[Preprint] Plain Language Summaries:

A Systematic Review of Theory, Guidelines, and

Empirical Research

Marlene Stoll[1,2] *, Martin Kerwer[1], Klaus Lieb[2], Anita Chasiotis[1]

[1]Leibniz Institute for Psychology (ZPID), Trier, Germany

[2]Leibniz Institute for Resilience Research (LIR), Mainz, Germany

* Corresponding author
E-Mail: ms@leibniz-psychology.org

Abstract

Background

Plain language summaries (PLS) have been introduced to communicate research in an understandable way to a non-expert audience. Guidelines for writing PLS have been developed and empirical research on PLS has been conducted, but terminology and research approaches in this comparatively young field vary considerably. This prompted us to review the current state of the art on the theoretical and empirical literature on PLS.

Main Objectives

Main objectives were (1) to develop a conceptual framework for PLS theory, and (2) to synthesize empirical evidence on PLS. The major research questions were how theoretical considerations on PLS can be conceptualized and what the empirical evidence of their effects on defined outcomes is.

Methods

Web of Science, PubMed, PsycInfo, and PSYNDEX were searched in July 2020. We included empirical investigations of PLS, reports on development or evaluation of PLS, PLS guidelines and theoretical articles referring to PLS for further analysis. Through content analysis, a conceptual framework was developed and empirical studies investigating the effects of PLS on defined outcomes were narratively synthesized.

Results

We identified 5,481 records, of which 72 articles met the inclusion criteria. All articles were used to develop a conceptual framework for PLS which comprises six categories each for PLS aims and PLS characteristics. Twenty-five articles empirically investigated effects of PLS on several outcomes, but study designs were too heterogeneous to identify definite criteria for high quality PLS. Insular studies identified effects on accessibility and knowledge

outcomes. For most criteria we identified from PLS writing guidelines, we found no empirical evidence.

Conclusion and Implications

Considerable work to establish and investigate PLS has been done, but empirical evidence on criteria for high-quality PLS is still scarce. The conceptual framework developed in this review may provide a valuable starting point for future guideline developers and PLS researchers.

Conflicts of Interest

The authors declare no conflicts of interest related to this article.

Introduction

Good research practices include the publication and dissemination of results as well as their honest and transparent communication [1,2]. It is further argued that the public—or at least relevant stakeholders—needs to have access to research, not only technically but also intellectually [3]. This means that the public needs to be able to understand what the researchers did, what the results mean and which practical implications can be drawn from them [3]. This information is mostly communicated by researchers via scientific publications, which is among other factors further motivated by the fact that funding agencies as well as promotion and tenure committees expect and postulate researchers to publish in high impact scientific journals [4,5]. The target audience of such publications as well as relevant gatekeepers, namely editors and reviewers of high impact journals, are other researchers. Consequently, this traditional way in which scientific publications are written and published requires researchers to stress the scientific implications of their research. The traditional communication of scientific findings therefore constitutes a scientific 'bubble' in which scientists communicate with each other about the meaning of their findings [6]. As is typical for such group formation processes, this bubble results in its own special type of language, shared knowledge and implicit and explicit norms which makes scientific communication harder to understand for those outside the scientific bubble (i.e., the public [7]). Such a context provides a breeding ground for the evolution of idiosyncratic (i.e., unique for a certain group of people) professional jargon. This lack of plain (i.e., easily comprehensible) language hinders the public from directly accessing scientific articles.

One viable and ready solution that accounts for the information needs of the public (or, alternatively, of gatekeepers such as journalists) within the current research ecosystem are Plain Language Summaries (PLS) - a lay-friendly summary format of scientific research. Each PLS is thought to provide a brief overview on a study and its main practical

implications in a manner that is understandable to laypersons. Various institutions provide some form of lay-friendly summary formats of scientific studies; especially institutions in biomedicine have been very prolific in this regard [8]. Still, there is no consensus on PLS criteria, i.e., what defines a PLS and what makes a high-quality PLS. Guidance on how to write PLS is scattered and often relates to very specific purposes of the respective institutions that provide the PLS [8]. To evaluate whether a PLS is effective in fulfilling its aim, e.g., to be understandable for laypersons, empirical research on the subject of PLS has been conducted [e.g., 9–14].

To shed light on the status quo of PLS writing guidelines as well as the empirical research on the effects of PLS on defined outcomes, we present a systematic review of established writing guidelines with their respective criteria and of the empirical evidence on whether PLS are effective in terms of relevant outcomes.

Theoretical background

Regarding the terminology of lay-friendly summaries in the form of PLS, there seems to be no broad consensus yet [8,15]. In the present paper, we consistently refer to 'Plain Language Summaries' (PLS), independent from what they are called in the referenced publications. PLS, in this review, are defined as relatively brief textual summaries of scientific publications targeted at laypersons which complement the respective traditional abstracts and summarize the whole scientific article in a balanced and easily understandable manner.

The considerable variation in the terms that are used to refer to PLS [8] may be partly related to the different *aims* that authors, stakeholders or publishers pursue with their PLS. Some of these stakeholders pursue the explicit aim of translating medical evidence into a PLS to enable patients to actively engage in the process of shared decision making [16]. For such

PLS also terms like 'clinical trial results summaries for laypersons' [17,18], 'patient lay summaries' [19] or 'consumer summaries' [20] are used. On the other hand, publishers of scientific journals—especially in other fields than medicine—may primarily aim to increase the impact and accessibility of their research. They might use terms like 'lay summaries' [e.g., 21–23], 'translational abstracts' [24] or 'lay abstracts' [e.g., 21]. An overview of the variety of PLS terminology can be found in Shailes [15] for PLS of scientific research in general, and in FitzGibbon et al. [8] for biomedical PLS.

Besides common aims (e.g., increasing the accessibility of research), PLS formats differ in various *characteristics*. Even for basic formal characteristics, such as the length of the PLS or the language they are written in [25], considerable variation exists. For example, the *Journal of Applied Sport Psychology* presets a word limit of 50 words for their 'lay summaries' [26] which are expected to be written in English language, while Cochrane specifies a limit of up to 700 words and makes considerable efforts for translating the PLS into multiple languages [27]. Once more, these differences in text characteristics, similarly to the differences in the terminology used to label the PLS, may be related to the specific aims that the specific parties (e.g., authors, publishers and other stakeholders) pursue by providing PLS. If it is, for example, aimed to reach out to other researchers to foster interdisciplinary exchange, providing English PLS may be a reasonable choice. On the other hand, if the aim is to reach out to the broader public in a more general way, PLS additionally have to be written in languages other than English, to maximize accessibility. Such differences might not only manifest themselves in varying languages or word limits of PLS, but also in varying recommendations of style or content in PLS writing guidelines, e.g., what the PLS should explain, or whether additional background information or statistical information should be provided. PLS may thus differ considerably in their characteristics, depending on the specific guidelines on which they are based (if at all) and which *criteria* these guidelines specify.

Criteria in this context are standards or restrictions with regard to characteristics (i.e., specific word limits or approaches for dealing with technical terms).

In empirical studies on the effectiveness of PLS, usually, such criteria are systematically varied and analyzed with regard to certain defined *outcomes* that are supposed to reflect the aims in terms of measurable, operationalized variables. For example, researchers could investigate the PLS aim of increasing public empowerment by evaluating whether people who read a PLS with plain language explanations of technical terms perform better in a knowledge test about the contents of the summary than people who read a PLS without such plain language explanations.

In sum, theory on the concept of PLS refers to the interconnection of these four main subject areas: PLS serve specific (1) *aims* (e.g., to improve laypersons' understanding of scientific findings) that are accomplished by certain (2) *characteristics* (e.g., use of language) with their related target values or (3) *criteria* (e.g., avoiding technical terms). Criteria can also be subject to empirical investigations (e.g., comparing PLS with different criteria) with regard to certain (4) *outcomes* (i.e. operationalized and measurable aims of PLS in empirical studies; e.g., knowledge tests).

In this review, PLS are considered a research subject as well as a service or intervention to make research understandable for laypersons. For this systematic review on PLS research and theory, we will therefore not only synthesize research on the subject using an *ontological* approach by addressing the question of what the topic constitutes and what it distinguishes from other topics (this refers to PLS characteristics). Since PLS are a specific form of 'research translation' service or intervention, our review additionally distills and discusses information from the literature on what a PLS is for (a *finalistic* approach referring to the aims of a PLS), what it should be like to fulfill this purpose (a *normative* approach referring to the criteria of a PLS) and, how its effectiveness can be evaluated (a *measurement-*

related approach referring to the outcomes of a PLS in empirical studies). Thereby, a comprehensive overview with regard to four main subject areas, namely the characteristics and aims of PLS as well as PLS criteria and measured outcomes according to the scientific literature, is provided. We particularly focus on existing guidelines and empirical investigations of criteria with regard to defined outcomes, to identify evidence-based criteria for writing PLS.

Objectives

The aim of this review is to give a comprehensive overview on the current understanding of PLS in the scientific literature and on evidence of their effects on certain defined outcomes. Therefore, we will investigate 1) aims, 2) characteristics, and 3) criteria that are named or defined in the context of PLS (e.g., in guidelines) as well as criteria and 4) outcomes that have been empirically investigated in the context of PLS research and evaluation. On that account, we will systematize theoretical research and empirical evidence on PLS by considering theoretical articles (including literature reviews) and opinion pieces, empirical studies as well as writing guidelines. With that said, the aim of our review is twofold.

First, we intend to establish a conceptual framework of PLS by outlining finalistic, ontological, normative and measurement-related approaches to capturing this research field. More precisely, this means that in the first step, we will synthesize the systematically reviewed literature with regard to four questions relating to the main subject areas of this review:

1) What are the *aims* or purposes of a PLS (finalistic approach; i.e., what are PLS for)?
2) What are the *characteristics* of a PLS (ontological approach; i.e., what are PLS constituted of)?

3) Which *criteria*, in terms of values, expressions or degrees of the aforementioned characteristics, define a PLS or are supposed or found to constitute a high-quality PLS (normative approach; i.e., what exactly should PLS be like)?

4) Which *outcomes* of PLS are investigated, and, consequently, how (well) are theoretical aims operationalized in empirical studies (measurement-related approach; i.e., how are PLS evaluated)?

Second, the established conceptual framework will enable us to sum up and integrate the empirical evidence on PLS against the background of the main subject areas regarding this research topic. This does also involve scrutinizing how well the empirically investigated outcomes correspond to the theoretically proposed aims as well as which criteria are listed in guidelines or are empirically investigated. By doing so, we will also be able to identify current gaps in the empirical research on PLS and reflect on what has been achieved so far in providing evidence-based guidelines for writing PLS.

Methods

Eligibility criteria

For this review, we searched for scientific publications on PLS (i.e., empirical and theoretical articles) as well as for published PLS guidelines. The term 'PLS', in this review, refers to research summaries that aim to translate published scientific evidence from language that is geared towards expert audiences to language that is geared towards lay audiences, and that accompany a scientific publication. Examples for such scientific publications are original research reports, meta-analytical studies or clinical study reports. This definition of PLS does explicitly not include popularized science news articles, blog posts or patient-education materials as these are not direct translations of scientific publications but (research) outputs or publications in their own right. In our interpretation, apart from translating the evidence of

research articles, the only autonomous scientific contribution a PLS may make is to report the evaluation of risk of bias or putting the reported evidence into perspective (e.g., by highlighting its practical implications or providing additional background information). This criterion is based on the consideration that evaluating risk of bias is just another way of translating the quality of a scientific finding for a non-expert audience that is expected to have no experience with regard to scientific standards, and that additional information on practical implications may help non-experts to understand the scientific finding. Finally, with 'PLS' we only refer to textual approaches for translating evidence and, therefore, not to infographics, videos or podcasts. Accordingly, we searched for publications and guidelines that investigate, discuss or describe PLS. All three of the following criteria needed to apply to the investigated, discussed or described PLS:

A. The PLS are summaries of published scientific evidence (i.e., the underlying evidence that is summarized is a scientific study such as a primary study or a systematic review).

B. The PLS aims at a lay readership.

C. The PLS uses the same communication format as the original scientific publication evidence (i.e., text).

We included English and German records of the following study types:

● quantitative and qualitative studies or reviews of such studies in which

a) characteristics, criteria or aims of PLS are investigated, or

b) PLS criteria or guidelines that combine several criteria are developed or evaluated;

● guidelines on how to write PLS;

● theoretical articles (e.g., opinion pieces, theoretical discussions, reviews, editorials, comments) that clearly bear upon PLS characteristics, outcomes or aims, or on PLS writing criteria or guidelines.

Information sources and information search

In July 2020 (last search on 2020/07/29), we systematically searched Web of Science, PubMed, PsycInfo and PSYNDEX using the search terms specified in S1 File. After the first selection process (see below), we performed a backward reference search of included articles. Additionally, we searched the websites of the journals for which we had found that they publish PLS for guidelines on writing PLS and searched the web for more of such guidelines.

Study selection

In the first step, titles and, if necessary, abstracts were screened to exclude irrelevant records based on the above-mentioned inclusion criteria. In a second step, the remaining potentially relevant records were assessed for eligibility by a full text screening. In both steps, double-screenings by two independent researchers were performed (see also Fig 1). Discrepancies were discussed and, if unsolvable, the decision was left to a third independent rater.

Data collection process and data items

MS, MK and AC independently extracted information regarding the following four subject areas in the form of text passages from the selected reports. Each record was evaluated by one reviewer. After that, they compiled the information in tables:

1) Aims of PLS: Which aims or purposes of PLS were mentioned?

2) Characteristics of PLS: What kind of PLS characteristics were mentioned?

3) Criteria for PLS: What information could be found on what makes a high-quality PLS as well as on what makes a PLS different from other types of research summaries?

4) Outcomes of PLS: In empirical studies on PLS, which outcomes were examined with regard to PLS?

After the text passages had been compiled, MS went through all passages again and collated them to the respective original record to ensure proper rendition. Study procedures were not preregistered.

Analysis

We based our approach for analyzing and summarizing the information from the full texts on qualitative content analysis [28]. As described above, we first extracted information (i.e., text passages) separately for each of the four subject areas (aims, characteristics, criteria, outcomes) which corresponded to the four approaches of describing the PLS research field from theory. In the next step, we categorized the information that we obtained for each subject area by means of identifying and labeling homogeneous groups of information.

Three of the authors (MS, MK, AC) with expertise on PLS each independently worked through the extracted text passages and proposed categories for the subject areas 'aims' and 'characteristics'. The proposed categories and according rationales were discussed by these three authors until an agreement for a set of categories for 'aims' as well as 'characteristics' was obtained. We then mapped the information we had extracted for the subject area 'outcomes' to these agreed aim categories and information for the subject area 'criteria' to the agreed characteristic categories. For this purpose, the first author (MS) allocated information about PLS outcomes and PLS criteria to one of the previously deduced categories of PLS aims and PLS characteristics, respectively. Afterwards, two other authors (AC, MK) reviewed the categorization and proposed changes in case of disagreement. These cases were discussed until consensus was reached. During and after this process, the final conceptual framework was developed.

Based on this framework, a narrative review of the empirical evidence on PLS as well as on PLS writing guidelines was performed. Empirical investigations on the effects of PLS on certain defined outcomes were synthesized in more detail with a focus on the experimental conditions (which were matched with respective characteristic categories), and on the outcome measurements (which were matched with respective aim categories).

Results

Study selection

We identified 5,350 records through database searching and 131 records through other sources (see above). After title- and full-text screening (see Fig 1 for further details), we included 72 studies in our review.

Fig 1. Study Selection Flow Diagram.
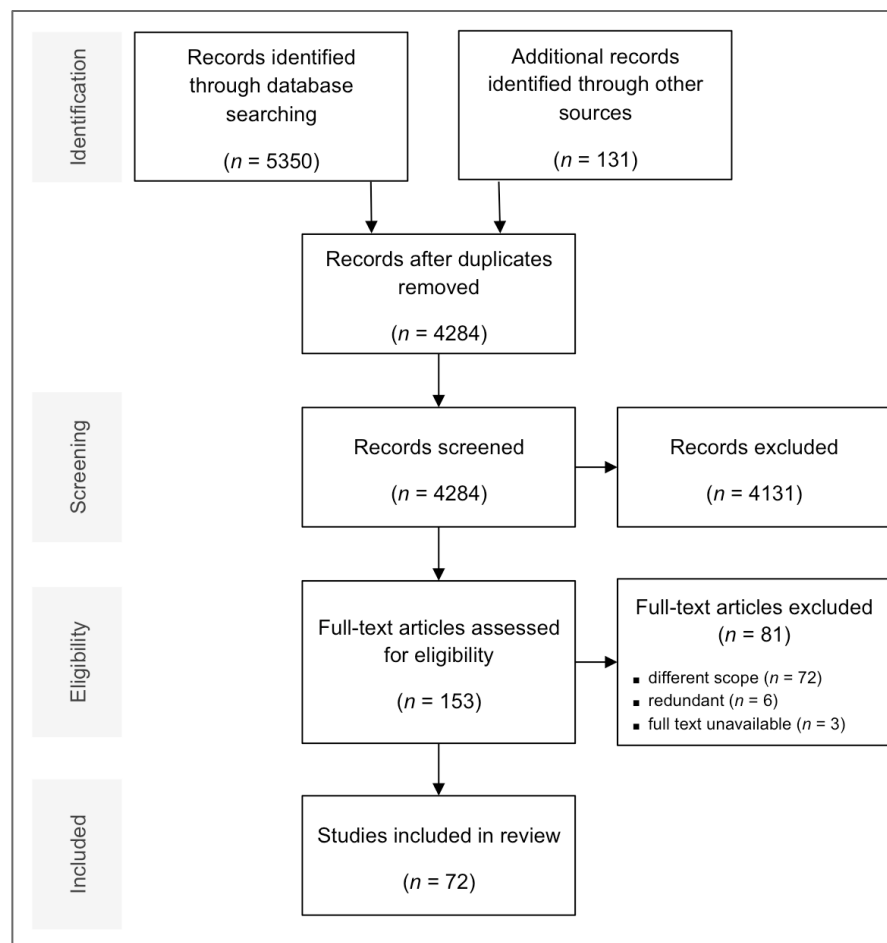
Study characteristics

Of the 72 included records, 31 (43%) were theoretical and 25 (35%) were empirical articles (see Fig 2). Sixteen articles (22%) were guidelines or articles that described the development of a guideline. Of the 31 theoretical articles, 7 (23%) were reviews and 24 (77%) were opinion pieces, editorials or comparable articles. Of the 25 empirical articles, 13 (52%) described experiments that quantitatively compared different formats of PLS ($n = 5$) or compared PLS with other summary formats ($n = 8$), 3 (12%) were studies that qualitatively compared different formats of PLS ($n = 2$) or compared PLS with other summary formats ($n = 1$), and 9 (36%) were studies that evaluated one specific type of PLS through user surveys or interviews. Of the 16 guidance-related records, 14 (88%) were guidelines and 2 (13%) were studies about guideline development. All studies are listed in S1 Table.

Fig 2. Study Characteristics of Studies included in this Review.
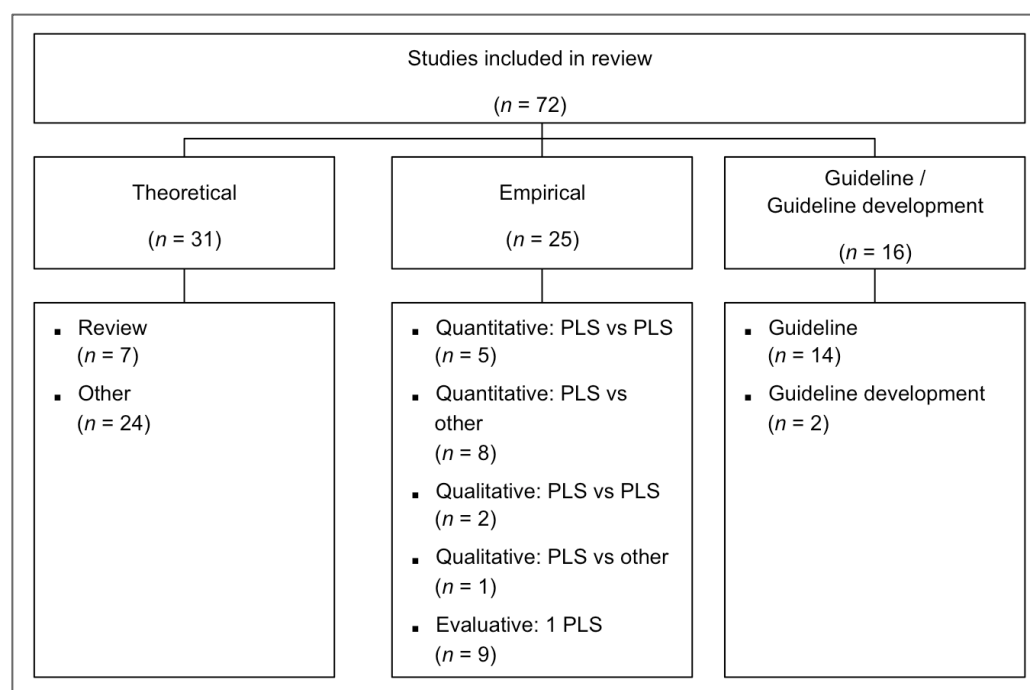
Information about PLS aims, characteristics, criteria and outcomes was extracted from all 72 studies. Specific information about criteria for writing a PLS was additionally extracted in detail from the 14 guidelines. Specific information about empirical evidence regarding PLS was additionally extracted and summarized in detail from the seven empirical studies that quantitatively or qualitatively compared different forms of PLS.

Aims of PLS

We firstly investigated all articles regarding the question: Which aims or purposes were mentioned? According to the results of our content analysis, information from the current literature on the aims of PLS can be divided into six categories which we labeled 'Accessibility', 'Understanding', 'Knowledge', 'Empowerment', 'Communication of

Research' and 'Improvement of Research'. See below for the description of each category and example quotes from text extractions.

Aim Category: Accessibility. This category comprises PLS aims that are geared towards providing laypersons with low-threshold information about research that is easy to find, highly visible, freely accessible, attractive and appealing to laypersons in general or specific non-experts such as for teacher training [29]. This also includes the technical accessibility of the file [30].

- Example Text Excerpt: "A key aspect of improving access to knowledge is to ensure not only that the content of the resource is appropriate but also that the format in which it is presented is fit for purpose." [13, p. 2]

Aim Category: Understanding. This category comprises PLS aims that are geared towards providing laypersons with information about research (including research questions, methods and results) that is understandable.

- Example text excerpt: "PLS help to make scientific research understandable [...] by describing complex research using nontechnical language that can be easily understood" [8, p. 2]

Aim Category: Knowledge. This category comprises PLS aims that are geared towards increasing laypersons' knowledge about specific subjects based on scientific evidence.

- Example text excerpt: "[...] evidence summaries are [...] instrumental resources for translating research to inform knowledge" [31, p. 93]

Aim Category: Empowerment. This category comprises PLS aims that are geared towards enabling laypersons to make informed, self-determined decisions and to foster public participation in decision processes.

- Example text excerpt: "Making it more likely that the findings of the research will be used to make a difference to service users' lives." [22, p. 2]

Aim Category: Communication of Research. This category comprises PLS aims that are geared towards enhancing the communication and dissemination of research by addressing a broad audience. Thereby, the trust in and impact of science on daily as well as political decisions and actions is thought to increase. For example, Phung et al. [32] stresses the interaction of different audiences, and Wada et al. [33] name the PLS as a tool to communicate with project funders.

- Example text excerpt: "The PLS is considered a main building block for dissemination of the review to the end-users of health information." [34, p. 3]

Aim Category: Improvement of Research. This category comprises PLS aims that are geared towards making a contribution to the improvement of research practice in itself, e.g. through increased transparency, exactness and improvement of writing style as well as through higher engagement in discussions regarding the relevance of research. Furthermore, PLS are thought to facilitate interdisciplinary communication. They are named, for example, to strengthen public support for the research enterprise [35], enhancing transparency and as an opportunity for science to engage in the media ecosystem [23].

- Example text excerpt: "And plain-language summaries can also be useful to authors when, for example, they need to explain their work in non-technical terms when applying for a fellowship or faculty position." [36, p. 1]

It must be noted that the first four aim categories are dependent on each other, however they present distinct aims: In order to empower laypersons to make informed decisions based on scientific findings (Empowerment category), laypersons need to have evidence-based knowledge (Knowledge category), which in turn is only possible if they understand the information about the evidence (Understanding category). For that, the base requirement is that the information is accessible (Accessibility category). Further, aims of the Communication of Research category represent ideal aims, often pictured as a bridge over the

gap between academia and the public, while aims of the Improvement of Research category include effects that these actions have on research itself. These effects are measurable irrespective of a (subjective) PLS reception.

Characteristics of PLS

We further reviewed the literature on PLS with regard to the question: What kind of PLS characteristics are mentioned? According to the results of our content analysis, characteristics of PLS can be organized into six categories which we labeled 'Linguistic Attributes', 'Formal Attributes', 'General Content', 'Presentation of Results', 'Presentation of Quality of Evidence' and 'Contextual Attributes'. See below for the description of each category and example quotes from text extractions.

Characteristic Category: Linguistic Attributes. This category comprises PLS characteristics that encompass the tone or style of the used language, the choice of words (e.g., handling of jargon and technical terms), or the text difficulty.

- Example text excerpt: "Plain languages summaries [...] often do not follow Cochrane writing standards [...], and are thus diverse in style, words usage, and possibly in literacy requirements." [37, p. 2]

Characteristic Category: Formal Attributes. This category comprises PLS characteristics on the formal level, such as word limits, standardized formulations, prespecified headlines, or inclusion of graphs or tables. This also includes whether a PLS follows a formal structure, e.g., characterized by the use of headlines and subheadlines or paragraphs.

- Example text excerpt: "Plain language summaries (...) have different word counts depending on the journal." [38, p. 2]

Characteristic Category: General Content. This category comprises PLS characteristics that concern a PLS' content, e.g. whether background information or key messages are

included, and the alignment of contents, e.g. a prespecified alignment of introduction, description of methods, results and conclusions.

- Example text excerpt: "The text should provide answers to the essential questions: Who, What, Where, When, Why, How? For example, the reader should easily be able to find answers to questions such as 'By whom was the research funded, and why?'" [22, p. 5]

Characteristic Category: Presentation of Results. This category comprises PLS characteristics that strike the presentation of results in a PLS, e.g., whether an effect size is mentioned, or the way statistical terms are handled.

- Example text excerpt: "Cochrane's Plain Language Expectations for Authors of Cochrane Summaries (PLEACS) standards recommend that it is not essential to provide numerical information in PLSs, but if there are numbers presented, the presentation should be consistent, comprehensive to the lay population in terms of absolute effects, and framed as natural frequencies [...]." [9, p. 2]

Characteristic Category: Presentation of Quality of Evidence. This category comprises PLS characteristics that strike the presentation of the quality of evidence in a PLS, e.g. whether GRADE-system (Grading of Recommendations, Assessment, Development and Evaluation) results, or authors' conflicts of interest are reported.

- Example text excerpt: "For example, in current plain language summaries authors use a variety of words to express the strength of the evidence and the magnitude of the effect of the interventions." [16, p. 495]

Characteristic Category: Contextual Attributes. This category comprises PLS characteristics regarding the general context of the PLS, e.g., the specific process of drafting, production or publication. These include information on the review process, on technical accessibility and target group.

- Example text excerpt: "Approaches [...] include [...] paying specific attention to the PLS as part of the editorial process, and/or moving the responsibility of writing the PLS to dedicated writers." [39, p. 2]

Criteria of PLS

PLS differ in the specific value of the aforementioned characteristics. We extracted information on PLS criteria to answer the following question: What information could be found on what makes a high-quality PLS as well as on what makes a PLS different from other types of research summaries? More precisely, what values (in terms of expressions or degrees) of the aforementioned characteristics are explicitly named or investigated in the literature on PLS? What values of these characteristics are found or supposed to constitute a high-quality PLS?

We found most information about criteria in guidelines or guideline development descriptions. There were also some empirical studies in which criteria were investigated. Less often, criteria were named in opinion pieces. To give an overview of the current empirical evidence and expert opinion regarding the 'ideal' value of a PLS characteristic, we matched the criteria extracted from the articles to the respectively fitting characteristic category.

Most criteria referred to characteristics of the Linguistic Attributes category [3,6,12,14,17–22,24,31,37,40–60]. For example, in some articles, it was recommended to use active rather than passive voice [14,22,57], and some articles made more or less specific recommendations regarding the use of jargon: avoid jargon [49,54,59,60]; use only 2% jargon in the whole text [6]; use only short words or sentences, avoid polysyllabic words or acronyms [17,43,48]; avoid technical terms [53,60]; avoid potentially misunderstood words [17] or define terms if necessary [19,53].

Further, there were many criteria that we matched to characteristics of the Formal Attributes category [14–21,24,26,36,40,44–46,48,49,51,55–57,59,61–65]. These included, for example, the exact word limit per PLS, reaching from 50 words [26] to 750 words [54], specific recommendations regarding headings (e.g., number main headings, but do not number subheadings [18]), or whether visual images should be used or not [17,20,48].

Other often named criteria referred to characteristics of the General Content category [14,17–20,22,24–26,36,39,40,43,46–50,53,55–57,59,60,62,63,65–69]. For example, there were recommendations regarding the first sentence or paragraph of the PLS: e.g., the first sentence should summarize the purpose of the (clinical) trial [69]; the first sentence should make clear to the reader who the summary has been written for and why it has been written [18]; the first sentence should include something that most readers can relate to [53]. Furthermore, recommendations were made as to which information should be included in the PLS: e.g., provide answers to the essential questions: Who, What, Where, When, Why, How? [22]; outline three main elements: primary scientific question, what was learned, and why it matters [43] or what should be avoided (e.g., PLS authors should avoid promotional content [17]).

We further identified a range of criteria for characteristics that could be linked to the Presentation of Results category [3,16,17,19,20,24,39,42,44,45,48,51,53–58,64]. In some articles, it was stated that statistical significance should be clearly explained if required, whereas p-values, confidence intervals or standard deviations should be avoided [e.g., 19]; others made recommendations to report sensitivity, specificity, and prevalence in natural frequencies [64]; one article concluded from research with focus groups that numbers should be completely omitted [44]. It was also stated that outcome probabilities should be presented in multiple ways and with consistent denominators [20]. Other guidelines by Cochrane

included the rule that results of no more than seven outcomes should be reported in the PLS [e.g., 56].

Criteria that we were able to link to characteristics of the Presentation of Quality of Evidence category were only rarely mentioned in the investigated articles [20,56,57]. Brehaut et al. [20] specified that risk estimates in PLS needed to be reported with the corresponding level of evidence. Further, Cochrane guidelines specified that the overall quality of the evidence should be reported as well as any factors that might affect the confidence in the results (bias risks like conflicts of interest [56]).

Lastly, we found some criteria that referred to the characteristics of the Contextual Information category [8,14,17,19–21,24,39,42,47–49,51,55,60,61,65,68–70]: For example, there were specifications regarding PLS authorship [8,49,61,69], where or how the PLS is or should be published (e.g., open access publishing [see 8,61]), and whether or how closely the PLS should be based on the scientific abstract [59].

We found guidelines for writing PLS from a variety of specialist societies such as the American Psychological Association, APA [24], Cochrane [56,57,71] and the Campbell Collaboration [54] as well as from scientific journals directed at authors encouraged to provide PLS together with manuscript submissions [45,59,60]. We also identified guidelines that specifically refer to the clinical trials results summary regulation in the EU [17,50,58] as well as general guidance in writing PLS for scientific writers [21,22,53]. The criteria mentioned in all 14 guidelines are provided in S2 Table.

Outcomes of PLS

We also aimed to know what kind of outcomes (i.e., operationalizations of PLS aims) are applied in the PLS literature and matched the information we found on defined outcomes of PLS research to one of the aim categories. We analyzed the studies with regard to the

question: How were PLS investigated (i.e., which outcomes were included) and, consequently, how did the empirical outcomes investigated in these studies correspond with the aforementioned theoretical aims of PLS? In the following, outcomes that are investigated in the PLS literature and their link to theoretical aim categories are summarized.

Many outcomes could be linked to aims of the Accessibility category. In their empirical studies, researchers investigated, e.g., the readability of the text [6,12,14,18,19,25,37,41,44,72,73], participants' enjoyment or preference of such a text in general [9,10,38,74], participants' satisfaction with text length [12,19,65] or participants' judgement regarding the usability of the PLS [3,11,20,25,48,75]. In order to measure these outcomes, researchers, for example, computed readability indices, such as the Flesch reading ease score [14,37,41,73], or participants were asked whether they perceived the information they cared about to be easy to find [48].

We further identified a wide range of outcomes that were linked to aims of the Understanding and Knowledge category. Aims of the Understanding category were investigated by asking participants whether they would perceive the text as understandable and by asking them about their user experience [18–20,25,38,44,48,65,74]. A typical outcome was to ask how easy or difficult readers found it to read the summary [e.g., 12], which had to be answered on a Likert scale. We further observed outcomes that cover the objective knowledge gain (Knowledge category) [9–11,13,18,38,48,72,74,76]. To assess aims of the Knowledge category, researchers typically used multiple choice tests (e.g., "This research focuses on a) HIV, b) FIV, c) Influenca, d) I don't know" [38, p.6]) or open-ended questions that referred to the content of the PLS ("What is external cephalic version in breech position - how would you describe that term to a friend?" [74]). Yet other outcomes included whether participants were able to name the purpose of the summary [11], how they judged

the effectiveness of a treatment that was described in the PLS [9] or their judgement on the quality of evidence [11].

Even more specific were outcomes that we linked to aims of the Empowerment category [9,11,12,18,20,25,48,65]. Readers were, for example, asked whether they would use such PLS to make certain decisions (mostly investigated in the context of health care, [e.g., 48]) or they were asked how supported and prepared they felt to make certain decisions [e.g., 20] or to discuss the subject with others [12] after reading the PLS.

In the empirical studies that we found, aims of the Communication of Research category were only examined indirectly [3,11,12,18,25,38,44,48,65,76]. Readers were, for example, asked who they think the summary has been written for [18], how important or relevant they perceived the related study or research to be [44] or whether they shared or reused the PLS [65].

Even less empirical research on PLS included outcomes that related to the Improvement of Research category [41,44,48]. This category was somehow represented in outcomes focusing on the perceived usefulness of science for the public in general which were asked after reading the PLS [44]. One study examined the association between the inclusion of a PLS with trial quality [41].

Conceptual framework

The derived categories for aims and characteristics as well as their relations with outcomes and criteria are illustrated in Fig 3. This conceptual framework of our synthesis of the PLS literature depicts the four main subject areas of theory and research on PLS. It indicates the main categories of a PLS's ascribed aims and characteristics together with examples of the respective outcomes and criteria, which are operationalizations and specifications of the aforementioned. The finalistic approach, namely, to ask what a PLS is

for, determines what it is made of (ontological approach) and thereby, its characteristics. These characteristics are specified by certain criteria which determine what a PLS should be like (normative approach). The eligibility of such criteria is evaluated by analyzing their impact on certain outcomes in empirical studies, which, in turn, guide the development of adequate criteria. Outcomes constitute the operationalizations of aims in empirical studies (measurement-related approach), and thereby, the effect of a PLS on certain outcomes guides the decision as to its suitability with regard to certain prespecified aims.

Fig 3. Conceptual Framework of Aims, Characteristics, Criteria and Outcomes investigated in PLS Research.
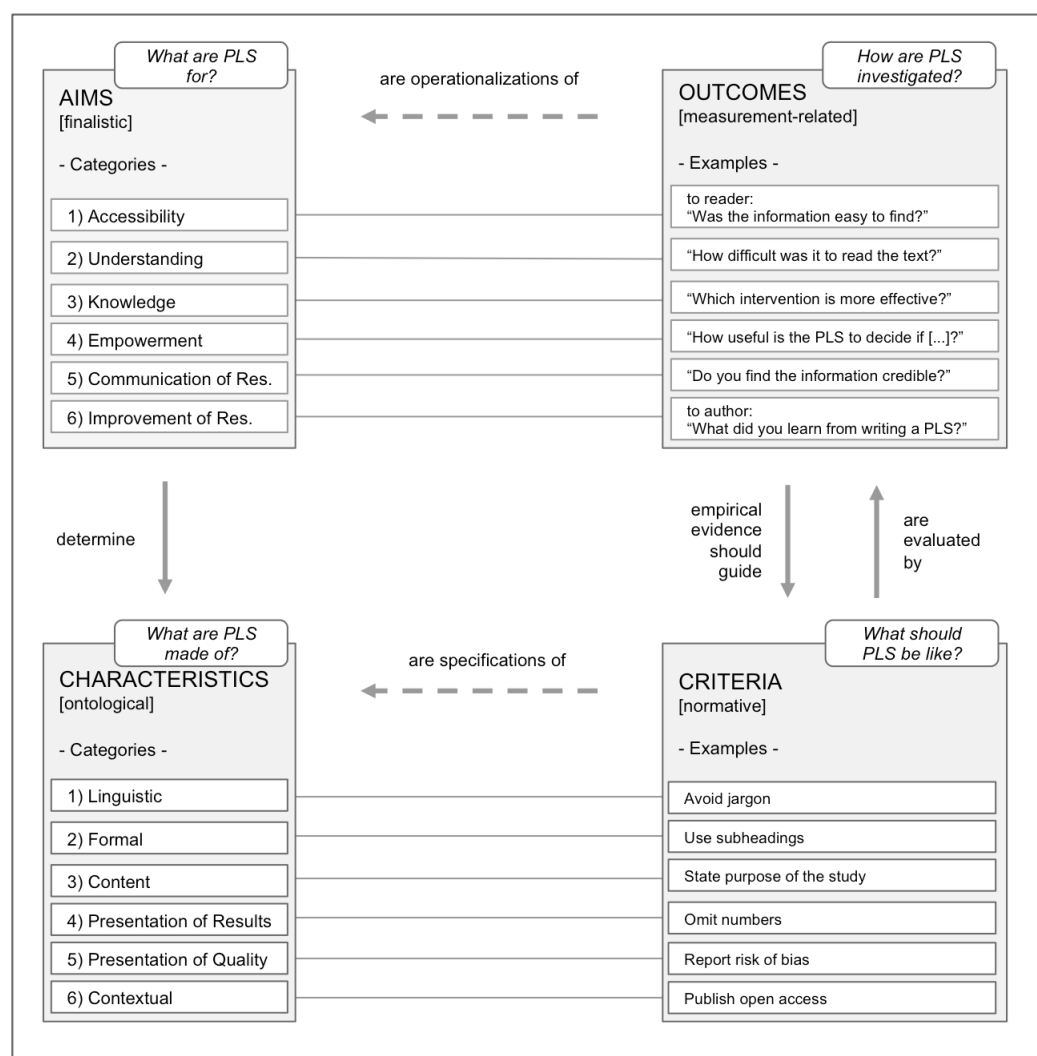
Empirical evidence on PLS

In this section, results of the 25 empirical articles on PLS are narratively summarized separated by study type. First, evaluative articles and articles in which one type of PLS was compared to other summary formats are briefly summed up. Second, empirical articles that compare different forms of PLS are described in more detail, matching investigated criteria with characteristic categories and investigated outcomes with aim categories.

Empirical articles that evaluated one type of PLS

We identified nine empirical articles on PLS that evaluated how readers reacted to a certain PLS, e.g., by focusing on user experience. Researchers evaluated Cochrane PLS that address common health issues [10,39], summaries of studies from the Newcastle Cognitive Function after Stroke cohort [44], consumer summaries of Cochrane Musculoskeletal Reviews [20], lay summaries on how package sizes affect the consumption of food, alcohol, and tobacco [25], lay summaries on open access journal articles [3], PLS of clinical trials [18,77] and PLS posted as 'eLife digests' [53].

Empirical articles that compared one type of PLS to other summary formats

Nine other empirical articles aimed to investigate the format of a PLS in general by comparing participants' responses after having read a PLS to (the same or other) participants' responses after having read another type of scientific text summary. PLS were compared to scientific abstracts [6,37,73,74,76], infographics [74] or graphical abstracts [38], blogposts [48,78], blogshots [10], podcasts [76], transcribed podcasts [76], Wikipedia articles [48], video abstracts [38], press releases [37], and systematic reviews with and without summary of findings tables [72]. There were statistically significant indications for the superiority of blogshots over PLS and Wikipedia articles with regard to the ease of use, user preference and

aesthetical judgement [48]; of videos and PLS over graphical abstracts and scientific abstracts with regard to comprehension, a feeling of understanding and a feeling of enjoyment [38]; of PLS over systematic reviews with and without summary of findings tables with regard to clarity and accessibility of information [72]; of infographics over PLS with regard to reading experience and user-friendliness, but not on knowledge [74]. Furthermore, scientific abstracts were found to be less readable [73] and to contain more jargon [6] than PLS, but at the same time, the amount of jargon in PLS was higher than recommendations for public understanding stipulate [6].

Empirical Articles that compared different forms of PLS

We identified seven empirical articles that investigated specific criteria of PLS by analyzing which criteria have an effect on defined outcomes. There were two qualitative studies that compared different PLS versions and asked readers about their experiences, and five quantitative studies that investigated how different PLS versions affected readers' response patterns (e.g., in knowledge tests). We linked the criteria investigated in these studies to their respective characteristic category and the outcomes investigated in these studies to the respective aim category (Fig 3).

Qualitative studies. Ellen et al. [79] investigated feedback of 18 Canadian health system managers and policy makers about PLS of systematic reviews. In their study, they presented three different PLS to each participant and conducted semi-structured interviews. They found that participants preferred structured text (bullet points, tables) with up-front key messages, including details on background, methods and applicability. Also, participants preferred evidence quality ratings (according to the GRADE method) in the summaries. They rather disliked text blocks, unstructured texts and summaries with less background information. Ellen et al. [79] also note that participants preferred a longer, structured PLS format over a shorter, unstructured format, suggesting that readers did not mind longer

documents as long as they were well structured and could be easily scanned. The characteristic categories that were addressed in this study hence were Formal Attributes, General Content, and Presentation of Quality of Evidence.

Glenton et al. [66] developed three different versions of a PLS and conducted semi-structured interviews with 34 members of the public in Norway, Argentina, Canada and Australia. Thereafter, a modified version of a PLS was developed and retested to produce a final version. The preliminary three different versions of the PLS differed in their presentation of results: one version using qualitative statements only, a second version using both qualitative statements and numbers, and a third version using qualitative statements and additionally numbers and symbols in a table. The authors found that most participants preferred the third version. The results of this study showed that participants had problems interpreting effect sizes, confidence intervals and continuous outcomes. The concepts of effect size, intervention effect and evidence quality seemed challenging to understand, along with the difference between a systematic review and an individual study. Partially, the research group was able to improve understanding by adding symbols with explanations for evidence quality and by rephrasing the introduction text with regard to the concept of a systematic review. The characteristic categories that were analyzed in this study were thus Formal Attributes, General Content, Presentation of Results and Presentation of Quality of Evidence.

Quantitative studies. In the following studies, criteria of PLS were systematically varied and quantitatively compared with regard to different defined outcomes. The experimental conditions, outcomes and results with the respective characteristics and aim categories are summarized in Table 1 (see S3 Table for a more detailed version).

Table 1. Quantitative Studies Comparing PLS vs. PLS: Criteria, Outcomes and Results.

Study (Sample Size)	Criteria	Outcome	Results
Santesso et al. (2015) ($n = 143$)	new format vs. current format	knowledge test; comprehension test; usability survey; preference	new > current for all outcomes except comprehension test
Silvagnoli et al. (2020) ($n = 167$)	readability level: low vs. medium vs. high	preference	medium > low; medium > high
Alderdice et al. (2016) ($n = 813$)	conclusion vs. no conclusion; certain vs. uncertain findings	knowledge test	uncertain findings: conclusion > no conclusion certain findings: no sign. effect
Buljan et al. (2020, BMC Med Res Method.), Trial 1 ($n = 91$)	positive framing vs. negative framing	knowledge test, usage of the described treatment; comprehension test	no differences
Buljan et al. (2020, BMC Med Res Method.), Trial 2 ($n = 245$)	natural frequencies vs. percentages	comprehension test; preference; knowledge test	no differences
Kirkpatrick et al. (2017) ($n = 60$)	original PLS vs. PLS rewritten by author vs. PLS rewritten by writer	understanding survey; reading ease	both rewritten versions > original in reading ease; no further sign. effects

Note. Only experimental conditions that investigate PLS criteria against each other are listed; further comparisons (e.g., with other summary formats) are not listed.

Santesso et al. [11] compared a new format of a PLS for Cochrane Reviews against the format that was current at the time of their study. The new format was more structured and results were presented not only qualitatively, but also quantitatively. The criteria that were tested in their experiment were the differences between the new format and the current format. They cover characteristics of the Formal Attributes, Presentation of Results and Presentation of Quality of Evidence categories. The investigated outcomes cover aims of the

Accessibility, Understanding and Knowledge categories: Participants who read the new format performed better in the knowledge-related outcomes and, overall, judged the new format more accessible, while comprehension of the purpose of the summary was low, with no statistical difference between the two formats [11].

Silvagnoli et al. [12] investigated how the complexity of PLS affected the readers' preference for the text format, thereby testing an aim of the Accessibility category. The criteria that were tested in this experiment were three different complexity levels of PLS in terms of readability scores (a Linguistic Attribute characteristic). The results showed that medium-level PLS with a readability that corresponds to a reading age of 14-17 years were preferred most, compared to low-level and high-level complexity PLS [12].

Alderdice et al. [13] investigated PLS of Cochrane Reviews with uncertain findings and certain findings and compared a PLS format with a conclusion to a PLS format without a conclusion (General Content category). The outcome was a multiple choice test that can be linked to aims of the Knowledge category. Only in PLS with uncertain findings, there was a statistically significant difference: Participants who read the uncertain PLS without conclusion performed worse than participants who read the uncertain PLS with conclusion [13].

Buljan et al. [9] conducted two trials that investigated the framing of numerical findings of Cochrane Review PLS. In trial 1, they varied whether results in the PLS were positively framed or negatively framed and in trial 2, they varied whether trial effectiveness and side effects were presented as natural frequencies or percentage scores. Thus, both trials investigated criteria that can be linked to characteristics of the Presentation of Results category. Outcomes in this study were operationalizations of aims of the Knowledge and Empowerment categories. There were no differences on those outcomes between the experimental groups in either trial [9].

Kirkpatrick et al. [14] compared two strategies to improve the quality of PLS in the National Institute for Health Research (NIHR) journals. They compared original PLS to PLS that were rewritten either by the author of the original scientific publication or by an independent professional writer, both with the help of a guideline. These experimental conditions represent characteristics of the Contextual Information category. The outcomes in this study were perceived ease of understanding (Understanding category) and reading ease (Accessibility category). The results showed that there was no statistically significant difference in terms of ease of understanding, and that both rewritten versions were significantly easier to read than the original [14].

Summing up the empirical evidence on comparison of different PLS, we note that an effect of specific criteria on outcomes was found in the following cases: PLS are more accessible if they are written on a medium text level [12], and if they are rewritten with the help of a guideline by either the same or an independent writer [14]. PLS impart more knowledge if they are presented with a conclusion than without a conclusion—but only if the study has uncertain findings [13]. PLS are preferred and impart more knowledge if they are presented in a more structured format [11], and participants state that they like PLS better that are structured, use quality ratings and give enough background information [79] as well as PLS that provide results with qualitative statements that are accompanied by numbers and symbols in tables [66].

No statistically significant effects of criteria were found in the following cases: There were no statistically significant differences found in the perceived accessibility between PLS that were rewritten by the scientific author versus rewritten by an independent writer [14] or in the ease of understanding between the original PLS and the rewritten version [14]. There were furthermore no statistically significant effects on understanding and knowledge outcomes between PLS in a general new format versus a current format [11]; on knowledge

outcomes between PLS that had a conclusion and those that had no conclusion in cases where findings of the study were certain [13]; between positive versus negative framing of results as well as between reporting results as percentages versus natural frequencies [9].

Interestingly, most of the studies we found investigated their research questions with samples that were not representative for the general public. Furthermore, sample sizes, overall, were comparably small: Four of the quantitative studies investigated samples between $n = 60$ and 245 [9,11,12,14]. One exception is Alderdice et al.'s [13] study with a sample of $n = 813$ [13]. In quantitative and qualitative studies, participants in these samples were often highly educated [12], students [9,13], or very selective, like, for example, public reviewers for a studies center [14] or health care managers and policy makers [79]. Only two studies used samples with members of the (general) public and patients that came from five different nations [11,66].

Empirical foundation of guideline criteria

Comparing the empirical evidence on the effectiveness of PLS criteria with criteria that are mentioned in guidelines (S2 Table, S3 Table), it becomes clear that the empirically investigated criteria only cover a fraction of the entirety of criteria that are mentioned in guidelines. In the Cochrane guidelines on how to write a PLS of a Cochrane intervention review [71], it is argued that these guidelines are built on empirical studies, two of which are also included in this review [11,66]. Due to these studies' holistic approach—testing the whole format rather than single criteria—these studies provide a solid empirical basis for the Cochrane guidelines. However, this approach makes it difficult to deduce the effectiveness of single criteria and to generalize the results to other guidelines. The guideline of the Campbell Collaboration refers to Cochrane and its empirical rationale [54], while the Summary of Clinical Trial Results for Laypersons-guideline is based on general health literacy principles [17]. Other guidelines that we found refer to this document of the EU expert group and

provide no further rationale [50,58]. Duke's [22] guideline is presented as a synthesis of various other guidelines and advice for writing PLS. However, in the six other guidelines for writing a PLS that we examined, we did not find any (empirical) rationale for the choice of criteria. We conclude that guidelines only rarely provide any empirical rationale for their choice of criteria.

Discussion

The aim of this review was twofold: First, we intended to develop a conceptual framework of the PLS subject in the scientific literature, and second, we aimed to synthesize empirical evidence on PLS by integrating it into the conceptual framework.

To develop a comprehensive conceptual framework, we took into account different approaches that complement each other. Applying a finalistic approach, we scrutinized the aims or purposes of PLS reported in the literature. We found that aims can be classified into the categories Accessibility, Understanding, Knowledge, Empowerment, Communication of Research and Improvement of Research. This classification of aims resembles Nutbeam's [80] prominent classification of health literacy levels. This is particularly noteworthy as the majority of articles about PLS that were included in our review stem from medical or public health journals. It is therefore sensible to keep in mind that the PLS literature has a strong focus on PLS of medical research, with the aim to increase health literacy. According to Nutbeam, health literacy can be classified into three progressive ability levels: The first level, 'functional health literacy' refers to the ability to understand health information and to have sufficient knowledge about health risks and the health system. This first necessary level is reflected in our PLS aim categories Accessibility, Understanding and Knowledge. The second level from Nutbeam's model is called 'interactive' or 'communicative' health literacy. In addition to the abilities required in the first level, the second level refers to the ability to

actively communicate about a health topic and derive meaning from health information as well as have the necessary social skills to discuss it with others. This second level is reflected in our PLS aim category Communication of Research. Nutbeam's third level, 'critical health literacy' refers to the ability to critically appraise health information and consequently, have more control over health decisions. This third level is reflected in the PLS aim category 'Empowerment'. There are further similarities between our PLS aim categories and theoretical models that describe product user experience. For example, Morville's honeycomb of user experience includes product findability, accessibility, usability, usefulness, credibility, desirability, and value [81]. Another model for user design is that of Buchanan [82], who stresses the three factors usability, usefulness and desirability [as cited in 75]. These models of user experience have already been applied to the particular use in evidence summaries by Rosenbaum [75], who emphasizes the importance of 'understandability' in this context. By taking these theoretical considerations together, we conclude that if a PLS's purpose is to reach a wider audience for scientific findings, it may not only be important to consider whether it is accessible for this audience at all, but also to take into account the question of *why* we might want to reach a wider audience for scientific findings. Is it because scientists simply want readers to understand what they are doing? Or do they even want to enable them to make certain decisions? Carefully considering such questions and reflecting on the aims PLS are supposed to achieve, ideally, could lead to even more target-oriented research on PLS, which finally improves the development of practical guidelines.

Taking the ontological approach, we strived to evaluate what PLS are constituted of. We found that characteristics which are discussed and evaluated in the current literature can be classified into the categories Linguistics Attributes, Formal Attributes, General Content, Presentation of Results, Presentation of Quality of Evidence and Contextual Attributes.

Building upon these categories, we, subsequently, pursued a normative approach to evaluate what a PLS should look like, i.e., PLS criteria that specify 'values' for certain characteristics that belong to those categories. PLS criteria were mostly related to the characteristics of the Linguistic Attributes, General Content and Formal Structure categories. Some criteria were used to *define* a PLS: in this case, they were meant to distinguish a PLS from a text that is not defined as a PLS (e.g., a PLS is a summary of a study that does not use jargon, while a scientific abstract is a summary of a study that does use jargon [21]). Other criteria were used as indicators for the *quality* of a PLS: these criteria were supposed to distinguish a good or serviceable PLS from a rather unhelpful PLS (e.g., not "dumbing down the research" [46, p. 5]). While criteria that we linked to characteristics of the Linguistic Attributes category were similar across articles (e.g., avoid jargon and use short sentences [14,21,53,57]), we observed a considerable diversity in those criteria that we linked to characteristics of the Presentation of Results category (e.g., report statistics if meaningful for the target group and/or report statistics in natural frequencies [20,48,64], vs. omit any numbers from the PLS [44,45]). Other criteria were highly specific based on the evidence they reported on. For example, the Cochrane guideline for PLS states that quality of evidence should be reported based on the GRADE-approach [56]. This is because the scientific publications that Cochrane PLS refer to—systematic reviews and meta-analyses—are all required to report the quality of evidence based on GRADE. Thus, this criterion makes sense for PLS of original publications that make use of GRADE, but it is of less significance for other PLS.

Lastly, taking a measurement-related approach, we asked which outcomes are investigated to evaluate PLS. Outcomes in empirical studies on PLS mostly related aims of the Accessibility, Understanding and Knowledge categories. Considering all investigated outcomes, we found that the effects of PLS were mostly investigated in terms of user experience, i.e. how accessible or understandable PLS are (perceived to be), and with regard

to knowledge gains. Thus, we conclude that the aims of the Accessibility, Understanding and Knowledge categories are well represented in empirical investigations of PLS. However, whether a PLS is accessible and whether readers understand and gain knowledge from it is closely intertwined, and a differentiated operationalization of these outcomes seems challenging. Furthermore, although aims of the Communication of Research as well as Improvement of Research categories were often named in theoretical articles, the effectiveness of PLS regarding these aims was scarcely investigated in empirical studies.

It is hardly surprising that regarding the characteristics, criteria and outcomes, there are much less theoretical linking points to be identified than to the aims. These three last components of our framework can be considered as tangible consequences of the (theoretical) aims that are somehow put into practice: The stipulated aims of a PLS determine its characteristics (what is it?), the standards that are applied (how should it be?), and what will be measured (what can it actually achieve?). In the end, all revert to the primordial aims that ultimately lead to composing a PLS: Characteristics form the mere basis for deriving specific values, the criteria, to reach desired outcomes which are mere operationalization of these aims. Therefore, we conclude that the theoretical basis of PLS to a very large extent can be attributed to considerations of its various aims and purposes.

Against the background of the conceptual framework, we investigated the empirical evidence on PLS. We found seven studies that investigated PLS criteria by either comparing two different PLS formats or by varying specific criteria within the same PLS format. In these studies, effects were observed on outcomes that can be linked to aims of the Accessibility and Knowledge categories. Here, medium text level and guideline-based PLS were perceived more accessible [12]. Furthermore, participants preferred such PLS that were structured, that provided background information and qualitative statements on results which were accompanied by numbers and symbols as well as an evidence quality rating [66,79].

With regard to other outcomes measuring Accessibility, Understanding or Knowledge, however, no statistically significant differences were observed. Changes in the formal structure of PLS only had a significant impact on knowledge if findings were uncertain, but not if findings were certain [13].

In the empirical studies that were included in our review, we did not find outcomes that could be linked to our theoretically proposed aim categories Communication of Research and Improvement of Research. This means that, although these aims were named in various theoretical articles dealing with the subject of PLS, they do not seem to have been empirically evaluated so far. The criteria we found in the theoretical and empirical articles, though, did resemble all proposed characteristic categories. However, they were highly heterogeneous and only rarely empirically investigated.

We further observed that some criteria were listed in guidelines very frequently, whereas to our knowledge, they had not been empirically evaluated. For example, most guidelines state that PLS should be written without jargon [17,49,53,54,57–60]. However, we found no studies that have experimentally varied the use of jargon specifically in PLS to investigate whether its use affects how laypersons perceive PLS. For example, it may be worth considering that a PLS which uses jargon while simultaneously providing explanations for such technical terms, e.g. by adding a glossary, might be easier to read and understand than a PLS in which jargon is replaced by lengthy periphrases.

Furthermore, there are conflicting criteria, e.g., some guidelines recommend to omit numbers completely [e.g., 24] while others stress the importance of communicating specific numbers [e.g., 56,57,71], such as risk ratios. These conflicting criteria might result from disciplinary differences or different aims and priorities concerning the PLS (e.g., accuracy vs. plainness). Another important finding is that empirical research on PLS was mostly conducted using small samples of highly educated participants. Of course, when PLS are

investigated, the required sample characteristics depend on the target audience. Since PLS are meant to communicate science in a way that laypersons can understand, it seems advisable to investigate an (approximately) representative sample of the population the PLS is directed at. To put this more bluntly: if the specific target group of a PLS are researchers from other domains, practitioners, stakeholders or other groups, whose members can be reasonably expected to be actually highly educated, investigating characteristics or the efficacy of this PLS in highly educated samples might be fully justified and even desirable. If this is, however, not the case (e.g., if one wants to reach to the public in general), investigating this PLS in highly educated samples imposes a significant threat on the external validity of the corresponding study. Researchers and providing agencies, therefore, should clearly define and communicate their specific audience and take this adequately into account when evaluating these PLS.

Strengths and limitations of the review

This review has some limitations as well as considerable strengths. The fundamental value of this review, at first, lies in its significant theoretical contribution: the proposed conceptual framework which is based on the exhaustive body of scientific literature on PLS, and which includes four basic approaches to comprehensively describe the research field. This framework can be used to design future studies on the effects of PLS on defined outcomes as well as help develop meaningful PLS guidelines. Second, this is, to our knowledge, the first attempt to map, summarize and discuss the entire current empirical evidence on PLS research. Although a comprehensive statement on the empirical evidence of specific PLS criteria is not (yet) possible, we were able to identify important questions and challenges that may contribute to future research on PLS and, thus, to the improvement of science communication as a whole. Finally, our twofold approach, developing a conceptual

framework and reviewing the empirical evidence on PLS, made it possible to integrate the latter into the first, putting single empirical findings on certain criteria into a broader explanatory context.

However, there are two main limitations for this study's evidence contribution. First, there is not yet broad consensus about the term 'Plain Language Summary'. Thus, we cannot fully rule out that there might be literature on lay summary formats that we missed in our search due to the fact that we did not know the respective term that was used (even though we made best attempts to be as thorough as possible in our systematic review). Second, there was high heterogeneity with regard to outcome (measures) in the empirical articles we found. Thus, we were not able to perform a meta-analysis or to combine the empirical results of the studies statistically.

Conclusions and future research recommendations

Considerable work has been done to establish lay-friendly summary formats that not only communicate scientific findings to laypeople but also simultaneously aim to retain as much scientific rigor and accuracy as possible. Our conceptual framework delineates four main approaches related to aims, characteristics, criteria and outcomes of PLS to describe the theoretical and empirical research on PLS, and reveals how they are intertwined in a meaningful way. It thereby constitutes a fertile ground for theory advancement on science communication tools, for hypothesis formulation and testing in empirical studies on PLS, and for writing guideline development. Our findings suggest that in the theoretical as well as the empirical literature, aims of PLS are clearly named and considerably correspond across articles. What's more, there already exists a significant number of valuable and useful guidelines on writing PLS. Also, empirical evaluations of (different types and formats of) PLS with varying criteria on different outcomes have been conducted in several studies.

However, their number is relatively low compared to the amount of theoretical literature which meticulously outlines the aims and specific characteristics of PLS. Consequently, we also observed a lack of empirically evaluated criteria in guidelines and the outcomes in empirical studies that we found did not represent all categories of aims that we extracted from the theoretical literature. Here, specifically, we recognized a lack of studies that investigated whether PLS improve research (practices) and whether the communication of research has improved. However, we admit that these aims might be challenging to discuss and to evaluate empirically. A major implication of our findings is the need for samples in empirical research on PLS which are approximately representative for the respective target group. Future studies on PLS should therefore consider their target audience and recruit their samples accordingly. More (ideally, randomized controlled) studies that investigate the effects of single criteria on specific outcomes are also needed. Afterwards, fully empirically supported recommendations on how to write PLS can be formulated. Such recommendations may complement current guidelines which at least partly still lack empirical foundation, as well as form the basis for the development of new guidelines which may be directed at a specific target group or deal with PLS from a certain discipline. Altogether, we believe our review to constitute a suitable starting point both for advancing theory on PLS and for designing and conducting empirical studies on the subject. It is our sincere hope that, in the end, these efforts serve such aims that are meaningful for individuals as well as for society as a whole.

Acknowledgments

References

1.   ALLEA. The European Code of Conduct for Research Integrity Revised Edition [Internet]. ALLEA - All European Academies; 2017 [cited 2021 Feb 18]. Available from: http://www.allea.org/wp-content/uploads/2017/03/ALLEA-European-Code-of-Conduct-for-Research-Integrity-2017-1.pdf

2.   World Medical Association. WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects [Internet]. 2013 [cited 2021 Feb 18]. Available from: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/

3.   Nunn E, Pinfield S. Lay summaries of open access journal articles: engaging with the general public on medical research. Learn Publ. 2014;27(3):173–84.

4.   Retzer V, Jurasinski G. Towards objectivity in research evaluation using bibliometric indicators – A protocol for incorporating complexity. Basic Appl Ecol. 2009;10(5):393–400.

5.   Fanelli D. Do Pressures to Publish Increase Scientists' Bias? An Empirical Support from US States Data. PloS One. 2010;5(4):e10271.

6.   Rakedzon T, Segev E, Chapnik N, Yosef R, Baram-Tsabari A. Automatic jargon identifier for scientists engaging with the public and science communication educators. PloS One. 2017;12(8):e0181742.

7.   Brüggemann, Michael, Lörcher, Ines, Walter, Stefanie. Post-normal science communication: exploring the blurring boundaries of science and journalism. 2020;19(3):A02.

8.   FitzGibbon H, King K, Piano C, Wilk C, Gaskarth M. Where are biomedical research plain-language summaries? Health Sci Rep. 2020;3(3):e175.

9.   Buljan I, Tokalić R, Roguljić M, Zakarija-Grković I, Vrdoljak D, Milić P, et al. Framing the numerical findings of Cochrane plain language summaries: two randomized controlled trials. BMC Med Res Methodol. 2020;20:1–9.

10. Buljan I, Tokalić R, Roguljić M, Zakarija-Grković I, Vrdoljak D, Milić P, et al. Comparison of blogshots with plain language summaries of Cochrane systematic reviews: a qualitative study and randomized trial. Trials. 2020;21:1–10.

11. Santesso N, Rader T, Nilsen ES, Glenton C, Rosenbaum S, Ciapponi A, et al. A summary to communicate evidence from systematic reviews to the public improved understanding and accessibility of information: a randomized controlled trial. J Clin Epidemiol. 2015;68(2):182–90.

12. Silvagnoli LM, Gardner J, Shepherd C, Pritchett J. Evaluation of plain-language summaries (PLSs): Optimizing readability and format. Curr Med Res Opin. 2020;35(2, SI):36.

13. Alderdice F, McNeill J, Lasserson T, Beller E, Carroll M, Hundley V, et al. Do Cochrane summaries help student midwives understand the findings of Cochrane systematic reviews: the BRIEF randomised trial. Syst Rev. 2016;5(1).

14. Kirkpatrick E, Gaisford W, Williams E, Brindley E, Tembo D, Wright D. Understanding Plain English summaries. A comparison of two approaches to improve the quality of Plain English summaries in research reports. Res Involv Engagem. 2017;3(1):1–14.

15. Shailes S. Plain-language Summaries of Research: Something for everyone. ELIFE. 2017;6:e25411.

16. Santesso N, Glenton C, Lang B. Evidence that patients can understand and use? Z Für Evidenz Fortbild Qual Im Gesundheitswesen. 2008;102(8):493–6.

17. Europäische Kommission. Summary of clinical trial results for laypersons: Recommendations of the expert group on clinical trials for the implementation of regulation (EU) No 536/2014 on clinical trials on medicinal products for human use [Internet]. Available from: https://ec.europa.eu/health/sites/health/files/files/clinicaltrials/2016_06_pc_guidelines/gl_3_consult.pdf

18. Raynor DK, Myers L, Blackwell K, Kress B, Dubost A, Joos A. Clinical trial results summary for laypersons: a user testing study. Ther Innov Regul Sci. 2018;52(5):606–28.

19. Rees T, Richter CA, Dennis N, James J, Gokool N. Development of a framework for publishing patient lay summaries in medical journals. Curr Med Res Opin. 2017;33:24–24.

20. Brehaut JC, Santesso N, O'Connor AM, Lott A, Lindgaard G, Syrowatka A, et al. Presenting evidence to patients online: what do web users think of consumer summaries of cochrane musculoskeletal reviews? J Med Internet Res. 2011;13(1):e5.

21. Dubé CE, Lapane KL. Lay abstracts and summaries: Writing advice for scientists. J Cancer Educ. 2014;29(3):577–9.

22. Duke M. How to Write a Lay Summary [Internet]. Edinburgh: Digital Curation Centre; 2012 [cited 2020 Dec 3]. (DCC How-to Guides). Available from: https://www.dcc.ac.uk/guidance/how-guides/write-lay-summary

23. Kuehne LM, Olden JD. Opinion: Lay summaries needed to enhance science communication. Proc Natl Acad Sci U S A. 2015;112(12):3585–6.

24. American Psychological Association. Guidance for translational abstracts and public significance statements: Demonstrating the public significance of research [Internet]. American Psychological Association. 2018 [cited 2020 Dec 3]. Available from: https://www.apa.org/pubs/journals/resources/translational-messages

25. Busert LK, Mütsch M, Kien C, Flatz A, Griebler U, Wildner M, et al. Facilitating evidence uptake: Development and user testing of a systematic review summary format to inform public health decision-making in German-speaking countries. Health Res Policy Syst. 2018;16(1):59.

26. Mellalieu S. Editorial. J Appl Sport Psychol. 2018;30(1):1–2.

27. Translate Cochrane evidence [Internet]. Cochrane. 2021 [cited 2021 Apr 20]. Available from: https://www.cochrane.org/join-cochrane/translate

28. Mayring P. Qualitative content analysis: theoretical foundation, basic procedures and software solution [Internet]. Klagenfurt; 2014 [cited 2021 Jan 28]. Available from: http://nbn-resolving.de/urn:nbn:de:0168-ssoar-395173

29. Seidel T, Mok SY, Hetmanek A, Knogler M. Meta-Analysen zur Unterrichtsforschung und ihr Beitrag für die Realisierung eines Clearing House Unterricht für die Lehrerbildung [Meta-analyses on teaching effectiveness and their contribution to the realization of a Clearing House Unterricht for teacher education]. Z Für Bild. 2017;7(3):311–25.

30. Taylor K, Rego L, Weber T. Recommendations to improve the EU non-technical summaries of animal experiments. ALTEX. 2018;35(2):193–210.

31. Koufogiannakis D, Kloda L, Pretty HJ. A Big Step Forward: It's Time for a Database of Evidence Summaries in Library and Information Practice. Evid Based Libr Inf Pract. 2016;11(1):92.

32. Phung H, Choe A, Díez-Ortega M, Eguchi M, Holden D, Mendoza A, et al. The Multiʻōlelo Initiative for language research communication. 2020;

33. Wada M, Sixsmith J, Harwood G, Cosco TD, Fang ML, Sixsmith A. A protocol for co-creating research project lay summaries with stakeholders: Guideline development for Canada's AGE-WELL network. Res Involv Engagem. 2020;6:22.

34. Jelicic Kadic A, Fidahic M, Vujcic M, Saric F, Propadalo I, Marelja I, et al. Cochrane plain language summaries are highly heterogeneous with low adherence to the standards. BMC Med Res Methodol. 2016;16:61.

35. Kuehn BM. The value of a healthy relationship. eLife. 2017;6.

36. Rodgers P. Plain-language Summaries of Research: Writing for different readers. eLife. 2017;6:e25408.

37. Karačić J, Dondio P, Buljan I, Hren D, Marušić A. Languages for different health information readers: Multitrait-multimethod content analysis of Cochrane systematic reviews textual summary formats. BMC Med Res Methodol. 2019;19(1):552.

38. Bredbenner K, Simon SM. Video abstracts and plain language summaries are more effective than graphical abstracts and published abstracts. PloS One. 2019;14(11):e0224697.

39. Glenton C. Assessing the feasibility and acceptability of approaches for improving the quality of Plain Language Summaries in Cochrane Reviews: a pilot study. Final Report. [Internet]. Cochrane Norway, editor. 2017 [cited 2020 Dec 3]. Available from: http://community.cochrane.org/sites/default/files/uploads/inline-files/Final%20report%20PLS%20pilot%2028th%20February%202017_0.pdf

40. Langendam MW, Akl EA, Dahm P, Glasziou P, Guyatt G, Schünemann HJ. Assessing and presenting summaries of evidence in Cochrane Reviews. Syst Rev. 2013;2(1):81.

41. Carvalho FA, Elkins MR, Franco MR, Pinto RZ. Are plain-language summaries included in published reports of evidence about physiotherapy interventions? Analysis of 4421 randomised trials, systematic reviews and guidelines on the Physiotherapy Evidence Database (PEDro). Physiotherapy. 2019;105(3):354–61.

42. Kaslow NJ. Translating psychological science to the public. Am Psychol.

2015;70(5):361–71.

43. Hauck SA. Sharing Planetary Science in Plain Language. J Geophys Res Planets. 2019;124:2462–4.

44. Barnfield S, Pitts AC, Kalaria R, Allan L, Tullo E. "Is all the stuff about neurons necessary?" The development of lay summaries to disseminate findings from the Newcastle Cognitive Function after Stroke (COGFAST) study. Res Involv Engagem. 2017;3(1):18.

45. Maras, Katie. Autism Manuscript Submission Guidelines [Internet]. SAGE Journals. 2021 [cited 2020 Dec 18]. Available from: https://journals.sagepub.com/author-instructions/AUT#Lay%20Abstracts

46. Linte C. Communicating your research in lay language [Student's corner]. IEEE Eng Med Biol Mag. 2009;28(3):5–7.

47. Simmons LW. Editorial. Behav Ecol. 2012;24(1):1.

48. Anzinger H, Elliott SA, Hartling L. Comparative Usability Analysis and Parental Preferences of Three Web-Based Knowledge Translation Tools: Multimethod Study. J Med Internet Res. 2020;22(3):e14562.

49. Duke M. Lay Summaries for Research Articles: A Citizen Science Approach to Bridge the Gap in Access. In 2015 [cited 2020 Dec 3]. p. 1–7. Available from: http://ebooks.iospress.nl/publication/40876

50. TransCelerate Biopharma Inc. Recommendations for drafting non-promotional lay summaries of clinical trial results [Internet]. 2015 [cited 2020 Dec 3]. Available from: http://www.transceleratebiopharmainc.com/wp-content/uploads/2015/04/TransCelerate-Non-Promotional-Language-Guidelines-v10-1.pdf

51. Barnes A, Patrick S. Lay Summaries of Clinical Study Results: An Overview. Pharm Med. 2019;33(4):261–8.

52. King SR, Pewsey E, Shailes S. An inside guide to eLife digests. eLife. 2017;6.

53. eLife. Plain-language summaries: How to write an eLife digest [Internet]. Inside eLife. 2017 [cited 2020 Dec 21]. Available from: https://elifesciences.org/inside-elife/85518309/plain-language-summaries-how-to-write-an-elife-digest

54. The Steering Group of the Campbell Collaboration. How to write a plain language summary for a Campbell systematic review [Internet]. The Campbell Collaboration; 2016 [cited 2020 Dec 3]. Available from: https://core.ac.uk/download/pdf/52568807.pdf

55. Cochrane. Plain Language Summary (PLS) Project 2020-1 April 2020 [Internet]. 2020 [cited 2020 Dec 3]. Available from: https://community.cochrane.org/sites/default/files/uploads/Plain%20Language%20Summary%20Project%20FINAL.pdf

56. Cochrane Norway. How to write a plain language summary of a Cochrane intervention review: Checklist [Internet]. 2016 [cited 2020 Dec 3]. Available from: https://www.cochrane.no/sites/cochrane.no/files/public/uploads/checking_a_cochrane_pls_15th_june_2018.pdf

57. Cochrane Methods. Methodological Expectations of Cochrane Intervention Reviews (MECIR): Standards for the reporting of plain language summaries in new Cochrane Intervention Reviews 2013 [Internet]. 1st ed. 2013 [cited 2020 Dec 3]. Available from: https://methods.cochrane.org/sites/default/files/public/uploads/pleacs_2019.pdf

58. Lionbridge. Plain Language Summaries: Sieben Regeln für eine wirkungsvolle Kommunikation [Internet]. 2019 [cited 2020 Dec 21]. Available from: https://www.lionbridge.com/de/blog/life-sciences/plain-language-summaries/

59. People and Nature. Plain Language Summary Guidelines [Internet]. British Ecological Society Journals. [cited 2020 Dec 21]. Available from: https://besjournals.onlinelibrary.wiley.com/pb-assets/hub-assets/besjournals/2575-8314_PaN/People%20and%20Nature%20Plain%20Language%20Summary%20Guidelines-1540981909900.pdf

60. AGU. Creating a Plain Language Summary [Internet]. AGU Advancing Earth and Space Science. [cited 2020 Dec 21]. Available from: https://www.agu.org/-/media/Files/Share-and-Advocate-for-Science/Toolkit---PLS.pdf

61. Anstey A. Plain language summaries in the British Journal of Dermatology: Connecting with patients. Br J Dermatol. 2014;170(1):1–3.

62. Richter B. Perspektive eines Co-ordinating Editors einer Cochrane Reviewgruppe (zum zehnjährigen Bestehen des Freiburger Deutschen Cochrane Zentrums). Z Evidenz Fortbild Qual Im Gesundheitswesen. 2008;102(8):483–6.

63. Rader T, Pardo Pardo J, Stacey D, Ghogomu E, Maxwell LJ, Welch VA, et al. Update of strategies to translate evidence from cochrane musculoskeletal group systematic reviews for use by various audiences. J Rheumatol. 2014;41(2):206–15.

64. Whiting P, Leeflang M, de Salis I, Mustafa RA, Santesso N, Gopalakrishna G, et al. Guidance was developed on how to write a plain language summary for diagnostic test accuracy reviews. J Clin Epidemiol. 2018;103:112–9.

65. eLife. Plain-language Summaries: Results of the 2016 eLife digest reader survey [Internet]. Inside eLife. 2017 [cited 2020 Dec 21]. Available from: https://elifesciences.org/inside-elife/19c97b89/plain-language-summaries-results-of-the-2016-elife-digest-reader-survey

66. Glenton C, Santesso N, Rosenbaum S, Nilsen ES, Rader T, Ciapponi A, et al. Presenting the results of Cochrane Systematic Reviews to a consumer audience: A qualitative study. Med Decis Mak Int J Soc Med Decis Mak. 2010;30(5):566–77.

67. Green-Brown L, Wigington P. Plain Language Summaries: A New EHS-Net Tool to Share Our Published Findings. J Environ Health. 2012;75(2):30–1.

68. Brown PA, Harniss MK, Schomer KG, Feinberg M, Cullen NK, Johnson KL. Conducting systematic evidence reviews: Core concepts and lessons learned. Arch Phys Med Rehabil. 2012;93(8):S177-84.

69. Dear R, Barratt A, Askie L, McGeechan K, Arora S, Crossing S, et al. Adding value to clinical trial registries: Insights from Australian Cancer Trials Online, a website for consumers. Clin Trials. 2011;8(1):70–6.

70. Coomarasamy A, Gee H, Publicover M, Khan KS. Medical journals and effective dissemination of health research. Health Inf Libr J. 2001;18(4):183–91.

71. Cochrane Norway. How to write a plain language summary of a Cochrane intervention review [Internet]. 2019 [cited 2020 Dec 3]. Available from: https://www.cochrane.no/sites/cochrane.no/files/public/uploads/how_to_write_a_cochrane_pls_12th_february_2019.pdf

72. Opiyo N, Shepperd S, Musila N, Allen E, Nyamai R, Fretheim A, et al. Comparison of

alternative evidence summary and presentation formats in clinical guideline development: A mixed-method study. PloS One. 2013;8(1):e55067.

73. Stricker J, Chasiotis A, Kerwer M, Günther A. Scientific abstracts and plain language summaries in psychology: A comparison based on readability indices. PloS One. 2020;15(4):e0231160.

74. Buljan I, Malički M, Wager E, Puljak L, Hren D, Kellie F, et al. No difference in knowledge obtained from infographic or plain language summary of a Cochrane systematic review: Three randomized controlled trials. J Clin Epidemiol. 2018;97:86–94.

75. Rosenbaum S. Improving the user experience of evidence. A design approach to evidence-informed health care [Internet] [PhD Thesis]. The Oslo School of Architecture and Design; 2010. Available from: https://aho.brage.unit.no/aho-xmlui/bitstream/handle/11250/93062/Rosenbaum_thesis.pdf?sequence=1

76. Maguire LK, Clarke M. How much do you need: A randomised experiment of whether readers can understand the key messages from summaries of Cochrane Reviews without reading the full review. J R Soc Med. 2014;107(11):444–9.

77. Pushparajah DS, Manning E, Michels E, Arnaudeau-Bégard C. Value of Developing Plain Language Summaries of Scientific and Clinical Articles: A Survey of Patients and Physicians. Ther Innov Regul Sci. 2018;52(4):474–81.

78. Barbara A, Dobbins M, Haynes RB, Iorio A, Lavis JN, Levinson AJ. User experiences of the McMaster Optimal Aging Portal's evidence summaries and blog posts: Usability study. JMIR Hum Factors. 2016;3(2):e6208.

79. Ellen ME, Lavis JN, Wilson MG, Grimshaw J, Haynes RB, Ouimet M, et al. Health system decision makers' feedback on summaries and tools supporting the use of systematic reviews: A qualitative study. Evid Policy J Res Debate Pract. 2014;10(3):337–59.

80. Nutbeam D. Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. Health Promot Int. 2000;15(3):259–67.

81. Morville P. User Experience Design [Internet]. Semantic Studios. 2004 [cited 2021 Apr 20]. Available from: http://semanticstudios.com/user_experience_design/

82. Buchanan R. Wicked problems in design thinking. Des Issues. 1992;8(2):5–21.

Supporting Information

S1 Table. Studies included in this Review.

S2 Table. PLS Guidelines and Criteria.

S3 Table. Quantitative Studies Comparing PLS vs. PLS: Criteria, Outcomes and Results.

S1 File. Search Terms.

S1 Table. Studies included in this Review.

Authors	Year	Study Characteristic
Alderdice et al.	2016	Empirical
Anstey	2014	Theoretical
Anzinger et al.	2020	Empirical
American Psychological Association	2018	Guideline
Barnes & Patrick	2019	Theoretical
Barnfield et al.	2017	Empirical
Bredbenner & Simon	2019	Empirical
Brehaut et al.	2011	Empirical
Brown et al.	2012	Theoretical
Buljan et al.	2018	Empirical
Buljan et al. (BMC)	2020	Empirical
Buljan et al. (Trials)	2020	Empirical
Busert et al.	2018	Empirical
Carvalho et al.	2019	Theoretical
Glenton	2017	Empirical
Cochrane	2020	Theoretical
Cochrane Methods	2013	Guideline
Cochrane Norway	2019	Guideline
Cochrane Norway	2017	Guideline
Coomarasamy et al.	2001	Theoretical
Dear et al.	2011	Theoretical

Dubé & Lapane	2014	Guideline
Duke	2015	Theoretical
Duke	2012	Guideline
Ellen et al.	2014	Empirical
Expert group on clinical trials for the implementation of Regulation (EU) No 536/2014	2017	Guideline
FitzGibbon et al.	2020	Theoretical
"Autism" Manuscript Submission Guidelines	2020	Guideline
Glenton et al.	2010	Empirical
Green-Brown & Wigington	2012	Theoretical
Hauck	2019	Theoretical
Jelicic Kadic et al.	2016	Theoretical
Karačić et al.	2019	Empirical
Kaslow	2015	Theoretical
King et al.	2017	Theoretical
Kirkpatrick et al.	2017	Empirical
Koufogiannakis et al.	2016	Theoretical
Kuehn	2017	Theoretical
Kuehne & Olden	2015	Theoretical
Langendam et al.	2013	Theoretical
Linte	2009	Theoretical
Lionbridge	2019	Guideline
Barbara et al.	2016	Empirical
Maguire & Clarke	2014	Empirical
Mellalieu	2018	Theoretical

Nunn & Pinfield	2014	Empirical
Opiyo et al.	2013	Empirical
"People and Nature" PLS Guidelines	2020	Guideline
Phung et al.	2020	Theoretical
Pushparajah et al.	2018	Empirical
Rader et al.	2014	Theoretical
Rakedzon et al.	2017	Empirical
Raynor et al.	2018	Empirical
Rees et al.	2017	Guideline Development
Richter	2008	Theoretical
Rodgers	2017	Theoretical
Rosenbaum	2010	Theoretical
Santesso et al.	2008	Theoretical
Santesso et al.	2015	Empirical
Seidel et al.	2017	Theoretical
Shailes	2017	Theoretical
Silvagnoli et al.	2020	Empirical
Simmons	2012	Theoretical
Stricker et al.	2020	Empirical
Taylor et al.	2018	Theoretical
The Steering Group of the Campbell Collaboration	2016	Guideline
TransCelerate Biopharma Inc.	2015	Guideline
Wada et al.	2020	Theoretical
Whiting et al.	2018	Guideline Development

eLife: PLS: Results of reader survey	2017	Empirical
eLife: PLS: How to write an eLife digest	2017	Guideline
"AGU" Tips for Plain Language Summaries	2020	Guideline

S2 Table. PLS Guidelines and Criteria Guidelines.

Guideline	Linguistic Attributes	Formal Attributes	General Content	Presentation of Results	Presentation of Quality of Evidence	Contextual Information
American Psychological Association ("translational abstract"), psychological science	Tone: ▪ more personal and friendly than scientific abstract ▪ do not overstate / oversimplify findings or conclusions Words: - Sentences: -	Text Length: ▪ 150 - 200 words Text Structure: - Use of Tables/Visuals: -	Title: - Content structure: ▪ follow a pattern of introduction, method, results, discussion Headlines: - Content: ▪ consider your audience ▪ clearly describe investigated problem ▪ describe participants only insofar as relevant to the audience; details of the sample only if it is remarkable in some way ▪ detailed information about study methods may be summarized or omitted ▪ emphasize conclusions that are relevant for the audience ▪ try to create a "take home message"	state the findings in clear, nontechnical language remove any statistics if article contains more multiple studies, summarize contents of all studies	-	purpose of text: ▪ clear communication of article content ▪ emphasis on article's value to educated public/professional audiences author of PLS: - review of PLS: - access: - context: ▪ recommendation for PLS as standard feature of each APA journal article relation to scientific abstract: ▪ scientific abstract is the foundation for the translational abstract ▪ translational abstract complements (rather than replaces) the scientific abstract ▪ essential message should be the same in both abstracts
Cochrane 2013, standards for the reporting of PLS ("PLS"), Cochrane Intervention Reviews	Tone: - Words: ▪ avoid technical terms and jargon (explain them if unavoidable) ▪ avoid long words / words with many syllables /	Text Length: ▪ 250 - 300 words Text Structure: ▪ use short paragraphs Use of Tables/Visuals: -	Title: ▪ restate review title in plain language if possible, otherwise explain terms ▪ avoid recommendations Content structure: ▪ review question ▪ background ▪ study characteristics ▪ key results	▪ present results for all main outcomes ▪ use consistent wording across outcomes ▪ report findings on harms that are described in the review and state whether they have been fully reported in the included studies	▪ describe overall quality of evidence for each of the main outcomes based on GRADE considerations ▪ describe any factor that could affect the confidence in the results ▪ provide key reasons for quality of evidence / limitations in lay terms	purpose of text: ▪ summary of the review that contains the crucial information in plain language and that will be understood by the general public author of PLS: - review of PLS:

	misunderstandable words • consider introducing an acronym or short term for repeated use • avoid regional terms (AE / BE) • use active voice Sentences: • one keypoint / sentence • avoid more than two hard words in a sentence unless you can explain them		• quality of evidence Headlines: • standard headings • consistent order • in bold type Content: • convey the question addressed in the review • shortly describe population, intervention and outcomes in Background section • give enough detail on study characteristics (incl. search date and population details)	• it is not essential to provide numerical data • do not present numerical data if estimations of effects are imprecise or uncertain • if numerical data is provided, use natural frequencies for dichotomous outcomes and accompany relative effects with absolute effect estimates • explain any statistical term • statics, if used, should provide valid, digestible summary of direction, size and precision of the effect estimates	• describe if quality of evidence is high • if impact of funding sources on quality of the evidence is considered in the review, include a statement in the PLS	- access: - context: • tailor messages across different summary versions of the review relation to scientific abstract: • consistent reporting of key messages between PLS, main text, SoF table and authors' conclusions.
Cochrane 2016, Checklist for PLS Review ("PLS"), Cochrane Intervention Reviews	Tone: - Words: • avoid or explain acronyms, jargon and technical terms • PLS authors can choose to refer to "we" or to "review authors", but be consistent Sentences: -	Text Length: • 400-700 words Text Structure: - Use of Tables/Visuals: -	Title: • if title is difficult to understand, consider re-writing it in plain language Content structure: • What is the aim of review? • Key messages • What was studied in the review? • What are the main results of the review? • How up-to-date is this review? Headlines: • use sub-headings Content: • explain that results come from a systematic study rather than a single study • describe if necessary: why this topic is important; the population; the intervention; the comparison group; the	• present results only for the most important outcomes, try not to present more than 7 outcomes • if no data was found, present outcomes nevertheless • present results consistently (similar words / expressions for similar effects) • use the provided standard sentences • use absolute numbers (not relative risks, odds ratios, or percentages)	• present quality or certainty for each outcome as presented in the SoF table • if quality/certainty is not high, avoid strong statements, add modifying statements	purpose of text: - author of PLS: - review of PLS: • the checklist is intended for use by reviewers of PLS access: - context: • a template, PLS examples and standardized statements are provided relation to scientific abstract: • ensure results are reported consistently between PLS and main text / abstract / SoF table

			outcomes; possible adverse effects • do not present recommendations			
Cochrane 2019 [1] ("PLS"), Cochrane Intervention Reviews	<u>Tone:</u> - <u>Words:</u> • avoid research jargon • refer to "study" rather than "trial" • use name of the outcome and name of intervention instead of "outcome" / "intervention" • use words like "parents", "women", etc. instead of "participants" <u>Sentences:</u> -	<u>Text Length:</u> • *see above* <u>Text Structure:</u> - <u>Use of Tables/Visuals:</u> • if PLS is published outside Cochrane Library, add a simplified version of SoF table	<u>Title:</u> • *see above* <u>Content structure:</u> • *see above* <u>Headlines:</u> • *see above* <u>Content:</u> • describe if necessary: why this topic is important; the population / health problem addressed in the review; the intervention and what it was compared to; the outcomes. • explain that results come from a systematic study rather than a single study • do not present recommendations	• *see above* • use standardized qualitative statements when reporting effects of an intervention • ideally, use numbers and words; if you use numbers, present them in parentheses after the qualitative statement • use absolute numbers (not relative risks, odds ratios, percentages or numbers needed to treat) • when presenting continuous outcomes using numbers, refer to the scale	• *see above* • presenting confidence intervals is mostly not necessary but it may be useful in some situations (example statement is provided)	<u>purpose of text:</u> - <u>author of PLS:</u> - <u>review of PLS:</u> - <u>access:</u> - <u>context:</u> • *see above* <u>relation to scientific abstract:</u> • *see above*
The Steering Group of the Campbell Collaboration (2016) ("PLS"), Campbell systematic reviews	<u>Tone:</u> • use direct language • accessible manner <u>Words:</u> • avoid jargon • specific terms that are familiar to policy makers and practitioners should be retained • verbs: present tense <u>Sentences:</u> -	<u>Text Length:</u> • 600 - 750 words <u>Text Structure:</u> - <u>Use of Tables/Visuals:</u> • text box: "What is the aim of this review?" <u>Form:</u> • no footnotes or references	<u>Title:</u> • headline style • summarizing main findings • reference to full title at the end of the PLS <u>Content structure:</u> • see "Headlines" <u>Headlines:</u> • use headings and additional subheadings if needed • Headlines: The Review in Brief; What is this Review about?; What are the main findings of this review?; What do the findings of this review mean?; How up-to-date is this review?; What is the Campbell	• report the study findings directly and in present tense • avoid selective outcome reporting • use qualitative statements when presenting the effects of the intervention • avoid numbers to increase accessibility • qualitative statements: similar words and expressions for similar levels of effect (additional appendix with standardised statements)	• included studies: optionally add statement about the quality of evidence • results: GRADE reporting system • decide whether the size of the effect is important, less important or not important to the user • use standardised statements about effect • presenting confidence intervals is mostly not necessary but it may be useful in some situations (standardized statement is provided)	<u>purpose of text:</u> • to make information about main findings available in an easily understandable format • to report this information in a consistent way <u>author of PLS:</u> • study authors submit PLS with final review <u>review of PLS:</u> • edited by the secretariat, revised version checked with lead study author • meta-information reported as last sentence in PLS <u>access:</u> - <u>context:</u> • results should be reported consistently between PLS

			Collaboration?; About this summary Content: ▪ assessed interventions (i.a.) ▪ primary outcomes ▪ results for each outcome and analysis of heterogeneity ▪ discussion of theory of change (i.a.) ▪ quality of evidence ▪ implications for policy, practice, research (i.a.)			and main text / abstract ▪ a template with suggested wording is provided relation to scientific abstract: -
expert group on clinical trials for the implementation of Regulation (EU) No 536/2014 ("lay summary" / "summary of clinical trial results for laypersons"), clinical trial results	Tone: ▪ avoid any promotional language Words: ▪ avoid jargon / technical / medical / scientific language ▪ remove unnecessary / complex words ▪ be consistent with use of words and define them ▪ explain underlying concepts if necessary ▪ avoid ambiguous words / phrases ▪ limit use of acronyms, and of abstract or multisyllabic words ▪ verbs: use active rather than passive voice ▪ texts should be aimed at literacy proficiency level of 2-3 (use metrics to measure text readability)	Text Length: ▪ as short as possible Text structure: ▪ bullet points ▪ white space between topics ▪ minimum of 12-point font ▪ avoid text in all caps or underlining Use of Tables/Visuals: ▪ use visuals to convey critical concepts but limited use of unnecessary images ▪ visuals should present one message per image and be clearly labelled with captions	Title: ▪ specific to the trial ▪ may be shortened / simplified Content structure: ▪ present general information before the details Headlines: ▪ use headlines and descriptive subheadings to organize information Content: ▪ focus on unambiguous, factual information ▪ no promotional content should be included ▪ avoid overwhelming with too much information ▪ describe adverse reactions	▪ describe every study arm and outcome ▪ Numbers: follow numeracy principle (links to additional information is provided) ▪ report frequencies both in numerical terms and percentages ▪ report all outcomes	▪ don't include promotional content	purpose of text: ▪ EU Clinical Trials Regulation 536/2014 (Article 37): sponsors need to provide summary results in a format understandable to laypersons (research participants and general public) author of PLS: - review of PLS: ▪ consider including patients, patient representative or advocates to ensure the summary meets its aims; consider help of medical writers with plain language expertise access: ▪ made available in the EU Portal and Database context: ▪ provide summary as a minimum in local language of where the trial took place ▪ where possible include English version ▪ a template with 10 elements that should be

	Sentences: ▪ make short and succinct sentences instead of long and complex ones					included in the summary and suggested wording is provided relation to scientific abstract: -
Lionbridge (2019): Seven rules for effective communication ("PLS"), clinical trial results	Tone: ▪ information should be presented factually and neutrally ▪ respectful tone so that study participants do not feel as victims; avoid marketing jargon or overly positive presentation Words: ▪ simple and unambiguous ▪ avoid polysyllabic words; complex technical terms (unless you explain them); scientific jargon that may be misunderstood or cause confusion Sentences: ▪ active sentences with a subject that executes an action ▪ short, simple sentences ▪ avoid subclauses and nested sentences	Text Length: - Form: - Use of Tables/Visuals: ▪ use visuals aids such as empty spaces or graphs if it enhances communication with the target group	Title: - Content structure: - Headlines: - Content: ▪ content and presentation should be oriented towards language, style and knowledge of laypersons	▪ report absolute, whole numbers ▪ report numbers without decimal places or as percentages ▪ avoid probabilities or relative risks	-	purpose of text: ▪ to inform persons with average education level about results and conclusions of clinical studies author of PLS: - review of PLS: - access: ▪ access to extensive guidelines for writing PLS only for members context: -
TransCelerate Biopharma Inc. ("lay summary"), clinical trial results	Tone: ▪ factual and objective tone Words: ▪ avoid superlative and enthusiastic	Text Length: - Form: ▪ use material that is fair and balanced in terms of	Title: - Content structure: - Headlines: -	▪ make only comments on the outcome that are factual in nature ▪ do not make inferences or assessments ▪ link to additional neutral	▪ include a statement that results are from a single trial and different results may be obtained from other studies ▪ include a statement that	purpose of text: ▪ written to be understandable to the general public ▪ recommendations to help prepare PLS that are not

	words ▪ use neutral language (link to additional guidance is provided) <u>Sentences:</u> -	formatting <u>Use of Tables/Visuals:</u> ▪ do not use materials that have a commercial appearance ▪ do not use brand colors / logos ▪ be fair and balanced in terms of formatting	<u>Content:</u> ▪ factual and objective content ▪ use accurate, non-misleading information ▪ include information on efficacy and safety data from the trial ▪ do not provide approval status ▪ material should be fair and balanced	language guide is provided	no therapeutic changes should be made based on the results of a single trial without consulting a healthcare professional	perceived as promotional <u>author of PLS:</u> ▪ sponsor of trial <u>review of PLS:</u> - <u>access:</u> ▪ posted to public websites, EU database ▪ provided to trial participants <u>context:</u> ▪ take care that PLS is only provided in a non-promotional context ▪ add a statement with link to ClinicalTrials.gov & EU clinical trial register <u>relation to scientific abstract:</u> -
Duke (2012): How to write a lay summary ("lay summary"), Digital Curation Center collaborating with Patients Participate! project	<u>Tone:</u> ▪ do not write to entertain <u>Words:</u> ▪ use everyday English words instead of complex words ▪ avoid meaningless terms ▪ use active voice and second person instead of third person ▪ use person-centered language, do not focus on circumstances, illness or disability ▪ write in an easily readable style <u>Sentences:</u> ▪ use short and clear sentences ▪ avoid complex grammatical	<u>Text Length:</u> ▪ adhere to convention <u>Form:</u> ▪ break text up into paragraphs <u>Use of Tables/Visuals:</u> -	<u>Title:</u> ▪ provide a good and relevant title <u>Content structure:</u> ▪ order the text logically and let it flow naturally ▪ adhere to convention ▪ provide a first sentence that gives a concise introduction into text <u>Headlines:</u> - <u>Content:</u> ▪ provide answers to the questions: Who, What, Where, When, Why, How? ▪ give concrete everyday examples ▪ make sure risks are appropriately communicated (i.a.)	-	-	<u>purpose of text:</u> ▪ to shortly report research to a general audience <u>author of PLS:</u> ▪ researchers <u>review of PLS:</u> - <u>access:</u> ▪ service providers may be responsible for the dissemination of research findings <u>context:</u> - <u>relation to scientific abstract:</u> -

	structures ▪ phrase positively rather than negatively					
Dubé & Lapane (2014): Lay Abstracts and Summaries: Writing Advice for Scientists ("lay abstract" / "summaries"), multidisciplinary	Tone: - Words: ▪ avoid long / multisyllabic / complicated words ▪ do not use acronyms (except commonly known ones) ▪ use active instead of passive voice ▪ check readability and reading level Sentences: ▪ shorten sentences (but avoid choppy writing)	Text Length: ▪ depends on purpose Form: ▪ check instructions Use of Tables/Visuals: -	Title: ▪ state the main impact of your work for your audience with a simple phrase Content structure: ▪ organize to make your story clear ▪ summarize the most important / relevant information at the beginning briefly Headlines: - Content: -	-	-	purpose of text: ▪ the goal: a summary that is accessible to the public while true to science author of PLS: - review of PLS: ▪ review from target audience and other scientists of your field access: - context: - relation to scientific abstract: ▪ don't copy your scientific abstract
eLife (2017): Plain-language summaries: How to write an eLife digest ("PLS" / "eLife digest"), life sciences	Tone: - Words: ▪ use words that are understandable to the widest group of readers ▪ avoid technical jargon (note that jargon can include common words that are used in a field-specific way) ▪ if scientific terms must be used, define each at first use in more everyday-language ▪ only use well-	Text Length: - Form: - Use of Tables/Visuals: -	Title: - Content structure ▪ First sentence: Include something that most readers will be able to relate to ▪ Following sentences: Get gradually more specific Headlines: - Content: ▪ 4 questions that should be answered: 1. What background information would someone who is completely unfamiliar with your field need to	▪ focus on findings highlighted in the title / abstract of your paper; explain them clearly and completely ▪ describe methodology with 1-2 sentences ▪ always mention which species, type of organism or cells you have studied	▪ avoid hype / exaggeration	purpose of text: ▪ explain findings of a eLife paper to a broader audience author of PLS: ▪ written by editors and writers working together with authors: the author of the scientific paper is asked to answer 4 questions; from that, the eLife Features team writes the digest review of PLS: - access: - context: ▪ published in a prominent position ▪ some are republished on

	known acronyms and do not use more than 3 acronyms overall ▪ rather use a few short words than one long one ▪ use verbs instead as nouns as much as possible Sentences: ▪ active sentences ▪ all sentences should be shorter than 35 words		know to understand the findings in your paper? 2. What exact research question did you set out to answer and why? 3. What are the most important findings of your paper? (always mention which species, type of organism or cells you have studied) 4. Who might eventually benefit from the findings of your study, and what would need to be done before we could achieve these benefits?			social media platform ▪ encouragement to re-use PLS in other places relation to scientific abstract: -
American Geophysical Union [several journals] ("PLS"), earth and space science	Tone: ▪ language and tone are different from scientific abstract Words: ▪ avoid jargon, incl. undefined / excessive acronyms, field-specific terms, obscure / unnecessary long words, words that have different meaning to non-scientists Sentences: - Style: ▪ use straight-forward descriptions ▪ contextualize information	Text Length: - Form: - Use of Tables/Visuals: -	Title: - Content structure: - Headlines: - Content: ▪ develop your take home message by explaining what the research is about, what you found, and why it matters/what the impact is. ▪ provide enough context for those outside of your specific area of science will need more context ▪ highlight the novelty and value of your research ▪ Think about: What was the research question (in the larger context of your field)? What did your study find? Why does it matter? What's the take-home message?	-	-	purpose of text: ▪ to explain your science to broader audiences author of PLS: - review of PLS: - access: - context: ▪ PLS may gain wider notice than a scientific abstract, it might be read by journalists, shared on social media, or quoted in a blog post relation to scientific abstract: ▪ contains the same information as scientific abstract, but tone and language are different
People and Nature [journal]	Tone: ▪ use clear and	Text Length: ▪ 250-300 words	Title: ▪ plain language title that	-	-	purpose of text: ▪ to raise the profile of your

("PLS"), human-ecology interactions	simple language ▪ simple and straightforward style Words: ▪ avoid jargon ▪ avoid scientific terms; if you must use a scientific term, explain in clear and simple terms what it is Sentences: -	Form: - Use of Tables/Visuals: ▪ try and include a photo or image, anything that makes you work more accessible and interesting	says what the paper is about in clear terms (a bit like a newspaper headline) ▪ short (< 120 characters) Content structure: - Headlines: - Content: ▪ include any important contextual background or findings that might make your work more relevant, interesting or memorable to the reader			work ▪ to make it accessible to the widest possible audience author of PLS: ▪ author of paper review of PLS: ▪ upload PLS at revision stage with your work ▪ will be edited and returned to author if too much jargon access: ▪ freely available to read context: ▪ PLS will be added to journal blog, included with the paper ▪ encouraged to reuse PLS by posting it on own blog, share on social media relation to scientific abstract: ▪ not simply a modified version of the scientific abstract
Autism [journal] ("lay abstract"), all aspects of autism spectrum disorders and related developmental disabilities	Tone: ▪ easily understandable Words: ▪ avoid technical terminology Sentences: -	Text Length: ▪ max. 250 words Form: - Use of Tables/Visuals: -	Title: - Content structure: - Headlines: - Content: ▪ Consider the questions: What is already known about the topic? What does this paper add? Implications for practice, research and policy	▪ avoid reporting of statistics	-	purpose of text: - author of PLS: ▪ author of paper review of PLS: ▪ provide lay abstract as part of submission access: ▪ will be made widely available to general public and particularly to autistic people and their families context: - relation to scientific abstract: -

i.a. = if applicable; GRADE = Grading of Recommendations Assessment, Development and Evaluation (specific formal process for grading systematic reviews); SoF = Summary of Finding table (standardized form to report results of Cochrane Reviews)

[1] listed are only changes to the 2016 version

S3 Table. Quantitative Studies Comparing PLS vs. PLS: Criteria, Outcomes and Results.

Study [sample]	Criteria *[characteristic category]*	Outcome *[aim category]*	Results
Santesso et al. (2015) [*n* = 143 members of the public and patients from 5 nations (Canada, Norway, Spain, Argentina, Italy)]	new format vs. current format: - new format: description of effects: qualitative and quantitative (absolute effects, natural frequencies in text; quantitative results in table) quality of evidence: provided in table, according to GRADE text structure: headings, question and answer format content structure: flow of information according to linguistic framework principles - current format: description of effect: qualitative quality of evidence: no criteria text structure: paragraph of text content structure: no criteria *[Formal Attributes]* *[Presentation of Results]* *[Presentation of Quality of Evidence]*	Primary Outcome: A) proportion of participants who correctly answered questions about the benefits and harms of the intervention and quality of evidence (multiple choice test, average of 5 questions) Secondary Outcomes: B) proportion of participants who correctly answered those 5 questions each C) overall correct answers D) comprehension of purpose of the summary E) usability F) ease of understanding G) accessibility H) preference for one format over the other *[Knowledge]* *[Understanding]* *[Accessibility]*	A) proportion of participants who correctly answered comprehension questions on average was higher for the new format than the current (53% vs. 18%, *p* < .001) B) proportion of participants who correctly answered single questions was higher for the new than the current format in 4 of 5 questions (*p* < .001) C) more correctly answered questions by participants who read the new format compared to participants who read the current format (*Mdn* = 3, *IQR*: 1-4; vs. *Mdn* = 1, *IQR*: 0-1, *p* <.001) D) no difference between formats regarding comprehension of the purpose of the study (32% vs. 45%, *p* = .17) E-G) more participants who read the new format compared to the current format reported that the information was easy to find, reliable, that the summary presented most important effects and the presentation helped to make a decision (all *p* < .05), no stat. sign. difference regarding ease of understanding H) greater preference for the new format (*p* unknown)
Silvagnoli et al. (2020) [*n* = 167, mostly higher-educated, from UK-based patient	readability low level of complexity (L1) vs. medium level of complexity (L2) vs. high level of complexity (L3)	preference (score 1-4) *[Accessibility]*	medium-level PLS with a readability that fits to an reading age of 14-17 years (L2) received highest preference ratings (PLS Psoriasis weighted means: 2.13 (L1) vs. 2.90 (L2) vs. 1.97 (L3); PLS Multiple Sclerosis weighted means: 2.37 (L1) vs. 2.47 (L2) vs. 2.40 (L3);

association websites and Facebook patient support groups]	*[Linguistic Characteristics]*		PLS Rheumatoid Arthritis weightes means: 2.38 (L1) vs. 2.77 (L2) vs. 2.08 (L3), *p* unknown)
Alderdice et al. (2016) [*n* = 813 midwifery students from UK and Ireland]	conclusion vs. no conclusion certain findings vs. uncertain findings *[General Content]*	proportion of participants who identified the appropriate response to describe the main results of the review *[Knowledge]*	no stat. sign. difference for conclusion vs. no conclusion for PLS with certain findings (63% vs. 61%; OR 1.13, 95% CI [0.41, 1.50]; RD 2.8%, 95% CI [-3.8, 9.5]; *p* = .41); stat. sign. more correct answers for conclusion vs. no conclusion for PLS with uncertain findings (45% vs. 37%; OR 1.35, 95% CI [1.02, 1.79]; RD 7.3%, 95% CI [0.60, 14.1]; *p* = .03)
Buljan et al. (2020, BMC Mes Red Methodol.), Trial 1 [*n* = 91, first-year medical students of University of Croatia]	positive framing (i.e., in terms of effectiveness) vs. negative framing (i.e., in terms of ineffectiveness) of health evidence *[Presentation of Results]*	Primary Outcomes: A) perceived effectiveness of described treatment (score 3-30) B) desire that treatment is offered by family doctor (score 3-30) C) readiness to use the treatment (score 3-30) Secondary Outcome: D) comprehension (brief multiple choice knowledge test, score 0-12) *[Knowledge]* *[Empowerment]*	no differences for positive vs. negative framing: A) M = 15.8 vs. M = 17.3; *Mean Differenc*e = 1.53, 95% CI [-0.33, 3.39]; BF_{10} = $1.31*10^{-4}$ B) M = 15.4 vs. M =16.1; *Mean Differenc*e = 0.69 95% CI [-1.00, 2.37]; BF_{10} = .036 C) M = 16.6 vs. M =17.1; *Mean Differenc*e = 0.52 95% CI [-1.39, 2.43]; BF_{10} = .035 D) M = 9.2 vs. M = 8.6; *Mean Differenc*e = -0.51 95% CI [-1.43, 0.35]; BF_{10} = $1.81*10^{-4}$
Buljan et al. (2020, BMC Mes Red Methodol.), Trial 2 [*n* = 245, students of University of Croatia and patients from hospitals or family practices]	presentation of treatment effectiveness as natural frequencies and side effects as percentages vs. presentation of treatment effectiveness as percentages and side effects as natural frequencies *[Presentation of Results]*	Primary Outcome: A) comprehension (brief multiple choice knowledge test, score 0-2) Secondary Outcomes: B) preference for this type of format for health information (score 1-10) C) perceived effectiveness of treatment for described medical condition (score 1-10) *[Knowledge]* *[Accessibility]*	A) "In Trial 2 we found no difference in CSR PLS comprehension when results were presented as natural frequencies or percentages (BF10 = 0.62, Bayesian t-test for independent samples)." (p.1) B), C) "Our study showed no differences in readers' perceived effectiveness and readiness to use the described treatment [...] when the results were presented as frequencies vs percentages." (p.6)

Kirkpatrick et al. (2017) [*n* = 60 members of the NETSCC's panel of public reviewers]	PLS written with 3 different strategies: original PLS vs. PLS rewritten with guideline by original author (author revised) vs. PLS written with guideline by independent writer (edited) [*Contextual Information*]	A) ease of understanding (score 1-4) B) reading ease (Flesch reading ease score, 0-100) C) free text comments [*Understanding*] [*Accessibility*]	A) no stat. sign. difference in terms of ease of understanding (original vs. edited, 56% vs. 72%; p = .06; author revised vs. original, 61% vs. 56%; p = .81; author revised vs. edited, 72% vs. 61%; p = .22) B) both rewritten versions were significantly easier to read than the original PLS (p <.001); no stat. sign. difference between the rewritten versions (p = .12) C) free text comments: most frequent negative comments ($n \geq 20$) on jargon/terminology, title is not clear, insufficient detail, ambiguous language; most frequent positive comments ($n \geq 20$): general positive comments, headings useful (only revised and edited versions) rather original than revised / edited PLS: need for headings, less detail

PLS = Plain Language Summary; GRADE = Grading of Recommendations Assessment, Development, and Evaluation; Mdn = median; M = mean; IQR = interquartile range; OR = odds ratio ; RD = risk difference; CI = confidence interval; CSR = Cochrane Systematic Review; BF = bayes factor; NETCSS = National Institute for Health Research Evaluation, Trials and Studies Coordinating Centre

Note. Only experimental conditions that investigate PLS criteria against each other are listed; further comparisons (e.g., with other summary formats) are not listed.

S1 File. Search Terms.

Web of Science: last search on 2020-07-17; 3309 Treffer
TI = ("plain language summa*" OR "plain-language summa*" OR "lay summa*" OR "plain English summa*" OR "non-technical summa*" OR "non technical summa*" OR "nontechnical summa*" OR "summa* for layperson*" OR "systematic review* summa*" OR "evidence summa*" OR "lay abstract*" OR "plain language abstract*" OR "plain-language abstract*"OR "infographic*") AND TI = ("quality" OR "standard*" OR "comparison" OR "effective" OR "evaluation" OR "critical review" OR "development" OR "user testing") OR (AB = ("plain language summa*" OR "plain-language summa*" OR "lay summa*" OR "plain English summa*" OR "non-technical summa*" OR "non technical summa*" OR "nontechnical summa*" OR "summa* for layperson*" OR "systematic review* summa*" OR "evidence summa*" OR "lay abstract*" OR "plain language abstract*" OR "plain-language abstract*" OR "infographic*") AND AB = ("quality" OR "standard*" OR "comparison" OR "effective" OR "evaluation" OR "critical review" OR "development" OR "user testing"))

PubMed: last search on 2020-07-29; 1744 Treffer
("plain language summa*"[Title/Abstract] OR "plain-language summa*"[Title/Abstract] OR "lay summa*"[Title/Abstract] OR "plain English summa*"[Title/Abstract] OR "non-technical summa*"[Title/Abstract] OR "non technical summa*"[Title/Abstract] OR "nontechnical summa*"[Title/Abstract] OR "summa* for layperson*"[Title/Abstract] OR "systematic review* summa*"[Title/Abstract] OR "evidence summa*"[Title/Abstract] OR "non-technical summa*"[Title/Abstract] OR "lay abstract*"[Title/Abstract] OR "plain language abstract*"[Title/Abstract]OR "plain-language abstract*"[Title/Abstract] OR "infographic*"[Title/Abstract]) AND ("quality"[Title/Abstract] OR "standard*"[Title/Abstract] OR "comparison"[Title/Abstract] OR "effective"[Title/Abstract] OR "evaluation"[Title/Abstract] OR "critical review"[Title/Abstract] OR "development"[Title/Abstract] OR "user testing"[Title/Abstract])

PsycInfo: last search on 2020-07-16; 287 Treffer
3 ("plain language summa*" or "plain-language summa*" or "lay summa*" or "plain English summa*" or "non-technical summa*" or "non technical summa*" or "nontechnical summa*" or "summa* for layperson*" or "systematic review* summa*" or "evidence summa*" or "non-technical summa*" or "lay abstract*" or "plain language abstract*" or "plain-language abstract*" or "infographic*").ti. or ("plain language summa*" or "plain-language summa*" or "lay summa*" or "plain English summa*" or "non-technical summa*" or "non technical summa*" or "nontechnical summa*" or "summa* for layperson*" or "systematic review* summa*" or "evidence summa*" or "non-technical summa*" or "lay abstract*" or "plain language abstract*"
or "plain-language abstract*" or "infographic*").ab. (550)
4 ("quality" or "standard*" or "comparison" or "effective" or "evaluation" or "critical review" or "development" or "user testing").ti. or ("quality" or "standard*" or "comparison" or "effective" or "evaluation" or "critical review" or "development" or "user testing").ab. (1387340)
5 3 and 4 (287)

PSYNDEX: Datum: last search on 2020-07-16; 10 Treffer
1 ("plain language summa*" or "plain-language summa*" or "lay summa*" or "plain English summa*" or "non-technical summa*" or "non technical summa*" or "nontechnical summa*" or "summa* for layperson*" or "systematic review* summa*" or "evidence summa*" or "non-technical summa*" or "lay abstract*" or "plain language abstract*" or "plain-language abstract*" or "infographic*").ti. or ("plain language summa*" or "plain-language summa*" or "lay summa*" or "plain English summa*" or "non-technical summa*" or "non technical summa*" or "nontechnical summa*" or "summa* for layperson*" or "systematic review* summa*" or "evidence summa*" or "non-technical summa*" or "lay abstract*" or "plain language abstract*" or "plain-language abstract*" or "infographic*").ab. (15)
2 ("quality" or "standard*" or "comparison" or "effective" or "evaluation" or "critical review" or "development" or "user testing").ti. or ("quality" or "standard*" or "comparison" or "effective" or "evaluation" or "critical review" or "development" or "user testing").ab. (75303)
3 1 and 2 (10)