

## Health in Bite Sized Pieces - Discovering Lack of Accessibility and Engagement in Lay Summaries

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### SUMMARY

Lay summaries are a series of short paragraphs (100-350 words in total) that summarize all parts of a research manuscript (including introduction, methods, results, discussion, and conclusion) in a concise way that is accessible for lay audiences to comprehend. They are typically written by the authors of the manuscript. Lay summaries are essential for journalists, non-experts, and patients who wish to learn more about their health through the literature. This study observes how accessible and engaging lay summaries are in the field of medical sciences. Five lay summaries were collected and analyzed from four different journals and were graded based on a customized rubric. Hence, a total of 20 lay summaries were collected and analyzed. The average score in section four of the rubric for all journals—which assessed accessibility and engagement of these lay summaries—was 1.5 out of 5. These low scores can be detrimental because they can hinder reader comprehension. Implications of this study are that it will provide awareness such that authors consider writing more accessible and engaging lay summaries. A limitation of this study is the small sample size, which limits the results found to only the lay summaries analyzed.

### ABSTRACT

The purpose of lay summaries is to summarize a research manuscript in a concise, accessible, and engaging manner for any reader to comprehend. This study seeks to analyze the amount of engagement and accessibility in lay summaries as part of medical research manuscripts. In this study, we analyzed a total of 20 lay summaries, five from each of the following journals: *Elife*, *Multiple Sclerosis and Related Disorders Journal*, *Epilepsy and Behavior Case Reports (EBCR)*, and the *Journal of Hepatology*. One grader marked all the lay summaries using a customized rubric. The lowest average scores for all journals were 1.5 out of 5 in the accessibility and engagement section of the rubric. The average total scores between *Elife* and *EBCR* and *Elife* and the *Journal of Hepatology* were both significant and were 5.1 and 6.7 marks different, respectively. The results from this study indicate that the accessibility and engagement of lay summaries are not as adequate as they should be in the field of medicine. An implication of this study is that it will provide awareness and bring these undiscovered issues into light so that authors may consider writing lay summaries that meet the needs of their audience. A limitation to this study is the small sample size.

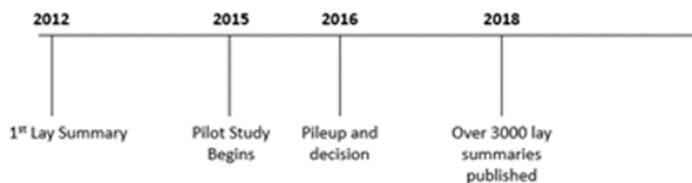
**Keywords:** Lay summary, engagement, accessibility, science communication, score

### INTRODUCTION

Lay summaries are critical for conveying scientific research to the general public. They are a series of short paragraphs that are generally 250-300 words in total.<sup>1</sup> Lay summaries summarize all the parts of a research manuscript in a way that is accessible for any member of the public to comprehend, regardless of their scientific background.<sup>1,2</sup> Lay summaries differ from research abstracts in that they are designed to be engaging and accessible.<sup>1</sup> Accessibility refers to the ease that one can comprehend text, while engagement refers to

how the writer interacts and keeps the audience interested throughout the piece. Although the origin of lay summaries is not entirely clear, *Elife* announced that its first lay summary was written in 2012 (Figure 1).<sup>3</sup> *Elife* is a scientific journal that houses peer-reviewed manuscripts.<sup>4</sup> In 2015, *Elife* staff brainstormed ways to engage the authors of manuscripts in creating lay summaries by running a pilot study of 100 authors who were offered to write lay summaries (Figure 1).<sup>3</sup> This pilot study was deemed successful as 79 out of the 100 authors submitted a lay summary.<sup>3</sup> By 2016, there was a pileup and rush to create lay summaries for *Elife*, possibly due to the increased awareness with re-

spect to the importance of lay summaries (Figure 1).<sup>3</sup> Consequently, Elife decided to select 60 manuscripts per month based on both topic and author enthusiasm to write a lay summary for Elife.<sup>3</sup> As of 2018, Elife has over 3,000 lay summaries published on their website (Figure 1).<sup>5</sup> There was no history found on the origin of lay summaries provided for Elsevier, which is a different scientific journal domain. However, despite the lack of history for Elsevier, it can be predicted that it follows a similar timeline to Elife's history. There was also no history found on the first lay summary or knowledge translation.



**Figure 1. History of Elife Lay Summaries.** The image above is a timeline depicting the dates to which the lay summaries evolved on Elife's website.<sup>3</sup>

### Rationale Behind Lay Summaries

Funding is a big part of writing lay summaries because it allows for more lay summaries to be published as part of research manuscripts. The Canadian Institute of Health Research (CIHR) is involved in providing grants to research studies.<sup>6</sup> The CIHR mandates that there be a lay knowledge translation with every research proposal before funding can be provided.<sup>6</sup> Having a lay summary as a part of a research proposal aids funders in understanding the significance of the research.<sup>7</sup> This raises the question—should taxpayers who monetarily contribute to the research have access to the research manuscript free of charge? If not, this can be a major disadvantage to the consumer as they would not be able to reap the benefits of what they have contributed to. In November 2021, the 41st conference for the United Nations Educational, Scientific, and Cultural Organization (UNESCO) was held. In the conference, it was mentioned that science is more efficient in improving reliability and reproducibility when open, clear, collaborative practices among scientists are coupled with accessibility and accuracy.<sup>8</sup> These aspects go hand in hand to impact decisions and policy formation.<sup>8</sup> This was especially evident during the COVID-19 pandemic, when access to scientific knowledge was needed more than ever to form evidence-based decisions. One such example was choosing whether or not to get vaccinated.<sup>8</sup> Therefore, open access to science that is understandable for any audience can help propagate knowledge that can be essential for certain human rights.<sup>8</sup>

On a separate note, when authors write lay summaries

to accompany their research, their papers gain more traction and visibility to the public.<sup>9</sup> A pilot study done by Elife has shown that only 42 out of the 300 readers of Elife lay summaries are considered lay audiences.<sup>3</sup> Of the 42, a small fraction of readers are patients, while the majority are retired individuals or educators.<sup>3</sup> The vast majority of lay audiences read lay summaries on the Elife website.<sup>3</sup> A possible diagnosis for this poor outreach to different audiences is that lay summaries are not physically accessible enough online for those who are in need. They are found exclusively on journal websites, which requires a specific and in-depth search string input to access. This can be justified from the feedback Elife received from participants, who stated that the lay summaries should have better online visibility, clarity in the content, and increased use of images and diagrams.<sup>3</sup> 89% of participants believed that other journals should also mandate lay summaries.<sup>3</sup>

### Journal Guidelines and Nomenclature

Lay summaries help to address the questions of who/what/where/when/how/why for a given study in a way that is appropriate for any member of the public to understand.<sup>1</sup> One method this can be achieved is by having lay summaries use active voice rather than passive voice to ensure maximal comprehension.<sup>1</sup> Active voice is where the subject is carrying through with the verb, while passive voice is where the verb is being done on the subject.<sup>10</sup> For example, active voice is, “the researchers observed”, whereas passive voice is, “it was observed by the researchers”. Active voice is essential to use in science communication because it is the easiest to understand and allows the reader to be in tune with the actions of the author.<sup>11</sup> Elsevier notes that lay summaries should avoid jargon, run-on sentences, and awkward sentence structure.<sup>1</sup> Researchers have observed that jargon is a weak spot in scientific literature.<sup>12</sup> Even though some scientists attempt to use less jargon when writing for the public, their writing is still far from being understood by non-experts.<sup>12</sup> There should also be no grammatical errors to prevent distraction for the reader. Additionally, the use of positive language rather than negative language is strongly preferred. An example of this usage would be translating “no significant difference in cholesterol between groups” to “cholesterol remained constant for both groups”, in which the latter is strongly preferred.<sup>14</sup> Since the use of positive language requires less words than negative language, positive language allows for a more direct message to the reader.<sup>13</sup> EBCR and the Journal of Hepatology had no guidelines for writing lay summaries, rather, their guidelines fell under Elsevier's guidelines as outlined above.

According to Elife, a lay summary should be approximately 350-400 words, whereas Elsevier recommends 200-300 words.<sup>3</sup> Elife guidelines suggest that language in a lay summary should be more active and

engaging rather than passive and formal.<sup>3</sup> Elife also indicates that lay summaries should not be viewed as creative writing pieces with imagery or poetry but rather as clear and concise.<sup>3</sup> Other key elements of Elife guidelines suggest that all sentences should be 35 words maximum, use verbs instead of nouns, and avoid using more than three common acronyms in total (ex. DNA).<sup>5</sup> Similar to Elsevier, Elife cautions authors of jargon use and complex terms that can be simplified (ex. novel versus new).<sup>5</sup> Elife also provides a skeleton template to follow, which includes a background (150 words), research question (75 words), important findings (100 words), who would benefit from findings, and future directions (75 words).<sup>5</sup> Additionally, Elife hires staff who create lay summaries based on the submission of author manuscripts.<sup>5</sup>

Although the different guidelines are set in place by these journals, there is no set system of quality control to monitor whether these suggestions are being incorporated. This contrasts the research manuscript, which undergoes multiple edits and reviews before publication. Arguably, the lay summary should undergo the same level of scrutiny since it is the first impression for readers who may not be well-versed in the field. If journals do decide to include a quality control system, it should be uniform across all journals so that the quality of lay summaries do not vary greatly from one journal to another.

### **Benefits and Importance of Lay Summaries - The Grand Scheme**

Lay summaries are helpful for patients who wish to know more about their health.<sup>14</sup> Patient access to literature, facilitated through lay summaries, is the primary source of information that can aid them in being informed and managing their health.<sup>14</sup> Lay summaries can also be helpful for patients who wish to be involved in randomized controlled studies, as lay summaries help patients obtain a sense of the interventions in which they may participate.<sup>15</sup> Some of the journals have patients check off for, or rate their comprehension on “plain language summaries” to ensure proper science communication.<sup>15</sup>

Many journalists also use lay summaries to their advantage to decode complex studies and share it with the public.<sup>9</sup> When a research manuscript does not contain a lay summary, there can be misinformation when journalists or the public attempt to translate a study. For example, the media portrayed the use of ivermectin in treating COVID-19 as effective, but the original research had mixed results.<sup>16</sup> Important messages can get lost in this manner due to the complex nature of scientific language and methodology. Lay summaries are never about “dumbing it down” but rather combining professionalism, accessibility, and engagement all in one.<sup>9</sup> In addition, lay summaries can be of use for

scientists who are experts in a certain area but non-experts in a different field. This would allow them to expand their research and expertise by allowing them to make connections between and upon other domains of science.<sup>9</sup> The pilot study conducted by Elife revealed that 93% of scientists who read digests in other fields found lay summaries useful.<sup>5</sup> The purpose of lay summaries should not be solely dedicated to those in a given field of research, but rather to obtain flexibility and reach out to other individuals with different educational backgrounds and interests.<sup>17</sup>

Lay summaries are typically located in areas that require subscription to the journal and cannot be shared on social media.<sup>15</sup> This makes lay summaries difficult to reach because it hinders the experience for patients who wish to seek information.<sup>15</sup> Researchers have also found that lay summaries have different titles such as “E-life digest”, “patient summaries”, “significance statement”, lay summary, “plain language summary”, “lay abstract”, and “author summary”.<sup>15</sup> This can be confusing for individuals who are attempting to find a lay summary as they are confronted with different names.<sup>15</sup>

### **Knowledge Gap**

Many researchers who conduct research in the field of science communication have identified how to properly write a lay summary and recommendations to go about doing so. However, few have written about the current status of lay summaries that are currently published. Previous research that analyzed lay summaries specifically looked into their location within an online journal, whether there was free access, and who it was written by.<sup>15</sup> We will be expanding on their findings and assess lay summaries on their language choices, accessibility, and engagement. Our research addresses the question: how accessible and engaging are lay summaries in the field of medicine? We hypothesize that the lay summaries of the journal articles are not language accessible for the public and many articles will not meet the standards for proper lay summaries.

## **METHODS**

For this study, the primary outcomes were to analyze accessibility and engagement in lay summaries. In order to observe these outcomes, we collected a series of 20 lay summaries. Five were from Elife, five were from Multiple Sclerosis and Related Disorders (MSRD), five were from Epilepsy Behavior Case Reports (EBCR) and five from the Journal of Hepatology. MSRD, EBCR, and the Journal of Hepatology had the same guidelines as Elsevier. Journals and lay summaries were chosen to be used based on whether their focus is in the field of medicine. After the lay summaries were collected, they were read and graded based on a custom designed rubric, as shown in Figure 2. One

researcher was responsible for grading all 20 lay summaries. Throughout the grading process, comments about spelling, grammar, and jargon were made, as denoted in Figure 2. Errors in the lay summaries were highlighted using the “add a comment” feature on a Microsoft Word document. An overall summary by the grader was included after grading the lay summary. After the individual sections were graded, a total score was calculated. Half points were given if a lay summary met half the criteria of one level, and half of the criteria of a higher level. In addition to using the rubric, the location and title of the lay summaries were noted. Microsoft Excel was used to tabulate the graphs by calculating the average, Q1, median, Q3, and range for each section of the rubric for each journal in Figures 3 and 4. Figure 4 was created using a boxplot for the total score of each journal. GraphPad was used to determine normality and significance. A one-way ANOVA was used to display significance while the Kolmogorov-Smirnov test was used to show normality for all four journals. The alpha value used was 0.05.

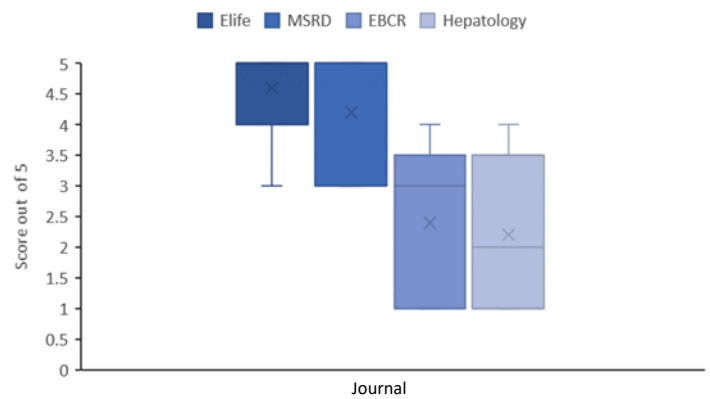
Content	Level 5 5 points	Level 4 4 points	Level 3 3 points	Level 2 2 points	Level 1 1 point	Criterion Score
Did you accurately summarize the study methods, results and conclusions?	You excelled at this task, providing information that was consistently on-point.	Your summary is mostly accurate but sometimes ambiguous.	Your summary is mostly accurate but incomplete, introducing the potential for confusion.	Your summary raises multiple questions or lacks focus and was difficult to unpack.	Your summary contains multiple inaccuracies.	/ 5
Did you accurately summarize the study rationale, implications and limitations?	You excelled at this task, providing information that was consistently on-point.	Your summary is mostly accurate but sometimes ambiguous.	Your summary is mostly accurate but incomplete, introducing the potential for confusion.	Your summary raises multiple questions or lacks focus and was difficult to unpack.	Your summary is off-point.	/ 5

Style	Level 5 5 points	Level 4 4 points	Level 3 3 points	Level 2 2 points	Level 1 1 point	Criterion Score
Is your writing clean, clear and logically organized?	Your writing is free of typos and grammatical errors and easy to follow, with smooth transitions that carry your reader from one thought to the next.	Your writing is clean and your sentences are strong, but the overall organization could be improved.	Your writing contains one typo, grammatical error, confusing sentence or awkward transition or it lacks some clarity in terms of sentence structure and organization.	Your writing contains more than one typo, grammatical error, confusing sentence or awkward transition.	Your writing has multiple mistakes or minimal flow.	/ 5
Is your writing tailored to its audience and purpose?	Your writing is a joy to read. You make complex concepts relatable and consider your audience from start to finish. In terms of the language you use and the organization of your thoughts.	Your writing is accessible and contains elements that will engage your audience.	Your writing is generally accessible and contains at least one element aimed at engaging your audience, but some parts fall flat.	Your writing is generally accessible but it lacks elements that will engage your audience and keep them reading from start to finish.	Your writing contains words or descriptions that are inaccessible to your audience or may bore them.	/ 5

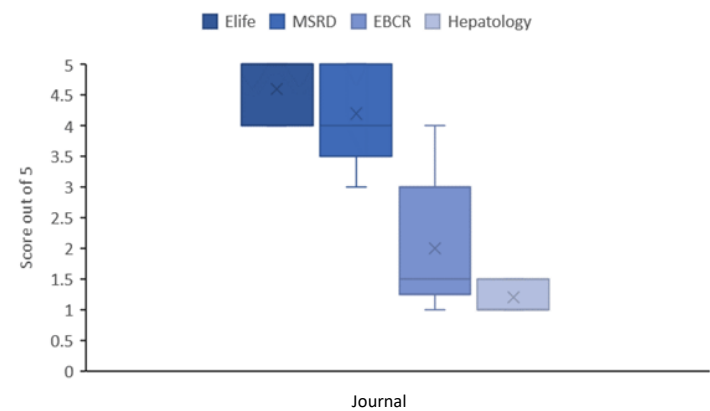
**Figure 2. Customized rubric based on a culmination of guidelines from a vast array of journals.** The rubric shown above was created by Dr. Katie Moisse and used when grading the lay summaries. This is the same rubric used to grade student lay summaries in science communication courses in the Faculty of Science at McMaster University. The rubric is divided into two sections – content and style. There are two sub sections within both content and style which outline the accuracy in the content section, and engagement and accessibility in the style section.

## RESULTS

**A**

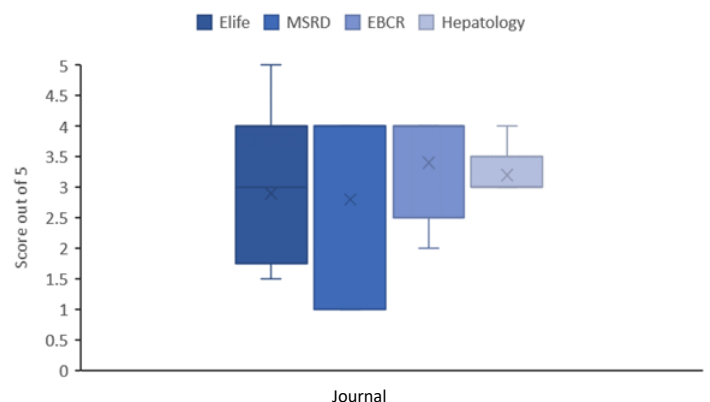


**B**



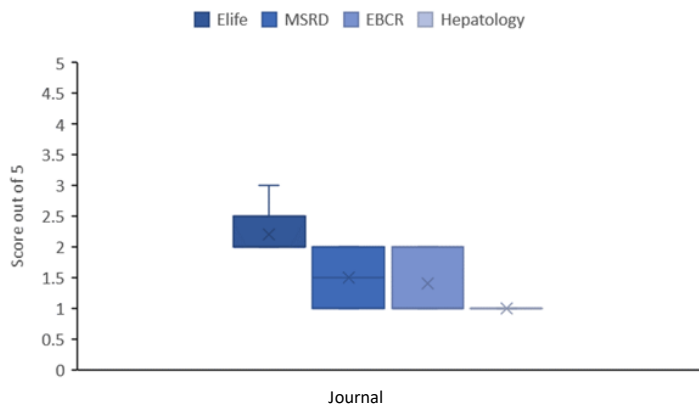
**Figure 3. Scores out of 5 for section one and two of the rubric.** The data in the graphs above was articulated by tallying the scores for each section of the rubric, then using Microsoft Excel to compute a boxplot. 5 lay summaries were selected from each journal. A. Section one: accuracy of methods, results and conclusions. B. Section two: accuracy of rational, implications, and limitations.

**A**

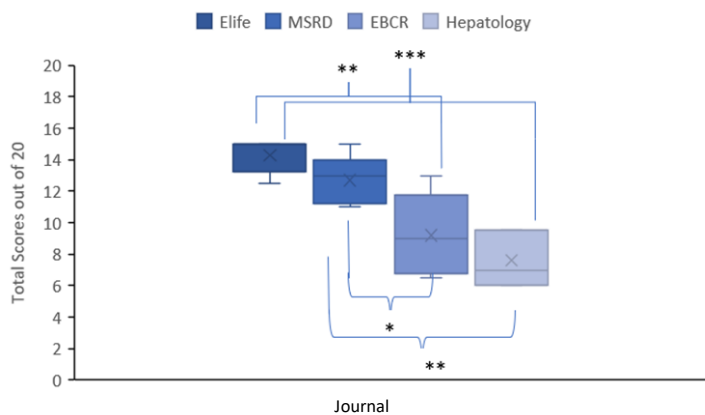




B



**Figure 4. Scores out of 5 for sections three and four of the rubric.** The data in the graphs above was articulated by tallying the scores for each section of the rubric, then using Microsoft Excel to compute a boxplot. Sample size used was 5 articles for each journal. Section three A was sentence structure, grammar and organization, and section four B was accessibility.



**Figure 5. Total score out of 20 for each journal.** The data shown above was found by totaling each lay summary from each journal. Microsoft Excel was used to tabulate the boxplot. Sample size used was 5 articles for each journal. The alpha value used was 0.05. The graph was noted with \* if p-value < 0.05, \*\* if p-value < 0.01, and \*\*\* if p-value < 0.001. GraphPad was used to determine statistical significance.

In this study, we looked at four journals: Elife (n=5), (MSRD) (n=5), (EBCR) (n=5), and Journal of Hepatology (n=5). These were analyzed based on the rubric as outlined in the methods. In terms of the accuracy of methods, results and conclusions within section one of the rubric (Figure 3A), it appears that many lay summaries left out important sections such as the methods. Some of the results sections were also lacking. This is especially seen for EBCR and Journal of Hepatology since they both had low means of 2.4 out of 5 for EBCR and 2.2 out of 5 for Journal of Hepatology

(Figure 3A). This section of the rubric had the same Q3 (5 out of 5), and the highest mean scores for Elife (4.6 out of 5) and MSRD (4.2 out of 5) (Figure 3A). Elife's mean score was higher than MSRD by 0.4 marks and nearly double EBCR and Journal of Hepatology. Two lay summaries out of the 20 analyzed were missing and or lacking results, while six were missing and or lacking the methods section.

For section two of the rubric, which outlined accuracy of rationale, implications, and limitations, more than half the articles from all journals were lacking information on implications. Out of all the articles, 11 were missing a comment about limitations. Elife and MSRD had the same Q3 (5 out of 5) (Figure 3B). The mean score for Elife and MSRD was 4.6 and 4.2 out of 5, respectively (Figure 3B). Q1 was greater by 0.5 marks for Elife than MSRD, 2.8 points greater for EBCR, and 3 points greater for the Journal of Hepatology (Figure 3B). The mean for EBCR and the Journal of Hepatology was 2 and 3 out of 5, respectively. Once again, the average scores for Elife and MSRD are nearly double EBCR and 1.4 fold greater than the Journal of Hepatology. Interestingly, the Q1 of MSRD (3.5 out of 5) and the Q3 of EBCR (3 out of 5) are similar (Figure 3B).

In terms of the language of lay summaries within section three of the rubric, Elife, MSRD, and EBCR had the same Q3 value of 4 out of 5 (Figure 4A). The mean scores for Elife, MSRD, EBCR and the Journal of Hepatology are 2.9, 2.8, 3.4, and 3.2, respectively. Here, EBCR has the highest mean while MSRD has the lowest mean. Many of the MSRD articles are filled with grammatical errors. Examples found in the lay summaries included missing commas, choppy sentence structure, run-on sentences, inappropriate capitalizations, repetition of words, and misuse of acronyms. Specifically, a lay summary done by Yoon & Cheong (2018) toggled between using dimethyl fumarate and its acronym (DMF) throughout the summary.<sup>18</sup> Notably, 70% of the lay summaries analyzed had at least one grammatical error. Another example of non-accessible grammar use is seen in the summary by Pommerich et al. (2018), where the authors use double negatives to mention the phrase, "not without limitations".<sup>19</sup>

Interestingly, the lay summaries published in MSRD exhibited more grammatical errors and sentence structure mistakes than the Elife journals. EBCR and the Journal of Hepatology had better grammar and sentence structure than Elife and MSRD (Figure 4A). Lay summary 7 by Thomsen et al. (2018) had the most jargon used in their lay summary.<sup>20</sup> Lay summary 9 by Roddam et al. (2019) had the most spelling and grammar errors, as well as poor sentence structure.<sup>21</sup> Lay summary 6 by Yoon & Cheong (2018) had the most sections missing in their lay summary and was lacking detail in these parts of their research manuscript.<sup>18</sup>

Interestingly, lay summaries 7, 9, and 6 mentioned above were all published in MSRDL. Lay summary 2, written by Dahlén et al. (2021) had the best results as it had the fewest number of errors and the best sentence structure.<sup>22</sup> This lay summary was published on Elife.

In section four of the rubric, it appears that engagement and accessibility of lay summaries is a task that very few of the analyzed summaries have accomplished. For example, a summary from Roddam et al. (2019) in Elife used a rather causal tone such as “mental health problems” as opposed to difficulties in mental health.<sup>21</sup> Engagement was graded based on how the writer speaks to the reader in terms of tone, expression, and relatability. Many of the lay summaries contained a large amount of jargon in both journals. Many words and terms that have gone unexplained in these summaries include autoimmune, delirium, EEG, tissue scaffolding, and gastric ulcers, to name a few. The Elife journals had over double the jargon than the MSRDL articles, but Elife’s articles were more engaging. Hence, both journals had the same mean score of 1.5 out of 5 (Figure 4B). However, Elife and MSRDL had half the amount of jargon in comparison to EBCR and the Journal of Hepatology (Figure 4B). The mean score for EBCR was 1.4 out of 5, and the mean score for the Journal of Hepatology was 1 out of 5 (Figure 4B). Jargon was found to take away from the summary by hindering the reader from full comprehension. The average score for all journals in section four of the rubric was 1.5 out of 5 (Figure 4B).

Overall, when comparing the average total scores between Elife and MSRDL, Elife lay summaries had a higher average total score and higher score for each section of the rubric than MSRDL (Figure 5). Elife’s average total score was 14.3 out of 20, while MSRDL’s score was 12.7 out of 20 (Figure 5). Elife had an average of 1.6 more points than MSRDL. The average overall score for Elife is significantly higher than EBCR by 1.55-fold ( $p$ -value < 0.01). Elife’s average overall score was also significantly higher than the Journal of Hepatology, by 1.88-fold ( $p$ -value < 0.001) (Figure 5). The average overall score for MSRDL is significantly higher than EBCR, by 1.2-fold ( $p$ -value < 0.05) and significantly higher than the Journal of Hepatology, by 1.67-fold ( $p$ -value < 0.01) (Figure 5). The average overall difference between Elife and EBCR, as well as Elife and the Journal of Hepatology are 5.1 and 6.7 marks, respectively (Figure 5).

Elife summaries were directly embedded in the online manuscript. Meanwhile, the MSRDL, EBCR, and Journal of Hepatology lay summaries were harder to find as they were separated from its corresponding research manuscript and located on another website. The Journal of Hepatology uses the term “lay summaries”, while Elife defines their lay summaries as Elife digests. MSRDL and EBCR titled their lay summaries to

be “100 word lay summaries”.

## DISCUSSION

The key findings from this study include how the scores for engagement and accessibility were 1.5 out of 5 overall. This justifies why there was a dip in the scores for section four of the rubric (Figure 4B), which was graded based on the component of engagement and accessibility. In section three of the rubric, EBCR has the highest mean (3.4) while MSRDL has the lowest mean (2.8) (Figure 4A). This may be because the lay summaries for EBCR were very short, and thus there was less room for grammatical and structural errors. For Elife and MSRDL, it appears that the accuracy in describing findings was better than the engagement and accessibility aspects of the rubric (Figure 3A and 3B). Engagement is an important aspect, because when absent, the reader does not feel compelled to continue to read. Knowledge retention also becomes limited.<sup>23</sup> In terms of accessibility, over 70% of the lay summaries used at least one jargon word that was not explained. This can lead to negative outcomes, because lay readers will not fully comprehend the science that is being portrayed. These findings contradict Elife and Elsevier’s journal guidelines, which state that jargon and complex terms must be simplified.<sup>5</sup> As previously noted, when constructing a lay summary, it is best practice to avoid any form of jargon.<sup>1</sup> If this is not possible, then explaining the jargon is absolutely necessary. Seeing that lay summaries are geared to those who do not understand the field in which they read about, jargon is of little use to their audience. Cramm et al. (2017) mentions that the most important tip when writing a lay summary is to keep the audience in mind.<sup>24</sup>

Furthermore, over 30% of the lay summaries used passive voice which also added complexity to the science being portrayed to the reader (Figure 4A). This can be harmful to the audience because it forms a psychological barrier between the reader and the information being conveyed.<sup>25</sup> Another aspect of accessibility was the name and location of the lay summary on the website. The location of the Elife lay summaries were convenient and simple to find as they were embedded within the manuscript itself. Conversely, the lay summaries in MSRDL, EBCR, and Journal of Hepatology were physically inaccessible, as they were difficult for patients to access (the lay summaries were on a separate webpage instead of grouped with their respective manuscript). Convenience is key for accessibility because without convenience, the summaries do not reach their intended audience. To add, the fact that Elife lay summaries were titled “Elife digests” and the Elsevier lay summaries were titled “100 word summaries” is potentially confusing for readers who may not be aware of the various names for a lay summary. In terms of sentence structure, over 50% of the sum-

maries had poor flow and sentence structure. This also impacts the accessibility of the summary for lay readers because choppy, unclear sentences can be distracting. This may lead the reader to spend extra time comprehending the piece.<sup>26</sup> From the findings, it appears that Elife lay summaries had significantly better overall scores than EBCR and Journal of Hepatology lay summaries (Figure 5). This could be because Elife hires staff who are trained to follow the guidelines for proper science communication in order to create lay summaries based on the authors' submission of their manuscripts.<sup>5</sup>

Other researchers found similar findings to our study in that the naming of the lay summary varied between journals.<sup>15</sup> These researchers found variations such as “plain language summaries”, “author summaries”, and “Elife digest”.<sup>15</sup> Other studies have also discovered that lay summaries that have not been edited and revised to fit the intended audience received the least amount of understanding from the public.<sup>17</sup> Although researchers themselves may not realize that writing a lay piece is important (since 34% of scientists strongly disagree that lay summaries benefit the public), it does not mean that researchers should not create them at all.<sup>17</sup> A study done by Kirkpatrick et al. (2017) found that lay summaries that were edited by editors with a background in writing and science had significantly higher scores on the Flesch scale ( $p$ -value < 0.001).<sup>17</sup> This was compared to lay summaries written by authors with no edits or background in science communication. The Flesch reading score is calculated from a formula that takes total words, total sentences, and total syllables into a formula and assigns a score on a scale of 0 to 100. Higher scores indicate better simplicity and ease of understanding.<sup>17</sup> These results are similar to the findings of our study in that Elife had higher scores, likely because a trained team is responsible for creating the lay summaries.

Implications of this study are that it will provide awareness and bring these undiscovered issues into the light. In this way, authors may consider writing proper lay summaries. This may also be a turning point for journals to instill a system or quality control policy to ensure that the lay summaries published are within high standards. Limitations of this study include the fact that there was only one grader who graded all 20 of the lay summaries. This could pose a potential risk for bias in the marking. Additionally, the sample size for this study was relatively small ( $n=20$ ), which reduces the generalizability of these findings. Future studies could also investigate impact factors and compare these impact factors for manuscripts with and without lay summaries. Flesch reading scores can also be calculated, which seeks to measure the ease of reading lay summaries.<sup>17</sup> Future studies can also evaluate how patients understand a poor lay summary with “spin” (misrepresentation of study results) versus the same lay summary without “spin”.<sup>27</sup> This

will allow researchers to see the relationship between “spin” and its impacts on reading comprehension. This study can bring awareness to authors such that they understand the need for science communication training in writing lay summaries. As demonstrated through Elife's better performance when writing lay summaries in comparison to the rest of the journals, scientists need formalized training in science communication to ensure that researchers are accurately and appropriately conveying important and impactful science.

## CONCLUSION

This study sought to explore the accessibility and engagement of lay summaries within the field of medicine. The results indicate that accessibility and engagement of lay summaries are not as adequate as they should be in the field of science and medicine because the average score in section four of the rubric for all journals was 1.5 out of 5 (Figure 4B). Although the sample size was small, our findings are significant in that the average overall difference between Elife and EBCR, as well as Elife and the Journal of Hepatology, are 5.1 and 6.7 marks different, respectively ( $p$ -value < 0.01 and  $p$ -value < 0.001) (Figure 5). Implications of this study show that science communication training is needed to enhance lay summaries and encourage the publishing of lay summaries to meet the needs of patients, stakeholders, and the general population.

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