

# VERB CHOICE IN MEDICAL RESEARCH ARTICLES (ESP)

Ilina Doykova\*

**Abstract:** *The corpus-based analysis of high frequency verbs used in research articles aims at establishing the lexical core, native and non-native researchers need for publishing in medicine. The verbs, extracted from two self-compiled corpora are structured as per the established format of the research article genre. The findings showed that in the Introduction, Methods, Results and Discussion sections there is great variation in the use of verbs, related to data observation, presentation, and description. Areas of difference in evaluative language and the preferred lexical structures in reporting scientific results are indicated. The predicative adjective construction is identified as a frequent strong verb substitute in the non-native scientific writing. Specific verb lists form a valuable source for the creation of teaching materials for university and PhD students.*

**Key words:** *English for specific purposes, medical research articles, verb variety*

## 1. Introduction

The present paper is a corpus-based study of verbs introducing citations, presenting results, argumentation and discussion of findings or indicating stance in medical research articles (MRA). The aim is to compare the core scientific verbs used by international and Bulgarian researchers, publishing in English in terms of their specific use in English for specific purposes (ESP).

The observations of Swales and Feak (2004) and Nesselhauf (2005) on the problem areas in academic writing, experienced by graduate students have provoked multiple corpus-based and corpus-driven studies in various disciplines recently. The importance of word frequency in academic vocabulary is stated by Coxhead (2000) and further studied by Granger and Paquot (2009) who compare the use of lexical verbs by native writers and advanced learners of English for Academic Purposes (EAP) to show verb specificity in different fields (business, linguistics, and medicine). The MRA genre analysis resulted in the establishment of a Medical Academic Word List comprising 623 word families and frequently used words in 32 specific subject areas (Wang, Liang, Ge 2008) and contrastive studies of reporting verbs in various disciplines such as the use of reporting verbs in 25 MRA introduction sections (Jirapanakorn 2012).

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\* PhD at Medical University of Varna, Varna, Bulgaria, e-mail: [ilina.doykova@abv.bg](mailto:ilina.doykova@abv.bg).

In view of Hyland's (2002) and Hyland and Tse's (2007) approach to teaching academic language in its specificity, we believe that the Bulgarian community of researchers and doctoral students would benefit from the present analysis of MRA for an improved lexical choice and precision in their English writing. This study is motivated by the observations on the repetitive use of certain verbs, the overuse of passive voice, and the multiple revisions in the scientific writing courses at the Medical University of Varna.

## **2. Research method**

All verb forms were statistically determined in 250 medical research articles with WordSmith Tools, Version 6 (Scott 2012) and the lexical items that occurred frequently in the separate sections of the medical RA were identified. The Bulgarian collection of MRA, published in English (BULRA corpus) was investigated for types of verbs, their active or passive use in the sentence and specific meaning. The BULRA corpus comprises 50 original papers and is gradually expanded to represent a broad specter of medical disciplines within the research article genre from peer-reviewed medical journals such as *Acta Medica Bulgarica*, *Folia Medica*, *Journal of Biomedical and Clinical Research*, *Scripta Scientifica Medica* and *Trakia Journal of Sciences*. Each paper is written by a different group of researchers and recently published (2015-2017). The total number of tokens (running words) in the BULRA collection is 167 957 (15 112 word types) and a lexical density of 27.39 words in 5 138 sentences.

The second collection of research articles of international researchers (INTRA corpus) contains 200 open access research papers, published in *BioMed Central* journal. This influential journal was selected and served as a reference corpus for its high impact factor (8.005). The size of the INTRA corpus is 955,104 words (25 097 word types) with a lexical density of 35.51 words in 12 363 sentences. The articles cover various fields in medicine such as surgery, clinical pathology, dermatology, nephrology, cardiovascular disorders, infectious diseases, nutrition, etc. A keyword list of all used verbs was compiled and compared to the BULRA keyword list of verbs.

## **3. Research question: Identification of key verbs in MRA**

To identify the verbs, characteristic of the medical research articles and eliminate past participle (A) and attributive adjective use (B), the BULRA corpus was grammatically annotated with the CLAWS C7 tagger (Fig. 1), developed at Lancaster University for parts of speech tags such as modal verb (VMO), infinitive forms (VVI), present and past participle (VVG, VVN) tags:

A. The rate of complications *observed* in PNS varies with different authors, although the method is minimally invasive.

B. Like other authors, we associated the *observed* hypovitaminosis with the reduced activity of the alpha-1-hy-droxylase, mild expression of vitamin D receptors and an increased loss of vitamin D transport proteins [12, 13, 14].

The\_AT0 exact\_AJ0 diagnosis\_NN1 of\_PRF chronic\_AJ0 myofascial\_AJ0 and\_CJC temporomandibular\_AJ0 pain\_NN1 conditions\_NN2 is\_VBZ often\_AV0 quite\_AV0 a\_AT0 challenge\_NN1 for\_PRP clinicians\_NN2 that\_CJT have\_VHB to\_TO0 unravel\_VVI the\_AT0 puzzle\_NN1\_SENT\_PUN The\_AT0 present\_AJ0 investigation\_NN1 provided\_CJS findings\_NN2 that\_CJT can\_VM0 be\_VBI useful\_AJ0 to\_TO0 create\_VVI a\_AT0 world-wide\_AJ0 database\_NN1

*Fig. 1 Verbs in BULRA corpus*

#### 4. Data analysis

The verbs in the corpus were sorted in a quantitative wordlist according to their frequency of occurrence and subsequently lemmatized. All verb forms from the BULRA wordlist were compared to the INTRA wordlist to obtain the keywords (high frequency verbs in both corpora) and the key verbs were observed and analyzed in concordance lines. The comparison revealed that certain key verbs occur more often in BULRA corpus and other verbs are not typically used as the negative key verbs in Fig.2:

N	Key word	Freq.	%	Texts	RC	Freq.	RC	%	Keyness
1	SHOWED	112	0,08	17	0				455,06
2	PRESENT	97	0,07	25	0				394,11
3	COMPARED	90	0,06	23	0				365,66
4	LEADS	62	0,04	14	69				90,06
5	DEFINED	18	0,01	12	0				73,12
6	EVALUATED	15	0,01	9	0				60,94
7	PROVIDE	14		7	0				56,87
8	TREATED	99	0,07	14	337	0,04			29,83
9	REDUCES	23	0,02	7	31				28,48
10	COLLECTED	10		6	265	0,03			-29,24
11	CONSIDERED	36	0,02	20	545	0,06			-29,56
12	ESTIMATE	8		3	246	0,03			-30,62

*Fig. 2 Keyword list in BULRA corpus*

The choice of reporting verbs enables the writers to position their work in relation to that of other members of the research community. Following Thompson and

Ye’s classification (1991) and according to their potential and function in the MRA, these may be categorized as textual (discourse verbs), mental (cognition verbs) and research (experimental) verbs. Other classifications such as Thomas and Hawes’ (1994) and Hyland’s (2002) use similar group names which are added here for reference (in brackets). The overuse of verbs, denoting static relations and passive voice forms together with the most frequent neutral verbs of reporting is illustrated in BULRA corpus (Table 1).

<b>Lemma</b>	<b>Occurrences</b>
Be [be, been, being, is, are, was, were]	3444
Have [have, has, had]	563
Show [show, shows, shown, showed]	236
Find [find, finds, found]	189
Use [use, uses, used]	126
Report [report, reports, reported]	114
Present [present, presents, presented]	106
Occur [occurs, occurred]	83
Observe [observe, observed]	69
Demonstrate [demonstrate, demonstrated]	56

*Table 1. Overused verbs in BULRA corpus*

The extracted verbs from the INTRA corpus show a considerable degree of variation and use in comparison to BULRA corpus. The notion of ‘optimal viewing arrangement’, introduced by Langacker (1987) predetermines the use of impersonal sentences, sentences with suppressed agentivity (in passive voice), and the high percentage of predicative adjective constructions in research articles (*be required, be recommended, be needed, be used, be prescribed, be considered, be consistent with*). Resultative constructions are supplied by many sources (3rd plural impersonal, reflexive verbs, and perfective aspect) to achieve such prominent features of scientific writing as objectivity and impersonal style (Hyland 2002).

The cluster analysis of frequent verbs and their patterns in BULRA shows passive voice preference and lack of variation in sentence structure (Fig.3a, b).

N	L5	L4	L3	L2	L1	Centre	R1	R2	R3	
1		IN	THE	AND	THE	WAS	OBSERVE	IN	THE	AND
2		OF	AND	THE	WAS	WERE	OBSERVE	ON	IN	THE
3		THE	GENERAL	PRACTIT	THEY	IS		BETWEEN		WITH
4		AL	IRREGUL	AFTER	ROUGHN	ARE		VERY		SURFACE
5				OF	CAN	BEEN		THE		DIET
6					AND	BE				ELECTRC
7					OF	SHOULD				FIRST
8					HAVE	THE				

Fig. 3a Patterns of *observe* in BULRA corpus

N	Cluster	Freq.	Set	Length
1	WAS PERFORMED IN	10		3
2	WAS PERFORMED USING	7		3
3	WAS PERFORMED WITH	5		3
4	WAS PERFORMED BY	5		3

Fig. 3b Patterns of *perform*

Further on, frequent negative predicative adjective constructions with stative reading (*not important, not essential, not able, not certain*) may be replaced by equivalent verbs or negatively prefixed constructions (*fail, lack, be absent, be arguable, be inferior, be insufficient, be incomplete*) for an improved readability and stronger focus on the presented results. Sentences in need of revision are the following samples:

1. The low response rate and mixed sampling inhibits generalization of the findings, but this was not our objective and, given the sufficient breadth of the data, it *should not be concerning*.
2. Although the exact mechanism involved in burn-induced mucosal damage *is not clear* yet, increasing evidence indicates decreased gastric mucosal blood flow, local and systemic liberation of cytokines and reactive oxidant intermediaries and changes in production of nitric oxide (NO) and prostaglandins (PGs) as a factor of mucosal damage (2-4).
3. Besides, the available laboratories *are not able* to meet the diagnostic demand of all the patients with CHF.12,26 Type 4 screening devices (one or two channels) are a meaningful solution to detect patients with SDB.

Common verbs *be, test, show, have, make, give, take* have specific lexical verb substitutes which add elegance and formality to scientific writing (*conclude, find, indicate, demonstrate, reveal, emphasize, support, allow for, exist, occur, appear, arise, emerge, observe, assess, achieve, measure, determine, confirm*, etc.) and the collocations could be established with the help of a reference corpus search. For example, the verb *make* is not the right choice for the noun *experiment* (*\*make an experiment*) but rather a literal translation of the Bulgarian phrase (правя експеримент) and when collocations are verified in the British National Corpus it becomes evident that only one lexical element in the collocation is identical. Thus, verbs such as *carry out/perform/conduct* prove to be the noun company (Fig. 4).

CARRIED	41	13308	0.31
CONDUCTED	35	2937	1.19
PERFORMED	28	3869	0.72
OBSERVATION	27	2777	0.97
SUBJECTS	27	7614	0.35
SUCCESSFUL	25	10564	0.24
EXPERIMENT	24	3091	0.78

Fig. 4 BNC search for collocations of *n. experiment*

In order to avoid such ‘omnipresent’ verbs and to strive for brevity and conciseness in scientific writing, verb-noun collocations (*make an assessment, make a presentation, make a conclusion*) may be replaced by specific verbs (*assess, present, conclude*) for an improved readability. Cognition verbs found in BULRA corpus (*appear, suggest, seem*) should also be used with care and limit:

4. Overall, although there was some evidence *to suggest* higher risk of IHD morbidity, it was limited.
5. In univariate analysis only two of the factors *appeared to be significantly associated with* the disease free survival (Table 2): T and N staging.
6. We think that a mix of hormones, their interplay with cytokines and the insulin signaling pathway *seem to be responsible for* the metabolic changes occurring during pregnancy.

Over the years academic writing style has been studied by many linguists such as Bell (1995), Swales and Feak (2004), Zeiger (2000), Gustavii (2017) and many others, who recommend the active voice as the more precise, shorter, and clearer alternative to the passive for all parts of the research article but Materials and Methods where it is used to emphasize findings. Thus, the revised versions of the passive sentences from BULRA corpus highlight the main idea (Table 2):

## BULRA samples

## Revision

7. In order <i>to provide</i> more significant results after Er: YAG laser treatment, further investigation <i>is needed</i> in the future.	Future investigations will provide significant results!
8. Antibiotics and steroids <i>are often used</i> to treat the lesions.	Lesions are often treated with antibiotics and steroids.
9. The method <i>was used</i> as a main and only method with 98% success in conservative dentistry.	This method was 98 % successful in conservative dentistry.
10. Epidural abscess formation with a craniocaudal length of 3.5 cm at this level <i>was observed</i> .	We observed an epidural abscess formation ...

*Table 2. Improved readability after passive-to-active transformation*

Thus, the external view point on behalf of the researcher is still preferred in the Bulgarian scientific writing and remains the dominant strategy in achieving objectivity. Sentences in the active voice with inanimate agents are the second syntactic option, featured in scientific writing. Contrary to academic writing in Bulgarian, the use of reporting verbs in combination with non-human subjects breaks no grammar conventions:

11. However, our approach accurately <i>predicts</i> whether an emerging pathogen remains below the critical epidemic threshold ( $R < 1$ ).
12. Our results <i>indicate</i> that serum iron reflects the iron deficiency and inflammatory activity: the amount of serum iron was significantly higher in healthy controls compared to RA ( $P=0.014$ ) (Table 1), which confirmed the hypoferrremia condition in RA patients.
13. These data clearly <i>demonstrate</i> that MitoQ not only suppresses release of the active forms of IL-1 beta and IL-18, but also their transcriptional up-regulation.
14. Recent research <i>has suggested</i> that cognitive disorders are a persistent trait of mental illnesses such as schizophrenia.

## 5. Results and Discussion

The present analysis showed that past participles, functioning either in predicative adjective patterns or in passive sentences, dominate the MRA texts. Past participles may represent resultative states or actions with a different degree of verbality or stability. In predicative adjective patterns, the verb *be* functions as a main verb with a stative reading and the past participle expresses a property/

state in predication and in passive voice it is used to denote a resultative action (Doykova, Sezova-Nankova 2015). Thus, when a resultative state, a fact, or a completed past action is described, researchers resort to verbal passive and stative resultative constructions (Appendix 1). Predicative adjectives referring to states as being more time-stable than verbs (Haspelmath1994) are also frequent.

The dominant verbs in the INTRA corpus vary slightly in their rank (as per frequency of use) when compared to the BULRA corpus but experimental verbs occupy top positions in both corpora (Table 3). Highly ranked certainty verbs that are found exclusively in BULRA are demonstrate, determine, detect, test, affect, establish, lead, diagnose. Tentative verbs such as recommend, hypothesize, speculate are rarely used.

Rank	BULRA		Rank	INTRA	
	Verb	Frequency		Verb	Frequency
1	use	120	1	study	895
2	increase	109	2	use	763
3	perform	68	3	report	704
4	report	78	4	show	686
5	lead	63	5	associate	560
6	cause	60	6	find	541
7	determine	58	7	increase	522
8	demonstrate	56	8	observe	498
9	show	53	9	include	476
10	observe	51	10	identify	434
11	establish	50	11	perform	409
12	include	47	12	consider	374
13	find	46	13	estimate	317
14	consider	41	14	assess	275
15	suggest	41	15	conduct	264
16	present	39	16	describe	235
17	treat	38	17	obtain	231
18	study	37	18	provide	212
19	occur	32	19	see	204
20	detect	28	20	calculate	201
21	test	24	21	measure	198
22	analyze	24	22	present	186
23	compare	22	23	treat	153
24	present	21	24	analyze	146
25	apply	20	25	indicate	128

*Table 3. Top 25 verbs in BULRA and INTRA corpora*



The key verbs and predicative adjective constructions, extracted from INTRA corpus demonstrate greater variety and specificity in the separate IMRD sections of the medical research article (Table 4):

Presenting the research topic  (Introduction)	investigate, examine, explore, determine, compare, analyze, assess, consider, evaluate, estimate, describe, develop, discuss, see, argue, indicate, hypothesize, concentrate on, focus on, propose, note, report, study, show, attempt to, examine, conduct, provide insight, would be useful, carry out, should be investigated, may be developed, better understand, deal with, aim at, motivate, report, address, validate, review
Experimenting  (Materials & Methods)	use, perform, analyze, conduct, test, perform, compute, recruit, select, enroll, choose, include, exclude, allocate, assign, group, divide, randomize, categorize, stratify, obtain, maintain, acquire, carry out, collect, gather, retrieve, assess, evaluate, consider, ascertain, measure, determine, define, detect, explore, calculate, compute, record, examine, classify, estimate, determine, use, apply, employ, present, summarize, express, associate, attempt, illustrate, identify, reveal, conduct, detect, investigate, establish, perform
Reporting  (Results)	assess, evaluate, examine, study, explore, compare to/with, contrast, match, characterize, probe, relate, correlate, associate, demonstrate, highlight, test, inform, confirm, ensure, establish, verify, obtain, differ, reduce, be related to, be similar, be different, show, indicate, suggest, reveal, exhibit, illustrate, exemplify, affirm, assert, testify, interpret, define, report, reveal, find, observe, view, review, perceive, regard, approach, study, have, present, perform, summarize, involve, search, survey, inspect, inquire, explore, investigate, identify, check, detect, determine, assess, analyze, calculate, ascertain, provide evidence, employ, utilize, implement
Defending  (Discussion)	associate to/with, correlate with, interact with, find, observe, use, explain, demonstrate, indicate, reveal, yield, explore, reason, clarify, confirm, occur, consider, need, examine, investigate, support, present, evaluate, reflect, provide, be consistent with, be attributed to, be applied to, suggest, propose, examine, establish, assume, assess, highlight, include, indicate, agree with, be limited to, be required, be needed, be essential, be bias free, speculate, report, suggest, note, predict, recommend, describe, indicate, emphasize

Concluding	conclude, present, propose, recommend, demonstrate, determine, assess, observe, show, summarize, suggest, serve, enhance, add to, support, find, estimate, identify, influence, contribute, be required, be recommended, be needed, be necessary, be prescribed, be considered, be helpful, be useful, need to, consider, focus (on), believe, think, refer
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*Table 4. Verbs and predicative adjective constructions, INTRA corpus*

Bulgarian authors adhere to neutral verbs and few verbs of cognition (consider) occur only in the conclusions section of the MRA. Contrary to the Bulgarian corpus, evaluative, mental and experimental verbs are preferred in INTRA corpus and suggestive of the type of research activities (assess, estimate, consider, indicate, identify). Strong evaluative verbs such as argue, support, confirm, claim, believe, associate, provide, conduct, treat, assess, estimate, indicate are also frequent in INTRA.

Worth mentioning is the similar use of research verbs such as show, report, observe, find, use, perform, analyze, study, include by both groups of researchers which could be attributed to their universal function in scientific discourse. Greater difference is found in the tense choice and verb meaning (suggest vs. propose) which points to certain grammar and lexical issues for further investigation.

## 6. Conclusions

In the standard four-section structure of the medical research article (Introduction, Methods, Results, and Discussion) a variety of verbs are employed to present the findings and produce a convincing manuscript. The purpose of the corpus-based study was to extract, describe and compare the characteristic use of lexical verbs, non-native speakers overuse or misuse in scientific papers. The set of 120 discipline-specific verbs from the specialized corpus will assist novice writers in their vocabulary development and writing practice. The specificity of the RA genre necessitates conventional choice of grammar and lexis which should be incorporated in the language teaching for specific purposes. The process of expanding the two corpora is on-going with the intention to investigate the variety of structures and the specifics of the MRA genre for effective instruction and course-book design.

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- BioMedcentral journal. <<https://www.biomedcentral.com>>
- CLAWS C7. <<http://ucrel.lancs.ac.uk/cgi-bin/claws72.pl>>
- British National Corpus. <<http://www.natcorp.ox.ac.uk/>>

**Appendix 1. Passive constructions and predicative adjective patterns in BULRA corpus**

[V <sub>pass</sub> ]		[be] +[Adj]
performed (69)	known (17)	be available (34)
increased (20)	conducted (16)	be similar (26)
included (52)	achieved (15)	be necessary (17)
established (47)	indicated (15)	be difficult (15)
determined (45)	obtained (14)	be responsible (13)
considered (39)	evaluated (13)	be useful (10)
treated (36)	expected (13)	be limited (8)
made (30)	affected (12)	be appropriate (7)
applied (29)	assessed (12)	be different (7)
identified (28)	carried out (11)	be crucial (5)
investigated (28)	given (9)	be consistent with (5)
analyzed (27)	examined (8)	be helpful (3)
expressed (27)	accepted (8)	be apparent (2)
described (25)	allowed (8)	be essential (2)
confirmed (25)	processed (8)	
detected (23)	approved (8)	
measured (23)	introduced (8)	
diagnosed (22)	needed (8)	
tested (22)	recommended (7)	
seen (21)	prescribed (7)	
estimated (20)	be required (4)	

**Appendix 2. Specific verbs in medical research articles, INTRA corpus**

acquire, add, address, affirm, agree, aim, allocate, analyze, apply, argue, assert, ascertain, assess, assign, associate, assume, attempt (to), believe, calculate, carry out, categorize, characterize, check, choose, claim, clarify, classify, collect, compare, compute, contrast, concentrate (on), conclude, conduct,

confirm, consider, contribute, correlate, deal (with), define, demonstrate, describe, detect, determine, develop, differ, discuss, divide, emphasize, employ, enhance, enroll, ensure, establish, estimate, evaluate, examine, exclude, exemplify, exhibit, explain, explore, express, find, focus (on), gather, highlight, hypothesize, identify, illustrate, include, indicate, influence, inquire, inspect, interact (with), interpret, investigate, involve, maintain, measure, motivate, need (to), note, observe, obtain, occur, perceive, perform, present, propose, provide, recommend, recruit, reduce, reflect, report, retrieve, reveal, record, review, search, see, select, serve, show, speculate, stratify, study, suggest, summarize, support, test, testify, understand, use, validate, verify, yield (120)