Impacts of Insurance on Colorectal Cancer Mortality: Insights from the National Inpatient Sample

Analysis for RCOP NIS GI10

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## Preamble:

* **Reference Papers:**
  + [Akinyemiju et al. 2016](https://doi.org/10.1186/s12885-016-2738-7)
  + [Galoosian et al. 2019](https://doi.org/10.1007/s10620-019-05809-x)
* **Study Objective**: Investigate the association between insurance payer and in-hospital outcomes in patients admitted with a principal diagnosis of colorectal cancer across U.S. hospitals from 2018 to 2020, adjusting for demographic, clinical, and hospital factors.
* **Data Source**: Cross-sectional analysis using the National Inpatient Sample (NIS) from 2018 to 2020, a nationwide database that captures inpatient admissions in the U.S.
* **Patient Selection**: Included all inpatient admissions with a principal diagnosis of colorectal cancer, identified using ICD-10-CM codes C18.xx, C19.xx, C20.xx, and C21.xx. Patients were categorized by primary insurance payer (Private, Medicare, Medicaid, Other).
* **Outcomes of Interest:**
  + In-hospital all-cause mortality
  + Total hospital length of stay (days)
  + Total charge, inflation adjusted to 2020 ($) [adjusted to 2020 dollars, using CPI data by the U.S. Bureau of Labor Statistics]
  + Complications:
    - Intestinal obstruction
    - Colostomy/enterostomy complications
    - Post-operative bleeding
* **Statistical Analysis**: Univariable and multivariable analyses were conducted to evaluate the associations of insurance payer with each outcome.
  + **Univariable Analysis:**
    - Design-based Kruskal-Wallis test for continuous outcomes.
    - Rao & Scott-adjusted Pearson’s Chi-square test for categorical outcomes.
  + **Multivariable Analysis:**
    - Logistic regression for binary outcomes (e.g., in-hospital mortality, complications).
    - Linear regression for continuous outcomes (e.g., length of stay, total charge).
  + Adjusted for:
    - **Demographics and Clinical Factors:** Age, sex, race, colorectal cancer location (colon, rectosigmoid junction, rectum, or anus), Charlson Comorbidity Index, residential income quartile.
    - **Hospital Factors:** Region, bed size, and teaching status.
* **Software:** All analyses were conducted using the R Statistical Language (Version 4.4.1; R Foundation for Statistical Computing, Vienna, Austria), employing survey-weighted methods to account for the complex sampling design of the NIS.

## Baseline Table:

| **Characteristic** | **Private** N = 118,295*1* | **Medicaid** N = 36,850*1* | **Medicare** N = 198,425*1* | **Other** N = 19,995*1* | **p-value***2* |
| --- | --- | --- | --- | --- | --- |
| Age, y | 56 (11) | 54 (11) | 75 (9) | 58 (13) | <0.001 |
| Sex |  |  |  |  | <0.001 |
| Female | 52,300 (44%) | 16,055 (44%) | 100,870 (51%) | 7,595 (38%) |  |
| Male | 65,990 (56%) | 20,795 (56%) | 97,555 (49%) | 12,400 (62%) |  |
| Race |  |  |  |  | <0.001 |
| White | 82,685 (72%) | 17,320 (48%) | 148,445 (77%) | 11,200 (58%) |  |
| Asian or Pacific Islander | 5,140 (4.5%) | 2,220 (6.1%) | 5,465 (2.8%) | 670 (3.4%) |  |
| Black | 12,925 (11%) | 7,435 (21%) | 21,160 (11%) | 3,280 (17%) |  |
| Hispanic | 10,285 (8.9%) | 7,300 (20%) | 13,480 (7.0%) | 3,255 (17%) |  |
| Native American | 515 (0.4%) | 385 (1.1%) | 860 (0.4%) | 155 (0.8%) |  |
| Other | 3,925 (3.4%) | 1,485 (4.1%) | 4,160 (2.1%) | 895 (4.6%) |  |
| Colorectal cancer location |  |  |  |  | <0.001 |
| Anus and anal canal | 2,335 (2.0%) | 1,480 (4.0%) | 4,190 (2.1%) | 670 (3.4%) |  |
| Colon | 75,180 (64%) | 21,530 (58%) | 150,170 (76%) | 12,370 (62%) |  |
| Rectosigmoid junction | 14,055 (12%) | 4,860 (13%) | 15,880 (8.0%) | 2,565 (13%) |  |
| Rectum | 26,725 (23%) | 8,980 (24%) | 28,185 (14%) | 4,390 (22%) |  |
| Metastasis | 41,030 (35%) | 15,690 (43%) | 59,380 (30%) | 8,190 (41%) | <0.001 |
| Income quartile |  |  |  |  | <0.001 |
| $1 - $51,999 | 25,245 (22%) | 13,610 (38%) | 53,770 (27%) | 6,980 (36%) |  |
| $52,000 - $65,999 | 29,125 (25%) | 9,700 (27%) | 53,705 (27%) | 5,365 (28%) |  |
| $66,000 - $87,999 | 30,465 (26%) | 7,520 (21%) | 47,220 (24%) | 4,270 (22%) |  |
| $88,000 or more | 31,850 (27%) | 5,170 (14%) | 40,840 (21%) | 2,810 (14%) |  |
| Hospital region |  |  |  |  | <0.001 |
| Midwest | 24,920 (21%) | 6,765 (18%) | 46,500 (23%) | 3,485 (17%) |  |
| Northeast | 22,015 (19%) | 7,870 (21%) | 37,525 (19%) | 2,110 (11%) |  |
| South | 48,785 (41%) | 11,090 (30%) | 76,475 (39%) | 11,755 (59%) |  |
| West | 22,575 (19%) | 11,125 (30%) | 37,925 (19%) | 2,645 (13%) |  |
| Hospital bedsize |  |  |  |  | <0.001 |
| Large | 64,030 (54%) | 20,570 (56%) | 101,970 (51%) | 11,030 (55%) |  |
| Medium | 33,000 (28%) | 10,025 (27%) | 57,195 (29%) | 5,465 (27%) |  |
| Small | 21,265 (18%) | 6,255 (17%) | 39,260 (20%) | 3,500 (18%) |  |
| Hospital location/teaching status |  |  |  |  | <0.001 |
| Rural | 6,585 (5.6%) | 2,365 (6.4%) | 18,250 (9.2%) | 1,725 (8.6%) |  |
| Urban, non-teaching | 17,530 (15%) | 5,460 (15%) | 36,555 (18%) | 3,285 (16%) |  |
| Urban, teaching | 94,180 (80%) | 29,025 (79%) | 143,620 (72%) | 14,985 (75%) |  |
| No. of comorbidities |  |  |  |  | <0.001 |
| No comorbidities | 10 (<0.1%) | 20 (<0.1%) | 0 (0%) | 0 (0%) |  |
| One comorbidity | 5 (<0.1%) | 5 (<0.1%) | 5 (<0.1%) | 5 (<0.1%) |  |
| Two or more comorbidities | 118,280 (100%) | 36,825 (100%) | 198,420 (100%) | 19,990 (100%) |  |
| *1*Mean (SD); n (%) | | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | | |

## Outcomes Table:

| **Characteristic** | **Private** N = 118,295*1* | **Medicaid** N = 36,850*1* | **Medicare** N = 198,425*1* | **Other** N = 19,995*1* | **p-value***2* |
| --- | --- | --- | --- | --- | --- |
| Died during hospitalization | 1,665 (1.4%) | 815 (2.2%) | 5,650 (2.8%) | 760 (3.8%) | <0.001 |
| Length of stay (days) | 4.0 (3.0, 7.0) | 5.0 (3.0, 9.0) | 5.0 (3.0, 9.0) | 5.0 (3.0, 9.0) | <0.001 |
| Inflation-adjusted total charge ($) | 71,208 (45,719, 113,050) | 76,059 (43,251, 132,890) | 71,690 (44,358, 119,491) | 68,325 (41,426, 113,597) | <0.001 |
| Intestinal obstruction | 590 (0.5%) | 205 (0.6%) | 1,160 (0.6%) | 95 (0.5%) | 0.5 |
| Colostomy/enterostomy complications | 635 (0.5%) | 315 (0.9%) | 835 (0.4%) | 175 (0.9%) | <0.001 |
| Post-operative bleeding | 665 (0.6%) | 225 (0.6%) | 1,425 (0.7%) | 110 (0.6%) | 0.086 |
| *1*n (%); Median (Q1, Q3) | | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | | |

## Multivariable Logistic Regression:

### All-Cause Mortality:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.33 | 1.07, 1.65 | 0.012 |
| Medicare | 1.05 | 0.89, 1.23 | 0.6 |
| Other | 2.29 | 1.83, 2.87 | <0.001 |
| Age, y | 1.03 | 1.02, 1.04 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.20 | 1.09, 1.32 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.19 | 0.91, 1.56 | 0.2 |
| Black | 1.24 | 1.07, 1.45 | 0.005 |
| Hispanic | 0.99 | 0.82, 1.19 | 0.9 |
| Native American | 0.33 | 0.11, 1.03 | 0.057 |
| Other | 1.38 | 1.02, 1.86 | 0.036 |
| Colorectal cancer location |  |  |  |
| Anus and anal canal | — | — |  |
| Colon | 0.87 | 0.62, 1.22 | 0.4 |
| Rectosigmoid junction | 1.05 | 0.73, 1.50 | 0.8 |
| Rectum | 0.61 | 0.42, 0.87 | 0.007 |
| Metastasis |  |  |  |
| No | — | — |  |
| Yes | 1.57 | 1.33, 1.85 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.84 | 0.73, 0.96 | 0.012 |
| $66,000 - $87,999 | 0.96 | 0.84, 1.10 | 0.6 |
| $88,000 or more | 0.83 | 0.71, 0.97 | 0.016 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.53 | 1.18, 2.00 | 0.002 |
| South | 1.03 | 0.89, 1.20 | 0.7 |
| West | 1.20 | 1.01, 1.42 | 0.041 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 1.29 | 1.15, 1.46 | <0.001 |
| Small | 1.56 | 1.21, 2.03 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.66 | 0.54, 0.80 | <0.001 |
| Urban, teaching | 0.53 | 0.45, 0.63 | <0.001 |
| Charlson comorbidity index | 1.23 | 1.19, 1.26 | <0.001 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Intestinal Obstruction:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.03 | 0.70, 1.51 | 0.9 |
| Medicare | 1.14 | 0.84, 1.55 | 0.4 |
| Other | 1.02 | 0.62, 1.67 | >0.9 |
| Age, y | 1.00 | 0.99, 1.01 | >0.9 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.76 | 1.43, 2.17 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.51 | 0.25, 1.05 | 0.066 |
| Black | 1.52 | 1.14, 2.03 | 0.005 |
| Hispanic | 0.84 | 0.58, 1.22 | 0.4 |
| Native American | 0.95 | 0.23, 3.86 | >0.9 |
| Other | 0.54 | 0.24, 1.22 | 0.14 |
| Colorectal cancer location |  |  |  |
| Anus and anal canal | — | — |  |
| Colon | 1.61 | 0.66, 3.93 | 0.3 |
| Rectosigmoid junction | 1.84 | 0.72, 4.68 | 0.2 |
| Rectum | 1.87 | 0.75, 4.67 | 0.2 |
| Metastasis |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.68, 1.35 | 0.8 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.15 | 0.88, 1.50 | 0.3 |
| $66,000 - $87,999 | 1.05 | 0.78, 1.40 | 0.8 |
| $88,000 or more | 0.93 | 0.68, 1.27 | 0.6 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.65 | 1.20, 2.26 | 0.002 |
| South | 0.87 | 0.65, 1.16 | 0.3 |
| West | 1.46 | 1.07, 1.99 | 0.018 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 1.47 | 1.15, 1.86 | 0.002 |
| Small | 1.32 | 1.00, 1.75 | 0.052 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.76 | 0.52, 1.10 | 0.15 |
| Urban, teaching | 0.46 | 0.33, 0.65 | <0.001 |
| Charlson comorbidity index | 1.01 | 0.95, 1.08 | 0.8 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Colostomy/Enterostomy Complications:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.31 | 0.95, 1.81 | 0.10 |
| Medicare | 1.10 | 0.79, 1.53 | 0.6 |
| Other | 1.44 | 0.96, 2.15 | 0.080 |
| Age, y | 0.99 | 0.98, 1.00 | 0.2 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.34 | 1.09, 1.65 | 0.005 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.74 | 0.41, 1.35 | 0.3 |
| Black | 1.25 | 0.92, 1.70 | 0.15 |
| Hispanic | 1.00 | 0.71, 1.41 | >0.9 |
| Native American | 0.45 | 0.06, 3.21 | 0.4 |
| Other | 1.07 | 0.60, 1.91 | 0.8 |
| Colorectal cancer location |  |  |  |
| Anus and anal canal | — | — |  |
| Colon | 0.36 | 0.21, 0.64 | <0.001 |
| Rectosigmoid junction | 1.09 | 0.61, 1.94 | 0.8 |
| Rectum | 1.37 | 0.79, 2.39 | 0.3 |
| Metastasis |  |  |  |
| No | — | — |  |
| Yes | 1.67 | 1.16, 2.40 | 0.006 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.96 | 0.73, 1.28 | 0.8 |
| $66,000 - $87,999 | 1.13 | 0.86, 1.49 | 0.4 |
| $88,000 or more | 0.71 | 0.51, 1.00 | 0.048 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.95 | 0.67, 1.35 | 0.8 |
| South | 0.79 | 0.59, 1.05 | 0.10 |
| West | 1.04 | 0.76, 1.44 | 0.8 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.73 | 0.56, 0.94 | 0.014 |
| Small | 0.70 | 0.51, 0.95 | 0.020 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.81 | 0.49, 1.33 | 0.4 |
| Urban, teaching | 0.91 | 0.58, 1.42 | 0.7 |
| Charlson comorbidity index | 0.99 | 0.92, 1.06 | 0.7 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

### Post-operative Bleeding:

| **Characteristic** | **OR***1* | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.07 | 0.76, 1.52 | 0.7 |
| Medicare | 1.13 | 0.87, 1.47 | 0.4 |
| Other | 0.93 | 0.58, 1.49 | 0.8 |
| Age, y | 1.00 | 0.99, 1.01 | 0.6 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.11 | 0.93, 1.34 | 0.3 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.41 | 0.90, 2.19 | 0.13 |
| Black | 1.50 | 1.15, 1.94 | 0.002 |
| Hispanic | 0.97 | 0.68, 1.37 | 0.9 |
| Native American | 2.89 | 1.28, 6.57 | 0.011 |
| Other | 1.06 | 0.59, 1.88 | 0.8 |
| Colorectal cancer location |  |  |  |
| Anus and anal canal | — | — |  |
| Colon | 1.02 | 0.56, 1.87 | >0.9 |
| Rectosigmoid junction | 0.80 | 0.40, 1.59 | 0.5 |
| Rectum | 0.86 | 0.45, 1.63 | 0.6 |
| Metastasis |  |  |  |
| No | — | — |  |
| Yes | 0.62 | 0.47, 0.82 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.89 | 0.68, 1.16 | 0.4 |
| $66,000 - $87,999 | 0.95 | 0.71, 1.26 | 0.7 |
| $88,000 or more | 1.32 | 1.01, 1.74 | 0.046 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.10 | 0.81, 1.49 | 0.5 |
| South | 1.07 | 0.82, 1.41 | 0.6 |
| West | 1.18 | 0.87, 1.61 | 0.3 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.95 | 0.76, 1.18 | 0.6 |
| Small | 0.91 | 0.70, 1.18 | 0.5 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.07 | 0.72, 1.60 | 0.7 |
| Urban, teaching | 0.89 | 0.62, 1.29 | 0.6 |
| Charlson comorbidity index | 1.07 | 1.01, 1.13 | 0.016 |
| *1*OR = Odds Ratio, CI = Confidence Interval | | | |

## Multivariable Linear Regression:

### Length of Stay:

| **Characteristic** | **Beta** | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 2.0 | 1.7, 2.2 | <0.001 |
| Medicare | 0.55 | 0.40, 0.69 | <0.001 |
| Other | 0.93 | 0.70, 1.2 | <0.001 |
| Age, y | 0.03 | 0.02, 0.04 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.26 | 0.16, 0.36 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.03 | -0.27, 0.33 | 0.8 |
| Black | 0.94 | 0.76, 1.1 | <0.001 |
| Hispanic | 0.24 | 0.02, 0.45 | 0.030 |
| Native American | 0.03 | -0.73, 0.79 | >0.9 |
| Other | 0.46 | 0.07, 0.86 | 0.022 |
| Colorectal cancer location |  |  |  |
| Anus and anal canal | — | — |  |
| Colon | -1.3 | -1.8, -0.81 | <0.001 |
| Rectosigmoid junction | -1.0 | -1.5, -0.50 | <0.001 |
| Rectum | -1.1 | -1.6, -0.61 | <0.001 |
| Metastasis |  |  |  |
| No | — | — |  |
| Yes | -0.87 | -1.1, -0.66 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | -0.05 | -0.18, 0.09 | 0.5 |
| $66,000 - $87,999 | -0.17 | -0.32, -0.02 | 0.027 |
| $88,000 or more | -0.38 | -0.55, -0.22 | <0.001 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.81 | 0.59, 1.0 | <0.001 |
| South | 0.44 | 0.30, 0.58 | <0.001 |
| West | 0.09 | -0.08, 0.25 | 0.3 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | -0.25 | -0.39, -0.12 | <0.001 |
| Small | -0.31 | -0.51, -0.12 | 0.002 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.66 | 0.45, 0.86 | <0.001 |
| Urban, teaching | 0.56 | 0.40, 0.73 | <0.001 |
| Charlson comorbidity index | 0.56 | 0.52, 0.60 | <0.001 |
| *1*CI = Confidence Interval | | | |

### Inflation-Adjusted Total Charge:

| **Characteristic** | **Beta** | **95% CI***1* | **p-value** |
| --- | --- | --- | --- |
| Insurance payer |  |  |  |
| Private | — | — |  |
| Medicaid | 8,758 | 5,037, 12,479 | <0.001 |
| Medicare | 5,426 | 3,090, 7,761 | <0.001 |
| Other | -3,092 | -6,453, 268 | 0.071 |
| Age, y | -79 | -163, 4.5 | 0.064 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 5,574 | 4,095, 7,053 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 6,180 | 465, 11,896 | 0.034 |
| Black | 3,800 | 1,060, 6,540 | 0.007 |
| Hispanic | 14,022 | 9,966, 18,078 | <0.001 |
| Native American | -11,290 | -21,412, -1,168 | 0.029 |
| Other | 15,780 | 7,498, 24,062 | <0.001 |
| Colorectal cancer location |  |  |  |
| Anus and anal canal | — | — |  |
| Colon | -5,460 | -12,267, 1,348 | 0.12 |
| Rectosigmoid junction | -908 | -8,209, 6,393 | 0.8 |
| Rectum | -944 | -7,863, 5,975 | 0.8 |
| Metastasis |  |  |  |
| No | — | — |  |
| Yes | -21,397 | -24,567, -18,228 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 431 | -1,817, 2,679 | 0.7 |
| $66,000 - $87,999 | -2,762 | -5,343, -182 | 0.036 |
| $88,000 or more | 540 | -2,753, 3,834 | 0.7 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 16,156 | 12,036, 20,275 | <0.001 |
| South | 16,853 | 13,829, 19,878 | <0.001 |
| West | 45,362 | 40,419, 50,305 | <0.001 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | -5,655 | -9,006, -2,304 | <0.001 |
| Small | -12,701 | -16,016, -9,386 | <0.001 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 36,231 | 32,579, 39,884 | <0.001 |
| Urban, teaching | 33,500 | 30,666, 36,334 | <0.001 |
| Charlson comorbidity index | 6,430 | 5,761, 7,098 | <0.001 |
| *1*CI = Confidence Interval | | | |