Assessment of the readability and quality of online patient education materials for the medical treatment of open-angle glaucoma

Lois Crabtree, Edward Lee

ABSTRACT

Objective Patient adherence to glaucoma medications is poor, and is linked to low literacy levels. Patients commonly use the internet to access health information, and it is recommended that patient information is written at an 11-year-old reading level. The aim of this study is to assess the readability and quality of online patient education materials for the medical management of open-angle glaucoma.

Methods and analysis The top 10 relevant Google searches for nine glaucoma medications (timolol, brimonidine, apraclonidine, dorzolamide, latanoprost, bimatoprost, travoprost, tafluprost and brinzolamide) and three generic searches were analysed for readability and accountability. Readability was assessed using Flesch Reading Ease Score (FRES), Flesch-Kincaid Grade Level (FKGL), Gunning Fog Index (GFI) and Simple Measure of Gobbledygook Index (SMOG). Webpages were classified by source and assessed using Journal of the American Medical Association (JAMA) benchmarks of accountability.

Results 111 articles were included in the analysis. Mean readability scores were: FRES 55.5 (95% CI 53.4 to 57.5); FKGL 9.7 (95% CI 9.3 to 10.1); GFI 12 (95% CI 11.6 to 12.4) and SMOG 9.3 (95% CI 8.9 to 9.6). One-way analysis of variance demonstrated no significant difference in readability score between source type. 9% of the webpages satisfied all 4 JAMA benchmarks. Pearson's correlation coefficient showed a correlation between the FRES and accountability score (r=0.19, p=0.045).

Conclusion The majority of online patient education materials for the medical treatment of glaucoma are written at a level too difficult for the general population and fail to meet accountability standards.

INTRODUCTION

Glaucoma

Glaucoma is the second leading cause of irreversible vision loss worldwide. The most common type of glaucoma in the UK is primary open-angle glaucoma. It is a chronic asymptomatic disease which affects 10% of people above the age of 75. The majority of patients are initially treated medically with eye-drops, the aim of which is to reduce intraocular pressure. Sustained patient adherence is critical to prevent disease progression.

The proportion of glaucoma patients who are non-compliant to medical therapy has been reported to be as high as 50%. Numerous reasons for non-compliance to glaucoma medications have been cited which include medication cost, tolerability, regimen-related factors and poor health literacy.

Health literacy

Health literacy is defined by the WHO as the achievement of a level of knowledge, personal skills and confidence to take action...
to improve personal and community health by changing personal lifestyles and living conditions, and is critical to health empowerment.\textsuperscript{19}

Literacy is the capacity to process written and verbal information. Patients with poor health literacy levels are less likely to understand and remember medication advice, and may take medications at the wrong frequency or dose and not understand the adverse effects.\textsuperscript{11,12} A study in the USA found a positive correlation between low health literacy levels and poor adherence to glaucoma medication. Of the 197 subjects, only 48\% could read at or above a 9th grade level. Subsequently, in order to improve compliance, the study recommended adapting the language used in ophthalmic patient education materials (PEMs) to ensure the material is accessible to more patients.\textsuperscript{13}

An American Medical Association Council of Scientific Affairs report concluded that patients with low health literacy have poorer health outcomes and less understanding of their medical conditions and treatment.\textsuperscript{14} In 2015, Public Health England and the Institute of Health Equity published a report which showed that up to 61\% of the working age population find it difficult to understand health and well-being information.\textsuperscript{15} Furthermore, 16\% of adults in England have the lowest level of proficiency in literacy, which is at or below the literacy levels for a 5–7 year old.\textsuperscript{16} The average literacy level in the UK is considered to be similar to that in the USA, which is equivalent to a 13 year old (eighth grade student in the USA).\textsuperscript{17}

Readability
Readability of written text is an objective measure of the reading skills one must possess to understand the material, and is measured in terms of US ‘grade levels’.\textsuperscript{18} The readability of text has a significant impact on the comprehension of the material by the patient.\textsuperscript{19} Despite this, health literacy and readability of online PEMs is often overlooked.\textsuperscript{20}

Health Education England advises that written patient information material should be written at a level that can be understood by an 11 year old.\textsuperscript{21} Similarly the American Medical Association recommends writing at a US grade level of 6 or less, which is equivalent to a 11–12 year old.\textsuperscript{22}

Previous research has shown that online health information can have an important role in influencing patients decision making regarding their health.\textsuperscript{23} Four out of five UK adults have access to the internet at home and a recent survey showed 88\% of internet users search for health related information online.\textsuperscript{24,25} However, no quality standard exists for these webpages providing health information, which may lead to misinformation or inaccuracies.\textsuperscript{26} A tool to assess the quality of webpages providing health information was created by the Journal of the American Medical Association (JAMA).\textsuperscript{27} They set out four benchmarks to assess the accountability of a webpage, which include authorship, attributions, disclosure and currency.

The readability of online PEMs for ophthalmological conditions such as age related macular degeneration, diabetic retinopathy and intravitreal injections has been reviewed in the literature, and has consistently found that materials are written above the recommended level.\textsuperscript{28–32} The aim of this study is to assess the readability and quality of online PEMs relating to the medical management of open angle glaucoma.

MATERIALS AND METHODS
A series of searches using the search engine Google were conducted in November 2021. Articles were included if they were written in English, and contained patient orientated information. The chosen search terms included either a medication trade name and brand name(s) or a generic search term. The medications included in the search were those recommended by National Institute for Health and Care Excellence for the treatment of open-angle glaucoma.\textsuperscript{32} The trade and brand names of each medication were included. The nine medications in the search were timolol (Blocadren, Timol), brimonidine (Alphagan), apraclonidine (Iopidine), dorzolamide (Trusopt), latanoprost (Xalatan, Xelpros, Monoprost), bimatoprost (Lumigan, Latisise), travoprost (Travatan), tafluprost (Zioptan, Saflutan, Taflotan, Tapros) and brinzolamide (Azopt). In addition to these medications, three generic search terms ‘glaucoma medication’, ‘glaucoma drops’ and ‘glaucoma treatment’ were also included. To gain the most relevant webpages the search terms used included ‘open angle glaucoma patient information’ as the prefix.

Duplicate websites, resources for healthcare professionals, patient forums, reviews of medications and academic research was excluded. If articles contained information relating to laser or surgical treatment for glaucoma, this was excluded from the readability assessment, but any general information about glaucoma was retained. The methodology used is consistent with other readability articles within ophthalmology and other medical and surgical specialties.\textsuperscript{30,33–36}

The top 10 relevant PEMs were selected for each of the 9 medications listed above and the 3 generic searches. This had potential to generate 120 PEMs. Once duplicates were excluded, nine PEMs were obtained for tafluprost, two for ‘glaucoma treatment’. Ten PEMs were obtained for all other search terms. This provided an overall total of 111 PEMs.

Patient and public involvement
Patients and the public were not involved in this research.

Webpage by source
Webpages were classified into ‘charities’, ‘non-clinical health information’, and ‘clinical health providers’. For the purposes of this study, a charity webpage was one affiliated to a registered charity. Non-clinical health information is any webpage providing patient information, which does not provide clinical services, and clinical
health providers is any webpage which provides patient information and clinical services.

**Readability assessment tools**

Readability was assessed using an online readability software. The following four scores were used to assess readability: Flesch Reading Ease Score (FRES), Flesch-Kincaid Grade Level (FKGL), Gunning Fog Index (GFI) and Simple Measure of Gobbledygook Index (SMOG). Readability is calculated by applying a mathematical formula to a passage of text (see **Table 1**). The tools consider different factors such as average number of words per sentence and/or number of syllables per word. The interpretation of each readability tool is described in **Table 2**.

These specific readability tools were chosen as they are commonly used to assess the readability of text, particularly in healthcare settings, and a combination of scores improves the accuracy of the results. All webpages had copyright notices, adverts, images, author names, disclaimers and reference lists removed prior to assessing readability.

**JAMA benchmarks**

To assess the accountability of online PEMs, JAMA benchmarks were applied. To comply with the JAMA accountability criteria, each PEM had to include the author, their affiliations and credentials (authorship), include a reference list (attribution), declare any sponsorship, advertising and a disclaimer (disclosure) and the date of the last review and/or update of the page (currency). The webpage was then given a score which ranges from 0 (no criteria fulfilled) to 4 (all 4 criteria fulfilled). The null hypothesis is that there is no association between how readable a webpage is and its accountability score.

**Statistical analysis**

Statistical analysis was completed with IBM SPSS V.27 software for Mac OSX. FRES, FKGL, SMOG, GFI scores and their respective mean values, SD and 95% CIs were calculated for each of the 12 search items. The data was normally distributed. The distributions of the study variables were amenable to parametric analysis, and mean values were compared using one-way analysis of variance.

To assess the degree of association between accountability and readability scores, Pearson correlation coefficient was used. Statistical significance was set at p<0.05, all p values represented were two sided.

**RESULTS**

Of the 111 PEMs obtained, the average length was 1411 words, and the average number of words per sentence was 15.3.

The FRES ranged from 15.2 (very difficult) to 79 (fairly easy), with an average of 55.5 (SD=10.8; 95% CI 44.7 to 66.3). The FKGL ranged from 0.39 (undergraduate level) to 11.59 (high school level), with an average of 5.44 (SD=1.77; 95% CI 3.73 to 7.16). The GFI ranged from 6 (elementary school level) to 17 (graduate school level), with an average of 10.2 (SD=2.48; 95% CI 8.84 to 11.56). The SMOG ranged from 3 (elementary school level) to 7 (graduate school level), with an average of 4.8 (SD=1.56; 95% CI 3.75 to 5.85).

**Table 1** Readability tools and their formulas

| Assessment tool                          | Formula                                                                 |
|------------------------------------------|-------------------------------------------------------------------------|
| Flesch Reading Ease Score                | 206.835 – (1.015 \times \text{average no of words per sentence}) – (84.6 \times \text{average no of syllables per word}) |
| Flesch-Kincaid Grade Level              | (0.39 \times \text{average no of words per sentence}) + (11.8 \times \text{average no of syllables per word}) – 15.59 |
| Gunning Fog Index                        | 0.4 (average no of words per sentence + (100 \times \text{average no of syllables per word})) |
| Simple Measure of Gobbledygook Index     | 3 + \sqrt{\text{Polysyllabic count}}                                      |

**Table 2** Readability tools and their interpretation

| Assessment tool                          | Interpretation                                                                                   | Standard                                                                                   |
|------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| Flesch Reading Ease Score                | Ranges from 0 to 100                                                                             | 0: Unreadable, 1: Primary school, 2: High school, 3: University graduate, 4: Graduate student |
|                                          | 0: Unreadable, <30: University graduate level, 40–60: Understood by 13–15 years old, 90–100: Very easy to read, understood easily by 11-year-old student (50,51) |
| Flesch-Kincaid Grade Level               | Indicates no of years of education required to understand the text                               | Grades were considered to be at the recommended level (grade 6) if they were ≤6.9          |
|                                          | Indicated no of years of education required to understand the text                              |                                                                                           |
|                                          |                                                    | At the recommended level if 6–6.9                                                           |
| Gunning Fog Index                        | Ranges from 6 to 17                                                                              | 6: Reading age of 11–12 years old, 17: University-level graduate (52)                      |
|                                          | Indicated no of years of education required to understand the text                              |                                                                                           |
|                                          |                                                    | Grades were considered to be at the recommended level (grade 6) if they were ≤6.9          |
| Simple Measure of Gobbledygook Index     | Indicated no of years of education required to understand the text                              |                                                                                           |
|                                          |                                                    |                                                                                           |
The internet has become a vital source of health information for patients in recent years and it can be a useful tool to help supplement verbal clinical advice. However, a large proportion is written at a higher reading level than recommended.39 Therefore, in this study the top 10 results (that satisfied the study inclusion criteria) from a Google search were chosen, as it was deemed unlikely that patients would look beyond these results for their information.

Our study showed that the majority of websites containing information about the medical treatment of glaucoma were classified as being too difficult to read for the majority of the population. On average, the FRES determined the articles to be ‘fairly difficult to read’ (55.5). This is the equivalent to reading the TIME magazine (FRES score 50).41 All of the articles had a FRES score which was above the recommended 6th grade level (11-year-old reading level), and 24% were written at a level suitable for a college graduate or higher.

On average the FKGL score was at the level of a 9th grade student (9.7), which is equivalent to a 14–15 year old. Ninety four articles (84.7%) had an FKGL score that was above the recommended reading level. The readability scores FRES, FKGL, GFI and SMOG did not significantly differ by type of website in this study. However, given that the majority of webpages contained information about the medical treatment of glaucoma were classified as being too difficult to read for the majority of the population. On average, the FRES determined the articles to be ‘fairly difficult to read’ (55.5). This is the equivalent to reading the TIME magazine (FRES score 50).41 All of the articles had a FRES score which was above the recommended 6th grade level (11-year-old reading level), and 24% were written at a level suitable for a college graduate or higher.

The readability of text may also be complicated by use of complex words, and the GFI takes this into account. The average GFI score was 12, which is at the education level of a high school senior and is above the recommended level of 6th grade student. According to the GFI, 111 (100%) of the articles were written at a level above the recommended range and equates to reading the Wall Street Journal.42 Similarly, the SMOG showed on average the articles were written at a 9th US grade level, with 108 (97.2%) of articles being written above the recommended range.

Our findings are consistent with previous studies within ophthalmology, and other surgical specialties.20 43 44 A systematic review conducted by Williams et al focusing on online PEMs in ophthalmology found that the materials are consistently written at a level that is too high for many patients to understand.28 Across the 13 studies included, the median FKGL score represented an 11th grade study level, which is higher than the results obtained in our study (9th grade).

In our study, websites were classified by source and analysed to see whether the readability scores varied between them. The readability scores FRES, FKGL, GFI and SMOG did not significantly differ by type of website in this study. However, given that the majority of webpages were from non-clinical health information sites (67%)

### Table 3  Mean (SD) readability index scores of patient education materials, classified by source

| Readability tool | Charities (n=12) | Clinical health providers (n=25) | Non-clinical health information (n=74) | Total (average across all sources, n=111) |
|------------------|-----------------|-------------------------------|--------------------------------------|----------------------------------------|
| FRES             | 50.7 (16.3)     | 56.0 (8.1)                    | 56 (10.5)                            | 55.5 (10.8)                            |
| FKGL             | 10.9 (2.8)      | 9.6 (1.6)                     | 9.4 (2.1)                            | 9.7 (2.1)                              |
| GFI              | 13.0 (2.2)      | 12.2 (1.7)                    | 11.8 (2.16)                          | 12.0 (2.1)                             |
| SMOG             | 10.1 (2.5)      | 9.3 (1.4)                     | 9.1 (1.6)                            | 9.3 (1.7)                              |

FKGL, Flesch-Kincaid Grade Level; FRES, Flesch Reading Ease Score; GFI, Gunning Fog Index; SMOG, Simple Measure of Gobbledygook Index.

### Webpage by source

When categorising the websites by source there were: 12 (11%) charities, 25 (22%) clinical health providers and 74 (67%) non-clinical health information websites. The readability scores did not differ significantly between source type: FRES (p=0.28), FKGL (p=0.08), SMOG (p=0.14), GFI (p=0.14) (see table 3).

### JAMA benchmarks

Out of all 111 search results, 10 (9%) met the requirements to satisfy all 4 JAMA benchmarks of accountability (see table 4).

Using Pearson correlation coefficient, only FRES was found to have a significant correlation with the accountability score (r=0.19, p=0.045). No significant correlation was found between the accountability score and FKGL (r=-0.096, p=0.315), GFI (r=-0.084, p=0.382) and SMOG (r=-0.118, p=0.217).

### DISCUSSION

The internet has become a vital source of health information for patients in recent years and it can be a useful tool to help supplement verbal clinical advice. However, a large proportion is written at a higher reading level than recommended.39

Research studying online browsing behaviours analysed 5 million Google searches and found that only 0.78% of Google searchers clicked on something from the second page.40 Therefore, in this study the top 10 results (that satisfied the study inclusion criteria) from a Google search were chosen, as it was deemed unlikely that patients would look beyond these results for their information.

### Table 4  Patient education materials and JAMA accountability

| JAMA accountability | No (%) (n=111) |
|---------------------|----------------|
| 0                   | 16 (14)        |
| 1                   | 13 (12)        |
| 2                   | 42 (38)        |
| 3                   | 30 (27)        |
| 4                   | 10 (9)         |

JAMA, Journal of the American Medical Association.
compared with charities (11%), a larger sample size may be required to interpret the results accurately.

There is concern about the accuracy of online health information, and a significant proportion of the material currently available is unreliable.\(^4\) When considering the accountability of the webpages, only 9% satisfied all four JAMA benchmarks of accountability (see table 4). The most common webpage to satisfy all four benchmarks was one that provides patient information on multiple glaucoma medications (www.patient.co.uk). The most common benchmark to be satisfied was disclosure (66.7%) whereas the least common benchmark to be satisfied was attribution (24.3%).

The association between the FRES score and JAMA accountability score \((r=0.19, p=0.045)\) indicates that more readable PEMs were also more likely to meet the accountability criteria. However, there was no significant association between the other readability scores and JAMA accountability.

Limitations of this study include the assumptions made by the use of readability tools. Although the number of syllables per word, or the length of sentences affect the readability of text, they do not take into account the context or meaning of the words used.\(^6\) Furthermore, images, tables, diagrams and the general layout and design of the page impacts the readability of the text, but is not considered when using such scores.

Furthermore, short monosyllabic but technical medical terminology may have been used within the articles and the tools could then underestimate the reading level required to comprehend the text. Similarly longer poly-syllabic words may not necessarily be more difficult to understand. For example, medication names (brinzolamide) may be repeated multiple times within the article, however, once initially understood within the text should not be difficult to interpret.

The literature reports that FKGL and FRES underestimate the readability score compared with SMOG. SMOG has been found to be more accurate in assessing readability when publishing online resources, and the readability of current glaucoma literature online could be compounding health inequalities.

People with limited health literacy are known to less successfully manage long term health conditions, and people with low financial and social resources are more likely to have low health literacy. By improving health literacy it can help improve patients adherence to medical instruction and empower them to effectively manage long-term conditions.\(^3\)

Our study indicates there is a need for greater awareness of readability when publishing online resources, and the readability of current glaucoma literature online could be compounding health inequalities.

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**Contributors**

LC was involved with planning, analysis and study write up. EL was involved with study design, data analysis and study write up. LC acted as guarantor.

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None declared.

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