

# THE STATE OF ART REGARDING SCIENTISTS, OUTREACH AND EVOLUTION: A SYSTEMATIC LITERATURE REVIEW DESIGN

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## Abstract

Scientists play a crucial role in the outreach activities and in the shape of the science-society relation over time. Nevertheless, there are some barriers that are holding scientists back from participating more actively in outreach initiatives, namely in the Evolution field. Taking this into account, the COST Action “Building on scientific literacy in evolution towards scientifically responsible Europeans – EuroScitizen (CA17127) has dedicated one of its Working Groups to Scientists, which is focused on ensuring efficient researchers’ engagement in outreach and in evolution in particular. In order to achieve this goal, there is an ongoing systematic literature review in progress which aims to identify the ways in which researchers can be involved in outreach and to enable the development of a set of good practices that improve science and evolution literacy. In this paper, the Review Protocol Design is presented and its role in enhance of the quality, replicability, reliability, and validity of these reviews is stressed.

Keywords: Scientists, Outreach, Evolution, Systematic Literature Review, EuroScitizen, COST Action.

## 1 INTRODUCTION

Outreach could be understood as “any scientific communication that [directly] engages an audience outside of academia” [1] (p. 244) and scientists are at its heart, playing a crucial role in the public acceptance of Science. In fact, scientists’ involvement in outreach seems to be expected by society [2] and it is one of the things most valued by the public [3]. Furthermore, scientists’ involvement in outreach activities contribute greatly to shape the science-society relation over time and, therefore, scientists also have a main role in the appropriate development of that relationship, which entails benefits for both scientists and society [4][5][6].

This scientists’ involvement in outreach is particularly important in one of the most important fields of science: Evolution, the foundation of modern biology. Evolutionary biology has great societal relevance and its findings have far-reaching implications for how society understands and acts, for instance, towards climate change, drug resistance, issues of food security and controversies in modern medicine, renewable energies and new technologies. In other words, “Only in the light of evolutionary knowledge, advances in medical research and the risks involved in biodiversity decline and climate change can truly be comprehended.” [7](p.2). However, it is frequently misunderstood or even rejected outright (idem).

Nevertheless, and despite these findings, there are some barriers that are holding scientists back from participating more actively in outreach initiatives, namely in the Evolution field [8][9]. Some of those barriers are related with the lack of recognition by peers, the lack of available time and the lack of rewards from their institutions [2][10][11]. Scientists also highlight that outreach activities are not part of their training or even are not perceived as a priority in their careers [2][9][12].

Considering the abovementioned scientists’ crucial role in Outreach and the need to increase their participation in Outreach, the COST Action “Building on scientific literacy in evolution towards scientifically responsible Europeans – EuroScitizen (CA17127) has dedicated one of its Working Groups (WG) to Scientists. The WG is focused on ensuring efficient engagement by researchers in outreach and in evolution in particular. Regarding its aims, this WG intends to provide a sound understanding of current practices involving researchers’ engagement in scientific outreach, to increase awareness about the benefits for both researchers and the general public from their interactions and to promote efficient actions. In order to achieve this purpose, one of its tasks is a systematic literature review which aims to

identify the ways in which researchers can be involved in outreach and to enable the development of a set of good practices that improve science and evolution literacy.

## 1.1 The systematic literature review

A systematic literature review intends to identify, select and critically appraise prior existing research in order to understand the breadth and depth of the existing body of work and identify gaps to explore [13][14] and aims “to provide a complete summary of the ‘current state’ of research on a particular question or concept/idea” [15] (p. 117). In this sense, a systematic review enables researchers to find the answers to a clearly formulated question [13]. To achieve the answers to the research question, it is crucial that it guides the literature review process so that the selection of the studies to be included in it points to the answers to the research question [14][16].

Since a systematic literature review should be valid, reliable and repeatable [14] it should follow a defined protocol where the criteria are clearly stated before the review is conducted [13][17]. Considered crucial to ensure rigor in the systematic review [18], the review protocol reduces the possibility of bias in data selection and analysis. It also increases the reliability of the review since it allows other researchers using the same protocol, to repeat the study and develop it [14][16]. In this sense, the review protocol should present the purpose of the study, the research questions, the inclusion criteria, search strategies, the quality assessment criteria and screening elements, as well as synthesis and reporting [19].

Although some authors consider a different number of steps in the protocol design, it seems they all focus on three major stages in the systematic literature review: planning the review, conducting the review and reporting the review. For instance, according to Xiao and Watson [14], the design of the systematic literature review protocol can rely in eight steps: (1) formulating the research problem; (2) developing and validating the review protocol; (3) searching the literature; (4) screening for inclusion; (5) assessing quality; (6) extracting data; (7) analysing and synthesizing data; and (8) reporting the findings. On the other hand, Fornari et al. [20] identify nine steps in the protocol design: (1) identification of the need for revision; (2) preparation of the proposed revision; (3) elaboration of the research protocol; (4) identification of the research; (5) selection of documents; (6) evaluation of the quality and relevance of the documents; (7) data processing; (8) synthesis of data; (9) obtaining evidence and application (see Table 1).

Table 1. Review Protocol Design.

	<i>Xiao and Watson (2019)</i>	<i>Fornari et al. (2019)</i>
Planning the review	1 -Formulate the Problem	1 - Identification of the need for revision
	2 - Develop and Validate the Review Protocol	2 - Preparation of the proposed revision
	-	3 - Elaboration of the research protocol
	-	4 - Identification of the research
Conducting the review	3 - Search the Literature	5 - Selection of documents
	4 - Screen for Inclusion	6 - Evaluation of the quality and relevance of the documents
	5 - Assess Quality	-
	6 - Extracting Data	7 - Data processing
	7 - Analyzing and Synthesizing Data	8 - Synthesis of data-
Reporting the review	8 - Report Findings	9 - Obtaining evidence and application

The second stage of the systematic literature review - conducting the review – is commensurate with highlight the Xiao and Watson’s step 3 (search the literature), step 4 (screen for inclusion), step 5 (assess quality) and step 6 (Extracting Data). In other words, we stress the selection of the documents (step 5), the evaluation of the quality and relevance of the documents (step 6) and step 7 (data processing) [20].

### ★ Search the literature/Selection of Documents

#### Literature sources

Currently, electronic data bases are the most used channels to find literature, since they compile the vast majority of scientific publications. Databases such Scopus, Web of Science, EBSCO, PubMed and others are the most common in the literature review process.

### *Keywords*

The keywords used in the search should be sourced from the research question. As stated by Kitchenham and Charters (2007), researchers could split the research question into concept domains, highlighting the main concepts. The use of Boolean operators in the search could be very useful in the search strings: “AND”, to join the terms; “OR”, to include synonyms.

### *Sampling Strategy*

Regarding grey literature (e.g. reports, theses, conference proceedings) on the one hand, it should be included in the search, since their omission may lead to a bias [16]. On the other hand, if the literature review is more selective in terms of quality, the grey literature should not be considered because it might not have the same quality when compared with peer-review studies [14]. And, as noted by Paez [21], “Gray literature's diverse formats and audiences can present a significant challenge in a systematic search for evidence” (p.233). On these grounds, therefore, we decided to exclude grey literature from the study.

### *Additional restrictions*

Other criteria used are related to (1) publication language, which could be, for instance, a language that all the researchers understand, (2) date range of publication and (3) source of financial supports [16][18].

#### ✦ Screen for inclusion; Assess quality / evaluation of the quality and relevance of the documents

### *Criteria for inclusion/exclusion*

According to Kitchenham and Charters (2007) the criteria of inclusion and exclusion should be based on the research question, i.e. the studies not related to the research question should be excluded and therefore not considered in the systematic literature review. This means that the inclusion and exclusion criteria allow for the classification of research and its reliable interpretation, which result in a set of literature manageable in the review process [14].

### *Screening procedure*

In order to ensure the implementation of the inclusion and exclusion criteria, some authors [14][16][19] suggest that two reviewers of the team work independently in the screening procedure. This assessment should be based in the articles' abstract and it should be inclusive, which means if in doubt, reviewers should include the article [14].

#### ✦ Assess quality / evaluation of the quality and relevance of the documents

### *Quality assessment procedure*

The quality assessment is based on the full texts and is a crucial stage in preparing the final studies that will embody the data processing and the synthesis of data. Reviewers should analyse carefully the full texts in the light of the assessment criteria. On the one hand, the criteria for quality assessment is related to ‘internal validity’, which entails studies free of methodological biases. On the other hand, it is associated to ‘external validity’ which calls for generalization of the studies. According to Xiao and Watson (2019) there is no consensus regarding the best way to deal with the quality assessment, but they underline that the most important is that the used criteria should be reasonable and defensible.

#### ✦ Extracting Data/ Data processing

### *Coding*

The process of data processing involves coding and it is important to bear in mind that the way in which the studies are coded will condition and influence the conclusions of the review [14]. In this sense, it could be important that the team of researchers code some papers together first in order to make sure everyone are coding similarly as suggested by Kitchenham and Charters [16].

In this paper, we addressed firstly a theoretical framework regarding the systematic literature review (Section 1 - Introduction) and following we will focus on our ongoing systematic literature review process, namely in the protocol design that we are rely on (Section 2 - Methodology). Then, the preliminary results of the ongoing systematic literature review will be presented (Section 3 - Results). Lastly, succeeding a

summary of the study's main results, we will underline the relevance of the systematic literature review in order to understand the status and practices of those conducting outreach in the field of evolutionary biology (section 4 - Conclusions).

## 2 METHODOLOGY

In order to enhance the quality, replicability and validity of the systematic literature review, the team follow a Review Protocol Design [14][20], which steps are organised in three main stages: Planning the review, Conducting the review and Reporting the review, as stated previously in Table 1. In this paper we focus on the second one - Conducting the review - namely in the Xiao and Watson's step 3 (Search the literature), step 4 (screen for inclusion), step 5 (Assess quality) and step 6 (Extracting Data). In other words, we stress the selection of the documents (step 5), the evaluation of the quality and relevance of the documents (step 6) and step 7 (data processing) [20]. In more detail, we intend to present the Literature sources, Keywords, Sampling Strategy, Additional restrictions, Criteria for inclusion/exclusion and Screening procedure.

The systematic literature review was designed to answer the research question: *What does the research literature reveal about the status and practises of those conducting outreach in the field of evolutionary biology?* The purpose of the review was, therefore, to establish what we know about how outreach is being delivered, where and by whom, as well as the motivation for doing outreach work. Besides, there was also the status of outreach – that is, did institutions, universities etc. see outreach as a high status or an essential aspect of their work, or was the status reliant upon the researcher and their desire to conduct outreach. The “practises” aspect of the question relates to the various models of outreach used. The research question was intended to be an open question that did not have any preconceived opinions or intended outcomes. This would allow us to review the widest range of literature available.

### 2.1 Literature sources

Several databases were used to find the published articles. The databases were chosen on the following criteria, that the database:

(a) contained peer reviewed articles rather than ‘grey’ literature; (b) allowed for complex search strings needed to narrow the resultant ‘hits’ to the most relevant articles; (c) included science and social science journals. Some commonly used search engines, such as Google Scholar were not included as the results from such searches often deliver grey material, books (e.g. books available on Google books) and much more search ‘noise’. It was also recognised that the pertinent and relevant results from such search engines would be included in the key academic databases. Accordingly, in this paper, Scopus and Web of Science databases were.

### 2.2 Keywords

Once the research question had been defined and agreed, the next step was to decide on search strings that would best reveal relevant literature. The keywords related to the research question and relevant to the search strings used were: Outreach; Public Engagement; Scientist; Evolution; Evolutionary biology; Communication; Biology; Participation; Scientific; Education. The search strings were devised through a process of trial and error using keywords, such as ‘outreach’, ‘public engagement’, ‘evolution’ etc. and combining these with Boolean search terms such as ‘AND’, ‘NOT’, ‘OR’ etc. Initial indications and trials suggested that there were many thousands of potential papers contained within each of the databases. This led to discussions on whether date limits should be imposed.

### 2.3 Sampling Strategy

The literature that could be included in the review is very varied. Given that the initial research question asked is: *what does the ‘research’ literature reveal?*, the group decided that only peer reviewed papers, published in mainstream journals from recognised, *bona fide* publishers were included. This had the effect of excluding the many predatory journals that publish often inferior work or that have work which is not properly or rigorously peer reviewed.

### 2.4 Additional restrictions

Language of publication - Much research is published in English, even when the context or country within which the research is carried out is not an English-speaking nation. While the group saw many

advantages to including non-English publications within the review, there were also some disadvantages. Initial pilot searches revealed that there were potentially large numbers of papers which could be used for the review. This indicated that the addition of non-English publications, while useful, may not add much to the overall outcomes of the project. There was also the issue of cross checking the analysis of the literature to increase confidence, validity and rigour. Our protocol for the analysis of the literature required that each paper was analysed by two of the group members. The results were then compared and refined so that for any resultant analysis we have a high level of confidence that it is accurate. The problem with the inclusion of other languages hinges on this aspect of the analysis. For example, one member of the group from Norway identified 70 papers, in Norwegian, which may be relevant to our review. No other group member was able to analyse a paper written in Norwegian. While abstracts of papers, even those written in other languages are often in English, this would not be enough to allow for an analysis to be carried out. For this reason, initially, only English language publications were included.

Date of publication – In order to be the most up to date as possible, the publications considered were from 2015 to 2020.

## 2.5 Criteria for inclusion/exclusion

In addition to the search strings the team decided to use key search parameters in order to increase the likelihood of identifying relevant results. The key parameters identified were that the terms in the search strings should appear in the title, abstract and keywords. Full text searches using the search strings were excluded as a trial search where full text could be revised increased the number of hits considerably, but on further investigation, it was revealed that some of the search terms appeared only in the full text by chance. The paper itself did not focus on, say outreach, but another topic and the term 'outreach' was merely an example of an activity that could be done.

## 2.6 Screening procedure

To ensure the implementation of the inclusion and exclusion criteria, two members of the team were working independently in order to validate the colleagues work.

As this systematic literature review is a work in progress, at the moment, the team is starting working in the *Quality assessment procedure* and in *Coding*, the latter using the webQDA, a qualitative data analysis software.

## 3 RESULTS

As mentioned before, our systematic literature review is an ongoing work, so we present not the results of our search and evaluation for inclusion. Rather we present the way we will present the results, since for literature reviews to be reliable and repeatable, reviewers should present their steps the more detailed possible. According to Moher et al. [22] researchers should report the findings from literature search, screening and quality assessment. The authors propose four major sections in the results presentation:

- 1 Identification - related to the records identified through database searching or through other sources;
- 2 Screening – indicating the records after duplicates removed as well as the records screened. In this last sub-section it is important to point the number of the records excluded and mention the reasons for that;
- 3 Eligibility - related to the full-text articles assessed for eligibility. In this section it is also important to present the number of full-text excluded and the reasons for exclusion.
- 4 Included – In this last section, reviewers should present the total/final number of the included articles.

Moher et al. [22] and other authors [14] suggest the use of flow diagrams to systematise the flow of the literature search and evaluation of inclusion. In the Figure 1, the Moher et al. [22] flow diagram is presented.

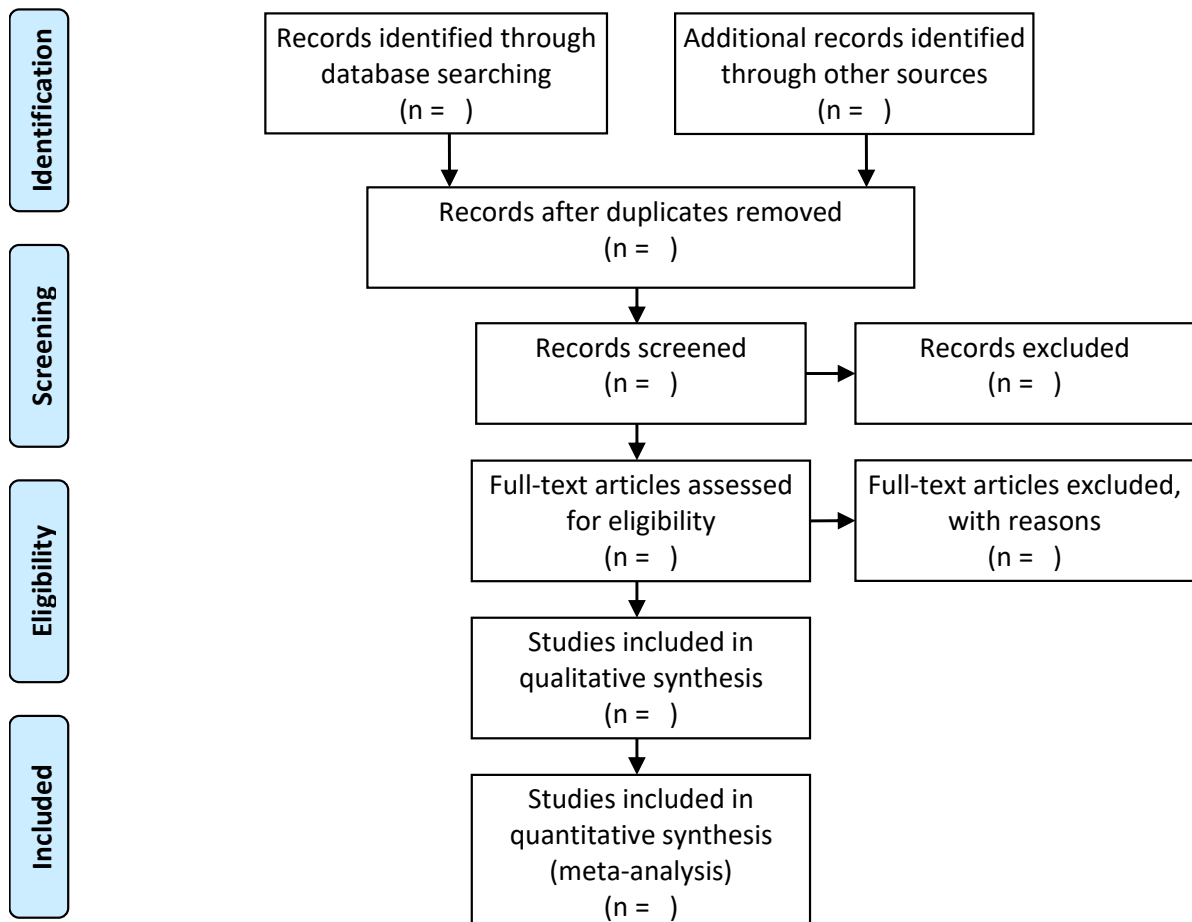


Figure 1. Flow diagram.

## 4 CONCLUSIONS

In this paper, the important role of scientists in the outreach activities in the shape of the science-society relation, namely on the topic of evolution, was emphasised. Consequently, the Cost Action EuroCitizen - Building on scientific literacy in evolution towards scientifically responsible Europeans (CA17127) is presented as well its WG Scientists, which main goal is to ensure efficient engagement by researchers in outreach and in evolution in particular.

Within this WG, a systematic literature review is being conducted aiming to identify the ways in which researchers can be involved in outreach and to enable the development of a set of good practices that improve science and evolution literacy.

As stated by William [15], a systematic literature review aims “to provide a complete summary of the ‘current state’ of research on a particular question or concept/idea” (p. 117). In order to be valid, reliable and repeatable [14], the systematic literature review should follow a defined protocol where the criteria are clearly stated before the review is conducted [13][17]. According to different authors [14][16][18][20] the review protocol reduces the possibility of bias in data selection and analysis and also increases the reliability of the review since it allows other researchers using the same protocol, to repeat the study and develop it. The review protocol should be reported in detail, including the purpose of the study, the research questions, the inclusion criteria, the search strategies, the quality assessment criteria and screening elements, as well as synthesis and reporting [19].

In this sense, we present our review protocol, with a special focus on the second stage of the protocol review: Conducting the review. In more detail, we presented our Literature sources, Keywords, Sampling Strategy, Additional restrictions, Criteria for inclusion/exclusion and Screening procedure.

Since our systematic literature review is still in progress, with this paper we intend to contribute positively to the discussion around systematic literature review and its review protocol design. Simultaneously, we have the opportunity to reflect and to improve our own research methodology, as Xiao and Watson

[14] say, “the literature review protocol is a living document. Changes can be made to it in the review process to reflect new situations and new ideas” (p.109).

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## REFERENCES

- [1] E. Poliakoff, Webb T., “What factors predict scientists’ intentions to participate in public engagement of science activities?” *Science Communication*, vol. 29, pp. 242–263, 2007
- [2] J. C. Besley, Nisbet, M., “How scientists view the public, the media and the political process.” *Public Understanding of Science*, vol. 22, pp. 644–659, 2011.
- [3] G. Revuelta, “Impacts of Science Communication on Publics, Cities and Actors.” *Journal of Science Communication*, vol. 13, no. 1, pp 1824–2049, 2014.
- [4] G. Clark, J. Russell, P. Enyeart, B. Gracia, A. Wessel, I. Jarmoskaite, et al., “Science Ed Programs That Benefit Students and Scientists.” *PLoS Biol*, vol.14, no. 2, 2016.
- [5] B. Trench, “Introduction to Commentary on Universities and Science Communication”, *Journal of Science Communication*, vol.16, no. 05, 2017.
- [6] T. Adnađević, T. Milosevic, D. Radovčić, “Exploratory study of evolution-themed, non-formal education in Europe.” Zenodo, 2020. Retrieved from: <http://doi.org/10.5281/zenodo.3712725>
- [7] P. Kuschmierz, A. Meneganzin, Pinxten, R. et al. “Towards common ground in measuring acceptance of evolution and knowledge about evolution across Europe: a systematic review of the state of research.” *Evolution: Education and Outreach*, vol. 13, no. 18, 2020. Retrieved from: <https://doi.org/10.1186/s12052-020-00132-w>
- [8] P. Jensen, “A statistical picture of popularization activities and their evolutions in France” *Public Understanding of Science*, vol. 20, pp. 26-36, 2011.
- [9] J. Varner, “Scientific Outreach: Toward Effective Public Engagement with Biological Science” *BioScience*, vol. 64, pp. 333–340, 2014.
- [10] O. Kassab, “Does public outreach impede research performance? Exploring the ‘researcher’s dilemma’ in a sustainability research.” *Science and Public Policy*, pp.1–1, 2019. Retrieved from: doi: 10.1093/scipol/scz024.
- [11] S. M. Mackay, E. W. Tan, D. S. Warren, “Developing a new generation of scientist communicators through effective public outreach” *Communications Chemistry*, 2020. DOI: 10.1038/s42004-020-0315-0
- [12] European Commission, “Horizon 2020 - Work Programme 2018-2020 Science with and for Society”, 2020. Retrieved from: [https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs\\_en.pdf](https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-swfs_en.pdf)
- [13] A. Dewey, A. Drahota, “Introduction to systematic reviews: online learning module Cochrane Training”, 2016. Retrieved from: <https://training.cochrane.org/interactivelearning/module-1-introduction-conducting-systematic-reviews>
- [14] Y. Xiao, M. Watson, “Guidance on Conducting a Systematic Literature Review” *Journal of Planning Education and Research*, vol. 39, no.1, pp. 93–112, 2019. DOI: 10.1177/0739456X17723971
- [15] J.D. Williams, *How to Read and Understand Educational Research*. London: Sage, 2020.
- [16] B. Kitchenham, S. Charters. *Guidelines for Performing Systematic Literature Reviews in Software Engineering. EBSE Technical Report*. Durham: University of Durham. 2007

- [17] D. A. Gough, S. Oliver, and James Thomas. *An Introduction to Systematic Reviews*. London: SAGE, 2012.
- [18] C. Okoli, K. Schabram. 2010. "A Guide to Conducting a Systematic Literature Review of Information Systems Research." *Sprouts: Working Papers on Information Systems*. Retrieved from <http://sprouts.aisnet.org/10-26>.
- [19] J. S. Gomersall, Y. T. Jadotte, Y. F. Xue, S. Lockwood, D. Riddle, and A. Preda.. "Conducting Systematic Reviews of Economic Evaluations." *International Journal of Evidence Based Healthcare*, vol. 13, no. 3, pp. 170–78, 2015.
- [20] L. F. Fornari, I. Pinho, A. P. Costa, "Review of Literature with Support of webQDA Software". *14th Iberian Conference on Information Systems and Technologies (CISTI)* DOI: 10.23919/CISTI.2019.8760950.
- [21] A. Paez "Gray literature: An important resource in systematic reviews." *Journal of Evidence-Based Medicine*, vol.10, pp. 233-240, 2017.
- [22] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altma, "The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement." *PLoS Med*, vol. 6, no. 7, 2009. DOI: 10.1371/journal.pmed1000097