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School of Community Health Sciences
University of Nevada, Las Vegas

Publications on Chronic Disease in Coal Dependent Communities in Central Appalachia

Susan Meacham, PhD, RD, Edward Via College of Osteopathic Medicine
Suporn Sukpraprut, PhD, Edward Via College of Osteopathic Medicine
Thomas Taber, MPH, OMS I, Edward Via College of Osteopathic Medicine
Diana Metzger, MPH, Post-baccalaureate Program, Edward Via College of Osteopathic Medicine

ABSTRACT

CONTEXT: Agency and nonprofit reports have traditionally been the source of health information in Appalachia. Recently, publications have appeared in the literature associating coal mining, specifically mountain top mining, with numerous chronic health conditions spurring debate among environmental and industry interest groups. Publication quantity and quality were objectively assessed. This article reports on a literature review and analysis of publications on chronic disease in coal dependent communities in Appalachia.

OBJECTIVE: To conduct a review and analysis of original, peer reviewed research publications on chronic health conditions in communities dependent on coal mining with a focus on central Appalachia and report on publication and research quantity and quality.

DATA SOURCES: Thorough searches were conducted using PubMed, EBSCO, and CiNAHL computerized databases to identify original, peer-reviewed research articles addressing 'Appalachia', 'health' and 'coal'.

STUDY SELECTION: The database search identified publications relevant to chronic health conditions (i.e., heart disease, lung disease, kidney disease, cancers, diabetes, obesity, etc.) and coal mining in central Appalachia.

DATA EXTRACTION: Quantitative measures of the literature review provided information on author collaborations, year of publication, frequency of publication by contributing authors, etc. Journal impact factors were noted and other objective qualitative criteria were considered.

DATA SYNTHESIS: Over 60 publications relevant to mining with 38 publications specific to Appalachia and health were identified. The publications were reviewed relative to relevance and article quality i.e., current, original research, application to central Appalachia and discussions of chronic human health and coal mining. Over the past five years most of the publications relevant to chronic disease and coal mining in central Appalachia resulted from a research group with a common author.

CONCLUSIONS: Science based evidence is needed and data must be provided by independent researchers from various disciplines of study to share different perspectives on how to alleviate the longstanding health disparities in central Appalachia. Studies will require the application of sound methodologies to validate the findings and support future interventions.

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INTRODUCTION

Thanks to the efforts of many local and national organizations, such as diabetes, cancer and rural health associations, data rich annual reports are available to support educational awareness and guide policy development (1–5). At the federal level the Appalachian Regional Commission (ARC) is the longest standing organization tasked with alleviating health disparities in an area recognized by its rurality and high numbers of underserved communities (6). Yet, health disparities persist and research literature on health in rural communities is sparse.

Researchers have just recently begun to study health disparities in Appalachia. Since 2007 a number of research publications have suggested environmental factors, such as coal mining activities, increase prevalence rates of chronic diseases in central Appalachia (2011) (7). In this communication we share an overview of data provided by various agencies on socioeconomic factors that contribute to elevated rates of chronic diseases in central Appalachia (1-17). From this context we explore the recent scientific literature publications on chronic disease in coal dependent communities in central Appalachia.

Appalachia is home to 25 million people with 42 percent considered rural residents, more than double the national average. Appalachia extends more than 1,000 miles along the spine of the Appalachian Mountains from southern New York to northern Mississippi. The Appalachian Region covers more than 205,000 square miles in 420 counties in all of West Virginia and parts of 12 other states (6). Mountainous terrain and forests cover over two-thirds of the region and contribute appreciably to local history and culture.

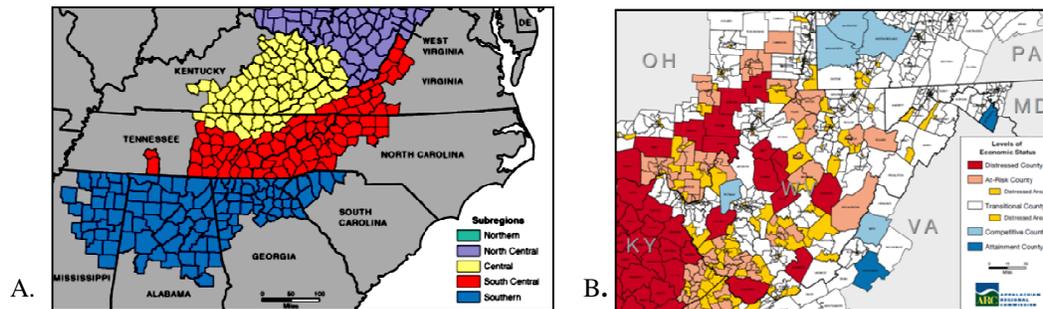


Figure 1. Central Appalachian sub-region counties (A) and economically distressed areas (B) in Kentucky, Tennessee, Virginia and West Virginia as defined by the Appalachian Regional Commission. Source: Appalachian Regional Commission (6, 15 16)

Central Appalachia is one of five sub-regions that include counties in the states of Kentucky, Tennessee, Virginia and West Virginia. As described in an ARC report in 2009 the Appalachian sub-regions are contiguous areas relatively similar in topography, demographics and economics which afford greater analytical detail (15). Central Appalachia displays the greatest health and economic hardships among the five sub-regions. Many counties in central Appalachia contain areas defined as economically distressed by the ARC.

Recently updated geographic classifications from the ARC are used to identify sub-regions within Appalachia and distressed areas within counties. Counties and areas are designated economically distressed if rated among the worst 10 percent of economies compared with those across the nation. The three factors used by the ARC to determine economically distressed counties and areas are the county's or area's unemployment rate, per capita income and 3-year poverty rate, all relative to national rates (6, 8, 16, 21)(Table 1.). This depiction of Appalachian

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economic status presents a more refined and accurate metric revealing the socioeconomic heterogeneity of the areas (Figure 1.) (15, 16).

In the past 40 years, the region's economic woes were thought to be a consequence of declines in the coal and tobacco industries (Figure 2.) (8, 16-21). Coal production has been the predominant economic driver in many of the rural communities in central Appalachia. Some of the most profitable mines in the world are located in this region. The region has a high-grade bituminous coal which is low in impurities and high in energy content. Despite advances in mining technology, operations, safety regulation and environmental protection have occurred in recent decades significantly improving environmental impacts and occupational health hazards, public concerns persist (7, 17-19).

In years past public awareness drew attention to an occupational health hazard for coal miners, "black lung" or pneumoconiosis. Regulations were put in place to address this occupational concern and effectively reduced the negative health consequence over time. Unfortunately, the prevalence of this occupational health condition recently increased and public concerns have resurfaced (24). Also, new concerns, or 'second hand effects', are thought to be affecting the health of residents in communities in close proximity to coal mining activities, particularly those associated with mountaintop removal or mountaintop mining (MTM) (25-46).

The impact of local economic conditions on individual and population health status is well documented. Until the recent recession the economic situation in much of Appalachia had been steadily improving. Between 1965 and 2008 poverty rates in Appalachia declined from 33 percent to 18 percent. Economically distressed counties in Appalachia in 1965 numbered 223 and by 2008 this number had been reduced to 81 counties. However, for fiscal year 2013 the number of counties considered economically distressed in Appalachia was 98, a 20 percent increase in just four years (22). Coincidentally, coal production was also reaching its peak production up through the early 1990's (Figure 2. A.).

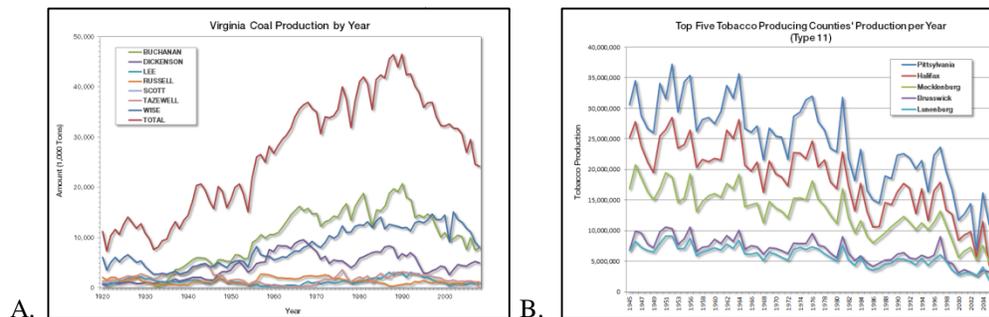


Figure 2. A. Annual coal production in southwestern Virginia counties with a general decline noted since 1990. Source: Appalachian Research Initiatives for Environmental Science, 1920-2011 (19). B. Type 11 tobacco production from 1945-2004 with production declines seen in selected south central Virginia counties in recent years. (NASS) (20).

In Appalachia, historically, the consequences of a reduced population and lower than average household incomes are associated with lower quality of life indices. Recent median household incomes (for 2006-2010 in adjusted 2010 dollars) reflected regional differences in economic situations. For the US population, the median household income was \$51,914, for the Appalachian Region, \$42,498, and for central Appalachia, \$32,278 (12). Within central

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Appalachia the impact has been disproportionate; three-fourths of the counties experiencing economic hardship are found in rural, mountainous and isolated areas. This trend is seen in reported per capita income means. The 2008 means for the nation and Appalachia were \$40,116 and \$32,411 and state means in central Appalachia even lower. These 2008 per capita income means are higher than the most recently available means reported for 2009 (Table 1.)(23).

Within central Appalachia differences in economic status can be seen between the states. Compared to surrounding states Virginia has the greatest differences between the 'haves and the have nots' when it comes to population growth, poverty, education, income and unemployment. While the state of Virginia experienced modest population growth from 2000 to 2010, the state's growth was 11.4 percent greater than the growth seen in the 25 counties and 7 independent cities in Virginia considered part of Appalachia. The poverty rate in Virginia was 7.6 percent lower and the unemployment rate 2.5 percent lower than the state's Appalachian Region. The greatest difference, however, lies in average per capita income where Virginia's Appalachian Region mean income (\$29,406) was two thirds that noted for the state average (\$44,075) (23). These factors present Virginia with the greatest challenges compared to neighboring states when creating policies and programs that can address diverse economic scenarios.

In Virginia indices have identified southwestern and south central Virginia as two regions with high chronic disease prevalence rates compared to the rest of the state (Figure 3.) (4). South central Virginia, not considered part of Appalachia, has experienced economic downturns like many areas in Appalachian Virginia. An initial observation could be made stating that due to changes in tobacco production the economic declines in south central Virginia closely mirror those related to coal production in southwestern Virginia (19-20).

Educational attainment is another metric strongly associated with health disparities (Table 1). In 2010, 17.6 percent of adults in Appalachia had a college degree compared to 24.4 percent for the nation. Again, among the mid-Atlantic state Virginia has the highest rate of college completion with 29.5 percent of the population college educated. In the Appalachian Region of Virginia the college completion rate was 14.2 percent, half that for the whole state (23) (Table 1). A lack of education is an additional social risk factor for increased prevalence of chronic disease.

Education is also a known factor contributing to economic well-being. High school and college completion rates are important factors for public policy in all sectors and the data readily available. Less obtainable are data on another aspect of education, health education, which may be of more practical importance. Health information, such as that needed for diabetic patients, has generally been provided to patients by physicians and health care team members. In Appalachia, there are fewer physicians, clinics and hospitals per capita than in other parts of the country. Thus, there are limited health education opportunities through traditional venues. It is not surprising that in this situation less than half of West Virginians with diabetes have taken a class in self-management. Further, demands on health care access will continue to be high as Appalachian communities also experience high rates of multiple morbidities and an aging population with limited social mobility and social support systems. Greater geographic isolation and restricted access to public transportation also contribute to limited access to health care and education in this region.

A similar pattern emerges in Virginia when comparing patterns of economic and educational determinants to patterns of prevalence of chronic diseases. Average annual age-adjusted cervical cancer incidence rates were 13.2 percent higher in Appalachia Virginia compared to non-

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Appalachia Virginia. The average annual age-adjusted lung/bronchus cancer incidence and mortality rates were 15.4 and 16.3 percent higher in Appalachia Virginia compared to non-Appalachia Virginia, respectively (1, 2).

Description	National	Overall Appalachia	State Level				Appalachian Region			
			Kentucky	Tennessee	Virginia	West Virginia	Kentucky	Tennessee	Virginia	West Virginia
Total population:										
Number	308,745,538	25,243,456	4,339,367	6,346,105	8,001,024 ^H	1,852,994	1,184,278	2,785,342 ^H	77,004	1,852,994
% population change from 2000 to 2010	9.7%	6.8%	7.4%	11.5%	13.0% ^H	2.5%	2.0%	10.1% ^H	1.6%	3%
Persons per square mile	87.4	123.5	109.9	153.9	202.6 ^H	77.1	65.0	138.4 ^H	68.9	77.1
Poverty rate:										
Blow poverty level										
N	39,537,240	3,677,476	719,746	967,189 ^H	752,446	310,368	282,739	441,371 ^H	127,977	310,360
%	13.5%	15.4%	17.4%	16.1%	10.1%	17.6% ^H	24.5% ^H	16.7%	17.7%	17.6%
Education:										
Completed high school										
N	146,496,014	12,140,835	1,961,397	2,843,244	3,801,694	927,767 ^L	477,407	1,256,274	354,269 ^L	927,767
%	80.4%	76.8%	74.1% ^L	75.9%	81.5%	75.2%	62.5% ^L	73.3%	69.2%	75%
Completed college										
N	44,462,605	2,783,320	453,469	732,688	1,374,988	182,960 ^L	79,693	292,570	72,828 ^L	182,960
%	24.4%	17.6%	17.1%	19.6%	29.5%	14.8% ^L	10.4% ^L	17.1%	14.2%	14.8%
Economic status:										
Per Capita Income average										
\$	\$40,166	\$32,411	\$31,936	\$34,833	\$44,075	\$31,634 ^L	\$24,899 ^L	\$31,340	\$29,406	\$31,634
%	100%	80.7%	79.5%	86.7%	109.7%	78.8% ^L	62.0% ^L	78.0%	73.2%	78.8%
Unemployment Rate										
N	14,265,000	1,171,980	217,537	317,026 ^H	277,562	63,374	31,620	141,133 ^H	33,813	63,374
%	9.3%	9.7%	10.5% ^H	10.5% ^H	6.7%	7.9%	12.2% ^H	10.6%	9.2%	8%

Sources: U.S. Census Bureau; USA TODAY analysis; Appalachian Regional Commission (ARC)

* Non-Appalachian region

^H represents the highest number or rate among KY, TN, VA and WV

^L represents the lowest number or rate among KY, TN, VA and WV

^H represents the highest number or rate among the central Appalachian regions in KY, TN, VA and WV

^L represents the lowest number or rate among the central Appalachian regions in KY, TN, VA and WV

Table 1. National, overall Appalachian Region, state and state Appalachian Region economic demographics for KY, TN, VA and WV for population, poverty, education, income and unemployment rate (2008). Source: Appalachian Regional Commission, 2011 (23).

The Virginia Diabetes Plan 2008-2017 reports that Appalachian counties in southwestern Virginia see a 63 percent increase in the prevalence of diabetes compared to the non-Appalachian counties and the same annual increases observed for the state and nation. People with diabetes who live in distressed or at-risk Appalachian counties are diagnosed with the disease about 3 years younger than comparable people in non-Appalachian counties. Younger onset of disease means greater risk of blindness, kidney disease, etc. Development of diabetes may actually be at an even younger age since it is likely that there is delayed diagnosis in the region due to less access to health care. Diabetes in Virginia, as nation-wide, is a costly, controllable, and preventable condition (3).

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Another typical demographic factor, age, impacts health disparities in central Appalachia. Central Appalachia has an elderly population increasing at a faster than average rate, partially due to ‘brain drain’ or the exodus of the young educated individuals able to find better employment elsewhere. With an increase in the elderly population predicted a simultaneous increase in the rates of chronic conditions can logically be expected.

Prevention quality indicators, acute, chronic and overall, have been created to reflect a composite rating reflecting a region’s status on diabetes, pulmonary disease, hypertension, congestive heart failure, low birth weights, dehydration, pneumonia, urinary infections, angina, diabetes (uncontrolled), asthma, amputations, etc. As the map in Figure 3.A. reveals there is a need for more services to prevent chronic health conditions in southwestern and south central Virginia.

Reports on children’s health are equally disturbing. For Virginia infant mortality in 2008 was, fortunately, the lowest in five years (6.7 deaths per 1,000 live births) yet, for rural areas the rate was 7.9 percent with an upward trend continuing during the past five years. Low birth weights were higher in economically depressed areas compared to a state average of 8.4 percent, with central Virginia reporting 10.0 percent and southwestern Virginia, 9.2 percent. As children enter school the rates of free and reduced meals illustrate that a great number of children qualifying to receive free and reduced meals are for children living in central and southwestern Virginia (Figure 3.B.) (4). The health disparities for the young and the aged are most prevalent in the same areas where the economic downturns have been most notable in Virginia, in the counties previously supported by coal and tobacco production (Figure 2.).

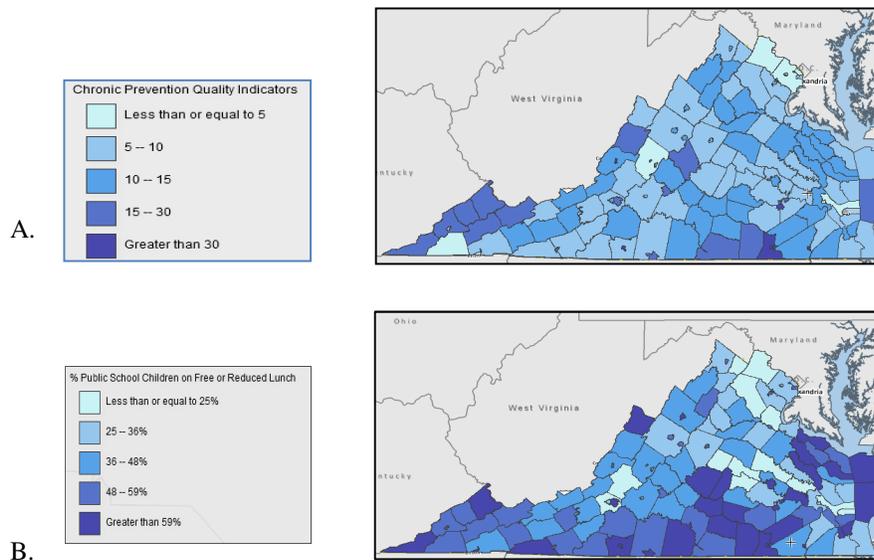


Figure 3. A. Chronic prevention quality indicators show a need for more services in southwestern and south central Virginia. B. School children that qualify for free or reduce lunches are also reported in high numbers for southwestern and south central Virginia. Source: Virginia Rural Health Association, 2011 (4).

Health disparities are described as “population-specific differences in the presence of disease, health outcomes, or access to health care” (47). While economic factors typically come to bear on health disparities so do ethnicity/race and age. Atypical for central Appalachia is the fact that

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ethnic and racial differences are not pronounced in this region. In Appalachia and central Appalachia the non-White or Hispanic ethnicity of the populations is currently close to 12 percent and 4 percent, respectively (1). Thus, traditional discussions of ethnicity and race, at least in central Appalachia, are not considered focal points for targeting health disparities.

The factors that appear to loom the largest in central Appalachia are those that widen gaps between counties achieving economic successes and those continuing to suffer from economic woes. Also, Appalachia generally lags behind the nation in employment growth during boom years and falls further during recessions. During the last decade a notable exception to this rule was experienced due to considerable growth in the coal mining industry. The Bureau of Labor Statistics employment index rated mining as the highest concentrated industry in Appalachia, 1.58 times the national share. In Appalachia from 2000-2008 the mining industry had the greatest job growth, 39.7 percent of any employment sector (21). The seemingly inconsistent economic reports, those of declining annual coal production in most areas in central Appalachia and the growth in coal related employment, brings this issue into focus for further research.

The data above have been reported by numerous state agencies and nonprofit organizations, i.e., the Appalachian Region Commission (6), the Appalachian Cancer Network (1, 2), the Virginia Diabetes Council (3), and the Virginia Rural Health Association (4), etc. Until recently, relatively few original research efforts have focused on factors impacting health or influencing positive intervention outcomes in the Appalachian Region. The purpose of this review was to find scientific research literature to explain why elevated rates of chronic health conditions in central Appalachia persist, particularly in coal dependent communities.

METHODS

A thorough literature search of PubMed, EBSCO, and CiNAHL was performed using search terms 'Appalachian', 'coal mine', and 'health' to identify relevant, peer-reviewed, original research articles, published in English, at the time of the search. General qualitative observations by the investigators were noted. Quantitative data included a count of articles published by years and by authors. Contributing authors, coauthors and journal impact factors (IF) were reported. Objective criteria based on article relevance have been included in a subsequent publication (manuscript accepted).

RESULTS

The searches produced relatively few publications meeting all the search criteria. Subsequent searches were performed to include articles that met some but not all of the search criteria. The broadest searching strategies using the search terms 'Appalachian', 'coal mine', and 'health' generated over 60 articles written in English. Of these, 38 articles addressed health in Appalachia but not all considering coal as an environmental factor. Some publications addressed international and national mining communities outside our geographic area of interest, discussed other types of mining (not coal), were written as commentaries, editorials or introductions to special editions or were not peer reviewed.

A number of general observations were also noted by the investigators. As a result of searching the CiNAHL database we uncovered a series of articles that did not appear in PubMed. CiNAHL, a database used by the nursing profession, produced the articles by Sharon Denham, PhD, RN. Also, it was noted that the study objectives of the publications assessed varied widely, focusing on evaluations of overall quality of life, risk factors and prevalence rates for chronic

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diseases, assessments of public data on disease and birth defects, and implicated effectiveness of assorted educational strategies to improve health. Publication authors were members of various schools of medicine, university departments, health departments, hospitals, cancer centers, etc. The authors represented a broad range of professions including physicians, pharmacists, psychologists, nurses, dietitians, social workers, etc.

Quantitatively, the 38 publications on chronic diseases in Appalachia appeared in peer-reviewed journals reporting between the year 2000 and the time of the search (Figure 4.). Almost half of these articles specifically addressed coal mining as an environmental factor impacting health. The publications were clearly identified into three author groups. The first group was spearheaded by Michael Hendryx, Ph.D., with the Department of Medicine at West Virginia University, Morgantown, WV. Dr. Hendryx and coauthors often reported on increased mortality and prevalence rates of chronic diseases, including birth defects, associated with the consequences of coal mining (7, 25-45). Another research group led by Sharon Denham, Ph.D., R.N., at Ohio University published articles focused on diabetes mellitus. While the efforts of Denham and colleagues targeted Appalachian communities they did not consider coal mining activities as variables of interest (48-57). The third group noted in this review included the small number of researchers who published single publications, independent of Denham and Hendryx, including a publication reassessing publicly available data reported by Hendryx and colleagues on coal mining and chronic disease (58-63).

Hendryx and coauthors published 23 articles that pertained to coal and health between 2007 and 2011 with the majority, (89 percent) or 16 of 18 of publications specific to rates of chronic diseases in coal mining communities in Appalachia (Figure 5.A.). The publications by Hendryx on chronic disease had 33 different authors with 4 co-authors appearing on 16 publications along with 22 others (25-27, 29-33, 35-42). Two independent publications by Blackley et al. (2011) (63) and Borak et al. (2012) (58), were authored by 7 different researchers and were the publications most closely aligned in objectives and methods to the work presented by Hendryx et al.

Denham and 20 coworkers published 9 articles during this time on diabetes in Appalachian communities, 5^(*) appeared as co-authors on two publications each (48, 50-57). Two publications by Hendryx and 2 coauthors included data on diabetes (31, 33) (Figure 5). Hendryx also appears on an additional publication in which electronic patient registries were the focus of a study to improve diabetes care and clinical outcomes in rural community health centers (44).

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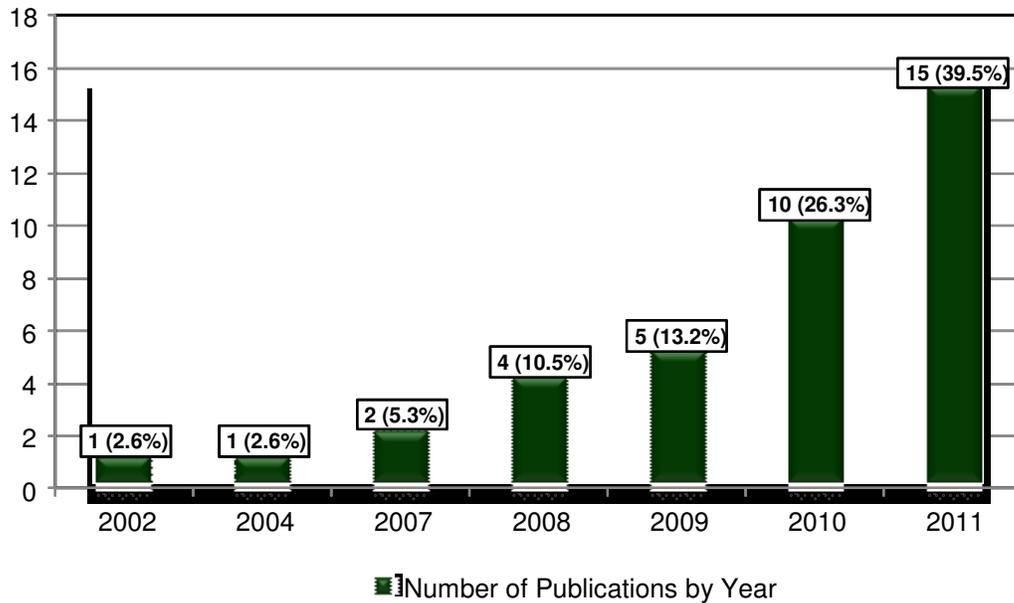


Figure 4. Numbers of publications related to chronic disease in Appalachian communities published in peer-reviewed journals since 2000 (7, 25-46, 48-58, 61-63, 65).

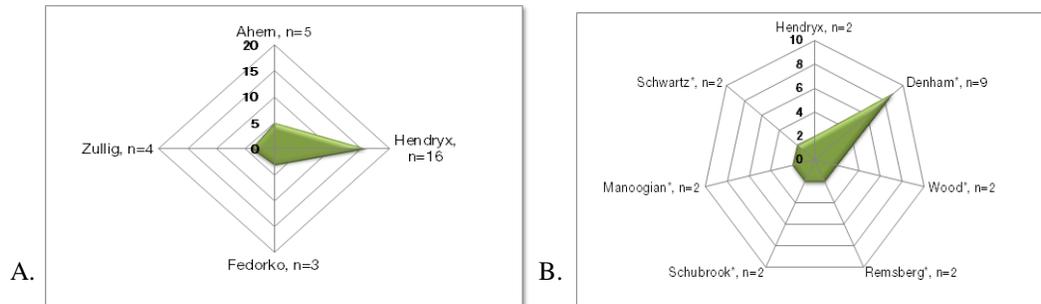


Figure 5. A. Publications from 2007-2011 on coal communities and chronic diseases have been authored by 33 different researchers, the 4 shown are authors on 16 of 18 relevant publications along with 22 other co-authors (25-27, 29-33, 35-42). Two independent publications appear with 7 additional authors (58, 63). B. Publications from 2007-2011 on diabetes and including Appalachian communities (n=9) have been authored by Denham with 20 coworkers, 5(*) with multiple publications (48, 50-57). Two publications by Hendryx and 2 additional authors included data on diabetes (31, 33).

Provided in Table 2 is a selection of the variety of journals in which many of the relevant articles on chronic health in coal dependent communities in Appalachia have been published. The majority of the work published appeared in journals with IF ranging from 1 to 4. The publication in *Science* appeared in the “Policy” section of the journal as a commentary and was not an original, peer-reviewed research article (43).

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Journal	Impact factor
Public Health Reports	1.083
Journal of Rural Health	1.410
Journal of Community Health	1.491
Journal of Toxicology and Environmental Health	1.637
Geospatial Health	1.705
International Archives of Occupational and Environmental Health	1.910
Annals of the New York Academy of Sciences	2.847
Environmental Research	3.500
American Journal of Public Health	3.850
Science (Policy section, not an original research contribution)	31.364
Journal of Health Disparities Research and Practice (new)	N/A

Table 2. Publications on chronic diseases in coal dependent communities in Appalachia have appeared in the following journals with quality based on the most recent impact factor (IF).

Article number	Year, journal, authors, reference number	Concluding statements in articles addressing chronic diseases in coal dependent communities in Appalachia.
1	2007, <i>J Toxicol Environ Health</i> , Hendryx et al. (33)	Exposure of particulates or other pollutants generated by coal mining activities may be linked to increased risk of COPD and hypertension hospitalizations. Limitation in the data likely result in an underestimate of associations.
2	2008, <i>Lung Cancer</i> , Hendryx et al. (37)	The set of socioeconomic and health inequities characteristic of coal-mining areas of Appalachia highlights the need to develop more diverse, alternative local economies
3	2008, <i>Am J Public Health</i> , Hendryx and Ahern (31)	Research is recommended to ascertain the mechanisms, magnitude, and consequences of a community coal-mining exposure effect.
4	2009, <i>Int Arch Occup Environ Health</i> , Hendryx (29)	Higher chronic heart, respiratory and kidney disease mortality in coal mining areas may partially reflect environmental exposure to particulate matter or toxic agents present in coal and released in its mining and processing.
5	2009, <i>Public Health Rep</i> , Hendryx and Ahern (32)	The human cost of the Appalachian coal mining economy outweighs its economic benefits.
6	2009, <i>Prev Med</i> , Hendryx and Zullig (39)	Cardiovascular diseases have been linked to both air and water contamination in ways consistent with toxicants found in coal and coal processing
7	2010, <i>Ecohealth</i> , Hitt and Hendryx (40)	Coal mining was significantly associated with ecological disintegrity and higher cancer mortality.
8	2010, <i>Public Health Rep</i> , Zullig and Hendryx (45)	Coal-mining areas are characterized by greater socioeconomic disadvantage riskier behaviors, and environmental degradation that are associated with reduced HRQOL (health related quality of life).
9	2010, <i>Geospa Health</i> , Hendryx et al. (35)	Further confirmation of observed phenomena is necessary with person-level studies, but the results add to the body of evidence that coal mining poses environmental risks to population health

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		in West Virginia.
10	2010, <i>J Rural Health</i> , Hendryx et al. (36)	The presence of coal mining as an independent risk factor for total, cancer, and respiratory mortality highlights the potential environmental threats posed by the extraction, processing and transportation of coal.
11	2011, <i>J Comm Health</i> , Hendryx et al. (38)	Efforts to reduce cancer and other health disparities in Appalachia must focus on mountain top mining portions of the region.
12	2011, <i>J Health Disparity Res Pract</i> , Hendryx (30)	Efforts to reduce longstanding health disparities in Appalachia must focus on those areas where disparities are concentrated: the Appalachian coalfields.
13	2011, <i>J Rural Health</i> , Esch and Hendryx (27)	Future research is necessary to examine the socioeconomic and environmental impacts of MTM on health to reduce health disparities in rural coal mining areas.
14	2011, <i>Am J Public Health</i> , Zullig and Hendryx (46)	Mountain top mining areas are associated with the greatest reductions in health-related quality of life even when compared with counties with other forms of coal mining.
15	2011, <i>Environ Res</i> , Ahern et al. (25)	Both socioeconomic and environmental influences in mountaintop mining areas may be contributing factors (to birth defects)
16	2011, <i>Ann NY Acad</i> , Epstein et al. (26)	Each stage in the life cycle of coal—extraction, transport, processing, and combustion—generates a waste stream and carries multiple hazards for health and the environment.

Table 3. Summary of concluding statements from publications between 2007 and 2011 authored by Michael Hendryx and collaborators on health in communities associated with coal mining activities (25-27, 29-33,35-40, 45, 46).

DISCUSSION

The ARC formed in the mid1960s at the time the problem of health disparities in the Appalachian Region was recognized, yet the problems persist. The ARC along with local, state and national reports from government agencies and nonprofit organizations have provided the vast majority of information available on chronic diseases, particularly in rural Appalachian communities. To fill the gap in knowledge based on science we conducted a literature search of computerized databases. Our quantitative findings are discussed below; however, a few general observations are mentioned briefly here. It was fortuitous to search several databases and find that the CiNAHL database produced a series of articles that did not appear in PubMed, those including Sharon Denham, PhD, RN. Quantitative findings indicated that relatively few articles have appeared in the scientific literature addressing coal mining, specifically mountaintop mining and chronic disease in Appalachian populations. The majority of articles relevant to chronic disease prevalence in coal dependent communities have been published recently, most since 2007. The timing of publications parallels the heightened controversies surrounding EPA permitting of MTM in central Appalachia.

Our search generated 38 publications appearing since the year 2000 reporting on chronic diseases and coal in Appalachian populations. The publications were clearly identified into three author groups. The first group was spearheaded by Michael Hendryx, Ph.D. with the Department of Medicine at West Virginia University, Morgantown, WV. Dr. Hendryx and coauthors reported on increased rates of chronic diseases and birth defects associated with the consequences of a single dependent variable, coal mining (7, 25-45). Upon further review we

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listed concluding statements from the suite of studies printed between 2007 and 2011 authored by Michael Hendryx and colleagues (25-27, 29-33,35-40, 45, 46) (Table 3.). Unlike the publications authored by Denham and colleagues and the independent researchers the conclusions made by Hendryx et al. have solicited controversy, prompted critiques and reassessment of their findings (58-60)

While the number of publications will generally reflect public interest on a topic care should be taken to also monitor publication quality. Prestigious journals are well known by those familiar with the field of study and are the most rigorous when accepting manuscripts for publication. The majority of the selected publication from our review appeared in a variety of journals, most with IF ranging from 1 to 4. Journal quality is vulnerable to subjectivity and by design often highly specific to a particularly scientific research niche.

Considerable conversation ensued following a commentary on MTM published in *Science* (Palmer et al., 2010) (43). *Science*, with an IF of 31.346, is among the most highly regarded scientific publications with an extensive readership and high standard for the scientific integrity of its peer-reviewed original research articles. However, the quality of the research shared in a commentary in the “Policy” section of the journal cannot appropriately be viewed equivalent in quality to the original peer-reviewed articles published in *Science*.

For comparison, the *American Journal of Public Health* with an IF = 3.84 is also considered a strong publication, but primarily by those within this discipline. The journal was recently rated third highest among 114 publications representing the broad discipline of public health. A journal devoted, for example, to rural health, a sub-discipline of public health, is narrower in scope and consequently has fewer publications and citations and, expectedly, lower IF ratings. The *Journal of Health Disparity Research and Practice* is a relatively new publication without enough information to receive an IF rating.

The IF was created by journal marketers to serve as “a numeric proxy” for research publication quality (64). Without qualitative factors to accompany the numeric values the IF becomes a relative index of a journal’s importance within its field but more appropriately it is an index of “readership”. The IF is determined by taking the frequency with which the average article is a journal has been cited in a particular year or period, generally, over the past 2-5 years. Thus, the higher the IF the more frequently the journal contents have been read and cited by others.

The IF must be used discreetly taking into consideration the stringency of review, other types of material published in a journal, such as commentaries, and variations between broad disciplines like public health and sub-disciplines, such as rural health and health disparities. Acknowledging these limitations we report on IF to draw attention to the need for objective measures of journal quality and thus, article quality for fair evaluations of science, particularly when being used to impact important and controversial public policies.

The studies published by the Hendryx group have undergone review, as will be discussed below, revealing methodology issues, contradictory findings within their own studies and contradictory findings compared to the findings of a limited number of investigators publishing independently on chronic health conditions in central Appalachia. Granted, successive changes in methodology are making use of the best available strategies and with each publication the West Virginia University group demonstrated stepwise improvements, utilizing the most recent techniques as they developed. The recurring messages from the research findings of Hendryx et al. in their recent publications appear to be driven by an objective to provide “proof” to pressure

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policy makers to eliminate coal mining, especially MTM, the sole source of the economy in many rural Appalachian areas. Ironically, this message contradicts a previous finding by Hendryx et al. in 2002 in which the authors stated that a healthy economy may be the most important factor to improve the health of a community (65).

Through no fault of previous work done the nature of the problem defies current research methodologies. More robust study designs, not possible with epidemiological research, are needed to delineate biochemical mechanisms directly linking environmental factors to the development of chronic disease in coal mining areas.

As stated earlier our literature review identified another author reporting consistently over time on Appalachian populations, Dr. Sharon Denham. Denham's group focused on a well-defined scope of work, diabetes. Denham et al. reinforced that there is a geographic dimension to poor health in rural Appalachia and confirmed that: 1) health disparities do exist in rural areas, 2) limited facilities and physicians are contributing factors, 3) diabetes education is insufficient, i.e., not enough programs are offered with adequate educator knowledge and qualifications and 4) problems affecting access to education are similar to those affecting access to health care. Denham and coauthors did not discuss the environmental impacts of coal mining in relation to this chronic condition.

The review of literature produced only three publications by researchers working independently without affiliations with Hendryx and Denham to address chronic health conditions in central Appalachian states. McGarvey et al. (2011) (61) investigated health disparities in Appalachian and non-Appalachian counties in Virginia to identify strategies to improve community health. They reported an increased rate of self-reported diagnoses of cancer from telephone surveys of adults. They did not report a higher rate of self-reported diagnoses for diabetes and heart diseases in Appalachian communities despite the higher rates reported statewide over the last decade. The authors provided evidence the unique, cultural aspects of Appalachia impact health care, i.e., northwestern European heritage, the Melungeon ethnicity, positive core values and independent self-reliance.

Schoenberg et al. (2011) (62) in a concerted effort to understand health vulnerabilities obtained primary data from a small population attending a single, non-specified federally qualified health clinic in Appalachian Kentucky. The group conducted personal interviews of 20 patients (85 percent females, 95 percent Caucasian). While study limitations were acknowledged, the researchers demonstrated that experiencing and managing multiple morbidities is complex and defies extrapolation from what we know about single disease self-management.

Blackley et al. (2011) (63) conducted a descriptive epidemiological study of cancer mortality rates in Appalachian counties of Tennessee and confirmed that cancer was a leading cause of death in this region. They compared the rates of all cancers combined and rates of specific cancers in Appalachian counties to those of the nation and rates of cancers in non-Appalachian counties within the 13 specified Appalachian states. Mortality rate differences between Appalachian and non-Appalachian counties exist with rates of all cancers and lung cancers higher among Appalachian counties than rates of in-state, non-Appalachian counties. They stated improvements in high school graduation rates, more than improvements in family income, could result in improvements in lung cancer mortality in Appalachian counties.

In response to conflicting data a fourth independent publication has appeared statistically reevaluating publicly available data considered by Hendryx and colleagues. Borak et al. (2012)

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(58) revealed methodology concerns and produced a conclusion conflicting with the original findings reported by the WVU researchers relating coal production to chronic diseases. Borak et al. reassessed the all-cause mortality rates for residents of Appalachia during the years 2000-2004, a time period considered to coincide with those described in the studies performed by Hendryx and coauthors (29, 32, 37). Borak et al. (2012) present their reassessment of the publicly available, secondary data used in three studies published by Hendryx et al. in 2008-2009. They reported that coal mining was not a significant variable impacting age-adjusted, all-cause mortality rates. Likewise, smoking and diabetes were not significant factors in the model. Borak et al. (2012) concluded that “residents in the distressed areas demonstrate generally higher rates of risky behaviors, i.e., smoking, prevalent obesity, less physical activity, less nutritious diets, and less use of preventative health services”.

Research interpretations should safe guard against the cumulative effects of numerous publications relating to coal mining and health from a single research group. Data need verification from multiple, independent researchers. Granted, the continual improvements in methodologies taken to date have been stepwise advances improving research quality on the impacts of coal, i.e., MTM, on human health. The next progressive step is to provide additional information, utilize better measures of human health and couple this with better measures of environmental factors to assess the true causal relationships. The biological mechanisms must be confirmed and more importantly used to influence policies and programs to improve human health. Challenges will continue to present as single biomarkers are seldom adequate to assign causal relationships when variables are an array of complex biological, economic, sociological and cultural realities.

CONCLUSIONS

Science conducted ‘for the sake of science’ is needed to confirm current published rates of chronic disease prevalence and mortality in coal dependent communities in central Appalachia. Readily modifiable factors influencing health care in central Appalachia must be realized and serve as pivotal agents of change in strategies designed to improve health outcomes. Osteopathic physicians are well trained to address the multifaceted nature of chronic diseases and use integrated whole health strategies to treat and prevent chronic diseases elevated in rural communities. There are many opportunities to integrate science based evidence, knowledge, technology and osteopathic care to minimize health disparities in culturally unique communities in Appalachia.

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