Health and *Well*-ness: Analysis of Key Public Health Indicators in Six of the Most Heavily Drilled Marcellus Shale Counties in Pennsylvania

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EXECUTIVE SUMMARY

This report[1] reviews mortality rates by selected major causes of death, as reported by each county to the Pennsylvania Department of Health,[2] for the Pennsylvania counties of Bradford, Greene, Lycoming, Susquehanna, Tioga and Washington, from 2000 (prior to the onset of shale development) through 2014. These counties were chosen because they represent the top Marcellus counties, or those with the most significant oil and gas development (900 or more wells)[3] since the first Marcellus Shale well was developed in Pennsylvania in 2004 and Marcellus development began in earnest in 2006. By analyzing any consistent relationship between the health data and the advent of shale development in these counties, one can determine the credibility of linking unconventional gas development to changes in health outcomes in these counties.

Major findings in the report include:

1. **There was no identifiable impact on death rates in the six counties attributable to the introduction of unconventional oil and gas development.** In fact, the top Marcellus counties experienced declines in mortality rates in most of the indices.
2. The proportion of elderly-to-total population increased significantly in the top Marcellus counties compared to the state. Based on this fact, death rates in these six counties would be expected to increase, **but this expected increase did not occur.**
3. During the period that unconventional gas development was introduced to these counties, the trends reflected a **positive economic change in the area.** Therefore, any increases in the death rates in the top Marcellus counties cannot be associated with negative changes to the economic viability of the population.
4. Unconventional gas development was **not associated with an increase in infant mortality** in the top Marcellus counties, as the mortality rate significantly declined (improved), even surpassing the improvement of the state.
5. Unconventional gas development **was not associated with an increase in deaths related to chronic lower respiratory disease (including asthma)** in the top Marcellus counties, as the overall chronic lower respiratory disease mortality rate declined (improved) or was variable for the six-county area. The only exception was Greene County where the increased mortality rate was consistent with the increase in the elderly population.
6. Unconventional gas development **was not associated with an increase in deaths related to cancer, heart disease, cerebrovascular disease, influenza or pneumonia, nephritis or nephrotic syndrome, or septicemia** in the top Marcellus counties, as the mortality rates significantly declined (improved).

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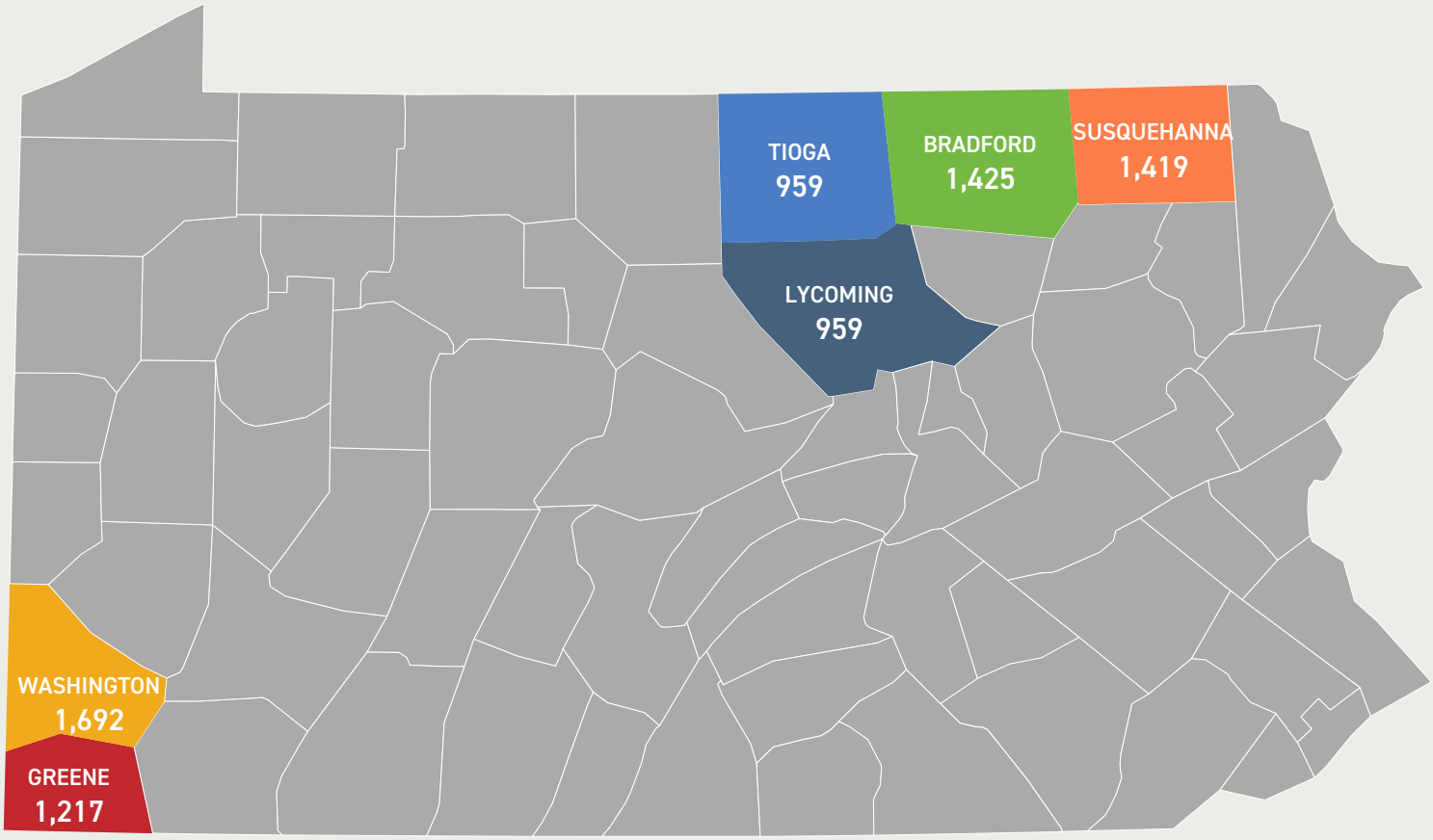
1 Susan Mickley graduated from Alfred University in 1977 with a BA in Business/Healthcare Administration. During her undergraduate years she completed an internship in London studying at the National Health System and its impact on public health. After graduation, she worked at a small hospital for a year before attending Yale University School of Medicine/Epidemiology and Public Health, where she received her Master's in Public Health in 1981. She was then granted an internship with the World Health Organization (WHO) in New Zealand, where she researched healthcare delivery systems to the islanders in the South Pacific. Over her 30-plus year career, she developed an expertise in public health needs assessment and long-range planning. This involved the identification of public health trends in specific populations and how healthcare providers and communities might meet those needs. Currently, Susan works as a freelance research consultant conducting health-related research. Energy In Depth (EID), a project of the Independent Petroleum Association of America, commissioned this report. Neither EID nor IPAA played any role in collecting, analyzing or presenting any of the data contained in this report, nor in influencing the author's findings and conclusions. They belong to her alone, and should not be construed as representing an official view or position of either IPAA or EID.

2 "Death Statistics," Pennsylvania Department of Health, 2017, http://www.statistics.health.pa.gov/HealthStatistics/VitalStatistics/DeathStatistics/Pages/default.aspx#.WgCBX4hrw2w.

3 "Wells Drilled By County," Pennsylvania Department of Environmental Protection, November 2017, http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Oil_Gas/Wells_Drilled_By_County.

PA. COUNTIES WITH GREATEST NUMBER OF MARCELLUS WELLS DRILLED (AS OF 2017)



INTRODUCTION

Oil and natural gas have been a part of the American landscape since the early 1800s, and were even believed to have been used by Native Americans for medicinal purposes[4] as far back as the 1400s. The first commercial natural gas well in the United States was drilled in Fredonia, N.Y., in 1821, and was used to keep the town's lamps illuminated for decades. This was followed by the Drake oil well[5] – long considered the first U.S. oil well – in 1859 in Titusville, Pa., which inspired the first U.S. oil boom and an oil rush that saw more seekers of riches than the California gold rush. New York and Pennsylvania have had some form of oil and gas extraction activity for almost 200 years. In fact, prior to the East Texas oil boom in 1901, Pennsylvania not only supplied the U.S.'s oil needs, but was also responsible for providing half of the world's oil.[6]

Source: Paleontological Research Institution,[7] *Drake Well Museum Collection, Titusville, PA*

In the 1950s, advances in geological research resulted in the discovery of a vast resource of oil and natural gas - primarily gas - locked in a shale bed that stretched across almost two-thirds of Pennsylvania at depths of 4,000 to 8,000 feet. This newly discovered resource was dubbed the Marcellus Shale after the town of Marcellus, N.Y., where there is an outcrop of the Marcellus layer above the ground.

The Marcellus Shale did not become commercially viable until the application of unconventional gas development in Pennsylvania in 2004,[8] where decades old horizontal drilling techniques are paired with the common well stimulation practice of hydraulic fracturing[9] to unlock oil and gas trapped in shale.

4 "Native Inventions and Innovations That Changed the World," Indian Country Today, July 13, 2017, https://indiancountrymedianetwork.com/history/traditional-societies/10-native-inventions-and-innovations-that-changed-the-world/.

5 Drake Well Museum & Park website, https://www.drakewell.org/.

6 Paleontological Research Institutions website, https://www.priweb.org/ed/pgws/history/pennsylvania/pennsylvania2.html.

7 Paleontological Research Institution, https://www.priweb.org/ed/pgws/history/pennsylvania/tarr_farm.html.

8 "Celebrating the Marcellus Shale Well That Started It All," Energy In Depth, Nov. 10, 2014, https://www.energyindepth.org/marcellus/celebrating-the-marcellus-shale-well-that-started-it-all/.

9 "What Is Hydraulic Fracturing?" Energy In Depth, June 1, 2015, https://www.energyindepth.org/videos/what-is-hydraulic-fracturing/.

According to the United States Geological Survey (USGS), the combination of horizontal drilling and hydraulic fracturing increased from six percent of new wells in 2000 to 42 percent in 2010.[10] Today, the Energy Information Administration (EIA) estimates that two-thirds of all U.S. natural gas produced[11] is developed using this method.

IMPACTS

Marcellus Shale oil and natural gas development in Pennsylvania has had significant impacts across the Commonwealth over the last decade since activity first began. While many of those impacts have been positive,[12] bringing jobs[13] and economic prosperity[14] to the region, there have also been allegations that this development is having negative health and environmental consequences.[15]

The benefits of unconventional gas development are being experienced at local, state, national and even international levels. A 2017 report[16] from ICF International found that the oil and gas industry added a value of $551 billion, or 2.9 percent of the total U.S. gross domestic product, in 2015. And the influx of oil and gas from shale development has helped the U.S. become a world leader in the export[17] of these resources.

The report also found that the increased use of natural gas will save consumers an estimated $100 billion by 2040. Further, the ICF report shows that the oil and gas industry provides roughly four million direct, indirect and induced jobs across the United States. Employment is a well-documented health factor. In fact, the Robert Wood Johnson Foundation has said that laid-off workers are 54 percent more likely to have fair or poor health[18] than those who are continuously employed, and are 83 percent more likely to develop a stress-related condition, including heart disease.

Increased natural gas use has also helped America lead the world in greenhouse gas emission reductions,[19] while also significantly reducing criteria pollutants such as sulfur dioxide (SO2), nitrogen oxide, (NOx), and particulate matter (PM2.5),[20] which have been linked to millions of deaths worldwide.

But alongside these benefits have been allegations of harm to the environment and human health from unconventional gas development. Common concerns include water contamination, impaired air quality, and earthquakes. Studies based on actual air and water samples near oil and gas activity — like those

10 "Trends in Hydraulic Fracturing Distributions and Treatment Fluids, Additives, Proppants, and Water Volumes Applied to Wells Drilled in the United States from 1947 through 2010— Data Analysis and Comparison to the Literature," United States Geological Survey, 2014. https://pubs.usgs.gov/sir/2014/5131/.

11 "Today in Energy," U.S. Energy Information Administration, May 5, 2016, https://www.eia.gov/todayinenergy/detail.php?id=26112.

12 "Benefits and Opportunities of Natural Gas Use, Transportation, and Production," ICF International, June 26, 2017, http://www.api.org/news-policy-and-issues/natural-gas-solutions/benefits-natural-gas-use.

13 "Impacts of the Natural Gas and Oil Industry on the US Economy in 2015," American Petroleum Institute, Aug. 1, 2017, www.api.org/~/.../Oil-and-Gas-2015-Economic-Impacts-Final-Cover-07-17-2017.pdf.

14 "The Local Economic and Welfare Consequences of Hydraulic Fracturing," Massachusetts Institute of Technology (MIT), Princeton University, the University of Chicago and the National Bureau of Economic Research (NBER), December 2016, https://papers.ssrn.com/sol3/Papers.cfm?abstract_id=2692197.

15 Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction), Concerned Health Professionals of New York, 2016, http://concernedhealthny.org/compendium.

16 "Benefits and Opportunities of Natural Gas Use, Transportation, and Production," ICF International, June 26, 2017, http://www.api.org/news-policy-and-issues/natural-gas-solutions/benefits-natural-gas-use.

17 "Impact of LNG Exports on the U.S. Economy, A Brief Update," ICF International, September, 2017, www.api.org/~/media/Files/.../LNG-Exports/API-LNG-Update-Report-20171003.pdf.

18 "Stable Jobs = Healthier Lives Infographic," Robert Wood Johnson Foundation, January 13, 2013, https://www.rwjf.org/en/library/infographics/infographic--stable-jobs---healthier-lives.html.

19 "Energy Related Carbon Emissions, 2016," Energy Information Administration, Oct. 5, 2017, https://www.eia.gov/environment/emissions/carbon/.

20 "Our Nation's Air," U.S. Environmental Protection Agency, August 2017, https://www.epa.gov/environmental-topics/air-topics.

conducted by the University of Cincinnati,[21] the Colorado Department of Public Health and Environment[22] and Pennsylvania's Department of Environmental Protection[23] — have shown such impacts to be largely exaggerated and often unfounded.

There have also been several studies conducted in recent years drawing associations between oil and gas activity and health issues like increased rates of infant mortality,[24] asthma,[25] cancer,[26] hospitalizations[27] and other ailments.[28] A vast majority of the epidemiological studies fail to show causation,[29] however, due to limitations such as the lack of baseline data, lack of actual air/water samples and failure to consider other confounding factors that could contribute to adverse health outcomes in the study regions.

PRIMARY INDICES AND METHODS

State reporting requirements for mortality rates[30] cover the major human body systems and causes of death:

- Chronic Lower Respiratory Disease (CLRD) including asthma
- Cancer
- Diseases of the Heart
- Stroke
- Cerebrovascular Disease
- Influenza and pneumonia
- Nephritis
- Septicemia

Using these categories to identify significant health trends has long been standard practice. As a result, there is substantial data that can be compared using the raw data, crude death rates and age-adjusted death rates over years, and even decades. These comparisons can identify significant changes and anomalies and lead the reviewer to seek causes for these anomalies. Trends can indicate causes for the diseases themselves, but are more an indicator of outcomes of treatment and access to care. Most importantly, trends can document the overall health of a population and whether it is improving or declining, particularly as it relates to longevity and survival.

It is important to note that a significant period of time is needed to identify valid trends with death rates; usually a decade is the minimum time period to determine if community heath is changing.

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21 "Another University of Cincinnati Study Finds No Health Concerns from Fracking, But Will It Be Published?" Energy In Depth-Health, Aug. 24, 2017, http://eidhealth.org/another-university-of-cincinnati-study-finds-no-health-concerns-from-fracking-but-will-it-be-published/.

22 "Oil and gas health assessment," Colorado Department of Public Health and Environment, 2017, https://www.colorado.gov/pacific/cdphe/oil-and-gas-health-assessment.

23 "Northeastern Pennsylvania Marcellus Shale Short-Term Ambient Air Sampling Report," Pennsylvania Department of Environmental Protection, Jan. 12, 2011, www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/.../Marcellus_NE_01-12-11.pdf.

24 "There's a World Going on Underground—Infant Mortality and Fracking in Pennsylvania," Scientific Research, April, 2017, https://www.scirp.org/Journal/PaperInformation.aspx?PaperID=75575.

25 "Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations," JAMA International Medicine, September, 2016, https://jamanetwork.com/journals/jamainternalmedicine/fullarticle/2534153.

26 Unconventional oil and gas development and risk of childhood leukemia: Assessing the evidence," Science of the Total Environment, January, 2017, http://www.sciencedirect.com/science/article/pii/S0048969716322392.

27 "Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates," PLOS One, July 15, 2015, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0131093.

28 "Study: Fracking associated with migraines, fatigue, chronic nasal and sinus symptoms," Johns Hopkins Magazine, Aug. 24, 2016, https://hub.jhu.edu/2016/08/25/fracking-health-migraine-sinus-fatigue/.

29 "Health Impacts of Unconventional Oil and Gas Development," Resources For the Future, Jun. 23, 2017, http://www.rff.org/research/publications/health-impacts-unconventional-oil-and-gas-development.

30 "Death Statistics," Pennsylvania Department of Health, 2017, http://www.statistics.health.pa.gov/HealthStatistics/VitalStatistics/DeathStatistics/Pages/default.aspx#.WgCBX4hrw2w.

One can hypothesize that if a new industry like oil and gas resource development is introduced into a community, the impact will show up over time in the health outcomes in that community. If it is a negative impact, the death rates will increase. Likewise, if it is positive, the death rates will decline or stay the same. The opposite of death rates are survival rates, so if there is a decline in death rates then one can posit that the survival rates for these diseases are improving and visa-versa.

An important factor that can increase death rates is the aging of the population. It is important to evaluate the age-adjusted death rates when comparing to trends in other areas. However, since this is based on the mix of population by age in 2000 as the adjustment factor, it can have errors and will not reflect a dramatic change in age groups in the population. It may also falsely skew trends in a community and show a false positive or a false negative trend. There is debate whether age-adjusted rates or crude death rates are the best indicator to employ, so this study includes both age-adjusted and crude death rates when appropriate.

By applying the standard protocol to this study, we seek to identify anomalies that are consistent across the six counties that may indicate if oil and natural gas development has adversely or positively impacted the health of the community, or had no impact at all. By combining the six counties into one area where oil and gas drilling has been the most active during the study period in Pennsylvania, we can get a comprehensive view of the impact of development on the population while eliminating individual county anomalies that are not consistent with the experience of the other counties. The six-county data will be compared to the statewide data to give a reference point to changes happening throughout the state. It is important to note that the statewide data include major cities, so a comparison must account for this fact. Beyond the scope of this study would be a comparison to a control group of six counties where oil and gas development is not occurring but the population, demographics, and urban factor are comparable.

DEMOGRAPHICS OF THE TOP MARCELLUS COUNTIES

A six-county area was selected for this study because it represents those counties which had at least 900+ wells drilled within each county from 2000 to 2015. These top Marcellus counties are: Bradford, Greene, Lycoming, Susquehanna, Tioga, and Washington. They provide a good sampling of the general populations throughout the Marcellus Shale region in Pennsylvania.

ELDERLY POPULATION

The demographics of the studied counties show that the elderly population (age 65 and over) increased at a faster rate than other age groups during the study period. From the period 2000 to 2015 the elderly population in these six counties increased 14.1 percent while the total population actually declined slightly. Therefore, it would be expected that the death rates for the primary indices, excluding infant mortality, would increase.

When compared to statewide numbers,[31] the increase in the elderly population is higher for the top Marcellus counties, and these counties did not experience the more than four percent increase in total population[32] that the state experienced. Therefore, the proportion of elderly-to-total population increased significantly in the six-county region compared to the state. [33] [34]

Figure 1 shows elderly population trends and overall population trends in the top Marcellus counties from 2000 to 2015. Figure 2 shows elderly population trends and overall population trends in the state as a whole from 2000 to 2015. Figures 3 and 4 show the top Marcellus counties have a higher percentage of elderly residents than Pennsylvania as a whole. With a stagnant total population growth of -0.65 percent, it also means the six-county population under 65 declined over the 15-year period.

31 "2016 County Health Profiles," PA.gov, 2017, http://www.statistics.health.pa.gov/HealthStatistics/VitalStatistics/CountyHealthProfiles/Pages/CountyHealthProfiles.aspx#.WepJMYZrzUJ.

32 United States Census, https://www.census.gov/.

33 "Pennsylvania Department of Health Health Profile Reports, Pennsylvania Department of Health, 2017, http://www.statistics.health.pa.gov/HealthStatistics/VitalStatistics/CountyHealthProfiles/Pages/CountyHealthProfiles.aspx#.WejJv4ZrzUI.

34 United States Census, https://www.census.gov/.

This aging of the population can be seen in the median age for each county compared to the state (Figure 5).

FIGURE 1: TOP MARCELLUS COUNTIES

YEAR	65+ POPULATION	CHANGE/ YEAR
2015	96,747	5.92%
2012	91,342	5.14%
2009	86,875	3.43%
2006	83,992	0.13%
2003	83,883	-1.07%
2000	84,786	
PERCENT CHANGE 2000-2015		
14.11%		

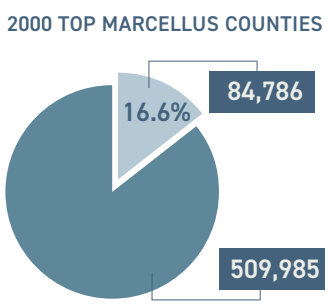
YEAR	TOTAL POPULATION	CHANGE/ YEAR
2015	506,652	-1.05%
2012	512,034	1.17%
2009	506,126	-0.77%
2006	510,029	0.18%
2003	509,134	-0.17%
2000	509,985	
PERCENT CHANGE 2000-2015		
-0.65%		

FIGURE 2: PENNSYLVANIA

YEAR	65+ POPULATION	CHANGE/ YEAR
2015	2,179,788	6.70%
2012	2,042,861	4.96%
2009	1,946,292	3.23%
2006	1,885,352	-0.86%
2003	1,901,798	-0.90%
2000	1,919,165	
PERCENT CHANGE 2000-2015		
13.58%		

YEAR	TOTAL POPULATION	CHANGE/ YEAR
2015	12,802,503	0.31%
2012	12,763,536	1.26%
2009	12,604,767	1.32%
2006	12,440,621	0.61%
2003	12,365,455	0.69%
2000	12,281,054	
PERCENT CHANGE 2000-2015		
4.25%		

FIGURE 3: PERCENTAGE OF ELDERLY IN TOTAL POPULATION



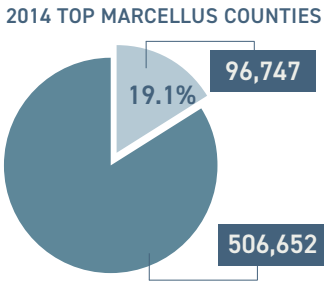
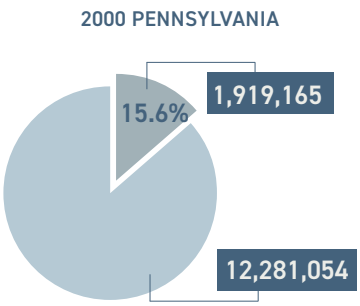


FIGURE 4: PERCENTAGE OF ELDERLY IN TOTAL POPULATION



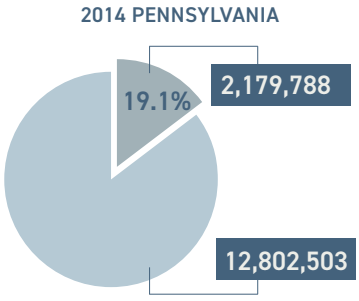


FIGURE 5: MEDIAN AGE

YEAR\AREA	BRADFORD	GREENE	LYCOMING	SUSQUEHANNA	TIOGA	WASHINGTON	STATE
2000	38.9	38.2	38.4	39.5	38.5	40.8	38.0
2010-2014	43.8	41.7	41.3	45.9	42.7	44.0	40.5
PERCENT CHANGE	12.6%	9.2%	7.6%	12.2%	10.9%	7.8%	6.6%

Age is a primary factor in general health and health outcomes. An increase in the age 65-and-over population is a significant factor in changes in the top Marcellus counties' death rates, since all but one of the health indices reported represents the top common causes of death for the elderly. The exception is the infant mortality rate, which is an age-specific death rate. It would be expected that causes of death for the elderly would increase with the increase of the elderly population, especially in a total population that declined or had no change. It is expected that this would increase the total population death rates for a population in an area, but as this study will show, this expected trend did not occur.

ECONOMIC TRENDS

Prior to analyzing health indices trends, it is important to review economic trends, as these may impact outcomes to some extent and need to be factored when performing an analysis. A quick evaluation of the economy in the study area[35] versus the state[36] is to look at the per capita personal income and the percentage of the labor force unemployed.

FIGURE 6: PER CAPITA INCOME

YEAR/AREA	BRADFORD	GREENE	LYCOMING	SUSQUEHANNA	TIOGA	WASHINGTON	STATE
2000	$21,415	$19,932	$23,252	$22,420	$21,038	$28,353	$29,504
2014	$38,448	$43,047	$39,766	$37,459	$34,360	$48,258	$47,679
PERCENT CHANGE	+79%	+116%	+71%	+67%	+63%	+70%	+62%

FIGURE 7: UNEMPLOYMENT RATES

YEAR/AREA	BRADFORD	GREENE	LYCOMING	SUSQUEHANNA	TIOGA	WASHINGTON	STATE
2000	5.7	5.7	5.8	6.9	6.9	5.0	4.7
2014	5.4	5.6	6.2	5.9	6.9	5.8	5.9
PERCENT CHANGE	-0.3	-0.1	+0.4	-1.0	-0-	+0.8	+1.2

The two primary economic indicators for the working population in the top Marcellus counties show that the workforce did better than the state workforce on all counts. Per capita income growth (Figure 6) was significantly higher than the state except for Tioga County, which was only slightly higher. The unemployment growth rate (Figure 7) also was significantly better than the state. Favorable economic indicators positively influence health outcomes, as the population can afford more health insurance, more preventative care, dental care, medical equipment, prescriptions and insurance from their employment.

35 The 2016 Pennsylvania Profile, www.statistics.health.pa.gov/HealthStatistics/VitalStatistics/CountyHealthProfiles/Pages/CountyHealthProfiles.aspx#.WejJv4ZrzUI.

36 United States Census, https://www.census.gov/.

BIRTH AND FERTILITY

Another important demographic to examine is birth and fertility, including the female population of childbearing age (Figures 8 and 9) and rates of birth and infant mortality (Figure 10). The changes in infant mortality indices – deaths age one year and younger per 1,000 births – are an important indicator of the health of a population. When there are reductions in infant mortality or no trend at all, it is considered a positive trend. Infant mortality rates can change because of fluctuations in the economic situations of females of childbearing age, the average age of females of childbearing age, or the extent and quality of prenatal and early infancy care.

FIGURE 8 FEMALE POPULATION (14-44) OF CHILDBEARING AGE IN TOP MARCELLUS COUNTIES

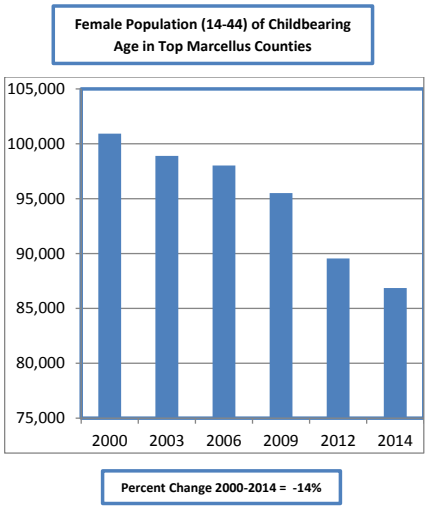
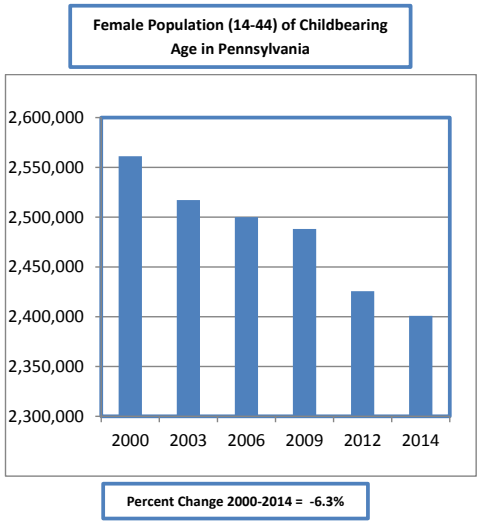


FIGURE 9: FEMALE POPULATION (14-44) OF CHILDBEARING AGE IN PENNSYLVANIA



Source: *Pennsylvania Health Profiles 2000-2016*[37] - *"These data were provided by the Division of Health Informatics, Pennsylvania Department of Health. The Department specifically disclaims responsibility for any analyses, interpretations, or conclusions."*

FIGURE 10: INFANT MORTALITY (INFANT DEATH RATES PER 1,000 LIVE BIRTHS)

COUNTY\YEAR	2000	2003	2006	2009	2012	2014
BRADFORD	2.8	2.8	8.0	ND	ND	ND*
GREENE	10.8	7.7	9.5	ND	ND	ND
LYCOMING	6.0	8.1	5.2	8.9	8.4	ND
SUSQUEHANNA	6.0	4.3	7.9	ND	ND	ND
TIOGA	4.2	2.3	2.3	ND	ND	ND
WASHINGTON	10.4	5.6	6.2	7.7	ND	5.0
PENNSYLVANIA	7.0	7.3	7.5	7.2	7.0	6.0

**ND = less than 10 events – considered statistically unreliable and are not displayed, unless otherwise noted.*

The Pennsylvania Department of Health advises caution when using rates with lower than 10 events because rates could fluctuate greatly in smaller populations.[38] In compliance with the state's recommendations, the six top Marcellus counties were combined to compare the 2000 and 2014 rates, because there were so few events in the individual counties in later years. The combined infant mortality rates for the six counties provided enough events to result in a statistically significant rate as follows:

37 The 2016 Pennsylvania Profile, www.statistics.health.pa.gov/HealthStatistics/VitalStatistics/CountyHealthProfiles/Pages/CountyHealthProfiles.aspx#.WejJv4ZrzUI.

38 Appendix A

FIGURE 11: INFANT MORTALITY (INFANT DEATH RATES PER 1,000 LIVE BIRTHS)

COUNTY\YEAR	2000	2014	PERCENT CHANGE
TOP MARCELLUS COUNTIES	7.44507	5.881237	-21.0%
PENNSYLVANIA	7.012902	5.981156	-14.7%
DIFFERENCE	+0.43	-0.1	6.3% GREATER DECREASE IN TMC

Figure 11 shows that the top Marcellus counties had greater improvement in the infant mortality rate than Pennsylvania as a whole. This is even more significant given the 2000 rate started higher than the Pennsylvania rate and the 2014 rate was lower in the top Marcellus counties than for the state.

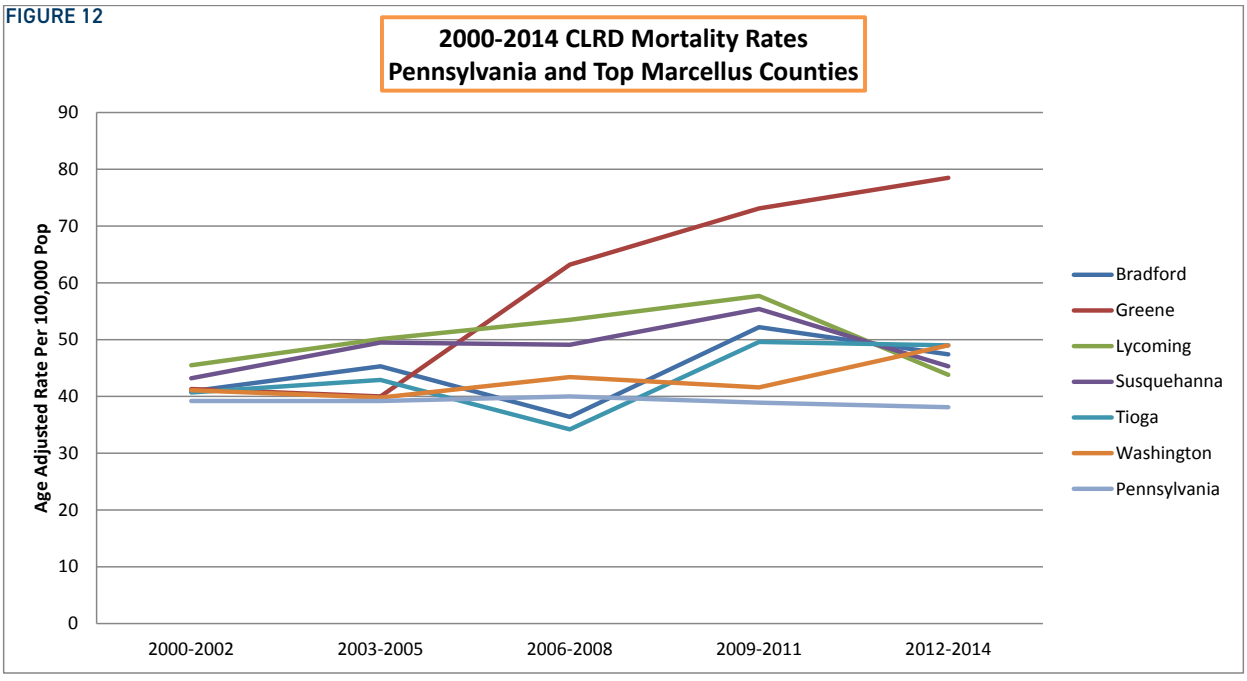
HEALTH TRENDS IN THE TOP MARCELLUS COUNTIES

The next section will evaluate the changing mortality rates for deaths in the specific health indices reported to the state. The overall trends in each disease index are an indicator of the changing health of a population. A consistent increase over the top Marcellus counties in any one of these indices could indicate a health trend contrary to what would be expected based on the demographics and economy. Specific trends within any indices may need further evaluation to determine the reasons for the changes. That analysis may be a function of low reported crude numbers or an anomaly that would need more evaluation by the Pennsylvania Department of Health.

CHRONIC LOWER RESPIRATORY DISEASE (CLRD) INCLUDING ASTHMA

Chronic Lower Respiratory Disease (CLRD) is a disease category predominately suffered by the elderly, therefore the death rate for CLRD would be expected to be highly influenced by an area's elderly population and percentage of elderly-to-total population. It is consistently one of the top five leading causes of death for the elderly both at the state and county levels.

FIGURE 12



As can be seen in Figures 12 and 13, the increase in the elderly population in the top Marcellus counties had only a slight association with trends in mortality deaths due to CLRD. The six-county area is consistently higher than the state from 2000-2014, which is in line with their higher elderly populations. During the same time period, there was significant improvement in the other causes of death for more treatable diseases such as cancer and heart disease (as will be seen later in the report), which lengthens the life span of the elderly and puts them at higher rates of respiratory diseases as the final cause of death. Much of the six-county area lies in the coal mining region where diseases of the respiratory system[39] are known to cause higher respiratory death rates as the population ages. Looking at the individual county age-adjusted rates, most areas realized an increase that was consistent with the increase of the elderly population.

FIGURE 13: CHRONIC LOWER RESPIRATORY DISEASE DEATH RATES

	2000-2002	2003-2005	2006-2008	2009-2011	2012-2014
BRADFORD	40.9	45.3	36.4	52.2	47.4
GREENE	41.3	40.0	63.2	73.1	78.5
LYCOMING	45.5	50.1	53.5	57.7	43.8
SUSQUEHANNA	43.2	49.5	49.1	55.4	45.3
TIOGA	40.7	42.9	34.2	49.6	49.0
WASHINGTON	41.1	39.8	43.4	41.6	49.0
PENNSYLVANIA	39.2	39.2	40.0	38.9	38.1

Three of the six shale counties — Bradford, Lycoming and Susquehanna— experienced significant declines in the CLRD death rates between 2009 and 2014. Their rates were almost at or below the national rate by 2014. Tioga's rate also declined from 2009-2014, but its rate was slightly above the national rate at 49 by 2014, and Washington's rate also was 49 by 2014. The only county that experienced a significant increase in the rate was Greene County, with an age-adjusted rate of 78.5 in 2014.

For the top Marcellus counties and the state, the increase was consistent and on par with what would be expected due to the increase of the elderly population, except for Greene County. In Greene County, the crude numbers used to calculate the rate are low, so producing a statistically reliable rate is difficult, lifestyle choices such as diet, exercise, and smoking could be different from other counties; and other anomalies beyond the scope of this study could be the reason for the rate increases.

A more in-depth review of Greene County is needed to determine if the age-adjusted rates are reflective of the real experience there. Figures 14 and 15 summarize Greene County's crude numbers and the crude death rates for the 65-and-older population and total population.

FIGURE 14

GREENE COUNTY	2000	2003	2006	2009	2012	2014
ACTUAL 65+ DEATHS	21	18	18	27	33	31
TOTAL POPULATION	40,672	40,398	40,432	39,245	38,085	37,843
CRUDE RATE	51.62	44.56	44.52	68.80	86.65	81.92

Crude rate = per 100,000 of total pop in the given year

39 United States Department of Labor, https://www.dol.gov/owcp/contacts/region-phi/3phibl.htm.

FIGURE 15

GREENE COUNTY	2000	2003	2006	2009	2012	2014
ACTUAL 65+ DEATHS	21	18	18	27	33	31
65+ POPULATION	6,193	6,047	5,913	5,941	6,174	6,456
65+POP CRUDE RATE	339.09	297.67	304.41	454.47	534.50	480.17

65+ POP Crude rate = per 100,000 65+ population in the given year

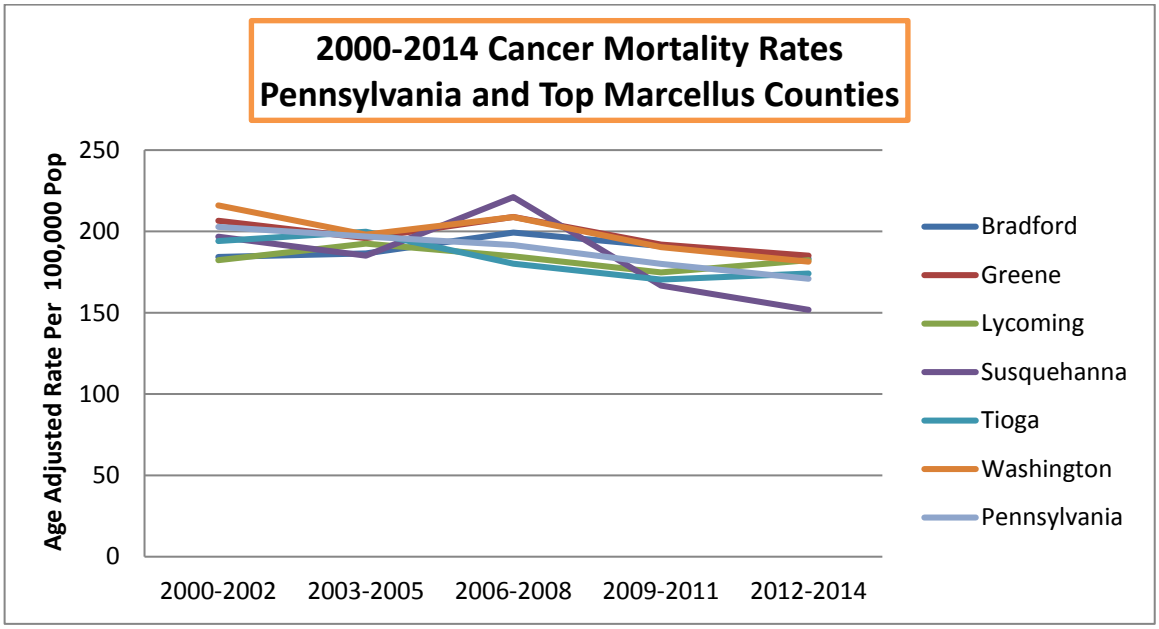
In looking at the real experience in Greene County based on the crude rates, the first trend that becomes evident is that the rate actually declines from 2012 to 2014. The data also show that the jump in the rates from 2000 to 2014 correlates with a significant increase in the number of actual deaths due to CLRD from 2009-2014 compared to 2000-2006. At the same time, the total population declined while the 65-and-over population significantly increased. In both scenarios, the crude rate significantly jumps in 2009 and then the raw numbers remain relatively steady in a range of 27-33. The county and the state need to look at the reporting mechanism during this time period. Was there a change in reporting causes of death on the death certificates or was there another reason for these increases?

CANCER

Cancer mortality rates would be expected to increase if there is a significant increase in the elderly population. Cancer mortality is experienced over all age groups, but is disproportionately experienced by those age 65 and over.[40] If there is not an increase in the top Marcellus counties, then other factors such as improving economy, better access to care, affordability of care, and improved preventative care could be reasons for the improvement along with lifestyle changes, quality of life and stress reduction.

As Figure 16 shows, cancer mortality rates remained steady or declined in the six top Marcellus counties from 2000-2014.

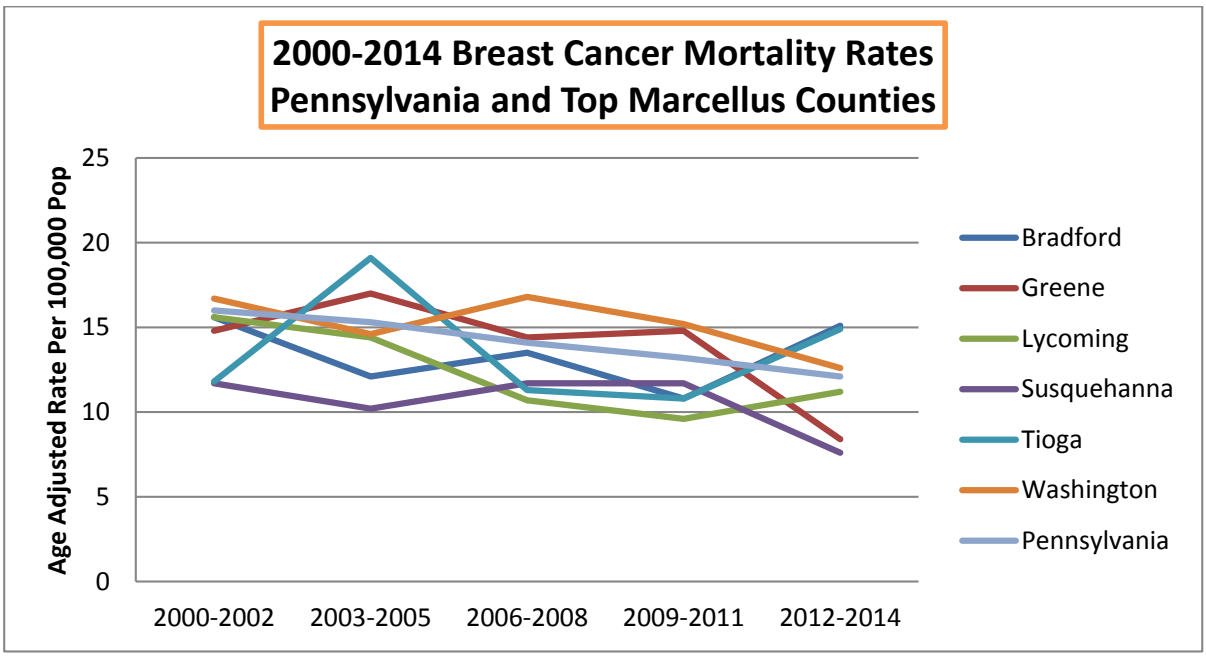
FIGURE 16



40 "Older Persons' Health," National Center for Health Statistics, Center for Disease Control and Prevention, https://www.cdc.gov/nchs/fastats/older-american-health.htm.

Breast cancer is one of leading causes of cancer deaths. The trends in breast cancer mortality are important to review to see if any area has experienced negative changes or improvements. As Figure 17 shows, breast cancer mortality rates improved overall. From 2000-2002, five of the seven areas (including the state), had rates above 15 deaths per 100,000 and two counties were below 15 deaths per 100,000. By 2014, all of the counties and the state had rates below 15 deaths per 100,000 and two counties had rates below 10 deaths per 100,000, which reflect a significant improvement.

FIGURE 17



The cancer mortality rates declined or were stable in all six counties, with an overall decline observed in the top Marcellus counties. Breast cancer mortality rates saw a significant decline.

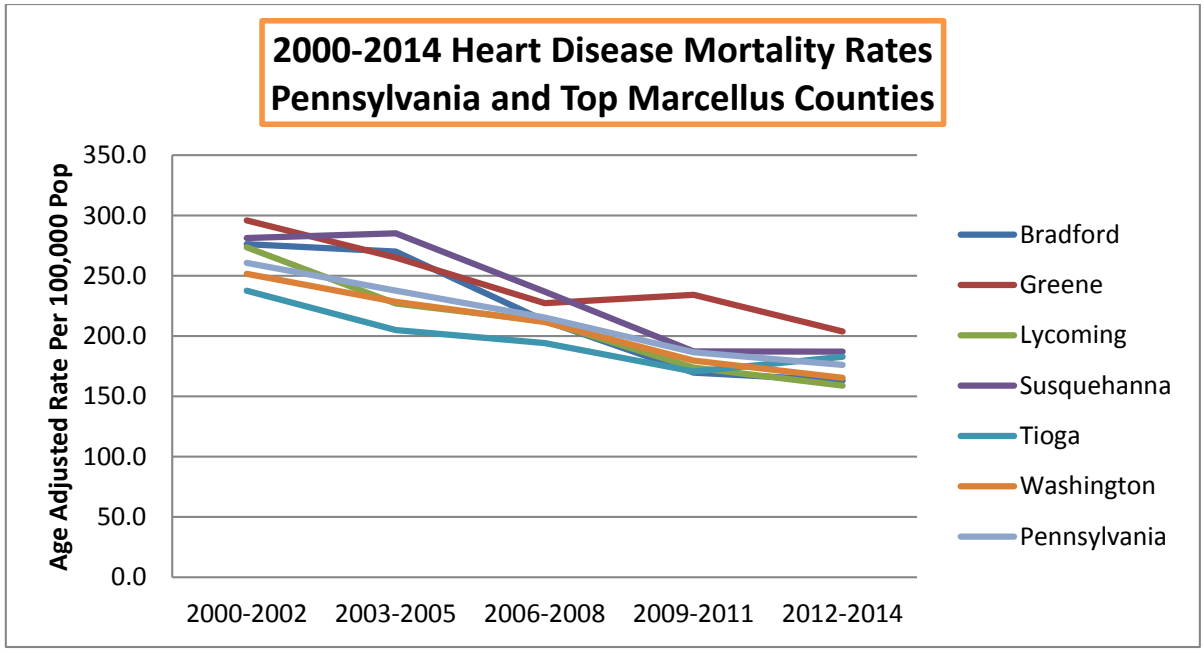
DISEASES OF THE HEART

The Center for Disease Control (CDC) is the supervisory government agency over health profile data, and it defines the indices and monitors the accuracy of health data submitted by the states. The CDC recognizes heart disease as an important disease and defines the parameters of the data and the impact of heart disease on a population.

As the leading cause of death[41] for men and women in the United States, heart disease is responsible for over 610,000 deaths each year – or one in four deaths. That equates to about one heart related death every minute. Further, about half of all Americans have at least one of the three top risk factors for heart disease: high blood pressure, high LDL cholesterol and/or they are smokers.

The following graph (Figure 18) of the six-county area and Pennsylvania trends in age-adjusted heart disease death rates shows a significant reduction in deaths due to heart disease.

FIGURE 18



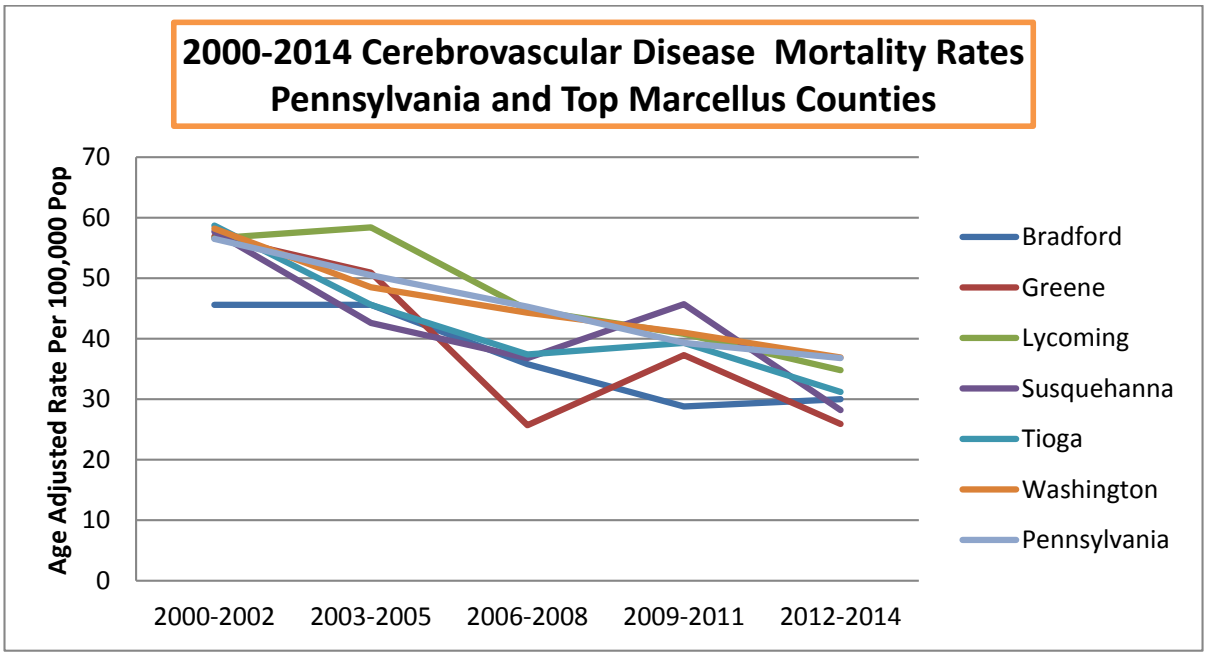
41 National Center for Chronic Disease Prevention and Health Promotion, Division for Heart Disease and Stroke Prevention, https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm.

CEREBROVASCULAR DISEASE (CD)

Stroke is the primary cause of death in the cerebrovascular disease category. The CDC explains[42] that as the fifth leading cause of death for Americans, one of every 20 deaths is the result of a stroke, accounting for more than 130,000 deaths each year. That equates to someone dying from a stroke every four minutes in the United States. While strokes may occur at any age, the risk of experiencing one increases with age.

As Figure 19 shows, death rates due to CD declined significantly for the state and the top Marcellus counties despite the increase in the elderly population.

FIGURE 19

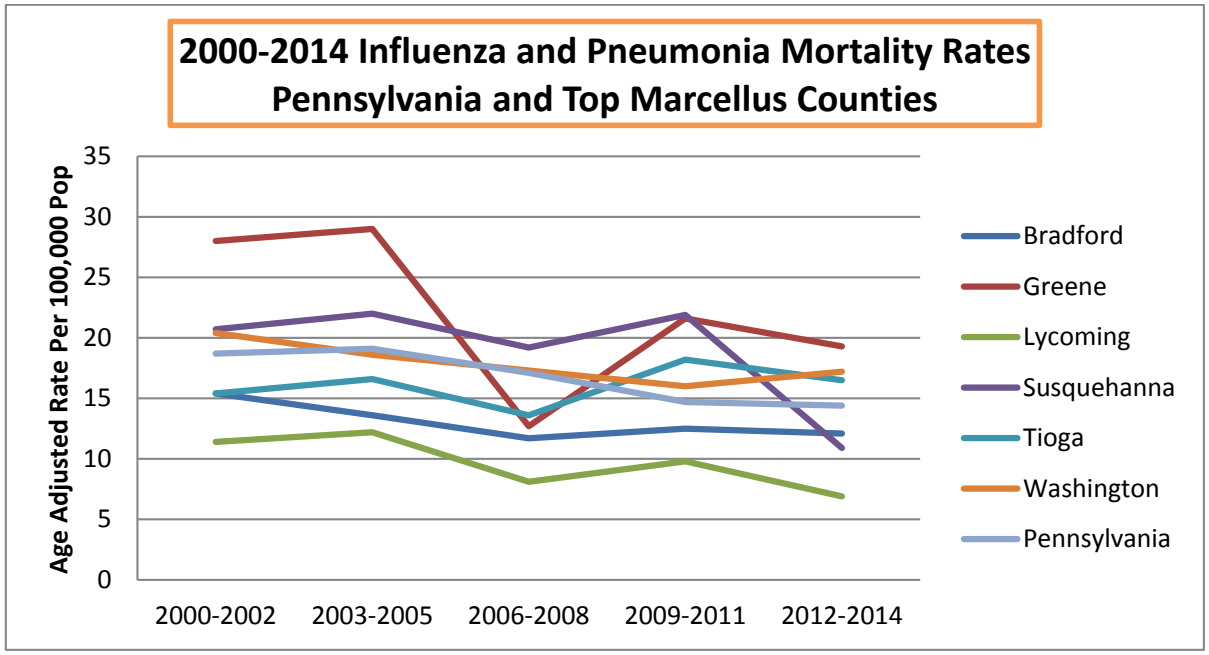


42 National Center for Chronic Disease Prevention and Health Promotion, Division for Heart Disease and Stroke Prevention, https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm.

INFLUENZA AND PNEUMONIA

Influenza is another indicator that impacts a large portion of the population, but particularly the elderly, young children or those with existing health conditions.

FIGURE 20

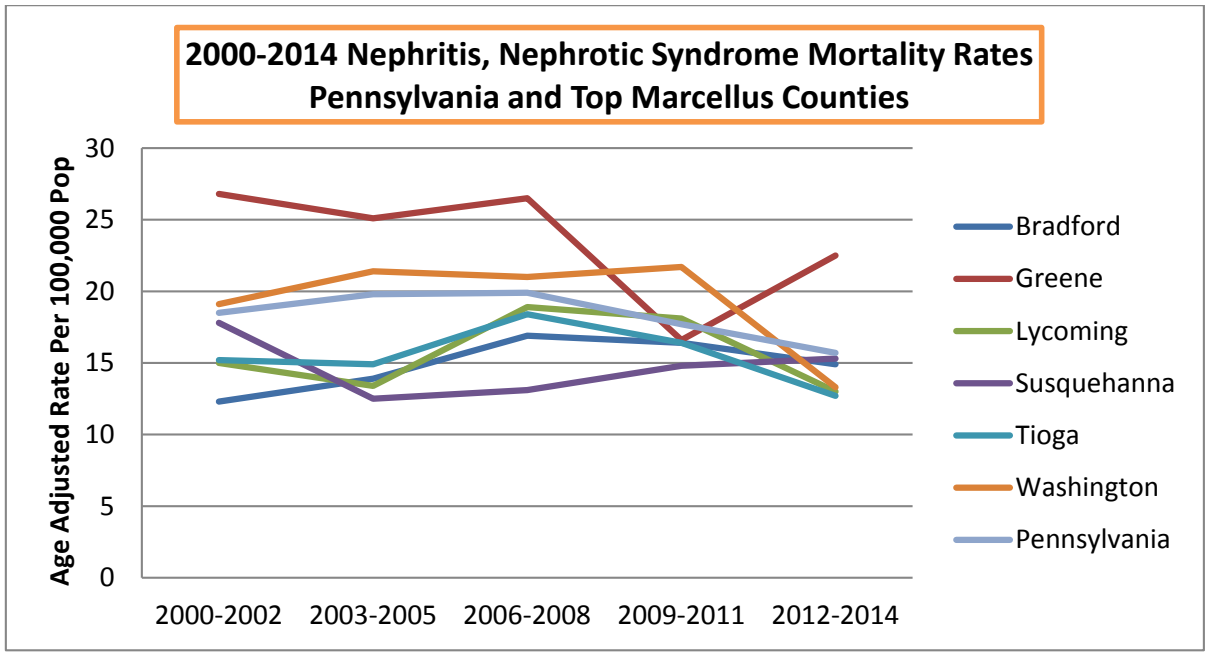


Influenza and pneumonia mortality rates (Figure 20) declined in all of the counties except Tioga, with significant declines in Susquehanna and Greene Counties. There was decline in the influenza mortality rate, with three counties exceeding a rate of 20 deaths per 100,000 in 2000 and none of the counties exceeding a rate of 20 deaths per 100,000 by 2014. Tioga increased slightly which was more than offset by the sharp decline in Susquehanna.

NEPHRITIS/NEPHROTIC SYNDROME (KIDNEY DISEASE)

The CDC lists[43] kidney disease as the ninth leading cause of death in the United States, impacting more than 20 million adults or 10 percent of the U.S. adult population.

FIGURE 21



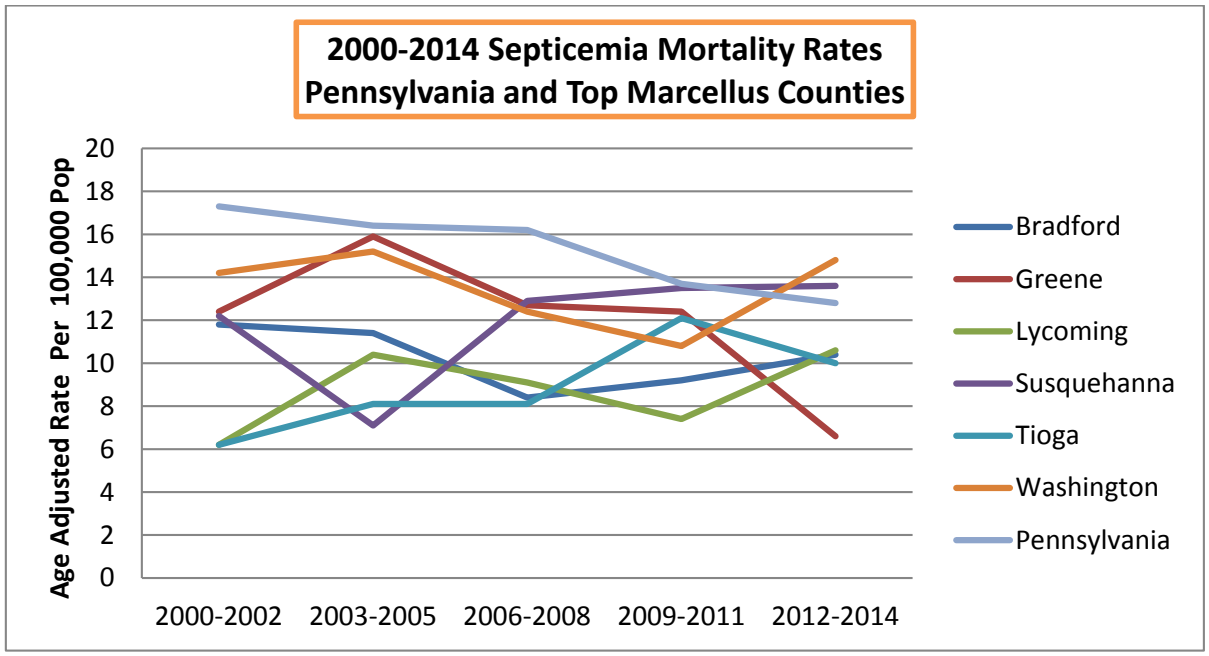
Nephritis/nephrotic syndrome mortality rates (Figure 21) declined in all of the top Marcellus counties and the state, except for a slight overall increase in Greene County. Except for Greene County, all counties and the state were at or below 15 deaths per 100,000 by 2014, while all but one was at or above 15 deaths per 100,000 in 2000. There was an overall decline in the nephritis/nephrotic syndrome mortality rate for the top Marcellus counties, despite the large increase in the elderly population.

43 Centers for Disease Control and Prevention: About CDC's Division of Diabetes Translation, https://www.cdc.gov/diabetes/about/.

SEPTICEMIA (SEPSIS)

The last mortality indices reported on in the health profiles report is septicemia. The CDC finds that more than 90 percent of adults and 70 percent of children who developed sepsis had a health condition that may have put them at risk, and that sepsis is most likely to occur in the elderly, children under the age of one, or individuals with weakened immune systems.

FIGURE 22



The increase in the elderly population would be a primary factor in the increase of sepsis in a community or area. Because of the significant increase in the elderly, a primary age group that is most susceptible to sepsis, it would be expected that the top Marcellus counties would have experienced a comparable increase in sepsis mortality rates. Septicemia mortality rates saw various changes in the rate from 2000-2014 in all of the counties (Figure 22). There were some counties that experienced a decline, some that saw an increase and some that saw no overall change. This variability reflects the nature of septicemia and its primary origin from the transmission of nosocomial diseases in to community (80 percent) and in healthcare settings (20 percent), the aging of the population, growing antibiotic resistance, delay of care common in the independent elderly, and the randomness of infectious disease. There was an overall slight decline in the septicemia mortality rate for the six-county Marcellus area despite the large increase in the elderly population.

CONCLUSION

This report reviewed the disease mortality indices reported to the state of Pennsylvania and the CDC for the six Pennsylvania counties where the most unconventional oil and gas development has occurred. Pennsylvania has a comprehensive database and a decades-long history of reporting this data, providing the reviewer a consistent, reliable and sanctioned independent database to draw from for this study. Most importantly, the source of the data is the Pennsylvania State Health Department, as part of the National Center for Disease Control reporting system, and therefore is not data generated by the researcher. This protects the conclusion from bias and ensures that the study can be replicated when peer-reviewed.

The results of this study suggest no identifiable impact on death rates in the top Marcellus counties as a result of unconventional gas development. In fact, in most of the indices the six counties experienced declines in mortality rates.

That does not mean one can conclude that oil and gas development caused this favorable decline in deaths; it merely indicates the activity did not likely cause the opposite to occur. However, economic prosperity[44] has been known to improve health outcomes and improve preventative care, diagnostic outcomes and treatments, as well as improve lifestyle factors that reduce the risk of early death.

Among the many researchers who have studied the impact of economics on health outcomes is internationally renowned public health researcher M. Harvey Brenner, Ph.D.,[45] who summarized this premise in one of his articles,[46] saying, "It is now among the firmest of epidemiological findings, across industrial societies, that socioeconomic status is inversely related to health status."

In other words, if a community's economic status improves, then the mortality rates in the community will usually decline. Dr. Brenner explained, "... key economic factors leading to improvements in the national economy mean longer life and reduced rates of mortality."

In fact, Dr. Brenner says this is the central factor in mortality rates declines, explaining that, "Economic growth, cumulatively over at least a decade, is the central factor in mortality rate decline in the U.S. over the 20th century."

> "It is now among the firmest of epidemiological findings, across industrial societies, that socioeconomic status is inversely related to health status"
>
> — M. Harvey Brenner, Ph.D.

44 Brenner, M.H., "Economic Growth Is the Basis of Mortality Rate Decline in the 20th Century." International Journal of Epidemiology, July 2005.

45 M Harvey Brenner, PhD has been professor in the Department of Social and Behavioral Sciences, UNT Health Science Center since 2005. He has been professor of Health Policy and Management at the Johns Hopkins University from 1979 to the present (part-time since 2005), and professor and chair of Epidemiology, Institute for Health Sciences, Berlin University of Technology (Germany), from 1997 to the present. Within the United States, Dr. Brenner has done the major work on the impact of the economy on physical and mental health for the United States Congress Joint Economic Committee. In addition to UNTHSC, Dr. Brenner has taught at Yale University and Harvard University, as well as Johns Hopkins University and Berlin University of Technology. He has served as a consultant for the United Nations Social Defense Research Institute, World Health Organization, Joint Economic Committee of the U.S. Congress, the European Union, and several European countries. Recipient of the 1997 – American Public Health Association "Career Award for Scientific Excellence". UNT Health Science Center and Speakerpedia, 2017, https://www.untsystem.edu/universities/unt-health-science-center.

46 Brenner, M.H., "Health Benefits of Low-Cost Energy – An Econometric Case Study," EM, Air & Waste Management Association, November 2005, 28-33.

These main economic predictors he identified are: real GDP per capita, the employment ratio, the unemployment rate, and the interaction between GDP and unemployment.[47] He concluded, "...while known risk factors to health, such as high consumption of tobacco, alcohol, and fatty foods, are additionally significant predictors of mortality, they are subordinate to the main economic predictors that routinely influence mortality."

This study's conclusions, based on the mortality rates of the six Pennsylvania counties where the most natural gas development has occurred are consistent with Dr. Brenner's findings.

> "**Economic growth**, cumulatively over at least a decade, **is the central factor in mortality rate decline** in the U.S. over the 20th century."
>
> — M. Harvey Brenner, Ph.D.

47 Brenner, M.H., "Economic Growth Is the Basis of Mortality Rate Decline in the 20th Century." International Journal of Epidemiology, July 2005

APPENDIX A

SOURCE: PENNSYLVANIA DEPARTMENT OF HEALTH - TOOLS OF THE TRADE

RELIABILITY OF RATES

A common problem experienced by public health professionals and agencies, especially at the local level, is how to reliably use rates when the number of events being studied is small. All statistics are subject to chance variation. However, rates based on an unusually small number of events should be of particular concern and caution. An example of this problem is mentioned below and recommendations on how to cope with it are also discussed.

A public health objective is usually stated in terms of reaching a certain point or level over time. For example, the 1990 objective (set by the U.S. Public Health Service) for the infant death rate is 9.0 per 1,000 live births. An infant death rate is a standard computation and routinely compared over time for achievement purposes. However, for areas with few infant deaths, the statistical unreliability of such a rate can cause problems. For example, if a county agency chose the 9.0 infant death rate as its goal for 1990 and computed a rate of 11.0 in 1990, they might assume that they did not reach their goal. Yet, if the annual rate was based on only 50 deaths, the rate has a 95% confidence interval of 8.0-14.0, which happens to include 9.0. In reality, the actual rate of 11.0 is not statistically different from the goal of 9.0.

When setting standards for achievement that requires the use of measurements such as rates, stating what the goal will be and when it is to be reached may not be enough. Some people may not be satisfied that the true rate falls within a six-point spread.

A rather easy solution to this problem is to increase the number of events in the computation. This could be done in two ways. First, one could enlarge the population base being studied so that more events are included. For example, instead of setting objectives for a small, rural county, several adjoining counties could be included. Changing the rate from an annual to a multi-year rate is a second approach. Three and five-year summary rates provide more accurate descriptions of events that do not occur very often. Also, use of "moving averages" can be another alternative. It is a more advanced use of multiple year rates which involves the computation of several multi-year rates over an extended period of time, such as five separate three-year summary rates for the last seven years of available data. For example, if 1986 was the most recent year for which data were available, a moving average over seven years (1980-1986) would involve computation of three-year summary rates for the periods 1980-82, 1981-83, 1982-84, 1983-85 and 1984-86. However, these "easy" solutions can create other problems. A county agency solely responsible for a small, rural area cannot justifiably include other adjoining counties in its figures. Also, use of only one or two multi-year rates due to the unavailability of much historical data can limit the range of trend analysis and both a multi-year rate and "moving averages" may not reflect recent medical advances or the timely testing of any new program interventions. Therefore, if these "easy" solutions do not work for you, your only alternative may be to use an unstable rate that can fluctuate widely from year to year and is not truly representative.

What can be defined as stable and unstable rates and how do you cope with unstable rates? If we defined a stable rate as one whose 95% confidence interval is 15% of the rate, then 1,600 events are needed. This is generally a rare number of events for any annual measurement below the state level in Pennsylvania. Because such a large number of events is necessary to compute a stable rate, you should always be cautious when setting health objectives that involve computation of rates. Regardless of the number of events involved, it's probably a good idea to compute and list a confidence interval for the rate to compare with the goal. If the goal lies within the confidence interval range, then you can state that the actual rate and the goal are not statistically different. As a rule, setting objectives based on 20 or more events (infant deaths, low birth weight infants, etc.) is a good standard to follow. If an objective involving more events can be created, then that objective should be used.

The following table shows you how to compute the length of 95% confidence intervals for rates based upon the number of events in the numerator of the rate. It can be used to measure the reliability of a rate you may have to use.

95 PERCENT CONFIDENCE INTERVALS FOR RATES BY THE NUMBER OF EVENTS INVOLVED

NUMBER OF EVENTS	CONFIDENCE INTERVAL
20	Rate ± 0.40 x Rate
30	Rate ± 0.36 x Rate
40	Rate ± 0.31 x Rate
50	Rate ± 0.28 x Rate
75	Rate ± 0.23 x Rate
100	Rate ± 0.20 x Rate
150	Rate ± 0.16 x Rate
200	Rate ± 0.14 x Rate
300	Rate ± 0.11 x Rate
400	Rate ± 0.10 x Rate
800	Rate ± 0.07 x Rate
1600	Rate ± 0.05 x Rate

In addition to the problems associated with rates based on small numbers, please remember that any rate in any given time frame for any given population is the ACTUAL rate. However, it may not represent the UNDERLYING rate - the rate that one would expect over time or a rate free of random variation from year to year. The implicit assumption is that a rate in a particular year represents a single selection from a collection of rates over a number of years.

ADJUSTED VS. SPECIFIC RATES

In "Adjusted Rates," you learned how to compute rates adjusted to one or more demographic factor/s, usually age, sex and/or race. These rates involved computations of specific mortality rates and, then, the mathematical use of a "standard" population to arrive at the final number. An adjusted rate is not a good indicator of the absolute level of mortality in a population, but is useful for purposes of comparison. However, some people contend that adjusted rates can easily lead to misinterpretation. They believe that age, sex and/or race specific rates are more useful descriptions of vital events and do not easily lend themselves to misinterpretation.

The following are some pros and cons about these two different types of rates:

An adjusted rate is an artificially created figure that enables comparison across time and space. It should only be compared with another adjusted rate that was computed using the same "standard" population. However, it does provide a single figure which can be easily used and adapted for comparative analysis. There is still the possibility of misuse of this type of rate by people unfamiliar with its meaning. For instance, multiplying an adjusted mortality rate by the actual population being studied will not produce a figure

representing the actual number of deaths. As an example, in our last issue, we computed County I's 1982 age-adjusted death rate as 907.9 per 100,000 population. County I's population in 1982 was 68,292. If you multiply 68,292 by .009079, you will get a figure of 620 rather than the actual number of 556 resident deaths in 1982 in County I. For this reason alone, adjusted rates should always be thoroughly qualified when being used.

A specific rate is a real number. It provides an absolute measurement as well as a useful statistical tool for comparison and trend analysis. For example, Pennsylvania's crude birth rate expressed as the number of resident live births per 1,000 total population has shown a gradual increase from 12.9 in 1978 to 13.6 in 1982. However, if you compute age-specific birth rates for each of those years (i.e. the number of live births per 1,000 total women for each five year age group 10-44), you will discover a significant decrease in the age-specific birth rates among women under 25 with corresponding significant increases for women 25 and over. This indicates a trend that actually reverses a past pattern. Unfortunately, use of specific rates in analysis can result in massive amounts of data with which to work and/or display. Large amounts of data can become difficult for user and audiences to digest.

Proper or improper use of adjusted or specific rates usually depends on the analyst's needs. Whichever serves the purpose of getting an important point across simply, clearly, and accurately is the most appropriate. But always make certain that both you and your audience understand exactly what the rate is you are using to make that important point of yours.

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