



This report, *Identifying Bright Spots in Appalachian Health: Statistical Analysis*, was produced through the “Creating a Culture of Health in Appalachia: Disparities and Bright Spots” research initiative funded by the Robert Wood Johnson Foundation (RWJF) and the Appalachian Regional Commission (ARC), and administered by the Foundation for a Healthy Kentucky. To date, this multi-part health research project has produced the following three reports:

1. *Health Disparities in Appalachia* (August 2017) measures population health in the Appalachian Region and documents disparities between Appalachia and the nation as a whole, as well as disparities within the Region.
2. *Identifying Bright Spots in Appalachian Health: Statistical Analysis* (July 2018) describes the results of the regression analysis used to assess how each of the Appalachian Region’s 420 counties scored on 19 different health indicators, and then identifies counties with better-than-expected outcomes, given their characteristics and resource levels. Through this process, 42 Appalachian counties were classified as Bright Spot counties.
3. *Exploring Bright Spots in Appalachian Health: Case Studies* (July 2018) presents in-depth studies of 10 of the 42 Bright Spot counties identified through the statistical analysis. This report explores local perceptions of practices that may be associated with better-than-expected health outcomes, and summarizes promising strategies that may be replicable in other communities.

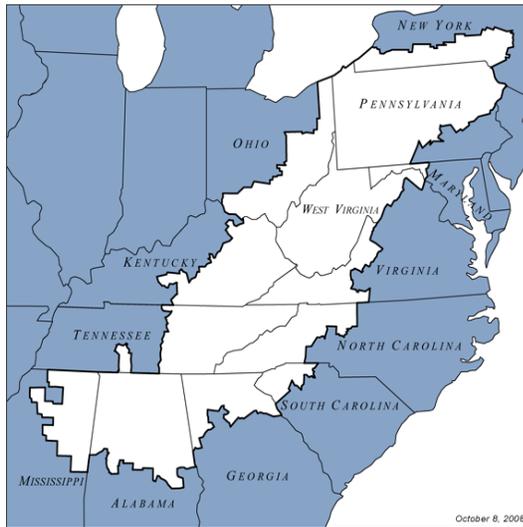
As described above, this report is the second in the series and is the quantitative companion to the third report, *Exploring Bright Spots in Appalachian Health: Case Studies*.

The reports offer a basis for understanding and addressing health in the Appalachian Region and for identifying factors that support a culture of health in Appalachian communities. They also explore activities, programs, and policies that may encourage better-than-expected health outcomes, many of which may be replicable in other communities.

The fourth and final report in the series, expected to be published in late 2018, will provide recommendations for practical strategies and activities that build on the findings of the first three reports.

## ABOUT THE APPALACHIAN REGION

The current boundary of the Appalachian Region includes all of West Virginia and parts of 12 other states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia (see Figure 1). The Region covers 205,000 square miles and 420 counties, and is home to more than 25 million Americans. Forty-two percent of the Region’s population is rural, compared with 20 percent of the national population.

**Figure 1: Map of the Appalachian Region**

## BRIGHT SPOTS ANALYSIS

### Overview

The primary objective of this report is to use regression analysis to identify Bright Spots, or counties in the Appalachian Region that have better-than-expected health outcomes given their characteristics and resource levels—that is, the socioeconomics, demographics, behaviors, health care facilities, and other factors that influence health outcomes. The second objective is to develop a systematic way to match the counties identified as Bright Spots with other counties in the Region to facilitate the exchange of ideas and lessons learned. The third objective is to identify the factors that appear to have the greatest impact on health outcomes—although this statistical analysis will provide *suggestions* rather than definitive *conclusions*.

The use of regression models and residual-based analyses is common in health research, though typically the focus of these research efforts is on how much the factors included in the model *explain* the outcome. In the Bright Spots analysis, however, the *unexplained* portions are of the greatest interest—that is, which counties are the most “unexpectedly” healthy given their characteristics and resources.

The model in this report bears some similarity to another research approach used to identify positive health outcomes that occur despite difficult circumstances. That approach, *positive deviance*, identifies the individuals, groups, and organizations affecting change at the local level, as opposed to macro-level policies at the state and national levels. The underlying principle of positive deviance is that by identifying individuals and groups that are overcoming challenges affecting a large number of people in a given community, researchers can identify specific, simple best practices that can be shared with other communities. Many of the best practices uncovered via the positive deviance approach originate from within the community and are implementable despite resource constraints.

Although the Bright Spots model does not fit wholly under the umbrella of positive deviance, this approach provided the motivation for our framework and the foundation for exploring counties through in-depth, field-based case studies.

## Methods

The general approach in this analysis assumes we can broadly measure health in a community, compare actual outcomes to expected outcomes, and determine whether a community exceeds expectations.

We first identified 19 county-level *outcome* measures that capture the overall health of a community (see Table 1). Some examples of these measures include the infant mortality rate, cancer mortality rate, percentage of adults who are obese, prevalence of diabetes, and prevalence of depression among Medicare beneficiaries. The selected outcomes represent both physical and behavioral health, as well as diagnosed and perceived health.

We then identified 29 county-level *drivers* known to affect individual and community health (see Table 2). The drivers were organized into broad categories, such as social determinants, health behaviors, and access to health care services. Examples of drivers include median income, percentage of adults with some college education, percentage of the population under age 65 who are uninsured, number of primary care physicians per 100,000 population, and percentage of adults who smoke.

A multivariate regression analysis determined the relationship between the 19 health outcome measures and the 29 driver measures, producing one expected value for each of the 19 outcome measures *for each Appalachian county*. The expected outcomes were then compared to the actual, observed outcomes for each county to identify counties that performed better than expected. In most counties, some of the 19 outcomes were better than expected and some were worse than expected. Each outcome residual was then standardized into a *z*-score to allow comparison across all outcome measures. We reversed signs on the outcomes so that positive *z*-scores indicated “good health.”

By using the average *degree* to which a county’s observed health outcomes exceeded expected values, the Bright Spots model identified counties that either did very well on a few outcomes or exceeded expectations—perhaps only marginally—across many outcomes.

Because access to resources differs between metropolitan and nonmetropolitan areas, the statistical analysis was applied independently to two geographic groups: metropolitan and nonmetropolitan counties. Inclusion in a U.S. Census Metropolitan Statistical Area defined a county as metro. However, because the metro and nonmetro datasets are distinct, average residuals of the two groups are *not* comparable.

**A county whose average of all 19 standardized outcome residuals scored in the top decile in either the metropolitan or nonmetropolitan group was classified as a Bright Spot.**

The variation in county location and economic status lends support to the study design—we did not aim to identify healthy counties with high levels of resources and the sorts of characteristics that support positive health outcomes, but rather counties encompassing a wide range of resource levels and characteristics that all managed to find a way to be healthier than expected. Bright Spots are places that exceed expectations, *regardless of the values of the drivers*. This is a strength of the approach, one that allowed us to focus on the positive aspects of communities *relative to their own characteristics and resource levels*.

**Table 1: Outcome Measures**

Category	Measure
Mortality	Years of potential life lost per 100,000
	Stroke mortality per 100,000
	All cancer mortality per 100,000
	Unintentional injury mortality per 100,000
	COPD mortality per 100,000
	Heart disease mortality per 100,000
Mental Health	Average mentally unhealthy days per person per month
	Suicide mortality per 100,000
	Percentage Medicare beneficiaries with depression
Child Health	Percentage of live births with low birth weight (<2500g)
	Infant mortality per 1,000 births
Chronic Disease	Percentage adults with diabetes
	Medicare heart disease hospitalizations per 1,000
	Average Hierarchical Condition Category (HCC) risk score per Medicare beneficiary <sup>a</sup>
	Percentage adults with obesity (BMI>30)
	Average physically unhealthy days per person per month
Substance Abuse	Percentage residents drinking excessively
	Poisoning mortality per 100,000
	Opioid prescriptions as percentage of Part D claims

Notes: a. Unless noted, information on each measure is included in the Disparities report in this series (Marshall, et al., 2017).

**Table 2: Driver Measures**

Category	Measure
Child Health	Teenage births per 1,000
Environment	Full-service restaurants per 1,000 population <sup>a</sup>
	Percentage with access to exercise opportunities <sup>a</sup>
	Air pollution (average daily particulate matter, PM <sub>2.5</sub> ) <sup>a</sup>
	Grocery stores per 1,000 population
	Students per teacher (primary and secondary school)
	Average travel time to work in minutes
Health Behaviors	Percentage of adults currently smoking
	Percentage of adults not physically active
	Chlamydia incidence per 100,000
Health Care System and Utilization	Primary care physicians per 100,000 population
	Dentists per 100,000 population
	Specialty physicians per 100,000 population
	Mental health providers per 100,000 population
	Percentage of physicians that e-prescribe
Quality	Percentage under 65 who are uninsured
	Percentage of Medicare diabetics with HbA1c testing
Social Determinants	Percentage of Medicare women with recent mammogram
	Percentage of total population in paid Social Assistance jobs <sup>a</sup>
	Income inequality ratio <sup>a</sup>
	Percentage eligible enrolled in SNAP (Food Assistance) <sup>a</sup>
	Percentage of households with no car and low access to grocery stores <sup>a</sup>
	Percentage of households spending >30% of income on housing <sup>a</sup>
	ARC Economic Index
	Social association rate per 10,000 population
	Percentage receiving disability benefits (OASDI and/or SSI)
	Percentage of adults with some college education
	Percentage of households with income below poverty line
Median household income	

### The Bright Spot Counties

Appalachian counties with an average standardized residual score in the top decile (10 percent) in either the metropolitan or the nonmetropolitan groups were identified as Bright Spots. Thus, the model identified 42 Appalachian Bright Spot counties: 15 in the metropolitan group and 27 in the nonmetropolitan group. The 42 counties in the top decile represent *the best of the better than expected*. In fact, scores for 202 counties were better than expected; the Bright Spots are simply those counties with scores in the top ten percent in their respective groups.

Bright Spot counties are located in all five Appalachian subregions and represent the diversity of communities across the Appalachian Region (see Figure 2).

**Figure 2: Map of the Bright Spot Counties in Appalachia**

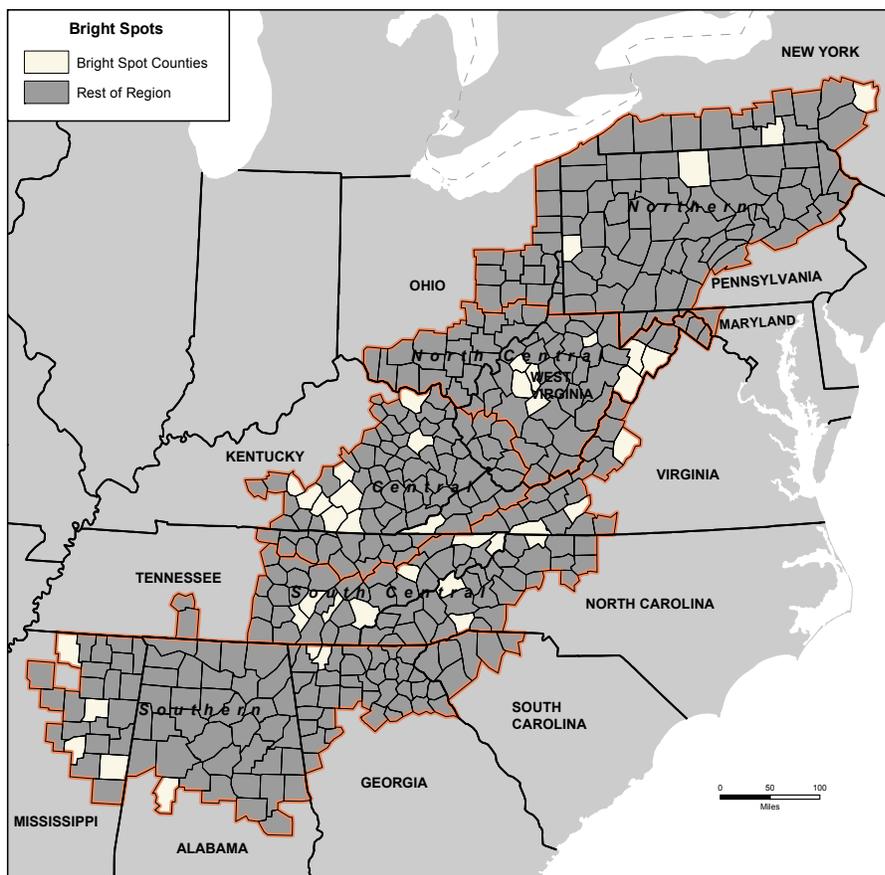


Table 3 lists the metropolitan Bright Spot counties, their average standardized residual score, and the outcome with the highest residual, which reflects the greatest *over performance* relative to available resources. Table 4 shows the same information for nonmetropolitan Bright Spot counties.

The higher the residual score, the more a county outperformed its expectations. The standardized residual scores represent standard deviations. For example, outcomes in a county with an average residual score of 0.47 were, on average, 0.47 standard deviations above the expected outcomes.

**Table 3: Metropolitan Appalachian Bright Spot Counties, Ranked by Average Outcome Residual**

Rank	County	State	Average Standardized Residual Score <sup>a</sup>	Highest Individual Residual <sup>b</sup>	
1	Wirt	West Virginia	0.47	Injury mortality	1.58
2	Clay	West Virginia	0.40	Heart disease mortality	1.51
3	Henderson	North Carolina	0.35	% obese adults	0.98
4	Hale	Alabama	0.35	Depression prevalence	1.10
5	Sequatchie	Tennessee	0.31	Poisoning mortality	1.22
6	Floyd	Virginia	0.30	COPD mortality	1.08
7	Sullivan	Tennessee	0.30	Poisoning mortality	1.23
8	Marshall	Mississippi	0.30	% opioid Rx claims	1.58
9	Madison	North Carolina	0.29	% obese adults	1.26
10	Whitfield	Georgia	0.29	Depression prevalence	0.97
11	Tioga	New York	0.27	Stroke mortality	0.87
12	Schoharie	New York	0.25	Average HCC risk score	0.83
13	Beaver	Pennsylvania	0.25	Average HCC risk score	1.00
14	Jefferson	Tennessee	0.24	Average HCC risk score	1.06
15	Catoosa	Georgia	0.24	Stroke mortality	0.90

Notes: a. Average residual score for the regression analysis involving 152 Appalachian metro counties

b. Highest of the 19 standardized residual outcome scores for each county.

**Table 4: Nonmetropolitan Appalachian Bright Spot Counties, Ranked by Average Outcome Residual**

Rank	County	State	Average Standardized Residual Score <sup>a</sup>	Highest Individual Residual <sup>b</sup>	
1	Wayne	Kentucky	0.72	Stroke mortality	1.79
2	Noxubee	Mississippi	0.58	COPD mortality	2.19
3	Calhoun	West Virginia	0.58	Injury mortality	2.02
4	Grant	West Virginia	0.49	Cancer mortality	1.88
5	McCreary	Kentucky	0.45	Poisoning mortality	1.94
6	Potter	Pennsylvania	0.45	Heart disease mortality	1.44
7	Taylor	West Virginia	0.42	Heart disease hospitalizations	1.20
8	Rockbridge	Virginia	0.41	Heart disease hospitalizations	1.37
9	Pulaski	Kentucky	0.40	Poisoning mortality	1.64
10	Green	Kentucky	0.40	YPLL	1.38
11	Lee	Virginia	0.40	Poisoning mortality	2.29
12	Russell	Kentucky	0.40	Heart disease hospitalizations	1.68
13	Bledsoe	Tennessee	0.39	Cancer mortality	1.88
14	Grayson	Virginia	0.39	Injury mortality	1.83
15	Hardy	West Virginia	0.38	% opioid Rx claims	1.21
16	Johnson	Tennessee	0.38	Poisoning mortality	1.52
17	Lincoln	Kentucky	0.37	% obese adults	1.37
18	Meigs	Tennessee	0.36	% opioid Rx claims	2.17
19	Pendleton	West Virginia	0.36	Poisoning mortality	1.48
20	Choctaw	Mississippi	0.35	Cancer mortality	1.69
21	Adair	Kentucky	0.35	Injury mortality	1.57
22	Lewis	Kentucky	0.34	Depression prevalence	1.78
23	Roane	West Virginia	0.33	Heart disease hospitalizations	1.35
24	Monroe	Tennessee	0.32	COPD mortality	1.18
25	Alleghany	North Carolina	0.31	YPLL	1.18
26	Chickasaw	Mississippi	0.31	Stroke mortality	1.61
27	Morgan	Kentucky	0.28	Injury mortality	0.92

Notes: a. Average residual score for the regression analysis involving 268 Appalachian nonmetro counties  
b. Highest of the 19 standardized residual outcome scores for each county

## KEY FINDINGS AND OBSERVATIONS

### Bright Spot Patterns and Clusters

The Bright Spots are not distributed evenly among the Appalachian states—Kentucky and Mississippi have proportionately more Bright Spot counties than other states.

On the other hand, the model did not identify any Bright Spot counties in Ohio, a state with 32 Appalachian counties. The other two states with no identified Bright Spot counties, South Carolina and Maryland, have only a few Appalachian counties: six and three, respectively. The absence of Bright Spots in these two states may be the result of small sample sizes, whereas the Ohio result suggests a pattern of lower-than-expected outcomes.

Several Bright Spot counties appear in geographic clusters, suggesting that factors leading to better-than-expected health may prevail across broad, multicounty areas. Clustering suggests the presence of some common factor that has improved the health of the cluster. The unit of analysis, the county, may be a proxy for a larger “community.” These communities may be in the service area of a particularly effective program, health care provider, or other resource. Alternatively, other factors, such as environment, local culture, and tradition, may also support a culture of health.

### Correlation of Specific Outcomes with Overall Health

Our approach allows us to broadly measure health in a community and determine whether that community exceeds expectations. We developed the average standardized outcome residual for this purpose, as it captures the degree to which a county’s outcomes exceeded expectations. However, it is important to keep in mind that the average standardized residual does not represent the entire composition of a county’s health status. For individual outcomes, even among counties identified as Bright Spots, there were still lower-than-expected values. These results suggest that community health cannot be painted with one broad brushstroke; rather, it is more accurately represented as a multidimensional combination of many different aspects of health.

One key aspect was to model the actual value of outcomes, rather than incorporate scales or indices. With this approach, we were able to find certain *individual* outcome measures that were more highly correlated with *overall* good health outcomes. Three of the 19 health outcome measures were consistently better than expected in the Bright Spot counties:

- **Premature mortality;**
- **Unintentional injury mortality; and,**
- **Poisoning mortality.**

Premature mortality (YPLL) had the highest correlation with the average standardized residual, supporting its use as a comprehensive measure of community health. Further, outcomes such as injury mortality and poisoning mortality were highly correlated with average standardized outcome residuals in the top-performing counties. Bright Spot counties—those in the top decile of average outcome residuals—tended to have better-than-expected poisoning mortality rates.

Unintentional injury was the fourth-leading cause of death in the United States in 2014, and includes deaths due to car accidents, falls, and poisoning. Poisoning mortality includes deaths due to overdose.

Among the ten counties with the *lowest* average standardized residuals in both the metropolitan and nonmetropolitan groups—20 counties altogether—only one county performed better than expected on poisoning mortality; many others had much higher poisoning mortality rates than expected. This suggests that poisoning mortality—and by extension, substance abuse—may have an important link to overall health for all counties.

### Seven High-Impact Drivers

The results of this analysis suggest that the following seven drivers predicted the most variation in the 19 health outcomes (the direction generally associated with better health is shown in parentheses):

- **Median income (higher);**
- **ARC Economic Index value (lower);**
- **Poverty rate (lower);**
- **Percentage of adults that smoke (lower);**
- **Percentage of adults that are physically inactive (lower);**
- **Percentage of the population receiving disability payments (lower); and,**
- **Teen birth rates (lower).**

These seven drivers were better predictors of health outcomes in the Bright Spot counties than drivers describing the supply of health resources, such as the supply of primary care physicians or the supply of specialty physicians.

**These findings suggest that focusing on improvements in these seven drivers may lead to the greatest overall impact on health in a community.**

Notably, a county's teen birth rate emerged as a key driver of community health across most of the outcomes. Teen pregnancy serves as a marker for economic opportunity in the community, captures “risky behavior” among teenagers, including unprotected sex, which is often associated with substance use (Salas-Wright, Vaughn, Ugalde, & Todic, 2015), and can have long-lasting effects on young parents. The teen birth rate serves as a marker for life course outcomes: daughters of teenage mothers are more likely to become teenage mothers themselves (Albert, 2002). Practical strategies aimed at limiting teen birth rates, such as comprehensive, medically accurate sex education courses and other public health interventions, may have long-lasting, positive effects.

### Matching Bright Spot Counties to Other Counties

Because the purpose of the research was to identify Bright Spots, explore best practices—or aspects of local culture in those communities that may be associated with better-than-expected health outcomes—and ultimately share those features with other communities, we calculated a measure to determine the similarity between each Appalachian county and each Bright Spot county.

Based on demographics, resources, and community characteristics, we used Euclidean distance analysis to create a propensity score, reflecting the similarity between the Bright Spot counties and other Appalachian counties. Table 13 in Appendix C shows the closest match for each county in Appalachia to one of the Bright Spot counties selected for case studies. Table 14 in Appendix C then shows each Appalachian county's best match out of the 42 Bright Spots identified through the statistical analysis.

## Opportunity to Live Healthy

Research shows that positive health behaviors consistently have large, statistically significant relationships to good health outcomes (National Institutes of Health, 2015). Results in this report support and amplify this finding. In this study, the drivers that described behaviors, such as the percentage of adults who smoke, the percentage of adults who are physically inactive, and the teen birth rate, were more highly correlated with good health outcomes than drivers quantifying the supply of health resources. Our findings suggest that traditional public health initiatives should accompany efforts to develop community health infrastructure. For example, funding for community health workers trained to communicate chronic disease prevention behaviors might reach deeper into community values and have a greater impact on population health than the supply of additional providers alone.

Overall, this study supports an emerging body of literature that attests to the association between positive population health outcomes and a community’s social, economic, and environmental factors.

## NEXT STEPS: CASE STUDIES

From the 42 Bright Spots, we selected ten counties for in-depth, field-based investigations. The ten case study counties represent the diversity of communities in the Appalachian Region. Table 5 shows the ten case study counties, which include two counties in each of the five Appalachian subregions, an even distribution between metro and nonmetro counties, and three of ARC’s five economic status classifications.

**Table 5: Characteristics of Selected Case Study Sites**

County	State	Subregion	Metro / Nonmetro	Average Outcome Residual <sup>a</sup>	2014 Population	Economic Status <sup>b</sup>
Wirt	WV	North Central	Metro	0.47	5,810	At-Risk
Hale	AL	Southern	Metro	0.35	15,393	Distressed
Sequatchie	TN	South Central	Metro	0.31	14,431	Transitional
Tioga	NY	Northern	Metro	0.27	50,464	Transitional
Madison	NC	South Central	Metro	0.29	20,951	At-Risk
Wayne	KY	Central	Nonmetro	0.72	20,728	Distressed
Noxubee	MS	Southern	Nonmetro	0.58	11,240	Distressed
Grant	WV	North Central	Nonmetro	0.49	11,829	Transitional
McCreary	KY	Central	Nonmetro	0.45	18,073	Distressed
Potter	PA	Northern	Nonmetro	0.45	17,451	Transitional

Sources: see Table 1 in Appendix B and Tables 3 and 5 in Appendix C

- a. Average outcome residuals are not comparable between metro and nonmetro groups
- b. ARC economic designation, fiscal year 2017

The findings from the case studies are discussed in the third report in this series, *Exploring Bright Spots in Appalachian Health: Case Studies*.