

## Age-related Survival Outcomes for Pancreatic Cancer by Age

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**Abstract.** *Background/Aim:* Pancreatic cancer has a very poor prognosis, though outcomes based on age are not well characterized. The aim of current study was to analyze the survival of patients with pancreatic cancer based on age. *Patients and Methods:* Using National Cancer Data Base (NCDB), we determined survival outcome based on age among patients with pancreatic cancer. *Results:* A total of 423,482 patients between 2004 and 2017 were included in the study. Patients aged between 18 and 40-years-old had the worst 3-year survival rate among stage 1 disease. Conversely, patients over 65-years-old had the worst 3-year survival rate and presented with more advanced disease (clinical stages 3 and 4). *Conclusion:* Older patients with more advanced disease had worse survival.

Despite recent advances in the diagnosis and treatment of pancreatic cancer, this malignancy still has a very poor prognosis (1). Currently, it is the 4th leading cause of cancer-related death in the US and is predicted to become the second leading cause of cancer death by 2030. The incidence of pancreatic cancer is 12.9 per 100,000 people, with an estimated 60,430 new cases in 2021 (1, 2). Important factors in predicting survival for patients with pancreatic cancer include stage and response to multimodal intervention, consisting of chemotherapy, radiation and/or surgery. Accordingly, the 5-year survival of patients who are candidates to undergo treatment for pancreatic cancer can substantially increase (3-5). However, not all patients can

complete multimodal therapy because of older age or complications/recovery from surgery. In some cases, neoadjuvant chemotherapy may be better tolerated, can potentially decrease surgery-related complications, and may be effective in converting unresectable tumors into resectable ones (6). Other important factors related to survival are socioeconomic and sociodemographic disparities among patients with pancreatic cancer. Many studies have demonstrated that not only the incidence of pancreatic cancer among African-American patients is higher than whites, but also the mortality is higher (7-9). In addition, some studies have demonstrated that in both genders, mortality of older patients with pancreatic cancer is significantly higher than that of younger peers (9, 10). To further investigate the relationship between age and pancreatic cancer, we utilized National Cancer Data Base (NCDB) to study patients with pancreatic carcinoma and characterize age-based outcomes.

### Patients and Methods

*Patients.* We conducted a retrospective study between 2004 and 2017 using the National Cancer Data Base (NCDB). The NCDB is a hospital-based cancer registry and joint project of the Commission on Cancer sponsored by both the American College of Surgeons and the American Cancer Society, which represents 70% of all newly diagnosed cancer cases in the US annually. Institutional Review Board approval was not required for the study.

The histology codes for adenocarcinoma (81403), duct cell carcinoma (85003), and islet cell carcinoma (81503) were based on the ICD-03/WHO 2008 classification. The primary site code for head of pancreas (C25.0), body of pancreas (C25.1), tail of pancreas (C25.2), pancreatic duct (C25.3), islets of Langerhans (C25.4), and other lesions of pancreas (C25.7, C25.8, and C25.9) were also based on the ICD-03/WHO 2008 classification.

Patients with pancreatic cancer from all stages, as per the American Joint Committee on Cancer (AJCC 6<sup>th</sup> and 7<sup>th</sup> edition) guidelines, were included. Patients with unknown stage were excluded from the analysis. Additional variables included treatment facility type, patients socioeconomic and demographic status, Charlson-Deyo Comorbidity (CDC) score, characteristics of tumor, history of radiotherapy and systemic therapies, surgical intervention, and survival.

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Table I. Summary of demographic and clinical characteristics by age group within clinical stage I.

Variable		Overall	18-40	40-65	>65	p-Value
Gender	Male	27,127 (48.2%)	478 (33.9%)	9,856 (51.3%)	16,793 (47.1%)	<0.001
	Female	29,106 (51.8%)	931 (66.1%)	9,346 (48.7%)	18,829 (52.9%)	
Race	White	47,417 (84.3%)	1,041 (73.9%)	15,512 (80.8%)	30,864 (86.6%)	<0.001
	Black	6,074 (10.8%)	250 (17.7%)	2,678 (13.9%)	3,146 (8.8%)	
	Native American	161 (0.3%)	4 (0.3%)	74 (0.4%)	83 (0.2%)	
	Asian	1,501 (2.7%)	63 (4.5%)	527 (2.7%)	911 (2.6%)	
	Other	507 (0.9%)	35 (2.5%)	218 (1.1%)	254 (0.7%)	
	Unknown	573 (1.0%)	16 (1.1%)	193 (1.0%)	364 (1.0%)	
	Hispanic origin	Non-Hispanic	51,477 (91.5%)	1,186 (84.2%)	17,545 (91.4%)	
	Hispanic	4,756 (8.5%)	223 (15.8%)	1,657 (8.6%)	2,876 (8.1%)	
Insurance status	Not insured	1,054 (1.9%)	90 (6.4%)	762 (4.0%)	202 (0.6%)	<0.001
	Private	17,052 (30.3%)	994 (70.5%)	12,301 (64.1%)	3,757 (10.5%)	
	Government	37,218 (66.2%)	303 (21.5%)	5,795 (30.2%)	31,120 (87.4%)	
	Unknown	909 (1.6%)	22 (1.6%)	344 (1.8%)	543 (1.5%)	
Income (\$)	<63,000	34,676 (66.6%)	808 (64.6%)	11,769 (67.1%)	22,099 (66.4%)	0.086
	>63,000	17,365 (33.4%)	442 (35.4%)	5,758 (32.9%)	11,165 (33.6%)	
Facility type	Community	2,798 (5.1%)	9 (5.6%)	793 (4.1%)	1,996 (5.6%)	<0.001
	Comprehensive	17,924 (32.6%)	30 (18.6%)	5,306 (27.6%)	12,588 (35.3%)	
	Academic	26,882 (48.9%)	93 (57.8%)	10,690 (55.7%)	16,099 (45.2%)	
	Other	7,381 (13.4%)	29 (18.0%)	2,413 (12.6%)	4,939 (13.9%)	
Urban/Rural	Metro	45,685 (84.3%)	1,198 (89.4%)	15,532 (84.1%)	28,955 (84.1%)	<0.001
	Urban	7,565 (14.0%)	129 (9.6%)	2,613 (14.1%)	4,823 (14.0%)	
	Rural	969 (1.8%)	13 (1.0%)	322 (1.7%)	634 (1.8%)	
Grade of tumor	Well differentiated	9,592 (17.1%)	640 (45.4%)	4,633 (24.1%)	4,319 (12.1%)	<0.001
	Moderately differentiated	12,981 (23.1%)	235 (16.7%)	5,088 (26.5%)	7,658 (21.5%)	
	Poorly differentiated	8,271 (14.7%)	55 (3.9%)	3,048 (15.9%)	5,168 (14.5%)	
	Undifferentiated	473 (0.8%)	5 (0.4%)	176 (0.9%)	292 (0.8%)	
	Adenocarcinoma <i>in situ</i>	24,916 (44.3%)	474 (33.6%)	6,257 (32.6%)	18,185 (51.0%)	
Primary site of tumor	Head	34,413 (61.2%)	487 (34.6%)	10,932 (56.9%)	22,994 (64.5%)	<0.001
	Body	6,282 (11.2%)	198 (14.1%)	2,281 (11.9%)	3,803 (10.7%)	
	Tail	8,277 (14.7%)	473 (33.6%)	3,492 (18.2%)	4,312 (12.1%)	
	Other	7,261 (12.9%)	251 (17.8%)	2,497 (13.0%)	4,513 (12.7%)	
Radiotherapy	None	48,928 (88.3%)	1,326 (95.0%)	15,752 (83.1%)	31,850 (90.9%)	<0.001
	Neoadjuvant	1,284 (2.3%)	12 (0.9%)	631 (3.3%)	641 (1.8%)	
	Adjuvant	5,166 (9.3%)	58 (4.2%)	2,561 (13.5%)	2,547 (7.3%)	
	Neoadjuvant and adjuvant	11 (0.0%)	0 (0%)	5 (0.0%)	6 (0.0%)	
	Intraoperative	5 (0.0%)	0 (0%)	1 (0.0%)	4 (0.0%)	
	Unknown	5 (0.0%)	0 (0%)	4 (0.0%)	1 (0.0%)	
	Positive	27,939 (49.7%)	980 (69.6%)	12,159 (63.3%)	14,800 (41.5%)	
	Unknown	955 (1.7%)	14 (1.0%)	279 (1.5%)	662 (1.9%)	
Systemic therapy	No	37,670 (71.7%)	1,199 (88.5%)	11,529 (63.6%)	24,942 (75.4%)	<0.001
	Neoadjuvant	1,919 (3.7%)	22 (1.6%)	886 (4.9%)	1,011 (3.1%)	
	Adjuvant	11,834 (22.5%)	123 (9.1%)	5,110 (28.2%)	6,601 (20.0%)	
	Both neoadjuvant and adjuvant	1,139 (2.2%)	11 (0.8%)	599 (3.3%)	529 (1.6%)	
	Intraoperative	3 (0.0%)	0 (0%)	2 (0.0%)	1 (0.0%)	
	Unknown	3 (0.0%)	0 (0%)	1 (0.0%)	2 (0.0%)	
Type of surgery on primary site of tumor	No surgery	25,883 (46.0%)	218 (15.5%)	5,817 (30.3%)	19,848 (55.7%)	<0.001
	Partial surgeries	5,425 (9.6%)	229 (16.3%)	2,417 (12.6%)	2,779 (7.8%)	
	Distal surgeries	8,425 (15.0%)	543 (38.5%)	3,947 (20.6%)	3,935 (11.0%)	
	Whipple/extended surgeries	12,167 (21.6%)	274 (19.4%)	5,189 (27.0%)	6,704 (18.8%)	
	Total pancreatectomy	3,185 (5.7%)	109 (7.7%)	1,362 (7.1%)	1,714 (4.8%)	
	Other	1,148 (2.0%)	36 (2.6%)	470 (2.4%)	642 (1.8%)	
	Unknown	36 (0.1%)	0 (0%)	0 (0%)	36 (0.1%)	
CDCC Score	Score 0	36,197 (64.4%)	1,194 (84.7%)	13,157 (68.5%)	21,846 (61.3%)	<0.001
	Score 1	13,817 (24.6%)	182 (12.9%)	4,414 (23.0%)	9,221 (25.9%)	
	Score 2	3,999 (7.1%)	25 (1.8%)	1,052 (5.5%)	2,922 (8.2%)	
	Score 3 and more	2,220 (3.9%)	8 (0.6%)	579 (3.0%)	1,633 (4.6%)	

Table II. Summary of demographic and clinical characteristics by age group within clinical stage 2.

Variable		Overall	18-40	40-65	>65	p-Value
Gender	Male	35,512 (50.5%)	403 (53.7%)	14,301 (54.8%)	20,808 (47.8%)	<0.001
	Female	34,802 (49.5%)	348 (46.3%)	11,776 (45.2%)	22,678 (52.2%)	
Race	White	58,940 (83.8%)	575 (76.6%)	21,111 (81.0%)	37,254 (85.7%)	<0.001
	Black	8,039 (11.4%)	113 (15.0%)	3,733 (14.3%)	4,193 (9.6%)	
	Native American	204 (0.3%)	7 (0.9%)	103 (0.4%)	94 (0.2%)	
	Asian	1,751 (2.5%)	29 (3.9%)	594 (2.3%)	1,128 (2.6%)	
	Other	576 (0.8%)	15 (2.0%)	240 (0.9%)	321 (0.7%)	
	Unknown	804 (1.1%)	12 (1.6%)	296 (1.1%)	496 (1.1%)	
	Hispanic origin	Non-Hispanic	63,809 (90.7%)	633 (84.3%)	23,559 (90.3%)	
	Hispanic	6,505 (9.3%)	118 (15.7%)	2,518 (9.7%)	3,869 (8.9%)	
Insurance status	Not insured	1,704 (2.4%)	59 (7.9%)	1,328 (5.1%)	317 (0.7%)	<0.001
	Private	21,568 (30.7%)	483 (64.3%)	16,123 (61.8%)	4,962 (11.4%)	
	Government	45,557 (64.8%)	178 (23.7%)	7,967 (30.6%)	37,412 (86.0%)	
	Unknown	1,485 (2.1%)	31 (4.1%)	659 (2.5%)	795 (1.8%)	
Income (\$)	<63,000	44,720 (67.5%)	453 (66.3%)	16,847 (68.9%)	27,420 (66.6%)	0.086
	>63,000	21,569 (32.5%)	230 (33.7%)	7,587 (31.1%)	13,752 (33.4%)	
Facility type	Community	3,357 (4.8%)	4 (2.9%)	1,179 (4.5%)	2,174 (5.0%)	<0.001
	Comprehensive	21,417 (30.7%)	27 (19.3%)	7,080 (27.2%)	14,310 (32.9%)	
	Academic	35,963 (51.6%)	96 (68.6%)	14,606 (56.0%)	21,261 (48.9%)	
	Other	8,966 (12.9%)	13 (9.3%)	3,212 (12.3%)	5,741 (13.2%)	
Urban/Rural	Metro	56,540 (83.2%)	619 (85.3%)	20,925 (83.2%)	34,996 (83.1%)	<0.001
	Urban	10,152 (14.9%)	97 (13.4%)	3,766 (15.0%)	6,289 (14.9%)	
	Rural	1,281 (1.9%)	10 (1.4%)	445 (1.8%)	826 (2.0%)	
Grade of tumor	Well differentiated	4,344 (6.2%)	151 (20.1%)	1,906 (7.3%)	2,287 (5.3%)	<0.001
	Moderately differentiated	14,913 (21.2%)	174 (23.2%)	6,417 (24.6%)	8,322 (19.1%)	
	Poorly differentiated	12,153 (17.3%)	120 (16.0%)	4,934 (18.9%)	7,099 (16.3%)	
	Undifferentiated	647 (0.9%)	12 (1.6%)	249 (1.0%)	386 (0.9%)	
	Adenocarcinoma <i>in situ</i>	38,257 (54.4%)	294 (39.1%)	12,571 (48.2%)	25,392 (58.4%)	
Primary site of tumor	Head	50,828 (72.3%)	471 (62.7%)	18,753 (71.9%)	31,604 (72.7%)	<0.001
	Body	5,870 (8.3%)	54 (7.2%)	2,190 (8.4%)	3,626 (8.3%)	
	Tail	4,714 (6.7%)	96 (12.8%)	1,886 (7.2%)	2,732 (6.3%)	
	Other	8,902 (12.7%)	130 (17.3%)	3,248 (12.5%)	5,524 (12.7%)	
Radiotherapy	None	58,928 (85.3%)	594 (80.3%)	20,207 (78.7%)	38,127 (89.4%)	<0.001
	Neoadjuvant	3,199 (4.6%)	40 (5.4%)	1,741 (6.8%)	1,418 (3.3%)	
	Adjuvant	6,881 (10.0%)	106 (14.3%)	3,682 (14.3%)	3,093 (7.2%)	
	Neoadjuvant and adjuvant	36 (0.1%)	0 (0.0%)	22 (0.1%)	14 (0.0%)	
	Intraoperative	5 (0.0%)	0 (0.0%)	4 (0.0%)	1 (0.0%)	
	Unknown	30 (0.0%)	0 (0.0%)	17 (0.1%)	13 (0.0%)	
	None	45,319 (70.4%)	459 (65.9%)	14,487 (60.3%)	30,373 (76.6%)	
Systemic therapy	Neoadjuvant	4,416 (6.9%)	48 (6.9%)	2,303 (9.6%)	2,065 (5.2%)	<0.001
	Adjuvant	12,348 (19.2%)	156 (22.4%)	6,002 (25.0%)	6,190 (15.6%)	
	Both neoadjuvant and adjuvant	2,270 (3.5%)	33 (4.7%)	1,240 (5.2%)	997 (2.5%)	
	Intraoperative	3 (0.0%)	0 (0.0%)	0 (0.0%)	3 (0.0%)	
	Unknown	8 (0.0%)	0 (0.0%)	3 (0.0%)	5 (0.0%)	
Type of surgery on primary site of tumor	No surgery	42,414 (60.3%)	245 (32.6%)	13,175 (50.5%)	28,994 (66.7%)	<0.001
	Partial surgeries	4,901 (7.0%)	86 (11.5%)	2,231 (8.6%)	2,584 (5.9%)	
	Distal surgeries	3,835 (5.5%)	95 (12.6%)	1,697 (6.5%)	2,043 (4.7%)	
	Whipple/extended surgeries	14,318 (20.4%)	237 (31.6%)	6,761 (25.9%)	7,320 (16.8%)	
	Total pancreatectomy	3,457 (4.9%)	58 (7.7%)	1,619 (6.2%)	1,780 (4.1%)	
	Other	1,389 (2.0%)	30 (4.0%)	594 (2.3%)	765 (1.8%)	
CDCC Score	Score 0	45,764 (65.1%)	628 (83.6%)	17,926 (68.7%)	27,210 (62.6%)	<0.001
	Score 1	17,441 (24.8%)	95 (12.6%)	6,083 (23.3%)	11,263 (25.9%)	
	Score 2	4,684 (6.7%)	15 (2.0%)	1,344 (5.2%)	3,325 (7.6%)	
	Score 3 and more	2,425 (3.4%)	13 (1.7%)	724 (2.8%)	1,688 (3.9%)	

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Table III. Summary of demographic and clinical characteristics, short-term outcomes by age group within clinical stage 3.

Variable		Overall	18-40	40-65	>65	p-Value
Gender	Male	20,178 (49.3%)	223 (57.0%)	8,709 (53.1%)	11,246 (46.6%)	<0.001
	Female	20,739 (50.7%)	168 (43.0%)	7,680 (46.9%)	12,891 (53.4%)	
Race	White	33,307 (81.4%)	280 (71.6%)	12,902 (78.7%)	20,125 (83.4%)	<0.001
	Black	5,446 (13.3%)	63 (16.1%)	2,626 (16.0%)	2,757 (11.4%)	
	Native American	111 (0.3%)	4 (1.0%)	54 (0.3%)	53 (0.2%)	
	Asian	1,254 (3.1%)	29 (7.4%)	483 (2.9%)	742 (3.1%)	
	Other	336 (0.8%)	7 (1.8%)	146 (0.9%)	183 (0.8%)	
	Unknown	463 (1.1%)	8 (2.0%)	178 (1.1%)	277 (1.1%)	
	Hispanic origin	Non-Hispanic	36,786 (89.9%)	314 (80.3%)	14,680 (89.6%)	
Hispanic	4,131 (10.1%)	77 (19.7%)	1,709 (10.4%)	2,345 (9.7%)		
Insurance status	Not insured	1,157 (2.8%)	36 (9.2%)	923 (5.6%)	198 (0.8%)	<0.001
	Private	13,226 (32.3%)	228 (58.3%)	10,101 (61.6%)	2,897 (12.0%)	
	Government	25,542 (62.4%)	103 (26.3%)	4,899 (29.9%)	20,540 (85.1%)	
	Unknown	992 (2.4%)	24 (6.1%)	466 (2.8%)	502 (2.1%)	
Income (\$)	<63,000	26,495 (67.8%)	261 (69.4%)	10,794 (69.3%)	15,440 (66.7%)	<0.001
	>63,000	12,597 (32.2%)	115 (30.6%)	4,785 (30.7%)	7,697 (33.3%)	
Facility type	Community	2,360 (5.8%)	4 (5.3%)	910 (5.6%)	1,446 (6.0%)	<0.001
	Comprehensive	13,501 (33.3%)	20 (26.7%)	4,966 (30.3%)	8,515 (35.3%)	
	Academic	19,703 (48.5%)	49 (65.3%)	8,595 (52.4%)	11,059 (45.8%)	
	Other	5,037 (12.4%)	2 (2.7%)	1,918 (11.7%)	3,117 (12.9%)	
Urban/Rural	Metro	33,150 (83.7%)	315 (82.5%)	13,159 (83.3%)	19,676 (84.0%)	0.303
	Urban	5,673 (14.3%)	57 (14.9%)	2,310 (14.6%)	3,306 (14.1%)	
	Rural	766 (1.9%)	10 (2.6%)	321 (2.0%)	435 (1.9%)	
Grade of tumor	Well differentiated	1,842 (4.5%)	27 (6.9%)	788 (4.8%)	1,027 (4.3%)	<0.001
	Moderately differentiated	4,463 (10.9%)	42 (10.7%)	1,994 (12.2%)	2,427 (10.1%)	
	Poorly differentiated	4,659 (11.4%)	61 (15.6%)	1,981 (12.1%)	2,617 (10.8%)	
	Undifferentiated	261 (0.6%)	6 (1.5%)	115 (0.7%)	140 (0.6%)	
	Adenocarcinoma <i>in situ</i>	29,692 (72.6%)	255 (65.2%)	11,511 (70.2%)	17,926 (74.3%)	
Primary site of tumor	Head	22,908 (56.0%)	218 (55.8%)	9,048 (55.2%)	13,642 (56.5%)	<0.001
	Body	7,316 (17.9%)	61 (15.6%)	3,014 (18.4%)	4,241 (17.6%)	
	Tail	1,886 (4.6%)	24 (6.1%)	787 (4.8%)	1,075 (4.5%)	
	Other	8,807 (21.5%)	88 (22.5%)	3,540 (21.6%)	5,179 (21.5%)	
	None	38,221 (94.9%)	348 (89.7%)	14,939 (92.5%)	22,934 (96.6%)	
Radiotherapy systemic therapy	Neoadjuvant	1,181 (2.9%)	20 (5.2%)	703 (4.4%)	458 (1.9%)	<0.001
	Adjuvant	840 (2.1%)	18 (4.6%)	480 (3.0%)	342 (1.4%)	
	Neoadjuvant and adjuvant	17 (0.0%)	0 (0.0%)	12 (0.1%)	5 (0.0%)	
	Intraoperative	10 (0.0%)	0 (0.0%)	6 (0.0%)	4 (0.0%)	
	Unknown	15 (0.0%)	2 (0.5%)	8 (0.0%)	5 (0.0%)	
	Systemic therapy	32,946 (91.7%)	289 (83.0%)	12,670 (88.3%)	19,987 (94.1%)	
Systemic therapy	1,413 (3.9%)	31 (8.9%)	798 (5.6%)	584 (2.7%)	1,413 (3.9%)	<0.001
	1,041 (2.9%)	20 (5.7%)	535 (3.7%)	486 (2.3%)	1,041 (2.9%)	
	538 (1.5%)	8 (2.3%)	338 (2.4%)	192 (0.9%)	538 (1.5%)	
	1 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.0%)	1 (0.0%)	
	3 (0.0%)	0 (0.0%)	2 (0.0%)	1 (0.0%)	3 (0.0%)	
	32,946 (91.7%)	289 (83.0%)	12,670 (88.3%)	19,987 (94.1%)	32,946 (91.7%)	
Type of surgery on primary site of tumor	No surgery	37,486 (91.6%)	323 (82.6%)	14,569 (88.9%)	22,594 (93.6%)	<0.001
	Partial surgeries	552 (1.3%)	9 (2.3%)	276 (1.7%)	267 (1.1%)	
	Distal surgeries	526 (1.3%)	7 (1.8%)	301 (1.8%)	218 (0.9%)	
	Whipple/extended surgeries	1,472 (3.6%)	37 (9.5%)	793 (4.8%)	642 (2.7%)	
	Total pancreatectomy	381 (0.9%)	8 (2.0%)	216 (1.3%)	157 (0.7%)	
	Other	500 (1.2%)	7 (1.8%)	234 (1.4%)	259 (1.1%)	
	CDCC Score	Score 0	27,941 (68.3%)	345 (88.2%)	11,806 (72.0%)	
Score 1	9,526 (23.3%)	37 (9.5%)	3,513 (21.4%)	5,976 (24.8%)		
Score 2	2,283 (5.6%)	6 (1.5%)	701 (4.3%)	1,576 (6.5%)		
Score 3 and more	1,167 (2.9%)	3 (0.8%)	369 (2.3%)	795 (3.3%)		

Table IV. Summary of demographic and clinical characteristics, short-term outcomes by age group within clinical stage 4.

Variable		Overall	18-40	40-65	>65	p-Value
Gender	Male	94,233 (52.8%)	1,327 (57.0%)	41,089 (58.3%)	51,817 (49.1%)	<0.001
	Female	84,179 (47.2%)	1,000 (43.0%)	29,356 (41.7%)	53,823 (50.9%)	
Race	White	147,393 (82.6%)	1,721 (74.0%)	56,031 (79.5%)	89,641 (84.9%)	<0.001
	Black	22,789 (12.8%)	413 (17.7%)	11,043 (15.7%)	11,333 (10.7%)	
	Native American	493 (0.3%)	18 (0.8%)	260 (0.4%)	215 (0.2%)	
	Asian	4,563 (2.6%)	97 (4.2%)	1,749 (2.5%)	2,717 (2.6%)	
	Other	1,380 (0.8%)	48 (2.1%)	637 (0.9%)	695 (0.7%)	
	Unknown	1,794 (1.0%)	30 (1.3%)	725 (1.0%)	1,039 (1.0%)	
Hispanic origin	Non-Hispanic	159,987 (89.7%)	1,911 (82.1%)	62,730 (89.0%)	95,346 (90.3%)	<0.001
	Hispanic	18,425 (10.3%)	416 (17.9%)	7,715 (11.0%)	10,294 (9.7%)	
Insurance status	Not insured	5,825 (3.3%)	247 (10.6%)	4,755 (6.7%)	823 (0.8%)	<0.001
	Private	55,726 (31.2%)	1,345 (57.8%)	42,655 (60.6%)	11,726 (11.1%)	
	Government	113,080 (63.4%)	641 (27.5%)	21,209 (30.1%)	91,230 (86.4%)	
	Unknown	3,781 (2.1%)	94 (4.0%)	1,826 (2.6%)	1,861 (1.8%)	
Income (\$)	<63,000	114,839 (67.2%)	1,581 (71.2%)	46,316 (68.9%)	66,942 (66.1%)	<0.001
	>63,000	55,970 (32.8%)	640 (28.8%)	20,926 (31.1%)	34,404 (33.9%)	
Facility type	Community	16,354 (9.3%)	29 (7.7%)	6,289 (8.9%)	10,036 (9.5%)	<0.001
	Comprehensive	71,101 (40.3%)	128 (34.1%)	25,908 (36.8%)	45,065 (42.7%)	
	Academic	64,774 (36.7%)	179 (47.7%)	28,932 (41.1%)	35,663 (33.8%)	
	Other	24,231 (13.7%)	39 (10.4%)	9,316 (13.2%)	14,876 (14.1%)	
Urban/Rural	Metro	147,390 (85.0%)	1,920 (85.8%)	57,507 (84.3%)	87,963 (85.5%)	<0.001
	Urban	22,840 (13.2%)	287 (12.8%)	9,514 (13.9%)	13,039 (12.7%)	
	Rural	3,080 (1.8%)	32 (1.4%)	1,228 (1.8%)	1,820 (1.8%)	
Grade of tumor	Well differentiated	4,677 (2.6%)	179 (7.7%)	2,076 (2.9%)	2,422 (2.3%)	<0.001
	Moderately differentiated	13,801 (7.7%)	229 (9.8%)	5,948 (8.4%)	7,624 (7.2%)	
	Poorly differentiated	22,334 (12.5%)	346 (14.9%)	9,670 (13.7%)	12,318 (11.7%)	
	Undifferentiated	1,400 (0.8%)	22 (0.9%)	631 (0.9%)	747 (0.7%)	
	Adenocarcinoma <i>in situ</i>	136,200 (76.3%)	1,551 (66.7%)	52,120 (74.0%)	82,529 (78.1%)	
Primary site of tumor	Head	62,948 (35.3%)	805 (34.6%)	24,704 (35.1%)	37,439 (35.4%)	<0.001
	Body	26,802 (15.0%)	293 (12.6%)	10,288 (14.6%)	16,221 (15.4%)	
	Tail	35,409 (19.8%)	485 (20.8%)	14,842 (21.1%)	20,082 (19.0%)	
	Other	53,253 (29.8%)	744 (32.0%)	20,611 (29.3%)	31,898 (30.2%)	
	Adenocarcinoma <i>in situ</i>	136,200 (76.3%)	1,551 (66.7%)	52,120 (74.0%)	82,529 (78.1%)	
Radiotherapy systemic therapy	None	175,273 (99.5%)	2,273 (98.5%)	69,023 (99.2%)	103,977 (99.7%)	<0.001
	Neoadjuvant	192 (0.1%)	7 (0.3%)	125 (0.2%)	60 (0.1%)	
	Adjuvant	663 (0.4%)	27 (1.2%)	393 (0.6%)	243 (0.2%)	
	Neoadjuvant and adjuvant	3 (0.0%)		2 (0.0%)	1 (0.0%)	
	Intraoperative	9 (0.0%)	1 (0.0%)	5 (0.0%)	3 (0.0%)	
Systemic therapy	None	154,926 (97.0%)	1,896 (91.9%)	60,428 (95.8%)	92,602 (97.9%)	<0.001
	Neoadjuvant	687 (0.4%)	40 (1.9%)	438 (0.7%)	209 (0.2%)	
	Adjuvant	3,915 (2.5%)	116 (5.6%)	2,060 (3.3%)	1,739 (1.8%)	
	Both neoadjuvant and adjuvant	233 (0.1%)	11 (0.5%)	150 (0.2%)	72 (0.1%)	
	Intraoperative	12 (0.0%)		6 (0.0%)	6 (0.0%)	
	Unknown	13 (0.0%)		11 (0.0%)	2 (0.0%)	
Type of surgery on primary site of tumor	No surgery	174,267 (97.7%)	2,134 (91.7%)	68,242 (96.9%)	103,891 (98.3%)	<0.001
	Partial surgeries	609 (0.3%)	33 (1.4%)	309 (0.4%)	267 (0.3%)	
	Distal surgeries	943 (0.5%)	62 (2.7%)	565 (0.8%)	316 (0.3%)	
	Whipple/extended surgeries	1,147 (0.6%)	52 (2.2%)	626 (0.9%)	469 (0.4%)	
	Total pancreatectomy	332 (0.2%)	17 (0.7%)	185 (0.3%)	130 (0.1%)	
	Other	1,114 (0.6%)	29 (1.2%)	518 (0.7%)	567 (0.5%)	
	Unknown	13 (0.0%)		11 (0.0%)	2 (0.0%)	
CDCC Score	Score 0	116,483 (65.3%)	1,978 (85.0%)	49,231 (69.9%)	65,274 (61.8%)	<0.001
	Score 1	42,732 (24.0%)	267 (11.5%)	15,230 (21.6%)	27,235 (25.8%)	
	Score 2	11,743 (6.6%)	40 (1.7%)	3,502 (5.0%)	8,201 (7.8%)	
	Score 3 and more	7,454 (4.2%)	42 (1.8%)	2,482 (3.5%)	4,930 (4.7%)	
	Unknown	13 (0.0%)		11 (0.0%)	2 (0.0%)	

Table V. Summary of overall survival outcomes by age group.

Stage	Survival	Total	18-40	40-65	>65	p-Value
1	1-year survival rate	0.95 (0.95, 0.95)	0.93 (0.91, 0.94)	0.95 (0.95, 0.95)	0.95 (0.94, 0.95)	<0.001
	3-year survival rate	0.72 (0.71, 0.72)	0.66 (0.63, 0.69)	0.72 (0.72, 0.73)	0.71 (0.70, 0.72)	
2	1-year survival rate	0.96 (0.95, 0.96)	0.95 (0.93, 0.96)	0.96 (0.96, 0.96)	0.95 (0.95, 0.96)	0.005
	3-year survival rate	0.77 (0.76, 0.78)	0.77 (0.73, 0.81)	0.77 (0.76, 0.78)	0.77 (0.76, 0.77)	
3	1-year survival rate	0.96 (0.95, 0.96)	0.95 (0.91, 0.97)	0.96 (0.95, 0.96)	0.95 (0.95, 0.96)	0.001
	3-year survival rate	0.76 (0.75, 0.77)	0.82 (0.74, 0.87)	0.77 (0.76, 0.79)	0.74 (0.72, 0.76)	
4	1-year survival rate	0.94 (0.93, 0.94)	0.93 (0.92, 0.94)	0.94 (0.94, 0.94)	0.93 (0.93, 0.94)	<0.001
	3-year survival rate	0.71 (0.70, 0.72)	0.77 (0.74, 0.80)	0.72 (0.71, 0.73)	0.68 (0.67, 0.69)	

*Statistical analysis.* To evaluate age-related survival outcomes, we divided patients into 3 groups based on their age (group I: 18-40 years, group II: 40-65 years, and group III: >65 years). Patient demographic & clinical characteristics were summarized by age group within each clinical stage using frequencies and relative frequencies. Associations were evaluated using the Chi-square test. Overall survival was summarized by age group within each clinical stage using the Kaplan–Meier method. Associations were evaluated using log-rank test. One- and 3-year survival rates with 95% confidence interval (CI) were calculated.

**Results**

A total of 423,482 patients between 2004 and 2017 were included in the study after application of inclusion and exclusion criteria. Patient demographic and clinical characteristics were summarized by age group within each clinical stage, and the results are shown in Table I, Table II, Table III and Table IV. Among younger patients, this group tended to have higher proportions of Black or Hispanic patients, and uninsured individuals with lower income. Table V reports the 1-year, 3-year, and median survival rate for each age group within each clinical stage. Patients aged between 18 and 40 had the worst 3-year survival rate among stage 1 disease. However, patients aged over 65 had the worst 3-year survival rate within the more advanced clinical stages 3 and 4.

**Discussion**

Age is an established factor for cancer prognosis (11-14). In this study examining pancreatic cancer, the youngest age group with early-stage disease displayed the 3-year survival rate. This finding was significant as many studies generally state that younger age leads to higher rates of survival. However, many of these studies did not account for clinical stage at which these patients were diagnosed. Furthermore, the oldest age group over 65 years had the worst prognosis for advanced clinical stage 3 and 4. This is consistent with a study performed in the UK that found younger patients aged between 20 and 40 had the best survival rate when diagnosed with a lower pathological

grade and at an earlier stage. Furthermore, they also found that patients older than 80 years had the worst survival rate (15-17). Another study observed that patients older than 70 had lower survival rate than their younger counterparts (18).

Regarding younger age groups, early onset pancreatic cancer generally is associated with more aggressive disease but not necessarily a worse outcome (18). Conversely, older patients’ overall survival may be influenced by comorbid conditions and more years of tobacco use. Clinical stage can alter approach to treatment, as operability and fitness for chemotherapy may vary accordingly. Surgical, medical, and radiation oncologists could also be more reluctant to pursue aggressive treatment in the elderly, whereas work harder to treat younger patients as stated by a study that analyzed the SEER Medicare database (18, 19).

Pancreatic cancer incidence continues to rise in the developing world. Age is an important indicator of prognosis. There remains a gap in how risk factors, socioeconomic backgrounds, and treatment modalities stratified by age affect prognosis. In our study, younger patients tended to be black or Hispanic, have lower income and have no insurance. Further study is needed to determine whether these differences are associated with poorer outcomes among patients with early-onset disease.

**Conflicts of Interest**

The Authors declare no conflicts of interest in relation to this study.

**Authors’ Contributions**

Project conception and design: AAK, KA, EG; Data collection: AAK, MAA; Data analysis: KA, EG; Editing: MB, SN, EG; Final approval: All Authors.

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## References

- 1 Key Statistics for Pancreatic Cancer. Available at: <https://www.cancer.org/cancer/pancreatic-cancer/about/key-statistics.html> [Last accessed on November 30, 2021]
- 2 Collisson EA, Bailey P, Chang DK and Biankin AV: Molecular subtypes of pancreatic cancer. *Nat Rev Gastroenterol Hepatol* *16*(4): 207-220, 2019. PMID: 30718832. DOI: 10.1038/s41575-019-0109-y
- 3 Midha S, Chawla S and Garg PK: Modifiable and non-modifiable risk factors for pancreatic cancer: A review. *Cancer Lett* *381*(1): 269-277, 2016. PMID: 27461582. DOI: 10.1016/j.canlet.2016.07.022
- 4 McGuigan A, Kelly P, Turkington RC, Jones C, Coleman HG and McCain RS: Pancreatic cancer: A review of clinical diagnosis, epidemiology, treatment and outcomes. *World J Gastroenterol* *24*(43): 4846-4861, 2018. PMID: 30487695. DOI: 10.3748/wjg.v24.i43.4846
- 5 Mizrahi JD, Surana R, Valle JW and Shroff RT: Pancreatic cancer. *Lancet* *395*(10242): 2008-2020, 2020. PMID: 32593337. DOI: 10.1016/S0140-6736(20)30974-0
- 6 Cloyd JM, Shen C, Santry H, Bridges J, Dillhoff M, Ejaz A, Pawlik TM and Tsung A: Disparities in the use of neoadjuvant therapy for resectable pancreatic ductal adenocarcinoma. *J Natl Compr Canc Netw* *18*(5): 556-563, 2020. PMID: 32380462. DOI: 10.6004/jnccn.2019.7380
- 7 Singal V, Singal AK and Kuo YF: Racial disparities in treatment for pancreatic cancer and impact on survival: a population-based analysis. *J Cancer Res Clin Oncol* *138*(4): 715-722, 2012. PMID: 22246279. DOI: 10.1007/s00432-012-1156-8
- 8 Murphy MM, Simons JP, Hill JS, McDade TP, Chau Ng S, Whalen GF, Shah SA, Harrison LH Jr and Tseng JF: Pancreatic resection: a key component to reducing racial disparities in pancreatic adenocarcinoma. *Cancer* *115*(17): 3979-3990, 2009. PMID: 19514091. DOI: 10.1002/cncr.24433
- 9 Nipp R, Tramontano AC, Kong CY, Pandharipande P, Dowling EC, Schrag D and Hur C: Disparities in cancer outcomes across age, sex, and race/ethnicity among patients with pancreatic cancer. *Cancer Med* *7*(2): 525-535, 2018. PMID: 29322643. DOI: 10.1002/cam4.1277
- 10 Ilić M, Vlajinac H, Marinković J and Kocev N: Pancreatic cancer mortality in Serbia from 1991-2010 - a joinpoint analysis. *Croat Med J* *54*(4): 369-375, 2013. PMID: 23986278. DOI: 10.3325/cmj.2013.54.369
- 11 Trumbull D, Lemini R, Elli EF, Bagaria SP, Attwood K and Gabriel E: Age-based trends of gastric adenocarcinoma in the United States. *Am Surg* *86*(12): 1721-1727, 2020. PMID: 32864987. DOI: 10.1177/0003134820947395
- 12 Trumbull D, Lemini R, Attwood K, Kukar M and Gabriel E: Gastric cancer disparities among Asian American subpopulations. *Anticancer Res* *40*(11): 6381-6385, 2020. PMID: 33109576. DOI: 10.21873/anticancer.14659
- 13 Gabriel E, Attwood K, Al-Sukhni E, Erwin D, Boland P and Nurkin S: Age-related rates of colorectal cancer and the factors associated with overall survival. *J Gastrointest Oncol* *9*(1): 96-110, 2018. PMID: 29564176. DOI: 10.21037/jgo.2017.11.13
- 14 Gabriel E, Ostapoff K, Attwood K, Al-Sukhni E, Boland P and Nurkin S: Disparities in the age-related rates of colorectal cancer in the United States. *Am Surg* *83*(6): 640-647, 2017. PMID: 28637568.
- 15 Vincent A, Herman J, Schulick R, Hruban RH and Goggins M: Pancreatic cancer. *Lancet* *378*(9791): 607-620, 2011. PMID: 21620466. DOI: 10.1016/S0140-6736(10)62307-0
- 16 Oberstein PE and Olive KP: Pancreatic cancer: why is it so hard to treat? *Therap Adv Gastroenterol* *6*(4): 321-337, 2013. PMID: 23814611. DOI: 10.1177/1756283X13478680
- 17 Wang H, Liu J, Xia G, Lei S, Huang X and Huang X: Survival of pancreatic cancer patients is negatively correlated with age at diagnosis: a population-based retrospective study. *Sci Rep* *10*(1): 7048, 2020. PMID: 32341400. DOI: 10.1038/s41598-020-64068-3
- 18 Picicucci M, Capurso G, Valente R, Larghi A, Archibugi L, Signoretti M, Stigliano S, Zerboni G, Barucca V, La Torre M, Cavallini M, Costamagna G, Marchetti P, Ziparo V and Delle Fave G: Early onset pancreatic cancer: risk factors, presentation and outcome. *Pancreatol* *15*(2): 151-155, 2015. PMID: 25708929. DOI: 10.1016/j.pan.2015.01.013
- 19 Amin S, Lucas AL and Frucht H: Evidence for treatment and survival disparities by age in pancreatic adenocarcinoma: a population-based analysis. *Pancreas* *42*(2): 249-253, 2013. PMID: 22836862. DOI: 10.1097/MPA.0b013e31825f3af4

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