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Title: Readability Assessment of Online Peripheral Artery Disease Education Materials

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Concept and design: All authors; Acquisition of data: TA, SH, ML; Statistical analysis: KT
Interpretation of data: All authors; Drafting of manuscript: TA, SH, ML; Critical revision of the article for important intellectual content: All authors; Supervision: JU

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ABSTRACT

Objective:

Online resources can be a valuable source of information for patients and have been shown to result in more inquiry during medical office visits, following physician medical recommendation more closely, and making self-directed lifestyle changes. The accessibility to these resources is
limited by the readability level of the article and the literacy level of the population. Peripheral
artery disease (PAD) is estimated to affect between 8 and 12 million people in the United States
with greater disease severity among under insured or un-insured populations. As PAD continues
to increase in prevalence, it is imperative that patients have access to comprehensible patient-
centered health information. This study aims to evaluate the readability of online PAD patient
education materials.

Methods:
The search engine Google was utilized to collect the first 25 patient-accessible online articles
pertaining to the search term “peripheral artery disease.” Articles were then categorized by
source type: hospital, professional society, or other. Readability was measured using the
following tests: Automated Readability Index (ARI), Coleman-Liau Index, (CLI) Flesch-Kincaid
Grade Level (FKGL), Gunning Fog, Linsear Write Formula, and the SMOG Index. Statistical
analyses were performed using Statistical Analysis Software (SAS), with p-values <0.05 being
statistically significant.

Results:
Twenty-five articles were categorized by source and statistically analyzed. The average
readability of PAD patient education materials was 10.8 and significantly above the AMA, NIH,
and USDHHS recommended reading level of 6th grade. Readability scores among source
categories were not significantly different.

Conclusions:
Commonly available online PAD resources are written at a grade level above that currently
recommended by medical societies. Hospitals, professional societies, and other stakeholders in
PAD patient education should take into consideration the readability of their materials to make
medicine more accessible. Readable articles may combat historic, and structural racism often
found in our health care system that marginalizes those with lower health literacy. It is
imperative to develop patient education at an appropriate level to enrich patient autonomy.

Keywords: readability, patient education material, health literacy, peripheral artery disease, PAD

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**INTRODUCTION**

The internet serves an important resource for health-related patient information. According to the
2019 Health Information National Trends Survey (HINTS), 72.7% of respondents first looked
for medical or health topics on the internet. Furthermore, 93% of American adults use the
internet, and it is estimated that this number will continue to rise. Online resources can be a
valuable source of information for patients and have been shown to result in more inquiry during
medical office visits, following physician recommendations more closely, and making self-
directed lifestyle changes. Although online patient education is an important source of
information, the accessibility to these resources is limited by the readability of the article and the
literacy level of the population.
Readability is defined as the ease with which a reader can understand a piece of text. In the United States, the average adult reads at a seventh to eighth-grade level. Moreover; 43 million U.S. adults possess low literacy skills and 8.4 million are functionally illiterate, meaning lacking the reading or writing skills necessary for daily living and most jobs. The American Medical Association recommends that the readability for online materials should be at or below the sixth-grade level, and ideally at the third- to fifth-grade level for practices with a high proportion of patients with lower literacy.

Peripheral artery disease (PAD), a progressive circulatory disorder characterized by systemic atherosclerotic changes leading to impaired perfusion, is estimated to affect 200 million worldwide and between 8 million to 12 million individuals in the United States. Though the spectrum of PAD may be broadly categorized into patients who experience chronic limb threatening ischemia (CLTI) or intermittent claudication, the clinical outcomes of CLTI are disproportionately borne by Black and Hispanic communities. The progressive nature of PAD in conjunction with uncontrolled medical conditions (hypertension, hyperlipidemia, diabetes mellitus, etc.), and poor access to preventative medical care may precipitate CLTI and limb amputations leading to diminished physical function and quality of life. A recent study showed that among hospitalized patients with CLTI, Black and Hispanic patients had an elevated risk of major amputation. PAD prevalence increases with age and risk factors such as smoking and diabetes, although U.S. rates are two to three times higher for older Black individuals when compared to non-Hispanic White individuals. Despite the widespread prevalence of PAD, it continues to be underdiagnosed due to a lack of awareness by both patients and healthcare institutions, indicating a need for improved access to quality patient education materials.
Studies assessing the readability of online medical education materials for thyroid surgery, lymphedema, and neurosurgery found that the average resource reading level is greater than the recommended sixth-grade level by the American Medical Association (AMA), National Institute of Health, and US Department of Health and Human Services\textsuperscript{12–14}. In this study, we utilize readability tests to assess various online peripheral artery disease resources and their associated patient education materials.

**METHODS**

This study was determined to be Institutional Review Board (IRB) exempt determined by the UCLA IRB prior to the commencement of any research.

**Data Collection**

Online patient education materials were accessed by performing an Internet search using the key phrase “peripheral artery disease” on the search engine Google (Google LLC, Mountain View, California) on September 8, 2021. Google was utilized as the only search engine because it comprises 88.3% of the market share for searches\textsuperscript{15}. The first 25 search results with patient information related to peripheral artery disease, peripheral arterial disease, and PAD were included and all articles consisted of at least 100 words. Additionally, we performed an Internet search using “peripheral arterial disease” and “PAD.” The search was performed in private browsing mode with account, tracking, and location settings disabled. Articles were excluded if the information was published in a non-English language, sponsored search advertisement, subscription-based, clinician-focused, or originated outside of the U.S. There were a total of 26
articles excluded, including duplicate websites (n=4), origin outside the U.S. (n=3), invalid text (n=8), and clinician focused (n=11, of these subscription-based was n=5).

The article text was copied and pasted into individual Microsoft Word documents as plain text format to avoid HTML tags. Text unrelated to the topic was removed, including web page navigation, copyright notice, disclaimers, date stamps, author information, hyperlinks, and source information. All tables, images, and website uniform resource locators were removed. Embedded punctuation, including decimals, colons, semicolons, parenthesis, and dashes within sentences were removed. Furthermore, bullet points and associated text, when not in sentence form, were removed.

**Readability Analysis**

All 25 articles were individually analyzed for their readability. Readability analysis was performed using six readability indices, including the Automated Readability Index (ARI), Coleman-Liau Index (CLI), Flesch-Kincaid Grade Level (FKGL), Gunning Fog Index (GFI), Linear Write Formula (LWF), and the Simple Measure of Gobbledygook (SMOG) Index using an online readability calculator. These metrics employ formulas assessing sentence length, word complexity, and syllable counts to evaluate for readability. All readability indices utilize numerical U.S. grade school level as the result, corresponding to the grade level one must have completed to understand a specific text. Increasing numerical value of grade level indicates that the text is more difficult to read. Utilizing the averages of ARI, CLI, FKGL, GFI, LFW, and SMOG scores determined the average grade level of the websites. Furthermore, article sources were categorized into hospital, professional society, and other. “Hospitals” were defined as
institutions that provide medical and surgical care to patients, primarily as inpatients. “Professional societies” were defined as organizations focused on the advancement of a particular profession or interest. “Other” included information from websites that did not fit in the previous two categories, including clinical practices, health information websites, etc.

**Statistical Analysis**

The mean values, standardized deviation (SD), and 95% confidence interval (CI) of all six indices were calculated with p-values <0.05 being statistically significant. A one-way T-test was utilized to compare the average readability value to the sixth grade reading level\(^{12,13}\). Kruskal-Wallis, a non-parametric test, was applied to determine variations in readability within our three categories. Statistical analyses were performed using Statistical Analysis Software (SAS) version 9.4 (SAS Institute Inc., Cary, NC, USA).

**RESULTS**

The top 25 patient education sites from a Google search for “peripheral artery disease” that met the inclusion criteria are located in **Table 1**, with associated readability scores and source category. Utilizing the terms “peripheral arterial disease” and “PAD,” 9 of the top 10 results were the same, with minimal variation in the remaining articles. The average U.S. grade school level for all education material analyzed was 10.8, with a range from 9.6 to 13, and all six mean readability indices were higher than the AMA recommended reading level of sixth-grade as shown in **Table 2** (p < 0.0001). The median readability scores for each test were ARI (9.9), CLI (11.0), FK (10.0), GFI (13.3), LWF (10.9), and SMOG (9.7). WebMD was found to have the lowest readability scores across all indices at ARI (5.9), CLI (7), FK (6), GFI (8.9), LWF (7.4),
and SMOG (6.4). The highest readability score in each index was ARI (pennmedicine.org, 15.3), CLI (medicine.net.com and pennmedicine.org, 14), FK (medicine.net.com, 13.9), GFI (medicine.net.com, 17.7), LWF (pennmedicine.org, 16.4), and SMOG (pennmedicine.org, 12.9). The websites pennmedicine.org and medicine.net.com were found to have the highest readability scores in multiple categories. Additionally, there were no statistically significant differences in readability levels observed between the following categories: hospital, professional society, and other (Table 2).

DISCUSSION
Since 1990, global PAD prevalence and deaths due to PAD have increased annually, and PAD prevalence doubles each decade of life across ethnic groups. As the U.S. population continues to age and diversify, it is critical that PAD patient education materials are written at a grade level accessible to all patients. Increased internet utilization coupled with readily accessible information has the potential to improve PAD understanding contingent upon the material being readable. Our study revealed that online patient education materials for peripheral artery disease were not tailored to the appropriate reading levels to allow patients with low literacy to actively engage in shared decision making, which has been previously found to improve patient satisfaction and clinical outcomes.

Health literacy, as defined by the National Library of Medicine, is “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions.” This form of literacy not only involves reading skills measured by grade level comparisons, but also incorporates speech, cultural
factors, and conceptual knowledge regarding health. Health literacy has been found to mediate the relationship between socioeconomic status (SES) and health disparities. Low SES has been consistently linked to health disparities resulting in poor health outcomes. Prior research examining the association between SES and PAD found that low SES was a strong predictor of PAD hospitalizations due decreased access to healthcare and increased traditional cardiovascular disease (CVD) risk factors. The risk of PAD hospitalizations was double in groups with low household income and low educational attainment. Additionally, areas with higher area deprivation indexes (ADI) describing neighborhood socioeconomic deprivation had a two-fold increase in the likelihood of PAD hospitalization. To effectively combat health disparities seen with PAD, health literacy should be improved in conjunction with expanded access to healthcare and increased opportunities to ascend the SES ladder in marginalized communities. Increasing accessibility of online patient education materials for PAD by making the reading level at or below the 6th grade level may minimize the negative associations between SES and PAD outcomes by augmenting this component of health literacy.

Structural racism has been well defined as a determinant of health. The effects of structural racism encompass disparate access to formal education and health education resulting in decreased health literacy levels in vulnerable populations. In 2020, the American Heart Association released a presidential advisory acknowledging structural racism as a fundamental cause of health disparities in CVD and declared its support of antiracist policies to improve the health of historically marginalized communities. A study from the National Assessment of Adult Literacy (NAAL) found that although Hispanic adults represented twelve percent of the NAAL population, they accounted for thirty-nine percent of adults with Below Basic prose
literacy\textsuperscript{30}. Black adults represented twelve percent and White adults represented seventy percent of NAAL population, however twenty percent of Black adults had Below Basic prose literacy compared to thirty-seven percent of White adults\textsuperscript{31}. Two-thirds of adults with low level of English literacy are born in the United States\textsuperscript{32}. Furthermore, there is a call to improve health literacy in U.S. immigrant adolescents\textsuperscript{33}. Due to inequitable education access, Black, Hispanic, and immigrant populations have lower health literacy levels, indicating that these populations may also have a disparate understanding of education materials that are above the 6\textsuperscript{th} grade reading level, as found in this study.

Current online PAD education materials do not meet national recommendations that promote the development of readable resources suitable for individuals with limited literacy. This study further highlights the discrepancy between the reading level of the U.S. population and readability of health information available online. Inaccessible online materials may act as another social determinant of health for adverse events related to the management of PAD in Black, Brown, and immigrant communities, further contributing to the health disparities prevalent in these communities. Our findings are a call to develop online patient education materials that are accessible to the U.S. population and to revise current guidelines that are above a 6\textsuperscript{th} grade reading level.

There are several limitations present in this study. Readability indices utilize elements such as sentence length and syllable count but do not take vocabulary, content, or culture into consideration to determine comprehension. Furthermore, when preparing the articles for analysis, substantial text that may have influenced readability was removed if it was not in
sentence form to prevent miscalculations. We only evaluated the first 25 search results with patient education materials pertaining to PAD. Previous research has demonstrated that 3% of the population goes beyond 10 search results when conducting a web-based search\textsuperscript{34}. We chose the top 25 articles to ensure the greatest number of potential websites were included, though the articles identified beyond the top 10 were likely of lower yield. Lastly, we did not assess associated multimedia content such as videos and infographics that can further contribute to patient comprehension.

CONCLUSION

This study demonstrated that available online patient education material for peripheral artery disease were written well-above the recommended sixth-grade reading level. Future studies should examine comprehensibility of all PAD materials including non-textual elements such as graphs, videos, and images. Steps should be taken to screen for the readability level of current and future patient resources to ensure and maintain accessibility for patients of varied literacy. To prevent further widening of health disparities related to literacy, interprofessional collaboration among healthcare professionals, researchers, and community stakeholders should prioritize the development of patient education materials at appropriate reading levels before disseminating to the public.

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doi:10.1371/journal.pone.0138511


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Table 1. Website Sources, Categories, and Readability Score by Indices. Abbreviations: GFOG, Gunning Fog; FKGL, Flesch-Kincaid Grade Level; CL, Coleman-Liau Index; SMOG, Simple Measure of Gobbledygook; AR, Automated Readability Index; LWF, Linsear Write Formula.
Table 2: Readability scores compared to suggested 6th grade reading level, Comparison of mean readability scores between various sources.

<table>
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<th>Readability Measurement</th>
<th>Readability Score (^{a})</th>
<th>Comparision to 6th-Grade Reading Level (p-value)(^{b})</th>
<th>Hospital ((n=10)^{a})</th>
<th>Other ((n=10)^{a})</th>
<th>Professional Society ((n=5)^{a})</th>
<th>p-value(^{b})</th>
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\(^{a}\) Mean (SD)

Ps <.05 were considered statistically significant; ARI=Automated Readability Index; CLI=Coleman-Liau Index; FK=Flesch-Kincaid Grade Level; GFI=Gunning Fog Index, LWF=Linsear Write Formula; SMOG=Simple Measure of Gobbledygook