Chapter 13
Relationship Between Health Outcomes and Health Factors: Analysis of 2016 Data in the Pacific Northwest Robert Wood Johnson Foundation *County Health Rankings and Roadmaps*

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13.1 Introduction

A half century ago, an anomalously low incidence of cardiovascular disease in Roseto, PA, prompted a series of articles attempting to uncover the possible cause [1, 2]. Ultimately, it was understood that previously ignored elements of social support and a sense of community were the most likely cause of this improved Health Outcome [3]. When societal changes lessened the impact of these social support structures, the improvement in Health Outcome evaporated [4].

This story sets the stage for a number of questions. How do we improve Health Outcomes? The answer is not trivial. In the years 2010–2016, the Center for Medicare and Medicaid Innovation has spent $6.5 billion exploring new models of payment to improve quality [5]. Have *Health Outcomes* actually improved as a result of this expenditure of resources? Some have, and some have not. Has the improvement been worth the expenditure? How do we know? How do we measure it? These are timely, important and, in many ways, yet unanswered questions.

We have developed computational methods to explore these questions which have been described in detail elsewhere (R.S. Gonnering, W. Wiley, K. Love, The relationship between health outcomes and health factors: analysis of the 2016 Arizona data, Robert Wood Johnson Foundation *County Health Rankings and Roadmaps*, unpublished manuscript). For this report, we will concentrate on the

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relationships between Health Factors and Health Outcomes in the Pacific Northwest. We wanted to explore this question: **Are better Health Factors automatically associated with better Health Outcomes?**

13.2 County Health Rankings and Roadmaps

The *RWJF County Health Rankings and Roadmaps* compiles data on *Health Outcomes* and *Health Factors* from virtually all of the counties in the United States. The *Health Outcomes Data* consists of data on *Length of Life* and *Quality of Life*, both given equal weight. The *Health Factors Data* are broken down into four main categories (Fig. 13.1):

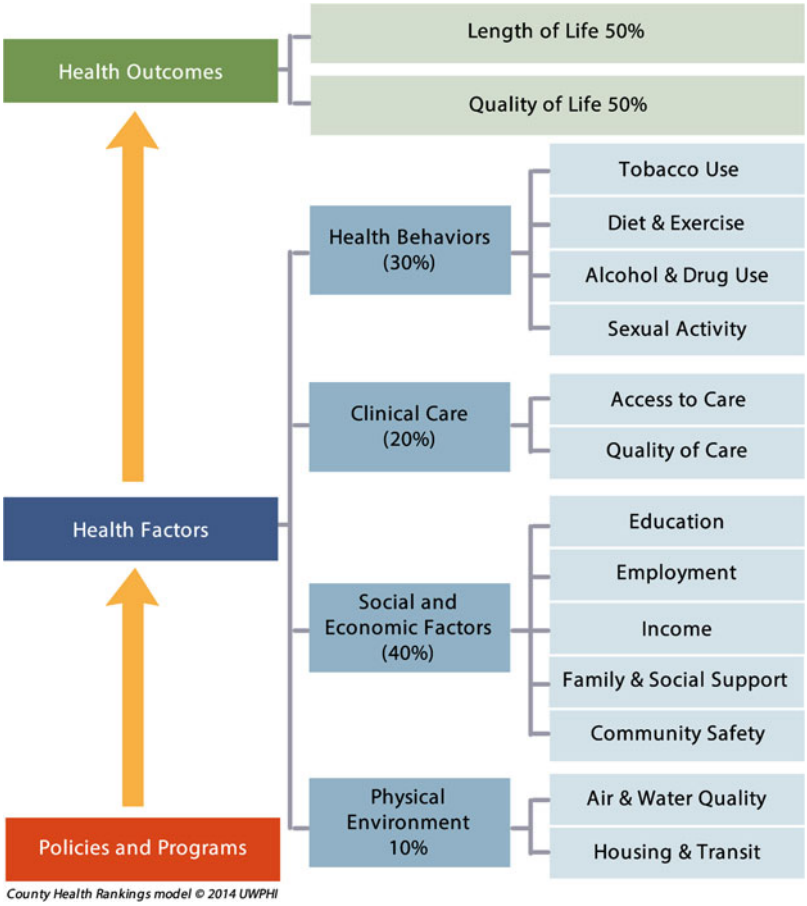

Fig. 13.1 County health rankings
http://www.countyhealthrankings.org/our-approach; Used with permission

- Social and economic factors (40%),
- Health behaviors (30%),
- Clinical care (20%)
- Physical environment (10%).

Each of the *Outcomes* and *Factors* is comprised of a number of subfactors listed on the website. While some subfactors are negative and others positive, the values are standardized so that a higher rank in each category indicates a better result. Within each state each county is ranked according to its *Health Outcome* and *Health Factors* taken as an aggregate as well as broken down into its main components. Ranking is given as to standing in the state as well as to the *Z*-score.[1] The rationale for assigning weights to the ranking data in the report is contained within the working paper of the University of Wisconsin Population Health Institute [6].

Our first observation is that there is a disconnect between the rankings of *Health Factors* and *Health Outcomes* for a number of counties in Washington, Oregon, Idaho, Wyoming, and Montana. The counties with a positive number had Health Outcomes better than would be expected by their *Health Factors*. Those with a negative number had *Health Outcomes* worse than expected. Those with a number close to zero had *Health Outcomes* expected by their *Health Factors* (Fig. 13.2).

However, the disconnection in the rankings gives only part of the picture. To explore the magnitude of the disconnection, we compared the *Z*-score of *Health Factors* and the *Z*-score of *Health Outcomes* (Fig. 13.3).

Interestingly enough, when grouped with the counties with the best *Health Outcomes* to the left, no pattern is identified (Fig. 13.4).

These graphs give a much more interesting picture of the relationships between *Health Outcomes* and *Health Factors*. The counties to the left of each graph show *Health Outcomes* better than expected from the *Health Factors*, while those to the right have worse *Health Outcomes*. The magnitude is given by the distance from the zero line. In general, counties that ranked higher in *Health Outcomes* also had *Health Outcomes* better than expected. However, there are notable exceptions, particularly in Montana.

In looking at the relationships between *Health Outcomes* and *Health Factors*, a binomial model was found to give the best fit (Fig. 13.5).

This binomial relationship between *Health Outcomes* and *Health Factors* appears to hold true for every state, with an R^2 varying between 0.45 for Idaho and 1.0 for Delaware and Hawaii (Fig. 13.6).

This binomial formula

$$Factors = a(Outcomes)^2 + b(Outcomes) + c \tag{13.1}$$

with differing constants a, b, and c for each state forms a "signature" representing the relationship between *Health Outcomes* and aggregate *Health Factors*. This signature is fairly consistent and relatively unique over time for each state. The

[1]The *Z*-score indicates how many standard deviations an element is from the mean.

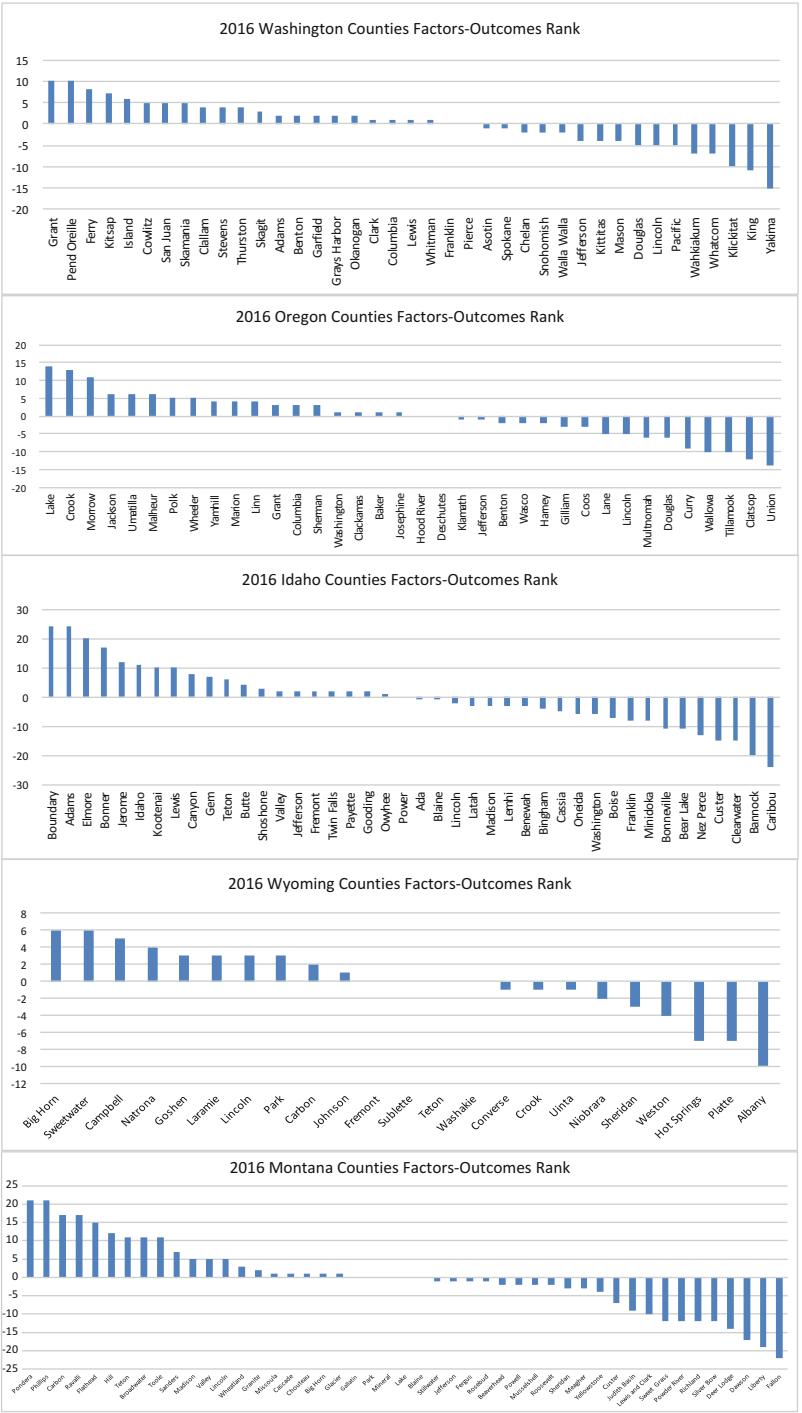

Fig. 13.2 Counties factors-outcomes ranks

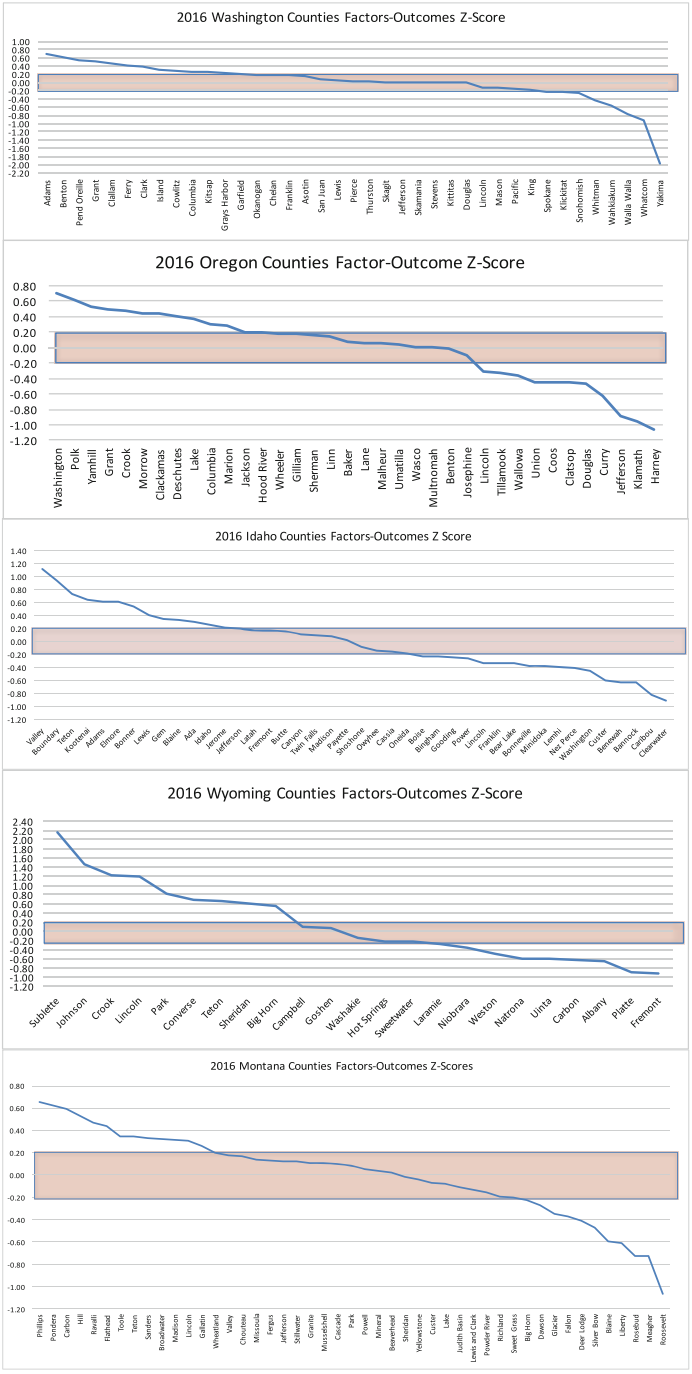

Fig. 13.3 Counties factors-outcomes *Z*-scores

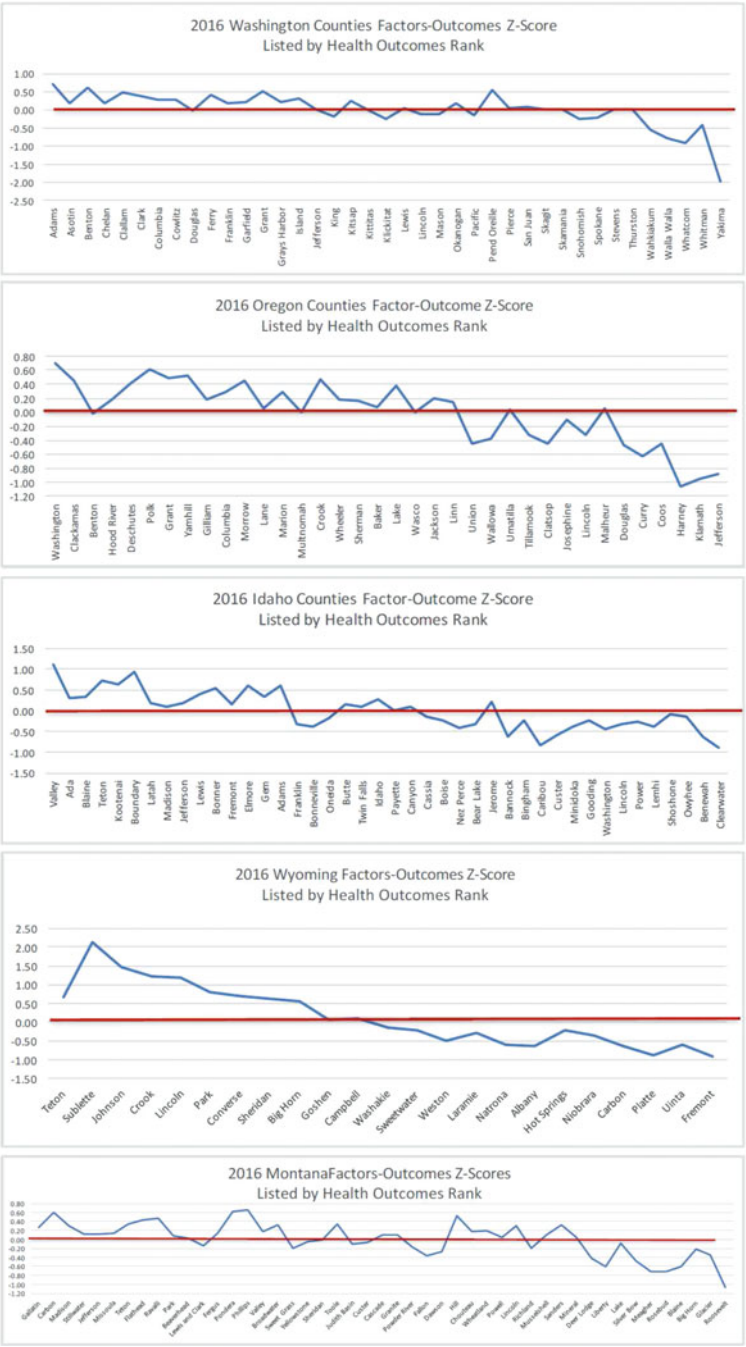

Fig. 13.4 Counties factors-outcomes *Z*-scores, listed by health outcomes rank

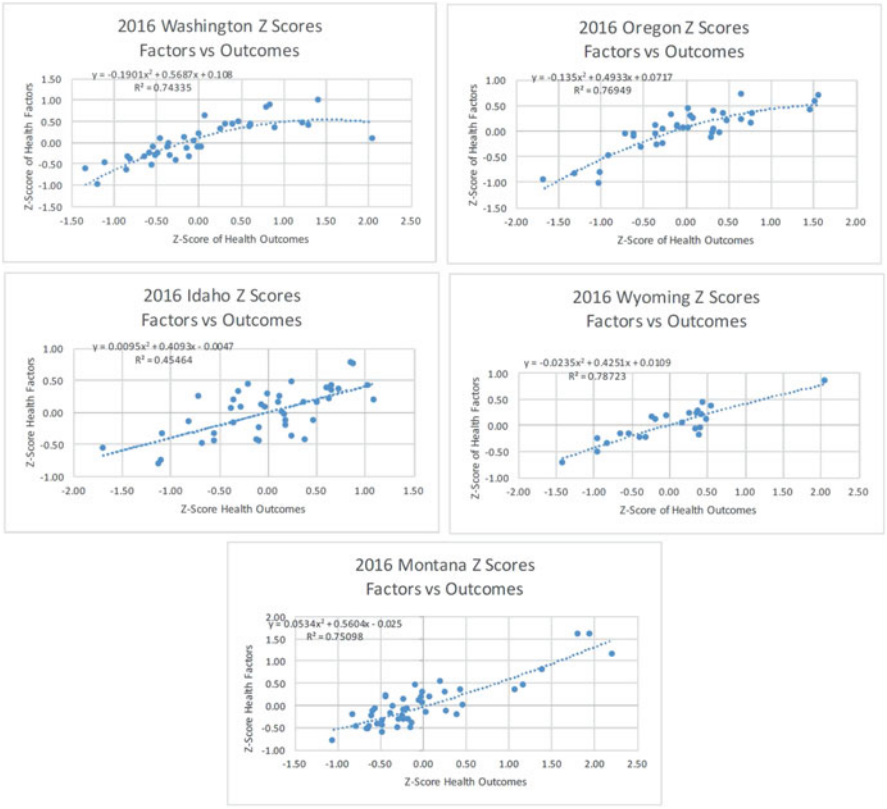

Fig. 13.5 *Z*-scores, factors vs outcomes

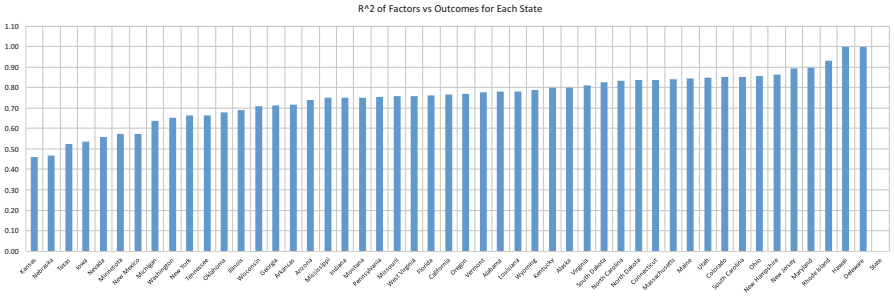

Fig. 13.6 Binominal relationship between health outcomes and health factors across all US states

state signature is further modified in each county, with a further adjustment of the impact of *Health Factors* on *Health Outcomes*. This is consistent with the initial figure showing the varying relative disconnect between *Health Factors* and *Health Outcomes*.

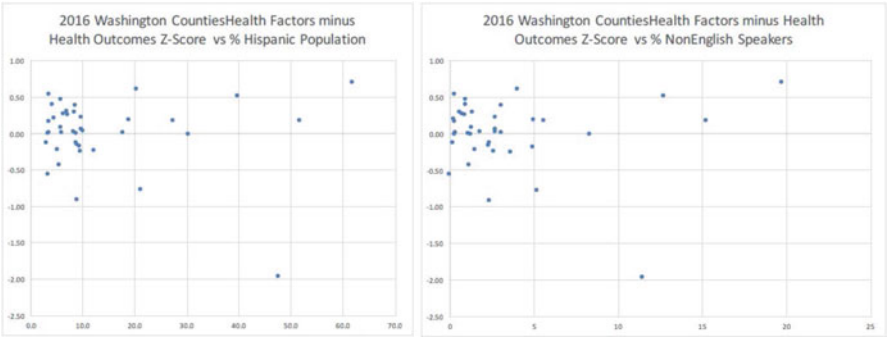

Fig. 13.7 "Hispanic Paradox"

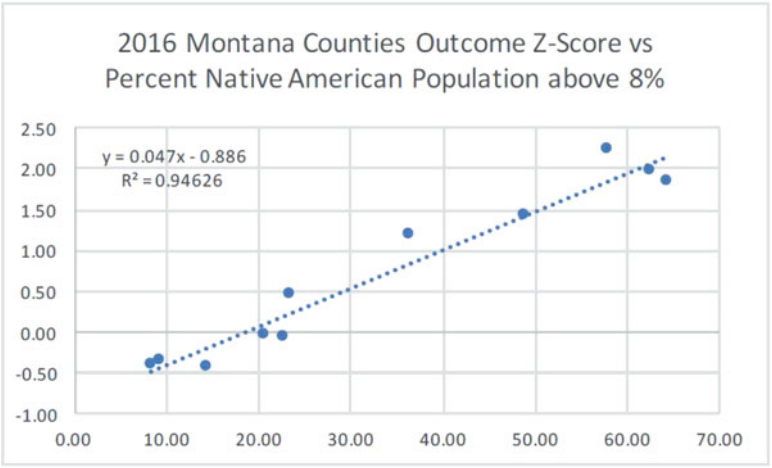

Fig. 13.8 Native American population

In some states, particularly in the Southwest, an "Hispanic Paradox" is seen, with *Health Outcomes* better than would otherwise be expected [7]. In the Pacific Northwest, this was seen only in Washington when the percent Hispanic population was above 28% and percent of non-English speakers above 13% (Fig. 13.7).

In Montana, the situation with counties with predominantly Native American populations showed the reverse. In counties with greater than 8% Native American population, there was a linear negative correlation with *Health Outcomes* (Fig. 13.8).

Finally, examination of this graph of the *Z*-scores of *Health Factors* versus *Health Outcomes* for Montana is most instructive (Fig. 13.9).

Liberty county has significantly better *Health Factors* than Pondera, yet has significantly worse *Health Outcomes*. "Something else" is retarding the expression of these positive factors. Just as in Roseto, that something else defied the medical

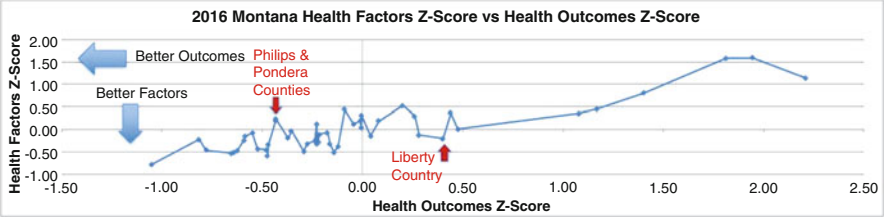

Fig. 13.9 Liberty County Anomaly

logic of the time, so too other elements are at play in understanding the data contained in the RWJF County Health Rankings. The challenge will be in finding them.

13.3 Conclusions

The relationship of *Health Factors* and *Health Outcomes* is nonlinear and complex. The data compiled in the RWJF study on County Health Rankings is a landmark beginning for investigations into what constitutes "health." While it is true that in order to improve the health of a community, improving all aspects of health (health behaviors, clinical care, social and economic factors, and physical environment) will be helpful, it is equally clear that some efforts will be more productive than others. In a situation of limited resources, it is imperative that those resources be utilized wisely so the maximum improvement for the maximum population will be possible. This analysis points out this is not always intuitive.

For example, a mild "Hispanic Paradox" is seen in Washington when the Hispanic population is greater than 28% and the population or non-English speakers is greater than 13%. In Montana, strongly negative Health Outcomes are seen in counties with a Native American population greater than 8% ($R^2 = 0.93883$).

13.4 Recommendations

- In Montana, efforts should be directed toward improving *Health Factors*, such as increasing healthy behaviors like reducing obesity, increasing physical activity, and smoking cessation, especially in counties with a high percentage of Native Americans.
- In Oregon and Wyoming, such an effort in improving *Health Factors* will be most successful in those counties which already have high Health Outcomes. They exhibit *positive returns*.

- In Washington and Idaho, the use of *positive deviance* could identify possible other factors that improve *Health Outcomes* in those counties in which the *Health Outcomes* are better than expected.

The Journey

This paper represents a way-stop on my own intellectual journey through Systems and Complexity Sciences for Healthcare. When I first learned of the concept of "complexity," I immediately attempted to apply that to health care. At least in my own experience, that was a mistake. I was applying my reductionist training to something that was the antithesis of reductionism. It was only after I investigated "complexity" in its totality that I was able to understand how it could be applied to my own experiences in health care. I am sure one is able to utilize the concepts of complexity science in isolation and concentrate on how they relate to the set of circumstances in health care. I am not able to do that. I need to be a "lumper" rather than a "splitter." I see health care as a seat at the larger table of complexity science, rather than a separate table by itself.

In *The Nature of Technology*, W. Brian Arthur makes the case that revolutionary jumps forward are often due to the combination of existing technologies and ideas in novel ways [8]. The "Pumps and Pipes" conferences in Houston bring together cardiovascular physicians, petroleum engineers, and aerospace scientists to discuss what actually are common problems from different perspectives. One of the organizers, Alan Lumsden, Chief of Cardiovascular Surgery at Houston Methodist Heart and Vascular Center, states "the answer to your problem is probably in the other guy's toolkit. The challenge is finding it" [9]. For my own journey, it is essential to interact with individuals outside of the health-care arena. I need to understand what is in their toolkit.

Take-Home Message
The relationship between *Health Factors* and *Health Outcomes* is ***complex*** and follow ***nonlinear dynamics***. Understanding this is necessary to improve health disparities.

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