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Methodology Article

Medicare Utilization and Payment Analysis

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Abstract

This analysis investigates the key factors driving total program payments in healthcare, focusing on the impact of coinsurance payments and visit frequency per enrollee. Using a combination of linear regression modeling and scenario analysis, we explored how changes in these factors affect overall program costs. The goal was to provide actionable insights for effective cost management in the healthcare program. The analysis proves that Coinsurance payments are a significant driver of total program costs. With each dollar increase in coinsurance payments correlate with an increase in total program payments. In Scenario 1, where coinsurance payments increased by 10% with no change in utilization, total program payments rose significantly to $1.22 billion. This finding underscores the cost sensitivity of the program to changes in out-of-pocket coinsurance amounts. Visit frequency per enrollee also plays a critical role in cost dynamics, though it has a complex relationship with total payments. In Scenario 2, a 5% reduction in coinsurance payments accompanied by a 10% increase in visit frequency led to a decrease in total program payments to $1.01 billion. This result suggests that higher utilization may help in reducing overall costs if it aligns with efficient or preventive care. Conversely, in Scenario 3, a 5% increase in coinsurance payments with a 10% decrease in visits led to a moderate increase in total program payments to $1.17 billion, indicating that lower utilization can reduce costs but may depend on the care's effectiveness. Based on our findings we recommend the following prescriptive analysis. Managing visit frequency per enrollee through preventive care programs or other efficient measures can significantly impact on total program costs, potentially reducing the need for frequent high-cost interventions. Adjusting coinsurance rates offers a lever for managing program costs. Lowering coinsurance might encourage utilization but could increase total program expenses. Conversely, increasing coinsurance payments could offset costs but may raise financial burdens for enrollees. A balanced approach is recommended. Leveraging scenario analysis as shown in this study can support proactive policymaking. This analysis could be relevant to policy makers to evaluate the financial implication of proposed changes to cost sharing mechanisms or programs affecting public health and utilization management.

Keywords

Coinsurance Payments, Healthcare Programs, Visit Frequency Per Enrollees, Preventive Care Programs, Policy Makers

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1 Descriptive Analysis

The data was downloaded from the CMS.GOV data repository, we initially transformed the data into more visualized pictures to be suitable for analysis. We had to view the structure and glimpse of the data to better review the variables that would be relevant for our analysis.

1.1. Data Structure

.. cols (
.. Year = Col double (),
.. `Area of Residence` = cocharacter (),
.. `Total Original Medicare Part B Enrollees` = Col number (),
.. `Total Persons with Utilization` = Col number (),
.. `Total Visits` = Col number (),
.. `Visits per Original Medicare Part B Enrollee` = Col double (),
.. `Visits per Person with Utilization` = Col double (),
.. `Total Program Payments` = Col number (),
.. `Program Payments per Original Medicare Part B Enrollee` = Col number (),
.. `Program Payments per Person with Utilization` = Col number (),
.. `Program Payments per Visit` = Col double (),
.. `Total Deductible Payments` = Col number (),
.. `Total Coinsurance Payments` = Col number ()

1.2. Summary of Data

Table 1. Data Summary.

Year Area_of_Residence Total_Original_Medicare_Part_B_Enrollees Total_Persons_With_Utilization		
Min.: 2013 Length: 9	Min.: 30842701	Min.: 23333929
1st Qu.: 2015 Class: character	1st Qu.: 32997329	1st Qu.: 24795838
Median: 2017 Mode: character	Median: 33077390	Median: 25236104
Mean: 2017	Mean: 32856634	Mean: 24957034
3rd Qu.: 2019	3rd Qu.: 33366109	3rd Qu.: 25661451
Max.: 2021	Max.: 33572564	Max.: 25686744
Total Visits Visits_per_Original_Medicare_Part_B_Enrollee Visits_per_Person_With_Utilization		
Min.: 255516353	Min.: 7.920	Min.: 10.61
1st Qu.: 263179723	1st Qu.: 8.130	1st Qu.: 10.83
Median: 273255145	Median: 8.380	Median: 10.96
Mean: 273922911	Mean: 8.337	Mean: 10.97
3rd Qu.: 284066773	3rd Qu.: 8.510	3rd Qu.: 11.07
Max.: 289787033	Max.: 8.760	Max.: 11.43
Total_Program_Payments Program_Payments_per_Original_Medicare_Part_B_Enrollee		
Min.: 5.694e+10	Min.: 1726	
1st Qu.: 6.432e+10	1st Qu.: 1941	
Median: 7.214e+10	Median: 2159	
Mean: 7.070e+10	Mean: 2156	
3rd Qu.: 7.776e+10	3rd Qu.: 2331	
Max.: 8.102e+10	Max.: 2602	
Program_Payments_per_Person_With_Utilization Program_Payments_per_Visit Total_Deductible_Payments		
Min.: 2297	Min.: 216.0	Min.: 417479657
1st Qu.: 2549	1st Qu.: 235.0	1st Qu.: 450019649

Year Area_of_Residence Total_Original_Medicare_Part_B_Enrollees Total_Persons_With_Utilization		
Median: 2811	Median: 254.0	Median: 598369101
Mean: 2837	Mean: 258.2	Mean: 554778619
3rd Qu.: 3195	3rd Qu.: 280.0	3rd Qu.: 628625967
Max.: 3355	Max.: 306.0	Max.: 649646347
Total_Coinsurance_Payments		
Min.: 1.516e+10		
1st Qu.: 1.670e+10		
Median: 1.776e+10		
Mean: 1.769e+10		
3rd Qu.: 1.861e+10		
Max.: 2.009e+10		
Data Glimpse		

Table 2. *Data Structure.*

<dbl> **2013, 2014, 2015, 2016, 2017, 2018, 201…**	
$ \`Area of Residence\`	<chr> "United States", "United States", "Unit…
$ \`Total Original Medicare Part B Enrollees\`	<dbl> 33042933, 32997329, 33145580, 33572564, …
$ \`Total Persons with Utilization\`	<dbl> 24959665, 24795838, 25236104, 25661451, …
$ \`Total Visits\`	<dbl> 268495302, 263179723, 273255145, 281369…
$ \`Visits per Original Medicare Part B Enrollee\`	<dbl> 8.13, 7.98, 8.24, 8.38, 8.50, 8.61, 8.7…
$ \`Visits per Person with Utilization\`	<dbl> 10.76, 10.61, 10.83, 10.96, 11.07, 11.1…
$ \`Total Program Payments\`	<dbl> 61046850527, 56943779186, 64320149374, …
$ \`Program Payments per Original Medicare Part B Enrollee\`	<dbl> 1848, 1726, 1941, 2027, 2159, 2331, 244…
$ \`Program Payments per Person with Utilization	<dbl> 2446, 2297, 2549, 2651, 2811, 3027, 319…
$ \`Program Payments per Visit\`	<dbl> 227, 216, 235, 242, 254, 271, 280, 293,
$ \`Total Deductible Payments\`	<dbl> 441859204, 417479657, 450019649, 552283…
$ \`Total Coinsurance Payments\`	<dbl> 16242280235, 15156323661, 16704157307, …

Year \`Area of Residence\` Total Original Medicare Part B Enrollee…[1] Total Persons With U…[2] \`Total Visits\`

Table 3. *Data Structure by Location.*

<dbl>	**<chr>**	**<dbl>**	**<dbl>**	**<dbl>**
1	2013 United States	33042933	24959665	268495302
2	2014 United States	32997329	24795838	263179723
3	2015 United States	33145580	25236104	273255145
4	2016 United States	33572564	25661451	281369719
5	2017 United States	33419284	25664755	284066773

<dbl>	<chr>	<dbl>	<dbl>	<dbl>
6	2018 United States	33366109	25686744	287263127

1.3. Standard Deviation

$\`Total Original Medicare Part B Enrollees\`
[1] 844,425.9
$\`Total Persons with Utilization\`
[1] 829,793.4
$\`Total Visits\`
[1] 12275518
$\`Visits per Original Medicare Part B Enrollee\`
[1] 0.2884008
$\`Visits per Person with Utilization\`
[1] 0.2396351
$\`Total Program Payments\`
[1] 8637720702

1.3.1. Total Original Medicare Part B Enrollees

Standard Deviation: 844,425.9

This is a moderately high standard deviation, suggesting that the number of enrollees across different regions or years varies significantly. While the overall number of enrollees may be large, the fluctuation between areas or period is noticeable [13].

1.3.2. Total Persons with Utilization

Standard Deviation: 829,793.4

This value is like the standard deviation for enrollees, which makes sense because utilization is dependent on enrollment. The relatively large standard deviation indicates significant variation in how many enrollees used Medicare Part B services across different regions or years.

1.3.3. Total Visits

Standard Deviation: 12,275,518

This very high standard deviation indicates that the number of visits varies greatly. Different regions or years could have widely different numbers of service visits, which might reflect differences in healthcare access, health needs, or utilization patterns.

1.3.4. Visits per Original Medicare Part B Enrollee

Standard Deviation: 0.2884

This low standard deviation suggests that the average number of visits per enrollee is consistent across different regions or time periods. Even though the total number of enrollees and total visits vary greatly, the average number of visits per enrollee does not fluctuate much [4].

1.3.5. Visits per Person with Utilization

Standard Deviation: 0.2396

Like the previous metric, this relatively low standard deviation shows that the number of visits per person who utilizes services is stable across different groups or periods. Despite fluctuations in the total number of visits or enrollees, individual utilization rates do not vary significantly [8].

1.3.6. Total Program Payments

Standard Deviation: 8,637,720,702

This very large standard deviation suggests a significant variance in the total payments across different regions or years. This could be due to differences in healthcare costs, usage rates, or population sizes across areas.

1.4. Histogram and Box Plot

We displayed the histogram with various key variables such as total payments within the period, and total utilization.

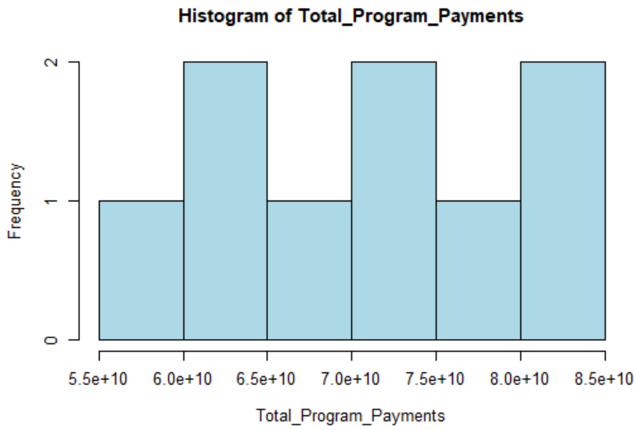

Figure 1. *Histogram of total payments.*

The data shows moderate variability in the total program payments, with payments distributed evenly across the different bins.

The highest frequencies (2 occurrences) appear around 6.0e+10 (60 billion) and 7.5e+10 (75 billion), indicating more program payments are concentrated in these ranges [5].

There is no skewness to either end, meaning the payments are spread out across the given range.

The Histogram shows there is consistent fluctuation in the number of payments varied over time.

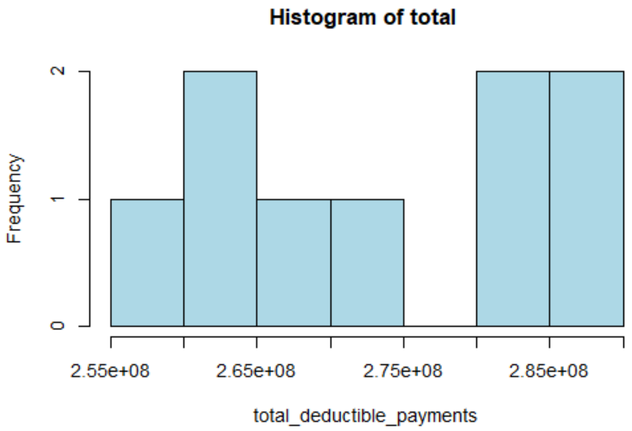

Figure 2. *Histogram of Total Deductible Payment.*

This histogram shows that the distribution of total deductible payments is spread over several ranges, with two peaks at approximately 2.65e+08 and 2.85e+08, each occurring twice. There are fewer occurrences in the middle and lower ranges of total deductible payments. This type of chart helps identify where the concentration of deductible payments lies and indicates potential variability in payment amounts.

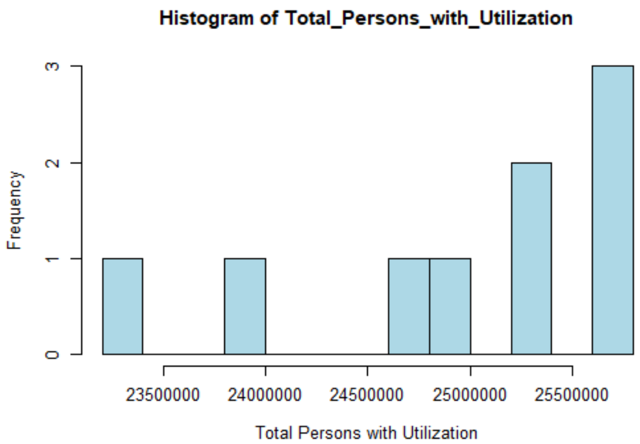

Figure 3. *Histogram of Total persons with utilization.*

X-Axis: The Total Persons with Utilization ranges from about 23.5 million to 25.5 million.

Y-Axis: The frequency (the number of occurrences) for each range of utilization. For example.

The data shows variability in the number of people utilizing services, with more people falling into the higher utilization range (around 25.5 million). This might suggest that larger populations are more frequently accessing services, or it could reflect regional or time-based differences in program usage [10].

1.5. Boxplot

1. Box:

The box shows the interquartile range (IQR), which is the middle 50% of the data. The bottom of the box is the 25th percentile (Q1), and the top of the box is the 75th percentile (Q3). The line inside the box represents the median (50th percentile).

A)We detected outliers in the data using visualizations like box plots and statistical methods like the 1.5 * IQR rule. For instance, our analysis of visits per Original Medicare Part B enrollee revealed an outlier significantly below the median, with fewer than 8 visits per enrollee, compared to the average of approximately 8.4 visits [11].

Potential Causes of Outliers:

A)Reporting Errors: These outliers could result from occasional reporting errors, such as misreported values or data entry mistakes.

B)Special Cases: Outliers might also reflect unique cases, such as individuals with limited access to healthcare or personal choices that limit their use of Medicare services [5].

Retention or Removal of Outliers:

A)Retention: To ensure that the analysis accurately reflects real-world variability, we should retain these outliers if they represent genuine variation in healthcare utilization. Retaining these outliers helps to capture healthcare access disparities or distinct patterns of care that could provide insights into underutilization or system gaps [9].

B)Removal: To avoid distorting the results, we remove the outliers if they are the result of data errors. However, in the absence of strong evidence of reporting errors, we retained the outliers, as they likely represent legitimate variations in service utilization. [12].

2. Whiskers:

A)The lines (whiskers) extending from the top and bottom of the box represent the range of the data within 1.5 times the IQR from Q1 and Q3.

The whiskers show the spread of the non-outlier data.

3. Outliers:

A)Any data points outside the range of the whiskers are considered outliers [8].

B)In this case, there's one outlier marked by a dot at the lower end, slightly below 8 visits per enrollee. This indicates that one observation had a notably lower number of visits than the rest of the data.

Interpretation:

A)The median number of visits per enrollee is approximately 8.4.

B)The IQR (middle 50%) ranges from around 8.2 to 8.6 visits.

C)Most of the data is relatively tightly clustered between 8.2 and 8.6 visits per enrollee, meaning That there is low variability in the number of visits for most enrollees.

D)The outlier shows a lower value (below 8 visits), suggesting that in one instance, the visits per enrollee were notably lower than the rest of the dataset.

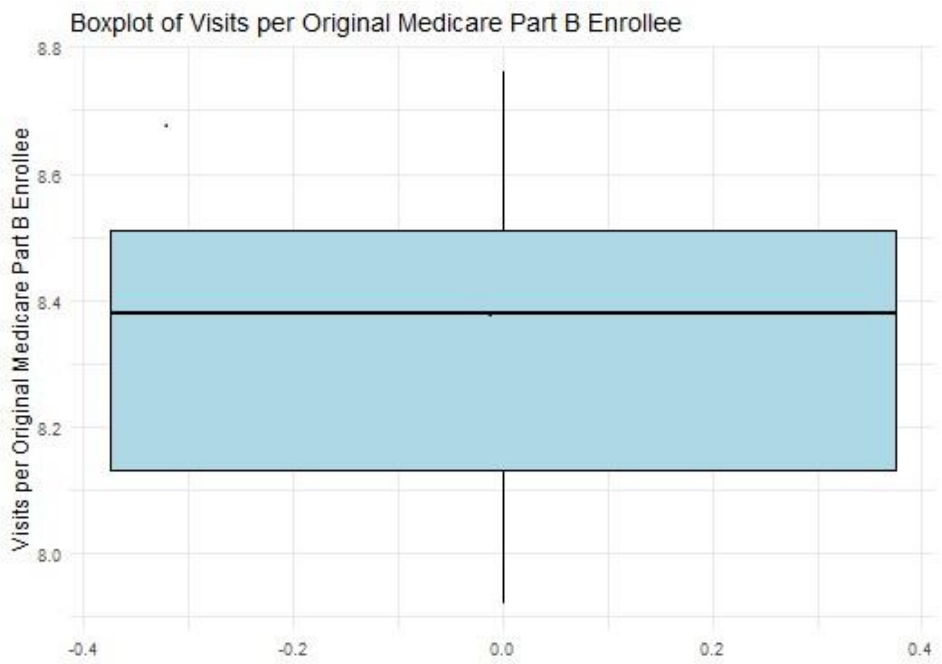

Figure 4. *Box plot of Originl medicare partB employees.*

The median number of visits per Original Medicare Part B enrollee is slightly above 8.2.
Most visits are within a range of about 8.2 to 8.4 visits (the interquartile range).
There is at least one outlier that falls slightly above 8.8 visits.

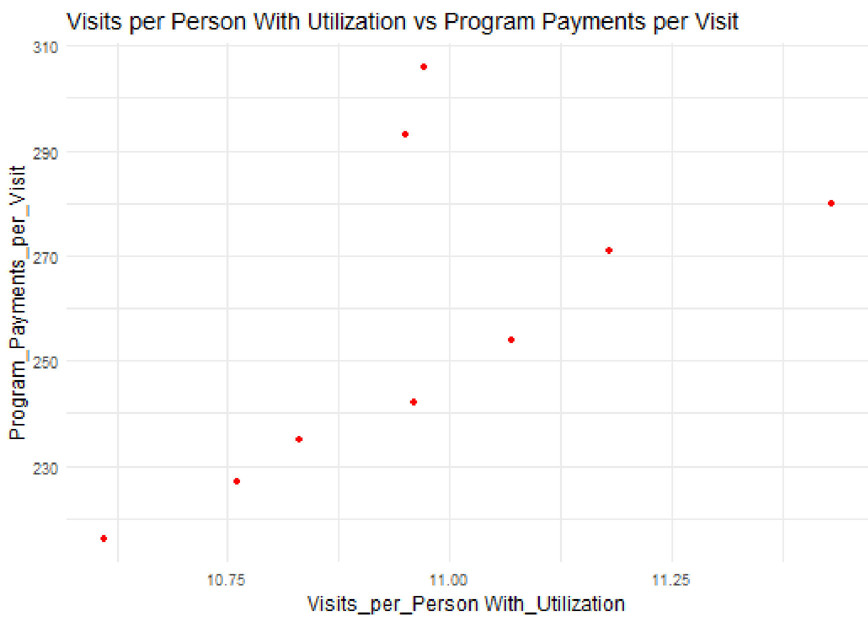

Figure 5. *Visit per person with utilization vs program Payments per visit.*

1.6. Key Interpretations

1. X-Axis (Visits per Person with Utilization):

A)The x-axis represents the number of visits per person who utilizes the program.

B)The range of values on the x-axis is between approximately 10.75 and 11.25 visits per person.

2. Y-Axis (Program Payments per Visit):

A)The y-axis represents the average payments made by the program for each visit.

B)The payment range on the y-axis spans from around 230 to 310 units (likely dollars or another currency).

3. Data Points:

A)Each red dot represents a pair of values: one for the number of visits per person and the corresponding program payment per visit.

B)The general pattern of the points suggests that there might be a positive relationship between the number of visits per person and the program payments per visit. As the number of visits per person increases (from left to right on the x-axis), the program payments per visit also seem to increase (moving upward on the y-axis).

1.7. Potential Insights

A) Positive Correlation: There seems to be a slight positive correlation, meaning that when the number of visits per person increases, the payments per visit tend to increase as well.

B) Cost Implications: This could indicate that higher utilization (more visits per person) is associated with higher program costs per visit, which might be due to the increased use of services, more expensive treatments, or additional medical interventions required for more frequent visits.

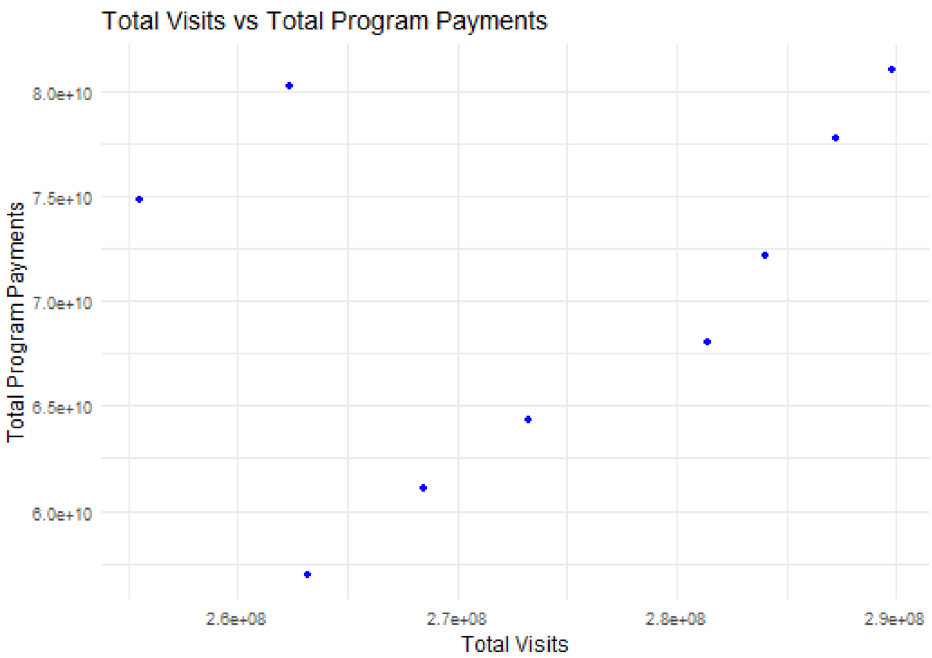

Figure 6. *Total Visits vs Total program payments.*

Positive Correlation

There appears to be a positive relationship between Total Visits and Total Program Payments, meaning that as the number of visits increases, the total payments also increase. This is an expected relationship, as more visits typically lead to more payments being made for services.

1.8. Scattered Plot Analysis

The scatter plot suggests that there is a positive correlation between total visits and total program payments. As the number of visits increases, the program payments also rise, though there is some variability in the relationship. The data points follow a general upward trend, though the relationship between visits and payments is not perfectly linear. This scatter plot shows the relationship between service usage and costs, providing insight into how utilization impacts Medicare spending.

The analysis of Medicare utilization and payment data provides critical insights into the program's efficiency and effectiveness. By examining metrics such as total visits, program payments, and visits per enrollee, we can identify trends in service utilization and highlight areas where the program can improve. For instance, identifying regions with lower-than-average visits per enrollee might reveal disparities in access to care, prompting targeted interventions to address these gaps [4].

This analysis also helps Medicare assess the alignment of program payments with actual service utilization. For example, regions where program payments are high but utilization is low may indicate inefficiencies or misallocations of resources. On the other hand, areas with high utilizationbut lower payments may require additional support to ensure adequate funding for necessary services [10].

Ultimately, the insights gained from this analysis contribute to Medicare's overarching goal of improving service delivery, optimizing resource allocation, and ensuring that beneficiaries receive the care they need. By focusing on both utilization and payment patterns, Medicare can develop more effective policies that enhance patient care while controlling costs.

Spread of Data: The data points are somewhat scattered but follow a general upward trend, indicating that the relationship is not perfectly linear but there is a consistent trend of increasing program payments with increasing visits.

In summary The scattered plot suggests that there is a positive correlation between the Total Visits and the Total Program Payments. As the number of visits increases, the program payments also ise, though there is some variability in the relationship.

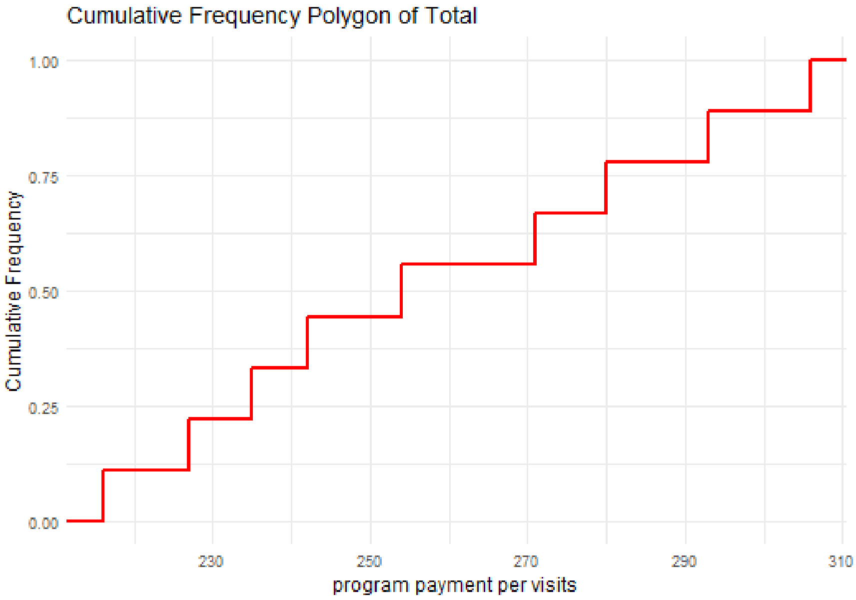

***Figure 7**. Cumulative frequency polygon of program payment per visit.*

A) The x-axis represents program payment per visit, with values ranging from approximately 230 to 310.

B) The y-axis represents the cumulative frequency, which measures the cumulative proportion of data points that fall below a certain payment value.

C) The steps in the polygon represent the cumulative percentage of visits that have payments at or below each specific value on the x-axis.

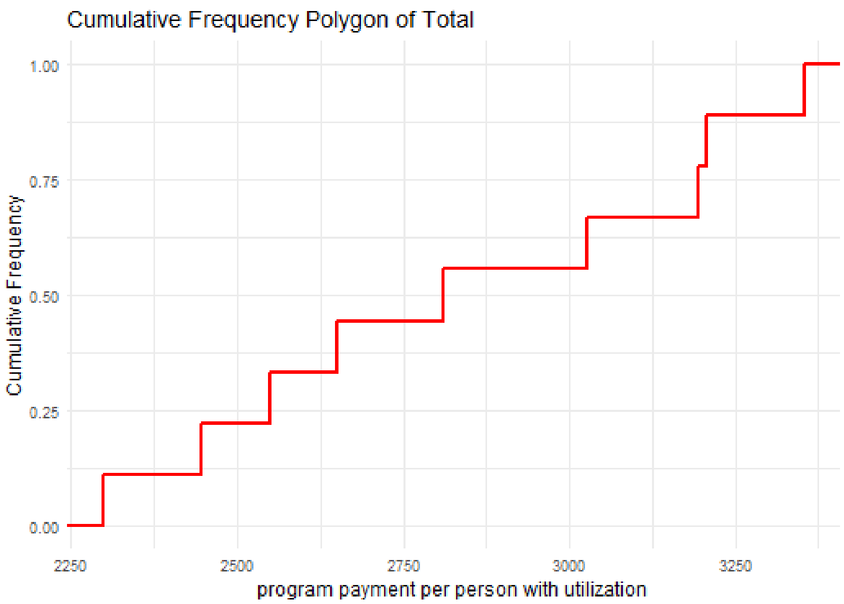

***Figure 8**. Cumulative frequency polygon of paymnt per person with utiliation.*

1.8.1. Distribution of Payments

The plot shows how payments are distributed across the enrollees. For example, around 50% of enrollees received program payments of approximately 2,100 or less, while 100% of enrollees received payments of 2,800 or less.

1.8.2. Gradual Increase

The smooth, gradual increase in cumulative frequency shows that payments are relatively evenly distributed between the lower and higher payment ranges.

1.8.3. Concentration of Payments

The relatively larger steps in some areas (e.g., around 2,200 to 2,400) suggest that a significant number of enrollees received payments within this range, indicating a concentration of program payments at certain values.

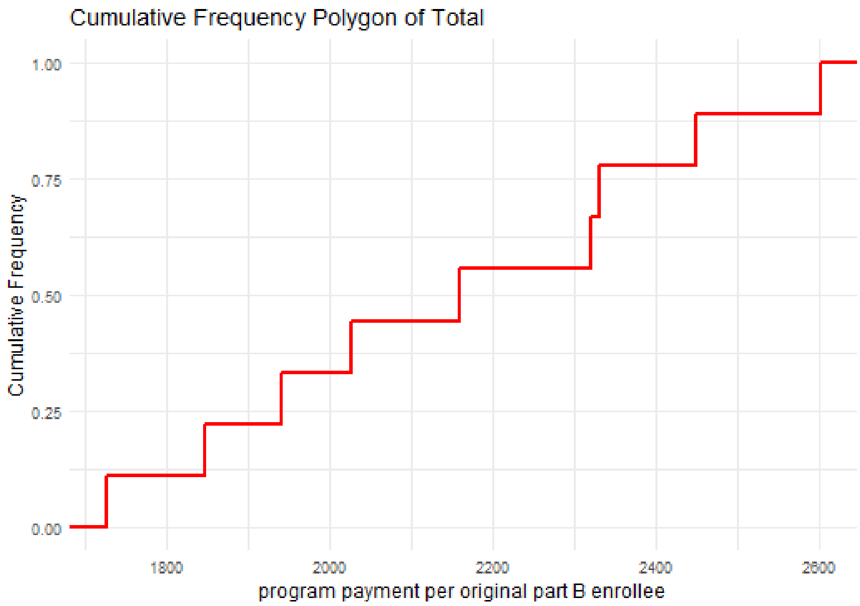

Figure 9. Cumulative frequency polygon of program payment per part B enrollee.

The plot demonstrates how payments are distributed, with more frequent payment values clustered around 2,000 to 2,500. Each step indicates the addition of enrollees receiving those specific payment amounts, with the final steps reaching the highest payment range.

$`Program Payments per Original Medicare Part B Enrollee`[1] 292.60

1.9. Correlation Matrix

Table 4. Results for Correlation matrix

Visits_per_Original_Medicare_Part_B_Enrollee	
Visits_per_Original_Medicare_Part_B_Enrollee	1.0000000
Program_Payments_per_Original_Medicare_Part_B_Enrollee	0.6125784
Program_Payments_per_Visit	0.4030853
Program_Payments_per_Original_Medicare_Part_B_Enrollee	
Visits_per_Original_Medicare_Part_B_Enrollee	0.6125784
Program_Payments_per_Original_Medicare_Part_B_Enrollee	1.0000000
Program_Payments_per_Visit	0.9699525

Visits_per_Original_Medicare_Part_B_Enrollee	
Program_Payments_per_Visit	
Visits_per_Original_Medicare_Part_B_Enrollee	0.4030853
Program_Payments_per_Original_Medicare_Part_B_Enrollee	0.9699525
Program_Payments_per_Visit	1.0000000

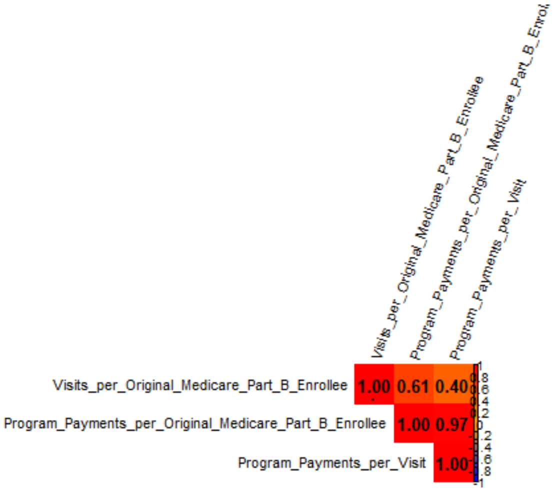

Figure 10. Correlation Plot.

The heatmap shows that program payments per enrollee are very closely tied to program payments per visit, with a nearly perfect correlation (0.97).

A) There is also a moderate positive relationship between visits per enrollee and both payments per enrollee and payments per enrollee.

B) The color intensity highlights these relationships, with red indicating stronger positive correlations.

2. Predictive Analytics

We used Total program payments as the Y variable to decide the amount paid by States. While also paying attention to key drivers of the key variable such asTotal visits, Total coinsurance payments and persons by enrollee.

int 225 290 284 222 242 220 218 230 216 217...

$ Total.Deductible.Payments num 6142547 1173254 4634108 5683847 31263573...

$ Total.Coinsurance.Payments num 2.52e+08 3.34e+07 2.06e+08 1.77e+08 1.17e+09...

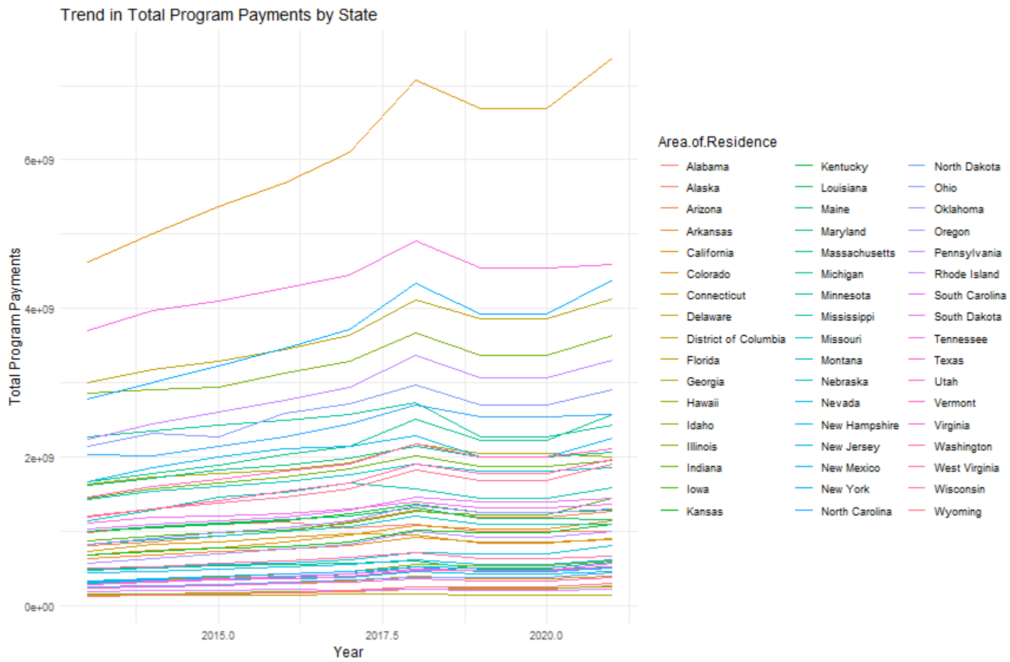

Figure 11. Trend in Total Program Payments by State.

2.1. Total Program Payments by State Analysis

We can see that Certain states appear to have significantly higher total program payments compared to others (e.g., California, New York, and Florida). These states likely have larger populations of Medicare Part B enrollees [8].

1. Trends Over Time:

A)Some states show a steady increase over time, while others have fluctuations or more dramatic shifts. This may show differences in healthcare costs, population changes, or state policies affecting program use.

2. Clusters of States:

A) Many states fall into a lower range of payments, clustered near the bottom, making it challenging to distinguish individual trends. We can refer to them as lower range states. Based on the above analysis we wanted to know what the drivers of Total program payments are, so we started with a collinearity test, to understand the collinearity with the key variable which is Y.

We did this test to check the positive or negative correlation between the relevant variables.

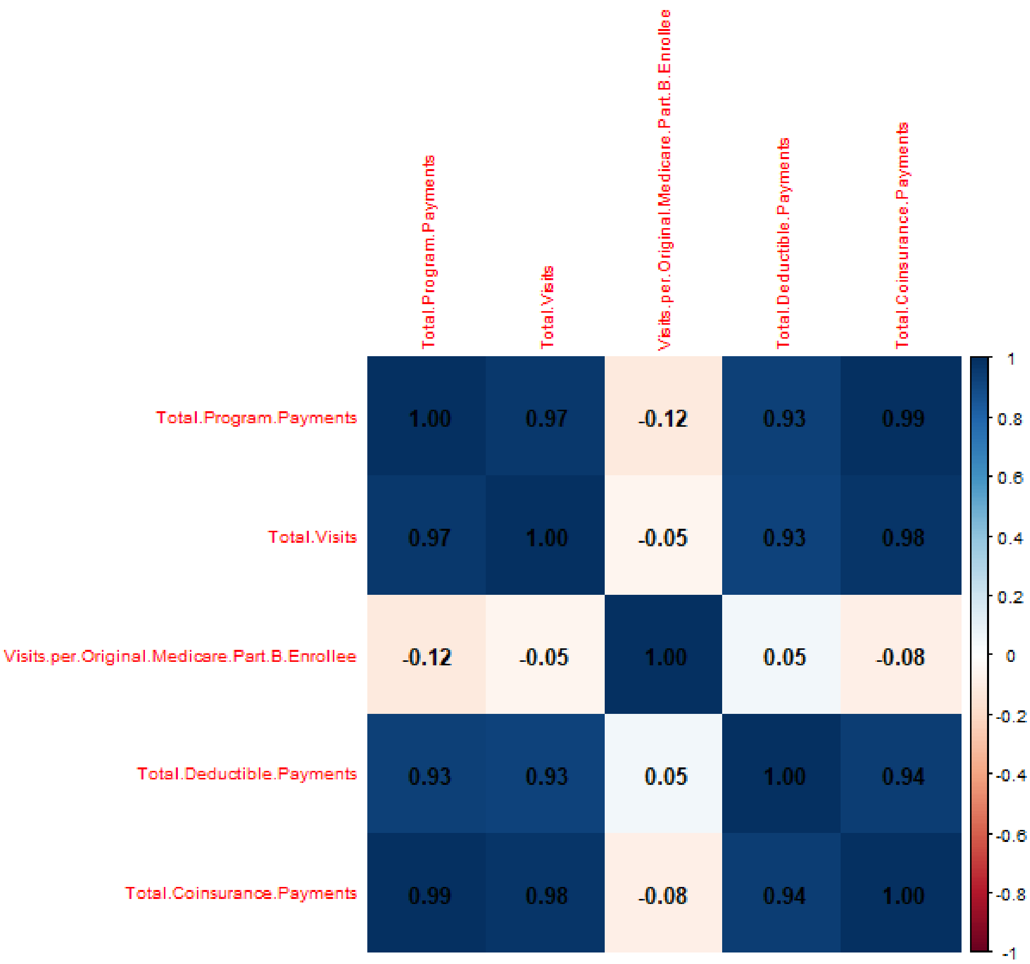

Figure 12. Correlation matrix plot.

2.2. Total Program Payments and Total Visits

There is a strong positive correlation (0.97) between Total Program Payments and Total Visits, indicating that as the number of visits increases, the total program payments also tend to increase. This makes sense, as more visits generally mean more services and thus higher payments [6].

2.3. Total Program Payments and Total Coinsurance Payments

Total Program Payments and Total Coinsurance Payments are almost perfectly correlated (0.99). This suggests that coinsurance payments are a significant part of total program payments.

2.4. Total Program Payments and Total Visits

There is a strong positive correlation (0.97) between Total Program Payments and Total Visits, indicating that as the number of visits increases, the total program payments also tend to increase. This makes sense, as more visits generally mean more services and thus higher payments [6].

2.5. Total Program Payments and Total Coinsurance Payments

Total Program Payments and Total Coinsurance Payments are almost perfectly correlated (0.99). This suggests that co-insurance payments are a significant part of total program payments.

2.6. Total Program Payments and Total Deductible Payments

There is a high correlation (0.93) between Total Program Payments and Total Deductible Payments as well, showing that deductible payments also contribute substantially to the total payments.

2.7. Visits per Original Medicare Part B Enrollee

The metric Visits per Original Medicare Part B Enrollee has weak or even slightly negative correlations with other payment metrics. This might suggest that the number of visits per enrollee does not directly influence total costs, possibly because other factors (such as the cost per visit) are more significant drivers of overall payments.

2.8. Program Payments and Total Deductible Payments

There is a high correlation (0.93) between Total Program Payments and Total Deductible Payments as well, showing that deductible payments also contribute substantially to the total payments.

2.9. Visits per Original Medicare Part B Enrollee

The metric Visits per Original Medicare Part B Enrollee have weak or even slightly negative correlations with other payment metrics. This might suggest that the number of visits per enrollee does not directly influence total costs, possibly because other factors (such as the cost per visit) are more significant drivers of overall payments.

3. Linear Regression Using Total Persons with Utilization

lm(formula = Total.Program.Payments ~ Total. Visits + Total.Persons.With.Utilization +
Total.Coinsurance.Payments, data = data)
Residuals:
Min 1Q Median 3Q Max
-445811163 -64801901 3704134 74620087 670851590
Coefficients:
Estimate Std. Error t value Pr(>|t|)
(Intercept) -8.528e+07 1.109e+07 -7.693 9e-14 ***
Total. Visits -4.559e+01 1.284e+01 -3.551 0.000423 ***
Total. Persons. With. Utilization 4.842e+02 1.323e+02 3.659 0.000282 ***
Total.Coinsurance.Payments 4.288e+00 1.176e-01 36.453 < 2e-16 ***

Signif. codes: 0 ***' 0.001 **' 0.01 *' 0.05 '0.1 '1
Residual standard error: 149500000 or 455 degrees of freedom
Multiple R-squared: 0.985, Adjusted R-squared: 0.9849
F-statistic: 9938 on 3 and 455 DF, p-value: < 2.2e-1

A) Coinsurance Payments: Given the strong positive relationship between Total Coinsurance Payments and Total Program Payments, monitoring and potentially managing coinsurance contributions could influence overall costs.

B) Visits Impact: The negative association with Total Visits might suggest that optimizing or managing the frequency of visits could help control costs without directly increasing total payments.

C) Utilization Levels: The positive coefficient for Total Persons with Utilization indicates that increasing the number of people using the program is associated with higher total payments. This metric could be useful for forecasting future program costs as utilization grows.

Based on this observation, we decided to do regression analysis with Visits per original Enrollee to see the impact and significance.

***Table 5**. Linear regression table.*

Residuals:				
Min	1Q	Median	3Q	Max
-428887070	-81883514	6737050	70504158	661816706

Coefficients:

Estimate Std. Error t value Pr(>|t|)				
(Intercept)	1.021e+08	3.802e+07	2.685	0.00751 **
Total.Visits	-6.362e+00	1.464e+01	-0.435	0.66409
Total.Persons. With.Utilization	6.182e+01	1.528e+02	0.405	0.68591
Total.Coinsurance.Payments	4.250e+00	1.147e-01	37.050	< 2e-16 ***
Visits.per.Original.Medicare.Part.B.Enrollee---	-2.043e+07	3.975e+06	-5.140	4.1e-07 ***

Signif. codes: 0 ***' 0.001 **' 0.01 *' 0.05 ' 0.1 '1

Residual standard error: 145500000 on 454 degrees of freedom

Multiple R-squared: 0.9858, Adjusted R-squared: 0.9857

F-statistic: 7877 on 4 and 454 DF, p-value: < 2.2e-16

3.1. Interpretation of Linear Regression Analysis

Total *Visits:*

1) Estimate: -6.362
2) P-Value: 0.664 (not statistically significant)
3) Interpretation: The coefficient is not statistically significant, suggesting that *Total Visits* does not have a meaningful impact on *Total Program Payments* when accounting for the other variables in this model.

Total *Persons with Utilization:*

1) *Estimate:* 61.82
2) *P-Value:* 0.686 (not statistically significant)
3) Interpretation: Like *Total Visits*, this predictor is not statistically significant, indicating it does not substantially impact *Total Program Payments* in this model.

Total *Coinsurance Payments:*

1) *Estimate:* 4.25
2) *P-Value:* <2e-16 (highly significant)

3.2. Interpretation

Total Coinsurance Payments has a strong positive relationship with Total Program Payments. For every additional dollar in coinsurance payments, total program payments increase by approximately $4.25. This variable is a key driver of overall program costs.

3.3. Visits per Original Medicare Part B Enrollee

1) *Estimate:* -20,430,000
2) *P-Value:* 4.1e-07 (highly significant)
3) *Interpretation:* This negative coefficient suggests that as the number of visits per enrollee increases, *Total Program Payments* decrease. This could imply that higher visit frequency per enrollee is associated with a more managed or efficient care approach, potentially reducing total costs.

3.4. Model Fit Statistics

Residual Standard Error: 145,500,000

This is the average distance that the observed values fall from the regression line. A smaller residual standard error suggests a better fit. In this context, although the residuals are large, this value may be expected due to the scale of Total Program Payments.

1) *Multiple R2R^2R2:* 0.9858

A)This value indicates that approximately 98.58% of the variability in *Total Program Payments* is explained by the predictors in the model. This high R2R^2R2 suggests that the model is very effective at explaining the variation in *Total Program Payments*.

2) *Adjusted R2R^2R2:* 0.9857

A)Adjusted R2R^2R2 accounts for the number of predictors relative to the sample size. With a value nearly identical to the R2R^2R2, it suggests that adding predictors did not significantly inflate the model's explanatory power unnecessarily. This indicates a robust model fit.

3) *F-Statistic:* 7877 (p-value < 2.2e-16)

A)This high F-statistic with a very low p-value confirms that the model is statistically significant. It indicates that at least one of the predictors contributes meaningfully to explaining *Total Program Payments*. We excluded the not-significant variables and used them to see the results.

3.5. Total Coinsurance Payments

1) *Estimate:* 4.236
2) *Interpretation:* For each additional dollar in *Total Coinsurance Payments, Total Program Payments* increase by approximately $4.24, holding other variables con-

stant. This strong positive relationship suggests that coinsurance payments are a significant driver of overall program costs.

3) *T-value and p-value:* The t-value (176.6) and p-value (<2e-16) indicate this is highly statistically significant, meaning it's very unlikely that this effect is due to random chance.

3.6. Visits per Original Medicare Part B Enrollee

1) *Estimate:* -21,370,000
2) *Interpretation:* For each additional visit per enrollee, *Total Program Payments* decrease by approximately $21.37 million, holding other variables constant. This negative relationship might suggest that higher visit frequency per enrollee is associated with more efficient or managed care, potentially reducing overall program costs.
3) *T-value and p-value:* The t-value (-6.438) and very low p-value (3.08e-10) confirm this is a statistically significant predictor as well.

3.7. Model Fit Statistics

1) *Residual Standard Error:* 145,200,000
2) A lower value indicates a better fit, but given the scale, this seems reasonable.
3) *Multiple R-squared:* 0.9858
4) This shows that 98.58% of the variability in *Total Program Payments* is explained by *Total Coinsurance Payments* and *Visits per Original Medicare Part B Enrollee*. This high value suggests a strong fit.
5) *Adjusted R-squared:* 0.9857
6) This value adjusts for the number of predictors in the model and is almost identical to the R2R^2R2, confirming that the model is not overfitting with unnecessary variables.
7) *F-statistics:* 15,820 (p-value < 2.2e-16)

This extremely high F-statistic with an extremely low p-value shows that the model is statistically significant, meaning at least one of the predictors significantly contributes to explaining Total Program Payments.

4. Time Series and Forecast

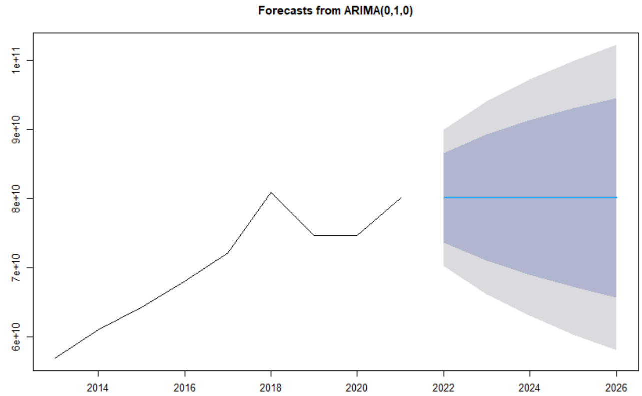

Figure 13. ARIMA forecast.

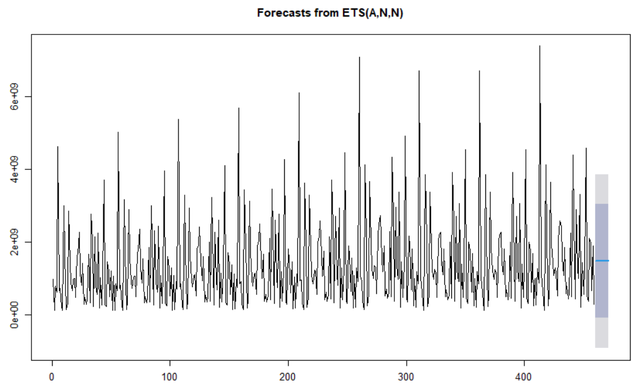

Figure 14. ETS forecast.

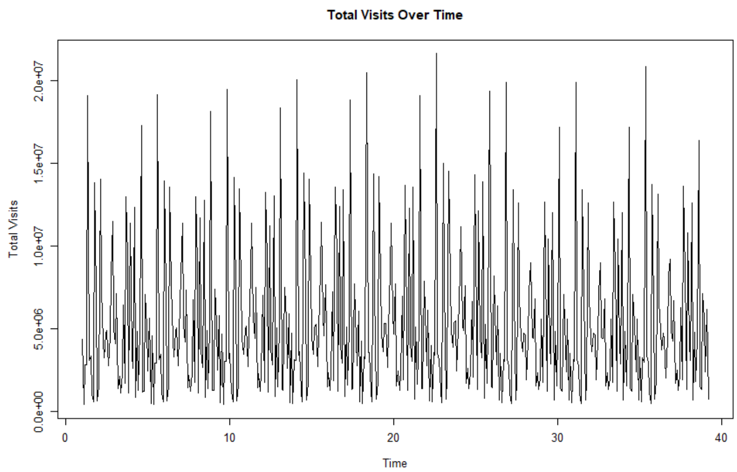

Figure 15. Time Series and Forecast of Total Visits.

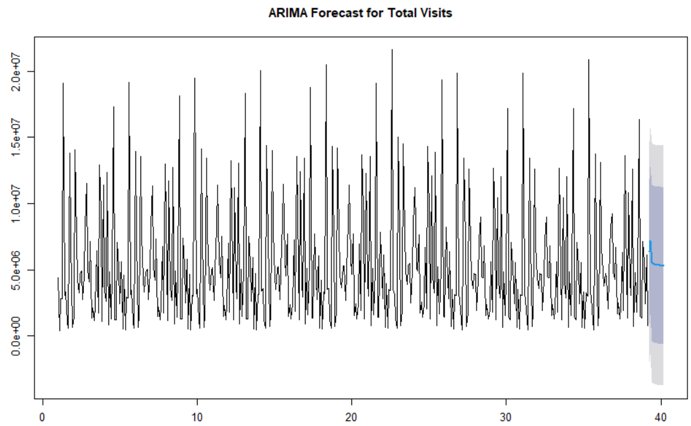

Figure 16. *ARIMA forecast of Total visits.*

ME RMSE MAE MPE MAPE MASE ACF1
Training set -7196.146 4239200 3284880 -121.3263 152.983 0.6954268 - 0.01408875

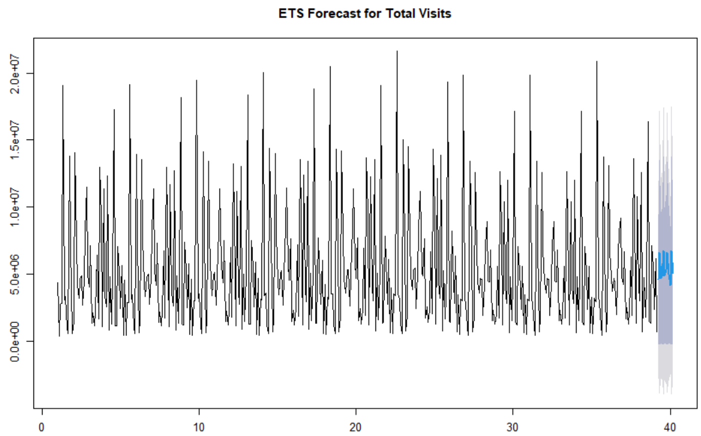

Figure 17. *ETS Forecast for Total visit.*

ME RMSE MAE MPE MAPE MASE ACF1
Training set -166955.2 4498853 3414049 -136.2102 162.4112 0.7227726 -0.1177637
TIME SERIES FOR MEDICARE ENROLLEE

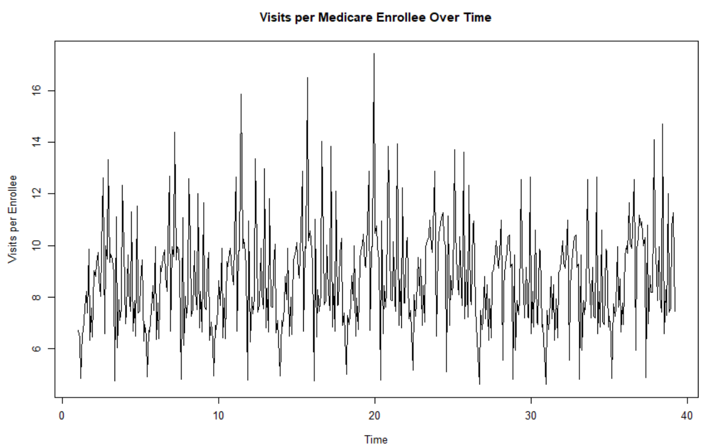

Figure 18. *ETS forecast for Medicare enrollee.*

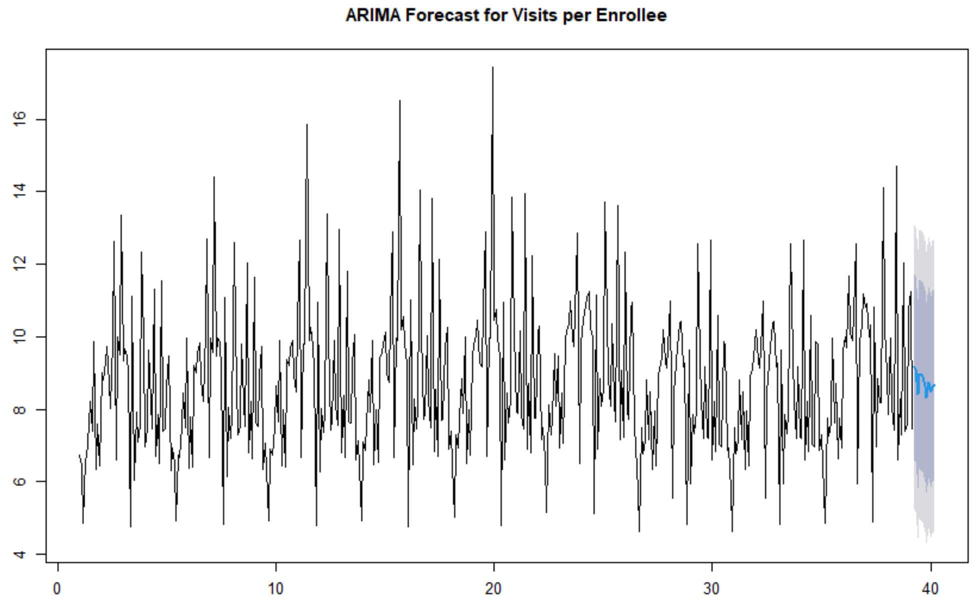

Figure 19. ARIMA forecast of Visits per enrollee.

Training set error measures:
ME RMSE MAE MPE MAPE MASE ACF1
Training set 0.03570873 2.057288 1.605635 -4.849598 19.6091 0.6782193 -0.06860874

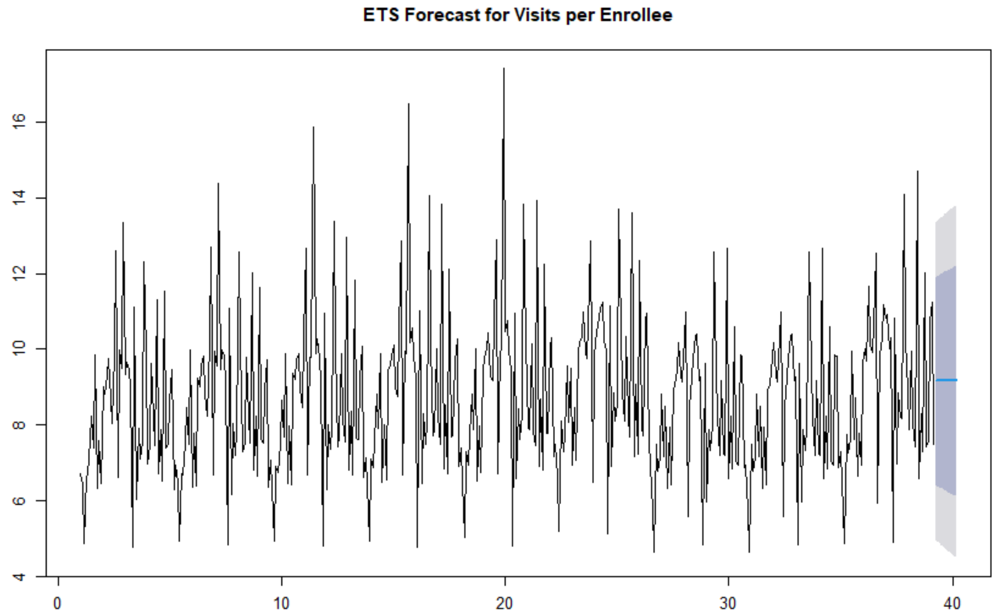

Figure 20. ETS forecast for Visit per enrollee.

TIME SERIES FOR TOTAL COINSURANCE PAYMENT
ARIMA (2,0,5) with zero mean
ME RMSE MAE MPE MAPE MASE ACF1
Training set 7922610 256338950 203321703 -3814.725 4299.618 0.3632636 0.004325064

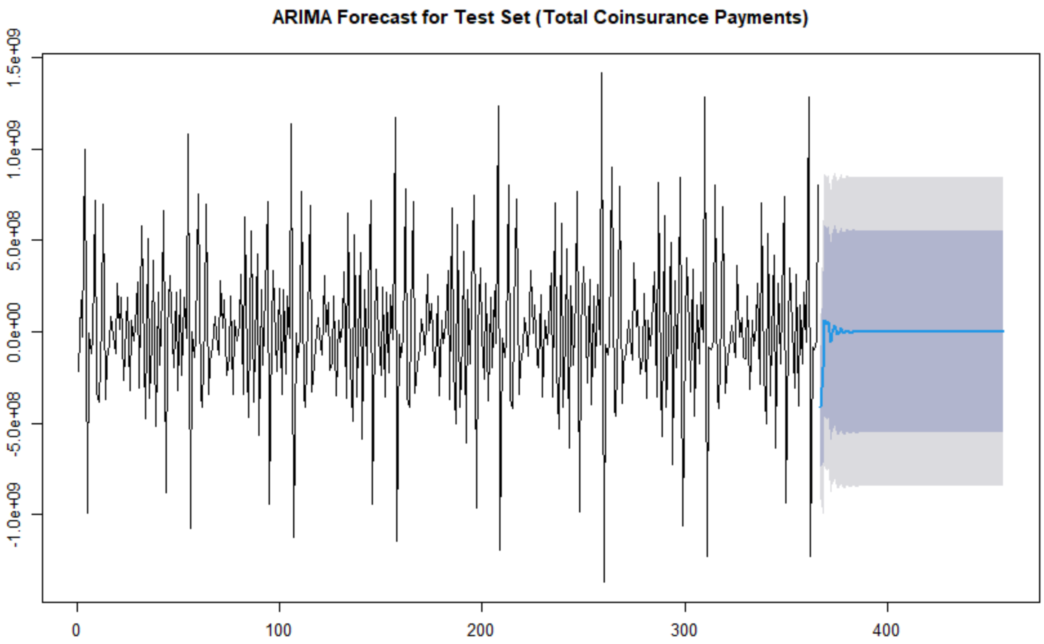

Figure 21. *ARIMA Total coinsurance payments.*

ME RMSE MAE MPE MAPE MASE ACF1
Training set 7922610 256338950 203321703 -3814.7248 4299.6175 0.3632636 0.004325064
Test set 1032995 406023241 297280002 103.2592 103.2592 0.5311337 NA

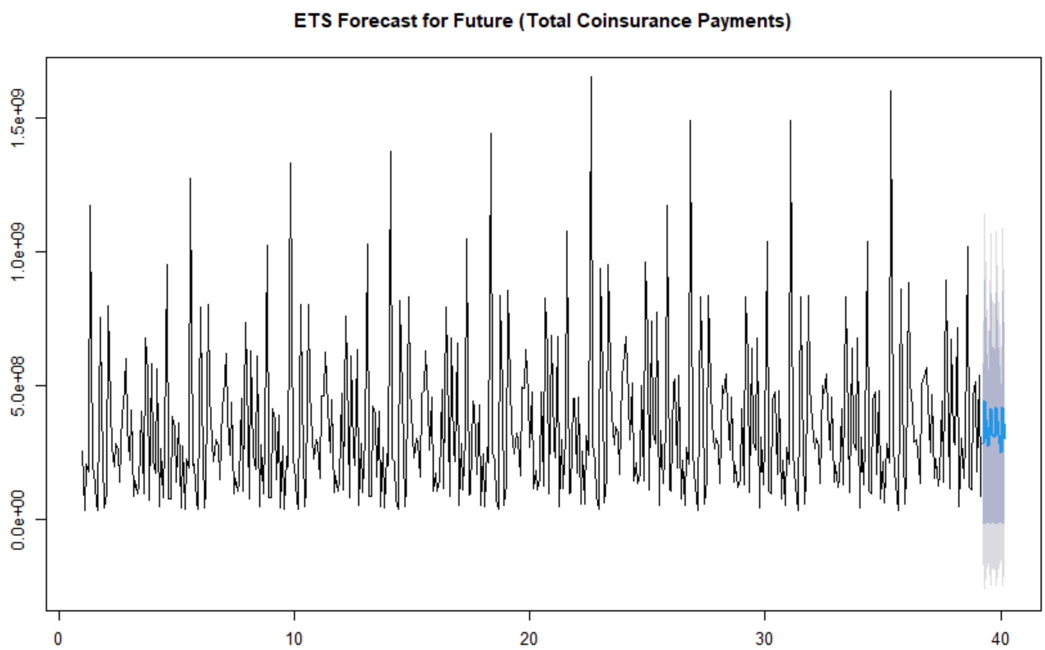

Figure 22. *ETS forecast for Total coinsurance payment.*

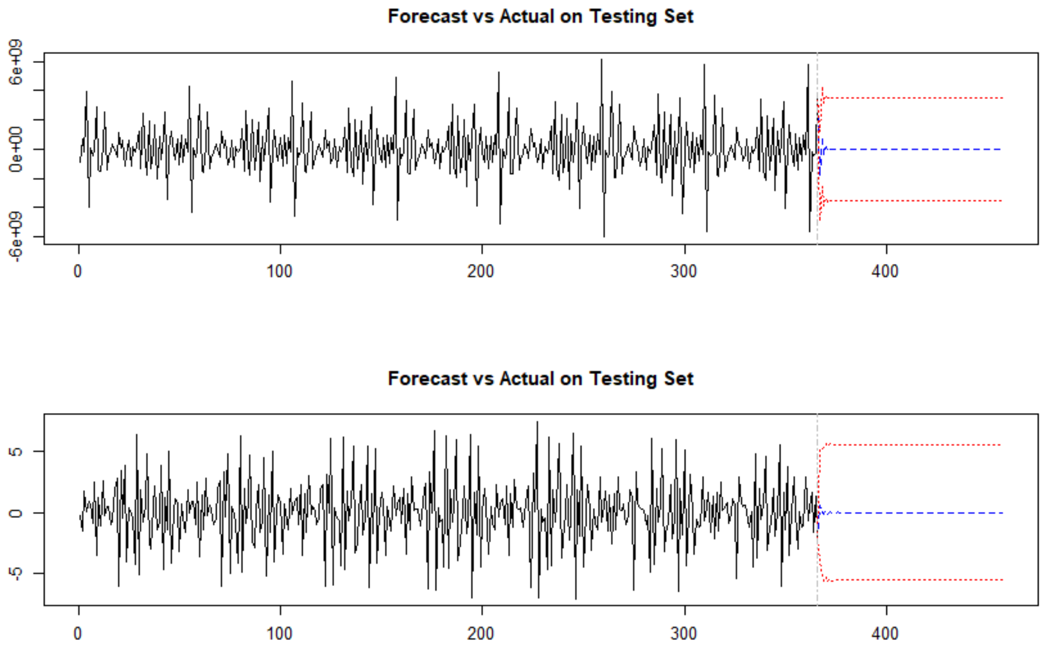

Figure 23*. Forecast vs actual On Testing set.*

Table 6*. Test set.*

	ME	RMSE	MAE	MPE	MAPE
Test set	-11782542	1869165094	1352430287	96.20633	100.5381

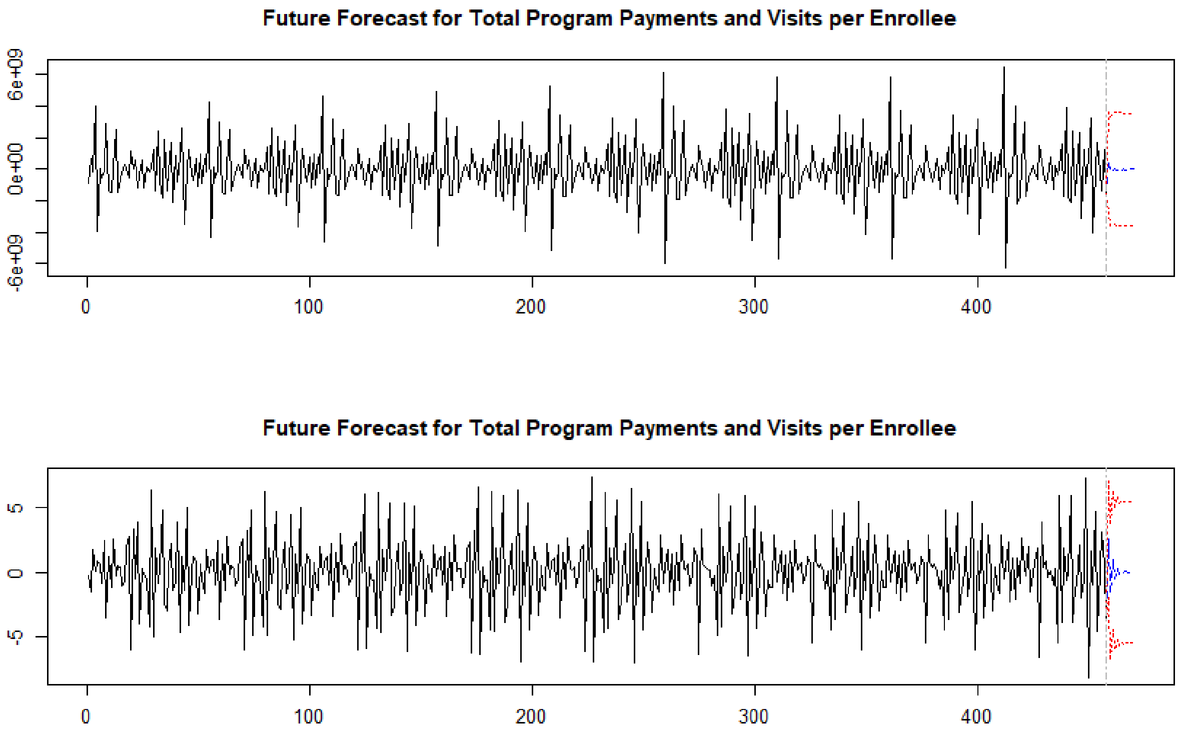

Figure 24*. Forecast for total program payment and Visits per enrolleelk.*

5. Prescriptive Analyses

Based on our predictive analytics and forecast analysis using ARIMA, which proved to be the most accurate model due to the variability in the data, we observed that the future trends remain uncertain. To address this, we simulated three potential scenarios to better understand possible outcomes [8].

5.1. Interpretation of Results

A) Forecast Values: The forecasts for both Total Program Payments and Visits per Enrollee demonstrate ongoing variability. The forecast intervals, represented by the dotted red lines, highlight the range within which future values are expected to fall. These intervals provide a visual measure of uncertainty [7].

B) Confidence Intervals: Wider confidence intervals indicate greater uncertainty in the forecast. Narrower intervals suggest higher confidence in the model's predictions, whereas wider intervals, as shown in this analysis, reflect less certainty and a broader range of potential future values.

5.2. Forecast Coinsurance and Visits per Enrollee for Prescriptive Analysis

To project each possible cost drivers, we decided to simulate and perform different scenarios:

5.2.1. Scenario_1 <- Simulate_Program_Payments (0.10, 0)% Increase in Coinsurance, no Change in Visits

Total Coinsurance: 157,473878282
New Coinsurance: 173,221,266110.2
Total Visits: 2,431047313
New Visits: 2431047313

Scenario 1 (10% Increase in Coinsurance Payments, No Change in Visits):

The estimated total program payments increased to This increase suggests that a rise in coinsurance payments leads to a higher overall program cost, as expected.

5.2.2. Scenario_2 <- Simulate_Program_Payments (-0.05, 0.10) 5% decrease in Coinsurance, 10% Increase in Visits

Average Coinsurance: 141,726490453.8
New Coinsurance: 165,347572196.1
Average Visits: 26,741,520,44.3
New Visits: 26,741,52044.3

Scenario 2 (5% Decrease in Coinsurance Payments, 10% Increase in Visits):

The estimated total program payments decreased to 64,665858525.8. This decrease reflects the impact of reduced coinsurance payments, which lowers the overall program payments. However, the increase in visits partially offsets the decrease, showing that higher utilization can raise program costs even when coinsurance contributions are lower.

5.2.3. Scenario_3 <- Simulate_Program_Payments (0.05, -0.10) 5% Increase in Coinsurance, 10% Decrease in Visits

Scenario 3 (5% Increase in Coinsurance Payments, 10% Decrease in Visits):

The estimated total program payments are 1,172,120,498. Here, the increase in coinsurance payments raises the total program payments, but the decrease in visits (utilization) helps mitigate the overall cost, indicating that less frequent utilization could help in managing program expenses even when coinsurance costs rise.

Table 7. *Simulation Table.*

Scenario	Coinsurance ($)	Total Visits	Average Total Program Payments ($)
Average coinsurance	157,473,878,282.00	—	646,658,585,258.00
Scenario 1 (+10%) – 0% change in visits	173,221,266,110.20	2,431,047,313.00	646,658,585,258.00
Scenario 2 (-5%) coinsurance	141,726,490,453.80	2,674,152,044.30	711,324,443,783.80
Scenario 3 (+5%) & 5% visit decline	165,347,572,196.10	2,187,942,581.70	581,992,726,732.20

Average Coinsurance: 297182817
New Coinsurance: 312041958
Average Visits: 8.378627
New Visits: 7.540765

Scenario 1: 10% Increase in Coinsurance Payments, No Change in Visits

1218154310

Scenario 2: 5% Decrease in Coinsurance Payments, 10% Increase in Visits

1011582729

Scenario 3: 5% Increase in Coinsurance Payments, 10% Decrease in Visits
1172120498

6. Recommendation/Conclusion

1) Increase Cost-Effectiveness by Managing Utilization: Encourage preventive care or efficient care management to reduce high-frequency visits, which could help reduce total program payments without compromising beneficiary health outcomes.
2) Adjust Coinsurance Rates to Control Program Costs: Carefully balancing coinsurance rates can manage total program payments effectively. Lowering coinsurance could reduce individual financial burdens, but this might increase overall program payments if it drives higher utilization.
3) Scenario Planning for Policy Adjustments: Use these scenarios to help policymakers understand the impact of different changes to cost-sharing and utilization management strategies, enabling data-driven decisions for sustainable program funding.

While this analysis provides valuable insights into Medicare utilization and payment dynamics, it is not exhaustive. The findings are limited by the scope of available data and the focus on select cost and utilization indicators. Future research could expand this work by incorporating additional variables such as regional healthcare access disparities, demographic influences, and provider-level performance metrics. Such expanded studies would provide a broader and more comprehensive understanding of the structural and financial dimensions shaping the U.S. healthcare system.

Abbreviations

AIC	Akaike Information Criterion
AICc	Corrected Akaike Information Criterion
ARIMA	Autoregressive Integrated Moving Average
BIC	Bayesian Information Criterion
CMS	Centers for Medicare & Medicaid Services
ETS	Exponential Smoothing State Space Model
HHS	U.S. Department of Health and Human Services
IQR	Interquartile Range
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MASE	Mean Absolute Scaled Error
ME	Mean Error
MPE	Mean Percentage Error
Part B	Medicare Part B (Medical Insurance)
RMSE	Root Mean Square Error
R^2	Coefficient of Determination
SD	Standard Deviation

Conflicts of Interest

The authors declare no conflicts of interest.

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