidity risks were consistently lower for migrants from this part of the world. Particularly elevated risks could be observed for cancers of the nasopharynx, liver, cervix uteri, prostate and lymphomas. In contrast, notably lowered risks were revealed for cancers of the oesophagus, colon and rectum, lung, breast, skin, ovary and bladder.

3.7. *Second-generation migrants*

Studies on cancer risk in second-generation migrants are still scarce and were included in this overview for the sake of completeness only. However, a convergence of risks towards the rates of the host population as well as less extreme risks was revealed by Hemminki and Li.[12] In addition, studies

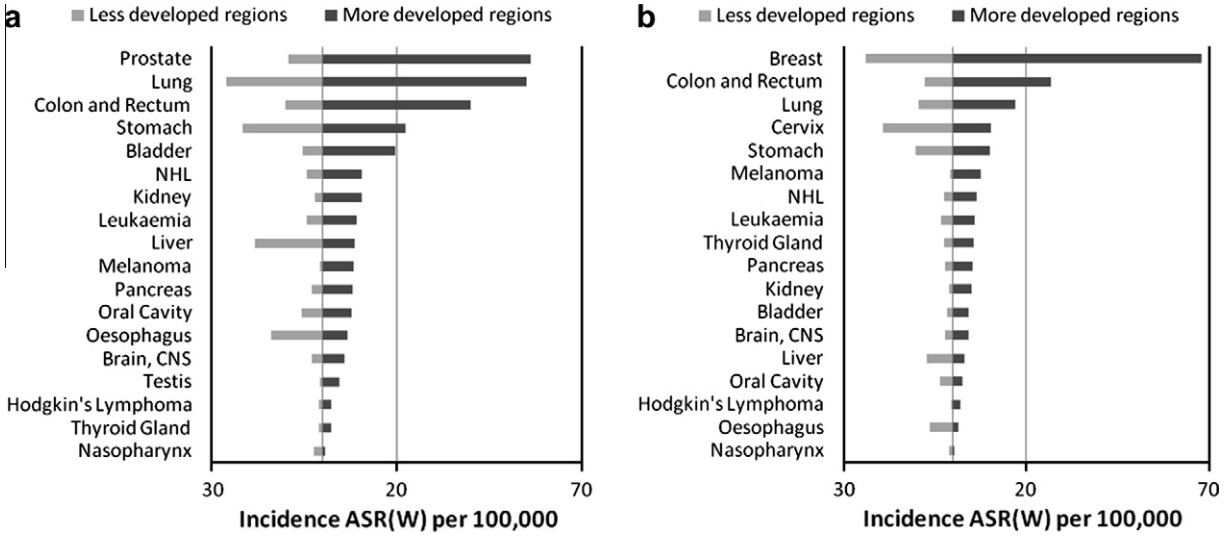


Fig. 1 – Cancer incidence in less and more developed regions for males (a) and females (b) according to IARC 2002.

assessing the effects of duration of residence or age at migration indicate an adaptation of rates, which also indicates a change of risk over time, i.e. after migration. Investigating cancer occurrence in second-generation migrants will become more relevant in future, due to the increasing age and size of this population group.

4. Discussion

Our findings suggest that migrants from non-western countries were more likely to develop cancers that are related to infectious diseases, compared with the general population of their industrialised host country. This is especially true for cancers of the oral cavity, nasopharynx, stomach, liver, gallbladder, cervix uteri, prostate and lymphomas. In contrast, almost all studies found lower risks for cancers that are strongly related to a 'western' lifestyle (poor diet, physical inactivity, reproductive factors, etc.), irrespective of the migrant origin. This is in particular the case for colorectal cancer and cancers of the pancreas, lung, breast, ovary, kidney and bladder. Some elevated risks could also be explained partly by important covariables such as socioeconomic status, especially for migrants originating from West Africa.

We also found that in most studies, migrants show cancer risks that are in between the corresponding risk of the native populations in their home and their host country. The majority of the findings tend to be in accordance with the rates, visualised in Fig. 1.

Whereas all-cancer incidence in the more developed countries amounts to 314 [age-standardised rate (ASR(W)) per 100,000] among males and 228 among females, less well-developed countries show an average of 159 for males and 129 for females.[24]

It can be observed that cancer sites with a comparatively high incidence in less well-developed regions also exhibit a high incidence for migrant populations from non-western countries residing in industrialised countries. This applies particularly for cancers of the liver, oesophagus, stomach and nasopharynx among males and cervix, stomach, liver, oesophagus and nasopharynx among females. In the same manner, low incidences in less well-developed regions are reflected by low incidences among migrant groups originating from these countries. This pattern could be confirmed in a recent study by Zanetti and colleagues,[25] who analysed cancer incidence in North Africa.

Mortality data show a similar picture, although the differences are less clear, which is mainly attributable to disparities in access to care and suboptimal communication on the dilemmas of treatment.

Our findings also concur with those of others from non-European countries and continents that host non-western migrants. McCredie and colleagues[26] for instance observed lower cancer incidences for migrants from various non-western origins in Australia and McDonald and Neily[27] could confirm similar results for migrant women in the United States.

A close relationship with individual exposure experienced during a life span could be confirmed for migrants of various origins. In addition to individual factors and health behaviour, the causal roles of exposure in the home country, i.e. before migration, during migration itself and in the host country, as well as the influence of social factors, certainly represent key factors in carcinogenesis.

Exposure to risk factors and adaptation to changing environments evolve over time and therefore cancer risk diversifies with the duration of residence, new exposures and new generations. Prospectively, a convergence of cancer risk (a simultaneous decrease in cancers with high incidence in migrants and an increase in those with a currently low incidence) towards the level of the rates in the native population of the host country can be expected over time and across migrant generations.[6,14,16,28]

Of course there are limitations to the comparisons conducted in this overview. Firstly, the definitions of the migrant groups and the study populations varied among studies and countries. Ethnicity proxies, such as 'self-assigned ethnicity' and name-based approaches, are in particular prone to misclassification bias, since a distinction between generations or for example intercultural marriages is not possible. Second, the comparability of studies is also limited with regard to the size, composition and time window of the study populations. It is also important to note that in some studies population data from censuses or surveys were used (instead of population-based registers), which is always a biased underestimate of the population at risk because as a rule only the head of the household is considered.

Third, migrant origins may sometimes have been collected in an inconsistent way, which was unavoidable in some cases (e.g. the allocation of Pakistan or Turkey).

Fourth, studies investigating both mortality and morbidity have been included, given the assumption of parallel effects, although mortality is mainly driven by (access to) treatment and the varying fatality rates of different cancers. Consequently, different measures of association have been pooled and compared on the basis of tendencies. The comparisons therefore lack a magnitude and only provide a rough estimation of risk disparities. Meta-analysis was not the aim of this overview.

The healthy migrant effect could partly explain the advantageous risks of migrants, but since effects seem to persist, its influence is probably marginal. Several studies also discussed the possible effects of the so-called salmon-bias, which assumes that migrants tend to return to their roots when they become ill. This is in most instances unlikely due to the fact that health services and treatment are often better in the host country and many migrants have already been joined by and settled with their families.

This is to our knowledge the first direct comparison of studies on cancer occurrence in migrant populations in Europe. Despite the limitations mentioned above, broad comparisons are feasible and will gain importance in the future. Prospectively, a transnational study of cancer occurrence in migrant populations could surmount many of these difficulties. This primarily concerns the definition of migrant groups requiring close networking between countries. In doing so, the results would be more reliable and the magnitude of the risk diversity could be studied in more detail. In order to appreciate the change in risk after migration, a comparison with data from the country of birth would be ideal.

Conflict of interest statement

None declared.

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