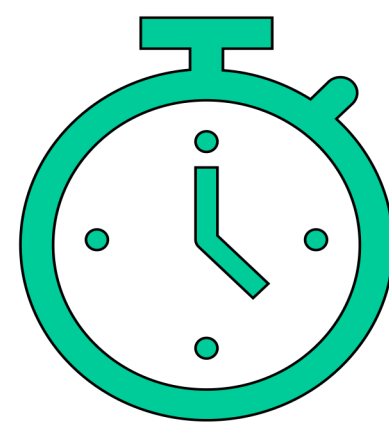


# The Economic Cost of Delays in Diagnosis of Appendicitis due to Sociodemographic Risk Factors

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## Background



There is evidence of delays in the diagnosis of appendicitis in both the adult and pediatric population, particularly among non-Hispanic Black patients, with clear adverse effects on length of stay and 30-day readmission.<sup>1-3</sup> The economic burden of these delays has not been quantified. This study sought to quantify the differences in hospital costs associated with delayed diagnosis of appendicitis, stratified by patient and hospital-level characteristics.

## Methods

This was a retrospective cohort study using data from the Healthcare Cost and Utilization Project's inpatient and emergency department (ED) databases for patients aged 18 to 64 who underwent appendectomy from 2016 to 2017. The primary outcome was total hospital cost of care calculated by applying cost-to-charge ratios to aggregated charges from any ED visits 7 days prior to and 30 days following appendectomy, after adjusting for wage index, inflation, and winsorization of outliers. The primary predictor was delay in diagnosis, defined as having a previous ED visit within 7 days pre-operatively with a diagnosis other than appendicitis and no surgery initially. A multivariable Poisson regression model was used to quantify the cost associated with delayed diagnosis.

## Results

There were 76,183 patients (51.1% female, 17.9% aged 55-64, and 10.8% non-Hispanic Black) who received an appendectomy, of which 2,028 (2.7%) were identified as having delayed diagnosis. Delayed diagnosis had a median cost of \$11,035 compared to \$9,179 for non-delayed diagnosis ( $p < 0.001$ ). Patients with delayed diagnosis had a 1.22 (95% CI, 1.16-1.28) times increased cost. Non-Hispanic Black patients had a 1.22 (95% CI, 1.17-1.27) times increased cost compared with non-Hispanic White patients. Hospitals serving greater than 50% Hispanic and non-Hispanic Black patients had a 1.15 (95% CI, 1.03-1.27) times increased cost.

Table 1. Median Aggregated Cost of Care (in USD) Stratified by Demographic Characteristics

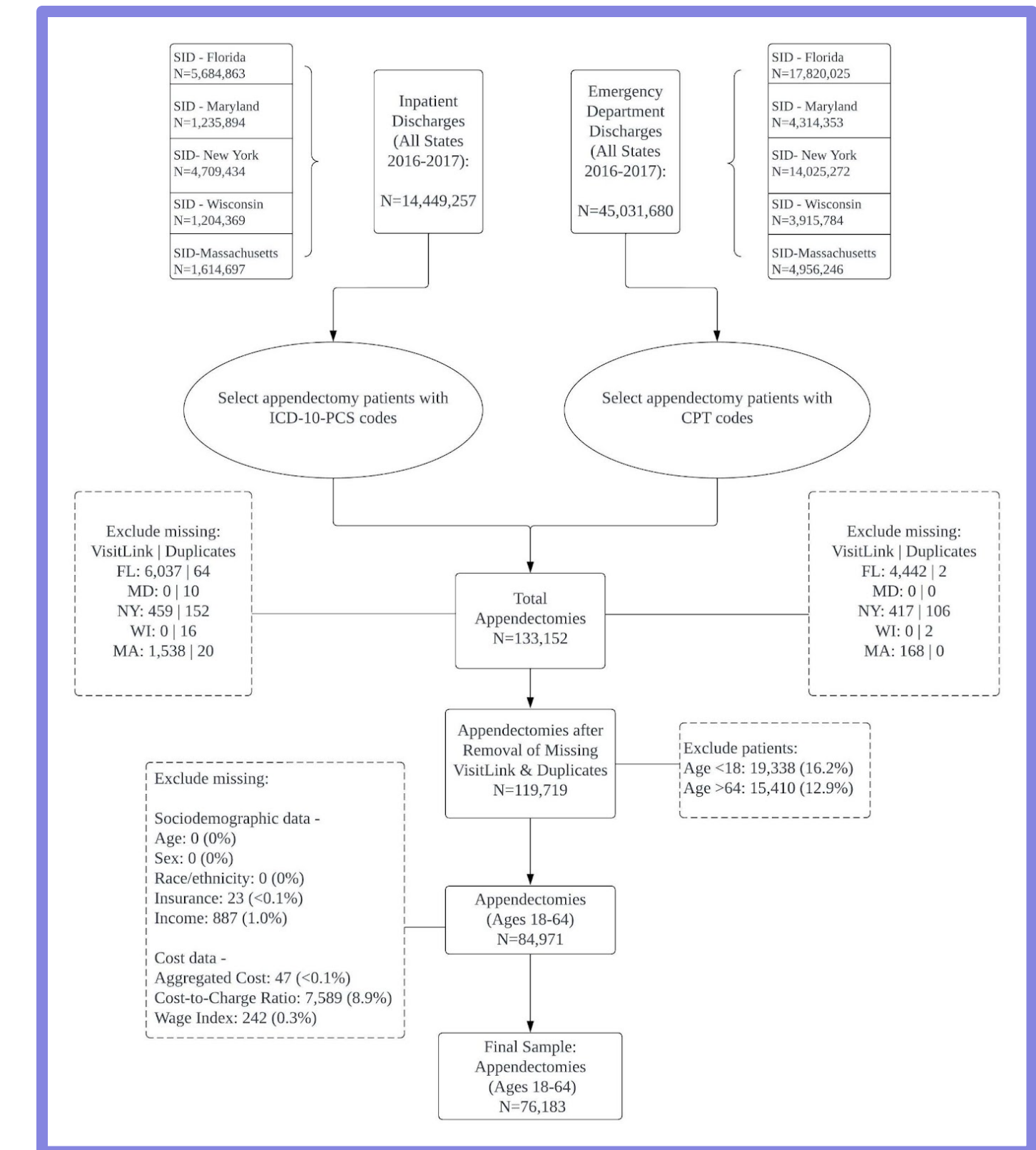
	Total N=76,183 Median Cost (IQR)	Delayed Diagnosis N=2,028 Median Cost (IQR)	Non-Delayed Diagnosis N=74,155 Median Cost (IQR)	Wilcoxon Rank Sum p-value
<b>Total</b>	\$ 9,214 (8,962)	\$ 11,035 (10,964)	\$ 9,179 (8,909)	<0.001
<b>Age</b>				
18-24	\$ 7,604 (6,549)	\$ 9,146 (8,601)	\$ 7,561 (6,525)	<0.001
55-64	\$ 12,245 (13,427)	\$ 14,495 (18,130)	\$ 12,207 (13,380)	<0.001
<b>Sex</b>				
Male	\$ 9,051 (8,755)	\$ 11,099 (10,665)	\$ 9,005 (8,695)	<0.001
Female	\$ 9,386 (9,159)	\$ 11,031 (11,171)	\$ 9,342 (9,102)	<0.001
<b>Race and ethnicity</b>				
Asian or Pacific Islander	\$ 10,277 (8,176)	\$ 16,429 (16,241)	\$ 10,245 (8,090)	<0.001
Hispanic	\$ 9,517 (7,666)	\$ 11,063 (9,370)	\$ 9,485 (7,585)	<0.001
Non-Hispanic Black	\$ 10,726 (10,621)	\$ 12,964 (11,465)	\$ 10,651 (10,601)	<0.001
Non-Hispanic White	\$ 8,571 (8,876)	\$ 10,543 (10,769)	\$ 8,526 (8,816)	<0.001
<b>Insurance Status</b>				
Medicare	\$ 14,327 (17,849)	\$ 16,451 (26,950)	\$ 14,293 (17,761)	0.271
Medicaid	\$ 10,488 (9,351)	\$ 11,415 (11,431)	\$ 10,459 (9,269)	0.001
Private Insurance	\$ 8,729 (8,608)	\$ 10,865 (10,661)	\$ 8,685 (8,553)	<0.001
<b>Zip-code Median Income Quartile<sup>a</sup></b>				
1	\$ 9,897 (9,249)	\$ 11,416 (10,200)	\$ 9,853 (9,202)	<0.001
2	\$ 8,864 (8,777)	\$ 10,760 (11,561)	\$ 8,808 (8,682)	<0.001
3	\$ 8,793 (8,570)	\$ 10,402 (11,169)	\$ 8,759 (8,513)	<0.001
4	\$ 9,387 (9,190)	\$ 11,787 (11,565)	\$ 9,339 (9,144)	<0.001

a. 2016 (Q1 \$1-\$42,999; Q2 \$43,000-\$53,999; Q3 \$54,000-\$70,999; Q4 \$71,000+); 2017 (Q1 \$1-\$43,999; Q2 \$44,000-\$55,999; Q3 \$56,000-\$73,999; Q4 \$74,000+)

Table 2. Poisson Regression Model of Aggregated Cost of Care on Delayed Diagnosis

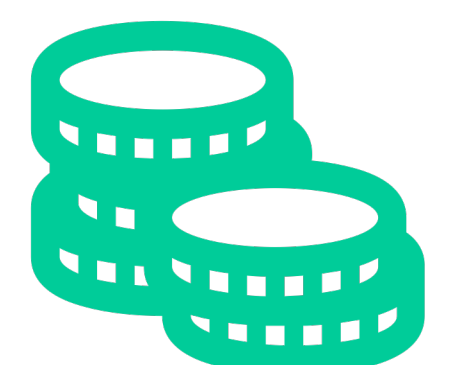
	aIRR	95% CI
<b>Delayed Diagnosis, N = 2,028</b>	1.22	(1.16-1.28)*
<b>Age</b>		
18-24	Ref	Ref
55-64	1.85	(1.78-1.92)*
<b>Sex</b>		
Male	Ref	Ref
Female	0.98	(0.95-1.01)
<b>Race and ethnicity</b>		
Non-Hispanic White	Ref	Ref
Non-Hispanic Black	1.22	(1.17-1.27)*
Hispanic	0.96	(0.92-1.00)*
Asian or Pacific Islander	1.00	(0.92-1.07)
<b>Insurance Status</b>		
Private Insurance	Ref	Ref
Medicare	1.52	(1.45-1.60)*
Medicaid	1.16	(1.12-1.21)*
<b>Percent Black/Hispanic Patients</b>		
<50%	Ref	Ref
≥50%	1.15	(1.03-1.27)*

Figure 1. Flow Diagram of Patient Sample Construction (2016 and 2017)



## Conclusion

There is evidence of increased cost of care for patients with delayed diagnosis. The increased cost burden is concentrated among non-Hispanic Black patients who tend to be treated at facilities treating a higher proportion of minority patients. Policies to address delayed diagnosis may help both improve outcomes and reduce inefficient healthcare spending.



## References

- Reyes AM, Royan R, Feinglass J, Thomas AC, Stey AM. Patient and Hospital Characteristics Associated With Delayed Diagnosis of Appendicitis. JAMA Surg. Published online January 18, 2023:e227055.
- Goyal MK, Chamberlain JM, Webb M, et al. Racial and ethnic disparities in the delayed diagnosis of appendicitis among children. Acad Emerg Med. 2021;28(9):949-956.
- Michelson KA, Reeves SD, Grubenhoff JA, et al. Clinical Features and Preventability of Delayed Diagnosis of Pediatric Appendicitis. JAMA Netw Open. 2021;4(8):e2122248.