Identifying high cost patients in managed care: An application of fractal mathematics

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BACKGROUND

Why did we conduct this study?

An editorial published by Fairman & Rucker in May 2009 in the Journal of Managed Care Pharmacy (JMCP) introduces the concept of fractal mathematics[1] to the managed care audience and suggests the application of fractal mathematics to predict high cost beneficiaries.

The Need for a Proof of Concept in Health Care Expenditures

In the four years since publication of the Fairman & Rucker (2009) article, no efforts to apply fractal mathematics to predicting health care expenditures could be identified in the literature.

What is Fractal Mathematics?

•The concept of fractal mathematics has been applied in various disciplines since Benoit Mandelbrot introduced it in the late 1970s. Mandelbrot explained that fractals are characterized by self-similarity, which is the tendency to form patterns that repeat over many orders of magnitude[2].

•Fractals are complicated geometric structures that observe the property of self-similarity. An object is said to display self-similarity "if it breaks down into smaller copies of itself"[3]. When Mandelbrot introduced the concept he demonstrated presence of fractals in naturally occurring shapes such as land mass, mountains, snow flakes etc.

•In the years since then, fractal mathematics has been applied in meteorology, soil sciences, geometry, and cartography among several other fields.

•In health care expenditure data, it is hypothesized that there is an 'inflection point' in the relationship between annual expenditure and frequency, indicating a significant and sudden change in the characteristics high and low cost patients. This holds the potential to lead to better understanding and prediction of health care costs[1].

OBJECTIVES

The primary objectives of this study were to utilize concepts from fractal mathematics to explain health care expenditures and to identify high cost and low cost patients using the administrative claims data.

METHODS

Data source

This study used the Mississippi Medicaid fee-for-service (FFS) claims data from January 1st 2008 to December 31st 2012. All dual-eligibles were excluded from the study.

Methods

The method described by Fairman & Rucker (2009) was applied to this data. Costs incurred across the study period were pooled for each beneficiary and then the log of the cumulative number of beneficiaries was plotted against the log costs. Costs were rounded off to the nearest $1000 to aid in interpretation and to better observe an inflection point that separates low and high cost beneficiaries. Graphs were also plotted for each of the individual years in the dataset to look for repetitions in the patterns found.

Analysis

Once the inflection point was identified, the beneficiaries with an annual cost above and below the inflection point were compared on their demographics using t-tests or Chi square tests, where appropriate. Both pharmacy and outpatient medical costs were included in the analysis. Inpatient medical costs were unavailable at the time of the study.

RESULTS

The graph plotted for each successive year from 2008 to 2012 and the graph plotted for overall data ranging all five years showed a similar pattern to the one shown in Figure 1 (2011).

RESULTS

The slope of the line appears to be gradual until an 'inflection point' is reached and then the line becomes steep. In the 2011 data, the inflection point was found to lie around $68,000 per year. While the exact position of this point varied from year to year, for the combined 5 years of data, the pattern was similar.

Figure 1: Graph showing distribution of log costs versus log cumulative frequencies for 2011

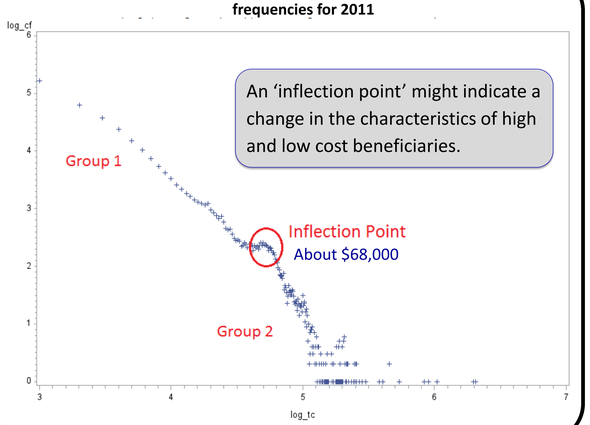

Table 1: Comparison of demographics among high and low cost groups

VARIABLE	GROUP 1 (Low cost)	GROUP 2 (High Cost)
	N = 835,604 (99.59)	N = 3,448 (0.41)
Age Mean±SD (in years)	22.4±21.8	50.2±21.9
RACE (p < 0.0001)	N (%)	N (%)
Caucasian	311,175 (37.24)	1,786 (51.8)
Hispanic	20,253 (2.42)	8 (0.23)
African American	467,998 (56.01)	1,494 (43.33)
GENDER (p < 0.0001)	N (%)	N (%)
Female	507,718 (60.51)	1,681 (48.75)

RESULTS

Table 2: Mean expenditure incurred in each group of patients

COST	GROUP 1 (Low cost group)		GROUP 2 (High cost group)	
	Mean	*Std Dev*	*Mean*	*Std Dev*
Pharmacy Costs ($)	11,715	26,731	359,224	275,793
Outpatient Costs ($)	1,762	5,615	43,231	288,433
Total Cost ($)	**9,953**	**25,327**	**315,993**	**95,207**

CONCLUSIONS

- The application of fractal mathematics in the field of managed care is a still in its infancy.
- The results from this study seem to convey both positive and negative aspects of the use of fractal mathematics.
- The similar pattern of results seen across multiple years (not shown) is encouraging and points towards the need for further research.

Take Away Point

Fractal mathematics has been used in more physics-driven disciplines such as soil physics, meteorology and rock mechanics. Health care does not follow known universal laws as the physical sciences.

REFERENCES

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