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**The Impact of a Potential Universal Single Payer Healthcare Finance System
on Pennsylvania Hospital Revenues**

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Abstract

The U.S. healthcare system is being constantly reformed. One popular policy proposal to overhaul the current healthcare system is to universally cover individuals under a single payer system of healthcare finance. Commonly known as “Medicare for All,” this proposal is a substantial departure from the structure of the current American healthcare finance system; it requires the elimination of all private payers in favor of a single public payer. This study focuses specifically on determining the impact of universal single payer on Pennsylvania acute care hospital net patient revenue (NPR). Three research questions are explored in this investigation:

- What are the primary causal pathways of the implementation of universal single payer on Pennsylvania acute care hospital NPR?
- Assuming current Medicare payment rates and no change in hospital service utilization patterns, what changes in NPR would we expect for Pennsylvania hospitals after establishment of universal single payer?
- Assuming current Medicare payment rates and no change in hospital service utilization patterns, would changes in hospital NPR differ by county-level indicators of health determinants?

This study first explores the potential impact of universal single payer on hospital NPR on a conceptual level, conducting a literature review and constructing a conceptual framework in the form of a Directed Acyclic Graph. Then, a quantitative analysis is conducted on current Pennsylvania hospitals to determine the precise impact that such a system would have. Data from the 2019 Pennsylvania Health Care Cost Containment Council (PHC4) Financial Analysis, 2019 Centers for Medicare and Medicaid Services (CMS) Inpatient Prospective Payment System

(IPPS) Proposed Rule Impact data, and 2018 County Health Rankings data were used to estimate the change in Pennsylvania hospital NPR associated with a shift from a mix of public and private payers to a single payer, based on the single payer adopting current Medicare payment rates and assuming that hospital service utilization does not change. These calculations are done using a generalized additive model (GAM) regression. Further, this study investigates whether those changes in revenues systematically differ based on demographics of the areas in which hospitals are located. This is followed and concluded with a discussion of what these results mean for the future of health policy and administration. Answering these questions will provide guidance to policy makers, hospital executives, and advocates.

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Chapter 1: Introduction

Motivation

The United States (U.S.) spends nearly twice as much on health care as a share of the economy when compared to other high-income countries (“U.S. Health Care, 2019). The World Health Organization ranks the U.S. healthcare system as #37 amongst 191 ranked countries (Tandon et al. 18). Still, the U.S. has the lowest life expectancy, highest suicide rates, highest rates of chronic disease and obesity, highest number of hospitalizations from preventable causes, and highest rate of avoidable death among OECD countries (“U.S. Health Care”, 2019). This contrast – between high spending and relatively poor outcomes – has been a controversial phenomenon among health policy researchers. There are certainly diverse viewpoints on the causes, and even more so, the solutions to the problems that the U.S. healthcare system faces. Despite the broad range of suggested causes and solutions to the U.S. healthcare system, one thing remains clear: the U.S. healthcare system has demonstrated a great need for reform.

Among these diverse viewpoints, some advocate for a fundamental structural change to the U.S. healthcare finance system in the form of a universal coverage under universal single payer. Commonly referred to as Medicare for All, this policy concept has garnered around 69% support from registered voters in a recent poll (Schulte, 2020). Two Medicare for All bills have been introduced in the 116th Congress by Representative Pramila Jayapal and Senator Bernie Sanders respectively: H.R. 1384 in the House of Representatives and S. 1129 in the U.S. Senate. Over 100 cosponsors in both the House of Representative and the Senate exist for these two pieces of legislation (Sanders, 2019). Regardless of different political opinions regarding this proposal, it is important to conceptually and empirically analyze the impacts of this bill simply

due to the popularity the concept has gained over the last several years. Doing so will provide additional information for policy analysts to advise politicians, health administrators, and advocates on the potential effects of the legislation.

Universal Single Payer of Healthcare Finance

In the context of this study, a universal single payer healthcare finance system (“universal single payer”) can be defined as one that covers all individuals (universal coverage) under a single public payer, in this case, Medicare. This also goes hand in hand with the elimination of all private insurance options along with most other public insurance options, such as Medicaid. The single public payer, Medicare, will be charged with determining reimbursement rates and fulfilling reimbursement for nearly all healthcare in the U.S. The Sanders-Jayapal bill would replace most programs established under the Affordable Care Act. Under the bill, cost-sharing would be eliminated entirely, and coverage would be broad, covering both acute and long-term care (Sanders, 2019).

Though this study specifically analyzes the federal Sanders-Jayapal Medicare for All proposal, it is important to note that other similar policy proposals have been proposed on the state level. One such example is the New York Health Act (NYHA) that would create a state Medicare-like system that would cover all residents of New York State (Hammond and Pope). This proposal is also characterized by the elimination of private health insurance plans and most other public insurance options, though these policies would of course be limited to New York State.

Purpose and Research Questions

This study focuses on potential impacts of universal single payer on Pennsylvania hospital NPR. Because of the complex nature of this relationship, a conceptual framework was first constructed in the form of a Directed Acyclic Graph to describe the qualitative causal relationship between factors universal single payer likely to affect hospital NPR (Greenland, Pearl, and Robins, 1999). Then, assuming current Medicare payment rates and no change in hospital service utilization patterns, a quantitative analysis was conducted using a generalized additive model (GAM) regression to estimate the possible impact of universal single payer on Pennsylvania hospital NPR. This study proposes the following research questions:

- What are the primary causal pathways of the implementation of universal single payer on Pennsylvania acute care hospital NPR?
- Assuming current Medicare payment rates and no change in hospital service utilization patterns, what changes in NPR would we expect for Pennsylvania hospitals after establishment of universal single payer?
- Assuming current Medicare payment rates and no change in hospital service utilization patterns, would changes in hospital NPR differ by county-level indicators of health determinants?

Using these research questions, it will be possible to estimate the impact of universal single payer on Pennsylvania acute care hospital NPR. Based on prior research (as discussed in Chapter 2) and assuming current Medicare payment rates along with no change in hospital service utilization patterns, it is hypothesized that Pennsylvania hospital net revenues would most likely decrease overall. It is hypothesized that this decrease will be seen most prominently with urban hospitals, richer areas, and specialty centers.

Chapter 2: Literature Review and Conceptual Framework

Methods of Literature Review

The two databases that were used to conduct this search were the PSU Libraries engine and PubMed. PSU Libraries, in particular, is quite useful as it conducts a thorough search among several databases that are accessible to Penn State students. PubMed was primarily used to double-check the search results of the PSU Libraries search. The primary search terms utilized included “hospital revenue”, “single-payer”, “Medicare for All”, and “Medicaid expansion”.

In terms of inclusion criteria, it was decided to narrow the search to include results only after 2000. Because of the constantly and rapidly developing healthcare market, it is important to include the most recent studies possible. Studies of particular interest are studies after 2010 that concentrate on the effects of Medicaid expansion in states which adopted such policy and studies that contemplate the implementation of a single-payer healthcare system, such as that of which is demonstrated in several European countries, on the finances of U.S. hospitals at a microeconomic level.

Identifying existing modelling techniques that aim to predict the financial impacts of hospitals due to Medicare expansion and increased regulation is also of key importance. The relationship between Medicare and the financial impact on hospitals is critical in exploring this in further detail on a microeconomic level. Qualitative relationship and case studies are also important in developing a conceptual framework regarding the interplay of a government payer, hospitals, and patients.

This initial search provided between 5,000 and 10,000 search results. Because of the large number of results, papers were selectively chosen to be included in the literature review based on importance, scope, impact, methodological integrity, and relevance to the topic at hand.

Review of Literature

Table 1: Literature Review Summary

Article Title	Year Published	Author(s)	Key Findings
Association Between the 2014 Medicaid Expansion and US Hospital Finances	2016	Fredric Blavin	Hospitals located in 19 states that implemented Medicaid expansion experienced increased Medicaid revenue and a decrease in uncompensated care costs compared to the hospitals located in 25 states that did not implement Medicaid expansion.
Understanding the Relationship Between Medicaid Expansions And Hospital Closures	2018	Richard C. Lindrooth, et al.	Medicaid expansion under the Affordable Care Act was associated with improved hospital financial performance and lower likelihood for closure, especially in areas with a high population of uninsured individuals, such as rural areas.
Uncompensated Care Decreased at Hospitals In Medicaid Expansion States But Not At Hospitals In Nonexpansion States	2018	David Dranove, et al.	Uncompensated care costs decreased from 4.1% to 3.1% of operating costs in Medicaid expansion states.
Hospitals' Negotiating Leverage with Health Plans: How and Why Has It Changed?	2003	Kelly J. Devers, et al.	Managed care plans in the late 1990s were associated with increased hospital negotiating leverage and subsequent increased hospital reimbursement. This is also associated with higher premiums.
Competition in Health Care Markets	2011	Martin Gaynor, Robert J. Town	This book chapter discusses the literature on health care services and health insurance.
The Increased Concentration of Health Plan Markets Can Benefit Consumers Through Lower Hospital Prices	2011	Glenn Melnick, et al.	Several findings are included in this paper. Firstly, broadly speaking, hospital market concentration exceeds health insurance plan market concentration. Secondly, greater hospital market concentration contributes to higher hospital prices. Thirdly and most importantly, concentrated health insurance plan markets can benefit consumers through lower hospital prices.
Maryland Exceptionalism? All-Payers Regulation and Health Care System Efficiency	2012	Mark Pauly, Robert Town	This journal article reviews the effectiveness of Maryland's all-payer health system.
Market Share Matters: Evidence Of Insurer And Provider Bargaining Over Prices.	2017	Eric T. Roberts, et al.	Results suggest that health insurer mergers can lower reimbursement to providers due to increased bargaining power.

Managed care's price bargaining with hospitals	2009	Vivian Y. Wu	Health insurance plans that have more subscribers and are more successful at channeling patients are able to extract high price discounts.
Medicare Payment and Hospital Provision of Outpatient Care to the Uninsured	2016	Daifeng He, Jennifer M. Mellor	A decrease in Medicare payment rates is associated with a decrease in uninsured outpatient visits at nonprofit hospitals an increase in uninsured outpatient visits at for-profit hospitals.
Countervailing Market Power and Hospital Competition	2020	Eric Barrette, et al.	Hospital mergers raise hospital prices more in areas with lesser health insurance plan concentration
The Sanders Single-Payer Health Care Plan	2016	John Holahan, et al.	A comprehensive overview on the Sanders-Jayapal Medicare for All legislation with estimates on total insurance coverage, national health expenditures, and more.
The Impact of Single-Payer on New York Hospitals	2018	Bill Hammond, Chris Pope	The implementation of the New York Health Act would decrease New York hospital revenues.
Associations between multimorbidity, healthcare utilisation and health status: evidence from 16 European countries	2016	Raffaele Palladino, et al.	Among persons aged 50 and older from 16 European nations, it was found that number of chronic conditions was positively associated with health care utilization.
Billing and insurance-related administrative costs in United States? health care: synthesis of microcosting evidence	2014	Aliya Jiwani, et al.	In 2012, billing and insurance related costs to the U.S. healthcare system totaled \$471 billion, 80% of which represents added costs of the current multi-payer system.
Contrary to Cost-Shift Theory, Lower Medicare Hospital Payment Rates For Inpatient Care Lead To Lower Private Payment Rates	2013	Chapin White	A 10% reduction in Medicare payment rates will lead to a 3% to 8% decrease in private payment rates, which is contrary to the cost-shifting view of reimbursement.
In the Shadow of a Giant: Medicare's Influence on Private Physician Payments	2016	Jeffrey Clemens, Joshua D. Gottlieb	An increase in Medicare's payment rates will lead to an increase in private payment rates. The influence that Medicare payment rates have on private payment rates will impact physicians, especially in regards to specialty choice.
Public and Private Health Insurance Premiums: How Do they Affect the Health Insurance Status of Low-Income Childless Adults?	2012	Gery P. Guy Jr., et al.	Higher public and private premiums lead to a greater number of uninsured low-income children. Subsidization of premiums leads to lower rates of uninsurance.

Readmission Rates After Passage of the Hospital Readmissions Reduction Program	2018	Jason H. Wasfy, et al.	The Hospital Readmissions Reduction Program resulted in a decrease in hospital readmissions, especially among those hospitals which were poor performers prior to the implementation of the policy.
The Growing Difference Between Public and Private Payment Rates For Inpatient Hospital Care	2015	Selden, et al.	There is a growing gap between public and private payment rates for inpatient hospital care. In 2012, this gap was 75.3%.
Unintended Consequences of Health Care Reform : Impact of Changes in Payor Mix on Patient Safety Indicators	2020	Alex J. Bartholomew, et al.	Medicaid expansion resulted in an overall improvement in patient safety. However, increased safety events occurred in those hospitals which have the greatest change in safety-net burden.

Literature Review Summary

A few key takeaways are important to note from the literature selected above. In this subsection, a brief overview of the relevant literature will be given in the context of this investigation. Topics of interest include hospital reimbursement rates, insurance market and hospital market competition, and uncompensated care. Various model papers will also be discussed in this subsection.

Under a universal single payer healthcare finance system, Medicare reimbursement levels are of key concern. To analyze this aspect of universal single payer, it is important to investigate the current circumstances with reimbursement levels first. In summary, the literature suggests a substantial gap between the reimbursement levels of Medicare and the reimbursement levels of private insurance. This gap has been growing substantially over time. In 1995, the average private payment per discharge was 45% higher than the average Medicare payment per discharge. In 2012, this gap increased to 75.3% (White, 2013; Selden et al., 2015).

Prior research has demonstrated that the popular cost-shift theory to explain the gap between private and Medicare reimbursement levels may not be entirely accurate. Under the cost-shift theory, it is believed that decreases in Medicare reimbursement rates result in an increase in private reimbursement rates, largely as a response to the financial demand from hospitals. However, two studies included in the literature review above suggest that Medicare payment rates are more likely to influence private payment rates in the same direction (Clemens 39; White, 2013). Specifically, as Medicare payment rates decrease, private payment rates will decrease and vice versa. The literature is clear in that Medicare acts to heavily influence prices in the private health insurance market and that the cost-shift theory is largely invalid (Frakt, 2014).

With the topic of universal single payer, it is also valuable to examine literature on hospital market and insurance market competition. The literature suggests that greater health insurance plan concentration can benefit consumers through lower hospital prices (Melnick, 2011). This is because fewer payers increases the bargaining power of purchasers, decreasing hospital prices. Secondly, health insurance mergers are associated with lower premiums and lower hospital reimbursements (Roberts, 2017). Thirdly, health insurance plans that are large and effective at channeling patients can extract higher price discounts through increased leverage (Wu, 2009).

Regarding hospital market competition, the literature suggests that hospital market concentration exceeds health insurance plan concentration in most markets (Melnick, 2011). Furthermore, greater hospital market concentration contributes to higher hospital prices (Melnick, 2011). Thirdly, hospital mergers raise hospital prices more in areas with a lower concentration of health insurance plans (Barrette 38).

The above key takeaways from the literature on hospital market and insurance market competition provided valuable insight when developing the conceptual framework discussed in the following subsection. On a conceptual level, under universal single payer, insurance market competition would be largely eliminated. As stated previously, the literature suggests that payers that are effective at channeling patients at high volume will allow for lower premiums and lower hospital reimbursements due to the increased bargaining power of the payer (Roberts, 2017). All else equal, the same concept would apply to universal single payer. Specifically, it is expected that a single payer would maximize buyer market power and would result in the lowest prices that still keep the provider in business (Chown et al., 2019).

The relationship between hospital market concentration and universal single payer is more difficult to determine and is largely based on policy decisions that have not yet been finalized. For example, the literature suggests that hospital mergers raise hospital prices more in areas with a lower concentration of health insurance plans (Melnick, 2011; Barlette 38). Additionally, hospitals often merge in order to counteract a highly concentrated health insurance market. However, this logic may not apply to an entirely public universal system because the system that Medicare would use to set rates would likely be more consistent over geographic areas and would be more dependent on factors such as hospital performance ratings, case mix, local costs of labor / capital, and more.

The literature review conducted also includes research on Medicaid expansion under the Affordable Care Act. Examining this topic gives insight into how hospitals may respond to a shift in payer mix. A few key takeaways are as follows. Several studies indicate that a decrease in uncompensated care costs followed Medicaid expansion (Blavin, 2016; Lindrooth, 2018; Dranove, 2016). Additionally, Medicaid expansion is associated with improved hospital financial

performance due to increased Medicaid revenue and lower likelihood for closure for hospitals with a high population of uninsured individuals (Blavin, 2016; Lindrooth, 2018). In a universal single payer healthcare finance system such as the Sanders-Jayapal proposal, uncompensated care costs would be largely eliminated. This would likely have a measurably positive impact on hospital NPR.

Two studies in particular were closely examined due to their high relevance to this investigation. The first is the Manhattan Institute's study titled "The Impact of Single-Payer on New York Hospitals" by Bill Hammond and Chris Pope (Hammond and Pope, 2018). This study investigates the impact that the New York Health Act would potentially have on New York hospital revenue. The New York Health Act is quite similar to the Sanders-Jayapal proposal in that private insurance would be eliminated in New York, and coverage would be issued similar to Medicare in coverage and payment rates. The study indicates that a significant decrease in hospital revenues would result. Specifically, a decrease in hospital revenues of 17% would be seen statewide, impacting 77% of the state's hospitals. This decrease of revenue would be lessened if Medicare increases its reimbursement rates. The paper predicts that this immediate decrease in hospital revenue may put several New York hospitals at risk of closure. However, it is important to note that the quantitative portion of this study solely focuses on applying the Medicare discount proportion to hospitals. It does not consider long-term structural changes in cost, which are examined in greater detail on a conceptual level in this investigation. One final takeaway from this study is that the specific policy decisions made under any universal healthcare legislation is of vital importance in determining the future of hospital finances. The various Medicare discount proportions examined in this study produced widely different results

in the health of hospital finances. These policy decisions should be carefully considered by universal healthcare policymakers to ensure the financial health of hospitals.

The second study is the Urban Institute's study titled "The Sanders Single-Payer Health Care Plan" (Holahan et al. 39). This study is a comprehensive analysis on the overall impact that the Sanders-Jayapal legislation would have on national healthcare expenditures. In summary, the study finds that total national health expenditure would likely increase by \$518.9 billion or 16.9%. This investigation is quite detailed; though many details are beyond the scope of this study, the findings should be understood to properly evaluate the implementation of a universal single payer healthcare system.

Conceptual Framework

After a thorough literature review, a conceptual model was developed in the form of a Directed Acyclic Graph or DAG (Greenland, Pearl, and Robins, 1999). The creation of a DAG enables a visual and systematic representation of direct causal relationships between several different entities or variables.

The first step in developing the DAG was identifying the initial exposure variable, also referred to as the independent variable or treatment. In the case of this study, it is the implementation of universal single payer. Next, it is important to identify the final effect, also known as the dependent variable, endpoint, or final outcome. In the case of this study, it can be said that the final outcome is hospital NPR. After identifying the cause and effect of the entire relationship, several variables were identified using the prior literature review that mediate or moderate the relationship between a universal single payer healthcare system and hospital net revenues. These variables include the following: community characteristics, insurance market competition, hospital competition, negotiated private payment rates, public payment rates,

hospital gross patient charges, payer mix, patient insurance status, patient case mix, hospital cost, hospital quality, uncompensated care, and patient utilization. Following the identification of key variables, causal relationships between these variables and the independent / dependent variables were systematically identified using the literature review. The final conceptual model is shown below.

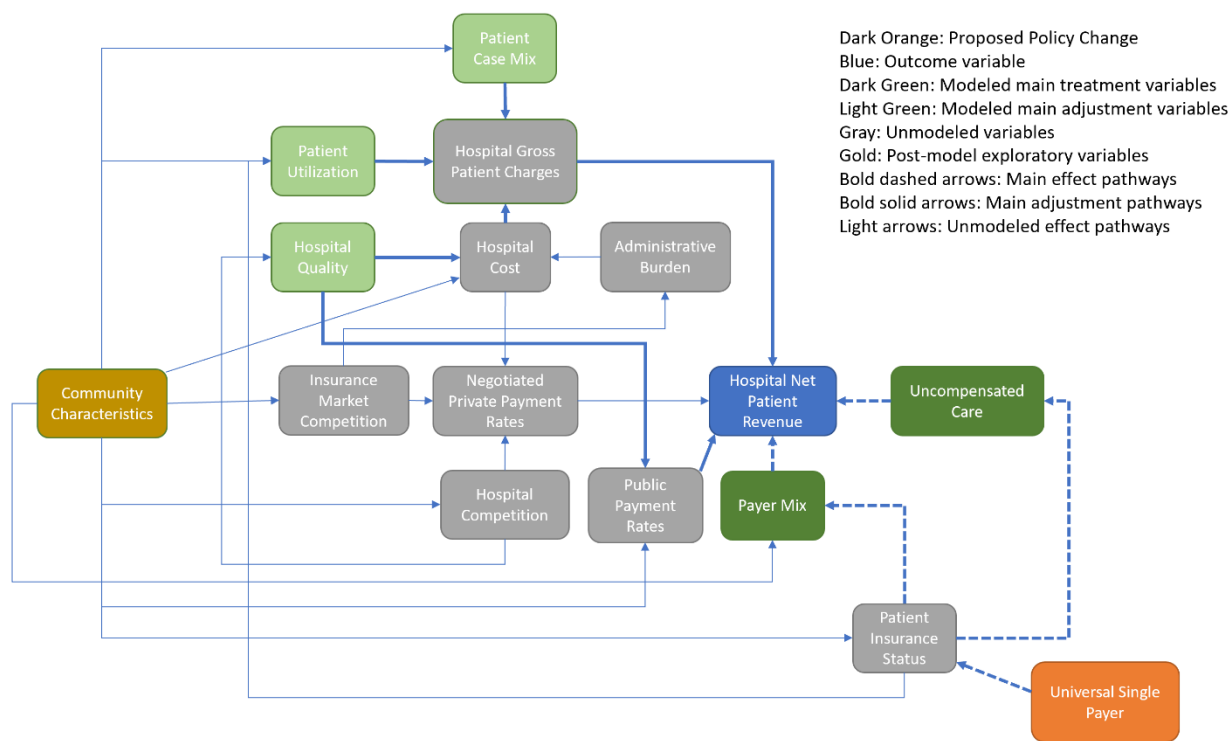


Figure 1: DAG conceptual framework describing the relationship between several key variables which determine hospital NPR. A color-coded key is included in the top right of the figure.

The conceptual framework in Figure 1 is coded with regards to the quantitative analysis conducted in this investigation. Two primary treatment variables were modeled: uncompensated care and payer mix. These two variables were selected due to their relatively large impact on hospital NPR due to a universal single payer healthcare system relative to other variables in the DAG. Another consideration is that these two variables can be quantitatively modeled using existing data. Both payer mix and uncompensated care are directly determined by patient insurance status. It is important to note that insurance status is not directly controlled for in quantitative analysis. Instead, proximate effects of insurance status are explored, including utilization, payer mix, and uncompensated care. These variables will be further modeled in quantitative analysis.

Five variables were used as adjustment variables: patient case mix, patient utilization, local labor costs, local capital costs, and hospital quality and average uncompensated care per claim. Adjusting for these variables allow for a standardized measure of the outcome variable, hospital NPR. Standardizing hospital NPR to account for differences in patient conditions (case mix), hospital size and average occupancy is of key importance to appropriately compare and analyze the NPR of different hospitals. The method of this standardization is discussed in Chapter 3.

Community characteristics at the county level, such as demographics, income level, unemployment rate, and more were used as post-model exploratory variables. These relationships will be further discussed in quantitative analysis.

The many causal connections shown in the above conceptual framework are summarized in Table 2.

Table 2: Conceptual Model Causal Connections Overview

Variable	What is Causes	Why it Causes
Community Characteristics	Patient Case Mix	The inherent health characteristics of an individual community will dictate patient case mix. For example, if there is a high smoking population in a certain community, it is expected for that community to have higher rates of lung cancer (Palladino et al.).
	Hospital Cost	Factors such as the cost of staff the cost of real estate and utilities, etc. will have an impact on hospital cost (Gaynor).
	Insurance Market Competition	There will be increased insurance market competition if the potential for profit is higher in a certain community (Gaynor).
	Public Payment Rates	Public payment rates account for various community factors, such as if the hospital incurs a high cost of labor or qualifies as a disproportionate share hospital (Wasfy et al.).
	Patient Insurance Status	Community characteristics like income will dictate patient insurance status.
	Payer Mix	Similar to impacting patient insurance status, community characteristics like income will dictate the payer mix. For example, poorer communities will have relatively higher populations of Medicaid patients.
	Patient Utilization	The accessibility to care, willingness to receive care, level of disease in a community, etc. will dictate the level of utilization in a particular community.
Insurance Market Competition	Negotiated Private Payment Rates	Greater insurance market competition leads to lower hospital reimbursement due to competition over offering the lowest premiums to subscribers (Melnick et al.).
	Administrative Burden	The more insurers in the market, the more hospital administrative resources needed to manage reimbursements and contracting with multiple insurers (Jiwani et al.).

Hospital Competition	Negotiated Private Payment Rates	The more hospital competition, the more bargaining power insurers have. As insurers gain bargaining power, reimbursement rates will decrease (Gaynor et al.).
	Hospital Quality	More hospital competition leads to greater hospital quality (Hussey et al.).
Negotiated Private Payment Rates	Hospital Gross Patient Charges	The higher private payment rates are, the higher gross patient charges will be (Hammond and Pope).
Public Payment Rates	Hospital Gross Patient Charges	Public payment rates directly impact the gross patient charges of the hospital via reimbursement.
Hospital Gross Patient Charges	Hospital NPR	Hospital gross patient charges – hospital patient cost = hospital NPR
Payer Mix	Hospital NPR	As the payer mix shifts, hospital gross revenue will shift depending on the difference between different private and public payers. For the purposes of this study, payment rates will remain constant (Hammond and Pope).
Universal Single Payer Healthcare System	Public Payment Rates	Payment rates themselves might shift depending on the legislation. The method of how payment is determined may also shift depending on various clauses in the legislation (Holahan et al.).
	Patient Insurance Status	In an M4A system, all individuals will be covered with Medicare (Holahan et al.). Thus, for the purposes of this study, the uninsured population will become nonexistent.
Patient Insurance Status	Uncompensated Care	As more individuals have access to insurance, less instances of uncompensated care / charity care will occur (Blavin).
	Patient Utilization	As more individuals have access to insurance, more utilization will occur (Palladino et al.).
	Payer Mix	The insurance status of a patient will directly impact the payer mix.
Administrative Burden	Hospital Cost	The level of administrative burden on a hospital translates directly into hospital cost (Blavin; Jiwani et al.).
Patient Case Mix	Hospital Cost	A more complex patient panel will involve greater care and subsequent greater hospital cost (Palladino et al.).

Hospital Cost	Hospital NPR	Hospital gross patient charges – hospital patient cost = hospital NPR
Hospital Quality	Hospital Cost	In order to achieve a greater hospital quality, hospital cost must be incurred (Hussey et al.).
Uncompensated Care	Hospital NPR	As uncompensated care decreases, hospital NPR will increase (Blavin).
Patient Utilization	Hospital Gross Patient Charges	As patient utilization increases, gross patient charges increase (Palladino et al.).

Chapter 3: Methods

Data

Data was retrieved from three sources: the 2019 Pennsylvania Health Care Cost Containment Council (PHC4) Financial Analysis, Centers for Medicare and Medicaid Services (CMS) 2019 Inpatient Prospective Payment System (IPPS) Proposed Rule Impact File, and 2018 County Health Rankings data retrieved from the University of Wisconsin Population Health Institute (“PHC4”; “FY 2019 IPPS”; “Pennsylvania.”). Datasets were imported and merged in RStudio using hospital Medicare ID numbers and county identifiers.

Several variables were included in the final dataset, which was used in a GAM regression. The target or dependent variable in all regressions was NPR per case mix adjusted occupied bed day. This standardized variable allows for an accurate estimate for NPR standardized for case mix, hospital bed size, and hospital occupancy. Referring to the DAG illustrated in Figure 1, the outcome variable in the conceptual framework is NPR and adjustment variables include case mix and utilization, which are accounted for in this model through creating the variable NPR per case mix adjusted occupied bed day (“standardized NPR”) as the final outcome variable.

The key treatment variables used in the regression are percentage of NPR from Medicare, percentage of NPR from Medicaid, and uncompensated care per claim amount - each of which is directly affected by universal single payer. The model also adjusts for hospital CMS operating cost index, and proxy value-based purchasing adjustment factor. The CMS operating cost index is used by Medicare to adjust inpatient payment rates to account for differences in labor and non-labor operating costs using a wage index and geographic adjustment factor. If the wage index is greater than 1, the percent labor share is 68.3% and the non-labor share is 31.7%. If the wage

index is less than 1, the percent labor share is 63% and the percent non-labor share is 37% (Medicare Program). CMS also uses a proxy value-based purchasing adjustment factor to adjust payments based on hospital quality indicators. In summary, using the 5 predictor variables of percent NPR from Medicare, percent NPR from Medicaid, an operating cost index, a quality adjustment factor, and a measure of uncompensated care will allow an estimate of a standardized NPR within the generalized additive model regression. It is important to note that these variables also relate to the DAG in Figure 1. Here, proxy value-based purchasing adjustment factor (a quality indicator) serves as an adjustment variable, while the payer mix variables (percent NPR from Medicare and percent NPR from Medicaid) and uncompensated care per claim amount serves as the main treatment variables.

Analysis

A generalized additive model was constructed using the variables described above (Hastie, Trevor, and Tibshirani, 1990). GAM was used due to its ability to fit possibly non-linear relationships between the payer mix and uncompensated care variables and standardized NPR.

A linear regression model would mean that the effect of a change in payer mix on NPR would be the same regardless of the baseline payer mix. For example, in a linear model, increasing the Medicare share from 60% to 70% would be predicted to have the same effect as increasing the Medicare share from 0% to 10%. This is considered to be unlikely. One approach is to add polynomial terms to the regression (e.g., Medicare share squared and Medicare share cubed), but polynomials can produce large swings at the “boundaries” of the data (i.e., 0% and 100%). Because this analysis is interested in predicting the effect of pushing the Medicare share to the 100% boundary and the Medicaid share and uncompensated care to zero, adding

polynomials would likely create unstable predictions. The shape of the relationship between each payer mix variable, uncompensated care and standardized NPR was determined by natural splines using three degrees of freedom, which allows the relationship with each variable to change directions or slopes twice. The two remaining adjustment predictor variables, which include proxy-based purchasing adjustment factor (a quality indicator) and operating cost index used 1 degree of freedom as the relationship was assumed to be linear standardized NPR for these variables.

Using the estimated GAM model, predictions were made as to how adjusted NPR would change if single payer finance were established. This estimate was calculated by setting the percent of NPR from Medicare to 100%, the percent of NPR from Medicaid to 0%, and setting average uncompensated care per claim to \$0. Then, the residual values from the GAM were added to the observed values to obtain the predictions shown in the Results section. The residual values describe the difference between what the model predicts and what is observed and represent the effect of unobserved factors on standardized NPR. The prediction assumes that the treatment variables included in this model are the only variables which would change in the case that the U.S. transitions to a universal single payer healthcare system. This assumption is further discussed in the limitations subsection.

Chapter 4: Results

Table 3: Input Variable Descriptive Statistics

Variable	Minimum	1 st Quartile	Median	Mean	3 rd Quartile	Maximum
%NPR Medicare	0.118	0.350	0.417	0.411	0.470	0.601
%NPR Medicaid	0	0.0629	0.094	0.114	0.141	0.573
Uncompensated Care Per Claim	0	0	387	441	617	4350
Operating Cost Index	0.815	0.858	0.930	0.943	1.028	1.16
Proxy Value-Based Adjustment Factor	0.99	0.997	1.00	1.00	1.00	1.02
NPR Per Case Mix Adjusted Occupied Bed Day (\$000s)	1.52	2.93	3.93	5.08	5.63	36.2
Hospitals: n = 133						

Table 4: GAM Estimation Summary Statistics

Variable	Df	Sum Sq	Mean Sq	F Value	Significance
%NPR Medicare	3	818	273	28.5627	***
%NPR Medicaid	3	255	84.9	8.8952	***
Uncompensated Care Per Claim	3	66.4	22.1	2.3189	*
Operating Cost Index	1	40.1	40.1	4.2029	**
Proxy Value-Based Adjustment Factor	1	17.7	17.7	1.8582	

Significance codes: *** = < 0.001; ** = < 0.05; * = < 0.1

Table 5: Predicted Change After Single Payer Healthcare Descriptive Statistics

Variable	Minimum	1 st Quartile	Median	Mean	3 rd Quartile	Maximum
Predicted Standardized NPR (\$000s)	-3.06	2.03	2.93	3.23	4.17	28.3
Change in Standardized NPR (\$000s)	-22.9	-2.88	-1.07	-1.85	-0.113	2.05
Percent Change in Standardized NPR	-171%	-54.8%	-24.9%	-30.9%	-3.54%	74.3%

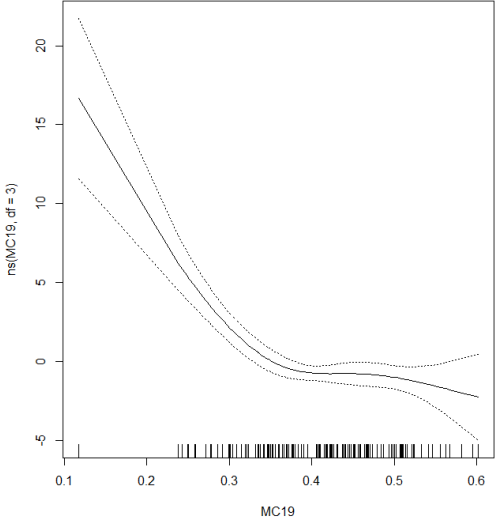


Figure 2: Contribution of Medicare share of NPR to standardized NPR. Dashed lines represent 95% confidence intervals.

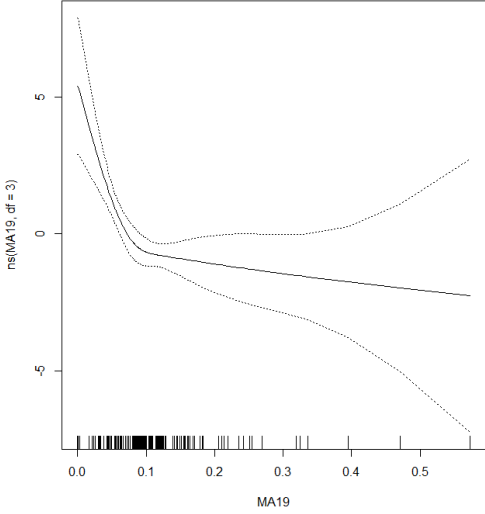


Figure 3: Contribution of Medicaid share of NPR to standardized NPR. Dashed lines represent 95% confidence intervals.

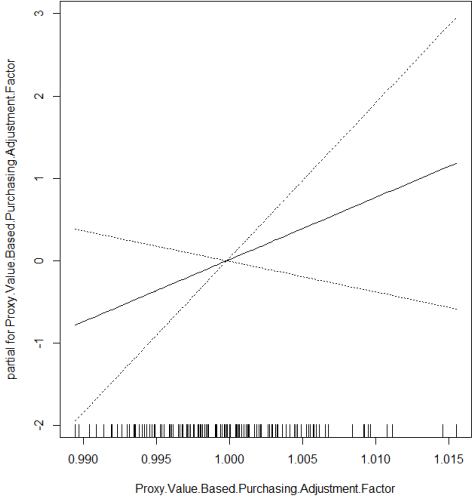


Figure 4: Contribution of proxy value-based adjustment factor to standardized NPR. Dashed lines represent 95% confidence intervals.

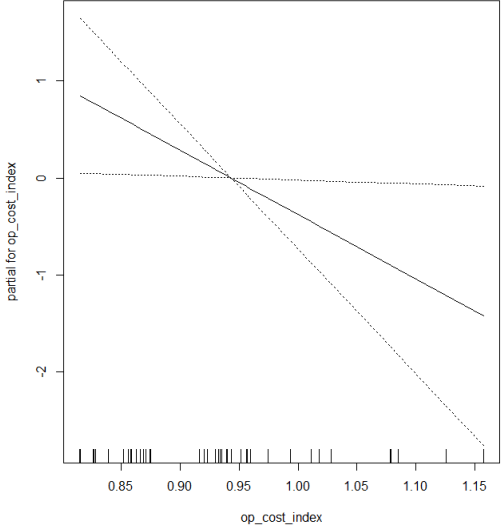


Figure 5: Contribution of operating cost index to standardized NPR. Dashed lines represent 95% confidence intervals.

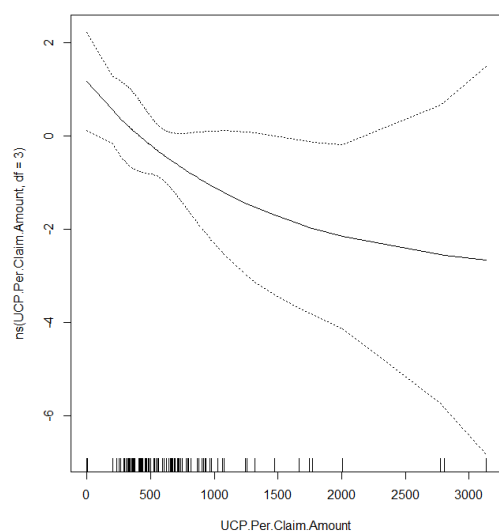


Figure 6: Contribution of Uncompensated Care Per Claim to Standardized NPR. Dashed lines represent 95% confidence intervals.

Figure 2 describes the contribution of percent NPR from Medicare to standardized NPR. Note that in Figures 2 through 6, the dashed lines represent 95% confidence intervals. As is seen, the percent of NPR from Medicare is associated with a steep drop in standardized NPR until approximately 35% NPR from Medicare. After this point, the magnitude of the downward slope decreases significantly. In other words, the initial 35% of NPR from Medicare is correlated with significant drops in standardized NPR; marginally speaking, additional NPR from Medicare (greater than 35%) has less of a predicted impact on standardized NPR.

A similar relationship can be seen in Figure 3, which describes the contribution of percent NPR from Medicaid to standardized NPR. There is a steep drop in standardized NPR until approximately 10% NPR from Medicaid. Hospitals earning greater than 10% NPR from

Medicaid experience an attenuated decrease in standardized NPR on the margin. This relationship is statistically significant.

Figure 4 shows the contribution of the operating cost index to standardized NPR. The operating cost index is an adjustment for operating cost and is defined in the Methods section. As is seen in the relationship, as operating costs increase, standardized NPR decreases as expected. Confidence intervals confirm this decrease, and the relationship is statistically significant.

Figure 5 shows the contribution of proxy value-based purchasing adjustment factor to standardized NPR. As previously stated in the Methods section, proxy value-based adjustment factor is an adjustment based on hospital quality indicators. As seen in Figure 8, as hospital quality increases, standardized NPR increases. However, it is important to note that this relationship is not statistically significant. The confidence intervals show that the relationship could either be positive or negative.

Figure 6 shows the contribution of uncompensated care per claim to standardized NPR. Findings show that as uncompensated care per claim increases, standardized NPR is expected to fall.

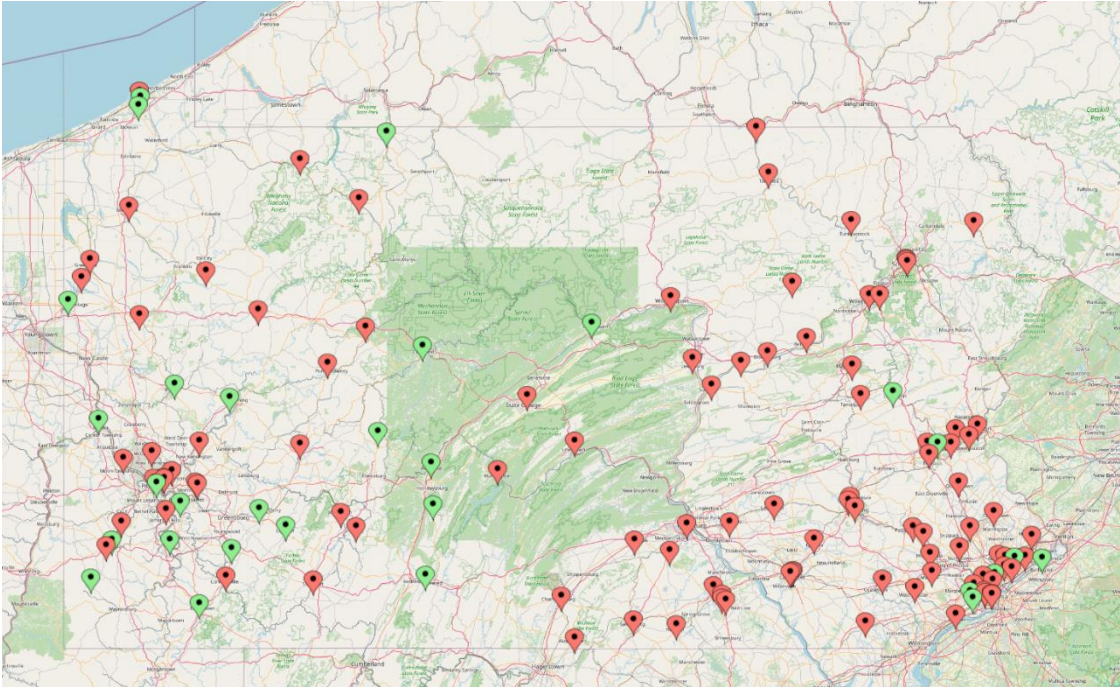


Figure 7: Geographically Illustrated Change in Standardized NPR. Red markings denote negative change in standardized NPR. Green markings denote positive change in standardized NPR.

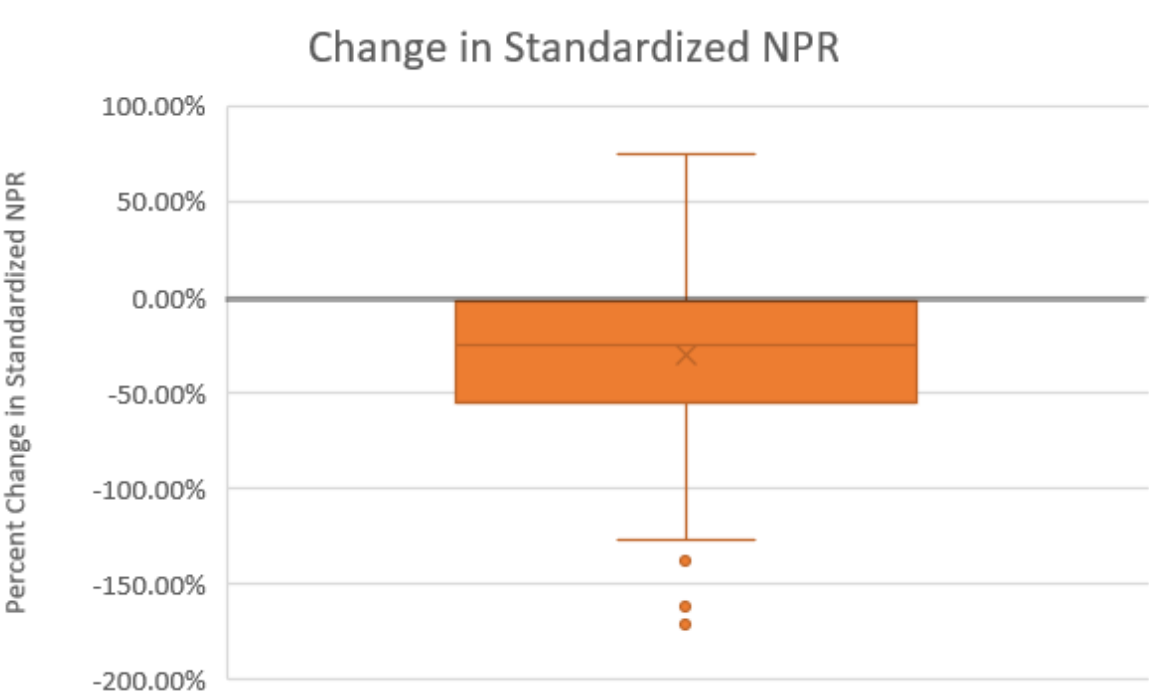


Figure 8: A Box Plot Illustrating Percent Change in Standardized NPR.

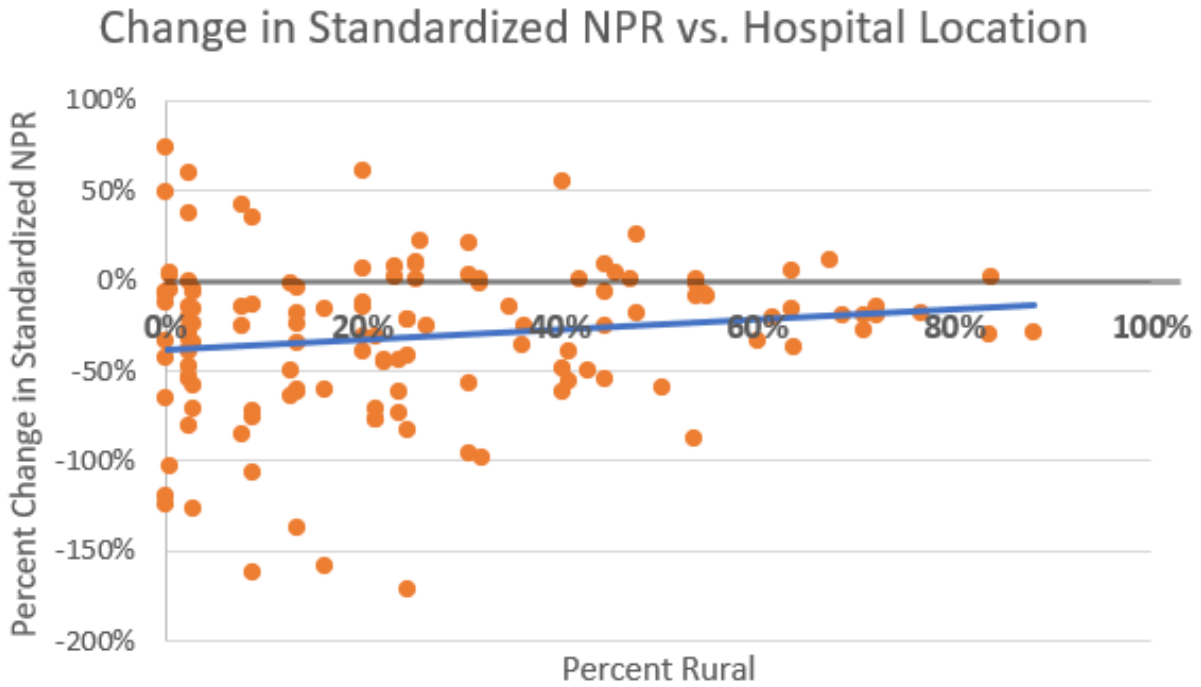


Figure 9: Change in Standardized NPR vs. Hospital Location; $R^2 = 0.0217$

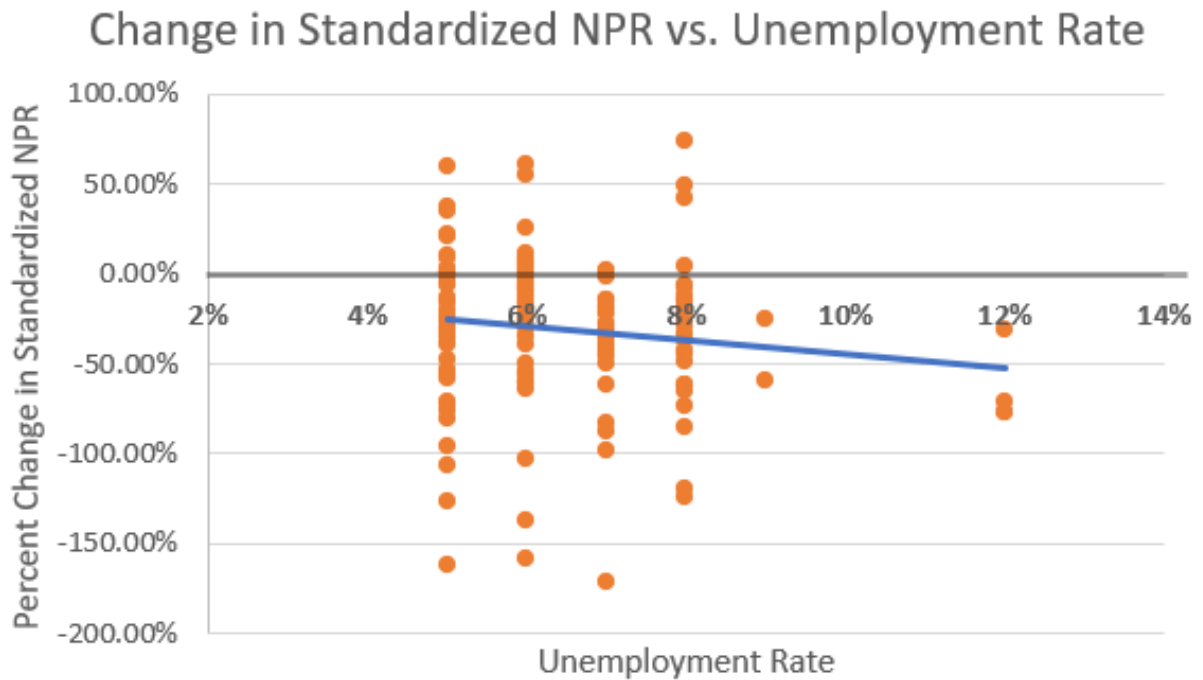


Figure 10: Change in Standardized NPR vs. Unemployment Rate; $R^2 = 0.0174$

Change in Standardized NPR vs. Median Household Income

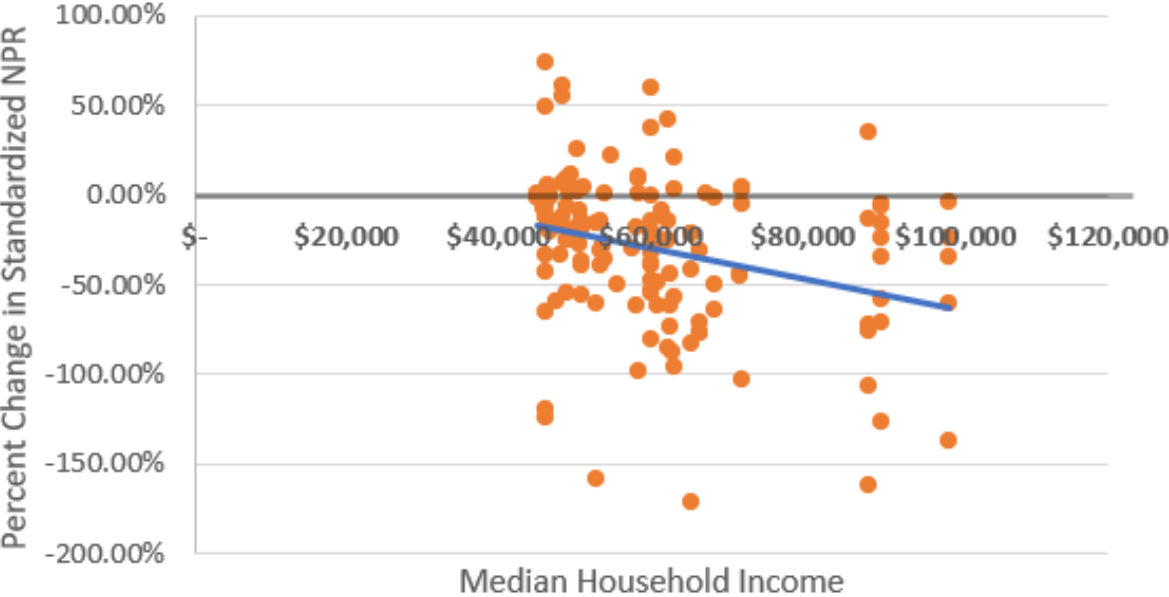


Figure 11: Change in Standardized NPR vs. Median Household Income; $R^2 = 0.0806$

Change in Standardized NPR vs. Percent Over 65

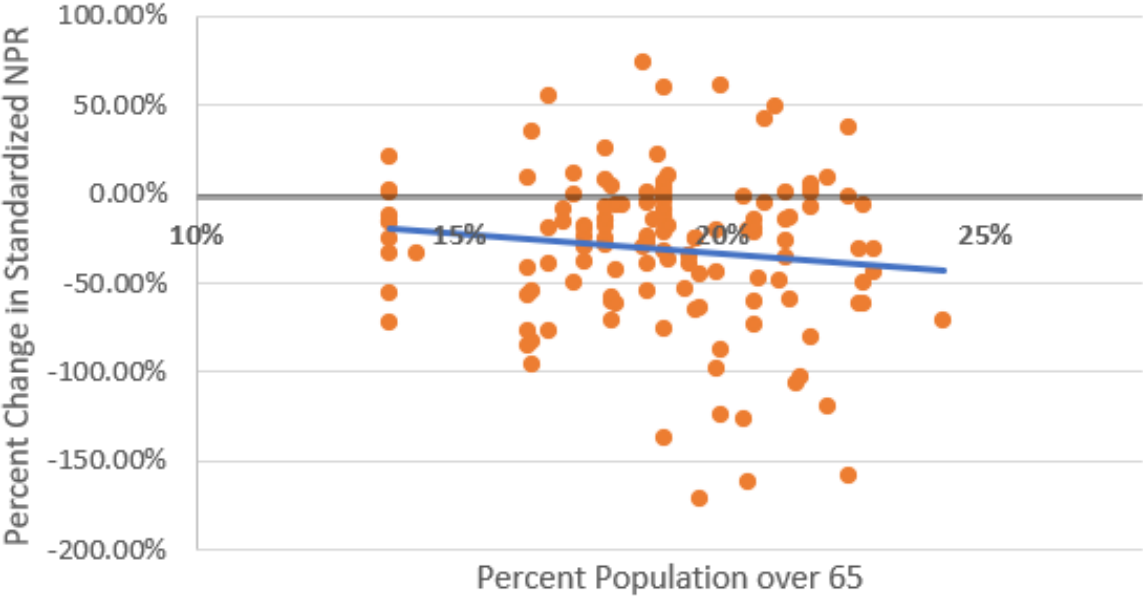


Figure 12: Change in Standardized NPR vs. Percent Population Over 65; $R^2 = 0.0163$

Predicted values for the change in standardized NPR following the establishment of universal single payer are shown in Table 5 and Figure 8. Assuming current Medicare payment rates, unchanged utilization patterns, and no changes in cost structure, the median Pennsylvania hospital will lose \$1,090 or -24.9% in case mix adjusted NPR per occupied bed day.

Differences and percent changes were calculated and compared against community characteristic variables, such as geographic location in Figure 7 and county-level percent rurality in Figure 9, county-level unemployment rate in Figure 10, county median household income in Figure 11, and percent population over 65 in Figure 12.

Figures 7 and 9 illustrate the change in standardized NPR when compared with geographic location. Figure 9 shows an interesting correlation, where as counties become more rural, the predicted percent change in standardized NPR increases (i.e., shifting to universal single payer is expected to have less of a negative effect). The relationship illustrated in Figure 10 shows the correlation between unemployment rate and change in standardized NPR. As unemployment rate increases, standardized NPR decreases (i.e., shifting to universal single payer is expected to have a greater negative effect). Figure 11 describes the change in NPR when compared with median household income. The relationship shows that as median household income increases, the percent change in NPR decreases (i.e., shifting to universal single payer is expected to have a greater negative effect). Finally, Figure 12 shows the relationship between the population over 65 and the change in standardized NPR. The trend illustrates that older counties are correlated with a more negative percent change in NPR.

Chapter 5: Discussion

Results Discussion

Results support the earlier hypothesis that Pennsylvania hospital net revenues would likely decrease overall and that the decrease will be seen most prominently with urban hospitals, richer areas, and specialty centers.

As can be seen in Table 5 and Figure 8, the median Pennsylvania hospital will lose \$1,090 or -24.9% in case mix adjusted NPR per occupied bed day. It is important to remember that this model assumes current Medicare payment rates, unchanged utilization patterns, and no changes in cost structure. The results in Table 5 and Figure 8 can largely be explained by the gaps in public and private payment rates. In 2012, this gap was 75.3% (Selden et al., 2015). In the model, percent NPR from Medicare has a large contribution to standardized NPR (as described below and as seen in Figure 2), which largely explains this effect. It is critical that key attention is paid to the overall reimbursement level in a universal single payer healthcare finance system to maintain the financial health of hospitals.

Figures 2 and 3 provide important insight into the revenue gap between private insurance and Medicare / Medicaid. As described in the literature review, the average private payment per discharge was 57% higher than the average Medicare payment per discharge in 2009 (White). The steep decline in standardized NPR seen between 0% and 35% NPR from Medicare and 0% and 10% NPR from Medicaid supports these previous studies. One reason why the correlations flatten after 10% and 35% respectively may be that the bulk of the potential revenue that could have been earned through lucrative private insurers likely lies in this range. Thus, any marginal increase of patient revenue earned through Medicare and Medicaid after 35% and 10% NPR respectively likely does not have a significant impact on standardized NPR. This finding was

possible due to the general additive modeling method using splines with 3 degrees of freedom that could represent different slopes across different ranges of the treatment variables. This relationship is statistically significant.

As is seen in Figure 4, as operating costs increase, standardized NPR decreases (i.e., shifting to universal single payer is expected to have a greater negative effect) as expected. It can be reasonably assumed that counties with greater costs of labor and higher prices will have lower standardized NPR. It is important to note, however, that this variable has a minimal contribution in the regression to standardized NPR and is not statistically significant.

This findings in Figure 5 supports prior literature that the relationship between hospital cost and quality is often minimal (Hussey). The statistical insignificance seen in Figure 5 could also be described by the low range of the proxy value-based adjustment factor, as the minimum is 0.99 and the maximum is 1.02. Like the operating cost index, this variable has a minimal contribution in the regression to standardized NPR and is not statistically significant.

Findings in Figure 6 show that as uncompensated care per claim increases, standardized NPR is expected to fall (i.e., shifting to universal single payer is expected to have a greater negative effect). Because of the impact of uncompensated care on hospital cost, this relationship is easily justified (Dranove et al., 2016). This relationship is significant in magnitude, though the F value is less than that of percent NPR from Medicare, percent NPR from Medicaid, and operating cost index.

Table 5 and Figures 7-12 discuss the predicted change in standardized NPR. As stated in the Methods section, the change in standardized NPR was achieved by adjusting percent NPR from Medicare to 100%, percent NPR from Medicaid to 0%, and uncompensated care per claim to \$0. Then, the residuals of the regression were added to the standardized NPR values to achieve

the predicted NPR values. One large assumption made in this calculation is that Medicare payment rates would remain consistent and there would be no change in hospital service utilization patterns. This limitation is further discussed in the limitations subsection.

The relationship seen in Figure 7 and 9, where rural counties are associated with an increased standardized NPR (i.e., shifting to universal single payer is expected to have less of a negative effect), may be explained by rural counties potentially having a higher concentration of poorer individuals. This would lead to a greater Medicaid share or higher uncompensated care, both being significant variables in the GAM model. This relationship is also seen in Figure 11, which shows that as median household income increases, the percent change in standardized NPR decreases (i.e., shifting to universal single payer is expected to have a greater negative effect).

The relationship illustrated in Figure 10 shows the correlation between unemployment rate and change in standardized NPR. Interestingly, as unemployment rate increases, change in standardized NPR decreases (i.e., the predicted reduction in NPR is greater). It was expected that unemployment rate would have a similar impact on changes in NPR as median household income and geographic location. However, the opposite relationship is seen. This is most likely explained by an unobserved variable that determines standardized NPR. Possibly, an increased unemployment rate takes a financial toll on hospitals which are understaffed, which counteracts the impacts of reduced uncompensated care due to a highly unemployed and subsequently poorer population. Theoretically speaking, a transition to a universal single payer healthcare system would help alleviate these strains due to a decreased administrative burden (Jiwani et al., 2014). However, this factor is not implemented into the generalized additive regressive model.

Furthermore, the trends seen in Figure 10 is based on data which has little variation, which may lead to an imprecise estimate of the relationship.

Figure 12 shows the relationship between the population over 65 and the change in standardized NPR and illustrates that older counties are correlated with a more negative percent change in NPR. It was expected that older counties would have a comparatively lesser impact on standardized NPR because of a greater Medicare population. A greater Medicare population, according to Figure 2, should have a marginally lower contribution to standardized NPR. However, this is not the case with the relationship shown in Figure 12. This interesting correlation could be described by the fact that older population tend to be wealthier, leading to a similar relationship as the one described in Figure 10. This could also be due to some unidentified, unforeseen, or uncontrolled variable.

Overall, the relationships shown in Figure 7-12 suggest that a transition to universal single payer would be predicted to have a less-negative impact (or perhaps even a positive impact) on NPR of hospitals in rural areas with low median household incomes. This may be largely due to higher rates of uncompensated care and Medicaid share of NPR in those areas.

Raw data demonstrated that outlier hospitals that incur a substantial decrease in predicted hospital NPR largely include specialty centers, including surgical centers, rehabilitation centers, and orthopedic centers. These institutions are most likely experiencing this severe decline in NPR because the procedures that they perform are most likely compensated for highly (especially relative to Medicare rates) by private insurance.

Limitations

There are limitations in the quantitative analysis discussed above that should be addressed. Firstly, and most importantly, the strongest assumption made in this investigation is

that the observed cross-sectional variation in public payer share of NPR and uncompensated care can be used to estimate the effect of universal single payer healthcare system, such as the one described in the Sanders-Jayapal proposal. However, it is important to note that this most likely will not be the case in a fundamental restructuring in the current healthcare system such as the one proposed by Sanders-Jayapal. Instead, this study demonstrates the potential results of a large structural change to the current healthcare system without taking into consideration the appropriate and accompanying drastic policy changes needed for success. If universal single payer is adopted, policy makers and health policy researchers must account for the health of hospital finances by appropriately adjusting the reimbursement system. If this factor is not considered, it could likely lead to widespread hospital shutdowns in certain areas within Pennsylvania if net operating costs are high. The conceptual framework in this study provides a broader overview of what should be considered in order to account for the health of hospital finances in the event that the United States transitions to a proposal similar to the Sanders-Jayapal proposal.

Furthermore, it is important to note that many variables determine NPR and broadly, net revenue. If those variables also affect the payer share and level of uncompensated care, they could result in biased estimates. The study attempted to account for observable measures of quality, cost, patient case mix and severity. However, as indicated in the qualitative conceptual framework portion of this investigation, there are likely several pathways at play which determine net revenue. Of these pathways, there are some which are difficult to measure quantitatively. Furthermore, even if it was possible to measure all pathways quantitatively, accurate estimates on how these variables would change in the event that the United States transitions to universal single payer would be difficult to achieve. This is the reason for which

qualitatively analyzing the impact of a potential single payer healthcare system on hospital finances is of key importance; quantitative analysis may not be the only needed approach when attempting to analyze certain causal pathways.

This investigation focused solely on the revenue side of hospital patient charges. Net operating costs (which are equally important in determining hospital profitability) were not included in this investigation. It is quite likely that a shift in the U.S. to a universal single payer healthcare system would have substantial impacts on both short term and long-term cost structure.

Future Study

Future study should focus on further quantitative and qualitative analysis on this subject. From a quantitative perspective, it is recommended that further study be done on how universal single payer would impact hospital net revenues under different reimbursement systems. As the Sanders-Jayapal proposal undergoes further maturation and modification, it is recommended that any potential changes to the reimbursement system be quantitatively modeled to show controlled and accurate estimate as to how each change would impact hospital finances in a negative and positive way. However, as stated previously, not all structural changes can be accurately modeled quantitatively due to the complex nature of long-term structural change. Thus, it is imperative the qualitative model in this study be further built upon and constructively criticized by health policy researchers in order to accurately gauge how a universal single payer healthcare system would impact hospital finances on a conceptual level.

Furthermore, it is recommended that future studies also examine the changes in short term and long-term structural changes in cost structure and their impact on hospital profitability.

This variable was included in the conceptual framework but was not quantitatively modeled in this investigation.

Beyond the purview of hospital finances, it is also critical to analyze the impact of universal single payer on other healthcare entities. As different proposals emerge, qualitatively and quantitatively modeling the impact of various proposals on different healthcare entities will prove vital in successful implementation of proposed change.

Chapter 6: Conclusion

In this investigation, a conceptual framework in the form of a Directed Acyclic Graph demonstrated the complex relationship among factors likely to determine the effect of universal single payer on Pennsylvania acute care hospital NPR. A generalized additive model regression analysis was conducted and demonstrated that, assuming current Medicare payment rates, unchanged utilization patterns, and no changes in cost structure, Pennsylvania hospital standardized NPR would likely decrease overall in the establishment of a universal single payer healthcare finance system. This decrease will be seen most prominently with urban hospitals, richer areas, and specialty centers. As the public debate over universal single payer continues among the American people and federal lawmakers, it is critical that health policy researchers further build upon literature that will contribute information to the discussion.

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EDUCATION

Early Assurance Program, Penn State College of Medicine

September 2019

- Accepted into a program through the Schreyer Honors College and Penn State College of Medicine which conditionally ensures matriculation into the Penn State College of Medicine Incoming Class of 2021.

Schreyer Honors College at The Pennsylvania State University

August 2017 – Present

- Eberly College of Science; College of Health and Human Development; Class of 2021
- Dual major: Biology; Health Policy and Administration

Hershey High School

August 2013 – June 2017

- Distinguished honor roll student; 9 AP courses and 8 honors courses completed

HONORS AND ACHIEVEMENTS

Alpha Epsilon Delta Pre-Health Honors Society, The Pennsylvania State University

August 2017 - Present

- *Nationally Inducted Member.* Participate in various healthcare-related activities and opportunities, including shadowing, volunteering, and attending seminars in order to interact with a variety of healthcare professionals.

MUSC National Health Administration Case Competition, Medical University South Carolina

October 2019

- *Semi-finalist.* Competed in the first health administration undergraduate national case competition with a team of three students to provide a business solution to the Medical University of South Carolina's expanding telestroke and telemedicine program.

Deloitte Case Competition, The Pennsylvania State University

February 2019

- *Semi-finalist.* Competed in a case competition with four team members in order to create a business plan for a company specializing in autonomous vehicles.

PwC Case Competition, The Pennsylvania State University

November 2018

- *Finalist.* Collaborated with team of four students to compete and place second in the annual PwC Case Competition, a data-driven business and consulting competition.
- Designed and created an artificial intelligence software in order to most efficiently and quantitatively relocate a business to another location.

President's Freshman Award, The Pennsylvania State University

January 2018

- Awarded the President's Freshman Award by achieving a 4.000 GPA and ranking in the top 2% of the Penn State Class of 2021 during the Fall 2017 semester.

LEADERSHIP EXPERIENCE

The Lion Caucus, The Pennsylvania State University

September 2017 – Present

- *President.* Strategically Plan and Direct The Lion Caucus, a university-affiliated organization devoted to advocating within federal, state, and local governments about unique issues that affect Penn State Students and educating students about pertinent political issues on behalf of The Pennsylvania State University.

College Independents, The Pennsylvania State University

August 2017 – May 2020

- *President.* Manage and conduct the College Independents, as well as collaborate with several political organizations in order to bring political events to campus.
- Discuss and gain perspective on pertinent current affairs and ideological issues with students across the political spectrum.

University Park Undergraduate Association, The Pennsylvania State University

August 2017 – December 2018

- *Governmental Affairs Committee.* Coordinated with local, state, and federal governments in order to address unique issues that pertain to Penn State students.
- *Academic Affairs Committee.* Innovated unique solutions that aimed to improve academically-relevant aspects of the University, such as textbook prices, syllabi availability, and diversity in the classroom.
- *Student Health Insurance Advisory Board.* Collaborated with faculty and students in order to ensure the smooth initiation of a mandatory health insurance program at Penn State.
- *Faculty Senate.* Served as the representative to the College of Health and Human Development in the Penn State Faculty Senate.
- *Freshman Council.* Built leadership, managerial, and problem-solving skills by representing university park freshman through the selective freshman council.

School Board Representative, Hershey High School

June 2016 – June 2017

- Selected to represent all students at Hershey Schools (Grades k -12) at administrative school board meetings.

MEDICAL EXPERIENCE

Primary Care Scholars Program, Penn State Health Milton S. Hershey Medical Center

June 2018

- Selected and participated in a two-week long preceptorship exploring the field of primary care in great depth.
- Shadowed various family physicians full time for a one-week long period in various subspecialties in primary care including obstetrics, pediatrics, geriatrics, and more.

Global Brigades, The Pennsylvania State University

June 2018

- Traveled to small villages in southern Ghana on a ten-day long humanitarian and medical mission trip.
- Assisted Ghanaian clinics to provide free healthcare by serving on various clinical stations including triage, pharmacy, consultation, optometry, house visits, and health education.

Healthcare Career Exploration Program, Hershey High School

March 2016 – June 2017

- Selected as 1 of 10 students to represent Hershey High School at the Hershey Medical Center as a daily intern for three periods a day.
- Observed and shadowed one of the few family physicians certified in acupuncture therapy in the central Pennsylvania area.
- Rotated through several dozen different professions including cardiology, pathology, oncology, optometry, nursing, and more.

INTERN EXPERIENCE

Greenlee Partners

May 2019 – August 2019

- Serve as an intern within the largest lobbying firm in Pennsylvania, specifically focusing on healthcare clients.
- Contribute to the lobbying team in multiple capacities, including drafting legislation, tracking legislation, meeting with clients, meeting with legislators, and completing administrative tasks.

COMMUNITY SERVICE AND INVOLVEMENT

Islamic Society of Greater Harrisburg

August 2013 – Present

- Organize, prepare, and tear down miscellaneous events sponsored by ISGH.
- Speak at events dedicated to promoting diversity and inclusion within the Central Pennsylvania community.

Association of Pakistani Physicians of North America (APPNA)

September 2013 - Present

- Serve as a youth leader within the Central Pennsylvania chapter of APPNA.
- Organize and participate in several APPNA events through many avenues, including introducing state and federal elected officials, introducing political candidates, serving as the M.C., and more.
- Collaborate with Pakistani Physicians in the Central Pennsylvania area to clean and maintain a section of highway in Hershey, Pennsylvania.

Penn State Lion Care, Bethesda Mission Center

June 2016 – August 2019

- Volunteered at a free clinic run purely by medical students in the impoverished area of downtown Harrisburg.
- Created a cheap device and method to track patient data across different patient rooms.

PUBLICATIONS AND RESEARCH

Pediatric Cardiology Research, Penn State Health Milton S. Hershey Medical Center

June 2018 – August 2018

- Conducted translational research on how to most efficiently conduct cardiopulmonary bypass in neonatal and pediatric patients.
- Focused specifically on the delivery of harmful microemboli to patients by exploring cardiopulmonary bypass parameters such as temperature, flow rate, venous reservoir levels, and vacuum assisted venous drainage negative pressure.
- Sathianathan, S., Nasir, R., Wang, S., Kunselman, A. R., & Ündar, A. (2019, December 4). In vitro evaluation of Capiox FX05 and RX05 oxygenators in neonatal cardiopulmonary bypass circuits with varying venous reservoir and vacuum-assisted venous drainage levels. *Artificial Organs*. doi:10.1111/aor.13404

Society of Teachers of Family Medicine

February 2017

- Presented a poster in Austin, TX in collaboration with the Penn State Milton S. Hershey Medical Center focusing on the benefits and pitfalls of my experience shadowing in family medicine in order to educate and encourage other medical institutions to create shadowing programs in primary care for high school students.
- Nasir, R., & Malone, M. (2017, February). *Benefits and Pitfalls During the Implementation of a Longitudinal Shadowing Experience for a High School Student in the Department of Family and Community Medicine*. Poster session presented at the Annual Conference on Medical Student Education, Austin, TX.