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Migration from Mexico to the United States: A high-speed cancer transition

Paulo S. Pinheiro [1], Karen E. Callahan[1], Mariana C. Stern[2] and Esther de Vries[3]

[1] University of Nevada Las Vegas, Epidemiology and Biostatistics, School of Community Health Sciences, Las Vegas, NV
[2] University of Southern California—Norris Comprehensive Cancer Center and Hospital, Keck School of Medicine, Departments of Preventive Medicine & Urology, Los Angeles, CA
[3] Pontificia Universidad Javeriana, Department of Clinical Epidemiology and Biostatistics, Bogota, Colombia

Differences and similarities in cancer patterns between the country of Mexico and the United States' Mexican population, 11% of the entire US population, have not been studied. Mortality data from 2008 to 2012 in Mexico and California were analyzed and compared for causes of cancer death among adult and pediatric populations, using standard techniques and negative binomial regression. A total of 380,227 cancer deaths from Mexico and California were included. Mexican Americans had 49% and 13% higher mortality than their counterparts in Mexico among males and females, respectively. For Mexican Immigrants in the US, overall cancer mortality was similar to Mexico, their country of birth, but all-cancers-combined rates mask wide variation by specific cancer site. The most extreme results were recorded when comparing Mexican Americans to Mexicans in Mexico: with mortality rate ratios ranging from 2.72 (95% CI: 2.44–3.03) for colorectal cancer in males to 0.28 (95% CI: 0.24–0.33) for cervical cancer in females. These findings further reinforce the preeminent role that the environment, in its multiple aspects, has on cancer. Overall, mortality from obesity and tobacco-related cancers was higher among Mexican origin populations in the US compared to Mexico, suggesting a higher risk for these cancers, while mortality from prostate, stomach, and especially cervical and pediatric cancers was markedly higher in Mexico. Among children, brain cancer and neuroblastoma patterns suggest an environmental role in the etiology of these malignancies as well. Partnered research between the US and Mexico for cancer studies is warranted.

Introduction

Variation in cancer patterns between similar populations across different geographic locations arises from differences in risk due to the interaction between genetics and environmental exposures to carcinogens, ranging from environmental and occupational exposures, radiation, pathogens, as well as lifestyle factors including unhealthy diet, obesity, and smoking. Cancer mortality, while largely influenced by this underlying risk (incidence), is also a function of survival among those who develop cancer. Migrant studies, comparing cancer outcomes between similar generations of immigrant populations and their respective country of origin, may shed light on the gene-environment interaction for different cancers, and provide insights into differences in access to and quality of treatment.[1]

Mexican populations in the United States (US), numbering approximately 5 million in 1970, predate current US borders.[2] Prior to 1970, most of the growth in populations of Mexican origin was accounted for by birth in the US.[2] However, a large wave of immigration from Mexico occurred during 1980–2000, resulting in a nearly sevenfold increase in the Mexican-origin population in only four decades.[2,3] Consequently, in 2012, there were almost 34 million Mexicans in the US, both immigrant and US-born, representing 11% of the total US population and 64% of all Hispanics.[3] As such, Mexicans in the US represent one of the largest diaspora populations in the world and the largest in the Americas.[3,4] Mexicans are diverse; the majority are Mestizo, descendants from generations of admixture between European and

Key words: cancer, mortality, Hispanics, California, Mexican American, childhood cancer, Mexico, acculturation, immigrant health, Latinos

Abbreviations: ALL: Acute lymphoid leukemia; CA: California (US state); CI: confidence intervals; CNS: central nervous system; CUP: cancers of unknown primary; HPV: human papillomavirus; ICCC: International Classification of Childhood Cancers; ICD-10: International Classification of Diseases-10th revision; IRR: incidence rate ratio; NHL: non-Hodgkin's lymphoma; NHW: non-Hispanic white; HCV: Hepatitis C virus; MRR: mortality rate ratio; SEER: Surveillance, Epidemiology and End Results; SSIMB: Mexican Social Security Institute; US: United States; WHO: World Health Organization

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Correspondence to: Paulo S. Pinheiro, University of Nevada, Las Vegas, Box 453063, 4505 S. Maryland Pkwy, Las Vegas, NV 89154, Email: paulo.pinheiro@unlv.edu; Tel: (702) 895-5717; Fax: (702) 895-5573

What's new?

Mexico and the U.S. state of California are intertwined by long-standing economic, cultural, and demographic relations. Little is known, however, about whether populations in both regions are also bound by commonalities in cancer incidence and mortality. Data presented here indicates disparate cancer mortality between closely related populations, including U.S.-born Mexicans, Mexican immigrants to the U.S., and populations in Mexico. Among adults, results indicate an increased risk and elevated mortality for most cancers for populations in the U.S. In sharp contrast, for childhood cancers, mortality outcomes are better in the U.S. than in Mexico, likely due to greater access to healthcare.

Indigenous Amerindian ancestors.[2] Given the historical movement of populations, Mexicans in the US and in Mexico are undoubtedly genetically related and certainly culturally connected.

Little is known about the cancer experience of Mexican origin populations in the US compared to their counterparts in Mexico. Directly comparing the occurrence of new cancers for these groups is not feasible, as cancer incidence data on US Hispanics is usually aggregated for all Hispanics.[5] Hispanic ethnic subgroup (e.g., Cuban, Puerto Rican, Mexican) is substantially incomplete in US cancer registries[6] and the only research to date that analyzed group-specific cancer incidence based on individual-level data was conducted in Florida, which has a relatively small Mexican population.[7] Additionally, population-based adult cancer surveillance has not yet materialized in the country of Mexico.[8] However, cancer mortality data for Mexico are available, as well as mortality data with birthplace information and specific ethnic group, including Mexican, for Hispanics in the US.[9] Since cancer mortality is a direct reflection of cancer incidence and survival,[10] it can meaningfully serve as an indicator of the cancer experience of a population.

In our study, we assess site-specific differences in cancer mortality between both adult and child decedents from Mexico and those of Mexican ancestry in the US, using mortality data from Mexico and the most populous US state, California. In 2010, the Golden State was home to more than one third, 12.1 million, of all Mexican Hispanics in the US.[11] The comparison of the cancer mortality experience between these populations will shed light on the net effects of the change in cancer risk between the two countries and/or the benefits of access to a highly-developed health care system, potentially resulting in better cancer survival.

Materials and Methods

For the US, individual-level mortality data from 2008–2012 were procured from the California Department of Health Vital Statistics. For each decedent coded as Hispanic in California, three variables were examined: birthplace codes, ethnicity codes (1 = Mexican, 2 = Puerto Rican, …, 9 = Hispanic unspecified) as well as the open-ended ethnicity text fields, which often contained specific descriptors such as "Mexican" or "Cuban" for cases otherwise described as Hispanic unspecified. This level of detailed scrutiny allowed for the accurate identification of Hispanic subgroup for 97.4% of the individuals. Among the remaining 2.6% of cancer deaths, all of whom were US-born, 2.5% ($n = 1{,}141$) were of unknown Hispanic ethnic subgroup. These were proportionally reassigned to a subgroup to assure comparability of rates using imputation models stratified by age, sex, and cancer site, using methodology described elsewhere.[7] The other 0.1% had two or more Hispanic subgroups listed in the text fields (e.g., Cuba, Mexico, etc.); for these individuals, the decedent was assigned to the first mentioned origin. From all Hispanic deaths in California, only those of Mexican origin were included in our study, categorized into two groups based on birthplace: those who were born in Mexico, hereafter referred to as Mexican Immigrants, and those born in the US, hereafter referred to as Mexican Americans. For the country of Mexico, aggregated cancer mortality data for 2008–2012 were obtained from the World Health Organization (WHO) Mortality database.[12]

Population denominators by birthplace for Mexican origin populations in California were obtained from the 5-year American Community Survey (2008–2012).[13] The overall annual populations for Mexican Immigrants and Mexican Americans in California were 4.5 million and 7.6 million, respectively. Population denominators for Mexico, 114.2 million annually, were obtained from the Organization for Economic Cooperation and Development.[14]

Cause of cancer death in both Mexico and California datasets was coded per the International Classification of Diseases-10th revision (ICD-10). We analyzed mortality by all-sites-combined, as well as for the 17 most common causes of cancer death. Cancer mortality rates for 2008–2012 for Mexican Americans, Mexican Immigrants and Mexicans, here defined as those who died in Mexico, were calculated per 100,000 persons, stratified by sex, annualized and age-standardized to the 2000 US Standard Population using eighteen age group bands, all 5-year except the last, which was 85 and older.

To directly compare mortality among adult-only Mexican populations, we used negative binomial regression and computed age-adjusted site-specific mortality rate ratios for Mexican Americans and Mexican Immigrants, with Mexicans as the referent population. Additional rate ratios stratified by age group for eight cancers were computed for lung, female breast, prostate, pancreas, and colorectal cancer, the most

Table 1. Average annual age-adjusted[1] mortality rates for selected cancers per 100,000, 2008–2012

	Mexico			Mexican Immigrants			Mexican Americans		
Male	***N***	**Rate**	**95% CI**	***N***	**Rate**	**95% CI**	***N***	**Rate**	**95% CI**
Oral cavity and pharynx	3,297	2.2	(2.2–2.3)	167	2.0	(1.7–2.3)	166	3.2	(2.7–3.8)
Esophagus	3,426	2.4	(2.2–2.5)	271	3.3	(2.9–3.8)	288	5.9	(5.2–6.7)
Stomach	14,553	10.0	(9.8–10.2)	660	7.9	(7.3–8.7)	392	8.1	(7.3–9.0)
Colorectum	10,700	7.1	(7.0–7.3)	937	11.8	(11.0–12.7)	1,058	21.0	(19.7–22.4)
Liver and intrahepatic bile duct	12,508	9.0	(8.8–9.1)	817	10.2	(9.4–11.0)[3]	1,217	21.6	(20.4–22.9)
Pancreas	8,469	5.8	(5.7–5.9)	700	9.5	(8.8–10.3)	614	12.3	(11.3–13.4)
Lung	21,227	15.4	(15.2–15.7)	1,561	23.9	(22.7–25.3)	1,364	30.1	(28.5–31.8)
Prostate	26,972	23.0	(22.7–23.2)	955	17.1	(16.0–18.3)	839	21.6	(20.1–23.2)
Kidney	5,421	3.5	(3.4–3.6)	353	4.4	(3.9–4.9)	403	7.7	(6.9–8.5)
Bladder	3,100	2.4	(2.3–2.5)	191	3.1	(2.7–3.6)	187	4.3	(3.7–5.0)
Brain	5,428	2.9	(2.8–3.0)	319	3.4	(3.0–3.9)	301	3.9	(3.4–4.4)
CUP	7,892	5.3	(5.2–5.4)	441	5.8	(5.2–6.4)	399	7.9	(7.1–8.7)
NHL	6,088	3.7	(3.6–3.8)	532	7.2	(6.5–7.9)	386	7.5	(6.7–8.3)
Leukemia	10,518	5.0	(4.9–5.1)	445	5.4	(4.8–6.0)	527	6.9	(6.2–7.7)
All-sites-combined[2]	168,663	116.3	(115.7–116.9)	9,557	130.6	(127.7–133.6)	9,306	182.8	(178.8–186.9)
Female									
Oral cavity and pharynx	1,680	1.0	(1.0–1.1)	64	0.8	(0.6–1.0)	72	1.1	(0.9–1.4)
Esophagus	1,150	0.7	(0.7–0.8)	41	0.5	(0.3–0.7)	64	1.0	(0.8–1.3)
Stomach	12,722	7.5	(7.4–7.6)	500	4.9	(4.5–5.4)	306	4.7	(4.2–5.3)
Colorectum	9,613	5.7	(5.6–5.8)	679	7.4	(6.7–8.0)	700	10.9	(10.1–11.8)
Liver and intrahepatic bile duct	13,874	8.5	(8.3–8.6)	522	6.1	(5.6–6.7)	467	7.5	(6.8–8.3)
Pancreas	9,577	5.9	(5.7–6.0)	700	8.4	(7.7–9.1)	567	9.2	(8.5–10.0)
Lung	11,352	7.0	(6.8–7.1)	942	11.5	(10.7–12.3)	1,052	17.2	(16.2–18.3)
Female breast	25,278	13.2	(13.0–13.4)	1,441	12.9	(12.2–13.7)	1,230	18.0	(17.0–19.0)
Cervix	19,464	10.4	(10.2–10.5)	357	3.0	(2.6–3.3)	228	2.8	(2.5–3.2)
Endometrium	3,626	2.0	(1.9–2.1)	343	3.4	(3.0–3.8)	290	4.5	(3.9–5.0)
Ovary	9,171	4.8	(4.7–4.9)	557	5.6	(5.1–6.2)[3]	478	7.3	(6.6–8.0)
Kidney	3,432	2.0	(1.9–2.0)	217	2.4	(2.1–2.8)[3]	236	3.6	(3.1–4.1)
Bladder	1,711	1.1	(1.1–1.2)	85	1.1	(0.8–1.3)	94	1.5	(1.2–1.9)
Brain	4,421	2.2	(2.1–2.2)	254	2.6	(2.2–3.0)	244	2.6	(2.3–3.1)
CUP	8,366	4.7	(4.6–4.8)	400	4.6	(4.2–5.1)	358	5.5	(4.9–6.1)
NHL	5,009	2.8	(2.7–2.9)	369	4.3	(3.8–4.8)	346	5.5	(4.9–6.1)
Leukemia	9,097	3.9	(3.8–4.0)	364	3.8	(3.4–4.3)	406	4.3	(3.9–4.8)
All-sites-combined[2]	175,733	98.3	(97.9–98.8)	8,968	95.9	(93.8–98.1)[3]	8,000	120.2	(117.5–123.0)

Abbreviations: CI, confidence interval; CUP, cancers of unknown primary, NHL, non-Hodgkin's lymphoma.
[1]Adjusted to the 2000 US Standard.
[2]All-sites-combined includes all cancers, including those not listed here.
[3]The confidence intervals for these specific cancers may be affected by an undercount of undocumented immigrants by the US Census; any conclusions about differences between populations for these cancers should be interpreted with caution.

common causes of cancer death, as well as cervix, liver and stomach, three infection-related cancers more common in Hispanic populations.[5,7,9] All models included decedents ages 35 and above; age-specific models used three broad age groups approximately representing younger adulthood, middle age, and seniors: ages 35–49, 50–64, and 65 and older. The age groups were modified for liver cancer to accommodate the known high prevalence of Hepatitis C virus (HCV), a major cause of liver cancer in the birth cohort of 1946–1965 in the US[15]; resulting groups for liver cancer were ages 35–44, 45–64, and 65 and older. Additionally, for prostate cancer, due to the skewed mortality experience toward older

Table 2. Mortality rate ratios[1] for selected cancers, 2008–2012

	Mexico Referent	Males				Females			
		Mexican Immigrants		Mexican Americans		Mexican Immigrants		Mexican Americans	
		MRR	95% CI	MRR	95% CI	MRR	95% CI	MRR	95% CI
Oral cavity and pharynx	1	0.91	(0.78–1.07)	1.43	(1.22–1.68)	0.69	(0.53–0.89)	1.12	(0.88–1.42)
Esophagus	1	1.43	(1.26–1.62)	2.38	(2.11–2.69)	0.67	(0.49–0.91)	1.46	(1.14–1.88)
Stomach	1	0.80	(0.72–0.88)	0.75	(0.67–0.84)	0.68	(0.62–0.75)	0.62	(0.55–0.70)
Colorectum	1	1.51	(1.36–1.69)	2.72	(2.43–3.03)	1.28	(1.19–1.39)	1.93	(1.79–2.09)
Liver and intrahepatic bile duct	1	1.10	(0.87–1.38)	2.62	(2.08–3.29)	0.70	(0.64–0.76)	0.88	(0.80–0.97)
Pancreas	1	1.49	(1.38–1.61)	2.08	(1.91–2.25)	1.30	(1.16–1.45)	1.51	(1.35–1.70)
Lung	1	1.27	(1.11–1.46)	1.62	(1.40–1.86)	1.43	(1.26–1.62)	2.23	(1.96–2.53)
Breast	1	–	–	–	–	0.97	(0.89–1.06)	1.34	(1.23–1.47)
Cervix	1	–	–	–	–	0.30	(0.26–0.34)	0.28	(0.24–0.33)
Endometrium	1	–	–	–	–	1.67	(1.49–1.86)	2.19	(1.94–2.47)
Ovary	1	–	–	–	–	1.05	(0.87–1.27)	1.38	(1.13–1.67)
Prostate	1	0.73	(0.66–0.80)	0.87	(0.79–0.97)	–	–	–	–
Bladder	1	1.20	(1.04–1.39)	1.74	(1.50–2.02)	0.90	(0.72–1.13)	1.39	(1.13–1.71)
Kidney	1	1.15	(1.03–1.28)[2]	2.09	(1.89–2.32)	1.18	(1.03–1.36)[2]	1.87	(1.63–2.14)
Brain	1	1.16	(1.03–1.30)[2]	1.33	(1.15–1.53)	1.16	(1.01–1.32)[2]	1.28	(1.09–1.50)
NHL	1	1.58	(1.30–1.92)	1.81	(1.47–2.12)	1.35	(1.11–1.64)	1.74	(1.42–2.14)
Leukemia	1	1.10	(0.92–1.31)	1.48	(1.23–1.77)	1.02	(0.90–1.16)	1.24	(1.08–1.42)
All-sites-combined[3]	1	1.04	(0.97–1.11)	1.49	(1.36–1.60)	0.90	(0.83–0.98)	1.13	(1.03–1.23)

Abbreviations: CI, confidence interval; MRR, mortality rate ratios; NHL, non-Hodgkin's lymphoma.
[1]Negative binomial regression rate ratios adjusted for age group, inclusive of ages 35+.
[2]The confidence intervals for these specific cancers may be affected by an undercount of undocumented immigrants by the US Census; any conclusions about differences between populations for these cancers should be interpreted with caution.
[3]All-sites-combined includes all cancers, including those not listed here.

ages, the three age groups used were 35–64, 65–74, and 75 and older.

Pediatric (ages 0–19) cancer mortality rates were calculated for the most common pediatric malignant causes of death per 1,000,000, both sexes combined, annualized and age-standardized to the 2000 US Standard Population using five age group bands: <1 year, 1–4, 5–9, 10–14, and 15–19. Benign brain and central nervous system (CNS) tumors as causes of death were excluded. Mortality rate ratios, computed using negative binomial regression, compared only the larger and statistically more stable pediatric populations of Mexican Americans to Mexicans, as there were very few Mexican Immigrant pediatric deaths in California.

Lastly, unlike for adult populations, cancer incidence data for children in Mexico exists, and because it adds to the understanding of the differences in mortality studied here, we proceeded to analyze cancer incidence differences among children between the two countries. We extracted childhood (ages 0–14) cancer incidence rates adjusted to the 2000 US Standard population from the Surveillance, Epidemiology and End Results (SEER) registry data from 2000 to 2013 in California, including only Hispanic children. Specific group is not reliably accurate for SEER cancer data; however, 90.1% of Hispanic children in California are of Mexican origin.[13] These were compared to the only available and previously published incidence data from Mexico, years 1996–2013 from the Registry of Cancer in Children, the longest-standing children's registry in Mexico, which includes children of beneficiaries of the Mexican Social Security Institute (SSIMB).[16] These data include childhood cancers (ages 0–14) that occurred in Mexico City and the federated states of Chiapas, Guerrero, Mexico State, and Morelos.[16] Rates were adjusted to the 2000 US standard population. Incidence rate ratios were computed using negative binomial regression; models included four age groups: <1 year, 1–4, 5–9, and 10–14.

For all rates, corresponding 95% confidence intervals (CIs) were calculated with gamma intervals modification. SAS 9.3 was used for data analysis. Our study was approved by the University of Nevada Las Vegas Institutional Review Board.

Results

Of the 380,227 adult cancer decedents identified who died between 2008 and 2012, 344,396 were in Mexico; 18,525 and 17,306 were Mexican Immigrants and Mexican Americans in California, respectively. Among males, the three leading causes of cancer death were prostate, lung and stomach for

Table 3. Mortality rate ratios,[1] with Mexico as reference, for selected cancers stratified by age group, 2008–2012

		Males				Females			
		Mexican Immigrant		Mexican American		Mexican Immigrant		Mexican American	
		MRR	95% CI	MRR	95% CI	MRR	95% CI	MRR	95% CI
Stomach	Young: 35–49	0.84	(0.58–1.24)	0.53	(0.33–0.86)	0.97	(0.81–1.17)	0.57	(0.41–0.79)
	Middle: 50–64	0.77	(0.66–0.88)	0.65	(0.53–0.80)	0.64	(0.54–0.76)	0.56	(0.44–0.71)
	Old: 65+	0.80	(0.71–0.90)	0.86	(0.75–0.99)	0.61	(0.53–0.70)	0.66	(0.57–0.76)
Colorectum	Young: 35–49	1.09	(0.91–1.31)	1.96	(1.61–2.31)	1.28	(1.05–1.56)	1.32	(1.01–1.72)
	Middle: 50–64	1.55	(1.39–1.74)	2.56	(2.28–2.89)	1.28	(1.11–1.48)	2.03	(1.75–2.35)
	Old: 65+	1.74	(1.58–1.92)	3.23	(2.96–3.53)	1.28	(1.14–1.44)	2.00	(1.79–2.24)
Liver	Young: 35–44	0.59	(0.35–1.00)	1.76	(1.11–2.79)	0.48	(0.28–0.82)	0.34	(0.14–0.81)
	Middle: 45–64	1.63	(1.18–1.84)	5.11	(4.67–5.60)	0.60	(0.51–0.71)	0.82	(0.69–0.99)
	Old: 65+	1.04	(0.90–1.20)	1.80	(1.57–2.08)	0.76	(0.68–0.85)	0.93	(0.83–1.03)
Pancreas	Young: 35–49	0.91	(0.70–1.19)	1.56	(1.15–2.10)	0.88	(0.64–1.19)	1.28	(0.90–1.82)
	Middle: 50–64	1.34	(1.17–1.53)	2.06	(1.78–2.37)	1.08	(0.93–1.26)	1.41	(1.19–1.68)
	Old: 65+	1.75	(1.58–1.94)	2.17	(1.95–2.42)	1.54	(1.36–1.75)	1.64	(1.43–1.87)
Lung	Young: 35–49	0.84	(0.67–1.06)	0.78	(0.55–1.09)	0.88	(0.67–1.16)	1.55	(1.17–2.06)
	Middle: 50–64	1.10	(0.99–1.23)	1.50	(1.33–1.70)	1.30	(1.14–1.49)	2.03	(1.77–2.34)
	Old: 65+	1.63	(1.52–1.74)	2.08	(1.94–2.22)	1.77	(1.56–2.00)	2.67	(2.37–3.00)
Breast	Young: 35–49	–	–	–	–	0.87	(0.78–0.96)	1.00	(0.87–1.14)
	Middle: 50–64	–	–	–	–	0.91	(0.84–0.99)	1.21	(1.10–1.34)
	Old: 65+	–	–	–	–	1.11	(1.01–1.21)[2]	1.69	(1.55–1.84)
Cervix	Young: 35–49	–	–	–	–	0.36	(0.30–0.43)	0.47	(0.38–0.59)
	Middle: 50–64	–	–	–	–	0.34	(0.29–0.41)	0.28	(0.22–0.36)
	Old: 65+	–	–	–	–	0.23	(0.18–0.28)	0.17	(0.13–0.23)
Endometrium	Young: 35–49	–	–	–	–	1.20	(0.89–1.60)	1.52	(1.06–2.17)
	Middle: 50–64	–	–	–	–	1.75	(1.47–2.09)	2.09	(1.70–2.56)
	Old: 65+	–	–	–	–	1.80	(1.53–2.13)	2.51	(2.13–2.95)
Prostate	Young: 35–64	0.77	(0.65–0.90)	0.74	(0.59–0.92)	–	–	–	–
	Middle: 65–74	0.69	(0.60–0.78)	0.82	(0.70–0.95)	–	–	–	–
	Old: 75+	0.74	(0.62–0.87)	0.93	(0.79–1.11)	–	–	–	–
All-sites-combined[3]	Young: 35–49	0.81	(0.71–0.93)	1.13	(0.99–1.30)	0.73	(0.69–0.77)	0.85	(0.80–0.91)
	Middle: 50–64	1.08	(1.04–1.13)	1.67	(1.60–1.74)	0.84	(0.81–0.88)	1.07	(1.01–1.12)
	Old: 65+	1.16	(1.12–1.20)	1.61	(1.55–1.66)	1.08	(1.01–1.16)[2]	1.37	(1.28–1.48)

Abbreviations: CI, confidence interval; MRR, mortality rate ratios.
[1]Negative binomial regression rate ratios.
[2]The confidence intervals for these specific cancers may be affected by an undercount of undocumented immigrants by the US Census; any conclusions about differences between populations for these cancers should be interpreted with caution.
[3]All-sites-combined includes all cancers, including those not listed here.

Mexicans; lung, prostate and colorectal for Mexican Immigrants; and lung, prostate and liver for Mexican Americans. For females, breast, cervix and liver were the three leading causes of cancer death for Mexicans, while breast, lung and pancreas led for both Mexican Immigrants and Mexican Americans in California. Mexican Americans had the highest rates for all-sites-combined and most cancer sites (Table 1).

For Mexican Americans, mortality for colorectal, kidney and endometrial cancers, all obesity-related,[17] was more than double that of Mexicans in Mexico; for pancreatic and esophageal cancers, mortality was over twice as high in Mexican American males and approximately 50% higher in Mexican American females (Table 2). Rate ratios examined pairwise (data not shown) demonstrated a pattern of successively increasing age-adjusted mortality risk, lowest for Mexicans, followed by Mexican Immigrants, and then Mexican Americans for endometrium, colorectal, pancreas, non-Hodgkin's lymphoma, and lung cancers in both sexes, as well as esophageal cancer in men. Conversely, there was no evidence of a significant monotonic decreasing pattern of

Table 4. Age-adjusted mortality rates[1] for pediatric cancers (ages 0–19) per 1,000,000 and mortality rate ratios,[2] 2008–2012

				Mortality rates						Mortality rate ratios		
				Mexico			Mexican American			Mexico	Mexican American	
Primary site	Most common type	ICD-10 Codes	Corresponding ICCC class	*n*	Rate	95% CI	*n*	Rate	95% CI	Referent	MRR	95% CI
Leukemias (all combined)		C91–95	I	5744	25.7	(25.0–26.4)	247	11.5	(10.1–13.0)	1	0.44	(0.39–0.50)
Acute lymphoid leukemia		C91 and C95	I(a)	4532	20.3	(19.7–20.9)	171	8.0	(6.8–9.3)	1	0.39	(0.34–0.45)
Acute myeloid leukemia		C92	I(b)	1179	5.3	(5.0–5.6)	71	3.2	(2.5–4.1)	1	0.62	(0.49–0.79)
Non-Hodgkin's lymphoma[3]		C82–85	II(b,c)	599	2.7	(2.5–2.9)	15	0.7	(0.4–1.2)	1	0.26	(0.16–0.44)
Brain and CNS[4]		C70–72	III	1437	6.4	(6.1–6.7)	133	6.1	(5.1–7.2)	1	0.94	(0.79–1.13)
Adrenal gland	Neuroblastoma	C74	IV	219	1.0	(0.8–1.1)	31	1.3	(0.9–1.9)	1	1.38	(0.95–2.01)
Kidney	Wilms' Tumor	C64	VI	242	1.1	(0.9–1.2)	15	0.7	(0.4–1.1)	1	0.61	(0.37–1.04)
Liver	Hepatoblastoma	C22	VII	283	1.2	(1.1–1.4)	17	0.7	(0.4–1.2)	1	0.60	(0.37–0.98)
Bone	Osteossarcoma	C40	VIII	780	3.5	(3.3–3.8)	48	2.3	(1.7–3.0)	1	0.66	(0.49–0.88)
Soft tissue	Rhabdomyosarcoma	C49	IX	367	1.6	(1.5–1.8)	26	1.2	(0.8–1.7)	1	0.73	(0.49–1.09)
All-sites-combined[5]		C00-C97	I to XI	9671	50.6	(49.7–51.6)	532	27.6	(25.4–29.9)	1	0.55	(0.50–0.59)

Abbreviations: CI, confidence interval; ICCC, International Classification of Childhood Cancers; ICD, International Classification of Diseases; MRR, mortality rate ratios.
[1]Adjusted to the 2000 US Standard.
[2]Negative binomial regression rate ratios.
[3]Includes Burkitt lymphoma.
[4]Only malignant cases.
[5]Includes all cancers, including those classes not listed.

Table 5. Age-adjusted[1] childhood (0–14) cancer incidence rates per 1,000,000 and incidence rate ratios[2]

		Incidence rates				Incidence rate ratios		
		Mexico		CA Hispanics		Mexico	CA Hispanics	
	ICCC Class	n	Rate (95% CI)	n	Rate (95% CI)	Referent	IRR	95% CI
Leukemias	I	2185	57.0 (54.6–59.4)	3457	64.2 (62.1–66.4)	1	1.12	(1.06–1.20)
Acute lymphoid leukemia	I(a)	1792	46.6 (44.4–48.8)	2843	52.8 (50.9–54.8)	1	1.13	(1.06–1.21)
Acute myeloid leukemia	I(b)	342	9.0 (8.1–10.0)	491	9.1 (8.3–9.9)	1	1.02	(0.86–1.21)
Non-Hodgkin's lymphoma[3]	II(b,c)	286	7.4 (6.6–8.4)	415	7.9 (5.7–6.8)	1	1.05	(0.89–1.23)
Brain and CNS[4]	III	573	15.0 (13.8–16.3)	1410	26.3 (25.0–27.8)	1	1.75	(1.59–1.93)
Neuroblastoma	IV	104	2.9 (2.4–3.6)	393	7.0 (6.3–7.8)	1	2.44	(1.96–3.03)
Kidney	VI	196	5.3 (4.6–6.0)	361	6.5 (5.9–7.2)	1	1.25	(1.05–1.48)
Liver	VII	86	2.3 (1.9–2.9)	152	2.7 (2.3–3.2)	1	1.15	(0.88–1.50)
Bone	VIII	259	6.9 (6.1–7.8)	372	7.2 (6.5–7.9)	1	1.04	(0.89–1.22)
Soft tissue	IX	255	10.2 (9.2–11.3)	560	10.5 (9.7–11.4)	1	1.00	(0.67–1.49)
All-sites-combined[5]	I to XI	4728	124.5 (121.0–128.1)	8456	157.4 (154.1–160.8)	1	1.26	(1.22–1.31)

SSIMB Mexico 1996–2013, SEER Hispanics in California (90.1% of Mexican origin) 2000–2013
Abbreviations: SSIMB, Mexican Social Security Institute, SEER, Surveillance, Epidemiology and End Results, ICCC, International Classification of Childhood Cancers, CI, Confidence Interval, CA, California; IRR, incidence rate ratios.
[1]Adjusted to the 2000 US Standard.
[2]Negative binomial regression rate ratios.
[3]Includes Burkitt lymphoma.
[4]Only malignant cases.
[5]Includes all cancers, including those classes not listed here.

mortality risk between Mexico, Mexican Immigrants and Mexican Americans for the three cancers with relatively lower mortality among Mexican immigrants in the US compared to Mexico: stomach, cervix, and prostate.

When stratified by age group, considerable variation was found (Table 3). For most sites—colorectal, pancreas, lung, breast, and endometrial—the older age groups (65+) had the greatest risk difference between Mexican Americans and Mexicans. For all-sites-combined cancer mortality in this older age group, Mexican American mortality was 61% higher in men, and 37% higher in women. However, in the younger age group (under 50), the two groups were remarkably similar, except for colorectal cancer among young Mexican Americans of both genders, liver and pancreatic cancers in young men and lung cancer in young Mexican American women. Notably, among younger women, all-sites-combined cancer mortality was 15% lower for Mexican Americans than women in Mexico, driven by lower mortality for cervix, liver, and stomach cancers. Among younger men, all-sites-combined mortality was similar between Mexican Americans and Mexicans, while slightly lower for Mexican Immigrants. For liver cancer, Mexican American men in the middle age group, representing the cohort born between 1945 and 1965, had mortality that was extreme, five times higher than Mexicans (MRR 5.11; 95% CI: 4.67–5.60) (Table 3).

Lastly, 9,671 pediatric cancer deaths from Mexico and 532 among Mexican Americans in California were analyzed (Table 4), as well as 4,728 incident childhood cases in Mexico and 8,456 among Hispanics in California (Table 5). All-sites-combined childhood incidence was 26% higher among Hispanics, with the largest excesses in cancer risk (incidence) found for brain (and CNS) and neuroblastoma, 75% and 144% higher, respectively. However, Mexican Americans in California had 45% lower mortality from pediatric cancers than Mexicans; the largest difference observed was for non-Hodgkin's lymphoma, with 74% lower mortality in California (Table 4).

Discussion

Our study reports substantial differences in cancer mortality between Mexican Americans, Mexican Immigrants in the US and Mexicans in Mexico. Patterns shift across the studied geographies, with mortality rates from stomach and cervical cancer (among the three leading causes of cancer death in Mexico) being superseded by lung and colorectal cancer among Mexican Americans and Mexican Immigrants. Broadly, we report that Mexican Americans aged 50 or older have higher mortality rates for a majority of cancers compared to the Mexican-based population, whereas Mexican Immigrants have rates that are in between the other two groups. Conversely, stomach, cervical, prostate, and pediatric cancer mortality were considerably higher in Mexico compared to the US.

Adult cancers

Overall, Mexican Americans and Mexican Immigrants are dying substantially more from obesity-related cancers[17] compared to Mexicans, including endometrium, colorectal, pancreas, non-Hodgkin lymphoma (NHL) and kidney, but also from other cancers including lung cancer, and among men,

liver and esophageal cancers. These differences contribute to the 49% higher all-sites-combined mortality observed for Mexican American males and 13% among females compared to the referent Mexican population. In women, however, the benefit of vastly lower mortality from stomach, liver, and especially cervical cancer experienced by populations living in the US compared to Mexico largely offsets the steep increases observed in other (obesity-related, lung) cancers.

Among Mexican Americans, for whom the prevalence of obesity is much higher than in Mexico,[18,19] mortality for colorectal, endometrial, and kidney cancers is more than double the mortality risk of Mexicans. This is consistent with recent research showing US-born Hispanic men with significantly higher colorectal and kidney cancer mortality than even non-Hispanic whites (NHWs).[20] For Mexican Immigrants, the vast majority of whom migrate in their twenties,[3,13] mortality for obesity-related cancers is lower than among Mexican Americans but higher than in Mexico, particularly for older immigrants, in accordance with reports documenting an increase in obesity prevalence with increased length of time in the US among Mexican Immigrants.[21] Similar to previous studies examining cancer in Hispanics,[20,22,23] we found that colorectal cancer in Mexicans is of special concern in the US, with higher mortality not only for those older than 50, despite screening being more readily available than in Mexico,[24] but also for those younger than age 50.

Mortality from tobacco-related cancers, such as lung, bladder, oral cavity, and esophageal cancer,[25] is unsurprisingly higher among Mexican Americans, given their higher smoking prevalence.[26] In women, lung cancer mortality is substantially higher in both Mexican Immigrants and Mexican Americans, which corresponds to historical smoking patterns and a very low smoking prevalence in Mexico among women.[26,27]

For breast cancer, Mexican American women, with higher prevalence of obesity,[18,19] and lower likelihood of the protective benefits associated with high fertility, young age at first childbirth, and breastfeeding, which are more prevalent in Mexico, have higher mortality than Mexican women in postmenopausal ages. The rates for Mexican Immigrants were not substantially different from Mexican women, suggesting that the availability of more widespread screening and improved access to quality treatment[28,29] in the US may balance out the likely increased risk associated with living in the US.

For the cancers described above, obesity-related, lung and breast, our findings raise important considerations. Mexican American populations have uniformly worse mortality than Mexicans in Mexico. This is despite broad availability of screening programmes in the US, which impact both incidence and survival, particularly for colorectal and breast cancers,[30] as well as better access to the finest treatment regimens available.[28,29] Within the US, barriers to health have been documented for Hispanics, including lack of access to quality health care,[31] lower cancer screening rates,[32,33] later stages at diagnosis,[5] delays in treatment,[34] and high health care costs[35] which may deter Mexicans, especially immigrants, from accessing the best available cancer treatments.[36] Disparities notwithstanding, however, SEER data, which includes California, a state where Hispanics are overwhelmingly of Mexican origin, have shown that US Hispanics have high all-stages-combined survival from cancer, similar to or only slightly lower than non-Hispanic whites for most cancers.[37] These unexpected positive outcomes among Hispanics despite health care disparities have been ascribed to strong extended family and community support systems.[34] In light of this very high cancer survival, similar to NHWs in the US, which is among the highest in the world,[38] the higher mortality observed in our study for Mexican populations in the US compared to Mexico can only logically be due to an increase in risk, and a substantial one. Higher cancer incidence and mortality for other immigrant populations in the US, particularly for cancers associated with smoking and obesity, have been previously reported[7,39]; therefore, it is not surprising that this extends to the large Mexican population in the US.

In contrast to the observations described above, a few common causes of cancer death in Latin American countries, cervical, stomach, and liver cancer for females,[40] were substantially lower among both Mexican Americans and Mexican Immigrants compared to Mexicans. For cervical cancer, survival is high in the US among Hispanics,[37] despite previously documented disparities in access to and use of pap screening.[31,41] Thus, in our study, lower incidence and better survival in the US, due to widely available screening, potential for early detection, and access to treatment including radiotherapy for middle and late stages, likely explains the markedly lower mortality rates among populations of Mexican origin living in the US compared to Mexico.[42] Similar patterns of substantially lower mortality rates from cervical cancer among immigrants compared to the country of origin were reported for non-Hispanic immigrants from Haiti and Jamaica,[39] demonstrating the efficacy of cervical cancer control programs in the US for foreign-born minority women. While it is possible that oncogenic HPV prevalence rates differ between Mexico and the US, the lack of difference in mortality between Mexican Immigrants and Mexican Americans in California suggests that cervical cancer screening and access to healthcare might be more important determinants of the considerably lower mortality in the US than variations in HPV risk. Notably, the mortality differences between women in Mexico and the US are higher among older women than those below age 50, which may indicate an improving quality and coverage of cervical cancer control efforts in Mexico in recent years.[42]

Compared to Mexico, US Mexican populations showed lower mortality for stomach cancer, a malignancy for which the general prognosis remains poor,[43] resulting in uniformly low survival. The lower mortality seen in our study for Mexican Immigrants and Mexican Americans is likely due to

lower risk of exposure to chronic *Helicobacter pylori* infection, a strong stomach cancer risk factor, in the US than in Mexico.[44] Especially evident among younger stomach cancer decedents, this risk difference is reflected in the age-specific patterns observed here by way of a cohort effect: mortality from stomach cancer in the youngest age group was similar between Mexican Immigrants and Mexicans, but much lower in Mexican Americans. However, in the older age groups, both Mexican Immigrants and Mexican Americans fare significantly better than their counterparts in Mexico.

The liver cancer results merit special attention in light of how this cancer disproportionately afflicts Hispanics in the US,[5,20] and the prominent role that hepatitis C (HCV) plays in US rates.[45,46] As other studies have demonstrated, patterns in the US for liver cancer differ between foreign-born populations and US-born, particularly according to gender.[7,20] HCV infection prevalence is especially high in the male US-born Hispanic populations,[47] and among the high-risk cohort of those born between 1945 and 1965.[15] Correspondingly, this same pattern applies to liver cancer.[20] In our study, the excess in liver cancer mortality rates is highest among Mexican American males of this high-risk cohort, aged 45–65 in 2010, who have five times greater mortality than men in Mexico. The adjacent age groups, younger than 45 and older than 65, likely have some overflow from this high-risk HCV cohort, with mortality nearly double that of their counterparts in Mexico. Mexican Immigrant males ages 45–64 also show higher mortality than in Mexico, but without data on age of immigration, it is unclear if this cohort is subject to an elevated HCV prevalence or other known risk factors for liver cancer, such as excessive alcohol consumption and obesity, common in Mexican populations.[48] Among women, the balance between the known risk factors may be substantially different from men, as suggested by gender-specific immigrant cancer patterns in other studies.[7,9,20,45,49] Mexican Immigrant women have the lowest liver cancer mortality rates. Further study is required on the specific prevalence of etiologic factors in women in order to fully understand these differences.

The findings for prostate cancer in our study are not readily understandable based on current knowledge about incidence and survival for this cancer. Mexican Immigrant males have significantly lower rates compared to both Mexican Americans and Mexicans, the latter having the highest mortality. Precise incidence of prostate cancer is unknown in Mexico[50] and comparison of prostate cancer incidence between countries is problematic, largely because it reflects the coverage of PSA screening in the population.[51] However, given that prostate cancer incidence is highest among African-descent populations,[39,51] as well as most developed countries, even among NHW populations,[52] it is possible that Mexican Immigrants carry a lower prostate cancer risk from Mexico. Parallel to this, prostate cancer survival, especially for non-localized stages, is impacted by early detection and widespread availability of diagnostic scans for staging, as well as access to complex treatment involving surgery, hormone and radiotherapy; thus, survival is likely to be higher in the US than in Mexico.[53] In fact, US Hispanics have been shown to have from prostate cancer survival similar to NHWs, 93% at 5 years.[37] Therefore, both Mexican Immigrants and Mexican Americans may benefit from high survival for cancers requiring treatment. Yet, compared to Mexican Immigrants, Mexican Americans have higher mortality, which may reflect a higher incidence of aggressive prostate cancers in this population, more similar to that seen in developed countries.[52,53]

A "healthy migrant effect" has been proposed for Mexican immigrants,[54] suggesting that those who migrate are, on average, healthier than both the population left behind and the receiving population, thus conferring protection to immigrants for many health conditions. However, consistent with our current study, evidence for this has been weak.[55] Particularly for cancer, adult lifestyles, including smoking, obesity, and diet, are important determinants, and most people will have their odds of adult cancer determined during their working lives. Since cancer is a disease which usually occurs at relatively advanced ages, and most Mexicans migrate during their working ages,[3,13] any advantage for Mexican Immigrants would manifest in a lower prevalence of risk factors that impact cancer rates. Looking at all three populations, and among all cancers analyzed, Mexican Immigrants only have the lowest mortality for esophageal cancer, and only among females, perhaps due to lower smoking and alcohol consumption among Mexican Immigrant women. Prostate cancer and liver cancer in females showed a similar pattern, lowest rates among Mexican Immigrants compared to Mexican Americans and Mexicans, but these lower rates could be explained by early detection and effective treatments for prostate cancer, and by the distinct epidemiology for liver cancer, as described above. Notably, the overall message for Mexican Immigrants depicted in our study is that their mortality patterns are unfavorable in comparison to Mexico for a wide range of cancers: lung, pancreas, endometrial, NHL, and colorectal. For women, if only two cancers driving the all-sites-combined mortality rates in Mexico, stomach and cervical, were removed from the aggregation, Mexican Immigrant women in the US would have significantly higher cancer mortality than women in Mexico.

Pediatric cancers

For children, our findings were vastly different: cancer mortality for most childhood cancers was much higher in Mexico than in the US. Pediatric cancers are distinct from adult cancers, with only a small proportion having preventable or even known causes.[56] To date, only radiation, prior chemotherapy and certain viral infections have been firmly established as environmental risk factors,[57] while weaker evidence also suggests an association with birthweight, often related to nutrition,[58] and parental smoking for some, but not all, pediatric cancers.[56,57] Rather, incidence of pediatric cancers reflects an inherent cancer risk largely attributable to chance in the

complex process of normal cell development, a chance genetic risk that has been posited as the main determinant of cancer in children.[57] This is supported by our examination of incidence among children in Mexico and US Hispanic children in California, which showed remarkably similar risk for many pediatric cancers between these two genetically related populations residing in different geographies, consistent with a genetic rather than environmental etiology.

Given the similarity seen here in incidence, differential survival from pediatric cancers likely explains the higher mortality seen for children in Mexico. Survival from pediatric cancers is dependent upon access to specialized centers, multidisciplinary teams, complex treatment protocols, and access to clinical trials,[56] and is far superior in developed high income countries.[38,59] Thus, the substantially lower mortality, 45% lower, for the Mexican American pediatric population in our study for leukemias, NHL, liver, and bone cancer, must reflect differences in survival attributable to better access to care in the US, where 90% of pediatric cancers are treated at childhood cancer specialty centers.[56] The most disparate result was for NHL, a cancer requiring complex chemotherapy, which more commonly afflicts adolescents ages 15–19. The unique specificities of this transitioning age group provide a challenge in determining appropriate cancer treatments, even in high-resource settings[60]; Mexico could lack optimal resources to provide this highly specialized care.

However, there were two distinct exceptions to the pattern of higher mortality for pediatric cancers in Mexico coupled with similar risk between Mexico and Hispanic populations. Brain cancer and neuroblastoma incidence rates were markedly higher, 75% and 144% higher, respectively, among Hispanics in California than children in Mexico. Nonetheless, even with this higher risk in the US, mortality rates were not dissimilar, as would be expected, despite likely advantages in treatment and survival for Mexican American children in California. Neuroblastoma, usually occurring during the first years of life, is the most common of the embryonal cancers; these immature cells are vulnerable to external influences in the development process.[56,57] Brain and CNS tumors are the most common solid tumors in children; to date, rare genetic conditions, previous high-dose radiation, and possibly high maternal consumption of cured meats are the only known environmental risk factors.[56–58,61] It is possible that some unknown environmental exposures explain the higher incidence in the US observed across every childhood age group analyzed (data not shown) for brain and CNS malignancies. Taken together, and given the genetic similarity but geographic dissimilarity between the comparison populations, this new evidence indirectly suggests, purely on the basis of descriptive epidemiology, that *in utero* and/or early childhood environmental exposures may be a stronger determinant of neuroblastoma and brain cancers than previously thought.

We are unaware of previous studies comparing the pediatric cancer risk for genetically-related populations living in different geographies of disparate economic development levels. While under-registration of childhood cancers in the Mexico registry, or problems with mortality data in Mexico, could be considered as an explanation for the lower numbers in that country, it seems unlikely such discrepancies would impact only neuroblastoma and brain cancers but not the other childhood cancers. Furthermore, any concern with the quality of the findings can be allayed by realizing that the mortality and incidence data sources are independent from each other in both countries, yet all four datasets point in the same direction.

Strengths and limitations

To our knowledge, this is the largest study comparing cancer mortality patterns between immigrants and their country of origin, encompassing many thousands of cancer decedents in each of the three groups under comparison. The main strength of our study is the use of population-based data, which eliminates selection bias as a potential explanation for any observed differences. Nonetheless, the study is subject to the usual limitations of descriptive epidemiology. There is the possibility of systematic errors in cause-of-death coding that may differ between California and Mexico. Our differences may be slightly overestimated as 17% of Hispanic adults in the US are mixed-race, thus partly non-Mexican; most of these have a non-Hispanic white parent or grandparent.[62] For children, the proportion with one non-Hispanic parent is even higher.[62] However, Mexican American decedents were also missed, since as many as 5% only identify as white, rather than Hispanic white or Mexican white.[63] The rates for Mexican Immigrants could be underestimated if any of those who spent the majority of their at-risk adult years in the US subsequently return to Mexico to die, a phenomenon referred to as the Salmon Bias.[64] However, researchers have shown this return migration to be minimal,[64] and the effect of any such migration would merely reinforce our finding of an increased mortality pattern for Mexican Immigrant populations when moving to the US. Lastly, while cancer patterns within Mexico may vary according to regional differences, Mexican Immigrants to California are predominantly from Baja California and the Central West Plateau, which includes Mexico City.[4]

The childhood incidence analyses were limited by the data availability, including differences in comparison periods and cut-off ages (14 instead of 19 used in mortality analyses). The Registry of Cancer in Children in Mexico only encompasses children whose parents have formal employment in Mexico; these children may not be entirely representative of all Mexican children. In California, we used aggregated Hispanics; however, since 90.1% of Hispanic children in California are of Mexican origin,[13] it is unlikely that this limitation would meaningfully confound our comparison. Some childhood cancers arise from previous cancer treatments, but we checked California SEER incidence for first primary tumors only (data not shown), and the differences with our data were negligible.

As previously mentioned, studies show disparities for Hispanics in the US for stage at diagnoses,[5] screening rates,[32,33] access to health care,[31] differences in treatment,[36] and cost barriers.[35] However, mortality data is not stage specific, and our data sources did not contain specific information on these determinants or other individual risk factors, including comorbidities. All mortality differences observed in this analysis are based on the interplay of all-stages-combined incidence and all-stages combined survival on a population level, rather than individual-level data.

Conclusion

In summary, we observed higher mortality for most adult cancers among Mexican Americans in California compared to both Mexican Immigrants and Mexicans. Given that overall cancer survival is certainly higher in the US compared to Mexico,[37,38] the higher mortality among Mexican Americans is likely due to a pronounced increase in risk for most cancers among Mexican Americans compared to Mexicans. "Negative acculturation," whereby immigrants adopt the unhealthy habits of the native population, including increases in alcohol intake, cigarette smoking, poor diet, sedentary lifestyle, and obesity, may explain some of the increased risk.[54] Our findings of fewer and smaller mortality differences in the under 50 age group between Mexico and the US Mexican origin populations suggest an increasing incidence among younger populations in Mexico which may be concomitant with known increases in risk factors in that country, especially obesity.[19]

For pediatric cancers, the outcomes characterized here diverge completely from adult patterns. Differences in cancer care and survival, rather than differences in risk, are likely the reason behind the unfavorable mortality disadvantage for Mexican children compared to their counterparts in the US. Epidemiologically, results are particularly intriguing for brain and CNS cancers and neuroblastoma, suggesting an environmental role in these malignancies.

There are currently over 34 million people of Mexican origin in the US, comprising 11% of the US population.[3] Our study highlights the need to increase focus on cancer prevention and control among Mexicans in the US. Moreover, it suggests several potential areas for improvement in the neighboring country of Mexico, such as childhood cancers and cervical cancer. It also suggests an increase in cancer incidence and mortality in Mexico via a cohort effect. At the population level, there is little cooperation between the Mexico and the US in terms of cancer surveillance. In an interconnected, globalized world, risk factors and cancer control are increasingly moving in tandem; effective efforts in combatting cancer, both in terms of research as well as medical practice, may be best accomplished with stronger research partnerships between the two countries.

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