ORIGINAL RESEARCH

A Health Communication Assessment of Web-based Obstructive Sleep Apnea Patient Education Materials

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ABSTRACT

Background: The current care pathway for screening, diagnosis, and treatment for obstructive sleep apnea (OSA) is often fragmented and heavily reliant on patient action, leading to delays and gaps in care, which disproportionately affect race and ethnic minorities. There is a need for well-designed, accessible patient education materials (PEMs) to improve OSA awareness and empower those at risk for the condition with the necessary knowledge and skills to adhere to treatment.

Objective: Our study aimed to evaluate the understandability, accessibility, actionability, and readability of web-based PEMs designed for patients with OSA and their families and caregivers.

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Methods: We engaged patients with OSA, clinicians, and patient advocates ($n = 11$) to identify a list of web-based OSA PEMs from the media, medical centers, medical device companies, and health professional and patient advocacy organizations. Two trained coders scored the PEMs using validated health communication assessments, including the Centers for Disease Control and Prevention Clear Communication Index (CCI; on a scale from 0 to 100%); the Patient Education Materials Assessment Tool (PEMAT), which features subscales for understandability and actionability, each measured from 0 to 100%; and readability measures, including the Simple Measure of Gobbledygook and Flesch-Kincaid, which correspond to grade levels.

Results: We identified 20 web-based PEMs, which included websites ($n = 12$, 60%), online flyers ($n = 4$, 20%), videos ($n = 3$, 15%), and one discussion board ($n = 1$, 5%). Scores on the CCI ranged from 21.4 to 85.7%. No PEMs met the CCI cutoff (90%). Scores on the PEMAT scales for understandability ranged from 37.5 to 100%. Scores on the PEMAT scales for actionability ranged from 0 to 100%. Fifteen percent of the PEMs met the PEMAT cutoff for understandability and actionability. Readability of the PEMs ranged from a 5th to a 15th-grade reading level, as scored by the Simple Measure of Gobbledygook and Flesch-Kincaid. Only one PEM (5%) met the recommended sixth-grade reading level.

Conclusion: Our study found that the majority of commonly used web-based PEMs for OSA did not meet recommended standards for clear communication and health literacy demands. OSA practitioners and future research should consider health communication best practices to design PEMs that reduce the gap between materials and average patient health literacy.

Keywords:
health communication; sleep apnea; sleep disorders; behavioral therapy

Current obstructive sleep apnea (OSA) care pathways, from symptom recognition to successful treatment, are fraught with a number of barriers for patients, family members, and caregivers (1) and may lead to delays in diagnosis and care and suboptimal treatment (2–4). The myriad of OSA treatment options, ranging from lifestyle modification to dental appliances, surgical options, and a variety of models of continuous positive airway pressure (CPAP) therapy, require clinicians to provide guidance on treatment decisions and to educate patients about implementation, including use (5, 6). Although the American Academy of Sleep Medicine (AASM) guidelines include a strong recommendation for patient education to be delivered together with CPAP therapy (6), not all clinicians have the time or resources to do so. Previous research has demonstrated that many patients with sleep apnea perceive that they are not provided with sufficient information about OSA by their clinicians and desire more information about the range of available OSA treatment options (7, 8). Early adoption and adherence of CPAP is of particular importance, as patients with OSA are required, unlike other medical therapies, to meet short-term adherence benchmarks for CPAP therapy (9) or risk losing access to therapy. Consequently, high percentages (>80%) of

patients with diagnosed but untreated OSA and suboptimal adherence rates persist (10, 11), particularly among health disparate populations (12, 13).

There is thus a critical need for accessible, understandable, and useable patient education materials (PEMs) that empower patients with information about OSA risk factors, symptoms, evaluation, and treatment. Well-designed PEMs have been shown to increase self-efficacy, defined as one's belief in their ability to perform a recommended behavior (14), as demonstrated by a community-based intervention to improve OSA awareness among underserved communities (15), and uptake of recommended action, as demonstrated in a trial evaluating a low-literacy decision aid for vaccination (16). Fundamental to the development of PEMs is the principle of health literacy, which is defined as a patient's capacity to obtain, process, and understand basic health information to make appropriate health decisions (17, 18). As 36% of U.S. adults demonstrate basic or poor health literacy, and low health literacy is disproportionate among overlapping risk factors for OSA (e.g., race and ethnic minorities and low English proficiency) (19), it is critical that OSA-related PEMs be designed with the aim of making information simple, easy to understand, and actionable (20).

Despite the promise of PEMs for addressing the challenges in OSA diagnosis and care, there has been little research to evaluate the quality of available PEMs regarding OSA symptoms, diagnosis, evaluation, and care. The web has tremendous potential as a delivery mechanism for PEMs on various OSA-related topics that may complement the care, support, and education they receive from their provider and is already a widely accessed platform for health information. According to nationally representative data, 75% of adults reported that the Internet is the place they start when seeking health information (21). Therefore, this study aimed to identify and evaluate commonly accessed web-based OSA PEMs using validated health communication assessment tools, including the Centers for Disease Control and Prevention (CDC) Clear Communication Index (CCI), the Patient Education Materials Assessment Tool (PEMAT) (22), the Simple Measure of Gobbledygook (SMOG) (23), and the Flesch-Kincaid Reading Level Index. In addition, we identify opportunities for improving the health literacy demands related to understandability, accessibility, actionability, and readability of OSA-related PEMs for patients, their family members, and the general public.

METHODS

Stakeholder PEM Identification

We enlisted our 11-person multidisciplinary team (formed and funded by Patient-Centered Outcomes Research Institute Engagement Award EADI #16493), representing diverse stakeholders, including sleep medicine physicians ($n = 3$), OSA and PAP adherence clinical researchers ($n = 4$), and patients and patient advocates ($n = 4$). Patients and patient advocates were either those with an OSA diagnosis and/or individuals affiliated with advocacy groups for patients with OSA (e.g., Alliance of Sleep Apnea Partners). Regarding the education level of the patients and patient advocates, one reported a college degree, two reported master's degrees, and one reported a doctorate. We queried physicians to identify web-based PEMs they or colleagues recommend to patients or that they thought are most likely used by patients and researchers to identify

web-based PEMs they were aware of through their work. Finally, we asked patients and patient advocates to list the PEMs that their physicians recommended, that they found online, or that they heard about from other patients, family, or friends.

The clinicians, patients, and patient advocates were asked to identify PEMs of the following types: *1*) resources produced by academic/medical organizations, *2*) patient-focused discussion boards or forums, *3*) resources provided by medical device companies, and *4*) resources produced by press or media outlets. By design, the PEMs were not systematically collected but were a collated collection of those perceived to be most commonly used by patients and most helpful for patients as part of routine care of patients with OSA.

Our stakeholders identified 20 PEMs in total. These included websites that featured videos and minimal text (hereafter termed videos), websites that featured static information in the form of a flyer (i.e., noninteractive content, hereafter termed online flyers), websites with mostly text information or text information accompanied by interactive elements, such as brief videos and hyperlinks (hereafter termed websites), and one discussion board.

Determining the Popularity of the PEMs Using Online Searches

The research team developed a set of Google search queries, which patients or the general population may use to learn more about OSA. Search terms included "sleep apnea," "sleep apnea symptoms," "sleep apnea diagnosis," "CPAP for sleep apnea," and "sleep apnea therapies." We then examined the search results to determine if the PEMs identified in this study by our stakeholders appeared on the top 20 hits from the searches above on Google.

Health Communication Assessments

To better equip patients with the knowledge and capacity to recognize, pursue, and adopt the diagnostic and therapeutic processes of OSA care and to meet their literacy needs, it is critical to design PEMs that are understandable, accessible, actionable, and readable. This study draws upon validated assessment tools from health communication research to evaluate commonly accessed web-based OSA PEMs.

The CDC CCI. We administered the CCI, which is a 20-item index for assessing the clarity of health communication materials (24). The CCI assesses seven domains: main message and call to action, language, information design, state of the science, behavioral recommendations, numbers, and risk. Each item on the CCI has a numerical score of zero or one. The scores are tabulated on a scale from 0 to 100%. Although 100% is optimal, a score of 90% or higher is considered passing (24).

PEMAT. We also used the PEMAT (22) to evaluate and compare the understandability and actionability of the information provided by the OSA PEMs. The PEMAT has separate tools for print and audiovisual materials. The scorecard has a total of 24 items for print materials (17 for understandability and 7 for actionability) and 17 for audiovisual materials (13 for understandability and 4 for actionability). Scores are tabulated on a scale from 0 to 100%, with scores above 70% indicating passing performance on each dimension (22).

SMOG and Flesch-Kincaid. Finally, we administered two readability scales to

assess the reading level of the OSA resources. First, we analyzed the materials using the SMOG, which considers information on both word and sentence length (23). The SMOG score and reading grade level is determined in two steps: first, the number of polysyllabic words in a subset of 10 sentences selected from the beginning, middle, and end of the resource, for a total of 30 sentences, is identified; then, the score is calculated as the square root of the total number of polysyllabic words plus three. Second, we calculated the Flesch-Kincaid Reading Level Index (25). The Flesch-Kincaid was determined using readability tools available in standard word processing software. Like the SMOG, the Flesch-Kincaid corresponds to the grade level required to read and comprehend the material. A sixth-grade reading level or lower is recommended for medical information (26).

Coding the PEMs according to the Health Communication Assessments

The first author (R.R.) trained two coders (authors K.N.M. and C.L.) on applying the CCI, PEMAT, SMOG, and Flesch-Kincaid assessments. Over several weeks, the coders pilot tested the battery of assessments for two resources and then discussed their results together with the first author to adjudicate initial coding discrepancies and to reach an agreement on a standardized coding procedure for subsequent articles. Interrater agreement, computed using Krippendorf α, was >0.95 (27), suggesting high agreement among coders. Disagreements were resolved via discussion between the two reviewers and the first author.

Statistical Analysis

The scores assigned by coders were tabulated using descriptive statistics. We calculated the percent of PEMs that meet the target CCI, PEMAT, and reading level cutoff scores. The top-scoring resources for each health communication instrument category (video, online flyer, and website) were identified, and their main messages were extracted from the PEM.

RESULTS

Results of the Health Communication Assessment Coding

Table 1 lists the descriptive characteristics summarizing the CCI, PEMAT, SMOG, and Flesch-Kincaid scores for each of the 20 PEMs assessed. The 20 web-based OSA resources identified included videos ($n = 3$, 15%), online flyers ($n = 4$, 20%), websites ($n = 12$, 60%), and one discussion board (5%). Results from the coding procedure identified patients ($n = 16$, 80%) as the most common intended audience for the resources, followed by the general public ($n = 3$, 15%) and, less commonly, patients and their families ($n = 1$, 5%).

None (0%) of the PEMs met the CCI's 90% cutoff score for clear and effective communication. The CCI scores for the 20 resources ranged from 21.4 to 85.7%. The two highest scoring resources on the CCI were a patient-focused website developed by ResMed and a patient-focused online flyer developed by the American Thoracic Society (ATS). The ResMed resource, which scored highest on the CCI (85.7%), was designed to offer tips and advice for more comfortable and effective use of a CPAP machine. The ATS resource, which scored the second highest on the CCI (82.4%), was designed to educate patients about alternatives to CPAP therapy.

Of all the resources (print and audiovisual), three (15%) met the 70% cutoff score for both understandability and actionability. PEMAT-P scores for the print resources ranged from 37.5 to 100%

Table 1. Summary of PEM intended audience, communication objective, and results on the CCI, PEMAT-P, PEMAT-AV, SMOG, and Flesch-Kincaid ($n = 20$)

PEM	Intended Audience	Communication Objective	CCI (%)*	PEMAT-P (%)†		PEMAT-AV (%)†		SMOG‡§	Flesch-Kincaid‡§
				Understandable	Actionable	Understandable	Actionable		
Websites ($n = 12$)									
American Academy of Dental Sleep Medicine	Patients	Explain oral appliance therapy	27.3	81.8‖	50.0	66.7	50.0	12	9.3
Apnea Partners: About Sleep Apnea	Patients	Educate patients on the risks, symptoms, and types of sleep apnea	40.0	70.6‖	33.3	—	—	13	9.1
Apnea Partners: Diagnosis	Patients	Prepare patients for their sleep study experience	64.3	60.0	60.0	—	—	10	8.9
Apnea Partners: Living with Sleep Apnea	Patients	Explain insurance issues with not wearing a CPAP and tricks to stay motivated using the CPAP and address common issues with CPAP machines	64.7	50.0	75.0‖	—	—	11	7
Apnea Partners: Treatment Options	Patients	Explain OSA treatment options	64.7	68.8	42.9	—	—	13	12.4
Mayo Clinic: Sleep Apnea	General public	Explain OSA symptoms, risk factors, and complications	64.7	87.5‖	100.0‖	—	—	12	8.3
NY Times	General public	Explain OSA symptoms and treatment	65.0	70.6‖	57.1	—	—	12	9.2
Philips Healthcare: I Think I Might Have Sleep Apnea	Patients	Inform potential patients about what OSA is, risk factors, and symptoms	65.0	87.5‖	80.0‖	75.0‖	100.0‖	15	10.6

Table 1. *Continued.*

PEM	Intended Audience	Communication Objective	CCI (%)*	PEMAT-P (%)†		PEMAT-AV (%)†		SMOG‡§	Flesch-Kincaid‡§
				Understandable	Actionable	Understandable	Actionable		
ResMed: Living with CPAP	Patients	Offer tips/advice for more comfortable and effective use of a CPAP machine	85.7	75.0‖	100.0‖	63.6	100.0‖	10	7.6
ResMed: Sleep Apnea Diagnosis	Patients	Explain OSA causes, symptoms, and treatment	65.0	82.4‖	80.0‖	91.7‖	100.0‖	10	6.1
WebMD: Apnea Myths	General public	Explain OSA causes, symptoms, and treatment	75.0	88.2‖	57.1	—	—	9	5.4‖
WebMD: Diagnosing Sleep Apnea	Patients	Inform and prepare patients for a sleep study	36.4	75.0‖	25.0	—	—	12	10.5
Online flyers ($n = 4$)									
American Academy of Sleep Medicine	Patients	Outline diagnostic testing options for OSA and prepare patients for conversations with medical providers	58.8	100.0‖	80.0‖	—	—	14	9.4
American Thoracic Society: CPAP for OSA	Patients	Explain the role and importance of CPAP in OSA treatment	58.8	37.5	80.0‖	—	—	13	10.2
American Thoracic Society: Oral Appliances	Patients	Explain oral appliances, including their side effects and use	47.1	58.3	100.0‖	—	—	12	8.7
American Thoracic Society: Other Therapies	Patients	Educate patients about alternatives to CPAP	82.4	71.4‖	100.0‖	—	—	13	8.9
Discussion board ($n = 1$)									

Table 1. *Continued.*

PEM	Intended Audience	Communication Objective	CCI (%)*	PEMAT-P (%)†		PEMAT-AV (%)†		SMOG‡§	Flesch-Kincaid‡§
				Understandable	Actionable	Understandable	Actionable		
CPAP Talk	Patients	Explain the importance of social support for CPAP	50.0	38.5	0.0	—	—	15	14.4
Videos ($n = 3$)									
Apnea Board	Patients	Inform patients about OSA and CPAP treatment	55.0	—	—	66.7	100.0‖	—	—
Harvard Healthy Sleep	Patients and family members	Explain OSA and its treatment	21.4	—	—	61.5	0.0	—	—
Mayo Clinic: Sleep Apnea	Patients	Explain how CPAP functions	57.1	—	—	72.7‖	100.0‖	—	—

Definition of abbreviations: CCI = Clear Communication Index; CPAP = continuous positive airway pressure; OSA = obstructive sleep apnea; PEM = patient education material; PEMAT-AV = Patient Education Materials Assessment Tool-Audiovisual; PEMAT-P = Patient Education Materials Assessment Tool-Print; SMOG = Simple Measure of Gobbledygook.

*The CCI defines a clear resource as one that has a score of 90%.

†A score of 70% or higher on the PEMAT subscales is defined as an understandable, actionable resource.

‡According to the American Medical Association, readable health information is designed at a sixth-grade reading level or below.

§Audiovisual resources are not scored on readability.

‖PEMs that meet the desired threshold on each health communication assessment tool.

Table 2. Main messages featured in the top-scoring PEMs by type

PEM	Main Messages
Top-scoring video	
Mayo Clinic: How CPAP Controls Sleep Apnea	• CPAP is a treatment option for OSA. • As you sleep, CPAP provides air at a pressure just high enough to prevent the collapse of your airway. • Some people require different pressures during the inhale and exhale cycle to help them breathe more normally or comfortably. • A variety of masks are available.
Top-scoring flyer	
American Thoracic Society: Other Therapies for Sleep Apnea	• For those who cannot use CPAP or want to try another option, there are other therapies that can work for people with OSA. • There are a number of different oral appliances used for OSA. • Losing weight, especially reducing fat deposits in the neck and tongue, can improve OSA. • Surgery is not frequently used to treat OSA in adults because it doesn't work very well for most adults. • When a therapy is working well, you should have little or no snoring. You may notice you sleep more restfully. You may see improvement in daytime sleepiness and fatigue.
Top-scoring websites	
ResMed: Living with CPAP: 7 tips for a better experience	• There are plenty of tips and tricks to make it easier to adjust to your OSA therapy so you can start getting quality sleep every night. • Practice makes perfect. • Use your CPAP mask every time you sleep. • Make small adjustments to your CPAP mask nightly. • Make sure your mask is fitted for YOU. • Use AutoRamp on your CPAP machine. • Use a CPAP humidifier if your nose or throat is dry. • Wear gloves if you're having trouble keeping your mask on.
ResMed: Sleep Apnea Diagnosis	• OSA is a serious sleep disorder that causes you to stop breathing during sleep. It's important to understand the signs and symptoms and consult your doctor if you think you might have it. • Effective OSA therapy, which includes the use of CPAP equipment, has been shown to help ease common symptoms and improve energy levels, productivity, and overall mind-body wellness.

Definition of abbreviations: CPAP = continuous positive airway pressure; OSA = obstructive sleep apnea; PEM = patient education material.

Table 3. OSA resources and website links (all accessed January 2021)

PEM	Search Terms That Included the PEM in the Top 20 Search Results on Google					PEM Website Link
	Sleep Apnea	Sleep Apnea Symptoms	Sleep Apnea Diagnosis	Sleep Apnea Therapies	CPAP for Sleep Apnea	
American Academy of Dental Sleep Medicine	X					https://www.aadsm.org/oral_appliance_therapy.php
Apnea Partners: About Sleep Apnea		X				https://www.apneapartners.org/about-sleep-apnea
Apnea Partners: Diagnosis						https://www.apneapartners.org/diagnosis
Apnea Partners: Living with Sleep Apnea						https://www.apneapartners.org/living-with-sleep-apnea
Apnea Partners: Treatment Options						https://www.apneapartners.org/treatment-options
Mayo Clinic: Sleep Apnea			X	X	X	https://www.mayoclinic.org/diseases-conditions/sleep-apnea/symptoms-causes/syc-20377631#:~:text=Difficulty%20staying%20asleep%20(insomnia),Irritability
NY Times						https://www.nytimes.com/guides/well/sleep-apnea-guide
Philips Healthcare: I Think I Might Have Sleep Apnea						https://www.usa.philips.com/c-e/hs/sleep-apnea-therapy/i-think-i-might-have-sleep-apnea/getting-diagnosed
ResMed: Living with CPAP						https://www.resmed.com/en-us/sleep-apnea/sleep-blog/living-with-cpap-7-tips-for-a-better-experience/
ResMed: Sleep Apnea Diagnosis	X	X				https://www.resmed.com/en-us / sleep-apnea/snoring-sleep-apnea-diagnosis/what-is-sleep-apnea/
WebMD: Apnea Myths						https://www.webmd.com/sleep-disorders/sleep-apnea/ss/slideshow-myth-fact
WebMD: Diagnosing Sleep Apnea		X				https://www.webmd.com/sleep-disorders/sleep-apnea/diagnosing-sleep-apnea
American Academy of Sleep Medicine						https://j2vjt3dnbra3ps7ll1clb4q2-wpengine.netdna-ssl.com/wp-content/uploads/2019/11/DTO-Patient-Guide.pdf
American Thoracic Society: CPAP for OSA						https://www.thoracic.org/patients/patient-resources/resources/cpap-for-osa.pdf
American Thoracic Society: Oral Appliances						https://www.thoracic.org/patients/patient-resources/resources/oral-appliances-sleep-apnea.pdf

Table 3. *Continued.*

PEM	Search Terms That Included the PEM in the Top 20 Search Results on Google: Sleep Apnea	Sleep Apnea Symptoms	Sleep Apnea Diagnosis	Sleep Apnea Therapies	CPAP for Sleep Apnea	PEM Website Link
American Thoracic Society: Other Therapies				X		https://www.thoracic.org/patients/patient-resources/resources/other-therapies-for-sleep-apnea.pdf
CPAP Talk						https://www.cpaptalk.com/wiki/index.php/Building_Your_CPAP_Support_Team
Apnea Board						https://www.apneaboard.com/sleep-apnea-information/sleep-apnea-videos
Harvard Healthy Sleep	X					http://healthysleep.med.harvard.edu/sleep-apnea
Mayo Clinic: Sleep Apnea					X	https://www.mayoclinic.org/diseases-conditions/sleep-apnea/multimedia/cpap/vid-20084718

Definition of abbreviations: CPAP = continuous positive airway pressure; OSA = obstructive sleep apnea; PEM = patient education material.

on understandability and from 0 to 100% on actionability. The two highest scoring resources on the understandability subscale were the online flyer from the AASM, which scored 100%, and the WebMD website on apnea myths, which scored 88.2%. The AASM online flyer was designed to outline diagnostic testing options for OSA and prepare patients for conversations with medical providers. The WebMD website aimed to debunk myths about OSA symptoms, causes, and treatment. Four resources scored 100% on the PEMAT-P actionability scale, including *1*) the ATS online flyer on oral appliances; *2*) the ATS online flyer on alternatives to CPAP; *3*) the ResMed website on living with CPAP; and *4*) the Mayo Clinic website on OSA symptoms, risk factors, and complications.

The scores on the PEMAT-AV for the seven audiovisual resources ranged from 61.5 to 92.7% on the PEMAT-AV understandability subscale and from 0 to 100% on the PEMAT-AV actionability subscale. The highest scoring resource on the PEMAT-AV understandability subscale was the ResMed website explaining an OSA diagnosis (91.7%). Several PEMs scored 100% on the PEMAT-AV actionability subscale, including *1*) the website from Philips Healthcare on OSA risk factors and symptoms; *2*) the ResMed website outlining tips and advice for more comfortable and effective use of CPAP; *3*) the ResMed website outlining OSA causes, symptoms, and treatment; *4*) the Apnea Board video that informs patients about OSA treatment; and *5*) the Mayo Clinic video, which explains how CPAP functions.

Scores on the SMOG ranged from a 9th-grade to a 15th-grade reading level, whereas scores on the Flesch-Kincaid readability index ranged from a 5th-grade to a 14th-grade reading level. The PEM

with the most accessible reading level score on both SMOG and Flesch-Kincaid index was the WebMD website on myths about OSA causes, symptoms, and treatment.

Across the five instruments, none of the commonly accessed, web-based OSA-related PEMs had an acceptable score on the CCI (0%); fewer than one quarter (15%) had acceptable scores on the PEMAT understandability and actionability dimensions; and one (5%) PEM had an acceptable score on the readability assessments. No resource scored favorably on more than one dimension (e.g., clarity and readability).

Main Messages from the Top-Scoring OSA PEMs

The main messages from the top-scoring resources in each category of PEM are displayed in Table 2. The main messages from top-scoring resources include simple, actionable information. For instance, the Mayo Clinic video on CPAP features messages such as "As you sleep, CPAP provides air at a pressure just high enough to prevent the collapse of your airway" and "A variety of masks are available." The top-scoring online flyer from ATS included main messages such as "For those who cannot use CPAP or want to try another option, there are other therapies that can work for people with OSA." One of the top-scoring websites from ResMed on living with CPAP featured messages such as "Practice makes perfect."

Results of the Google Queries for PEMs Identified in this Study

We identified several PEMs that appeared in the top hits of one Google search query, including the American Academy of Dental Sleep Medicine website on oral appliance therapy and the WebMD website on an OSA diagnosis. The Mayo Clinic OSA website was returned in the top 20 hits for three search queries, including "sleep apnea diagnosis," "sleep apnea therapies," and "CPAP for sleep apnea." The ResMed website on an OSA diagnosis was returned in the top 20 hits for two search queries, including "sleep apnea" and "sleep apnea diagnosis." Table 3 displays the search queries and PEMs included in the top 20 hits for each query.

DISCUSSION

Our study is among the first available in the published literature to apply validated health communication tools to evaluate web-based PEMs for patients, their families, and the general public about OSA. Results from our study indicate that the majority of available web-based OSA PEMs fail to meet communication standards for understandability, accessibility, actionability, and readability. Specifically, all assessed resources scored below the CDC CCI 90% threshold for the clarity and understandability of health information. According to the PEMAT, which assesses understandability and actionability, scores ranged widely on understandability (print PEMs from 38 to 100%; AV PEMs from 62 to 100%) and on actionability (from 0 to 100% for both print and AV PEMs). We also found that all the resources assessed were above the sixth-grade reading level (28) recommended by the American Medical Association (28).

The significant variability in understandability, accessibility, actionability, and readability of available PEMs for OSA identified in this study has concerning implications. Designing OSA materials at too high of a reading level without careful consideration of health communication principles, such as clarity and readability, limits the utility of OSA-

related PEMs for the majority of patients. Second, low English proficiency and associated poor health literacy present a more than twofold increased risk for poor health (29), and a review of the literature demonstrates that poor health literacy exacerbates health disparities (30). Therefore, failing to design patient-centered, low-literacy resources has likely played a role in exacerbating well-documented disparities in OSA burden, diagnosis, and care (31–33). These OSA-related health disparities may have far-reaching impacts given the higher burden of OSA-related conditions among vulnerable populations, such as those with low English proficiency, as well as lower rates of CPAP adherence among health disparate groups.

Fortunately, our study identified several PEMs that scored well on the various health communication metrics. We extracted the main messages from these resources, which were largely readable, understandable, and clear. For instance, the Mayo Clinic video on OSA featured simple, straightforward messages, such as "A variety of masks are available," and the ResMed website on diagnosis included a main message that "Practice makes perfect." Future OSA PEM designers may consider using these or similar messages when designing their PEMs. Finally, we conducted several Google search queries for various OSA topics, such as "sleep apnea diagnosis" and "CPAP and sleep apnea," and we found several top-scoring resources, including the Mayo Clinic video and the ResMed websites, appeared in the top hits of several searches. It is possible that these PEMs appear frequently in searches because of their readability, understandability, and clarity, highlighting the importance of addressing these domains in the development of OSA PEMs.

Future Research

Previous research has shown that when materials and interventions can be designed to address the standards of clear communication and appropriate reading level (sixth grade or below), self-efficacy and uptake of the recommended health behaviors greatly improve (15, 16). Given the poor performance we observed in our study of existing web-based OSA-related PEMs, our findings illuminate several avenues for future research to design OSA-related PEMs that address the critical gaps in diagnosis and treatment adherence. First, it is important that findings regarding the readability, understandability, and clarity of existing PEMs, such those obtained through the present investigation, be shared with key stakeholders, such as the designers and creators of the PEMs, and disseminated more broadly. Second, future researchers and designers of OSA-related PEMs may consult the health communication readability tools, such as the SMOG or Flesch-Kincaid, to ensure that PEMs meet the recommended sixth-grade reading level (28) before dissemination. The Flesch-Kincaid reading level can be easily assessed using tools available in many word processors. Third, health communication metrics, such as the CCI or PEMAT, may be useful reference tools for pretesting OSA-related PEMs before they are released to ensure they score favorably on these batteries assessing understandability, accessibility, actionability, and readability before dissemination.

Limitations

Although this study used validated health communication tools to assess resources

for OSA PEMs directly elicited by patients and clinicians, our work has some limitations. First, we identified OSA resources through a convenience sample of stakeholders composed of sleep clinicians, researchers, patients, and patient advocates. These individuals certainly are not representative of all stakeholders, nor did we perform a comprehensive review of all available OSA-related PEMs. Future research may consider larger, more systematic efforts to identify the most commonly accessed OSA resources, including paper resources provided by health teams for those patients with limited technology skills or access, paid resources, or electronic medical record–embedded health education tools. Second, we assessed performance with two trained coders. It is possible that different coders would have made different judgments of the resources; however, scoring procedures were standardized.

Conclusions

Our study identified and evaluated the understandability, accessibility, actionability, and readability of commonly accessed web-based OSA PEMs for patients, families, and the general public using validated health communication instruments. We found that, overall, these widely available OSA resources score relatively low on health communication assessments and below thresholds for understandability, accessibility, actionability, and readability. In addition, we found the required reading ability for the resources was well above the recommended sixth-grade reading level. Future designers of OSA-related PEMs should consider using these health communication assessments in their pilot testing of messages, visuals, and videos before they are released to improve their usability and impact on care.

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