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**Title:** Algorithm-based readability assessment of online patient educational material for Erythropoietic Protoporphyria

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**Dear Editor,**

Erythropoietic protoporphyria (EPP) is a rare disorder caused by the accumulation of protoporphyrin due to enzyme deficiencies in the heme metabolic pathways<sup>1</sup>. There are many treatment options that can be used to reduce protoporphyrin levels before they cause severe liver damage. The disease involves cutaneous manifestations of photosensitivity, which can have a severe negative impact on patients' quality of life. However, it can be managed with diligent application of broad-spectrum sunscreen (SPF > 30), oral beta-carotene, and sun-protective clothing<sup>2</sup>. It is crucial that patients understand the complexities of this chronic disease so they

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can make educated decisions about their treatment protocol and effectively manage its progression. Patients should be able to find easily accessible and readable information online regarding EPP.

We used quantitative methods to measure the readability of websites providing patient education material for this disease. On June 30<sup>th</sup>, 2021, a Google search query for “erythropoietic protoporphyria patient information” was conducted, yielding 378,000 results. Two authors (VK, JV) independently screened the top 50 websites and discarded two links for not containing information relevant to EPP patient education. Salient educational content from the remaining 48 sites was extracted and input into the readabilityformulas.com calculator<sup>3</sup>.

Six different algorithms were used to quantitatively assess the grade level readability of these articles: Gunning Fog Index, Flesch-Kincaid, Coleman-Liau, SMOG Index, Automated Readability Index, and the Linsear Write Formula. Each algorithm outputs a readability score based on several factors such as number of syllables and sentence length. A score of 10.2 means the text can be understood by an average 10<sup>th</sup> grade student. The average readability score across the 6 algorithms for the 48 articles was 14.16 with ranges from 12.30 (SMOG Index) to 16.51 (Gunning Fog), indicating that readers had to be at the college level and beyond to understand the articles (Fig. 1). Each of the six algorithms demonstrated that readability of these online articles were at least six grade levels higher than the American Medical Association (AMA) recommendation of a target 6<sup>th</sup> grade reading level for patient educational content.<sup>4</sup>

Another readability algorithm, the Flesch Reading Ease Score, was used to compare the differences in article reading ease between those written by MDs and those by non-MDs. A lower Flesch Reading Ease score indicated more difficult reading. We found that MD authors composed more complex articles (mean = 25.94, n = 36) in comparison to their non-MD counterparts (mean = 35.54, n = 12) (p = 0.046), demonstrated by their lower Reading Ease scores (Fig. 2). However, there was no difference between reading ease of articles authored by dermatologists (mean = 26.61, n = 17) compared to those by non-dermatologists (mean = 28.24, n = 31) (p = 0.71). Study weaknesses include a small sample size of 48 sites, and a limited target audience, as the online articles were only written in the English language.

The results of this study suggest that more work needs to be done in order to improve health literacy and patient education, which ultimately impact health outcomes<sup>5</sup>. Online articles

are still several grade levels more complex than they should be for their intended audience. EPP is a complicated disease that needs to be understood by patients in order to reduce complications and improve quality of life. In order to make online patient educational material easier to be read and understood, there should be increased collaboration between physicians and online content providers.

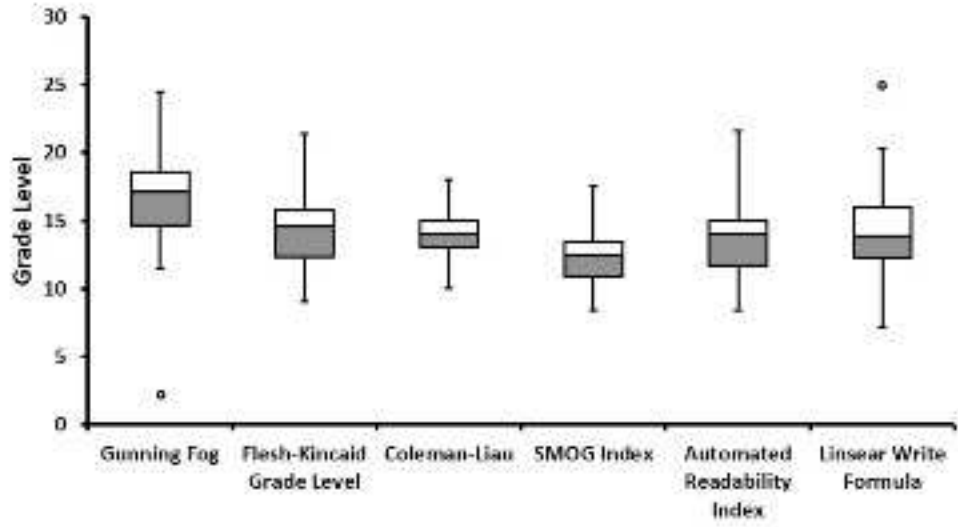
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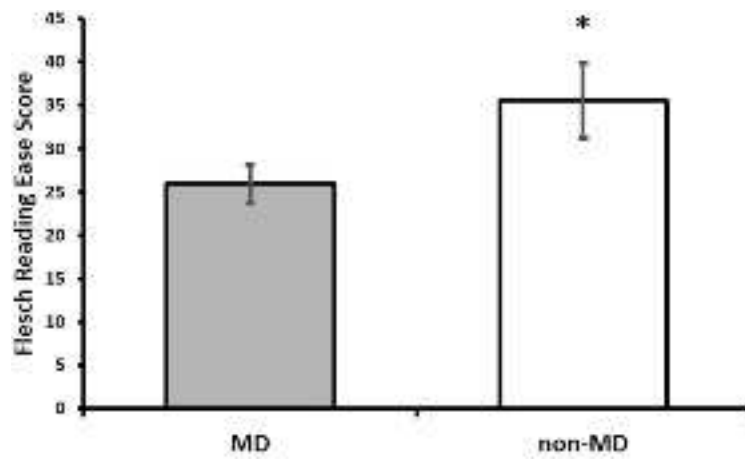
## Figure Legends

**Fig. 1: Average grade level assessment of online educational sites regarding Erythropoietic Protoporphyrria.** Box and whisker plot analysis was conducted using 6 readability algorithms: Gunning Fog (median = 17.1), Flesch-Kincaid (median = 14.55), Coleman-Liau (median = 14), SMOG index (median = 12.5), Automated Readability Index (median = 14), and Linsear Write Formula (median = 13.9).

**Fig. 2: Readability Ease Comparison between MD Authors and non-MD Authors.** Results of Two-tailed Student's t-test results showed that Flesch Reading Ease Scores for MD authors (mean = 25.94, standard deviation = 13.33, n = 36) were significantly lower ( $p = 0.046$ ) than non-MD authors (mean = 35.54, standard deviation = 14.59, n = 12).



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