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SCIENTIFIC INVESTIGATIONS

Underrecognition of sleep-disordered breathing and other common health conditions in the West Virginia Medicaid population: a driver of poor health outcomes

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Study Objectives: To assess the prevalence rates of sleep-disordered breathing (SDB) in a high-risk and rural-dwelling Medicaid population with significant comorbidities.

Methods: Our study analyzed anonymized administrative claims data from West Virginia (WV) Medicaid. Claims data from 2019 were aggregated at the individual level to assess the overall prevalence of SDB and related conditions among adult Medicaid beneficiaries. The prevalence rate of SDB, specifically among individuals who had comorbid congestive heart failure, chronic obstructive pulmonary disease, or obesity, was determined. Finally, we compared our prevalence estimates from this Medicaid database with prevalence rates from national datasets including the Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System.

Results: Of the total 413,757 Medicaid enrollees ≥ 18 years old analyzed, 36,433 had a diagnosis code of SDB for an overall prevalence of 8.8%. Based on national datasets and our study cohort characteristics, we conservatively estimated the prevalence of SDB in this WV Medicaid population to be 25%. For our secondary analyses, we determined the prevalence of SDB in specific disease cohorts of congestive heart failure (SDB prevalence 45%), chronic obstructive pulmonary disease (SDB prevalence 27%), and obesity (SDB prevalence 14%).

Conclusions: Our analysis of WV Medicaid claims data indicates that SDB and other important medical conditions are underrecognized in this vulnerable, high-risk, primarily rural population. Interestingly, SDB was identified at high rates in the disease cohorts of interest. Our team believes SDB represents an ideal target/model for addressing the growing health disparities in the United States, which is a major concern for all stakeholders in health care.

Keywords: sleep-disordered breathing, obstructive sleep apnea, rural health disparity, large database analysis

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BRIEF SUMMARY

Current Knowledge/Study Rationale: Health disparities in the United States, especially the urban-rural health divide, remain a major concern for all stakeholders in health care. This disparity is compounded in sleep medicine as specialists in the field and centers of expertise are located almost exclusively in large urban academic medical centers. Our previous work suggested that sleep-disordered breathing is underrecognized and ineffectively treated in Appalachian communities. To further evaluate this disparity, we used administrative claims data from the West Virginia Bureau for Medical Services.

Study Impact: Our analysis demonstrates that sleep-disordered breathing and other important medical conditions are underrecognized in this vulnerable, high-risk, primarily rural population. Sleep-disordered breathing represents a model disease for potentially addressing disparity in these disadvantaged rural communities.

INTRODUCTION

West Virginia (WV) has the highest rates of obesity, cardiovascular disease, and smoking-related pulmonary illness in the United States.[1–4] Sleep-disordered breathing (SDB) consists of several separate breathing disorders, including obstructive sleep apnea (OSA) and central sleep apnea. OSA is a common but underdiagnosed clinical problem characterized by upper airway narrowing and closure during sleep that results in intermittent nocturnal hypoxemia and fragmented sleep. Central sleep apnea is characterized by airflow limitation in the absence of respiratory effort. SDB is independently associated with daytime sleepiness and metabolic and cardiovascular risk.[5] Given the high prevalence of obesity in WV, a known risk factor for SDB, identification and treatment of SDB could have a positive impact on the health of this medically underserved rural state.[6] Our tertiary care academic hospital at West Virginia University (WVU) is unique in that it serves almost an exclusively rural Appalachian population.[7] Our previous work suggests that SDB is underrecognized in rural WV.[8] While SDB is a common clinical problem that is underdiagnosed and undertreated, even in modern, urban settings, we suspect this underrecognition is

further exacerbated by the significant health care disparities in our region.[9–11] A better understanding of SDB recognition, diagnosis, and management patterns could have important implications for improving neurocognitive, metabolic, and cardiovascular outcomes in our rural population.

WV is one of the poorest states in the United States, with approximately one-third of the population receiving health care coverage from Medicaid.[12] Many of these patients receive primary care at Federally Qualified Health Centers. These community-based health care centers receive funds from the US Health Resources and Services Administration Health Center Program to provide care in underserved areas.[13] We hypothesized that SDB is underrecognized in this vulnerable Medicaid population. To test this hypothesis, we used administrative claims data from the West Virginia Bureau for Medical Services to assess the prevalence of SDB and related conditions among adult Medicaid enrollees in 2019 and compared this with national prevalence studies and national databases as described below. As part of our analysis, we included disease processes highly prevalent in the region whose outcomes have been shown to improve with successful identification and treatment of SDB.[14–17] We included a demographic analysis to evaluate whether certain characteristics informed the diagnosis of SDB in this large rural sample.

METHODS

Data source

This retrospective study analyzed anonymized administrative claims data from WV Medicaid. The WVU Office of Health Affairs has a Memorandum of Understanding with the West Virginia Department for Health and Human Resources to use state data sources for approved research projects. This partnership provides WVU faculty access to anonymized Medicaid claims data that are updated monthly. These data include all claims, encounter, and enrollment data for Medicaid beneficiaries. Record-level claims data from 2019 were aggregated at the individual level to assess the overall prevalence of SDB and related conditions among adult Medicaid beneficiaries. While there are inherent problems with utilizing claims data, we elected to use this database for a number of reasons: (1) this in one of the state's largest patient databases representing approximately one-third of the state's population, thus this analysis would give us a broad general sense of recognition patterns; (2) our population of interest is disadvantaged rural-dwelling individuals, which make up a significant portion of patients in this database; (3) the intent of this large database study is to lay the foundation for future research aimed at getting a more granular view of SDB recognition patterns in Appalachia.

Study sample

This study included all 413,757 WV Medicaid beneficiaries ≥ 18 years old enrolled in the program for any period in calendar year 2019. We used *International Classification of Diseases, Tenth Revision* (ICD-10), codes (decimals omitted for accuracy as these are not present in our database) to assess the prevalence of SDB by itself and together with common comorbid conditions. We utilized the Clinical Classification Software (CCS) from the Agency for Healthcare Research and Quality to help identify different diagnostic codes of interest.[18] CCS groups all 77,000 ICD-10 diagnosis codes into ~250 different clinically relevant categories, allowing for simpler identification of relevant codes such as obesity, chronic obstructive pulmonary disease (COPD), and heart failure. As mentioned above, we included obesity, COPD, and heart failure as 3 comorbid conditions of interest as they are highly prevalent in WV and outcomes have been shown to improve with successful identification and treatment of SDB.[14–17]

For example, the numerous ICD-10 codes for heart failure (I50 heart failure, unspecified, I501 left ventricular failure, unspecified, I502 systolic [congestive] heart failure, I5020 unspecified systolic [congestive] heart failure, I5021 acute systolic [congestive] heart failure, I5022 chronic systolic [congestive] heart failure, I5023 acute on chronic systolic [congestive] heart failure, I503 diastolic [congestive] heart failure, I5031 acute diastolic [congestive] heart failure, I5032 chronic diastolic [congestive] heart failure, I5033 acute on chronic diastolic [congestive] heart failure) all fall into CCS category 108, the clinically relevant category of "Congestive Heart Failure, non-hypertensive."

COPD ICD-10 codes included J42 Unspecified chronic bronchitis, J439 Emphysema, unspecified, J449 Chronic obstructive pulmonary disease, unspecified, J984. These codes are classified CCS 127 Chronic obstructive pulmonary disease and bronchiectasis. We also included CCS code 133 Other lower respiratory diseases. This includes ICD-10 codes for J984 Other disorders of the lung, J988 Other specified respiratory disorders, and R0600 Dyspnea, unspecified.

Obesity was coded under CCS 58 Other nutritional; endocrine; and metabolic disorders. ICD-10 codes included were E6601 Morbid (severe) obesity due to excess calories, E6609 Other obesity due to excess calories, E661 Drug-induced obesity, E662 Morbid (severe) obesity with alveolar hypoventilation, E663 Overweight, E668 Other obesity, and E669 Obesity, unspecified. Those identified as obese were stratified by body mass index (BMI) based on ICD-10 codes. Z6841 BMI 40.0–44.9 (kg/m^2) adult, Z6842 BMI 45.0–49.9 (kg/m^2) adult, Z6843 BMI 50–59.9 (kg/m^2) adult, and Z6844 BMI 60.0–69.9 (kg/m^2) adult.

Finally, the CCS scheme codes SDB under 259—Residual codes. This includes ICD-10 codes G4731 Primary central sleep apnea, G4733 Obstructive sleep apnea (adult) (pediatric), G4734 Idiopathic sleep related nonobstructive alveolar hypoventilation, G4736 Sleep related hypoventilation in conditions classified elsewhere, G4737 Central sleep apnea in conditions classified elsewhere, and G4739 Other sleep apnea.

Our team debated whether to utilize specific diagnostic codes for the conditions of interest or to include broader diagnostic codes for the study. For instance, we considered utilizing only G4733 obstructive sleep apnea (adult) (pediatric) for this analysis but given the limitations with using billing codes, particularly relying on nonspecialists to accurately code obstructive sleep apnea, our team felt including all codes for SDB would provide better insight into recognition patterns of these rural providers. Similarly, for COPD, we included broad codes,

such as J984 Other disorders of the lung. We elected to use these broad terms as our hypothesis is that these disorders are underrecognized. Using broader terms ensured that we were erring on the side of overcoding these conditions and thus if we found disorders undercoded it would not be in error simply because the codes were too focused. The intent of this large database study is to lay the foundation for future research aimed at providing a more granular view of sleep apnea recognition patterns in rural-dwelling populations.

Data analysis

We separated Medicaid enrollees' demographic data for 2019 based on the presence of an SDB diagnosis code and performed chi-square and *t* tests to assess demographic differences between those with an SDB diagnosis code vs those without a SDB diagnosis code (**Table 1**). Unfortunately, smoking status was not available.

We calculated the overall prevalence of SDB, COPD, congestive heart failure (CHF), and obesity among the 2019 Medicaid population. We also calculated the rate of SDB specifically among individuals who had comorbid CHF, COPD, or obesity (**Table 2**). The overall disease prevalence was calculated as the total number of individuals with a particular diagnosis divided by the total number of Medicaid enrollees. An individual was classified as having a diagnosis if they had at least 1 professional or facility claim with a relevant primary or secondary diagnosis code at any point in 2019. SDB prevalence in specific comorbid conditions was calculated by dividing the number of individuals with comorbid SDB by the total number of individuals with the medical condition—for example, the number of enrollees with CHF and SDB divided by the number of enrollees with CHF.

Finally, we compared the calculated prevalence estimates from this Medicaid database with prevalence rates from national studies and databases including the Centers for Disease Control and Prevention (CDC), including the Behavioral Risk Factor Surveillance System (BRFSS).[9,19–22] This surveillance system of adult health conditions conducted by telephone surveys collects data regarding their health-related risk behaviors, chronic health conditions, and use of preventive services. BRFSS started in 1984 in 15 states and now collects data in all 50 states as well as the District of Columbia and 3 US territories, completing over 400,000 interviews each year and making it the largest continuously conducted health survey system in the world. The combined state BRFSS data have been validated by other national household survey data, including the National Health Interview Survey and the National Health and Nutrition Examination Survey, for major health outcome measures and chronic diseases.[23–25] With the increase in the number of people who are either mostly-cellphone and cellphone-only, the BRFSS has updated its sampling design, including weighting technology (ie, Iterative Proportional Fitting or Raking) that has been validated and officially integrated in BRFSS surveys since 2011.[26] The validity and reliability of the BRFSS survey have been reviewed in detail.[27] Unfortunately, the BRFSS does not include data on SDB. To complete this assessment, we compared our sample with large national data including the Wisconsin Sleep Cohort.[9,21,22]

This research was supported by the WVU Health Sciences Center Office of Health Affairs and approved by the WVU Institutional Review Board (Exempt Protocol number 2009114469).

RESULTS

Of the total 413,757 Medicaid enrollees analyzed, 36,433 had a diagnosis code of SDB for an overall prevalence of 8.8%. For our secondary analyses, we determined the number of enrollees with CHF (17,831; prevalence, 4.3%), COPD (70,533; prevalence, 17.1%), and obesity (58,853; prevalence, 14.2%).

Demographic analyses (**Table 1**) demonstrated that individuals with SDB were more likely to be older, White, female, and have a fee for service vs managed-care enrollment. Individuals with one of the comorbid conditions of interest had a statistically higher prevalence of SDB. The prevalences of diagnosed SDB specifically among populations with different comorbidities of interest are presented in **Table 2**. Of the 17,831 enrollees with a diagnostic code of CHF, 7,981 had a comorbid SDB diagnostic code for an SDB prevalence rate of 44.8% in this cohort. For comorbid COPD, 20,968 of the 70,533 individuals had a diagnosis of SDB, for a prevalence rate of 29.7%. Last, of the 58,853 individuals with comorbid obesity, 16,081 had SDB for a prevalence rate of 27.3%. We further categorized obesity by BMI based on diagnostic codes and found that over half of the cohort with a BMI greater than 60 had a diagnostic code of SDB (53.9%).

Comparison of our coding data to national datasets was completed for SDB, CHF, obesity, and COPD. Based on our populations' characteristics, we estimated that the prevalence of SDB in this WV Medicaid population would be 25%. Our analysis demonstrates that 8.8% of Medicaid enrollees carried an SDB diagnostic code in 2019. The CDC's databases were queried for reports on prevalence rates of obesity (40%), CHF (15%), and COPD (20%) in WV.[20,28,29] Our analysis of the Medicaid database identified prevalence rates based on billing codes for CHF of 4.3%, COPD of 17.1%, and obesity of 14.2%.

DISCUSSION

In our analysis of WV Medicaid claims data from 2019 we showed the prevalence of SDB to be 8.8% as compared with estimations of 20–50% noted in larger cohort studies.[9,21,22] We also found lower prevalence rates of diagnostic codes for other common comorbid health conditions that have important clinical implications in the context of SDB. For instance, WV has the highest obesity rate in the United States, approaching 40%, yet only 14.2% of Medicaid enrollees carried this diagnosis code.[1] WV also has one of the highest heart failure death rates in the country, with an average 219 per 100,000 annual death rate compared with the national average of 174 per 100,000 based on 2016–2018 CDC data.[20] Medicaid provides health care coverage for approximately one-third of the WV population. One would assume this high death rate would correlate to

Table 1—Medicaid enrollees' demographic data for 2019 based on the presence of an SDB diagnostic code.

	Population with SDB (n = 36,433; 8.8%)	Population without SDB (n = 377,324; 91.2%)	*P*
Sex (n = 413,757)			
Male	14,553 (39.9%)	162,699 (43.1%)	< .0001
Female	21,880 (60.0%)	214,622 (56.9%)	
Missing	3		
Race (n = 413,757) 0 missing			
African American	1,437 (3.9%)	15,703 (4.2%)	< .0001
White	32,179 (88.3%)	323,685 (85.8%)	
Hispanic	37 (0.1%)	314 (0.1%)	
Other	35 (0.1%%)	428 (0.1%)	
Unknown/missing race code	2,745 (7.5%)	37,194 (9.9%)	
Age (n = 413,757), 0 missing			
n	36,433 (8.8%)	377,324 (91.2%)	< .0001
Mean (years)	52.6	43.0	
SD	14.8	17.0	
Age group (years) (n = 413,757)			
18–29	2,906 (8.0%)	104,292 (27.6%)	< .0001
30–39	4,478 (12.3%)	81,299 (21.6%)	
40–49	7,433 (20.4%)	65,367 (17.3%)	
50–59	10,405 (28.6%)	60,350 (16.0%)	
60–69	7,135 (19.6%)	38,887 (10.3%)	
70–79	2,760 (7.6%)	16,204 (4.3%)	
80–89	1,069 (2.9%)	8,332 (2.2%)	
90+	246 (0.7%)	2,578 (0.7%)	
Missing	3		
Claim type (n = 413,757), 0 missing			
FFS	17,480 (48.0%)	158,777 (42.1%)	< .0001
MCO	18,953 (52.0%)	218,547 (57.9%)	
Medicare/Medicaid dual eligibility (n = 413,757), 0 missing			
Medicaid only	23,303 (64.0%)	297,101 (78.7%)	< .0001
Medicare/Medicaid	13,130 (36.0%)	80,223 (21.3%)	
Comorbidities, 0 missing			
CHF	7,981 (21.9%)	9,850 (2.6%)	< .0001
COPD	20,968 (57.6%)	49,565 (13.1%)	
Obesity*	16,081 (44.1%)	42,772 (11.3%)	
BMI (in kg/m^2), 40	4,282 (11.8%)	9,742 (2.6%)	
BMI, 45	2,923 (8.0%)	5,124 (1.4%)	
BMI, 50	2,596 (7.1%)	3,448 (0.9%)	
BMI, 60	922 (2.5%)	789 (0.2%)	

Data are presented as n (%) unless otherwise indicated. *This represents all obesity codes including BMI 40–60 categories and patients with an unspecified obesity code. BMI = body mass index, CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease, FFS = fee for service, MCO = managed-care organization, SDB = sleep-disordered breathing, SD = standard deviation.

a high prevalence of CHF in the population, yet only 4% of 2019 Medicaid enrollees had a Medicaid claim with a heart failure diagnosis code in 2019. While this finding, in part, may be explained by inaccurate coding, we suspect other factors must also be involved to explain such a large discrepancy. For instance, given the geographic isolation and health care access issues of our Appalachian communities, underrecognition and delayed recognition also likely play an important role in heart failure outcomes (ie, when patients with CHF are finally identified, they are so sick they die at higher rates).

Table 2—Rates of SDB in cohorts of CHF, COPD, and obesity among Medicaid enrollees aged 18 to 90+ in 2019.

	Total with Chronic Condition	With SDB	Rate with SDB
CHF	17,831	7,981	44.8%
COPD	70,533	20,968	29.7%
Obesity (total)	58,853	16,081	27.3%
BMI (kg/m^2)			
40–44.9	14,024	4,282	30.5%
45–49.9	8,047	2,923	36.3%
50–59.9	6,044	2,596	43.0%
60+	1,711	922	53.9%

BMI = body mass index, CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease, SDB = sleep-disordered breathing.

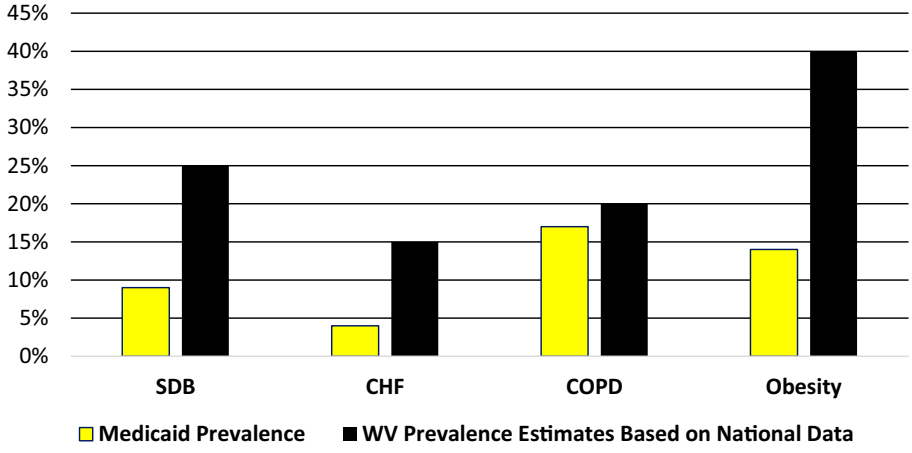
Based on the diagnostic codes, providers did seem to a better job at identifying COPD than these other conditions. WV has the highest smoking rate in the United States and the CDC database suggests a COPD prevalence of up to 20%.[2,4,29] Our data demonstrated 17.1% of Medicaid enrollees had a claim with a COPD diagnosis code.

Figure 1 illustrates the prevalence of these chronic conditions in our study population vs prevalence estimates based on national datasets. These findings are consistent with underdiagnoses of serious health conditions and have significant implications in terms of health outcomes for our Appalachian population. First, it is important to note that SDB is a common clinical problem that is currently underdiagnosed and undertreated even in urban settings despite data showing that SDB is increasing in prevalence.[9] This high prevalence has been attributed, in part, to the increase in obesity, a known important risk factor for SDB. No region has been hit harder by the obesity epidemic than Appalachia. According to the CDC's BRFSS, WV has the highest obesity rate of any US state, at 40%.[1] Thus, SDB should be highly prevalent in this Appalachian Medicaid cohort. However, consistent with our previous work, these data suggest that SDB is underrecognized in the region as only 8.8% of Medicaid enrollees carried an SDB diagnostic code in 2019.[8]

A second important finding in our study is the poor recognition of other comorbid medical conditions that are highly prevalent in the region. This finding is consequential as it suggests that a significant number of individuals are likely to have SDB and another serious comorbid health condition that are unrecognized. SDB that is comorbid with CHF, COPD, or obesity, particularly morbid obesity, represents well-described SDB phenotypes that have significant health implications and represent diagnostic/treatment challenges.[30–34] Research suggests that identification and effective treatment of SDB in patients with CHF, COPD, and obesity (particularly with obesity hypoventilation syndrome) significantly improves outcomes.[14–17,34–36]

Unfortunately, our database does not provide the billing code in a way that we could accurately determine which of the

Figure 1—West Virginia Medicaid database disease prevalence based on diagnostic code vs national and state disease prevalence estimates.



*Prevalence estimates for SDB, CHF, COPD, and obesity for the target population generated from references 1–4,20,29,30. CHF = congestive heart failure, COPD = chronic obstructive pulmonary disease, SDB = sleep-disordered breathing, WV = West Virginia.

comorbid conditions in our analysis was diagnosed first. Given our clinic experience and the above-mentioned underrecognition of SDB, we suspect that SDB is secondarily diagnosed. Regardless of the temporal relationship, SDB seemed to be appropriately considered in the disease cohorts included in our study based on diagnostic coding. For instance, an estimated 40–70% of patients with CHF have SDB.[37] When we analyzed the cohort of patients from our database with CHF, we found that 45% of these individuals had a concomitant diagnosis of SDB. One possible explanation for appropriate diagnosis of SDB in these other common chronic disease cohorts is that primary care providers managing these patients are aware of the association between SDB and the health conditions included in our study (CHF, COPD, obesity) but may not identify these serious health conditions early in their course. Alternatively, although the overall coding rate for CHF was lower than expected, the providers who are coding this condition may also be the same providers who are aware of the association between SDB and CHF. This subset of providers may also be more likely to code SDB correctly.

National data for the prevalence of SDB in the COPD and obesity populations are less clear. Early work on the so-called "overlap syndrome" suggested that SDB and COPD were 2 common medical conditions that, due to their high prevalence in the general population, concomitantly developed in a number of individuals.[38] However, the prevalence of SDB in individuals with COPD was not markedly different from that in the general population. More recent work suggests that SDB is highly prevalent in those with moderate-to-severe COPD (65.9%); however, large national studies confirming this finding have yet to be completed.[39] Similarly, the literature on the prevalence of SDB in obesity is complex, reflecting a multitude of factors important in the development of SDB, such as ethnicity, sex, age, fat distribution, and craniofacial structure. Despite these multiple factors, obesity is clearly a risk factor for SDB. Work by Sharma and colleagues[17] has shown a high prevalence of SDB in those with a BMI ≥ 30. As mentioned, WV has the highest rates of obesity and smoking-related illness in the country.

While at least a subset of providers seem to be identifying (or at least billing for) SDB in patients with COPD, CHF, and/or obesity, it is likely that a number of patients with these conditions are going unrecognized. Unfortunately, our results strongly suggest that, in general, primary care providers are underrecognizing serious health conditions and would benefit from additional training to provide optimal care to a highly vulnerable rural population.

Our team believes improved identification of SDB in this vulnerable population may represent "low-hanging fruit" for improved health outcomes in Appalachia. CHF, COPD, and obesity are complex disease processes to manage and, despite specialty care, are progressive in nature with poor outcomes.[40–45] Our previous work in rural communities looking to improve outcomes in COPD through telemedicine with increased access to specialty care demonstrated minimal impact on outcomes.[46] However, our team believes that SDB offers a unique opportunity to intervene and improve the outcomes in our population through empowering primary care providers. Prior research indicates that primary care providers can be effectively trained to manage SDB.[47,48] A low-cost SDB education/quality-improvement initiative targeting providers in this region may lead to significant improvements in health outcomes with limited resource investment from this already taxed health care system.

As discussed above, we compared our data with prevalence data from the CDC, including the well-validated BRFSS. Unfortunately, this system does not contain information on SDB. We estimated the SDB prevalence of our population based on previous epidemiologic studies as well as follow-up analysis of the Wisconsin cohort suggesting that 20–50% of the adult population have some degree of SDB depending on the population and diagnostic criteria.[9,21,22] Based on this analysis, we conservatively estimated the prevalence of SDB in this WV Medicaid population to be 25%.

This report suggests a staggering underrecognition of SDB and other important disease processes including COPD, CHF, and obesity in our Medicaid population. However, certain limitations of our analysis should be considered. First, these data are only representative of the enrolled population of Medicaid beneficiaries and may not reflect disease prevalence for the entire WV population. Regardless, these data represent one-third of the WV population and identify a vulnerable and disadvantaged group who likely play a significant role in driving poor outcomes for Appalachia and WV. Second, we utilized ICD-10 codes and CCS to assess disease prevalence. While this is the most effective tool to get a broad understanding of disease-recognition patterns, it relies on accurate coding by providers. For instance, a provider may be managing heart failure with a beta-blocker but codes hypertension with the beta-blocker instead of CHF. It is also possible that some conditions are more likely to be miscoded than others. For example, the discrepancy between estimates of obesity prevalence in Medicaid claims data relative to other data sources is larger than the discrepancy for other disease categories (**Figure 1**). There is always some degree of error in coding, but this fact is unlikely to dramatically alter the results of this large database study. Another important limitation on the patient side is whether an individual (with or without SDB) seeks care. Based on our model, this database would not include an individual who had zero billing codes for the year 2019 (ie, not in numerator or denominator). However, if a provider is not actively following SDB, it may only be coded when first diagnosed with no additional codes after that point. For instance, a patient diagnosed with SDB in 2018 but not followed up for this diagnosis in 2019 and who yet had visits for other diagnostic codes would be counted as not having SDB but be included in the general population pool (ie, not in the numerator but added to the denominator). Our team believes this limitation would have minimal impact on our findings for several reasons:

1. Once the diagnosis is made and treatment is initiated with positive airway pressure (PAP) therapy (at least in most cases), the diagnostic code would be required for replacement supplies every 3–6 months.
2. SDB is typically not diagnosed and addressed in 1 appointment but the process is over months. There would be a code for the appointment considering the diagnosis, another code for the diagnostic study, another code for

the therapeutic study and/or initiation of PAP therapy, and another code for the mandatory 3- to 6-month follow-up. If not treated with PAP therapy there would be another code for surgical intervention, oral appliance therapy, or upper airway stimulator implantation (typically after PAP failure).

3. These findings are in line with multiple other studies demonstrating that SDB is underdiagnosed, including a recent study suggesting that there are 1 billion people globally with unrecognized sleep apnea.[9–11] Again, this global issue of underdiagnosing SDB is likely exacerbated in our rural communities with limited access to care and other health care disparities.

Finally, identification of SDB is only the first step in improving outcomes. Our data suggest that, in the small subset of individuals who were successfully identified as having one of the studied disease processes, SDB was appropriately identified. Yet, the analysis does not show if these individuals with SDB were effectively treated. SDB in these patient populations can be complex to treat and previous research evaluating primary care management of SDB specifically excluded patients with COPD, CHF, and severe obesity.[47,48] This fact is further complicated by prior reports suggesting poor adherence in general to the gold-standard therapy for OSA, PAP.[49] Further analysis is required to assess management by providers of SDB in this population.

CONCLUSIONS

Our analysis of WV Medicaid claims data from 2019 indicates that SDB and other important medical conditions (CHF, COPD, obesity) are undercoded compared with national averages in this vulnerable, high-risk, primarily rural population. This finding suggests that SDB is underrecognized and may have important implications for the health of our West Virginian communities. The most consequential finding of our study is that a significant number of individuals are likely to have SDB and other serious comorbid health conditions that are not recognized. Effective treatment of SDB in patients with CHF, COPD, and obesity (particularly with obesity hypoventilation syndrome) significantly improves the trajectory of these disease processes. While some of the discrepancy between our findings and national data could relate to problems on the patient side seeking care, this large discrepancy likely relates to problems on the provider side as well. Our team highlights SDB in these findings as this represents a disease that has potential for management by primary care providers in these areas, particularly with improvements in technology which has simplified (moved out of the sleep laboratory) diagnosis and treatment. Empowering these providers to effectively identify and treat SDB would likely have a significant impact on health outcomes in these rural communities with significant health care disparity.

ABBREVIATIONS

BRFSS, Behavioral Risk Factor Surveillance System
BMI, body mass index
CCS, clinical classification software
CDC, Centers for Disease Control and Prevention
CHF, congestive heart failure
COPD, chronic obstructive pulmonary disease
OSA, obstructive sleep apnea
PAP, positive airway pressure
SDB, sleep-disordered breathing
WV, West Virginia
WVU, West Virginia University

REFERENCES

1. Centers for Disease Control and Prevention. Adult Obesity Prevalence Maps for All 50 states, the District of Columbia, and US Territories. https://www.cdc.gov/obesity/data/prevalence-maps.html. Accessed November 1, 2020.
2. Centers for Disease Control and Prevention. COPD Death Rates and Prevalence in the United States https://www.cdc.gov/copd/data.html. Accessed November 1, 2020.
3. Centers for Disease Control and Prevention. Total Cardiovascular Disease Death Rate per 100,000, 35+, All Races/Ethnicities, Both Genders, 2017–2019 per State. https://nccd.cdc.gov/DHDSPAtlas/?state=State. Accessed November 1, 2020.
4. Centers for Disease Control and Prevention. State Tobacco Activities Tracking and Evaluation (STATE) System. https://www.cdc.gov/statesystem/cigaretteuseadult.html. Accessed November 1, 2020.
5. Stansbury RC, Strollo PJ. Clinical manifestations of sleep apnea. *J Thorac Dis.* 2015;7(9):E298–E310.
6. Epstein LJ, Kristo D, Strollo PJ Jr, et al; Adult Obstructive Sleep Apnea Task Force of the American Academy of Sleep Medicine. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. *J Clin Sleep Med.* 2009;5(3):263–276.
7. Rural Health Information Hub. County Metropolitan Classification for West Virginia. https://www.ruralhealthinfo.org/data-explorer?id=191&state=WV. Accessed November 11, 2020.
8. Stansbury R, Abdelfattah M, Chan J, et al. Hospital screening for obstructive sleep apnea in patients admitted to a rural, tertiary care academic hospital with heart failure. *Hosp Pract* (1995). 2020;48(5):266–271.
9. Peppard PE, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol.* 2013;177(9):1006–1014.
10. Benjafield AV, Ayas NT, Eastwood PR, et al. Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. *Lancet Respir Med.* 2019;7(8):687–698.
11. Kapur V, Strohl KP, Redline S, Iber C, O'Connor G, Nieto J. Underdiagnosis of sleep apnea syndrome in U.S. communities. *Sleep Breath.* 2002;6(2):49–54.
12. US Census Bureau. Income, Poverty and Health for West Virginia. https://data.census.gov/cedsci/profile?g=0400000US54. Accessed November 11, 2020.
13. Health Resources and Services Administration. Eligibility Criteria for Federally Qualified Health Center. https://www.hrsa.gov/opa/eligibility-and-registration/health-centers/fqhc/index.html. Accessed October 26, 2021.
14. Marin JM, Soriano JB, Carrizo SJ, Boldova A, Celli BR. Outcomes in patients with chronic obstructive pulmonary disease and obstructive sleep apnea: the overlap syndrome. *Am J Respir Crit Care Med.* 2010;182(3):325–331.
15. Mokhlesi B, Masa JF, Brozek JL, et al. Evaluation and management of obesity hypoventilation syndrome. An official American Thoracic Society Clinical Practice Guideline. *Am J Respir Crit Care Med.* 2019;200(3):e6–e24.
16. Kauta SR, Keenan BT, Goldberg L, Schwab RJ. Diagnosis and treatment of sleep disordered breathing in hospitalized cardiac patients: a reduction in 30-day hospital readmission rates. *J Clin Sleep Med.* 2014;10(10):1051–1059.
17. Sharma S, Mukhtar U, Kelly C, Mather P, Quan SF. Recognition and treatment of sleep-disordered breathing in obese hospitalized patients may improve survival. The HoSMed Database. *Am J Med.* 2017;130(10):1184–1191.

18. Agency for Healthcare Research and Quality. Clinical Classifications Software for ICD-10. https://www.hcup-us.ahrq.gov/toolssoftware/ccs10/ccs10.jsp. Accessed November 11, 2020.
19. Centers for Disease Control and Prevention. BRFSS Prevalence Data and Analysis by Location. https://www.cdc.gov/brfss/brfssprevalence/index.html Accessed November 11, 2020.
20. Centers for Disease Control and Prevention. Interactive Atlas of Heart Disease and Stroke. https://nccd.cdc.gov/DHDSPAtlas/Reports.aspx. Accessed November 11, 2020.
21. Heinzer R, Vat S, Marques-Vidal P, et al. Prevalence of sleep-disordered breathing in the general population: the HypnoLaus study. *Lancet Respir Med.* 2015;3(4):310–318.
22. Tufik S, Santos-Silva R, Taddei JA, Bittencourt LRA. Obstructive sleep apnea syndrome in the Sao Paulo Epidemiologic Sleep Study. *Sleep Med.* 2010;11(5):441–446.
23. Fahimi M, Link M, Mokdad A, Schwartz DA, Levy P. Tracking chronic disease and risk behavior prevalence as survey participation declines: statistics from the Behavioral Risk Factor Surveillance System and other national surveys. *Prev Chronic Dis.* 2008;5(3):A80.
24. Mokdad AH, Stroup DF, Giles WH; Behavioral Risk Factor Surveillance Team. Public health surveillance for behavioral risk factors in a changing environment. Recommendations from the Behavioral Risk Factor Surveillance Team. *MMWR Recomm Rep.* 2003;52(RR-9):1–12.
25. Nelson DE, Holtzman D, Bolen J, Stanwyck CA, Mack KA. Reliability and validity of measures from the Behavioral Risk Factor Surveillance System (BRFSS). *Soz Praventivmed.* 2001;46(Suppl 1):S3–S42.
26. Li C, Balluz LS, Ford ES, Okoro CA, Zhao G, Pierannunzi C. A comparison of prevalence estimates for selected health indicators and chronic diseases or conditions from the Behavioral Risk Factor Surveillance System, the National Health Interview Survey, and the National Health and Nutrition Examination Survey, 2007-2008. *Prev Med.* 2012;54(6):381–387.
27. Pierannunzi C, Hu SS, Balluz L. A systematic review of publications assessing reliability and validity of the Behavioral Risk Factor Surveillance System (BRFSS), 2004-2011. *BMC Med Res Methodol.* 2013;13(1):49.
28. Centers for Disease Control and Prevention. Heart Failure Death Rates by U.S. Counties. https://www.cdc.gov/heartdisease/heart_failure.htm. Accessed November 12, 2020.
29. Centers for Disease Control and Prevention. Model-Based COPD Prevalence by Census Tract, United States 2014. https://www.cdc.gov/copd/pdfs/COPD_tract2014_saeColor_2.pdf. Accessed November 12, 2020.
30. Edwards BA, Redline S, Sands SA, Owens RL. More than the sum of the respiratory events: personalized medicine approaches for obstructive sleep apnea. *Am J Respir Crit Care Med.* 2019;200(6):691–703.
31. Eckert DJ. Phenotypic approaches to obstructive sleep apnoea—new pathways for targeted therapy. *Sleep Med Rev.* 2018;37:45–59.
32. Berg G, Delaive K, Manfreda J, Walld R, Kryger MH. The use of health-care resources in obesity-hypoventilation syndrome. *Chest.* 2001;120(2):377–383.
33. Howard ME, Piper AJ, Stevens B, et al. A randomised controlled trial of CPAP versus non-invasive ventilation for initial treatment of obesity hypoventilation syndrome. *Thorax.* 2017;72(5):437–444.
34. Mansfield DR, Gollogly NC, Kaye DM, Richardson M, Bergin P, Naughton MT. Controlled trial of continuous positive airway pressure in obstructive sleep apnea and heart failure. *Am J Respir Crit Care Med.* 2004;169(3):361–366.
35. Kaneko Y, Floras JS, Usui K, et al. Cardiovascular effects of continuous positive airway pressure in patients with heart failure and obstructive sleep apnea. *N Engl J Med.* 2003;348(13):1233–1241.
36. Naranjo M, Willes L, Prillaman BA, Quan SF, Sharma S. Undiagnosed OSA may significantly affect outcomes in adults admitted for COPD in an inner-city hospital. *Chest.* 2020;158(3):1198–1207.
37. Gupta A, Quan SF, Oldenburg O, Malhotra A, Sharma S. Sleep-disordered breathing in hospitalized patients with congestive heart failure: a concise review and proposed algorithm. *Heart Fail Rev.* 2018;23(5):701–709.
38. Flenley DC. Sleep in chronic obstructive lung disease. *Clin Chest Med.* 1985;6(4):651–661.
39. Soler X, Gaio E, Powell FL, et al. High prevalence of obstructive sleep apnea in patients with moderate to severe chronic obstructive pulmonary disease. *Ann Am Thorac Soc.* 2015;12(8):1219–1225.
40. Chen J, Normand SL, Wang Y, Krumholz HM. National and regional trends in heart failure hospitalization and mortality rates for Medicare beneficiaries, 1998-2008. *JAMA.* 2011;306(15):1669–1678.
41. Cresci S, Pereira NL, Ahmad F, et al. Heart failure in the era of precision medicine: a scientific statement from the American Heart Association. *Circ Genom Precis Med.* 2019;12(10):458–485.
42. Heffner JE, Mularski RA, Calverley PM. COPD performance measures: missing opportunities for improving care. *Chest.* 2010;137(5):1181–1189.
43. Patel AR, Patel AR, Singh S, Singh S, Khawaja I. Global Initiative for Chronic Obstructive Lung Disease: the changes made. *Cureus.* 2019;11(6):e4985.
44. Mingrone G, Panunzi S, De Gaetano A, et al. Bariatric surgery versus conventional medical therapy for type 2 diabetes. *N Engl J Med.* 2012;366(17):1577–1585.
45. Greenway FL, Fujioka K, Plodkowski RA, et al; COR-I Study Group. Effect of naltrexone plus bupropion on weight loss in overweight and obese adults (COR-I): a multicentre, randomised, double-blind, placebo-controlled, phase 3 trial. *Lancet.* 2010;376(9741):595–605.
46. Leonard R, Forte M, Mehta D, Mujahid H, Stansbury R. The impact of a telemedicine intervention on home non-invasive ventilation in a rural population with advanced COPD. *Clin Respir J.* 2021;15(7):728–734.
47. Chai-Coetzer CL, Antic NA, Rowland LS, et al. Primary care vs specialist sleep center management of obstructive sleep apnea and daytime sleepiness and quality of life: a randomized trial. *JAMA.* 2013;309(10):997–1004.
48. Mayos M, Peñacoba P, Pijoan AMP, et al. Coordinated program between primary care and sleep unit for the management of obstructive sleep apnea. *NPJ Prim Care Respir Med.* 2019;29(1):39.
49. Weaver TE, Grunstein RR. Adherence to continuous positive airway pressure therapy: the challenge to effective treatment. *Proc Am Thorac Soc.* 2008;15;5(2):173–178.

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