Temporal trends of incidence and mortality in Asian-Americans with pancreatic adenocarcinoma: an epidemiological study

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Abstract

Background Pancreatic cancer is the fourth most common cause of cancer-related deaths in the United States, with an estimated 45,750 deaths in 2019. Mortality outcomes seem to differ based on the ethnicity of the patients, with most studies focusing on the mortality and survival of Caucasians and African Americans. Little attention has been given, however, to Asian-American patients diagnosed with pancreatic adenocarcinoma (PAC). In this study, we aimed to investigate mortality rates in Asian-American patients with PAC.

Methods The SEER 13 registries (Surveillance, Epidemiology, and End-Results) of the National Cancer Institute were used to study PAC cases during 1992-2015. The incidence and incidence-based mortality rates per 100,000 person-years, and the annual percentage changes were calculated using SEER*stat software and Joinpoint regression software.

Results A total of 5814 PAC cases in Asian-American patients were identified. Most patients were older than 60 years (77.6%) and had metastatic disease (55.8%). The overall incidence of PAC among Asian-Americans was 5.740 per 100,000 person-years (95% confidence interval [CI] 5.592-5.891]. Incidence rates were highest among males and patients older than 60 years. PAC incidence rates among Asian-Americans increased by 1.503% (95%CI 1.051-1.956; P<0.001) per year over the study period. PAC incidence rates increased over the study period for all sex, age, and stage subgroups. PAC incidence-based mortality among Asian-Americans increased by 4.535% (95%CI 3.538-5.541; P<0.001) per year over the study period.

Conclusion The incidence of PAC in Asian-Americans, as well as incidence-based mortality rates, are on the rise, irrespective of age, sex or stage subgroup.

Keywords Pancreatic adenocarcinoma, Asian-Americans, racial disparities, SEER

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Introduction

Approximately 56,770 patients were diagnosed with pancreatic cancer and 45,750 died from the disease in the United States (US) in 2019 [1]. Those estimates constitute an increase from 2018 to 2019 by 1330 and 1420 cases, respectively, ranking pancreatic cancer as the fourth most common cause of cancer-related deaths in both American men and women [1,2]. Despite recent advances in cancer therapy worldwide, 5-year survival rates for pancreatic malignancies remain low, increasing only from 4% to 9% in the last 4 decades [3,4]. Thus, efforts are needed to understand the underlying causes of this disease, to improve the knowledge of its epidemiological features and to translate these findings into the management of pancreatic cancer.

In 2018, 458,918 new cases and 432,242 deaths were attributed worldwide to pancreatic cancer, with 46.7% of new cases and 46.4% of deaths occurring in Asia [5,6]. However, Asian patients have rarely been studied, probably because they show a lower incidence compared to Whites (Hispanic or non-

Hispanic), American Indians/Alaskan Natives, and Blacks [7]. Low socioeconomic status, healthcare access, obesity, diabetes, and smoking status are all linked to the outcomes of pancreatic cancer and vary based on ethnicity [8-10]. Taking this into consideration, studying the influence of modifiable and non-modifiable risk factors on the temporal trends of pancreatic cancer incidence and mortality is justified and would enable a better understanding of the epidemiology of this malignancy.

In the US, Asian-Americans account for more than 6% of the total population and, because of immigration, are the racial group that has increased its numbers the most [11]. Thus, research that seeks to establish the impact of pancreatic cancer on Asian populations would help establish public policy and affect disease patterns in the future. In addition, an epidemiological approach to the subject of pancreatic cancer in Asian-Americans would enable policymakers to understand the importance and influence of genetics, ethnicity and environmental factors in the development of this malignant disease. In this study, we aim to describe the incidence and mortality trends over the last 2 decades in Asian-American patients with pancreatic adenocarcinoma (PAC).

Patients and methods

Data source

We used the SEER*stat software (version 8.3.5) to obtain data of PAC cases diagnosed during 1992-2015 from SEER 13 registries [12]. The "Incidence-SEER 13 Regs Research Data, Nov 2017 Sub (1992-2015)" database covers approximately 13.4% of the US population (based on the 2010 census) [13,14].

Study population

The study included Asian-American patients with PAC diagnosed during 1992-2015; "Site Recode ICD-O-3/WHO 2008 classification; Pancreas: C250-C259" and "Histology recode - broad groupings; adenoma and adenocarcinoma: 8140-8389" variables were used for this selection. We only included histologically confirmed cases; cases whose diagnosis relied only on autopsy or death certificates were excluded.

Within this population, we looked into the following variables: sex, age at diagnosis (and age at death), state, stage at diagnosis (using SEER historic stage A) and site of the tumor within the pancreas (using the "primary site" variable).

Outcomes

We calculated 2 primary outcomes: incidence and incidence-based mortality rates. Cancer incidence rate was defined as the number of new cancers of a specific site/type occurring in a specified population during a year. Incidence rates were adjusted to the 2000 US standard population and expressed as the number of cancers per 100,000 person-years. These rates were calculated during 1992-2015 according to demographic and tumor characteristics. Incidence-based mortality rates were calculated as the number of pancreatic cancer deaths among cases diagnosed over person-time at risk among people in the SEER areas [15]. We then calculated the annual percentage changes (APCs) in incidence and incidence-based mortality rates over the study period, according to baseline demographic and tumor characteristics.

Statistical analysis

The SEER*stat software (version 8.3.5) was used to calculate all incidences and incidence-based mortality rates. The National Cancer Institute's Joinpoint Regression Program, version 4.5.0.1 was used to calculate APCs [16]. The Joinpoint Regression software used t-tests to determine if APCs were statistically significant from zero; the difference was considered statistically significant for values of P<0.05. The software analyzed rates over time and detected significant changes in APCs, then selected the best model with the minimum number of joinpoints [17]. All statistical tests were 2-sided.

Results

Baseline characteristics

We reviewed 5814 PAC cases diagnosed during 1992-2015 among Asian-American patients and met our inclusion criteria (Table 1). Most of these patients were older than 60 years (77.6%) and had metastatic disease (55.8%). The most common subsite for PAC was the head of the pancreas (46.6%), followed by the tail (14%) and the body (12.3%).

During the study period, 5075 Asian-American patients died from pancreatic cancer and were included in the incidence-based mortality analysis (Table 1). Most of these deaths occurred in patients older than 60 years (81.7%) who had metastatic cancer (59.2%).

Incidence rates and trends over time

The overall incidence of PAC among Asian-Americans during the study period was 5.740 per 100,000 person-years (95% confidence interval [CI] 5.592-5.891). Incidence rates were highest among males (6.478, 95%CI 6.239-6.724) and people older than 60 years (28.031, 95%CI 27.211-28.869). The states of Iowa and Hawaii had the highest incidence of PAC among Asian-American patients: 7.070 (95%CI 4.573-10.879) and 6.836 (95%CI 6.510-7.175), respectively, while the state of Michigan had the lowest incidence (3.994, 95%CI 3.028-5.234) (Table 1).

PAC incidence rates among Asian-Americans increased by 1.503% (95%CI 1.051-1.956; P<0.001) per year over the study period. Rates did not change significantly during 1992-2002

Table 1 Pancreatic adenocarcinoma incidence and mortality rates in Asian-Americans (1992-2015)

Characteristic	Incidence of pancreatic adenocarcinoma		Mortality of pancreatic adenocarcinoma	
	Cases, No (%)[a]	Rate (95% CI)[b]	Cases, No (%)[a]	Rate (95% CI)[b]
Overall	5,814 (100)	5.74 (5.592 - 5.891)	5,075 (100)	5.091 (4.951 - 5.235)
Sex				
Male	2,895 (49.8)	6.478 (6.239 - 6.724)	2,547 (50.2)	5.814 (5.586 - 6.050)
Female	2,919 (50.2)	5.154 (4.967 - 5.346)	2,528 (49.8)	4.521 (4.345 - 4.702)
Age at diagnosis, y				
<60	1,305 (22.4)	1.330 (1.258 - 1.404)	927 (18.3)	0.962 (0.901 - 1.026)
>60	4,509 (77.6)	28.031 (27.211 - 28.869)	4,148 (81.7)	26.042 (25.249 - 26.854)
State				
California	3,377 (58.1)	5.423 (5.240 - 5.612)	2,902 (57.2)	4.747 (4.574 - 4.925)
Connecticut	68 (1.2)	4.690 (3.528 - 6.220)	56 (1.1)	4.155 (3.040 - 5.648)
Georgia	124 (2.1)	6.087 (4.922 - 7.532)	88 (1.7)	4.586 (3.552 - 5.911)
Hawaii	1,664 (28.6)	6.836 (6.510 - 7.175)	1,528 (30.2)	6.243 (5.933 - 6.567)
Iowa	33 (0.6)	7.070 (4.573 - 10.879)	27 (0.5)	5.980 (3.666 - 9.643)
Michigan	71 (1.2)	3.994 (3.028 - 5.234)	56 (1.1)	3.467 (2.540 - 4.680)
New Mexico	30 (0.5)	6.089 (3.968 - 9.203)	27 (0.5)	5.730 (3.645 - 8.826)
Utah	56 (1)	5.989 (4.444 - 7.973)	44 (0.9)	4.867 (3.470 - 6.711)
Washington	391 (6.7)	5.560 (5.003 - 6.169)	347 (6.8)	5.093 (4.553 - 5.687)
Stage at diagnosis[c]				
Localized	532 (9.2)	0.533 (0.488 - 0.581)	308 (6.1)	0.329 (0.293 - 0.369)
Regional	1,721 (29.6)	1.701 (1.621 - 1.784)	1,481 (29.2)	1.494 (1.418 - 1.573)
Distant	3,244 (55.8)	3.179 (3.070 - 3.292)	3,002 (59.2)	2.971 (2.865 - 3.081)
Site in the pancreas				
Head of the pancreas	2,707 (46.6)	2.679 (2.578 - 2.783)	2,375 (46.8)	2.390 (2.294 - 2.490)
Body of the pancreas	715 (12.3)	0.706 (0.655 - 0.761)	610 (12)	0.611 (0.563 - 0.662)
Tail of the pancreas	816 (14)	0.794 (0.740 - 0.851)	662 (13)	0.657 (0.607 - 0.709)
Pancreatic duct	23 (0.4)	0.023 (0.014 - 0.035)	22 (0.4)	0.022 (0.014 - 0.034)
Islets of Langerhans	11 (0.2)	0.011 (0.005 - 0.019)	9 (0.2)	0.009 (0.004 - 0.017)
Other specified parts of the pancreas	95 (1.6)	0.092 (0.074 - 0.113)	71 (1.4)	0.069 (0.054 - 0.088)
Overlapping lesions of pancreas	496 (8.5)	0.492 (0.449 - 0.538)	452 (8.9)	0.455 (0.413 - 0.499)

[a]Cases included first primary tumors that matched the selection criteria, were microscopically confirmed, and were not identified only from autopsy records or death certificates; [b]Rates were calculated as number of cases per 100,000 person-years and age-adjusted to the 2000 US standard population; [c]Using SEER historic stage A
CI, confidence interval

(APC 0.461%, 95%CI -1.833 to 0.930; P=0.49), increased by 3.060% (95%CI 2.026-4.104; P<0.001) per year during 2002-2013, then stabilized since 2013. PAC incidence rates increased over the study period for all sex, age, and stage subgroups. Rates of adenocarcinoma of the head of the pancreas did not change significantly over the study period, but rates of adenocarcinoma of both the body and the tail increased significantly over the study period. Table 2 describes PAC incidence trends during 1992-2015 by sex, age at diagnosis, stage at diagnosis and site. Fig. 1 shows PAC incidence trends among Asian-Americans for selected characteristics.

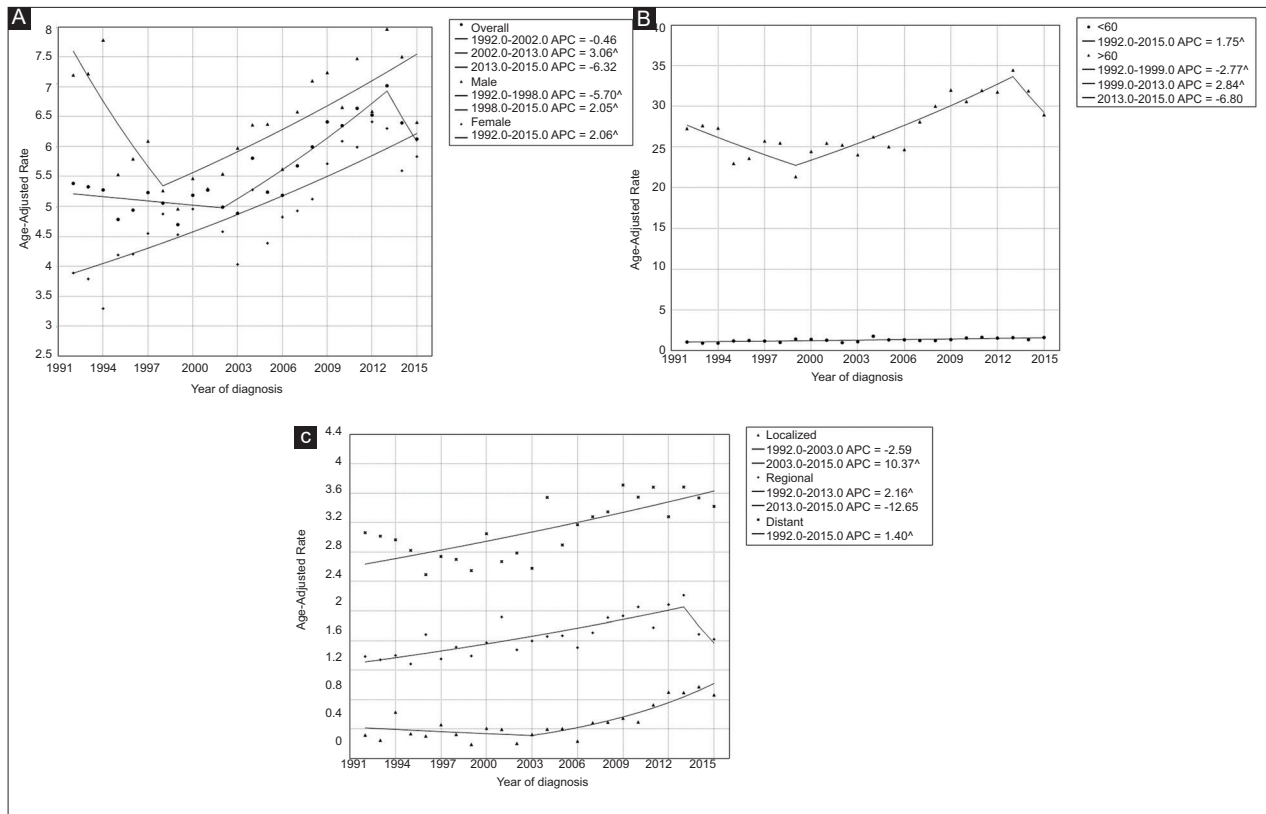**Incidence-based mortality rates and trends over time**

The overall incidence of PAC among Asian-Americans during the study period was (5.091, 95%CI 4.951-5.235). PAC incidence-based mortality rates were highest in males (5.814, 95%CI 5.586-6.050), and people older than 60 years (26.042, 95%CI 25.249-26.854) (Table 1).

PAC incidence-based mortality among Asian-Americans increased by 4.535% (95%CI 3.538-5.541; P<0.001) per year over the study period. However, during 2013-2015 there was a significant decrease in PAC incidence-based mortality:

Table 2 Trends in pancreatic adenocarcinoma incidence rates among Asian-Americans (1992-2015)

Variable	Overall (1992-2015)		Trends									
			1			2			3			
	APC[a] (95%CI)	P-value[b]	Year	APC[a] (95%CI)	P-value[b]	Year	APC[a] (95%CI)	P-value[b]	Year	APC[a] (95%CI)	P value[b]	
Overall	1.503 (1.051-1.956)	<0.001	1992-2002	-0.461 (-1.833 to 0.930)	0.49	2002-2013	3.060 (2.026-4.104)	<0.001	2013-2015	-6.320 (-15.997 to 4.473)	0.223	
Sex												
Male	0.872 (0.126-1.624)	0.024	1992-1998	-5.701 (-10.798 to 0.312)	0.04	1998-2015	2.053 (1.140-2.974)	<0.001				
Female	2.064 (1.488-2.643)	<0.001	1992-2015	2.064 (1.488-2.643)	<0.001							
Age at diagnosis, y												
<60	1.754 (0.903-2.613)	<0.001	1992-2015	1.754 (0.903-2.613)	<0.001							
>60	1.422 (0.871-1.976)	<0.001	1992-1999	-2.774 (-5.425 to -0.049)	0.047	1999-2013	2.842 (2.012-3.679)	<0.001	2013-2015	-6.797 (-17.608 to 5.431)	0.224	
Stage at diagnosis[c]												
Localized	5.619 (3.718-7.555)	<0.001	1992-2003	-2.586 (-9.020 to 4.302)	0.432	2003-2015	10.370 (6.734-14.129)	<0.001				
Regional	1.566 (0.818-2.320)	<0.001	1992-2013	2.161 (1.453-2.874)	<0.001	2013-2015	-12.647 (-28.812 to 7.188)	0.183				
Distant	1.398 (0.858-1.942)	<0.001	1992-2015	1.398 (0.858-1.942)	<0.001							
Site in the pancreas												
Head of the pancreas	0.371 (-0.087 to 0.831)	0.107	1992-2015	0.371 (-0.087 to 0.831)	0.107							
Body of the pancreas	3.322 (2.030-4.630)	<0.001	1992-2015	3.322 (2.030-4.630)	<0.001							
Tail of the pancreas	4.113 (2.798-5.444)	<0.001	1992-2015	4.113 (2.798-5.444)	<0.001							

[a]Annual percentage changes (APCs), calculated using Joinpoint regression software; [b]Two-sided P-value was calculated using the t-test to determine the significance of APC change; [c]Using SEER historic stage A
CI, confidence interval

Figure 1 Trends in annual overall pancreatic adenocarcinoma incidence among Asian-Americans, and incidence by sex (A), age (B), and stage (C)
APC, annual percentage change

APC -25.252% (95%CI -36.006 to -12.691; P<0.001). PAC incidence-based mortality rates increased for all sex, age, stage and site subgroups during the study period. Interestingly, incidence based-mortality rates decreased significantly between 2013 and 2015 in most subgroups, except for patients younger than 60 years, patients with metastatic disease and patients with adenocarcinoma of the tail of the pancreas. Table 3 describes PAC incidence-based mortality trends during 1992-2015 by sex, age at death, stage and site. Fig. 2 shows PAC incidence-based mortality trends among Asian-Americans for selected characteristics.

Discussion

According to our results, the incidence and mortality rates of PAC, and especially malignancy of the body and tail of the pancreas, showed an overall increase during the last 2 decades in Asian-American patients, irrespective of age, sex or stage subgroup. Our analysis provides new insights into the epidemiology of PAC in Asian Americans, emphasizing that, despite the positive health profile stereotype attributed to American Asians, PAC incidence and mortality rates have shown an increasing trend over the last 2 decades.

These changes might be explained by an increasing prevalence of risk factors among American Asians. For example, obesity prevalence has been increasing worldwide

and it has also become an epidemic in Asians [18-20]. Smoking prevalence, however, has decreased in the last 2 decades, as emphasized by Li *et al* in a study of 83,447 Chinese subjects. The authors analyzed data coming from the China Health and Nutrition Survey 1991-2011, emphasizing that smoking prevalence decreased by 9.0% in men (from 60.6% in 1991 to 51.6% in 2011) and by 1.1% in women (from 4.0% in 1991 to 2.9% in 2011). Despite this reduction, both sexes smoked more cigarettes daily in 2011 compared to 1991: 16.5 vs. 15.0 cigarettes/day in men and 12.4 vs. 8.5 cigarettes/day in women. Moreover, smoking-attributed deaths in the Chinese population increased during the study period by 100,000 cases, from 800,000 to 900,000 [21]. Our results are consistent with other studies of Asian patients that reported an increase in incidence and mortality rates in the last 20 years. Wu *et al* concluded that age-adjusted incidence and incidence-based mortality for PAC increased during 2000-2014, whereas mortality rates increased during 2000-2005 but decreased during 2005-2014 [22]. According to their findings, based on 119,412 cases of PAC extracted from 18 SEER registries, both incidence and mortality trends increased during the study period, irrespective of ethnicity [22]. In China, there was a significant increase in newly diagnosed pancreatic cancer cases and pancreatic cancer-attributed deaths from 2009 to 2011. In 2009, Chen *et al* reported 6220 new cases of pancreatic and 5650 deaths [23]. However, He *et al* recorded nearly 13 times more cases in 2011: 80,344 new pancreatic cancer cases and

Table 3 Trends in pancreatic cancer incidence-based mortality rates among asians residing in the US (1992-2015)

| Variable | Overall (1992-2015) | | Trends | | | | | | | | |
| | APC[a] (95%CI) | P-value[b] | 1 | | | 2 | | | 3 | | |
			Year	APC[a] (95%CI)	P-value[b]	Year	APC[a] (95%CI)	P-value[b]	Year	APC[a] (95%CI)	P-value[b]
Overall	4.535 (3.538-5.541)	<0.001	1992-2013	5.491 (5.055-5.928)	<0.001	2013-2015	-25.252 (-36.006 to -12.691)	0.001			
Sex											
Male	3.738 (2.724-4.761)	<0.001	1992-1999	0.290 (-3.553-4.287)	0.877	1999-2013	5.842 (4.536-7.165)	<0.001	2013-2015	-23.655 (-39.738 to -3.278)	0.028
Female	5.166 (3.873-6.435)	<0.001	1992-2013	6.340 (5.580 – 7.106)	<0.001	2013-2015	-29.838 (-46.052 to -8.750)	0.011			
Age at diagnosis, y											
<60	2.908 (1.191-4.654)	0.002	1992-2004	8.009 (5.324-10.762)	<0.001	2004-2013	-0.040 (-3.425 to 3.464)	0.981	2013-2015	-26.035 (-49.415 to 8.152)	0.112
>60	4.784 (3.750-5.827)	<0.001	1992-2013	5.727 (5.156 – 6.300)	<0.001	2013-2015	-24.039 (-37.670 to -7.426)	0.009			
Stage at diagnosis[c]											
Localized	4.977 (3.156-6.829)	<0.001	1992-2015	4.977 (3.156-6.829)	<0.001						
Regional	4.522 (2.869-6.201)	<0.001	1992-2013	5.915 (5.027-6.811)	<0.001	2013-2015	-41.815 (-59.104 to -17.218)	0.005			
Distant	4.960 (3.996-5.932)	<0.001	1992-2013	5.825 (5.156-6.498)	<0.001	2013-2015	-18.721 (-34.194 to 0.390)	0.054			
Site in the pancreas											
Head of the pancreas	3.452 (2.323-4.593)	<0.001	1992-2013	4.460 (3.862-5.061)	<0.001	2013-2013	-29.935 (-44.403 to -11.701)	0.005			
Body of the pancreas	5.877 (4.316-7.461)	<0.001	1992-2015	5.877 (4.316-7.461)	<0.001						
Tail of the pancreas	6.447 (4.521-8.409)	<0.001	1992-2013	7.825 (5.989-9.693)	<0.001	2013-2015	-33.133 (-64.093 to 24.523)	0.191			

aAnnual percentage changes (APCs), calculated using Joinpoint regression software; bTwo-sided P-value was calculated using t test to determine the significance of APC change; cUsing SEER historic stage A
CI, confidence interval
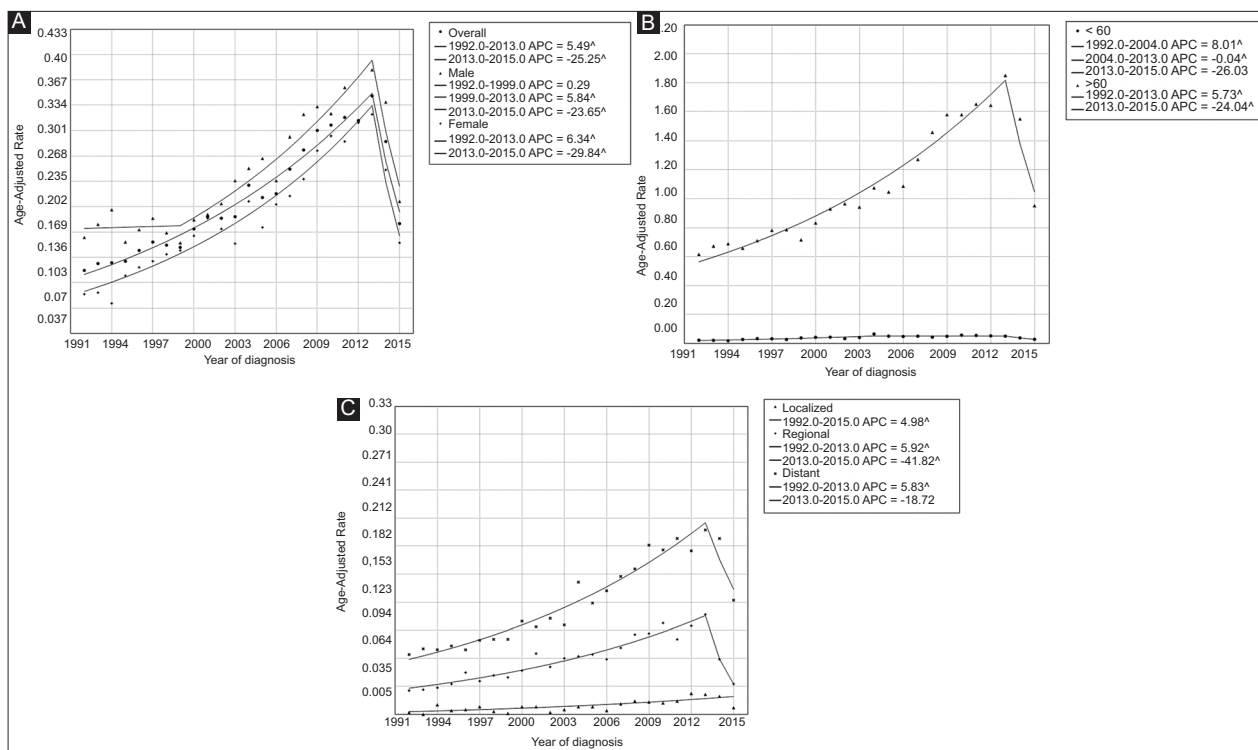
Figure 2 Trends in annual overall pancreatic adenocarcinoma incidence-based mortality among Asian-Americans, and incidence-based mortality by sex (A), age (B), and stage (C)
APC, annual percentage change

72,723 deaths. Furthermore, their analysis identified a 1.14-fold elevation in mortality rates from 2003 to 2011, from 2.85 to 3.26 per 100,000, and an APC equal to 1.68 [24]. In Taiwan, PAC incidence increased rapidly during 2002-2013, whereas mortality started to decline after the introduction of novel therapeutic agents targeting this disorder [25]. Chang *et al* concluded, based on research conducted on 18,320 new cases of pancreatic cancer diagnosed during 2002-2013, nearly 60% of which were PAC, that the incidence rate of PAC increased during the study period from 2.61 to 3.87 per 100,000, with an APC of 3.94 [25].

There can be no doubt that genetic predisposition plays an essential role in PAC development and evolution and might explain the better outcomes in Asian patients. A recent Japanese study, focusing on the evaluation of osteonectin/SPARC (secreted protein acidic and rich in cysteine) stromal expression in 179 PAC patients post-curative resection, identified that SPARC-negative cases (109 cases, 60.9%) had a 5-year overall survival of 19.8%, compared with 8.1% in SPARC-positive cases (70 cases, 39.1%) [26]. Shintakuya *et al* also reported that high expression of SPARC in the peripheral stroma independently predicts poor disease-free survival (hazard ratio [HR] 1.72, 95%CI 1.12-2.68; P=0.013) and overall survival (HR 3.34, 95%CI 2.11-5.51; P<0.001) in PAC patients. They analyzed cytoplasmic and stromal SPARC expression in 211 patients who underwent curative resection and were treated with either gemcitabine + S-1 or gemcitabine alone, and discovered a high stromal SPARC expression in 59.2% of cases and a high cytoplasmic

SPARC expression in 26.1% of cases, but only stromal and not cytoplasmic expression of SPARC predicted disease-free and overall survival in PAC patients [27]. Gundewar *et al* published similar results after studying SPARC stromal expression in 88 PAC cases. In their research, PAC patients with low stromal expression of SPARC had a better survival compared with cases that showed high SPARC expression in the peritumoral stroma (25.3 months vs. 11.5 months; P=0.020). However, in this Swedish study, SPARC expression was positive in a higher percentage, i.e., 77.3%, when compared to expression reported in Japanese populations, i.e.,. 39-59% [26-28]. Infante *et al* studied SPARC expression in the tumor stroma of 299 PAC patients who underwent surgical resection and found 200 (67%) stroma-positive cases. Moreover, they emphasized that median survival was better in SPARC-negative than in SPARC-positive cases (30 months vs. 15 months; P<0.001) [29]. Thus, we may hypothesize that genetic factors play a key role in the better outcomes of PAC in Asian patients, including Asian-Americans.

A multicenter study conducted in Japan reported that, in Japanese patients diagnosed with early pancreatic cancer, the most common risk factor for the aforementioned malignancy was diabetes and that in 70% of the subjects enrolled at least one risk factor was present [30]. Moreover, it seems that in the US, the prevalence of diabetes is higher in non-Hispanic Asians (20.6%) compared to Caucasians (11.3%) [31]. Even so, overweight and obesity rates are lower in Asians in comparison with other ethnic groups in the US, and this probably has an impact on pancreatic cancer characteristics in this ethnic group [7]. Although racial

disparities in pancreatic cancer outcomes might be explained by variations in risk factors amongst different races, further research is needed to understand the observed disparities. However, epidemiologic studies detailing the temporal trends of pancreatic cancer risk factors in Asian patients are lacking, and descriptive studies may shed light on the potential underlying causes of the rising trends of incidence.

Pancreatic cancer remains a challenging disease in clinical practice and represents the seventh cause of death attributed to cancer worldwide. The disease has a clinically silent nature and is often discovered at an advanced stage, thus having a poor prognosis [32]. Taking into consideration that screening for PAC is currently not recommended, particular attention should be given to means of primary prevention, i.e.,. identifying and tackling risk factors [32,33]. Risk factors for PAC can be divided into modifiable risk factors (smoking, alcohol consumption, obesity, dietary factors, occupational exposure) and non-modifiable risk factors (sex, ethnicity, genetics, diabetes mellitus, non-O blood group, *Helicobacter pylori* infection). Despite efforts to focus the available therapeutic armamentarium on risk factors and a likely decline in mortality in recent years, by 2030 pancreatic cancer is expected to rank as the second cause of cancer-related death after lung cancer [32,34]. From 2018 to 2030, both the incidence and mortality due to pancreatic cancer will increase worldwide: Africa (+114.1% and +114.8%, respectively), Latin America and the Caribbean (+99.3% and +101.0%, respectively), Asia (+88.8% and +90.8%, respectively), Oceania (+72.2% and +74.6%, respectively), North America (+50.6% and 57.2%, respectively), and Europe (+29.3% and 31.6%, respectively) [32].

Previous studies have reported ethnic disparities concerning the management and outcome of patients diagnosed with pancreatic cancer. However, these studies have focused mainly on differences between Caucasians and African Americans [8,35]. Current knowledge emphasizes that African Americans have a higher incidence of PAC and a worse prognosis compared to other ethnicities [8,36]. Nipp *et al* revealed that Asian patients diagnosed early with PAC have a median survival that is better (8.7 months) compared to African Americans or Hispanics (6.6 months for both subgroups) and similar to that of Caucasians (9.0 months). Asian patients diagnosed in an early stage had the highest survival rate at 3 years (10.3%) compared to Whites (9.9%), Hispanics (6.5%) or Blacks (6.4%). Furthermore, these results persisted in Asian patients diagnosed in late stages: a higher overall survival (3.3 months) was recorded versus Caucasians (2.9 months) or African Americans and Hispanics (2.6 months for both subgroups) [37]. A study conducted in Thailand also confirmed that outcomes in Asians and Caucasians with pancreatic cancer are similar, although the overall survival is lower (5.1 months) [38]. Isherwood *et al* reported that Asians/Asian British had higher overall survival and survival for subjects who received palliative therapy (6.1 months and 5.1 months, respectively) compared to White British (4.6 months and 3.7 months, respectively). Median survival in subjects who underwent surgical resection was, however, similar (25.0 months in Asians/Asian British vs. 20.7 months in White British) [39].

Some of the observed disparities can be explained by differences in the prevalence of pancreatic cancer risk factors. Obesity

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Summary Box

What is already known:

- In 2018, 458,918 new cases and 432,242 deaths were attributed worldwide to pancreatic cancer
- Pancreatic cancer is the fourth most common malignancy worldwide; however, 5-year survival rates remain low, increasing only from 4% to 9% in the last 4 decades
- 46.7% of new pancreatic cancer cases and 46.4% of deaths occur in Asia

What the new findings are:

- Asian-Americans show an increase in the incidence and mortality rates of pancreatic adenocarcinoma (PAC)
- Body and tail malignancies, in particular, showed an overall increase during the last 2 decades in Asian-American patients
- PAC incidence is increasing irrespective of age, sex or stage subgroup

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and dietary factors, socioeconomic status, access to healthcare, diabetes, smoking, excessive intake of alcohol, chronic pancreatitis and familial history of pancreatic malignancy are considered risk factors for PAC [7,8,30]. Asian females and males seem less likely to smoke in comparison with other ethnic groups [7]. Cigarette consumption rates are the lowest in Asian women, whereas in men only Hispanics smoke less than Asians [7].

This study had a number of limitations. Due to its retrospective nature, sources of bias could not be controlled. Numerous patient comorbidities are missing from the SEER database, which can make adjusting for different patient baseline characteristics inadequate. The lack of reporting of environmental exposure or individual lifestyle habits limits the study of influential risk factors. Because of the short study period, we did not use time-series analysis and instead we used the *t*-test, which may miss information. In addition to that, SEER lacks sufficient information on radiation and systemic chemotherapy. However, by using the SEER database, which covers approximately 28% of the US population, we managed to observe differences in an extensive cohort of patients.

In conclusion, the incidence of PAC has been increasing worldwide and survival rates remain low, with little improvement despite ongoing efforts. The incidence of PAC in Asian-Americans, and especially malignancy of the body and tail of the pancreas, as well as incidence-based mortality rates, increased overall during the study period, irrespective of age, sex or stage subgroup. Further research is needed to understand the observed trends and to improve PAC surveillance and prevention in Asian-Americans.

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