What are the most frequently used adjectives in medical and biology articles related to COVID-19?

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Abstract: The present corpus-based study is devoted precisely to this aspect, investigating, specifically, which are the most used adjectives in a corpus of medical and biology texts dedicated to Covid-19 (CORD-19 corpus), and comparing the data obtained with a corpus of general scientific academic texts available on Sketch Engine (DOAJ corpora - Open Access Journals corpora- English), in order to verify any quantitative and qualitative differences in the frequency and use of qualifying adjectives in the two different text types.

Key words: Linguistics, Applied Linguistics, Discourse analysis, Corpus, Covid-19.

1. Introduction

The pandemic wave of Covid-19 inevitably had a decisive impact on our way of communicating, leading, right from the first months of the global spread of the virus, to the proliferation of neologisms and very peculiar discourse strategies aimed at describing this hitherto unknown viral agent and at persuading citizens to stay at home and, subsequently, to get vaccinated.

Most linguistic studies have focused precisely on these aspects of Covid-19 related discourse and there have been many corpus-based publications devoted to the emergence of new words in English and other languages (Al-Salman & Haider, 2021), to the analysis of the communicative strategies implemented by various governments to build collective identities and invite people to isolate themselves (Berrocal &Al, 2021), and to the critical study of news reports to verify possible changes in journalistic discourse in the pandemic era (Yu, Lu & Hu, 2021).

Interestingly, however, very few linguistic studies (Shen & Tao, 2021) have been devoted to the academic scientific discourse related to Covid-19, despite the fact that, since the advent of the pandemic in February 2020, the collective effort of scientists worldwide to contain the virus and find an effective cure or vaccine has resulted in a huge production of medical, biological and pharmaceutical scientific articles on the subject.

The linguistic interest in this issue is by no means secondary: scientific academic discourse generally follows very precise communicative parameters, one of which is objectivity (Wiebe, Bruce, & O'Hara 1999; Bruce & Wiebe 2000), evidenced, first and foremost, by the extremely limited use of qualifying expressions, including qualifying adjectives.

Since scientific production in the Covid-19 era evidently took place in a context of extreme uncertainty, due to scientists' very limited prior knowledge of this dreaded viral agent, it is interesting to find out whether the scientific discourse on Covid uses different, or rather less objective, communicative parameters than the general academic-scientific discourse.

2. Literature review

In linguistics, adjectives have been the subject of extensive studies: some of these studies have focused on categorising this part of speech; others have taken a corpus-based approach, aimed at analysing adjectives in various types of discourse, including Covid-related discourse. In this literature review we will present some of the most important studies in this regard.

In grammar, adjectives are words with a lexical meaning referring to the properties or qualities of a noun, such as "high", "beautiful", "red", etc. (Rießler, 2016). Adjectives in English can either be attributive or predicative. Attributive adjectives precede the noun as a rule, while predicative adjectives follow the noun (Rießler, 2016) and tend to be evaluative. Evaluative adjectives play an important role in constructing personal opinions in the discourse (Yasunori, 2010: 15) and indicate judgment (Rittman et al., 2004: 350).

Adjectives can also be limiting (possessive, numerals, quantifiers, demonstrative, interrogative) or descriptive. The latter, which are the most common ones, describe the permanent or perceived qualities of a noun and they can either be classifying or qualifying. Qualifying adjectives are "gradable" (which means it is possible to graduate their intensity by adding

an adverb of degree, such as very, quiet, enough) and they can be put in comparative or superlative forms. Classifying adjectives place people and things into categories or classes (Oxford University Press), they cannot normally be graded and don't generally have comparative and superlative forms. Examples of classifying adjectives are "dead", and "married".

According to Khamying (2007), there are eleven types of adjectives. These categories include some of the ones previously mentioned, as can be seen below:

No	Types	Functions	Examples
1.	Descriptive Adjective	escriptive Adjective To attribute or qualify people, animals, things, or places in order to describe its features	
2.	Proper Adjective	To modify noun in terms of the nationality, this type is originated from proper noun.	He employs a Chinese book.
3.	Quantitative Adjective	To modify noun for particular details in quantifying	He ate much rice at school yesterday.
4.	Numeral Adjective	To attribute or qualify people, animals, things, or places in order to describe its features	 Cardinal Numeral adjective Ex. My hand has five fingers. Ordinal Numeral adjective Ex. I am the seventh son of my family. Multiplicative adjective Ex. Some roses are double.
5.	Demonstrative Adjective (this, that, these, those)	To modify noun in terms of the nationality, this type is originated from proper noun.	I invited that man to come in.
6.	Interrogative Adjective	To modify noun for particular details in quantifying	What book is he reading in the room?
7.	Possessive Adjective	To express possession of a noun by someone or something	This is my table.
8.	Distributive Adjective	To modify noun by dividing or separating into different parts	Every soldier is punctually in his place.
9.	Emphasizing Adjective	To modify noun by highlighting or emphasizing the texts	Supansa is my own girl-friend.
10.	Exclamatory Adjective	To modify noun by using interjection words	What a man he is!
11.	Relative Adjective	To modify noun and combine sentence which are related between the first and second sentences	Give me what money you have.

Some studies (Wiebe, Bruce, & O'Hara 1999; Bruce & Wiebe 2000) have shown a positive statistical correlation between subjectivity - understood as the presentation of personal opinions and evaluations through language (Banfield 1982; Wiebe 1994) - and the presence of adjectives. Wiebe (2000) in fact states that "the mere presence of one or more adjectives is useful for predicting that a sentence is subjective". Expressions of subjectivity, such as the adjective "fascinating", are usually found in subjective sentences.

According to Wiebe, there are different types of subjectivities but he focuses on three types: "positive evaluation (e.g., fascinating), negative evaluation (e.g., terrible), and speculation (e.g., probably)". News reporting and Internet forums, in which opinions are expressed, provide an ideal context for subjective sentences (Wiebe 2000). This should not be the case for medical and biology articles since subjective sentences tend to be avoided. In fact, as Memišević and Matešić (2015) stated, "the rules for writing scientific texts in English prescribe, among other things, an extremely limited use of qualifying expressions in general, and this includes evaluative adjectives."

Similarly, Rittman et al. (2004), stated that "in general, documents with many adjectives tend to be scored subjective; documents with few adjectives tend to be scored objective." In a study they carried out they measured the objectivity of texts, among other qualities and observed the presence of subjective adjectives, i.e. those adjectives where an opinion or judgment can be perceived. They hypothesized that "the relative occurrence of subjective adjectives in a document will be negatively correlated with the document's objectivity scores, more than will the relative occurrence of adjectives that are not members of the subjective adjective subclass (...) ". Eventually, they found out that "when subjects are asked to evaluate the objectivity of a document, there is a statistically significant correlation between these judgments and the presence of subjective adjectives." (Rittman et al. 2004: 357).

Tutin (2019) performed a corpus study on evaluative adjectives referring to scientific nouns. Evaluative adjectives are what Wiebe would call subjective adjectives. Her study dealt with evaluative adjectives in French academic writing in the field of humanities and social sciences. She split evaluative adjectives into "axiological", which refer to the value of something or someone, and "non-axiological", which are rather "neutral". Axiological adjectives were adjectives like "interesting", "relevant", and "bad", whereas non-axiological adjectives were divided into 7 different sub-categories: "degree" (e.g.: "large" and "numerous"), "comparison" (e.g.: "similar", "different"), "importance" (e.g.: "essential", "main"), "complexity" (e.g.: "easy"), "novelty" (e.g.: "new"), "time" (e.g.: "recent", "old"), and "other" (e.g.: "paradoxal").

Tutin discovered that "axiological evaluation is not very common, in contrast to more "neutral" evaluative types" In fact, according to her, "in order to convince the reader, authors seem to avoid very subjective evaluation in scientific writing". Also, "argumentation in academic writing does not seem to use overtly positive or negative judgement. Authors prefer more subtle and less subjective evaluative devices like adjectives pertaining to time, novelty and importance."

Reyhan Agçam and Mahmut Özkan (2015) analysed evaluative adjectives in a corpus-based study on evaluation adjectives in academic English. Evaluative adjectives involve a judgment about the quality, importance, amount, or value of something. According to Agçam and Özkan (2015), Swales and Burke (2003) categorize evaluative adjectives into seven groups across academic writing and academic speech according to their denotations as acuity (e.g. smart, stupid), aesthetic appeal (e.g.: beautiful, elegant), assessment, deviance, relevance, size (e.g. small, huge) and strength (e.g. weak, strong).

In a further classification, Swales and Burke (2003) divided each category into two groups: centralized and polarized adjectives. Centralized adjectives are those adjectives that are moderate, as opposed to polarized adjectives, which are extreme (e.g.: "beautiful = positive polarity; ugly = negative") (Rittman et al., 2004: 351). The authors then "reported that evaluative adjectives were found much more frequently in academic speech than academic writing. They also revealed centralized adjectives were prevalent in both corpora as opposed to the polarized adjectives were

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more frequented in academic writing than academic speech, and that polarized adjectives such as essential, fundamental and marginal were considerably used in academic writing. Those centralized assessment adjectives were especially common in academic writing while their polarized counterparts were mostly found in academic speech" Agçam and Özkan (2015).

A similar research project to the current one — a corpus-based analysis of the most frequent adjective[s] on Covid-19 — was carried out by Idda Astia and Sofi Yunianti (2020). 20 adjectives were selected and were ordered into four of the ten different categories defined by Khamying (2007): descriptive, quantitative, emphasising, and numeral. The authors found out the most frequently used adjectives were descriptive, followed by quantitative, emphasising, and, finally, by numeral adjectives. However, their research project only focuses on the 20 most frequent adjectives, and, therefore, the analysis of the categories cannot realistically be representative of all adjectives. Moreover, the research lacks a more in-depth analysis of the use of those specific adjectives in context. The present research project aims to provide a more representative, elaborated, and meaningful analysis.

3. Methodology

A corpus-based analysis was carried out using the COVID-19 corpus and the software Sketch Engine. Data were analysed with a quantitative and qualitative approach and then compared with the results of the analysis of a reference corpus of generic academic papers (DOAJ corpora - Open Access Journals corpora) in English, in order to identify any substantial differences between the two.

The COVID-19 corpus consists of a collection of publications and preprints in English that were released as part of the COVID-19 Open Research Dataset (CORD-19) on March 16, 2020 (Sketch Engine). More specifically, the corpus contains more than 280,000 international papers (224,061,570 words) in Biology, Medicine, and Chemistry published from 1970 to 2020 and

focused on the study of Covid-19 and related historical coronaviruses such as SARS and MERS (CORD-19 Open Research Dataset).

The majority of these papers (70%) were published in 2020, relate to Covid 19 and are sourced from PubMed Central (PMC). Other articles of the dataset are derived from the World Health Organization (WHO) Covid-19 Database and a number of other publishers such as Elsevier[,] bioRxiv, medRxiv and Springer Nature (Wang 2020).

The DOAJ Corpora – Open Access Journals Corpora (English) consists of 659,132 scientific papers (2,662,763,697 words) in English, related to medicine, social science, technology, and humanities and mostly published from 2007 to 2014 in leading journals (of which the most frequent are PLoS ONE, Acta Crystallographica Section E, BioMed Research International, The Scientific World Journal, Mathematical Problems in Engineering and Sensors).

Even though it is important to be "aware that the corpus may not capture all the patterns of the language, nor represent them in precisely the correct proportions" (Sinclair, 2004), the purpose of a corpus (in this case, Sketch Engine) is to study language in context with the help of algorithms that analyse "authentic texts of billions of words to identify instantly what is typical in language and what is rare, unusual or emerging usage". Therefore, a corpus-based discourse analysis was considered to be the most effective option to analyse which are the most frequently used in COVID-19-related academic articles and what this may mean.

First, we carefully considered previous corpus-based analyses, and carried a thorough research of previous works about different categories of adjectives. The latter allowed us to select the following concepts: polarization, centralization, and limiting, descriptive, classifying, qualifying, evaluative, axiological, and non-axiological adjectives. These concepts were used to divide adjectives into categories. Then, the quantity of adjectives compared to the total amount of words in the corpus was looked at in order to calculate the percentage of adjectives used in the whole corpus. Afterwards, the 100 most frequently used adjectives were selected from the Wordlist option on Sketch Engine. This allowed us to make the analysis more representative. Data were divided into six main categories, in order to understand the function of adjectives:

1) limiting;

- 2) descriptive and classifying;
- 3) evaluative, descriptive, qualifying, non-axiological, and centralized;
- 4) evaluative, descriptive, qualifying, non-axiological, and polarized;
- 5) evaluative, descriptive, qualifying, axiological, and centralized;
- 6) evaluative, descriptive, qualifying, axiological, and polarized.

These categories were adapted from previous categorizations, as we borrowed terminology using a typological perspective. We used, indeed, a combination of categories to make the classification comprehensive.

The most interesting features could be tested and reported by checking adjectives frequency and concordance. The results were compared with data drawn from the analysis of the second corpus (i.e. DOAJ Corpora - Open Access Journals Corpora-English).

4. Findings & discussion

Overall, out of the 224,061,570 words available on the COVID-19 corpus, 24,874,370 are adjectives (11.10%). According to Wiebe (2000), scholarly articles should be "objective" and, therefore, should not contain a high quantity of adjectives. In fact, since Wiebe had stated that the presence of adjectives is useful to determine whether a sentence is subjective or not, compared to the totality of words, 11.10% seems to be a relatively low quantity of adjectives, especially considering that there are no polarized, axiological, adjectives.

We then automatically extracted the 100 most frequent adjectives, and analysed them in order to be able to assign them to their respective categories, namely 1) limiting (numerals and quantifiers, or "quantitative" adjectives in Khamying's words), 2) descriptive and classifying, 3) evaluative, descriptive, qualifying, non-axiological, and centralized, 4) evaluative, descriptive, qualifying, non-axiological, and polarized, 5) evaluative, descriptive, qualifying, axiological, and centralized, and 6) evaluative, descriptive, qualifying, axiological, and polarized.

It is clear that, deciding whether certain adjectives are polarized or centralized without context can be relative and subjective. For this reason, we analysed where adjectives appear in context by analysing concordance. This allowed us to comprehend the primary function of these adjectives in the COVID-19 corpus and identify which nouns are modified by those adjectives in order to place them in the correct categories.

Certain words were not treated as adjectives. For instance, the word "such" (4) was analysed in context by checking concordance. The result was that in 50 out of 100 sentences this word was followed by "as". "Such as" is not an adjective but a prepositional expression used to introduce examples of something we mention. Its synonyms are "like", "namely", "being". Similarly, "due" (23) was not considered as an adjective since, after observing its contexts, we found that in 100 out of 100 cases it was used together with "to", forming "due to", which is a preposition. The following adjectives were excluded from the analysis: "more" (11), "most" (32), "less" (71), and "least" (55). They were treated separately since they can be used in comparative and superlative forms. In this case, they precede an adjective, and can also be used with adverbs.

Considering the fact that six words were not analysed as adjectives the final number of different adjectives is 94, As shown in Table A:

Limiting	Descriptive	Evaluative/	Evaluative/	Evaluative/	Evaluative/

(numerals	Classifying	Descriptive/	Descriptive/	Descriptive/	Descriptive/
and		Qualifying/	Qualifying/	Qualifying/	Qualifying/
quantifiers)		Non-axiological/	Non-axiological/	Axiological/	Axiological/
		Centralized	Polarized	Centralized	Polarized
Several	Viral (1)	High (3)	Important (12)	Good (39)	
(16)	Other (2)	Different (6)	Significant (13)		
Many (17)	Human (6)	Low (9)	Major (38)		
First (20)	Clinical (7)	Similar (15)	Great (53)		
Single (40)	Respiratory (8)	Large (18)	Essential (90)		
Multiple	Immune (10)	New (21)	Key (99)		
(41)	Specific (14)	Same (24)			
Various	Positive (19)	Small (25)			
(47)	Infectious (22)	Common (28)			
Further	Infected (26)	Early (33)			
(49)	Severe (27)	Possible (34)			
Total (51)	Acute (29)	Potential (35)			
Additional	Available (30)	Recent (44)			
(54)	Present (31)	Effective (45)			
Few (59)	Cellular (36)	Normal (56)			
Individual	Antiviral (37)	Likely (58)			
(68)	Bacterial (42)	Standard (79)			
Second	Negative (43)	Consistent (81)			
(69)	Primary (46)	Rapid (82)			
[Number]	Public (48)	Relative (77)			
(91)	Molecular (50)	Functional (84)			
Mean (94)	Previous (52)	Strong (85)			
	Genetic (57)	Long (87)			
	Recombinant	Old (95)			
	(60)				

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	Medical (61)				
	Active (63)				
	Secondary (64)				
	Inflammatory				
	(65)				
	Initial (66)				
	Chronic (67)				
	Current (68)				
	Local (70)				
	Able (72)				
	Direct (73)				
	Critical (74)				
	Binding (75)				
	Structural (76)				
	Diagnostic (78)				
	Experimental				
	(80)				
	Global (83)				
	Natural (86)				
	Animal (88)				
	Particular (89)				
	General (92)				
	Biological (93)				
	Epithelial (96)				
	Healthy (97)				
	Complete (98)				
	Final (100)				
1		1	1	1	1

As can be seen, 49 out of the 94 most frequently used adjectives (52.12%) are classifying adjectives. These adjectives are usually not put in the comparative and superlative forms, and are usually not gradable. They place the noun they refer to into classes.

The second most represented category in the corpus is that of the evaluative, descriptive, qualifying, non-axiological, and centralized adjectives (24 occurrences, or 25,53%). These adjectives imply a discrete personal opinion or judgment. However, they are neutral and, this is why they are centralized. In fact, they are not positive, negative, or related to speculation, as Wiebe (2000) had indicated. This is consistent with what Swales and Burke had concluded, that is, that "centralized adjectives were prevalent in corpora as opposed to the polarized adjectives" categories (Ağçam, R., & Özkan, M. 2015). As for the remaining occurrences, 14 (14.89%) are limiting adjectives, 6 (6.38%) belong to the evaluative, descriptive, qualifying, non-axiological, and polarized category (even though they do not refer to the value of the noun, they tend to have a positive polarity) and there is only one adjective (1.06%) that's evaluative, descriptive, qualifying, axiological, and centralized: "good". This adjective refers to the value of a noun but it's not at extreme adjective, like "amazing". The adjective "great" was also analysed as it could have been considered axiological and polarized. However, most of the times it refers to the size of a noun.

There are no adjectives (0%) that are axiological, evaluative, descriptive, qualifying, and polarized. We decided to leave this category on the table even though there were no adjectives belonging to this group because their absence is a relevant finding. An example of this category are the following adjectives - which were previously mentioned: stupid, beautiful, huge, ugly, etc. These adjectives rather than being centralised are indeed positive and negative, and imply a high level of personal judgment.

In accordance with the type of articles included in the corpus, 17 (18.08%) of the most frequent adjectives are highly related to science and medicine: viral (1), clinical (7), respiratory (8), immune (10), infectious (22), infected (26), cellular (36), antiviral (37), bacterial (42), molecular (50),

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genetic (57), medical (61), chronic (62), inflammatory (65), diagnostic (78), biological (93), and epithelial (96).

This study shows that the most common adjectives encountered in the CORD-19 corpus are descriptive and classifying. This is coherent, since the type of articles they appear in belong to the scientific field and, more specifically, they are related to biology, a field in which ideas and concepts are divided into classes rather than judged "subjectively".

In order to discover any peculiarities in the use of adjectives in Covid-related discourse compared to general academic articles, we repeated the same analysis on the DOAJ Corpora - Open Access Journals Corpora-English, automatically extracting the 100 most common adjectives and checking their concordances. After excluding from the analysis the words "observed", "such", "due", "more", "most", "less", and "least", which, as in the case of the Covid-19 Corpus, could not be considered adjectives, we assigned the 93 remaining adjectives to their respective categories, as shown in Table B:

Limiting	Descriptive	Evaluative/	Evaluative/	Evaluative/	Evaluative/
(numerals	Classifying	Descriptive/	Descriptive/	Descriptive/	Descriptive/
and		Qualifying/	Qualifying/	Qualifying/	Qualifying/
quantifiers)		Non-axiological/	Non-axiological/	Axiological/	Axiological/
		Centralized	Polarized	Centralized	Polarized
Several (20)	Other (2)	High (1)	Important (12)	Good (15)	
Many (18)	Human (19)	Different (3)	Significant (6)		
First (11)	Clinical (26)	Low (5)	Major (45)		
Single (33)	Specific (22)	Similar (14)	Great (27)		
Multiple (53)	Positive (24)	Large (7)	Key (74)		
Various (30)	Available (25)	New (16)	<u>Main (34)</u>		
Further (50)	Present (21)	Same (8)	Average (37)		

Total (17)	Negative (42)	Small (13)	Necessary (87)	
Additional	Primary (51)	Common (44)		
(59)	Molecular (76)	Early (43)		
Few (60)	Previous (29)	Possible (23)		
Individual (55)	Genetic (69)	Potential (46)		
Second (38)	Active (64)	Recent (56)		
[Number] (75)	Initial (54)	Effective (63)		
Mean (31)	Current (28)	Normal (41)		
Certain (93)	Local (35)	Likely (84)		
Maximum(70)	Able (80)	Standard (39)		
Last (91)	Direct (83)	Consistent (72)		
Overall (82)	Critical (97)	Relative (36)		
	Experimental (40)	Functional (71)		
	Global (65)	Strong (48)		
	Natural (77)	Long (62)		
	Particular (61)	Short (78)		
	General (58)	Old (95)		
	Final (89)	Complex (73)		
	Social (52)	Simple (96)		
	Physical (68)	Original (85)		
	Environmental (90)			
	Economic (88)			
	Spatial (79)			
	Future (98)			
	Linear (81)			
	Independent (66)			
	Free (94)			
	Statistical (67)			
	Constant (86)			

Cori	responding (57)		
Rea	l (100)		

Table B

Overall, out of the 2,662,763,697 words available on the DOAJ Corpora - Open Access Journals Corpora-English, 279,183,653 are adjectives (10.48%).

Also, as shown in table B, exactly as in the Covid 19 corpus, the most frequent category of adjectives in the DOAJ Corpora - Open Access Journals Corpora-English is descriptive/classifying adjectives (39 occurrences or 41.93%), followed by Evaluative/Descriptive/Qualifying/Non-axiological/Centralized adjectives (27 occurrences, or 29.03%) and by numerals and quantifiers (18 occurrences or 19.35%).

5. Conclusion

Contrary to our expectations, the Covid 19 Corpus and the DOAJ Corpora - Open Access Journals Corpora-English are fairly uniform as regards the most frequent adjectives, both quantitatively and qualitatively.

This finding shows that, despite the uncertainty associated with the Covid-19 topic, the medical researchers have maintained the 'objective' style that characterises academic scientific papers. More in detail, the fact that, in Covid-19 related medical texts, most of the evaluative adjectives analysed are non-axiological and centralized - along with the absence of polarized, axiological, evaluative adjectives - shows the impartiality and unbiasedness of the texts analyzed, a finding that is absolutely consistent with the type of academic articles included in the corpus.

Also, not surprisingly, some of the most common descriptive adjectives found in the academic articles related to Covid-19 are technical and, more specifically, related to medicine and biology.

Authors choose specific terms to refer to certain ideas and concepts in order to present accurate scientific information. This use of specific terminology allows them to describe facts in an "objective" manner.

6. Reflection

The results of our corpus-based study, which was conducted using a a descriptive-comparative approach, gave us the opportunity to demonstrate that, in terms of linguistic "objectivity" and frequency and use of adjectives, medical articles related to Covid are substantially comparable to academic articles related to other scientific topics.

These results, although interesting, are partially "weakened" by three issues: first, as mentioned above, the Covid-19 corpus includes both medical and biology-related texts, but it was not possible to quantify exactly the number of articles belonging to each of these two categories. Given that most articles were sourced from PubMed, it is likely that there was an overrepresentation of medical texts.

Similarly, the DOAJ Corpora - Open Access Journals Corpora-English contains articles related to a variety of scientific disciplines, including humanities, which makes the comparison between our two corpora less " centered."

In addition, the two corpora are very different in size, so this might constitute a bias.

Furthermore, as much as an attempt was made to make the adjective classification as "objective" as possible using a rigorous method based on previous research, it is evident that a certain degree of "subjectivity" remained in the choice of categories.

In any case, beyond the obvious limitations, this study is certainly valuable and interesting because it helps to shed some light on the peculiarities of the academic discourse related to

Covid-19, which, as mentioned in the introduction, has remained relatively underresearched in the field of linguistics.

Moreover, this study is potentially replicable in other languages, which would help us to find out whether, in the international setting, the same substantial uniformity exists between the Covid 19 discourse and general academic articles in terms of frequency and use of adjectives.

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