



Systematic review of conceptual criticisms of homeopathy

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ABSTRACT

Homeopathy is the subject of frequent debates, especially in public media. This systematic review aims to give an overview of conceptual criticisms of homeopathy in the scientific literature. The literature search was conducted in four databases (EMBASE, PubMed, Web of Science, PhilPapers) on August 25, 2020. Included were peer reviewed articles in English or German criticising the basic concepts of homeopathy as main topic; excluded were articles criticising homeopathy primarily based on analysis of empirical clinical and/or preclinical data. The formal structure of publications included was evaluated regarding the recommended structure for scientific publications (IMRaD, acronym for 'Introduction', 'Methods', 'Results' and 'Discussion'). Arguments criticising the concepts of homeopathy were extracted and classified into groups. The literature search revealed 5139 articles, of which 15 articles (published between 1959 and 2020) met the inclusion criteria. These articles complied only partly with the IMRaD structure; just four articles considered with 8 or 9 IMRaD criteria the majority of the defined 11 IMRaD criteria. Extracted arguments against the concepts of homeopathy were classified into five groups: 'Conflict with current scientific principles and the foundations of modern medicine', 'Lack of a scientific basis', 'Arguments based on scientific theories', 'Ethical considerations and social consequences', 'Lack of empirical clinical evidence'. This classification is intended to provide a basis for future in-depth scientific analyses and discussions. Based on the number of articles found in the peer reviewed literature, it can be concluded that the on-going discussion about homeopathy in the public media is not reflected in a corresponding academic debate.

1. Introduction

Homeopathy has been the subject of public and academic debate ever since it was established by the German physician Samuel Hahnemann at the end of the 18th century [1–3]. It was developed as an alternative to the prevailing medical treatments of the time, which were often harsh and sometimes caused more harm than good [2]. This led Hahnemann to seek less aggressive cures; in particular, he observed curative effects when using substances that were chosen according to the 'Law of Similars' (see below) and had been serially diluted and succussed (shaken vigorously). Based on his observations, Hahnemann established the Law of Similars and the Law of Infinitesimals as two of the pillars of homeopathy.

The Law of Similars states that patients presenting with a given set of symptoms should be treated with remedies that generate symptoms that are as similar as possible when administered to healthy volunteers. The Law of Infinitesimals means that remedies in homeopathy usually are serially diluted and succussed ('potentised'), often to dilution levels beyond the inverse of Avogadro's

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number. Hahnemann developed homeopathy at a time when the concept of a “spirit-like vital force” was more common. This vital force was seen as a possible explanation for life and health, the development, existence, and treatment of diseases; and the mode of action of homeopathic remedies. Together with the idea of a vital force, these pillars constitute the fundamental concepts of homeopathy [2].

Following the discovery of microorganisms by Virchow in 1871, researchers generated explanatory models for many health issues by referring to cellular and molecular processes [4,5]. These discoveries have made the concept of a vital force, and consequently, homeopathy, appear outdated and no longer compatible with the current scientific paradigm. Nevertheless, homeopathy is used to the present day worldwide [6] and investigations indicate the presence of specific effects of homeopathic remedies [7,8], emphasising the need for further research in this field.

Upon a cursory scan of current public media, criticisms of homeopathy appear to be quite common. Homeopathy is often reported to be implausible, unscientific, and based on an outdated theory, leading to the conclusion that it should be rejected. The intensity of this debate can be assessed by searching for articles about homeopathy in daily newspapers in the database NexisUni® (LexisNexis, New York, NY, USA); 77 articles about homeopathy were found in this database within a timeframe of five years (1 January 2015–31 December 2019) in five different transregional daily newspapers in German (‘Der Tagesspiegel’, ‘Die Presse’, ‘Die Welt’, ‘Mitteldeutsche Zeitung’, ‘Die Tageszeitung’), yielding about 15 reports per year from just these five newspapers. Most of these articles displayed a negative view of homeopathy.

The intention of this systematic review was to gain an overview of the criticisms of the basic concepts of homeopathy in peer reviewed academic literature and to determine whether it mirrors the public debate. Therefore, as a starting point for further scientific discussion, we conducted a systematic review of peer reviewed articles with conceptual criticisms of homeopathy as their main topic. To the best of our knowledge, such an analysis has not been conducted previously. Based on the impression that homeopathy is frequently debated in public media and criticised as unscientific, we hypothesised that we would find a correspondingly intense discussion articulating criticisms of the basic concepts of homeopathy in the academic literature. Peer review, a recognised quality standard for scientific publications, was an inclusion criterion in our literature search [9,10]. We hypothesised that a considerable number of peer reviewed articles would criticise the concepts of homeopathy.

The secondary aim of this systematic review was to analyse the formal IMRaD structure (see below) of the publications found and to extract and classify stated arguments against the concepts of homeopathy as a basis for future in-depth analyses of the scientific soundness of the basic concepts of homeopathy.

We assessed the scientific reporting structure of the articles found using a newly developed IMRaD scoring system. IMRaD is an abbreviation for a uniform structuring of scientific articles into the sections ‘Introduction’, ‘Methods’, ‘Results’ and ‘Discussion’. A basic structure like IMRaD facilitates reading of the study and helps the reader to comprehend the research approach [9,11–14]. IMRaD generally represents one of the three primary requirements of scientific journals, together with the peer review process and editorial decisions [15]. The IMRaD text structure is recommended for scientific publications [13,16–18] and is not only a formal requirement of many journals but also one of the evaluation criteria used for peer review [12–14,19].

Additionally, we extracted the arguments against the concepts of homeopathy stated in the analysed articles and classified these arguments into groups. This classification can serve as a basis for further analysis and in-depth academic discussions in the future. Judging the validity of these arguments is beyond the scope of this investigation.

2. Methods

2.1. Literature search

A systematic literature search strategy was designed to identify peer reviewed articles that critically assessed and examined the concepts of homeopathy. Peer review was chosen as an inclusion criterion to ensure a minimum quality standard [9,10]. Peer review is sometimes criticised for being slow, subjective, expensive and inconsistent [19–22]. Despite these criticisms, it is generally accepted and supported by the scientific community. According to some publications, most researchers believe that peer review improves the quality of published texts, that there can be no quality control without this process, and that there is a need for peer review [21,23]. Furthermore, following the inclusion criteria, the articles had to focus on conceptual criticisms of homeopathy as their main topic. Publications in English or German were eligible. Non peer reviewed articles such as editorials, comments, opinions, letters, and books, and articles which raised criticisms not of the concepts of homeopathy themselves but only of its empirical foundation as assessed by experimental trials, such as in meta-analyses, clinical trials and experimental studies, or reviews thereof, were excluded. Additionally, publications were excluded if criticism of the concepts of homeopathy was solely used as an example of illustrating another main topic.

The EMBASE (Elsevier, Amsterdam, Netherlands), PubMed (National Center for Biotechnology Information, Bethesda, MD, USA), Web of Science (Clarivate Analytics, Philadelphia, PA, USA), and PhilPapers (Centre for Digital Philosophy at the University of Western Ontario, London, Ontario, Canada) databases provided the basis for the literature search. If applicable, presets within the databases EMBASE, PubMed and Web of Science were used: for publication types ‘(journal) article’ and ‘review’ and for languages ‘English’ and ‘German’. Conceptual criticisms of homeopathy in peer reviewed articles were searched for using the search string ‘(homeopath* OR homoeopath*) AND (critique OR criticism OR against OR ethics OR implausibility OR plausibility OR philosophy OR dogma OR religion OR belief OR faith OR concept OR superstition OR conviction OR skeptics OR skeptics OR skepticism OR skepticism OR weltanschauung OR ‘world view’ OR scientism OR scientificity OR ‘evidence based’ OR fundamentalism OR contradiction OR rejection OR epistemology OR legitimacy OR pseudoscience OR phenomenology OR dangerous OR harms OR ‘para medicine’) NOT meta-analysis’. In PhilPapers, it was not possible to choose presets or use the above-mentioned search string. Thus, each term in the search

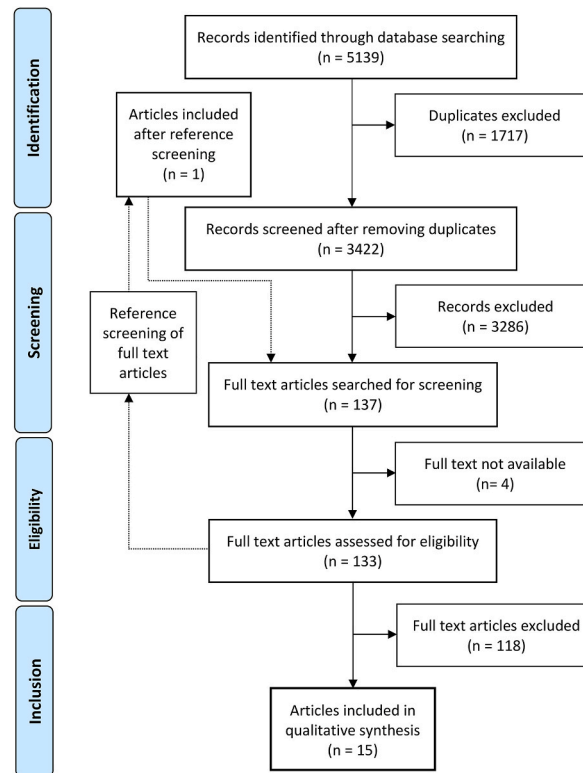


Fig. 1. PRISMA 2009 flow diagram for the inclusion process of publications in this systematic review (adapted from Ref. [24]). Numbers represent combined data from searches independently performed by two reviewers.

string had to be searched separately combined with ‘and homeopathy’ in parentheses. The search was performed on August 25, 2020.

Two reviewers independently performed the literature search applying the same search strategy (AÜ and VS). The resulting lists of articles were combined and processed using EndNote (version X9; Clarivate Analytics, Philadelphia, PA, USA). After removing duplicates, both reviewers screened the titles and abstracts for eligibility, followed by full-text screening of the remaining articles (see Fig. 1). Additionally, the reference lists of the included articles were examined to identify additional articles. Discrepancies between the reviewers were resolved through discussion.

This systematic review was performed according to the current recommendations of the ‘Preferred Reporting Items for Systematic Reviews and Meta-Analysis Approach’ (PRISMA) [24] where applicable. Due to its qualitative and exploratory design, this systematic review was not registered, nor was a review protocol prepared.

2.2. IMRaD scoring system of formal structure

An IMRaD scoring system, rating the formal IMRaD structure of the publications, was developed to score each article that met the inclusion criteria. Following the well-established IMRaD structure for academic publications, the sections ‘Introduction’, ‘Methods’, ‘Results’ and ‘Discussion’ were considered as important.

The section ‘summary’ or ‘abstract’ as an overview of the article was not rated in the IMRaD scoring system because it provides no new content. Every IMRaD section of each article was awarded points according to the required features of the section. The maximum score was 11 points. The rating system is presented in Table 1.

The points available for each section were defined as follows:

The introductory section of an article should present what is already known about the topic to the readership by providing helpful background information supported by references [25,26]. Additionally, the purpose of the publication must be explained, stating the main question and hypothesis/thesis to be addressed [9,27]. Stating a hypothesis/thesis is an important starting point for any kind of research, either experimental or philosophical. The articles could therefore be awarded up to three points in this section: one point each for background information with references, main question and hypothesis/thesis.

The methods section contains a detailed description of the procedure used to investigate the stated hypothesis/thesis. We believe that purely theoretical and/or philosophical investigations should also state their methods, especially referring to their underlying assumptions, such as how science or pseudo-science is defined in the present context. Descriptions of the methods should be as detailed as possible, so that other researchers can assess and reproduce the procedure [9,25,26]. A description of the study design, including guidelines, can also be found in this section [25]. In the IMRaD scoring system, one point was given if a method was mentioned, and an

Table 1

IMRaD scoring system to examine the formal structure of articles based on typical criteria of the IMRaD elements. Each important structural section of the peer reviewed articles was evaluated by assigning points for defined sub-elements of each section. A maximum score of 11 points was possible.

IMRaD element of the publication	Assessed criterion	Possible points
1. Introduction	a) Theoretical background with references mentioned	1
	b) Formulated main question	1
	c) Hypothesis/thesis stated	1
2. Methods	a) Methods stated	1
	b) Methods described in detail	1
3. Results	a) Results stated	1
	b) Results in accordance with methods stated	1
4. Discussion	a) Discussion of the results regarding hypothesis/thesis	1
	b) Critical analysis of own results	1
	c) Results related to other scientific investigations in this research field	1
5. Formal structure	a) Clear separation of the article in all 4 important parts of a scientific article (IMRaD)	1
Total points		11

additional point if the method was explained in detail. Any procedure mentioned to obtain the results was considered a method in this scoring system. A description of a method was regarded as detailed if the authors provided specific information regarding the techniques used.

The results section should state all the essential results obtained using the aforementioned methods, even if the results do not support the hypothesis/thesis [9,26]. In the IMRaD scoring system, one point was assigned if results were stated, and a further point if all the results mentioned were mainly based on the methodological approach described in the methods section.

It is essential for the discussion section to provide an overview of the study's major findings and their interpretation in relation to the stated hypothesis/thesis [26]. These results should also be considered in a research context [27]. This section contains a comparison of the authors' own results with those of other published studies on the topic and a discussion of any differences. In addition, a critical discussion of the strengths and weaknesses of the study is required [9]. In the IMRaD scoring system, one point was given for a discussion of the authors' own results regarding the stated hypothesis/thesis, another for a critical analysis of these results and a third point for comparison with other scientific works in the field.

The final possible point in this scoring system was for the overall structure and comprehensibility of the article, according to the IMRaD structure. The introduction, methods, and results sections of an article are built upon each other; and should be clearly distinguished. We did not assess the sequence of the IMRaD sections in our scoring system because of possible variations. Sometimes, the results and discussion sections are combined [27], although this is not recommended [25,28]. Furthermore, it is common in some journals to state the methods at the end of the text following the structure IRDaM ('Introduction', 'Results', 'Discussion' and 'Methods') [29]. Articles were assigned one point if there was a clear separation of the text in the IMRaD sections. This point was given even if the results and discussion were connected, provided both were clearly identifiable.

Two reviewers (AÜ and VS) undertook the scoring independently and discrepancies between both reviewers were resolved by discussion.

2.3. Classification of arguments against the concepts of homeopathy

As a first step towards content-related analysis, arguments against the concepts of homeopathy were extracted from the selected publications, summarised and classified into groups. Therefore, the included articles were analysed thoroughly by two reviewers (AÜ and VS) independently from each other, to identify arguments against the concepts of homeopathy. For each article, the two reviewers compiled a list of arguments. We focussed on a collection of arguments and providing a basis for future analysis and scientific discussions. Therefore, we included only genuine statements. We excluded statements that seemed to be meant only rhetorically, such as anecdotal remarks or statements criticising Hahnemann and his colleagues on a personal level, as these do not constitute criticism of homeopathy itself. Arguments were included in this analysis independent of the IMRaD scoring of the articles' formal structure. The lists of both reviewers were compared and discussed to reach a consensus, and were combined afterwards.

In the second step of this classification process, arguments that were the same or belonged to the same overarching topic were summarised and assigned to contextual groups. Every argument listed against the concepts of homeopathy was classified in one of these groups. The decision to choose and define these specific groups of arguments was critically questioned and discussed by all authors.

3. Results

3.1. Literature search

Using the search strategy described above, 5139 publications from 1877 to 2020 were identified (Fig. 1). After removing 1717

duplicates and screening the titles and abstracts, focusing on conceptual criticisms of homeopathy, 3286 articles were excluded and 136 articles remained for full-text screening. The full text was not available for four of these publications. Examination of the references in these articles revealed an additional interesting publication for full-text screening. After reading the full text of 133 articles, 118 were excluded based on the exclusion criteria. Finally, 15 peer reviewed articles that focused on conceptual criticisms of homeopathy were included in the analysis [30–44]. A total of 15 articles were published between 1959 and 2020, yielding an average publication frequency of 0.25 articles per year.

3.2. IMRaD scoring system of formal structure

The IMRaD scoring system for assessing the formal structure of articles based on the typical criteria of the IMRaD sections (Table 1) was applied to the 15 publications that met the inclusion criteria. The publications obtained total scores ranging from 1 to 9 out of 11 possible points (Table 2). Four publications met the majority of the defined criteria, reaching a total score of 8 or 9 points [39,42–44]. Six publications were lacking approximately half of the relevant criteria and gained 3 to 5 points [30,32,34,35,38,41]. Five publications gained only 1 or 2 points because features of the IMRaD structure were barely present [31,33,36,37,40]. No analysed article was structured as IRDaM.

3.3. Classification of arguments against the concepts of homeopathy

Arguments against the basic concepts of homeopathy presented in the 15 articles were extracted, summarised into 13 arguments, and classified into groups. The following five groups of arguments were compiled (see Table 3):

Group A: Conflict with current scientific principles and the foundations of modern medicine. Group A contains three arguments that essentially expound the position that homeopathy is obsolete, unscientific, implausible, or irrational.

Group B: Lack of a scientific basis. Group B contains statements that the mode of action of the homeopathic remedies had not yet been identified.

Group C: Arguments based on scientific theories. Group C contains criticisms based on arguments from philosophy of science.

Group D: Ethical considerations and social consequences. The arguments of Group D describe homeopathy as dangerous for science and patients, deception of patients and self-deception of therapists, a waste of resources, and profit-seeking, a practice that is not ethically justifiable.

Group E: Lack of empirical clinical evidence. Group E comprises arguments pointing to a lack of clinical evidence for homeopathic remedies, criticism of homeopathy trials and lack of reproducibility of the studies.

Table 4 provides an overview of the publications that contain arguments against the concepts of homeopathy. The publications by Hopff [34–37] are nearly identical and it was therefore decided to consider them as one publication for this overview.

Twelve of the total 13 arguments were considered by the publication of Schmacke [41] which gained 5 out of 11 total points in the IMRaD scoring.

Cukaci et al. and Grams, Hopff, Marx, and Smith [30,31,34–37,40,43] refer to eight to ten arguments in their publications. Totals of 1–4 points were given to these articles in the IMRaD scoring with the exception of the publication by Smith [43] which was given 8 points. Three to six arguments were found in the publications of Grimes, Hausteine and Kurz [32,33,38] which were given 2–5 total IMRaD points, as well as in the works of Martini, Sehon et al. and Weymayr [39,42,44] with an IMRaD scoring of 9 total points.

All publications analysed [30–44] considered arguments A1 and A2, which state that homeopathy is outdated, in contradiction to

Table 2

Results from the scoring system of the IMRaD structure for the 15 articles included in this systematic review: Evaluation of important criteria of the formal structure of scientific texts resulting in a total score for each article. Checkmarks show which criteria have been met and hyphens mark missing criteria. A description of each criterion is given in Table 1.

Publication	First author initials	Introduction			Methods		Results		Discussion			Formal structure	Total score out of 11	
		1a	1b	1c	2a	2b	3a	3b	4a	4b	4c			5a
Cukaci et al., 2020	CC	✓	✓	–	–	–	✓	–	–	–	–	✓	–	4
Grams, 2019	NG	–	–	–	–	–	✓	–	–	–	–	–	–	1
Grimes, 2012	DG	✓	✓	–	✓	✓	✓	–	–	–	–	–	–	5
Hausteine, 1996	KH	✓	–	–	–	–	✓	–	–	–	–	–	–	2
Hopff, 1987	WH	✓	–	–	–	–	✓	–	–	–	–	–	–	2
Hopff, 1990	WH	✓	–	–	–	–	✓	–	–	–	–	–	–	2
Hopff, 1993	WH	✓	–	✓	–	–	✓	–	–	–	–	–	–	4
Hopff, 1996	WH	✓	✓	–	–	–	✓	–	–	–	–	–	–	3
Kurz, 1992	RK	✓	✓	–	–	–	✓	–	–	–	–	–	–	3
Martini, 1959	PM	✓	✓	✓	✓	✓	✓	✓	–	✓	–	✓	–	9
Marx, 1985	HM	–	–	–	–	–	✓	–	–	–	–	✓	–	2
Schmacke, 2020	NS	✓	✓	✓	–	–	✓	–	–	–	–	✓	–	5
Sehon et al., 2010	SS	✓	✓	✓	✓	✓	✓	✓	–	✓	–	✓	–	9
Smith, 2012	KS	✓	✓	–	✓	✓	✓	✓	–	✓	–	✓	–	8
Weymayr, 2013	CW	✓	✓	–	✓	✓	✓	✓	–	✓	–	✓	–	9

Table 3

Classification of arguments against the concepts of homeopathy found in the 15 peer reviewed articles analysed. First author initials (see Table 2) refer to the name of the first author of the publication in which the corresponding argument was found.

Classification of arguments against homeopathy		Sources
Group A: Conflict with current scientific principles and the foundations of modern medicine		
A1	Homeopathy is based on antiquated scientific knowledge, and has not evolved in over 200 years. The concepts of homeopathy and explanatory models for the effect of homeopathic remedies contradict current physical and chemical laws and are refuted by modern medicine.	CC, CW, DG, HM, KH, KS, NG, NS, PM, RK, SS, WH
A2	Homeopathy is implausible, irrational, dogmatic and unscientific.	CC, CW, DG, HM, KH, KS, NG, NS, PM, RK, SS, WH
A3	Homeopathy only observes, collects and treats symptoms whilst lacking an accurate diagnosis. Homeopathic remedies are chosen phenomenologically on the basis of an incoherent collection of symptoms called 'repertory' but without any ordering principle based upon the underlying disease, as is the norm in conventional modern medicine.	HM, NS, PM, RK, WH
Group B: Lack of a scientific basis		
B1	Mode of action of homeopathic remedies has not yet been identified.	CC, HM, KS, NS, RK, SS, WH
Group C: Arguments based on scientific theories		
C1	Homeopathy should be rejected on the basis of two philosophy of science concepts: the 'simplicity principle' and 'concept of scientability'.	CW, NS, SS
C2	The concepts of homeopathy are based on faith and ideology. Homeopathy is best considered as a world view, religion or sect.	CC, CW, HM, KH, NG, NS, WH
Group D: Ethical considerations and social consequences		
D1	Homeopathy is dangerous for science and for patients.	KS, NG, NS, RK, WH
D2	Homeopathy deceives patients and induces self-deception of therapists.	NS, PM
D3	Homeopathy is a waste of resources and a for-profit activity.	CC, HM, KS, NG, NS, WH
D4	Homeopathy is ethically unjustifiable, even when used as placebo if not declared as such.	CC, KS, NS
Group E: Lack of empirical clinical evidence		
E1	There is no clinical evidence that homeopathic remedies are effective beyond placebo. Homeopathic clinical studies are full of methodological and statistical flaws.	CC, CW, DG, HM, KS, NG, NS, PM, RK, SS, WH
E2	Homeopathic drug trials with healthy people are not carried out to today's standards; many different symptoms are observed in these drug trials that can not all have been generated by the homeopathic remedies and can not be reproduced.	CC, HM, KS, NG, WH
E3	The principle of similarity is based on a wrong observation: Hahnemann's self-experiment with cinchona is not reproducible and it is questionable whether cinchona is able to cause fever.	CC, HM, KH, NG, NS, PM, WH

Table 4

Overview about which analysed publication contains which arguments against the concepts of homeopathy. For better overview in which publications the corresponding arguments were found, first author initials are listed. Checkmarks indicate mentioned arguments and hyphens mark not mentioned arguments in the respective publication. For a description of the argument codes and the arguments themselves see Table 3. In addition, the total IMRaD score of the publications is stated (see Table 2).

Publication	First author initials	Argument code													Total IMRaD score
		A1	A2	A3	B1	C1	C2	D1	D2	D3	D4	E1	E2	E3	
Cukaci et al., 2020	CC	✓	✓	-	✓	-	✓	-	-	✓	✓	✓	✓	✓	4
Grams, 2019	NG	✓	✓	-	-	-	✓	✓	-	✓	-	✓	✓	✓	1
Grimes, 2012	DG	✓	✓	-	-	-	-	-	-	-	-	✓	-	-	5
Haustein, 1996	KH	✓	✓	-	-	-	✓	-	-	-	-	-	✓	✓	2
Hopff, 1987/1990/1993/1996	WH	✓	✓	✓	✓	-	✓	✓	-	✓	-	✓	✓	✓	2/2/4/3
Kurz, 1992	RK	✓	✓	✓	✓	-	-	✓	-	-	-	✓	-	-	3
Martini, 1959	PM	✓	✓	✓	-	-	-	-	✓	-	-	✓	-	✓	9
Marx, 1985	HM	✓	✓	✓	✓	-	✓	-	-	✓	-	✓	✓	✓	2
Schmacke, 2020	NS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	5
Sehon et al., 2010	SS	✓	✓	-	✓	✓	-	-	-	-	-	✓	-	-	9
Smith, 2012	KS	✓	✓	-	✓	-	-	✓	-	✓	✓	✓	✓	-	8
Weymayr, 2013	CW	✓	✓	-	-	✓	✓	-	-	-	-	✓	-	-	9

current physical and chemical laws, irrational and unscientific. Argument E1 states that homeopathy is not effective beyond the placebo effect and criticises the quality of homeopathic clinical studies. This argument was considered in all articles except for that of Hausteil [33]. Only the publications by Martini and Schmacke [39,41] referred to argument D2, claiming homeopathy to be deception of patients and self-deception of therapists.

4. Discussion

In this systematic review, a literature search revealed 15 publications that met the inclusion criteria, spanning a time frame of more than 60 years (1959–2020), corresponding to a publication frequency of 0.25 articles/year. There were two periods within these 60 years during which most publications were published: five articles between 1990 and 1996 and seven between 2010 and 2020. Thus, there seem to be phases of greater interest in this topic, possibly related to public or political debates. The absolute number of 15 peer reviewed publications containing conceptual criticisms of homeopathy within the past 60 years seems small, given the frequency at which homeopathy is discussed in the public media. Our initial hypothesis was that there would be a correspondingly intense academic discussion with criticisms of the concepts of homeopathy in peer reviewed journal articles. As our literature search yielded only 15 articles published over 60 years, we conclude that our initial hypothesis must be rejected and that an in-depth scientific debate around the concepts of homeopathy has hardly taken place.

4.1. Completeness of literature search

Some publications in peer reviewed journals identified in our literature search criticised the concepts of homeopathy as an example in the context of a different main topic [45–50]. Based on our inclusion criteria, these publications were excluded from further analysis because we included only articles that focussed on conceptual criticisms of homeopathy as their main topic.

Older publications not included in the current databases could not be identified by our search strategy. Thus, there could be an unknown number of older publications that in principle would meet our inclusion criteria; however, we assume that the main outcome of our investigation regarding the publication frequency of such articles in recent decades would not change.

Because the focus was on publications which critically addressed the concepts of homeopathy, we excluded publications which solely claimed a lack of empirical or experimental evidence.

By focusing on four main scientific databases (PubMed, EMBASE, Web of Science, and PhilPapers), performing a search with broad search terms, and having two reviewers independently assess the results, we assume that we identified most of the relevant literature in this field.

4.2. IMRaD scoring system of formal structure

The IMRaD format was developed and adopted in the course of the 20th century [51] and came out of a long period of observation and analysis of the structure of scientific articles [28]. Currently, this text structure is generally recommended for scientific publications [11,13,14,16–18] and is a formal requirement of many journals used for peer reviewed publications [11–14,19]. Even if the IMRaD structure is more common in experimental research, its basic elements apply to all academic texts; the aim needs to be presented clearly, the approach needs to be comprehensible, and the results need to be discussed with reference to the relevant literature. Formatting a scientific publication according to the IMRaD structure promotes understanding of the study [11–14,51].

In our IMRaD scoring system, only four out of 15 articles had scores of more than 7 (out of 11 possible) points and complied with the majority of IMRaD features. The remaining eleven articles followed this structure only partly and gained 5 or fewer points (see Table 2). In these cases, it was challenging to identify and evaluate the IMRaD elements and score them, especially if the analysed articles had no clear formal structure or IMRaD sections.

Within the IMRaD scoring system, some points are interconnected. For example, if point 2a for mentioning methods was not awarded, the publication could not gain point 3b for relating the results to the methods. Similarly, not gaining point 1c to set a hypothesis/thesis rules out point 4a for discussing the results in relation to the hypothesis/thesis. Furthermore, if an entire section was missing, no final point 5a was given for following the IMRaD structure. This reflects the importance of all sections, each of which is regarded as necessary for article comprehensibility. If no method was described, it would be much more difficult to understand how the results were obtained. Because the scoring was not always unambiguous, two reviewers (AÜ and VS) independently applied the IMRaD scoring system and then discussed differences to arrive at a common rating, in order to minimise bias.

We did not expect that so many of the authors would fail to provide references supporting their claims, or to discuss their own results in relation to other findings in this research field. This applied to the introductory section in two cases [31,40] and to the discussion section in eleven of the included articles [31–39,42,43]. Without reference, it is unclear how a stated result relates to the findings of other researchers.

The value of the IMRaD text structure for publication has been critically discussed. It is argued that the IMRaD structure was not developed to improve the quality of scientific articles but to meet the requirements of reporting research [52]. In addition, it is argued that the overall IMRaD structure of a scientific text should not be considered as a criterion of quality because every section must be assessed individually [53]. Furthermore, criticism of the entire IMRaD structure can be found with proposals for change; omitting to mention the process of rethinking and improving study design would not show the reality of scientific progress [9,52,54]. However, one can argue that a scientific article should show what was done in a clear, understandable, and detailed manner, so that other researchers can assess, understand, criticise and reproduce it. Therefore, it is important for scientific articles to be structured and

straightforward. The IMRaD structure promotes this by facilitating the reading of publications and locating specific information [11–14]. In our opinion, this should also apply to academic articles in philosophical and ethical fields of research. For these reasons, analysis of the IMRaD structure has also been used to assess the quality of scientific texts [55].

Hence, assessing the IMRaD structure using our newly developed IMRaD scoring system was the first step in analysing and classifying the articles included in the present review.

The absence of the IMRaD structure in a given article indicates that it does not comply with the recommended standards for scientific articles; however, this does not necessarily mean that the arguments against the concepts of homeopathy stated in these articles are of low quality. This review is not a qualitative analysis of those arguments; for this purpose, further investigation using an appropriate methodology is necessary.

4.3. Classification of arguments against the concepts of homeopathy

To identify arguments relevant to our investigations, the selected publications were screened for regarding genuine statements criticising the concepts of homeopathy.

As a first step towards analysing these arguments, we classified them into five groups (see Table 3). Other classifications are also possible, such as focusing on outcomes for society and classifying by alleged harmful consequences for patients, scientific reputations, or economies. We saw the advantage of our classification system using these five groups in that it created a list of arguments levelled against the concepts of homeopathy as a basis for further discussions at the academic level. Therefore, a classification that separates scientific arguments from ethical conclusions is appropriate.

The first two arguments of the Group E, ‘Lack of empirical clinical evidence’ – a claimed lack of clinical evidence for homeopathic remedies and criticisms of homeopathic studies or homeopathic drug trials – were included in the arguments list although they are not technically conceptual criticisms. However, these arguments support conceptual criticisms in a broader sense as any argument in favour of homeopathy would be untenable in the absence of a minimum of evidence.

5. Conclusion

This systematic review aimed to provide an overview of peer reviewed articles which criticised the concepts of homeopathy. We hypothesised that these concepts would be discussed extensively in peer reviewed scientific journals because of our impression that discussions on homeopathy regularly occur in public media. Using the chosen broad search strategy, only 15 publications spanning more than 60 years met the inclusion criteria. Therefore, it seems that discussions in the public media are not reflected in a corresponding academic debate in peer reviewed journals.

The IMRaD scoring system was used to examine compliance with the formal IMRaD structure recommended for scientific publications. Most of the 15 articles found in the literature search did not adhere to the IMRaD structure. Just four out of 15 articles met the majority of the defined 11 IMRaD criteria, attaining a total score of 8 or 9 points each.

Additionally, to gain a list of arguments against the concepts of homeopathy as a basis for future academic discussions, we summarised and classified the arguments stated in the analysed articles into five groups: ‘Conflict with current scientific principles and the foundations of modern medicine’, ‘Lack of a scientific basis’, ‘Arguments based on scientific theories’, ‘Ethical considerations and social consequences’ and ‘Lack of empirical clinical evidence’.

Contrary to our hypothesis, the critical discussion on the basic concepts of homeopathy does not seem to be very intense at the academic level. Therefore, we conclude that a scientific discussion about the basic concepts of homeopathy has not really taken place in the academic literature, contrary to the perception circulated in the mainstream public media. Further in-depth analysis of the quality of the arguments cited against the concepts of homeopathy is necessary to lay the basis for a high-quality discussion of these concepts in scientific literature.

Data availability statement

The data associated with the study have not been deposited into a publicly available repository, but are available upon reasonable request.

CRediT authorship contribution statement

Viola Maria Schulz: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Annekathrin Ücker:** Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. **Claudia Scherr:** Methodology, Supervision, Writing – review & editing. **Alexander Tournier:** Methodology, Supervision, Writing – review & editing. **Tim Jäger:** Conceptualization. **Stephan Baumgartner:** Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

Declaration of competing interest

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

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