

# Quality Score Among Patients With Metastatic Pancreatic Ductal Adenocarcinoma: Trends, Racial Disparities, and Impact on Outcomes

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## Abstract

**Background:** Evaluation of the quality of care delivered to patients with metastatic pancreatic ductal adenocarcinoma (mPDAC) has been limited. We sought to examine trends and racial/ethnic disparities in quality of care among patients with mPDAC as well as the impact on outcomes using a novel and easily applied quality metric. **Methods:** Medicare beneficiaries diagnosed with mPDAC between 2005 and 2019 were identified using SEER-Medicare data. Achievement of a quality score based on 3 criteria was assessed: (1) cancer-specific survival (CSS) >12 months, (2) receipt of systemic therapy, and (3) utilization of hospice/palliative care services. We examined factors associated with achieving the quality score, including race/ethnicity, social vulnerability index (SVI), and year of treatment. The impact of the quality score on CSS was also analyzed. **Results:** Among 14,147 patients with mPDAC, 62.2% (n=8,794) received systemic therapy, 83.3% (n=11,791) utilized palliative care/hospice services, and 13.7% (n=1,933) had CSS >12 months after diagnosis. Achievement of at least one quality criterion increased over time (from 84.5% in 2005 to 97.0% in 2019;  $P<.001$ ). Multivariable analysis showed that a high overall SVI (odds ratio [OR], 0.70; 95% CI, 0.54–0.91) was independently associated with lower odds of meeting at least one quality criterion. This effect was mainly driven by the SVI subthemes of high socioeconomic status (OR, 0.66; 95% CI, 0.48–0.90) and high racial/ethnic minority status (OR, 0.75; 95% CI, 0.60–0.93). Achievement of quality score  $\geq 1$  (excluding CSS criterion) was associated with improved overall survival (1-year CSS, 14.5% vs 3.2%;  $P<.001$ ). **Conclusions:** Approximately 9 in 10 patients with mPDAC achieved at least one of the quality score criteria, though racial/ethnic minority patients and socially vulnerable populations had lower achievement. Lower quality score achievement was associated with poorer long-term survival. These findings highlight the need for targeted interventions to meet quality metrics for all patients with mPDAC to mitigate disparities in end-of-life care.

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## Background

Pancreatic ductal adenocarcinoma (PDAC) is a highly aggressive malignancy of the exocrine pancreas, accounting for >90% of all pancreatic cancers.<sup>1,2</sup> The incidence and mortality rates associated with PDAC have increased over the past decade,<sup>2</sup> and projections suggest that new PDAC diagnoses and PDAC-related deaths in the United States and Europe will more than double by 2030.<sup>3,4</sup> Approximately half of patients with PDAC present with metastatic disease at diagnosis, whereas the majority of those with localized disease will develop metastases within 1 year following locoregional treatment.<sup>5</sup> Despite recent advances in systemic therapies, metastatic PDAC (mPDAC) is considered incurable, with the life expectancy of these patients typically not exceeding 6 months.<sup>5,6</sup>

Treatment goals among patients with mPDAC include controlling tumor growth to prolong life, managing symptoms, and maintaining quality of life. Although systemic chemotherapy often provides a survival benefit over best supportive care in mPDAC,<sup>6,7</sup> it can also significantly compromise quality of life near death.<sup>8</sup> Managing psychologic distress and cancer-related pain can also significantly impact quality of life, as well as influence long-term prognosis, underscoring the importance of palliative care in patients with terminal cancer, including mPDAC.<sup>9</sup> To date, evaluation of the quality of care delivered to patients

with mPDAC has been limited. In addition, few available studies have reported on either palliative care utilization or systemic chemotherapy administration separately in the setting of mPDAC.<sup>10,11</sup> Furthermore, studies on racial/ethnic disparities in PDAC have mainly focused on one specific domain of care without providing a more holistic assessment of the end-of-life care.<sup>12,13</sup> As such, a comprehensive assessment of the quality of care and outcomes of patients with mPDAC is lacking. Whether quality of care and outcomes of patients with mPDAC have improved over time is also largely unknown. To this end, the objective of this study was to assess trends and racial and socioeconomic disparities in a quality score encompassing different domains of care, including systemic chemotherapy, palliative care/hospice services, and cancer-specific survival (CSS), among patients with mPDAC. Additionally, we sought to evaluate the impact of the quality score on patient outcomes following the diagnosis of mPDAC.

## Methods

### Data Sources and Study Cohort

Data were derived from the linked SEER-Medicare database.<sup>14</sup> SEER-Medicare captures data from approximately 95% of people aged  $\geq 65$  years in the SEER files, which are then matched to

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Medicare medical claim files.<sup>14,15</sup> Patients diagnosed with mPDAC (stage IV) between 2005 and 2019 were included in the analytic cohort. Those with other primary cancer diagnoses before mPDAC were excluded. To ensure at least 1 year of Medicare claims data before diagnosis, patients were required to have Medicare Part A and B coverage for at least 12 months before enrollment, and only those aged  $\geq 66$  years were included. Individuals enrolled in Medicare Advantage or HMO plans were excluded. Additionally, patients who were censored within 12 months following mPDAC diagnosis were excluded.

### Variables of Interest and Outcomes

Variables of interest included patient age, sex, Charlson comorbidity index (CCI) score, race, social vulnerability index (SVI), marital status, region (Midwest, Northeast, South, West), rurality (metropolitan, nonmetropolitan area), median household income at census tract level, and year of diagnosis/year period. CCI score was calculated using comorbidities<sup>16</sup> coded in encounters up to 1 year prior to mPDAC diagnosis, with the diagnosis itself included in the calculation. SVI is a composite measure ranging from 0 to 100, with higher values indicating greater vulnerability.<sup>17,18</sup> SVI data for each patient were abstracted from the CDC and calculated at the census tract level. Patients were then stratified into SVI tertiles, with the lowest tertile representing low vulnerability, the middle tertile indicating average vulnerability, and the highest tertile denoting high vulnerability. SVI encompasses 16 indicators across 4 main subthemes: (1) socioeconomic status, (2) household characteristics, (3) racial and ethnic minority status, and (4) housing type and transportation.<sup>19</sup> For this analysis, patients were also divided based on subtheme tertiles to indicate categories of vulnerability related to each social domain.

The primary outcome was an mPDAC quality score, defined as the achievement of at least one of the following mPDAC quality criteria: (1) receipt of guideline-concordant systemic therapy, (2) receipt of palliative care or hospice services, or (3) cancer-specific survival (CSS)  $> 12$  months. According to the NCCN Clinical Practice Guidelines in Oncology (NCCN Guidelines) for PDAC, patients with mPDAC and good/intermediate performance status are recommended to enroll in a clinical trial or receive systemic therapy.<sup>20</sup> For patients with poor performance status, available options include palliative/best supportive care, systemic therapy, and palliative radiotherapy. However, for individuals who are unable/unfit to receive systemic therapy, palliative care/hospice consultation should at least be offered, given the poor prognosis associated with the disease. Alternatively, if a patient is unable/not eligible to undergo systemic therapy and does not receive palliative care/hospice, they should be expected to have a CSS of  $\geq 12$  months, as anything less would meet the “end-of-life” care criteria for palliative or hospice care services.<sup>21,22</sup> As such, a quality score  $\geq 1$  was considered the primary outcome of this study, as previously described.<sup>23</sup> Systemic therapy episodes were captured using a combination of SEER variables and relevant Medicare encounters to maximize appropriate coding. Palliative care encounters were identified using palliative care encounter codes (V66.7 and Z51.5), as previously described.<sup>10,24</sup> Claims associated with hospice services were identified from the hospice file within the Medicare component of the SEER-Medicare linked database.<sup>25</sup> This study was approved, and informed consent for the limited dataset was waived by the Institutional Review Board of The Ohio State University.

### Statistical Analysis

Descriptive statistics were presented as median values with IQRs for continuous variables and frequencies with percentages for categorical variables. The association of different patient characteristics with the achievement of at least one mPDAC quality criteria (quality score  $\geq 1$ ), as well as each individual quality criteria, was assessed using logistic regression analysis. A separate multivariable logistic regression model was conducted to evaluate the interaction between year period and SVI, adjusting for all relevant covariates. Trends in outcomes over time were assessed using the Cochran-Armitage test. Differences in CSS among patients with a quality score of 0 and  $\geq 1$  and those a quality score of 0, 1, and 2 were analyzed using the Kaplan-Meier method and the log-rank test. Given that CSS  $> 1$  year was one of the individual quality criteria, it was excluded from the quality score calculation for the survival analysis. All statistical tests were 2-sided, with significance assessed at  $\alpha = .05$ . All analyses were conducted using Stata, version 18.0 (StataCorp LLC).

## Results

### Study Cohort and Quality Score

A total of 14,147 Medicare beneficiaries with mPDAC were included in the analytic cohort (Table 1). Median patient age was 68 years (IQR, 66–74). Most patients were female ( $n = 7,486$ ; 52.9%) and White ( $n = 11,144$ ; 78.8%), with a CCI score of 6 ( $n = 12,236$ ; 86.5%). Overall, 13.7% ( $n = 1,933$ ) of patients had CSS  $> 1$  year, 62.2% ( $n = 8,794$ ) received systemic therapy, and 83.3% ( $n = 11,791$ ) received palliative care/hospice services (Table 1). In turn, 93.3% ( $n = 13,192$ ) of patients achieved a quality score  $\geq 1$ , whereas 955 patients did not achieve any of the individual quality criteria (Figure 1A). Compared with individuals with a quality score of 0, those with a quality score  $\geq 1$  were younger (median age, 68 vs 72 years), more frequently female (53.3% vs 47.6%), more often married (56.1% vs 48.2%), and had a lower CCI score (CCI  $> 6$ , 12.9% vs 22.0%) (all  $P < .001$ ) (Table 1).

### Disparities in Quality Score Based on SVI and Subthemes

Racial and socioeconomic disparities in achieving mPDAC quality criteria were observed. Of note, patients with a quality score  $\geq 1$  were more frequently White (79.4% vs 70.2%), had low SVI (32.1% vs 22.5%), and resided in areas with the highest median household income (top quartile: 24.1% vs 19.2%) compared with those with a quality score of 0 (all  $P < .001$ ). On multivariable analysis, high SVI was independently associated with 28% lower odds of receiving palliative/hospice services (odds ratio [OR], 0.72; 95% CI, 0.61–0.85), 12% lower odds of receiving systemic therapy (OR, 0.88; 95% CI, 0.77–0.99), and, in turn, 30% lower odds of achieving a quality score  $\geq 1$  (OR, 0.70; 95% CI, 0.54–0.91). In contrast, high median household income was associated with higher odds of receiving systemic chemotherapy (fourth quartile: OR, 1.51; 95% CI, 1.29–1.75), higher odds of achieving CSS  $> 1$  year (fourth quartile: OR, 1.61; 95% CI, 1.30–1.99) and, in turn, higher odds of achieving a quality score  $\geq 1$  (third quartile: OR, 1.39; 95% CI, 1.08–1.79) (Table 2). Among younger patients with mPDAC (age 66–70 years) and no other documented comorbidities (ie, CCI=6), 26.5% (2,008/7,589) did not receive systemic therapy. Notably, those who received chemotherapy were less likely to have high SVI than those who did not receive chemotherapy (31.1% vs 37.3%;  $P < .001$ ). Although rurality was not associated with achieving a quality

**Table 1.** Characteristics of Patients With mPDAC Relative to Quality Criteria

	Total n (%)	Quality Score 0 n (%)	Quality Score ≥1 n (%)	P Value
Patients, n	14,147 (100.0)	955 (6.7)	13,192 (93.3)	
Age, median (IQR), y	68 (66–74)	72 (66–78)	68 (66–74)	<b>&lt;.001</b>
Age group				<b>&lt;.001</b>
66–70 y	8,551 (60.4)	435 (45.5)	8,116 (61.5)	
71–75 y	2,705 (19.1)	207 (21.7)	2,498 (18.9)	
76–80 y	1,801 (12.7)	164 (17.2)	1,637 (12.4)	
>80 y	1,090 (7.7)	149 (15.6)	941 (7.1)	
Sex				<b>&lt;.001</b>
Female	7,486 (52.9)	455 (47.6)	7,031 (53.3)	
Male	6,661 (47.1)	500 (52.4)	6,161 (46.7)	
CCI score >6	1,911 (13.5)	210 (22.0)	1,701 (12.9)	<b>&lt;.001</b>
Race				<b>&lt;.001</b>
White	11,144 (78.8)	670 (70.2)	10,474 (79.4)	
Non-White	3,003 (21.2)	285 (29.8)	2,718 (20.6)	
SVI (census tract level)				<b>&lt;.001</b>
Low	4,453 (31.5)	215 (22.5)	4,238 (32.1)	
Average	4,447 (31.4)	276 (28.9)	4,171 (31.6)	
High	4,444 (31.4)	346 (36.2)	4,098 (31.1)	
Unknown	803 (5.7)	118 (12.4)	685 (5.2)	
Marital status				<b>&lt;.001</b>
Single	5,765 (40.8)	447 (46.8)	5,318 (40.3)	
Married	7,856 (55.5)	460 (48.2)	7,396 (56.1)	
Unknown	526 (3.7)	48 (5.0)	478 (3.6)	
Region				.920
Midwest	1,272 (9.0)	86 (9.0)	1,186 (9.0)	
Northeast	876 (6.2)	64 (6.7)	812 (6.2)	
South	5,133 (36.3)	342 (35.8)	4,791 (36.3)	
West	6,866 (48.5)	463 (48.5)	6,403 (48.5)	
Rurality				.696
Nonmetropolitan	1,913 (13.5)	133 (13.9)	1,780 (13.5)	
Metropolitan	12,233 (86.5)	822 (86.1)	11,412 (86.5)	
Year period				<b>&lt;.001</b>
2005–2008	3,676 (26.0)	484 (50.7)	3,192 (24.2)	
2009–2012	3,585 (25.3)	245 (25.7)	3,340 (25.3)	
2013–2016	3,901 (27.6)	154 (16.1)	3,747 (28.4)	
2017–2019	2,985 (21.1)	72 (7.5)	2,913 (22.1)	
Median household income				<b>&lt;.001</b>
Bottom quartile	3,309 (23.4)	284 (29.7)	3,025 (22.9)	
Second quartile	3,334 (23.6)	190 (19.9)	3,144 (23.8)	
Third quartile	3,318 (23.4)	175 (18.3)	3,143 (23.8)	
Top quartile	3,359 (23.7)	183 (19.2)	3,176 (24.1)	
Unknown	827 (5.9)	123 (12.9)	704 (5.4)	
CSS >1 year	1,933 (13.7)	—	1,933 (14.7)	—
Hospice/Palliative care	11,791 (83.3)	—	11,791 (89.4)	—
Systemic chemotherapy	8,794 (62.2)	—	8,794 (66.7)	—

Bold indicates statistically significant P value. Abbreviations: CCI, Charlson comorbidity index; CSS, cancer-specific survival; mPDAC, metastatic pancreatic ductal adenocarcinoma; SVI, social vulnerability index.

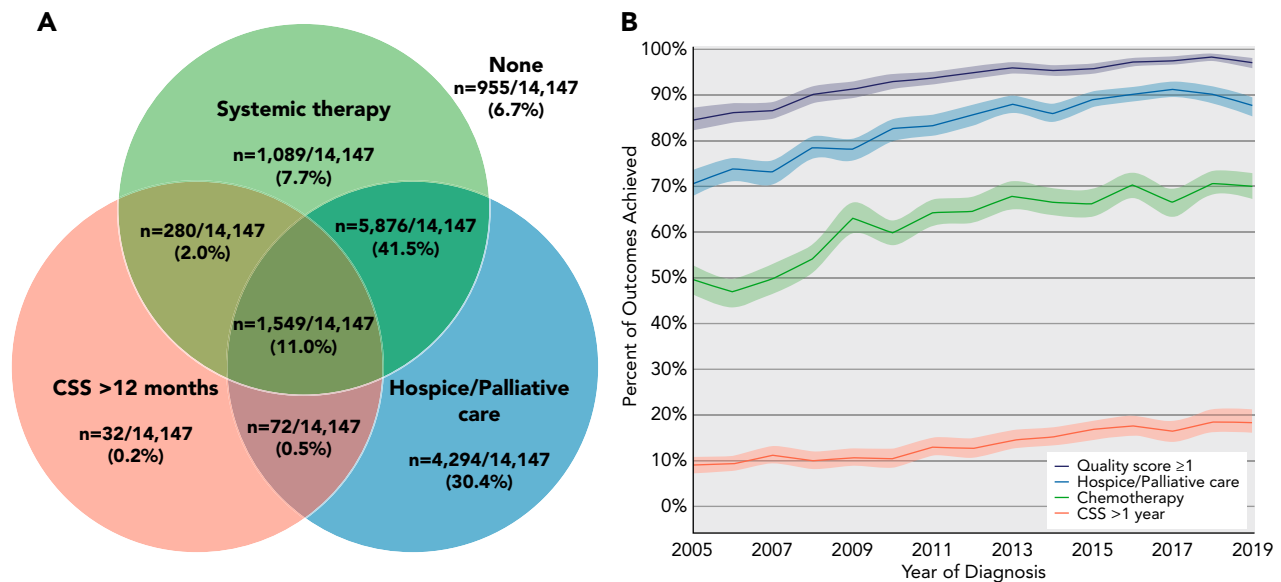
score ≥1, patients residing in metropolitan areas were less likely to receive systemic therapy yet more likely to experience CSS >1 year. The distribution of quality scores and individual score components across different predictors is summarized in Supplementary Table S1 (available online in the supplementary materials).

Analysis of different SVI subthemes demonstrated that a high SVI related to socioeconomic status (ie, lower socioeconomic status) was independently associated with 34% lower odds of achieving a quality score ≥1 (OR, 0.66; 95% CI, 0.48–0.90). In addition, a high SVI related to racial and ethnic minority status (ie, a greater proportion of racial and ethnic minorities)

was independently associated with 25% lower odds of achieving a quality score ≥1 (OR, 0.75; 95% CI, 0.60–0.93) (Table 3). In contrast, SVI subthemes related to household characteristics or housing type and transportation were not independent predictors of achieving a quality score ≥1 among patients with mPDAC (Table 3, Supplementary Table S2).

**Trends in Quality Score Over Time and Impact on Outcomes**

Among patients with mPDAC, the utilization of palliative care/hospice services increased from 70.6% in 2005 to 87.6% in 2019



**Figure 1.** (A) Venn diagram illustrating the distribution of patients meeting each individual quality score criterion over time. (B) Trends in the achievement of each quality score criterion over time.

Abbreviation: CSS, cancer-specific survival.

( $P_{\text{trend}} < .001$ ). Similarly, the administration of systemic chemotherapy increased from 49.6% in 2005 to 69.9% in 2019 ( $P_{\text{trend}} < .001$ ). The percentage of patients surviving past 1 year after mPDAC diagnosis also increased from 9.1% in 2005 to 18.3% in 2019 ( $P_{\text{trend}} < .001$ ). In turn, the achievement of a quality score  $\geq 1$  improved from 84.5% in 2005 to 97.0% in 2019 ( $P_{\text{trend}} < .001$ ) (Figure 1B). After adjusting for competing factors, patients diagnosed with mPDAC between 2017 and 2019 had approximately 5 times higher odds of achieving a quality score  $\geq 1$  (OR, 5.20; 95% CI, 3.93–6.87) compared with those diagnosed between 2005 and 2008 (Table 2). Although patients diagnosed in more recent years were less likely to have high SVI (2005–2008: 36.0%; 2009–2012: 36.0%; 2013–2016: 31.3%; 2017–2019: 30.0%;  $P < .001$ ), a separate model incorporating an interaction between year period and SVI demonstrated that more recent year of diagnosis was associated with higher odds of achieving a quality score  $\geq 1$ , regardless of SVI (Supplementary Table S3).

Overall, the median CSS following an mPDAC diagnosis was 3.3 months (95% CI, 3.2–3.4), with a 1-year CSS of 13.8%. The 1-year CSS increased slightly from 10.0% in 2005–2008 to 17.7% in 2017–2019 ( $P < .001$ ). After excluding CSS as a quality criterion, patients with a quality score  $\geq 1$  had improved 1-year CSS compared with those who did not meet any individual quality criteria (14.5% vs 3.2%;  $P < .001$ ; Figure 2A). Not surprisingly, the improved CSS associated with a quality score  $\geq 1$  was driven by the receipt of systemic therapy. Among patients with mPDAC, 1-year CSS varied based on treatment received: quality score 0: 2.0% versus quality score 1 (palliative care/hospice only): 1.6% versus quality score 1 (systemic therapy only): 20.4% versus quality score 2 (palliative care + systemic therapy): 20.9% ( $P < .001$ ; Figure 2B).

## Discussion

PDAC is a highly lethal malignancy arising from the exocrine pancreas.<sup>1</sup> Fewer than 20% of patients present with localized, resectable disease, whereas the majority are diagnosed with unresectable or metastatic PDAC.<sup>1,5</sup> Systemic chemotherapy and

palliative care/hospice are main components of mPDAC care.<sup>5</sup> To date, a comprehensive assessment of quality-of-care domains in mPDAC, as well as racial and socioeconomic disparities in its management, remains lacking. This study was important because we specifically examined a composite quality score encompassing systemic chemotherapy, palliative care/hospice services, and 1-year CSS among patients with mPDAC. Of note, 93.3% of patients met at least one quality score criterion, whereas 6.7% did not meet any. Although the proportion of all individuals achieving these criteria increased over time, socially vulnerable populations mainly relative to socioeconomic and racial/ethnic minority status had lower likelihood of achieving at least one of the quality score criteria. Despite the overall poor prognosis of mPDAC, meeting at least one quality score criterion was associated with improved CSS, which was mainly driven by the receipt of systemic chemotherapy.

Although originally proposed for patients with metastatic urothelial cancer,<sup>23</sup> the quality score may be applicable to all patients with metastatic cancer, including mPDAC. Indeed, patients with mPDAC and good/intermediate performance status should qualify for systemic therapy as recommended by the NCCN Guidelines for PDAC, provided they are not enrolled in a clinical trial (criterion 1).<sup>20</sup> For those ineligible for systemic therapy and not expected to survive at least 1 year, palliative care and/or hospice services are recommended within the first year of diagnosis (criterion 2). Alternatively, if a patient is unable or ineligible to receive systemic therapy and does not receive palliative care/hospice, they should have a CSS of at least 12 months (criterion 3), because anything less would meet the criteria for “end-of-life” care for palliative or hospice care services.<sup>21,22</sup> Thus, patients with mPDAC should meet at least 1 of the 3 quality criteria, which are easily identifiable within administrative datasets.

The current study demonstrated that 62.2% of patients with mPDAC received systemic chemotherapy and 83.4% received palliative care/hospice services, whereas only 13.7% survived past 1 year following diagnosis. In turn, most patients met at least

**Table 2.** Multivariable Logistic Regression Analysis to Assess Factors Associated With a Quality Score  $\geq 1$  and Individual Quality Criteria

	Quality Score $\geq 1$		Hospice/Palliative Care		Systemic Therapy		CSS >1 Year	
	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value	OR (95% CI)	P Value
<b>Age group</b>								
66–70 y	Ref		Ref		Ref		Ref	
71–75 y	0.99 (0.81–1.20)	.898	1.18 (1.03–1.34)	<b>.015</b>	0.57 (0.52–0.63)	<b>&lt;.001</b>	0.58 (0.50–0.67)	<b>&lt;.001</b>
76–80 y	0.92 (0.73–1.14)	.437	1.29 (1.10–1.50)	<b>.001</b>	0.37 (0.33–0.42)	<b>&lt;.001</b>	0.39 (0.31–0.48)	<b>&lt;.001</b>
>80 y	0.70 (0.55–0.90)	<b>.005</b>	1.39 (1.14–1.70)	<b>.001</b>	0.20 (0.17–0.23)	<b>&lt;.001</b>	0.23 (0.16–0.33)	<b>&lt;.001</b>
<b>Sex</b>								
Male	Ref		Ref		Ref		Ref	
Female	1.38 (1.18–1.61)	<b>&lt;.001</b>	1.36 (1.22–1.50)	<b>&lt;.001</b>	1.11 (1.03–1.21)	<b>.008</b>	1.18 (1.06–1.31)	<b>.002</b>
CCI score >6 (ref: CCI=6)	0.56 (0.47–0.67)	<b>&lt;.001</b>	0.89 (0.78–1.03)	.114	0.52 (0.47–0.58)	<b>&lt;.001</b>	0.56 (0.47–0.68)	<b>&lt;.001</b>
<b>SVI (census tract level)</b>								
Low	Ref		Ref		Ref		Ref	
Average	0.73 (0.59–0.91)	<b>.004</b>	0.85 (0.75–0.99)	<b>.039</b>	0.92 (0.82–1.02)	.106	1.02 (0.90–1.17)	.719
High	0.70 (0.54–0.91)	<b>.008</b>	0.72 (0.61–0.85)	<b>&lt;.001</b>	0.88 (0.77–0.99)	<b>.046</b>	0.96 (0.80–1.14)	.638
<b>Marital status</b>								
Single	Ref		Ref		Ref		Ref	
Married	1.32 (1.13–1.55)	<b>.001</b>	1.06 (0.95–1.18)	.276	1.53 (1.41–1.65)	<b>&lt;.001</b>	1.44 (1.29–1.61)	<b>&lt;.001</b>
<b>Rurality</b>								
Nonmetropolitan	Ref		Ref		Ref		Ref	
Metropolitan	0.88 (0.70–1.10)	.272	1.15 (1.00–1.33)	.054	0.75 (0.67–0.85)	<b>&lt;.001</b>	1.24 (1.04–1.48)	<b>.015</b>
<b>Median household income</b>								
Bottom quartile	Ref		Ref		Ref		Ref	
Second quartile	1.39 (1.12–1.73)	<b>.002</b>	1.13 (0.98–1.31)	.086	1.22 (1.09–1.37)	<b>.001</b>	1.39 (1.18–1.64)	<b>&lt;.001</b>
Third quartile	1.39 (1.08–1.79)	<b>.010</b>	1.12 (0.95–1.33)	.171	1.22 (1.07–1.39)	<b>.003</b>	1.37 (1.13–1.66)	<b>.001</b>
Top quartile	1.11 (0.83–1.49)	.472	0.93 (0.77–1.13)	.469	1.51 (1.29–1.75)	<b>&lt;.001</b>	1.61 (1.30–1.99)	<b>&lt;.001</b>
<b>Year range</b>								
2005–2008	Ref		Ref		Ref		Ref	
2009–2012	1.88 (1.57–2.25)	<b>&lt;.001</b>	1.63 (1.44–1.86)	<b>&lt;.001</b>	1.39 (1.25–1.55)	<b>&lt;.001</b>	0.95 (0.81–1.13)	.576
2013–2016	3.21 (2.60–3.96)	<b>&lt;.001</b>	2.75 (2.39–3.16)	<b>&lt;.001</b>	1.39 (1.25–1.56)	<b>&lt;.001</b>	1.20 (1.02–1.41)	<b>.027</b>
2017–2019	5.20 (3.93–6.87)	<b>&lt;.001</b>	3.20 (2.73–3.74)	<b>&lt;.001</b>	1.29 (1.15–1.46)	<b>&lt;.001</b>	1.23 (1.04–1.46)	<b>.014</b>

Bold indicates statistically significant P value.

Abbreviations: CCI, Charlson comorbidity index; CSS, cancer-specific survival; OR, odds ratio; SVI, social vulnerability index.

one of the proposed quality criteria (93.3%), whereas only 6.7% of the cohort failed to meet any of the criteria. The percentage of patients with mPDAC meeting at least one quality item was significantly higher than that reported among patients with metastatic urothelial cancer (40.2%).<sup>23</sup> This difference can largely be

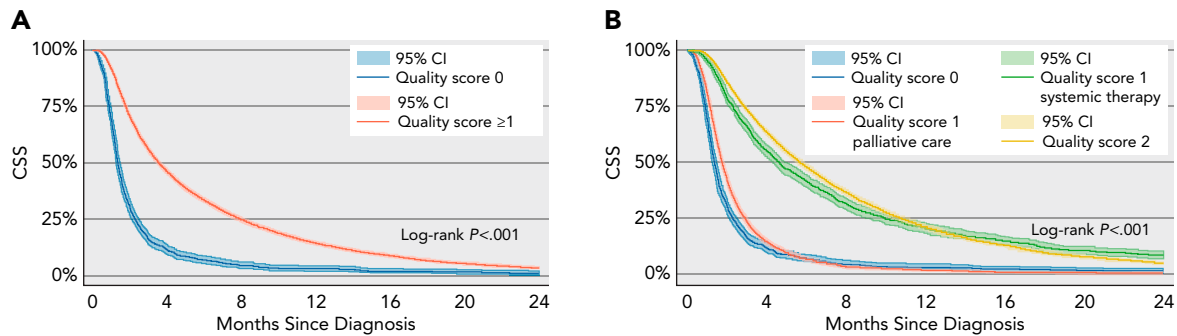
attributed to the higher chemotherapy rates among patients with mPDAC (62.2% vs 35%) and the major discrepancies in palliative care services (83.4% vs 4.4%) compared with patients with metastatic urothelial cancer, despite a similar percentage of patients with CSS >1 year following diagnosis of metastatic disease (13.7% vs 12.2%, respectively).<sup>23</sup> Importantly, this study also noted an increasing trend in achievement of quality score criteria over time among patients with mPDAC. Of note, more recent year of diagnosis was associated with higher odds of achieving a quality score  $\geq 1$ , irrespective of SVI (Supplementary Table S1). In particular, a steady increase in utilization of palliative care/hospice services was noted from 2005 (70.6%) to 2019 (87.6%), suggesting that palliative care has been widely adopted as an integral part of management of patients with mPDAC.<sup>10</sup> Similarly, the use of systemic chemotherapy for mPDAC increased substantially over time (from 49.6% in 2005 to 69.9% in 2019), which likely reflects the progressive development of new, more effective chemotherapeutic regimens along with earlier recognition and better management of chemotherapy-related side effects.<sup>11,26</sup> For instance, gemcitabine monotherapy was common until 2009, after which FOLFIRINOX emerged as a treatment option following a phase III trial in 2011<sup>27</sup> and has since been increasingly used. Subsequently, a phase III trial published in 2013<sup>28</sup> demonstrated that combination therapy with gemcitabine plus nab-paclitaxel improved overall and progression-free survival among patients with mPDAC, and since then has increasingly been adopted as

**Table 3.** Association of SVI Subthemes With a Quality Score  $\geq 1$

Variables	OR (95% CI)	P Value
<b>Socioeconomic status</b>		
Low	Ref	
Average	0.77 (0.61–0.98)	<b>.037</b>
High	0.66 (0.48–0.90)	<b>.008</b>
<b>Household characteristics</b>		
Low	Ref	
Average	1.05 (0.87–1.28)	.603
High	1.11 (0.88–1.40)	.364
<b>Racial and ethnic minority status</b>		
Low	Ref	
Average	0.91 (0.75–1.11)	.355
High	0.75 (0.60–0.93)	<b>.008</b>
<b>Housing type and transportation</b>		
Low	Ref	
Average	1.12 (0.91–1.37)	.279
High	1.12 (0.89–1.40)	.348

Bold indicates statistically significant P value.

Abbreviations: OR, odds ratio; SVI, social vulnerability index.



**Figure 2.** Kaplan-Meier curves showing differences in CSS among patients with mPDAC by quality score: **(A)** 0 versus  $\geq 1$  and **(B)** 0, 1, and 2. Abbreviations: CSS, cancer-specific survival; mPDAC, metastatic pancreatic ductal adenocarcinoma.

an alternative treatment option for these patients.<sup>11,26</sup> In turn, despite the overall poor prognosis of patients with mPDAC, an improvement in 1-year CSS was noted over the study period (from 9.1% in 2005 to 18.3% in 2019;  $P < .001$ ).

Prior studies have highlighted racial and ethnic disparities in end-of-life care among patients with terminal cancer.<sup>12,13</sup> Consistent with previous literature, the current study found that high overall SVI and, more specifically, high SVI subtheme racial/ethnic minority status were independently associated with lower odds of achieving at least one of the mPDAC quality criteria. In particular, high overall SVI was associated with 28% lower odds of receiving palliative/hospice services (OR, 0.72; 95% CI, 0.61–0.85), 12% lower odds of receiving systemic therapy (OR, 0.88; 95% CI, 0.77–0.99) and, in turn, 30% lower odds of achieving a quality score  $\geq 1$  (OR, 0.70; 95% CI, 0.54–0.91). Examining the racial/ethnic minority status subtheme, high SVI (ie, a higher proportion of racial and ethnic minorities) was independently associated with 25% lower odds of achieving a quality score  $\geq 1$  (OR, 0.75; 95% CI, 0.60–0.93). Similarly, higher SVI related to the socioeconomic status subtheme was associated with 34% lower odds of achieving a quality score  $\geq 1$  (OR, 0.66; 95% CI, 0.48–0.90). Of note, patients who met at least one quality criterion had improved CSS compared with those who met none. Not surprisingly, the improved CSS in this patient subgroup was mainly driven by receipt of chemotherapy (Figure 2A–B). Early palliative care measures have been shown to significantly improve quality of life for individuals with terminal illnesses.<sup>29</sup> Moreover, adherence to NCCN Guidelines and receipt of systemic chemotherapy, especially among patients with good performance status, can significantly affect long-term outcomes and should be considered a quality criterion. Previous studies have reported low compliance with NCCN Guidelines among patients with early-stage PDAC, leading to detrimental effects on survival.<sup>30,31</sup> The current study also found that 35% of individuals with mPDAC and no other documented comorbidity (ie, CCI=6) did not receive systemic therapy (Supplementary Table S3). Perhaps more interesting, even among the theoretically more favorable patients (ie, age 66–70 years, no other comorbidities), 26.5% (2,008/7,589) still did not receive systemic therapy. Within this group, those who received systemic chemotherapy were less likely to have high SVI (31.1% vs 37.3% for no chemotherapy;  $P < .001$ ). Collectively, the findings suggest that marked racial and socioeconomic disparities persist among patients with mPDAC. Additionally, the data suggested that a significant number of younger patients with no documented comorbidities did not receive systemic chemotherapy,

largely due to high SVI. These results underscore how social determinants of health may drive quality of care and outcomes for patients with mPDAC. They also highlight the need for continued efforts to address barriers to quality care among socially vulnerable and disadvantaged populations.

The findings of this study should be interpreted in light of certain limitations. As a registry database was used, the potential for information bias due to possible miscoding cannot be excluded. Additionally, the SEER-Medicare database includes only patients aged  $\geq 65$  years, and therefore the results of this study cannot necessarily be extrapolated to younger populations. Nevertheless, given that the median age at pancreatic cancer diagnosis is 71 years,<sup>5</sup> the study population was generally representative. Furthermore, palliative care services were identified based on Medicare claims, meaning that encounters without an associated claim could not be captured. Nevertheless, the relevant ICD codes have been validated in prior studies.<sup>10,24</sup> Although 83.4% of patients in our cohort received hospice/palliative care services, we were unable to estimate how many of the remaining patients were offered but declined these services. In addition, due to the limitations of SEER data to identify all chemotherapy episodes, Medicare claims data were also used to maximize appropriate coding and provide the most accurate treatment information.<sup>32,33</sup>

## Conclusions

In our study, 9 in 10 patients with mPDAC met at least one quality score criterion, though achievement was lower among racial/ethnic minority patients and socially vulnerable populations. Over time, there was an increasing trend in the utilization of palliative care/hospice services and systemic chemotherapy, along with a slight improvement in CSS among patients with mPDAC. Notably, failing to achieve at least one quality score criterion was associated with worse long-term survival. These findings highlight the need for targeted interventions to improve quality metrics for all patients with PDAC to mitigate disparities in end-of-life care.

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**Data availability statement:** The data for this study was sourced from the linked SEER-Medicare database. There are restrictions to the availability of this data which is used under license for this study. Permission to access the data can be obtained from the National Cancer Institute and the Center for Medicare & Medicaid Services.

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