Hedging in Medical Articles from Two Pandemics

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Abstract

As academic and scientific disciplines continue to evolve, it remains essential for scholars to present their claims with caution. Hedging, a vital linguistic tool, is pervasive in academic writing, although its boundaries are not strictly defined. This research tracks the changes in the use of hedging within medical literature, underpinning the idea that linguistic patterns reflect societal changes. Our study focuses on the analysis of hedging devices within a corpus of 30 medical articles, spanning two distinct pandemic periods: the 1918-1919 influenza pandemic and the 2020-2021 COVID-19 pandemic. A comprehensive review, involving contextual analysis, was conducted for each article to identify hedging instances. Types of hedges were documented and their frequency was calculated, while ambiguous cases were clarified through in-depth discussions and consistency checks. Our analysis confirms that contextual conditions influence both the frequency and types of hedges used. The results show a significant decrease in overall hedging frequency between the two pandemic periods, with approximators declining sharply while shields remained stable. This shift, along with a reduction in the variety of hedging devices used, suggests an evolution towards more precise quantification and a more formulaic style in scientific writing, while maintaining caution in knowledge claims. The conclusions drawn in this paper contribute to our understanding of scientific discourse and its evolution.

Keywords: hedges, medical articles, COVID-19, Spanish flu

1. Introduction

Scientific discourse presents unique characteristics. As disciplines constantly evolve, there is a need for writers to present their claims with certain caution. Scientific writing reconciles the objectives of asserting originality and pursuing peer validation, a process that resembles negotiation where authors simultaneously assert and mitigate claims, use strategies that promote a sense of community, recognize shared knowledge, and honor different perspectives (cf. Crompton, 1997; Hyland, 1996, 1998a, b). As such, hedging is an important strategy in academic and scientific discourse and has been extensively researched in different genres and discourse types. Despite much discussion about hedges (Lakoff, 1972; Fraser, 2010; Brown & Levinson, 1978; Hyland, 1995; Salager-Meyer, 1995; Crompton, 1997; Lewin, 2001), there is still no clear agreement on their exact definition and structure. The challenge arises from the polypragmatic nature of hedging devices, which can express a range of meanings, often simultaneously. Consequently, they cannot be classified into distinct categories, which makes it challenging to clearly distinguish one meaning from another (Hyland, 1996). Despite this challenge, careful contextual analysis can bridge the gap between a writer's intentions and the language employed (Salager-Meyer, 1994).

Despite extensive research on hedging, few studies have approached it from a diachronic perspective. The present paper takes on a socio-historical approach in tracking the trends in hedge distribution and change under the premise that the language content reflects the changes in society (Salager-Meyer & Defives, 1998). The purpose of the paper is to describe and explain changes in the use of hedging devices by comparing two periods: 1918-1919 (Spanish flu) and 2020-2021(COVID-19).

The influenza pandemic of 1918-1919, also known as the Spanish flu (Flu), was the most devastating pandemic of the 20th century. Although its exact origin remains unclear, it spread in three waves of varying severity, infecting approximately 500 million people worldwide. Estimates of the death toll vary, ranging from 17 million (Spreeuwenberg et al., 2018) to between 50 and 100 million (Johnson & Mueller, 2002). Considering that the world population was only a fraction of what it is today, this would account for 175 to 350 million people today (Barry, 2005).

The first cases of SARS-CoV-2, the virus responsible for the COVID-19 pandemic, emerged in China in December 2019. The virus rapidly spread across the globe, infecting more than 300 million people and resulting in over 5 million deaths to date, according to real-time data from the Johns Hopkins Coronavirus Research Centre. Despite the differences between these two pandemics, they were chosen for comparison due to the similarity in scientific uncertainty, with both periods posing significant threats to public health.

This research aims to provide a quantitative corpus-based analysis of hedging devices used in medical articles. These articles were published during two separate epidemic periods, each marked by high uncertainty and separated by a span of 100 years. The comparable scenarios offered by these two periods provide a unique opportunity to observe changes in language use over time. The focus of this paper

is to answer the following research questions:

1) How has the overall frequency of hedges changed?

2) Has the outbreak of a crisis influenced the frequency?

3) What are the preferred types of hedges in each period?

This paper is structured as follows: First, it examines the concept of hedging, analyzing its underlying principles and challenges. This is followed by a review of previous diachronic research. The subsequent sections outline the methodology, present the results, and provide a discussion of the findings and their implications. Finally, the paper concludes by summarizing the key insights.

2. Literature Review

2.1 A Brief Account of the Concept of Hedging

Despite being a well-established concept in linguistics, the functions and forms of hedging exhibit considerable variation across the literature. The term *hedge* was first introduced by Lakoff (1972) to describe linguistic expressions such as *sort of* that "make things fuzzier or less fuzzy" (p.195). Brown and Levinson (1978, 1987) later expanded the concept of hedging to include the attenuation of the illocutionary force of a speech act. Since then, multiple scholars have proposed various classifications of hedges, reflecting the multifaceted nature of the concept.

For instance, Prince et al. (1982) categorize hedges into *approximators* and *shields*. Approximators modify the truth value of a statement, while shields express uncertainty about the speaker's commitment to the proposition. The following examples from Prince et al. (1982, p. 4) illustrate this distinction:

(1) a. His feet were blue.

  b. His feet were *sort of* blue.

  c. *I think* his feet were blue.

In 1b, the quality of being blue is modified by the phrase *sort of*, rendering the interpretation "His feet were non-prototypically blue" (pp. 4-5) and, therefore, modifying the proposition in 1a. However, there is no doubt of the speaker's commitment to the truth value of the proposition. By contrast, while 1c conveys the same proposition as 1a, the speaker is not fully committed to its truth value, as indicated by the phrase *I think*.

Prince et al. (1982) further subdivide these categories into two types. Approximators include *adaptors* (Lakoff's *hedges* - markers such as *sort of* that indicate class membership based on prototypicality features of an item) and rounders (markers such as *approximately*, which convey a range or imprecision). Shields, however, convey a certain level of uncertainty regarding the speaker's commitment to the truth condition of a proposition. These shields can be categorized into *plausibility shields,* which express doubt, and *attribution shields*, which attribute the proposition to someone other than the speaker.

Similarly, Hübler (1983) refers to *hedges* as words or phrases that weaken the validity of a claim, and distinguishes them from *understatements*, which render the propositional content indeterminate. Caffi (1999, 2007), on the other hand, proposes a three-category taxonomy. *Bushes* affect the truth value of the proposition, *hedges* affect the illocutionary force or speaker's commitment to a speech act, and *shields* ascribe responsibility for the information provided to a source other than the speaker.

Although some words and phrases are commonly used to illustrate prototypical hedges, it is important to note that hedging does not comprise a closed set of linguistic items. Rather, hedging is an open-ended functional class determined by authors' intentions. Salager-Meyer (1995) summarizes four main reasons for hedging. First, hedging can be used as a face-saving strategy, to reduce personal liability in claims that might potentially be proven false. Secondly, it is also a means to show the degree of certainty in and accuracy of a claim. Rather than being a signal of imprecision, this actually allows the author to make a more truthful and precise claim by citing the state of their current knowledge. In addition, following Myers (1989), hedging is also a politeness strategy by which new claims are tentatively presented to the research community. Finally, it has been claimed that the use of hedging is to some extent motivated by authors conforming to the conventions of established writing styles (Banks, 1994). These motivations for using hedges need not necessarily exclude one another, for making accurate claims is a means of saving face. Similarly, the necessity of advancing claims with caution, and giving readers the chance to evaluate these claims, might have led to hedging becoming conventionalized.

If hedges are defined by authors' intentions, it follows that determining whether a particular expression was used as a hedge is not always possible. Furthermore, the inherent polysemy of certain words creates ambiguity, making it challenging - if not impossible - to discern the authors' intentions in some contexts. One such case is presented by modals like *may* and *could*, which can have root or epistemic meanings, as in the following examples by Hyland (1998a):

(2)   Regulation of D1 protein degradation *may* be controlled by occupation of the Q_B binding site.

(3)   This *could* be sufficient for hemoglobin to function in the facilitation of diffusion of O2 to the rapidly respiring cells in the vicinity of the root tip and in…

As Hyland explains, the examples in (2) and (3) are ambiguous between a root (e.g., "It is possible for this to happen under certain circumstances") and an epistemic (e.g., "I believe that this can happen/explain what happens") meaning.

The various definitions and theoretical accounts of the concept have led to wider (e.g., Salager-Meyer, 1994; Hyland, 1995) and narrower (e.g., Crompton, 1997) conceptions of hedging. According to Crompton (1997), "A hedge is an item of language which a speaker uses to explicitly qualify his/her lack of commitment to the truth of a proposition he/she utters" (p. 281), emphasizing that this definition applies only to propositions, which represent the main speech act in academic writing. Similarly, in Hyland's (1995) view, "items are only hedges in their epistemic sense and only when they mark uncertainty" (p. 34). However, Hyland expands this definition to include speakers' attitudes and proposes that hedges are used to show: "a) a lack of complete commitment to the truth of a proposition or b) a desire not to express that commitment categorically" (p. 34).

In this paper, the authors adopt Fraser's (2010) definition as a starting point: "HEDGING is a rhetorical strategy, by which a speaker, using a linguistic device, can signal a lack of commitment to either the full semantic membership of an expression (PROPOSITIONAL HEDGING) or the full commitment to the force of the speech act being conveyed (SPEECH ACT HEDGING)" (p. 17). For ease of reference, the term *shield* will be used to refer to speech act hedging and the term *approximator* to refer to propositional hedging. Although the nature of hedging is acknowledged to be essentially epistemic, Hyland's broader view of hedging as a more general mitigation strategy is also adopted. In this sense, devices that mitigate the force of what is being said, such as hedged performatives, are also included in this study.

Both shields and approximators can be realized by different parts of speech. Table 1 shows prototypical examples of each category.

Table 1. Shields and approximators, their different part of speech realizations with examples

Shields	Modal verbs	*may, might, could…*
	Lexical verbs	*think, believe, suggest…*
	Adjectives	*possible, probable…*
	Adverbs	*possibly, probably…*
	Nouns	*probability, likelihood*
	Conditionals	*if*
	Other	*Such evidence as has been collected confirms the conclusion*
Approximators	Adjectives	*approximately, about*
	Adverbs	*relative, substantial*
	Nouns	*number, degree*
	Determiners?	*most, something*
	Phrases	*at least, most if not all*

2.2 Previous Diachronic Research

Hedging has been extensively researched, and the number of studies and dimensions studied is a testament to the complexity of the topic. There are studies on hedging in different registers, disciplines, genres, periods, and languages. Some studies examine hedging on its own; some as part of broader investigations into academic or scientific discourse.

Diachronic research into academic/scientific discourse has found notable changes in language use over time. Atkinson (1996) examines scientific writing from 1675 to 1975 in one particular journal, the *Philosophical Transactions of the Royal Society of London*. Results show a gradual decrease in author-centered rhetoric, which is realized by a number of linguistic features, stance markers (including hedges and possibility modals) being one of them.

Gross et al. (2002) trace the development of scientific articles from the 17th to the 20th centuries. Even though their study has a broad scope, they quantify hedges as one of the features shaping the style of communication. No clear increasing or decreasing pattern emerges from their data, as the use of hedging varies from century to century: 0.2 per 100 words in the 17th century, 1.3 in the 18th century, 0.7 in the 19th century, and 2.2 in the 20th century. The authors also present data from the 20th century divided into 25-year intervals. Their data shows no difference in the amount of hedging from the beginning (2.1/100 words from 1901 to 1925) to the end of the century (2.2/100 words from 1976 to 1995)[i].

Riccioni et al. (2021) examine uncertainty in a corpus of medical articles from the *British Medical Journal* from 1840 to 2007. However, although their classification of uncertainty markers partially overlaps with other authors' classification of hedges, this study focuses only on a specific type of uncertainty markers, namely, subjectivity uncertainty markers (i.e., those in which there is an explicit reference to the author(s)). While, in line with Atkinson (1996), subjectivity uncertainty markers decline over the 167-year period, related research by the same authors suggests that uncertainty in general remained stable. Total uncertainty fluctuated between 16% and 23% in the four periods studied, a difference that was not found to be statistically significant (Zuczkowski et al., 2016, as cited in Riccioni et al., 2021).

Another diachronic study that covers a broad time span and focuses on medical English is Salager-Meyer and Defives (1998). The authors analyze texts from 1810 to 1995 across four different categories (shields, approximators, agentless passives, and emotionally-charged expressions). The findings show a slow and gradual decrease of hedges over the 185-year period, although a closer look at the data suggests that this is due to a much higher frequency of approximators in the 19th century. Whereas the distribution of each category is relatively stable from 1810 to 1930 (when each category accounts for 20 to 32% of the total hedges used), approximators decline to 12% and shields increase to 40% from this point onwards. Regarding the sharp decline of approximators, the authors argue that measurements were not as important in 19th-century medicine, when "research results used to be reported vaguely and qualitatively by means of adverbs or adverbial expressions" (Salager-Meyer & Defives, 1998, p. 156), as they are today. At the same time, the increase in the use of shields

reflects "the cautiousness, humility, diffuseness and tameness of today's scientific writing" (Salager-Meyer & Defives, 1998, p. 161).

Hyland and Jiang (2016) compare stance features in journal articles from four disciplines (applied linguistics, sociology, electrical engineering, and biology) at three different points in time (1965, 1985 and 2015). The concept of stance, according to the study, encompasses three main components: evidentiality (including hedges and boosters), affect, and presence. Focusing on hedges in particular, data shows that their use has decreased in applied linguistics and sociology articles over the 50-year period, but increased in electrical engineering and biology articles. This latter decrease, however, is not as pronounced as the increase in the other two disciplines.

In another study, Liu and Yang (2021) replicate Hyland and Jiang's (2018) design (which uses the same corpus as their 1996 study) at three similar points in time (1960, 1990 and 2020), but using four different disciplines: education, history, mechanical engineering and physics. Contrary to Hyland and Jiang, they find a decrease in hedging in all four disciplines.

However, Poole et al. (2019) show that stance does not necessarily evolve in the same direction even when closely related disciplines are considered. Their study examines the use of epistemic stance markers in biochemical research published between 1972 and 2017. In particular, they study research articles on a specific topic, chemotaxis, citing a 1972 seminal publication. Although the time periods are similar and disciplines related, Poole et al.'s results do not replicate Hyland and Jiang's results for journal articles in biology. In contrast, their findings show a downward trend in the use of hedging in general. The authors emphasize the difference between examining a particular topic/phenomenon and more general investigations into, for example, a discipline. Thus, they conclude that their findings correspond to the development of a particular phenomenon whose understanding has increased with time, leading to a greater consensus and less uncertainty.

Dealing with changes in discourse in more recent times, Rezaei et al. (2021) investigate the evolution of stance markers in three leading applied linguistics journals at three points in time: 1996–2002, 2003–2009, and 2010–2016. Data provided shows a 12% decrease in the use of hedging over these 20 years, with frequencies per 10,000 words totaling 574.6 in the first period, 505.9 in the second, and 502.9 in the third. Similarly, Yao et al. (2023) analyze recent changes in the evolution of hedges expressing doubt and uncertainty in the journal *Science*. Their study covers 25 years, from 1997 to 2021, and their findings show a significant decline in the use of these hedges.

In short, these studies showcase the complexity of the topic and the multiple variables that may affect the results. Some studies focus on hedging in particular, whereas others have a broader scope and examine stance or metadiscourse, where hedging is just one of the dimensions. Some studies focus on a particular discipline or journal, or even a particular topic, whereas others offer comparisons across different disciplines, or yet, scientific discourse in general. Some studies cover broad time spans, while others look at (perhaps subtler) changes in narrower periods. Differences also exist in the way data is collected and the way results are analyzed and presented, not to mention the difficulty in conceptualizing hedges discussed in the previous section. These differences in study design mean that direct comparisons can be difficult.

Collectively, however, it is possible to extract some general trends. Many studies have found a decline in the use of hedging over time, although a more fine-grained analysis can provide important insights. While there might be specific reasons for the decline in hedging in more recent times (see Vinkers et al., 2015; Cao et al., 2020; Hyland & Jiang, 2021b, for accounts on how increasing publication competition might be leading to a more promotional discourse where uncertainty is played down in favor of more positivity), it is not so clear whether hedging has been steadily decreasing over time. Some studies do not find a decreasing trend in the use of hedges or uncertainty markers (Gross et al., 2002; Zuczkowski et al., 2016). Salager-Meyer and Defives (1998) do find a slow general decrease, but this is mostly due to approximators being a lot more frequent before than they are now. Shields, by contrast, are much more common than approximators from the mid-20 century onwards.

2.3 Language in Crises

Some recent synchronic research has also advanced the question of whether a time of crisis can have an impact on the way research is reported. For example, Bordignon et al. (2021) examined the use of positive, negative, and hedge words in preprint abstracts at the onset of the COVID-19 pandemic (from January 1 to April 12, 2020) and compared them to those published in 2019. They found that *can* and *may* were the most frequent hedges, and that there was an increase both in the number of hedges and in the number of abstracts containing hedges during the pandemic. In addition, Hyland and Jiang (2021a) compared *hyping* in medical research before and right at the start of the pandemic (between January and July 2020). *Hype* is understood as the use of language intended to promote, embellish, or even exaggerate aspects of research, and the authors searched the corpora (two sets of 200 articles each) for a list of 400 hype items which included boosters and positive attitude markers. While the findings show an overall increase in hype, the ratio between boosters and attitude markers varies between the two corpora. In the COVID-19 corpus, boosters make up a smaller percentage of the total use of hyping devices, which the authors hypothesize is related to the novelty of the virus and the difficulty in establishing certainties. These two studies, together with Poole et al. (2019), suggest that the novelty of a topic, together with the urgency that accompanies a health crisis, can influence the features of discourse.

3. Method

The methodology employed in this study is informed by the research objectives and the theoretical background. This study used a corpus-based methodology, as it has several advantages. Corpora facilitate the identification of linguistic patterns that may otherwise be overlooked by researchers. They provide information regarding the frequency of occurrence and co-occurrence of a linguistic item with

other things. As evidenced by linguistic change, even less common patterns or borderline situations can offer valuable insights into a system's structure and dynamic features. Furthermore, corpora provide access to contextual information of linguistic items. This is particularly beneficial for studying pragmatic phenomena like hedging, where the precise function is heavily dependent on co(n)textual elements, with different contexts yielding different implicatures.

Our analysis compared 15 papers written during the Influenza pandemic (1918-1919) to 15 papers produced during the COVID-19 pandemic (2020-2021). The Flu papers comprised 48933 words, whereas the COVID-19 papers contained 57556 words. The articles from each period were selected primarily based on the similarity of their topics, types, and lengths. The corpus size was determined based on similar research[ii].

Each article was carefully examined for the presence of hedges. A manual search was the preferred method for this study due to the polypragmatic nature of hedges, and the open-endedness of this functional category. To ensure thoroughness and accuracy, every article was reviewed three times by each of the authors, which also influenced the size of the corpus. During the manual search process, the authors encountered ambiguous cases, which were resolved through detailed discussions and the following tests, which were applied depending on the type of hedge:

1. Crompton (1997) proposed a test to identify hedging in academic writing. This test asks, "Can the proposition be restated in such a way that it is not changed but that the author's commitment to it is greater than at present?" (p. 282). If the answer is yes, then the proposition is considered hedged. To illustrate this concept, consider the example: "Little information exists on the frequency and severity of the disorder." Attempts to restate this with greater commitment invariably change its meaning. For instance, "Information exists on the frequency and severity of the disorder" or "No information exists on the frequency and severity of the disorder" (ibid) both alter the original proposition's intended meaning. This demonstrates how the original statement uses hedging to convey a specific level of certainty or uncertainty about the available information.

2. The Negation and Procedural Expressions Test posits that true hedges, as procedural expressions, lack inherent meaning and cannot be directly negated without changing the sentence's meaning. However, they can be transformed into questions while maintaining their procedural nature. For example, "It may be possible that..." becomes unnatural when negated but retains its hedging function when turned into a question: "May it be possible that...?"

3. The Omitting Hedges and Sentence Validity Test suggests that removing a true hedge should not render a sentence ungrammatical or illogical, though it may alter the level of assertion. For instance, "It could be argued that this approach has limitations" remains valid when shortened to "This approach has limitations," albeit with increased assertiveness. This test helps distinguish genuine hedges from essential sentence components.

After conducting a manual search, the authors compiled a list of hedges. Subsequently, an extra layer of automatic searches was performed to verify the consistency of our findings. All identified hedging devices were then categorized based on previously defined classifications. Some words, due to their polysemy, required additional discussions for accurate categorization. All in all, the authors conducted a contextual analysis to identify hedges, documented their frequency, and calculated their percentages relative to the total word count.

4. Findings and Discussion

The subsequent section will present the research findings, with each result followed by a discussion.

4.1 Hedge Frequencies

The analysis reveals notable diachronic changes in the frequency of hedging devices employed between the 1918-1919 Spanish flu period and the 2020-2021 COVID-19 pandemic period. An overall decline in the number of hedges used is evident in our data. As Figure 1 illustrates, the total frequency of hedges is substantially higher in the Flu papers (264 instances per 10,000 words) compared to the COVID-19 pandemic papers (168 instances per 10,000 words).
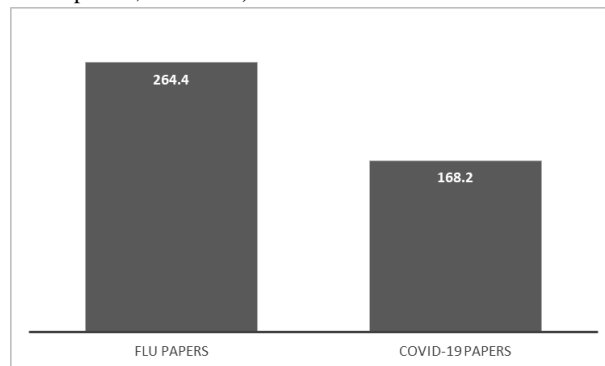

Figure 1. Total number of approximators and shields per 10,000 words

These findings align with previous research by Salager-Meyer and Defives (1998), which also observed an overall slow decline in the total frequency of hedges from earlier to later periods. Hedging frequencies for the 20 century reported by Gross et al. (2002)[iii] and Hyland (1995, 1998b)[iv] lie in between our results. The higher frequency observed at the beginning of the century in the present study may be attributed to the high uncertainty created by the Spanish flu pandemic. Even though this explanation cannot account for the lower frequency observed in the COVID-19 articles, it is important to note that different social factors might be at work at any one time. As mentioned previously, there is a growing body of research that suggests an increasingly competitive publication market might be driving authors towards making stronger claims in order to promote their research (Vinkers et al., 2015; Cao et al., 2020; Hyland & Jiang, 2021b). In fact, most studies that focus on the development of hedging from the mid- or late-20th century to the beginning of the 21st century, consistently show a decline in hedging across different disciplines (Hyland & Jiang, 2016[v]; Liu & Yang, 2021; Rezaei et al., 2021; Yao et al., 2023).

While overall frequencies allow for comparisons with previous studies to some extent, a closer look at the data reveals meaningful insights. The drop in hedging was particularly pronounced for approximators, which fell by almost 60% in frequency per 10,000 words (from 130 to 53) between the two periods. This decrease in approximators is also consistent with Salager-Meyer and Defives' (1998) finding that vague quantification was more common in 19th-century medical writing before precise measurements became the norm. In contrast, the frequency of shields declined only slightly (from 135 to 115). This suggests that while scientists' ability and tendency to make precise quantitative claims increased over time, they continued to regularly mark epistemic uncertainties and limitations through hedging devices at a relatively stable rate. In sum, the sustained use of shields may reflect the constant need in scientific writing to qualify knowledge claims and indicate appropriate levels of confidence, even as the language becomes more precise in other ways.
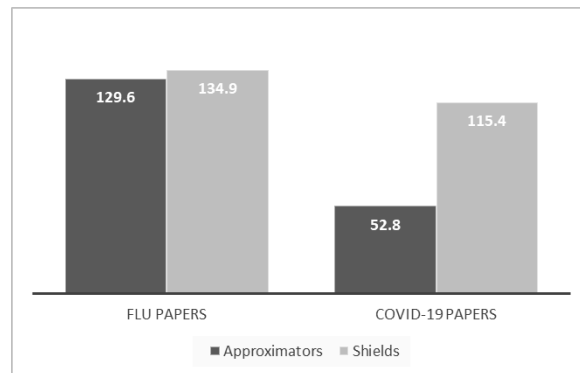

Figure 2. Total frequency of approximators and shields per 10,000 words

Moreover, not only did the overall frequency of hedges decrease over the 100-year period, but so did the variety of distinct hedging devices employ. Figure 3 shows the number of unique approximators and shields per 10,000 words. In Flu papers, 25 different shields and 18 approximators were used, in contrast to 13 and 9, respectively, in COVID-19 papers. This difference in the number of unique devices used also leads to a difference in average frequencies (see Figures 4 and 5). For approximators, on the one hand, this difference is small: in Flu papers, each approximator is used an average of 7 times, and in COVID-19 papers 6.2. Shields, on the other hand, show a bigger increase: whereas in Flu papers, each shield is used an average of 5.2 times, in COVID-19 papers this number reaches almost 9. These data suggest that a smaller repertoire of hedging expressions became favored over time. Especially, in the case of shields, their higher token frequencies suggest they have become more entrenched as preferred hedging devices in recent scientific writing, contributing to a more formulaic and conventionalized style.

It should be noted, nonetheless, that average frequencies might obscure part of the picture as there seem to be some preferred devices in both periods, while many others are used only one or two times. A more detailed analysis would therefore reveal the preferred devices in each period, and any changes that might have occurred.
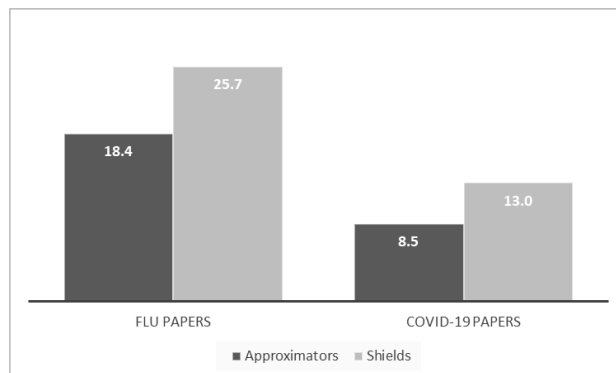

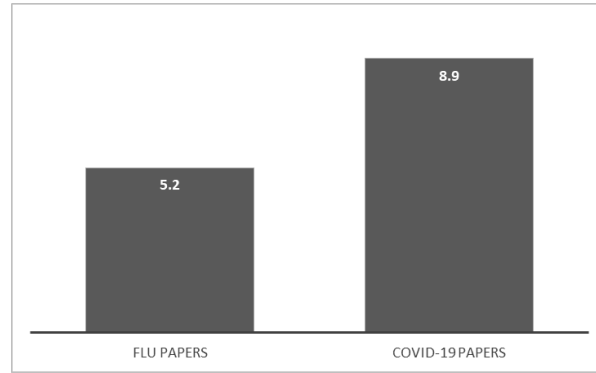Figure 3. Number of unique approximators and shields per 10,000 words
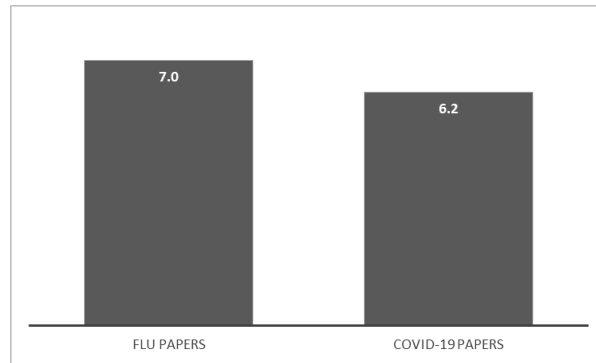
Figure 4. Average frequency of shields

Figure 5. Average frequency of approximators

4.2 Types of Devices

This section examines the types of hedging devices used within each period. Section 4.2.1 examines shields and section 4.3.2 examines approximators. Each subsection first aims to determine which devices were preferred at each time. Second, they look at whether there have been any diachronic changes between the two periods.

4.2.1 Shields

The data in Table 2 reveal interesting similarities and differences in the use of shields between Flu and COVID-19 papers. Verbs clearly dominate as the preferred shields, being used over 50% of the time in both Flu (51.36%) and COVID-19 (54.22%) papers. However, notable differences emerge in the use of the other devices. Adverbs experience a substantial decrease of 70.7%, dropping from 15.45% in Flu papers to just 4.52% in COVID-19 papers. On the other hand, adjectives show an even more marked increase of 107.7%, rising from 10.15% to 21.08%. Finally, the use of nouns also increases from 12.12% to 19.58%, a 61.6% difference. In short, the preferred order of devices differs between the two periods. While verbs and adverbs, in that order, are the preferred devices in Flu papers, verbs, followed by adjectives and nouns are the preferred devices in COVID-19 papers (see Figure 6 for an illustration of these changes).

The frequent use of nouns is a well-established feature of contemporary academic writing (e.g., Biber et al., 1999; Biber & Gray, 2013). Research on historical linguistics has documented an evolution towards an increasing use of nouns and phrasal noun modifiers in detriment of verbs and clausal structures, a trend that is most evident in scientific writing (Biber & Gray, 2016; Biber & Gray, 2013). This has led to increasingly complex noun phrases over time (Biber & Clark, 2002; Gross et al., 2002), which have, in turn, led to a compressed expression style (Biber & Clark, 2002). Thus, this increase in nominal modification can be a reason for the higher presence of adjectives in our COVID-19 data.

Table 2. Types of Shields in Flu and COVID-19 papers

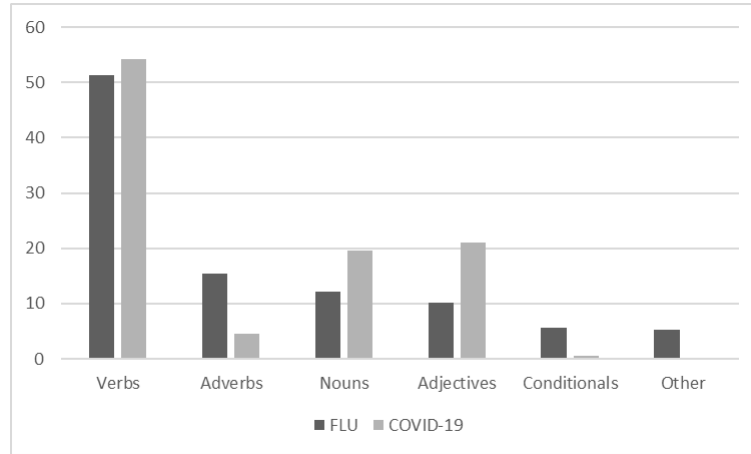| Item	Flu papers		COVID-19 papers	
	Total	%	Total	%
Verbs	339	51.36	360	54.22
Adverbs	102	15.45	30	4.52
Nouns	80	12.12	130	19.58
Adjectives	67	10.15	140	21.08
Conditionals	37	5.61	4	0.60
Other	35	5.30	-	-

Figure 6. Types of Shields in Flu and COVID-19 Papers

Nevertheless, verbs remain the preferred shielding devices. Even though, as noted above, a decrease in the use of verbs over time has been observed, this is not as strong as the increase in the use of nouns (Biber & Gray, 2013)[vi]. In our data, despite the percentage of verbs out of total hedges slightly increases, their frequency per 10,000 words decreases from 69.28 to 62.55. Moreover, our data does find a marked decrease in the use of adverbs, which is consistent with research that has found a decline in clausal modification over time.

Table 3 displays findings categorized by verb type. Percentages represent the use of each verb type relative to the total number of verbs; frequencies are calculated per 10,000 words. Modal and lexical verbs are the predominant types; nevertheless, particularly in Flu articles, other combinations emerged that were challenging to classify into either of these categories. In line with previous research (cf. Hyland & Jiang 2016; Poole et al., 2019), the use of modals has declined with time. Notably, although modals constituted the predominant verbs for expressing uncertainty in Flu papers (46.02% vs. 38.94%), this pattern is reversed in COVID-19 articles, where lexical verbs are more prevalent overall (53.33% vs. 44.72%).

Individually, whereas m*ay*[vii] is still the preferred shield in our data in both periods, there are noticeable changes in lexical verbs. *Seem* and *believe*, in the top three lexical verbs in Flu papers, practically disappear from our COVID-19 data[viii], and are replaced by *suggest* and *estimate*[ix]. *Indicate* completes the top three of the most common lexical verbs in both periods. As for the rest of the modals, *would* retains its position as the second most common modal, whereas the use of *might* decreases in favor of *could*, which shows the most remarkable change and becomes the third most used modal.

Table 3. Types of Verbs in Flu and COVID-19 Papers

Flu papers				COVID-19 papers		
Item	Total	%	Frequency	Total	%	Frequency
Total verbs	339	100	69.28	360	100	62.55
Modals	156	46.02	31.88	161	44.72	27.97
Lexical	132	38.94	26.98	192	53.33	33.36
Modal+lexical	37	10.91	7.56	7	1.94	1.22
Other VP	14	4.13	2.86	-	-	-

As mentioned above, Flu papers contained examples of different combinations of verbs. These include combinations of modals and another verb (e.g., *would seem*, *would indicate*), and other verbal phrases (e.g., *seem to indicate*, *intended to suggest*), which are practically absent in COVID-19 papers, and reflect the shift towards simplified syntax and clausal complexity (Gross et al., 2002; Biber & Gray, 2016).

Another observation from Table 2 is the disappearance of the 'Other' category in COVID-19 data. This category encompassed phrasal structures that were challenging to classify within the other categories, such as negative constructions and questions. Despite its limited scope, the category echoes the conclusion above concerning a shift from a diverse and personalized language towards a more conventionalized and informative one.

4.2.2 Approximators

Data for approximators shown in Table 4 also reveals a clear contrast between the preferred device and the other devices employed by authors. Adverbs emerge as the most frequently used approximators in both cases, with 290 instances (45.74%) in Flu papers and 147 instances (48.36%) in COVID-19 papers. This suggests a preference for adverbial approximators in scientific writing across both periods. The most significant change was the decrease in the use of *about* as an approximator, while the frequency of *approximately* remained unchanged. However, due to the decrease in *about* and *almost*, *approximately* became the preferred choice in COVID-19 articles. As for other adverbs, words like *quite*, *usually*, *somewhat*, and *fairly*, which were relatively common in Flu papers, were less prevalent or absent in COVID-19 papers.

Table 4. Types of Approximators in Flu and COVID-19 Papers

Item	Flu papers		COVID-19 papers	
	Total	%	Total	%
Adverbs	290	45.74	147	48.36
Nouns & Noun Phrases	147	23.19	22	7.24
Phrases	90	14.20	67	22.04
Adjectives	63	9.94	39	12.83
Prepositions	24	3.79	11	3.62
Determiners & Pronouns	20	3.15	18	5.92

However, there are notable differences in the other approximator types. In Flu papers, nouns and noun phrases are the second most common approximators (23.19%), followed by phrases (14.20%), adjectives (9.94%), prepositions (3.79%), and determiners and pronouns (3.15%). In contrast, the distribution in COVID-19 papers shows a different pattern. While phrases are the second most common approximators in COVID-19 papers (22.04%), following adverbs, adjectives increase slightly (12.83%) and the use of nouns and noun phrases is significantly lower (7.24%). Finally, prepositions (3.62%), and determiners and pronouns (5.92%) are also the two least common categories in COVID-19 papers.
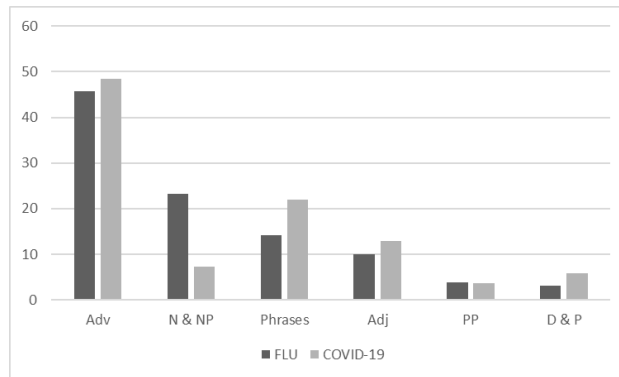

Figure 7. Types of Approximators in Flu and COVID-19 Papers

Leaving aside prepositions, determiners, and pronouns, which appear in too small numbers to allow for meaningful comparisons, and phrases, which form too diverse a category to be compared quantitatively, our data shows a moderate 29.1% increase in adjectives and a marked 68.8% decrease in nouns. It is noteworthy, however, that the difference in the frequency of nouns and noun phrases as approximators is brought about by the high frequency of a single noun, *number*, and the relatively high frequencies of two other nouns, namely, *degree* and *case*. The word *number* appears a total of 49 times in the Flu data (10 times per 10,000 words), as opposed to only four instances in the COVID-19 data (0.69 times per 10,000 words). *Degree* and *case* have a frequency of over 3 instances per 10,000 words in the Flu data but are absent from COVID-19 data. These three nouns are used across Flu papers to express vague quantification, as in the following examples:

(4) **A number of** the patients dying in this stage of early emphysema came to autopsy.

(5) …it can be traced back with a fair **degree** of certainty to the fifteenth century…

(6) We were able to culture many of the **cases** in the first day of the disease.

In short, the primary distinction between the periods appears to lie in the overall frequency of approximators, rather than the specific devices used, with the possible exception of a few nouns. These changes suggest a shift towards more precise, quantifiable approximation in scientific writing over the past century. The reduced variety of approximators in COVID-19 papers might indicate more standardized language practices, and the reduced numbers of approximators themselves reflect advancements in measurement techniques and data analysis, which enable researchers to report more accurate results.

4.2.3 Broader Implications

The linguistic shifts in this study reveal insights into evolving scientific standards, pressures in academic publishing, and adaptations in writing during crises. A notable finding is the decline in approximators in COVID-19 papers, aligning with Salager-Meyer and Defives (1998). This reflects a growing emphasis on precision and evidence-based results, facilitated by technological advancements in data collection and analysis. For example, the Spanish Flu study "Results of prophylactic vaccination against pneumonia at Camp Wheeler" relied on physical inoculations and monitored pneumonia cases post-vaccination. In contrast, the COVID-19 study ("Immune Correlates Analysis of the mRNA-1273 COVID-19 Vaccine Efficacy Clinical Trial") employed molecular techniques, including neutralizing and binding antibodies using WHO-standardized units. Vaccine efficacy was evaluated through statistical models like Cox cumulative

incidence curves, correlating antibody levels with infection risk. This shift from observational methods to precise molecular techniques highlights the diminished need for vague language in scientific communication, prioritizing clarity and specificity.

In addition to technological factors, the pressures of academic publishing may also play a significant role in the reduction of hedging, which is the second key finding of this study. Our results corroborate the downward trend in hedging observed by Hyland and Jiang (2016), Liu and Yang (2021), Rezaei et al. (2021), and Yao et al. (2023). The competitive nature of publishing drives researchers to adopt a more assertive tone to promote their work and gain visibility. Hedged statements, often associated with caution and uncertainty, may be perceived as less impactful, prompting authors to favor language that communicates findings with greater confidence. This trend toward assertiveness in scientific discourse, as noted by Vinkers et al. (2015) and Hyland and Jiang (2021b), suggests that publication pressures are contributing to a more promotional and standardized writing style.

The third finding, which concerns the reduced variety of hedging devices observed – in COVID-19 papers, – indicates a shift toward a more conventionalized scientific writing style. As Salager-Meyer and Defives (1998), and Salager-Meyer (2011) concluded, the evolution of scientific writing lies more in the types of hedging devices used than in their overall frequency. Further evidence of this standardization is the growth in the use of adjectives and noun phrases as shields in COVID-19 papers, reflecting the evolution of academic and scientific writing toward more nominal and phrasal structures (Biber & Gray, 2013, 2016). This likely reflects ongoing standardization in academic and scientific writing, where specific linguistic structures – such as verbs, nouns and adjectives – are preferred for expressing uncertainty. The consistent use of these specific hedging devices points to a community-wide agreement on the appropriate language for academic discourse, reinforcing the standardization of scientific writing practices.

Furthermore, the study's findings highlight the connection between the evolution of scientific writing and the unique demands of crises, such as pandemics. The decline in hedging observed in COVID-19 papers, compared to those from the 1918 influenza pandemic, underscores how scientific discourse adapts to the urgency of unfolding crises. During pandemics, the need for clear, actionable information becomes paramount as researchers, policymakers, and the public make rapid decisions based on available data. This context drives a shift toward more direct and assertive language, as seen in the decreased use of approximators and the preference for standardized forms of hedging, like shields.

To sum up, the evolution in scientific writing practices – from advancements in research methodologies to the pressures of publication and the specific demands of crisis communication – has led to a more assertive and conventionalized discourse. This shift ultimately shapes the way scientific knowledge is communicated and understood both within the scientific community and in the broader public sphere.

4.2.4 Limitations and Further Research

While the corpus is comprehensive in covering articles from two global pandemics, there are limitations concerning its size and representativeness that should be acknowledged. The study examined 15 articles from each pandemic. A relatively limited sample size means that the results may not capture the full range of hedging practices employed in scientific writing during these periods. Future studies could benefit from expanding the corpus size to include a larger and more diverse set of articles.

Additionally, the selection process for articles focused on specific types within medical literature. The criteria for article selection, while aiming for comparability across the two pandemics, may introduce a bias toward certain linguistic practices. For instance, the articles chosen may predominantly represent research papers, potentially excluding other forms of scientific writing, such as reviews or editorials, which might employ different hedging strategies. This raises questions about the representativeness of the findings, as the hedging practices observed here may not necessarily apply to all scientific discourse from the pandemic periods. Therefore, future research could broaden the scope to include articles from a wider range of subfields, publication types, and even different languages, to enhance the study's representativeness.

Moreover, the study's comparison of pandemics separated by a century involves differences in scientific practices, journalistic styles, and publication norms. The 1918-1919 influenza pandemic and the 2020-2021 COVID-19 pandemic occurred in vastly different historical and scientific contexts, which may have influenced the types and frequency of hedging used in scientific writing. Modern advancements in data analysis, increased precision in measurement techniques, and the competitive nature of current academic publishing further complicate direct comparisons. While these factors provide a fascinating context for examining linguistic shifts, they also highlight the limitation of this study in fully representing the diversity of scientific discourse during these periods.

In light of these constraints, the current study offers a valuable snapshot of diachronic changes in hedging practices. However, the findings should be interpreted with an understanding of these limitations. Expanding the corpus in future research to include more articles, a wider array of journals, and a variety of medical disciplines will help create a more holistic picture of hedging practices in scientific communication. Additionally, examining medical articles published immediately before and after pandemic periods could provide further insight into how crises impact hedging strategies in scientific writing.

5. Conclusion

This study investigated the diachronic changes in hedging practices in scientific writing by analyzing research papers from two global pandemics: the 1918 influenza and the 2020 COVID-19 outbreaks. The findings revealed significant shifts in both the frequency and types of hedging used over the 100-year period, with a notable overall decline in hedge frequency, particularly in the use of approximators,

while the use of shields remained relatively stable.

This trend aligns with earlier research by Salager-Meyer and Defives (1998), who suggested that changes in scientific writing across time periods are more related to the types of hedging devices used than their overall frequency. The decline in hedging observed in this study falls between the frequencies reported by Gross et al. (2002) and Hyland (1995, 1998b) for 20th-century scientific writing and corroborates the downward trend reported by Hyland and Jiang (2016), Liu and Yang (2021), Rezaei et al. (2021), and Yao et al. (2023).

The study also uncovered that, contrary to what might have been expected given the novelty of the COVID-19 pandemic, hedging frequency did not increase. This finding suggests that external factors, such as competition in the publication market and the urgency for rapid dissemination of research, may have influenced authors to adopt a more assertive tone, potentially counterbalancing the natural tendency to hedge in uncertain situations.

Furthermore, the increased use of adjectives and noun phrases as shields in COVID-19 papers reflects a move towards more standardized, nominalized, and phrasal structures in scientific writing (as noted by Biber & Gray, 2013, 2016). The ongoing reliance on shields underscores the continued necessity for researchers to qualify their knowledge claims and express caution in scientific communication, despite advancements in data analysis and measurement techniques.

The study's findings carry important implications for understanding the evolution of scientific discourse, particularly during periods of crisis. The observed linguistic shifts not only illustrate a trend toward more precise and standardized language but also highlight how external factors, including technological advancements and publication pressures, shape the way scientific knowledge is communicated. The decline in the variety of hedging devices points to a broader standardization in academic writing, which may affect both the scientific community's internal discourse and its communication with policymakers and the public. During pandemics, the need for direct, actionable information seems to drive a preference for clearer, more assertive language, reinforcing the dynamic nature of scientific communication.

In conclusion, this study contributes to our understanding of the dynamic evolution of scientific writing, particularly in the use of hedging during pandemic-related research. The observed trends highlight the complex interplay between linguistic practices, technological advancements, academic pressures, and the unique demands of crisis communication. Continued examination of these factors is essential to fully understand how scientific discourse evolves and adapts to the changing landscape of research and societal expectations.

Authors' contributions

All authors were responsible for all stages of the research process. All authors read and approved the final manuscript.

Competing interests

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.

Informed consent

Obtained.

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The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Copyrights

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Notes

[i] See Jovic et al. (2023) for similar frequencies in present-day spoken data.

[ii] Salager-Meyer (1994): 20 articles; Hyland (1995): 26 articles in cell and molecular biology; Bazerman (1988): 40 articles in spectroscopy; Dudley-Evans and Henderson (1993): 22 articles in economics.

[iii] 2.2 hedges per 100 words (or 220 per 10,000)

[iv] Hyland (1995) reports a frequency of more than one hedge in every 50 words in a corpus of 26 research articles in cell and molecular biology published between 1988 and 1993. Hyland (1998b) reports a very similar frequency (one hedge every 49 words) in a corpus of 56 research articles belonging to eight different disciplines: mechanical engineering, electrical engineering, marketing, philosophy, sociology, applied linguistics, physics and microbiology.

[v] This study found a decline only in two 'soft' disciplines (applied linguistics and sociology). Biology and electrical engineering showed slight increases.

[vi] Biber and Gray (2013) report an increase in nouns of 125 per 1,000 words, but a decrease in verbs of only 15 per 1,000 words from the nineteenth to the twentieth centuries.

[vii] *May*, together with *would*, is reported as the most common hedge by Hyland and Jiang (2016). In addition, it is one of the most frequent modals, together with *can* and *will*, in Poole et al. (2019).

[viii] Our COVID-19 corpus did not contain any instances of *seem*, and only one instance of *believe*.

[ix] Biber and Gray (2013) report a decrease of at least 100 times per million words for the verb s*eem* from 1900 to 2005. Conversely, they report an increase of the same magnitude for the verbs *suggest* and *estimate*.

Appendix A

List of articles

Spanish flu 1918-1919

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Covid articles

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