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Review Article

Readability assessment of vaccine information: A systematic review for addressing vaccine hesitancy

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ABSTRACT

Objective: Vaccine hesitancy is a problem attracting growing attention and concern. Communication can be an effective tool to counteract vaccine hesitancy and promote optimal vaccine uptake. Readability has been recognized as one of the more important aspects of health communication for achieving good health literacy. We reviewed studies of readability assessment in the area of vaccine communication.
Methods: We conducted a systematic literature search in September 2020, using four online databases (Medline, CINAHL, PsycArticles, and PsycINFO). We included studies that assessed the readability level of online and offline vaccine information materials.
Results: We found 12 articles that were appropriate for inclusion. Ten of the studies were published after 2016. The readability levels of the majority of the materials assessed were found to be difficult and higher than 8th-grade level.
Conclusion: Readability assessments of vaccine information are scarce. The limited evidence shows that the readability level of vaccine information supplied by health care providers is more difficult to read than recommended. More studies on the readability of vaccine information are recommended.
Practice implications: Difficulty reading vaccine information may influence attitudes toward acceptance of or hesitancy to take vaccines. It is recommended that health care professionals use guidelines and tools to create easy-to-read vaccine information.

Contents

Abbreviations: SMOG, Simple Measure of Gobbledygook Grade Level; FHGL, Flesch–Kincaid Grade Level; FRE, Flesch–Kincaid Reading Ease; GFI, Gunning Fog Index; CLI, Coleman–Liau Index; ARI, Automated Readability Index; FRG, Fry Readability Graph; PEMAT, Patient Education Materials Assessment Tool; SAM, Suitability Assessment of Materials

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1. Introduction

Vaccines have long been lauded as one of the most important public health achievements of the past century. In the past decade, however, a growing number of individuals have begun to perceive vaccination as risky. Vaccine hesitancy, defined as "delay in acceptance or refusal of vaccines despite availability of vaccination service," is a problem attracting growing attention and concern [1]. Communication can be an effective tool, if used in a planned and integrated strategy, to counteract vaccine hesitancy and promote optimal vaccine uptake [2]. Communication intervention tools have been proposed and tested to address vaccine hesitancy; formats include print media [3], digital media [4], and face-to-face [5]. However, to date, few effective evidence-based tools for communicating with vaccine-hesitant individuals, or addressing vaccine hesitancy at the community level [6,7] have been developed. Therefore, further assessment of communication methods is important for the development of effective tools to address vaccine hesitancy.

Readability is one of the essential qualities that is evaluated in the assessment of health communication tools. Readability is defined as the reading comprehension level a person must have to understand written materials; this determination is made by systematic formulas [8]. Some of the English readability assessment tools used in health care settings include the Flesch–Kincaid Reading Ease (FRE) test, Flesch–Kincaid Grade Level (FKGL) test, Gunning Fog Index (GFI), Fry Readability Graph (FRG), and Simple Measure of Gobbledygook Grade Level (SMOG) [9,10]. Validated readability assessment tools and formulas are also available for other languages such as Spanish [11], German [12], and French [13]. These assessment tools calculate readability on the basis of factors such as average sentence length and word difficulty level. Readable text is one of the most important requirements for developing effective written health communication tools [9,10]. For example, one study indicated that participants who read easier-to-read vaccine materials showed significantly greater comprehension and recall immediately after reading and at a 3-month follow-up than participants who read standard materials [14]. However, written health communication tools are often written at readability levels that are difficult to read for the majority of the intended audience [15].

There have been no reviews of vaccine information readability studies and, thus, knowledge of this topic is sparse. The present study was, therefore, undertaken to provide the first systematic review focused on studies that objectively assessed the readability levels of online and offline vaccine information materials using readability formulas. We aimed to collate the evidence, find challenges, and guide future research and practice with a view to improving vaccine communication and addressing vaccine hesitancy. Our research questions were as follows: 1) what are the characteristics of previous studies that assessed the readability of vaccine information? 2) what did previous studies reveal regarding the readability levels of vaccine information? 3) what determinants of readability (e.g., difficulty of words, organization of texts) did previous studies assess, and what results did they reveal?

2. Methods

2.1. Search strategy

We conducted a systematic literature search on September 1, 2020, following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statements [16] guidelines. We used the combination of keywords: (vaccine OR vaccination OR immunization OR vaccine hesitancy) AND readability. We searched the resulting titles and abstracts in four online databases (Medline, CINAHL, PsycArticles, and PsycINFO). We did not filter by year, language, or publication type. Additionally, we searched the reference lists of the included studies manually to identify studies that had not been captured via the online database search.

2.2. Study selection

We included studies that assessed the readability levels of online and offline vaccine information materials using readability formulas. Studies that did not assess the readability levels of vaccine information materials, such as a study protocol, a population survey, a study of medical informatics, a scale development, a development of a mobile application, and a development of an educational curriculum, were excluded (see Fig. 1). The first author (TO) conducted the initial screening. Another author (HO) then independently screened all articles. When there were discrepancies between the authors' assessments, they were resolved through discussion.

2.3. Data extraction and synthesis

We extracted the relevant data from each study, including publication year, country where the study was conducted, language of the information that was assessed, readability formula that was used, material that was assessed, provider of material, and the main results of the assessment of the readability level. When the included studies reported characteristics of texts that influence ease of reading (e.g., sentence length, word difficulty, organization of texts) and readers' perception regarding ease of reading, we also extracted those data. The first author (TO) conducted the data extraction using a form of Microsoft Excel (Redmond, Washington, U.S.). Another author (HO) then verified all data extraction, checking for accuracy and completeness. When there were disagreements between the authors' assessments, they were resolved through discussion. The data were aggregated and analyzed in terms of the study objectives. A descriptive analysis of the included studies was conducted, identifying common patterns in the results concerning the study characteristics, assessment of readability levels, and other characteristics of texts that influence ease of reading.

3. Results

The search yielded 39 articles published between 1994 and 2020. After analyzing the relevant titles and abstracts, and the full texts, we identified 12 articles that we deemed fit for inclusion and subsequently reviewed them (see Fig. 1).

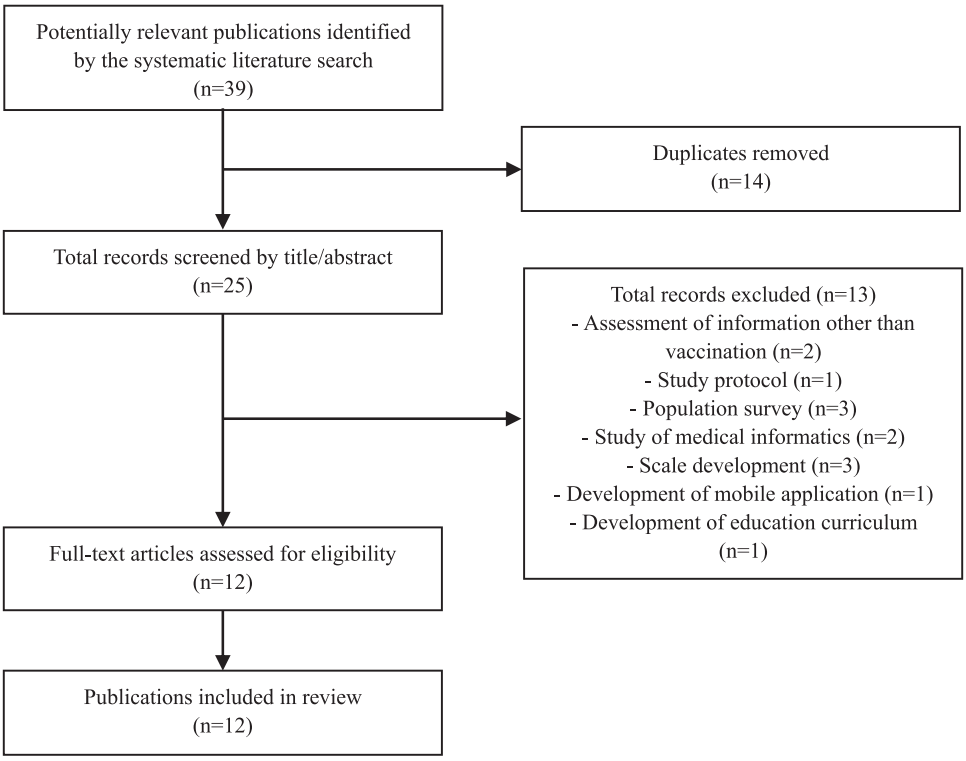

Fig. 1. Search process flow chart.

3.1. Study characteristics

An overview of the included studies is presented in Table 1. Ten of the twelve studies were published after 2016 [17–26]; these studies assessed the readability of online vaccine information, except for one study that assessed print materials [23]. Seven studies were conducted in the United States [18–20,22,23,26,28], two in Canada [21,27], two in Japan [24,25], and one in Australia [17]. Ten studies assessed the readability of English texts [17–23], and another two assessed that of Japanese texts [24,25]. Seven studies assessed HPV vaccine information [19,21–23,25–27]; two assessed influenza vaccine information [18,24]; one studied childhood vaccination information [28]; and the other two assessed vaccine information in general [17,20]. Five studies assessed pro- and anti-vaccination information separately; all of these studies analyzed online information [18,20,24–26]. Eight studies reported the provider of the materials; five studies assessed materials by governments and/or public institutions [17,21–23,28]; one study assessed newspaper articles [27]; and two studies assessed online messages by health care professionals and non-health care professionals separately [24,25].

3.2. Readability assessment

As Table 1 shows, the included studies used SMOG, FKGL, FRE, GFI, FRG, the Coleman–Liau Index (CLI), and the Automated Readability Index (ARI) to assess the readability of English texts, and jReadability was used to assess Japanese texts. The most frequently used readability formulas were SMOG and FKGL, which were used in seven studies and six studies, respectively.

All of the 10 studies from English-speaking countries showed that the readability of most of the vaccine information assessed was higher than 8th-grade level [17–23,26–28]. These studies showed that none or only a small amount of the assessed vaccine information was at the recommended 5th- to 6th-grade level or lower. Two studies from Japan also showed that vaccine recommendation messages were considered difficult to read and that pro-vaccination messages were significantly more difficult to read than anti-vaccination messages [24,25].

3.3. Assessment of characteristics other than readability

As Table 1 shows, four studies reported the results of an assessment of characteristics other than readability levels [17,21,23,28]. One study [17] used the Patient Education Materials Assessment Tool (PEMAT) [29]. Another study [23] used the Suitability Assessment of Materials (SAM) [30] in addition to the PEMAT [29]. These two studies showed that the majority of vaccine information materials scored low on understandability and suitability [17,23]. One study assessed text coherence and reported that vaccine information materials have a lower level of coherence than that is needed for lay audiences [21]. One study compared the readability level required to understand childhood vaccination pamphlets with the reading level of parents in a pediatric clinic [28]. This study reported that 86% of the parents surveyed did not have a reading level sufficient to understand the pamphlets [28].

4. Discussion and conclusion

4.1. Discussion

We systematically reviewed studies that assessed the readability of vaccine information materials using readability formulas. We discuss our findings in terms of study characteristics (research question 1), readability level (research question 2), and assessments of characteristics other than readability level (research question 3).

Regarding study characteristics (research question 1), despite the history and richness of readability studies in the area of public health, research on the readability of vaccine information materials did not appear in the literature until recently; moreover, our analysis indicates that such research has increased since 2016. Considering the rich repository of systematic reviews on readability studies of

Table 1
Studies reviewed for readability of vaccine information.

Ref.	Year	Country	Language	Readability formula	Material (n)	Provider of material	Main results	Assessment of other than readability
Abdi et al. [17]	2020	Australia	English	SMOG[a], FKGL[b]	Online immunization resources (25)	State government and health organizations	The majority of resources were difficult to read and were above a 5th grade level. The average readability score indicated an 11th grade reading level.	Only half of the resources met the PEMAT[c] threshold score for high understandability.
Gandhi et al. [18]	2020	The United States	English	FRE[d], FKGL	Pro- and anti-influenza vaccine Facebook posts (477)	Not reported	The average grade level of pro-vaccine posts was higher than 11th grade reading level.	None
MacLean et al. [19]	2019	The United States	English	FKGL, GFI[e], CLI[f], SMOG, FRE	HPV vaccination websites (100)	Not reported	The readability of the majority (75%) of websites was deemed "difficult" (> 10th grade). Only a few websites were graded as "easy" (< 6th grade).	None
Xu et al. [20]	2019	The United States	English	SMOG	Online pro- and anti-vaccination articles (923)	Not reported	Almost all vaccine articles exceeded the American average reading comprehension level.	None
Tulsieram et al. [21]	2018	Canada	English	GFI, SMOG	Provincial department/ ministry of health's HPV information websites (7)	Provincial governments	The majority (six out of the seven provinces) of websites' readability levels were "difficult"; some postsecondary education was necessary to understand the information (> 12th grade).	Text coherence was not adequate for the lay individuals to understand.
Calo et al. [22]	2018	The United States	English	FKGL, GFI, CLI, SMOG, ARI[g]	HPV vaccination messages online (267)	Government, medical association, Medscape, medical journals, educational clearinghouses	The majority (62%) were rated as "not easy to read" (≥ 9th grade). Only 12% had a readability rating of "easiest to read" (≤ 6th grade).	None
Chhabra et al. [23]	2018	The United States	English	FRE, FKGL, GFI, SMOG, FRG[h]	HPV vaccination counseling print materials (38)	State government	Four documents (10.5%) were rated at a 6th grade reading level or lower, and 15 documents (39.5%) at a 10th grade or higher reading level.	68% of materials were categorized as "unsuitable" by the SAM[i]. Mean PEMAT score was 42%, which was much lower than the threshold for high understandability.
Okuhara et al. [24]	2017	Japan	Japanese	jReadability	Pro-and anti-influenza vaccination online messages (145)	Health professionals and non-health professionals	93% of pro-vaccination messages were difficult to read; anti-vaccination messages were significantly easier to read.	None
Okuhara et al. [25]	2017	Japan	Japanese	jReadability	Pro-and anti-HPV-vaccination online messages (270)	Health professionals and non-health professionals	The mean readability of pro-vaccination messages was a little difficult; anti-vaccination messages were considerably easier to read.	None
Fu et al. [26]	2016	The United States	English	FKGL	Critical and noncritical HPV vaccination web pages (116)	Not reported	Web pages required viewers to have advanced reading skills—nearly at the 12th grade level. Vaccine-critical Web pages required reading levels above the 13th grade, which was two grades higher than that required by noncritical Web pages.	None
Abdelmutti and Hoffman-Goetz [27]	2009	Canada	English	SMOG	Newspaper articles of HPV vaccines (164)	National newspapers	The readability of articles was at a high level, was well beyond that which could be easily understood by the general public, and could be categorized as inadequate (higher than 8th grade level).	None
Melman et al. [28]	1994	The United States	English	FRG	Childhood vaccination information pamphlets (3)	The Centers for Disease Control and Prevention.	Materials required 11th grade reading level on average.	86% of caretakers did not have a reading level sufficient to understand any of the materials.

[a] Simple Measure of Gobbledygook Grade Level.
[b] Flesch–Kincaid Grade Level.
[c] Patient Education Materials Assessment Tool.
[d] Flesch–Kincaid Reading Ease.
[e] Gunning Fog Index.
[f] Coleman–Liau Index.

patient education materials [31,32], the total of 12 vaccine information studies found in our study is a relatively meager amount. Most of the studies were conducted in the United States and assessed English-language text, online information, and HPV vaccine information (primarily concerning the adverse reactions that have become a topic of debate in recent years). No study was reported from European countries or Asian countries other than Japan. We found no studies that assessed languages other than English and Japanese. Future studies need to be conducted in a wider variety of countries and need to assess the readability of vaccine information materials written in languages other than English and Japanese. Additionally, future studies need to assess the readability of information about vaccines other than HPV vaccines, such as MMR vaccines and COVID-19 vaccines, because vaccine hesitancy with respect to these vaccines is also a problem globally [33–36]. Four out of twelve studies did not identify the provider of information. However, identifying the providers of information is essential in order to take efficient measures to improve the readability of vaccine information. Future studies should assess the readability of vaccine information separately by the provider.

Regarding readability levels (research question 2), we found that the readability levels of vaccine information were higher than an 8th-grade level in most of the assessed materials, despite the recommendation that patient education materials should be written at a 5th- to 6th-grade level or lower [37]. These findings concur with many other studies showing that health information other than that about vaccinations tends to be written above the average high school comprehension level [10,38]. To date, the most commonly studied interventions for vaccine hesitancy have used written educational information (e.g., brochures, pamphlets, and posters) [6,39]. Information from health care providers is one of the most influential factors in changing vaccine-hesitant individuals' decisions [40]. In such cases, written vaccine information supports a standardized approach to counseling and helps ensure that barriers are addressed [23]; furthermore, this plays an important role in individuals' decision-making about vaccination [23]. Difficulty in reading written vaccine information may affect vaccine acceptance or hesitancy in the following ways.

It is recommended that public health communicators pay special attention to health literacy, defined as "the degree to which individuals have the capacity to obtain, process, and understand basic health information" [41]. Low health literacy affects provider–patient/parent communication [42,43] and is associated with poorer health outcomes and decreased use of preventive services [44]. This also applies to vaccination. Understanding vaccine information requires a certain level of literacy and numeracy, which makes it difficult to convey the vaccine information to lay individuals, especially if they have low health literacy [45]. Inadequate literacy is associated with lower vaccination adoption rates, supposedly due to the complexity of vaccine information and multiple steps required for successful adoption of vaccination [46]. The accessibility and appropriateness of health communications have generally been discussed in terms of readability in the field of health literacy [44]; the lowest awareness of health information and the greatest risk of infection are evident in less-educated populations [47]. Because reading vaccine information is more difficult for those with lower health literacy, they may be less informed about the benefits of vaccination and susceptible to anti-vaccination sentiment [48]. Thus, to address vaccine hesitancy, a communication approach that considers health literacy——namely, conveying information in an easy-to-read manner——is needed.

Additionally, according to studies of processing fluency, difficult-to-read text is less liked and trusted [49] than easy-to-read text. Processing fluency refers to the ease or difficulty with which information can be processed [49]. Human judgment is influenced by the content of thoughts, as well as by the metacognitive experience

g Automated Readability Index.
h Fry Readability Graph.
i Suitability Assessment of Materials.

of processing those thoughts [50]. Processing fluency is a metacognitive cue that affects human judgment [50]. One review of fluency studies argues that fluently processed information produces more favorable attitudes in its readers [51]. For example, one study showed that participants indicated that they were less likely to feel they could trust information when they read difficult-to-read material than when they read easy-to-read material [52]. If the vaccine information from health care providers is easy to read, readers may find it easier to trust the information. Thus, the readability of vaccine information is considered to be crucial for generating readers' favorable attitudes toward vaccination.

Regarding assessments of characteristics other than readability level (research question 3), we found that eight studies out of the twelve examined only readability levels using readability formulas. However, there are various factors that contribute to the ease of reading vaccine information in addition to those that can be assessed by readability formulas. Two of the included studies [17,23] assessed vaccine information using the PEMAT [29] and one of them also used the SAM [30], in addition to readability levels. The PEMAT includes 17 criteria for assessing understandability, which are categorized into content, word choice and style, use of numbers, organization, layout and design, and use of visual aids [29]. A score of greater than 70% indicates higher understandability [29]. The two included studies using the PEMAT showed that the majority of vaccine information materials did not meet the PEMAT threshold score for high understandability [17,23]. The included study using the SAM assessed materials in the following five domains: content, literacy demand, graphics, layout and typography, and learning simulation [23]. When the SAM score is less than 40%, the material is categorized as "unsuitable." [30] The included study showed that 68% of the vaccine information examined was categorized as "unsuitable." [23] Furthermore, these two included studies reported that much of the vaccine information examined used medical terms without definition, did not use visual aids, and lacked a summary at the end of the material [17,23]. These characteristics would have made the vaccine information difficult to read and understand for lay audiences. A strong negative correlation has been reported between the average reading grade level of material that has been assessed using readability formulas and readers' perceptions of how easy the material is to understand [53]. Future studies should use broader assessment tools such as the PEMAT [29] and the SAM [30] to assess the understandability of vaccine information objectively in addition to using readability formulas. Such extensive assessment will contribute to improving the understandability as well as the readability of vaccine information.

One included study assessed text coherence (i.e., semantic connectedness, cohesion, and consistency in the texts) and showed that the coherence of the vaccine information was not adequate for lay individuals to read and understand it [21]. Readability scores are calculated by accounting for factors such as word difficulty and sentence length. However, other factors such as text coherence that readability formulas cannot assess are also determinants of the ease of reading and understanding of vaccine information [21]; future studies should assess such factors.

One included study compared the reading level of caretakers in a pediatric clinic with the required readability level of vaccine information pamphlets that were targeted to caretakers [28]. This study reported that the median reading grade level of caretakers was 6.9 [28]. However, the assessment using a readability formula showed that the reading grade level required for those pamphlets averaged 11.1 [28]. This study found that 86% of caretakers did not have a reading level sufficient to understand the vaccine information pamphlets [28]. No other included studies besides this study assessed the reading level of the targeted audiences. Future studies should assess the reading level and comprehension of audiences in addition to the readability level of vaccine information materials; this will contribute to reducing the gap between the literacy level of vaccine-hesitant audiences and the literacy level required to read vaccine information.

With a view to improving vaccine communication, we should consider the various factors that affect vaccine hesitancy, such as misinformation and lack of trust in health care institutions and professionals, as well as lack of information [1]. Providing information alone cannot increase vaccine confidence among vaccine-hesitant individuals [6,39]. An integrated approach that takes into account multiple factors is needed to address vaccine hesitancy [7,40]. For example, provision of vaccine information by trusted health care professionals in combination with providing well-written vaccine information may increase vaccine confidence because the interaction between patients and health care providers is a fundamental factor in changing the decisions of vaccine-hesitant individuals [40,54,55]. Evidence-based strategies for effective tailored communication are needed in vaccine communication from organizations to communities and individuals, as well as between individuals [36,56]. Written information offline and online is widely used in such vaccine communication. Ease of reading is the cornerstone to ensure the success of vaccine communication using written information. More extensive research and practice are needed to understand the actual status of the readability of vaccine information and to improve it.

The present study has some limitations. Although we systematically retrieved the studies using a combination of keywords in multiple databases, we may still have missed some publications, such as studies that assessed readability as a piece of a larger analysis. Although we focused on readability levels that are calculated by readability formulas, there are other factors that influence the ease of reading vaccine information, as mentioned earlier. Our systematic search of the literature did not include those studies that assessed only factors that cannot be measured by readability formulas. However, this is the first systematic review of the literature that assessed the readability of vaccine information, and the findings described in this review provide a promising starting point for further research and practice to improve vaccine communication and address vaccine hesitancy in terms of readability.

4.2. Conclusion

This study showed that assessment of vaccine information readability is scarce. The limited evidence shows that the readability level of most vaccine information from health care providers is more difficult to read than what is recommended. Difficulty of reading vaccine information may influence attitudes toward acceptance of or hesitancy to take vaccinations. Readability is a simple but important and unexplored field of study and practice in vaccine communication that seeks to address vaccine hesitancy. We call for more studies on improving the readability of vaccine communication and suggest the following questions, which should be addressed in future research. What is the readability level of vaccine information materials that have not been assessed in previous studies? What is the readability level of vaccination information materials other than those for HPV vaccinations? What is the readability level of non-English and non-Japanese vaccine information? Are their readability levels also too high? What is the level of other determinants of ease of reading vaccine information than those that can be assessed by readability formulas? What is the gap between the reading level of vaccine-hesitant audiences and the required readability level in reading vaccine information?

4.3. Practice implications

To make vaccine information easy to read, available guidelines such as the PEMAT [29], the CDC clear communication index [57],

and the CDC Simply Put guide [9] recommend that when health care professionals create written health care information, technical language should be revised into everyday language; long sentences should be shortened; information should be ordered into a logical sequence; and informative headers should be added to each section. Additionally, health care professionals can use readability assessment tools to make texts more readable. Many readability tools are available on the internet [9,10]. When those tools deem vaccine information difficult to read, health care professionals can revise the text to use plain language, the active voice, and shorter words and sentences [9,10]. Health care professionals should create readable vaccine information using such guidelines and tools to communicate more successfully with vaccine-hesitant individuals and to address vaccine hesitancy at the community level.

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CRediT authorship contribution statement

Tsuyoshi Okuhara: Conceptualization, Data extraction and synthesis, Writing - original draft, Writing - review & editing, Funding acquisition. **Hirono Ishikawa:** Writing - review & editing. **Haruka Ueno:** Writing - review & editing. **Hiroko Okada:** Data extraction and synthesis, Writing - review & editing. **Mio Kato:** Writing - review & editing. **Takahiro Kiuchi:** Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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