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Medical Uncertainty and the Art of Communication: Exploring Modality Applied in Medical Journal Abstracts

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Abstract

Medicine is a science dealing with uncertainty and the art of judging probability. For effective communication, doctors, researchers, or health sciences writers, need to master the use of modality whereby unreal situations can be discussed. How modal verbs — the most commonly used type of modality applied in the writing of health and medical sciences — are used in general English can differ from scientific contexts, and within different scientific fields a modal verb may not be used in the same way. This study aims to analyze the use of modal verbs in the abstracts of medical articles published in the past 5 years to enable researchers or medical writers to select the most suitable linguistic devices for their contexts. Modals were discovered to function variously in different parts of medical abstracts, with the highest number in the final part of the abstract structure. In the majority of the abstracts analyzed, usage was found not to be speculation on the part of the author but rather to address the evidence and circumstances. Modals were also found to be context-based

and relate to the choices of the tense, voice, reality status, and situation type. The findings can benefit scientific writers and provide EAP, ESP, and EST instructors material for communicative practice.

1. INTRODUCTION

"Medicine is a science of uncertainty and the art of probability," according to William Osler, one of the most influential physician-professors of the 19th and early 20th centuries. The statement clearly rings true of many situations experienced within the medical fields. For instance, terminally-ill patients have been known to miraculously survive. Moreover, the same medicine may not lead to the same results in different patients, or even within the same patient at different times. All this implies that medicine needs to deal with the *chance* of what may happen and address the evidence showing possibility or probability (Chayakul, 2012; Wellbery, 2010).

In terms of communication, the use of modality — "the linguistic phenomenon whereby grammar allows one to say things about, or on the basis of, situations which need not be real" (Portner, 2009, p. 1) — is needed for delivering medical messages (Vihla, 1999). Modal verbs (e.g. *should* and *may*) are the most commonly used type of modality applied in the writing of health and medical sciences (Muangsamai, 2018) and are significant linguistic devices employed in scientific fields, playing an important role in medical language (Hyland, 1998; Vihla, 1999; Yamazaki, 2001; Yang et al., 2015).

Although previous research has analyzed the use of modality in academic fields, the majority of these works focus on the general use of language (e.g. Kratzer, 2012; Portner, 2009). Some linguists have studied the use of modality in particular fields (e.g. Qian & Pan, 2019; Wallwork, 2013); nevertheless, as Hyland (2006) states, the same linguistic tools may function differently in various genres. How modal verbs function in scientific texts can differ from their use in general English or other disciplines (Yamazaki, 2001).

In medical texts, linguists (e.g. Muangsamai, 2018; Salager-Meyer, 1992; Vihla, 1999) have also yielded different aspects concerning this type of linguistic device. However, there seems to be a dearth of studies analyzing how modal verbs have specifically been applied in medical

abstracts, the most read parts of medical articles (Mogull, 2018) or "the starting point of any professional reading" (Salager-Meyer, 1992, p. 94). This study, thus, aims to analyze the use of modal verbs in the abstracts of medical articles published in the past 5 years to enable researchers or medical writers to select the most suitable linguistic devices for their contexts.

Not only can the comprehension of linguistic modality, or modal verbs in particular, help medical professionals communicate effectively with patients and their families, such understanding can also increase their chance of having academic and research papers published in international contexts and contribute to the development of treatment and other aspects of the medical fields (Muangsamai, 2018; Yang et al., 2015). Moreover, the knowledge concerning modal verbs benefits not only medical writers but also scholars in other fields as they are one type of linguistic modality, a device used to propose the key messages of academic works and research studies.

2. REVIEW OF LITERATURE

Communicators can choose various linguistic tools to convey modality. These choices include:

1. modal verbs (henceforth *modals*) (e.g. Physician burnout *can* lead to major medical errors.)
2. verbs indicating beliefs or assumptions (e.g. I *believe* that this is not the case.)
3. verbs applied with inanimate subjects referring to particular information or research results (e.g. Our findings *imply* that smoking is linked to the risk of lung cancer.
4. modal adverbs (e.g. This is *possibly* caused by a virus.)
5. expansion of the predicator (e.g. Differences in obesity *are unlikely to* provide an explanation for this case.)
6. adjectives (e.g. *Possible* treatment includes radiology.)
7. projecting clauses of relational process (e.g. *It is likely that* the failure results from negligence.)
8. the change of parts of speech (e.g. changing from the adjective *possible* as in 'It is *possible* that the relatives do not have the time to take

care of the patient.' to the noun *possibility* as in 'The *possibility* exists that the relatives do not have the time to take care of the patient.'

(Portner, 2009; Yang et al., 2015).

Regarding written discourse, among all the aforementioned modality devices, modals are the semantic tools most commonly discovered in research articles (Petchkij, 2015) and written discourse in medicine and health science (Muangsamai, 2018). They are the most commonly used modality devices expressing epistemic modality or the writers' assumption or judgment (Hyland, 1994). In other words, they play a very significant role in hedging in academic texts, and in general, English users also typically depict modality via the use of modals (Hardjanto, 2016).

Despite the fact that, in typical English lessons, modals are discussed, the basic elements studied may not be adequate for writing the language for specific purposes. Yamazaki (2001), for instance, points out that whereas it has been stated in a number of English grammar books for non-native speakers that the modal *may* indicates higher probability than *might*, statistical analysis demonstrated no significant difference between the certainties that writers of scientific texts attributed to these two modals. In addition, those who study English as a foreign language may have been exposed to the meaning distortion of particular modals. To illustrate, in Thailand the modal *can*, when translated into Thai, is usually fixed with the meaning regarding ability despite its relation to other meanings related to possibility and permission (Krairerk & Mallikamas, 2014). Meaning distortion has also been witnessed in English-French translation. When a deontic *must* showing the writer's judgment used in medical abstracts, for instance, is translated into French, the verb *devoir* in the indicative mood is typically the choice of translation, which in contrast demonstrates the sense of being unbiased (Martikainen, 2018). Moreover, research articles have unique characteristics which inexperienced readers/writers, or those who study English as a foreign language in particular, may find difficult to understand (Muangsamai, 2018).

Importantly, different genres also matter in terms of linguistic choices. Scholars in the field of humanities, for example, are likely to be more tentative or use more hedging devices in the discussion section of a research article than those who write basic sciences and agriculture

articles (Afshar et al., 2014). In the work of Hardjanto (2016), comparing the use of modals in the research articles of five particular fields, modals were applied most frequently in linguistics and economics, and least used in natural sciences and engineering texts, with their use in health sciences discourse coming in between.

In scientific fields, different details also exist among various scientific genres. For instance, while *may* and *would* are likely the two most commonly used modals in engineering and natural sciences research articles, medical research writers adopt *may* and *might* most frequently (Hardjanto, 2016). In the same discipline of medical writing, differences can also be found. Although both Salager-Meyer (1992) and Vihla (1999) discovered that *may* is the most commonly used modal in medical texts, the two disagreed in terms of the levels of certainty: *may* could portray high probability (Salager-Meyer, 1992) or merely possibility (Vihla, 1999). In addition, Muangsamai (2018) analyzing health and medical science reports in the New Scientist journal found that *can* is the most typically applied modal.

Many medical discourse analysts (e.g. Ferguson, 2001; Carter-Thomas and Rowley-Jolivet, 2008; Lysanets et al., 2017) assert that the analysis of medical writing elements should be integrated into tertiary courses of English for Specific Purposes. Modals should be considered as required elements the usage of which needs to be mastered by those aspiring to be medical writers. They are part of hedges, essential factors of any specialized discourse, and are typically applied in medical writing or communication (Martikainen, 2018). Nowadays, in the digital era, as readers read abstracts first to determine whether they will continue to read the articles (Mogull, 2018; Salager-Meyer, 1992; Zhao & Wu, 2013), medical writers cannot overlook the art of using modals in the abstracts.

Some research studies deal with the use of particular modals; however, these research materials are not resources for medical writing. Krairerk and Mallikamas (2014), for instance, analyze the different meanings of *can* but focus on English-Thai translation and the texts were fiction. Although several researchers (e.g. Salager-Meyer (1992), Vihla (1999), Yang et al. (2015), and Muangsamai (2018)) have studied modality in medical discourse, not many specifically analyze the use of modals in medical abstracts. Bongelli et al. (2019) explore modals in biomedical articles but focus on the comparative analysis of a medical

journal and a popular science magazine and do not pay sole attention to modals but to other linguistic devices as well.

Despite the fact that some research studies concern the application of modals in medical abstracts, what they focus on does not meet the requirements of the present study. For example, Alonso-Almeida and Cruz-Garcia (2011) limit their analysis of modals in medical abstracts to only one modal (i.e. *may*), while medical writers need to know the details of all possible choices. Martikainen (2018) explores the use of modals in medical abstracts but simply focus on the distortion in French translation. Almost two decades ago, Salager-Meyer (1992) studied the relations of different tenses and modal verbs to the functions of different stages of medical abstracts. However, the present study also discusses other grammar aspects connected to the communicative functions of modals as well as any different trends discovered in different decades.

Modals are associated with other grammatical elements, such as tense, voice, and verb type (Krairerk & Mallikamas, 2014; Montkhongtham, 2017). The verb strings of a sentence can be analyzed in terms of modality, tense and aspect, voice, reality status, and situation type (Maldonado, 2007; Montkhongtham, 2017; Portner 2009; Radden & Dirven, 2007).

2.1 Modality

Portner (2009) discusses different levels of modality analysis: sentential modality, sub-sentential modality, and discourse modality. This research study focuses on sentential modality as the research findings can be revealed to medical writers who need to master sentential elements/structure in order to convey their messages effectively. The study also covers discourse modality as linguistic analysis cannot fully separate certain parts of a whole.

In the framework of Portner (2009), modality is divided into (1) epistemic modality (EM), (2) priority modality (PM), and (3) dynamic modality (DM). While EM, as previously mentioned, demonstrates the speaker's judgement relating to the degree of probability or possibility of the event (e.g. He *must* arrive anytime soon. He said he was at the front of the hospital already), PM concerns goal-oriented modals, further

divided into (2.1) deontic PM, (2.2) bouletic PM, and (2.3) teleological PM.

Although the three subtypes of PM differ, all of them portray the idea that something else is more important than the action itself. To illustrate, the modal *must* in "Those who have travelled to the specified countries affected by the virus outbreak *must* quarantine themselves for two weeks" is considered to portray deontic PM. In such statement the modal marks the speaker's thinking concerning the quarantine action to be carried out, as in an obligation, for the good of the travellers and society (moral judgement). In addition, the modal *should* in "The patient thinks his doctor *should* let him smoke" portrays bouletic PM since the modal implies the importance of fulfilling the patients' expectation rather than the permission itself. Moreover, the modal *could* in "Tennis players *could* choose one of the following patterns as their warm-down routine after a tough competition" portrays teleological PM. The modal *could* is used to provide a suggestion concerning the action of doing a warm-down routine, while the top priority implied is injury prevention.

Next, Portner (2009) further divides DM into (3.1) volitional dynamic modality (VDM) and (3.2) quantificational dynamic modality (QDM). While VDM is sub-categorised into (3.1.1) ability VDM, (3.1.2) opportunity VDM, and (3.1.3) dispositional VDM, QDM is further divided into (3.2.1) existential QDM, and (3.2.2) universal QDM.

According to Portner (2009), dynamic modals are associated with the idea of the potential changes of circumstances. VDM concerns volitional individuals, and the three sub-types are related to different details. First, ability VDM as portrayed with the modal *can* and its negative form in "You *can* buy conditions for becoming healthy, but you *can't* buy good health," for example, shows one's ability or what one can or cannot do no matter the given circumstances. No matter what you do, no matter what other people do, or no matter where you are, you can buy, for instance, packages of exercise and healthy food, but you can never actually buy good health without committing yourself to certain actions. However, opportunity VDM highlights the idea of being dependent on changing circumstances. The modal *can* in "Mr Smith *can* be healed if he follows these steps" portrays opportunity VDM as the modal indicates the opportunity of recovery depending on the patient's actions. Next, dispositional VDM concerns the way someone usually thinks and acts or his/her character. One example is the modal *will* in

"Mrs Williams *will* not be happy if she hears that from the doctor." The modal indicates dispositional VDM since it is related to the reaction or state of mind shaped by the character of this particular patient.

Moreover, Portner (2009) states that quantificational modals generate existential or universal quantification over the individuals. To illustrate, the following statements both contain an indefinite noun as the subject: (1) "A smoker's lungs *can* be affected" and (2) "A smoker's lungs *will* be affected." Nonetheless, the modals in these statements differ in detail as they cause the subjects to receive different interpretations in terms of the expression of quantity. The modal *can* in (1) indicates a meaning similar to "*Some* smokers' lungs will be affected," so the modal *can* is considered to portray existential QDM. On the contrary, the modal *will* in (2) highlights a meaning closer to "*All* smokers' lungs will be affected," and thus considered to portray universal QDM.

2.2 Tense and aspects

Radden and Dirven (2007) elaborate on tense and aspect by providing the following categorizations: (1) simple tenses (present, past, and future), (2) complex tenses with anterior times (present perfect, past perfect, and future perfect), and (3) complex tenses with posterior times (present prospective, past prospective, and future prospective).

2.3 Voice

Maldonado's (2007) framework of grammatical voice in cognitive grammar categorizes voice into: (1) active-direct, (2) passive, (3) antipassives, and (4) inverse.

2.4 Reality status

Radden and Dirven (2007) further developed their reality status model from Langacker's (1991) conclusions concerning the immediacy of reality perceived by the participants of the speech event and the notion of potential and projected reality. Radden and Dirven (2007) focus on four types of reality status: known reality, immediate reality, projected reality, and potential reality. Factual reality (i.e. known reality and immediate reality) is portrayed when no modals are adopted. While known reality is

associated with the use of past tense, as in "The parents never *had* a chance to explain," immediate reality is related to the use of present tense, as in "The parents never *have* a chance to explain," for example. However, when future tense is applied, projected reality is portrayed (e.g. "The parents *will never have* a chance to explain"), while potential reality is depicted with the use of certain modals, such as *can* and *may*. For example, the modal *may* as in "The parents *may* never have a chance to explain" indicates potential reality.

2.5 Situation type

Radden and Dirven (2007) proposed 13 types of situation type. Elements influencing the categorization of situation are related to staticity, boundedness, duration, and telicity. First, if the content verb of a verb string indicates a situation that remains constant through time, it is considered to be a stative verb or a *state* (e.g. "Genes identified as essential in human cell lines or knockout mice may *be* distinct from those in living humans (Bartha et al., 2018) in which 'to be distinct' does not involve change but extends across time), whereas a verb depicting a situation associated with internal change or action is considered to be a dynamic verb or an *event* (e.g. "Question prompt lists can *increase* the number of questions asked by patients without increasing consultation length…" (Licqurish et al., 2019) in which 'increase' is related to internal change). Second, states are unbounded, no matter if they are temporary or lasting states. While a bounded event is an event expressed by the non-progressive aspect and is viewed with a beginning and an end (e.g. the verb *offer* in "Therefore, monitoring wildlife cancers could *offer* interesting and novel insights into potentially unique non-age-related mechanisms of carcinogenesis across species" (Pesavento et al., 2018), an unbounded event concerns progression or the beginning and the end are not expressed (e.g. "Haploinsufficiency *is emerging* as a critical aspect of gene essentiality…" (Bartha et al., 2018) and "To do this, key cell types and cell states that are implicated in autoimmune diseases will *need to be defined*" (Gutierrez-Arcelus et al., 2016)). Third, a durational event depicts duration (e.g. "How can we *treat* cancer more effectively?" (Schneider et al., 2017), whereas a punctual event does not portray duration (e.g. "PDBs can *arise* during the abortive activity of DNA topoisomerases…" (Ashour et al., 2015). Fourth, the difference between

an atelic verb and a telic verb is that, unlike the former, the latter involves "a series of cumulative phases to a conclusive end-point" (Radden & Dirven, 2007, p. 182). The verb *experience* as in "Patients may *experience* adverse cardiovascular events related to their cancer treatment or as a result of an exacerbation of underlying cardiovascular disease" (Curigliano et al., 2016), can thus be considered atelic, whereas the verb become as in "With longer periods of survival, late effects of cancer treatment may *become* clinically evident years or decades after completion of therapy" (Curigliano et al., 2016) is classified as telic.

States are divided into five subcategories (i.e. indefinite lasting states, temporary states, habitual states, temporary habitual states, and everlasting states), all of which are stative, unbounded, durational (indefinite and limited duration), and atelic.

Next, events are formed with dynamic verbs and are further categorized into eight subtypes: accomplishments, activities, achievements, acts, accomplishing activities, unbounded activities, culminating activities, and iterative activities

Moreover, besides these grammar aspects, the five stages of an abstract may also relate to how modals make meanings. The conventional types of information provided in an abstract include background information, the purpose of the study, methodology, results, and conclusions or recommendations (Weissberg & Buker, 1990).

3. RESEARCH OBJECTIVES

The objectives of this study are to explore:
1. the modals used in medical abstracts and their functions, and
2. the relation of the modals used in medical abstracts and other grammatical patterns, namely tense and aspect, voice, reality status, and situation type in terms of meanings

4. METHODOLOGY

4.1 Materials and data collection

Modal verbs adopted in the abstracts of 100 articles published in five medical journals with the highest impact factors were analyzed. The highest impact factors were based on the information of the year 2018.

Twenty abstracts were selected from each of the following journals published during 2015-2019.

(1) CA - A Cancer Journal for Clinicians (CA) (Impact Factor: 72.576)
(2) MMWR. Recommendations and reports: Morbidity and mortality weekly report. Recommendations and reports / Centres for Disease Control (MMWR) (Impact Factor: 48.894)
(3) Nature Reviews Genetics (NRG) (Impact Factor: 30.428)
(4) Nature Reviews Cancer (NRC) (Impact Factor 28.061)
(5) Nature Reviews Immunology (NRI) (Impact Factor: 26.208)

(Scimago Journal & Country Rank, n.d.)

While some studies may have focused on the selection of native-speaking writers, this study did not pay attention to the writers' nationality or the location of their institution. According to Coxhead (2020), "nobody is a native speaker of academic English." Those who have published their works are considered experienced writers. Bocorny (2020) also considers publishing papers in a peer-review journal "adequate" for academic analysis and recommends looking for high-impact journals rather than adopting the traditional view of native and non-native speaking writers. Moreover, articles published in peer-review journals are also reviewed by language editors, which ensures the quality of writing.

4.2 Data analysis

After sentences with modal verbs were manually extracted from the above-mentioned journal abstracts, the verb strings of each sentence were studied in terms of the following grammatical aspects: (1) modality, (2) tense and aspect, (3) voice, (4) reality status, and (5) situation type.

In terms of modality analysis, Portner's (2009) framework of sentential modality was applied. Then Radden and Dirven's (2007) categorization of tense and aspect, Maldonado's (2007) framework of grammatical voice in cognitive grammar, and Radden and Dirven's (2007) models of reality status and situation type were used in this study to analyze the verb strings of each modalized sentence. Besides these particular elements, the context (e.g. the content of the abstract or the stage of the abstract in which the modal appears) was also considered.

The researcher determined whether each modal is applied in (1) the beginning / opening sentence, (2) the body / central part, or (3) the final part / closing sentences.

Three examples of data analysis are provided below.

Modalized sentence 1: "This perspective *presents* key methodological, technical, practical and organizational challenges that *must be considered* by decision-makers responsible for the allocation of health-care resources to obtain robust and timely information about the relative cost-effectiveness of the increasing numbers of emerging genomic tests" (Payne et al., 2018).

This sentence was extracted from the abstract of an article published in *Nature Review Genetics*. It is included in the final part of the abstract, indicating discussion or conclusion. According to Portner's (2009) model of sentential modality, this sentence, with the use of the modal *must*, portrays deontic PM, depicting the goal of obtaining robust and timely information as being more important than the action of consideration itself. In terms of tense and aspect, present simple is used for both verb strings (*presents* and *must be considered*). The modal *must* in this statement expresses the meaning that this is something that needs to be done right now.

Next, the first verb string (*presents*) indicates the use of active-direct voice whereas the other (*must be considered*) expresses passive voice. The active-direct voice is applied for the first verb string to emphasize that this perspective presents particular information. In other words, the highlight is on the perspective and its capability. However, the passive voice is chosen for the modalized verb string so as to focus on the action of consideration, not to concentrate on any agents who consider.

In terms of reality status, the first present-simple verb string (*presents*) portray immediate reality, emphasizing that presenting is something that happens here and now. Nevertheless, with the modal *must*, the verb string (*must be considered*) depicts potential reality, indicating that the consideration action should be something that happens now and that it can happen now. As for situation type, both verb strings express activities, which, according to Radden and Dirven

(2007), are bounded, durational, and atelic events. Presenting and considering are durational and do not depict a conclusive end point.

Modalized sentence 2: "Finally, an overview of the policies related to insurance coverage and reimbursement *will give* the clinician an overview of important trends in the diagnosis, treatment, and management of cancer-related lymphedema" (Shaitelman et al., 2015).

This sentence was extracted from the abstract of an article published in *A Cancer Journal for Clinicians*. It is in the final part or the conclusion area dealing with the implications of the study. Through the perspective of Portner (2009), in terms of sentential modality, the statement portrays EM, which indicates the writer's judgment relating to the probability of clinicians being given the overview of important trends. In terms of tense and aspect, future simple is used. The modal *will* plus an infinitive indicates an event that has not yet occurred but one that will occur in the future. The verb string indicates the use of active-direct voice and projected reality, which relates to the use of future tense. As for situation type, an act is expressed as the verb string portrays a bounded, punctual, and atelic event (Radden & Dirven, 2007). The action of giving does not take time, but the verb *give* itself does not express a conclusive end-point.

Modalized sentence 3: "Any condition leading to high levels of DNA damage *will result in* replication stress, which *is* a source of genome instability and a feature of pre-cancerous and cancerous cells" (Gaillard et al., 2015).

This sentence was extracted from the abstract of an article published in *Nature Reviews Cancer* and included in the beginning or the stage providing background information. In terms of sentential modality, universal QDM is expressed with the modal *will* as well as the determiner *any*. Being used together the modal and the determiner express the sense that *every* condition leading to high levels of DNA damage will result in replication stress, with no exception.

The first verb string of this sentence or the modal *will* plus the infinitive *result in* indicates the use of future simple. It is something that will happen when this kind of condition is realized. Different from the

first, the second verb string (*is*) is used with present simple, indicating the present characteristics of replication stress.

Moreover, active-direct voice is applied for both verb strings, showing that the authors concentrate on the non-human agents (*any condition leading to high levels of DNA damage* and *replication stress*) and their characteristics.

As for reality status, *will result in* expresses projected reality, typically associated with the use of future simple whereas *is* depicts immediate reality. The modal *will* shows that it is something that will happen, unlike *is*, which portrays immediate reality relating to the characteristics of replication stress.

In addition, according to Radden and Dirven's (2007) framework of situation type, the first verb (i.e. *result in*) expresses an achievement whereas the other (i.e. *is*) portrays an indefinite lasting state (ILS). The verb *result in* is a bounded, punctual, and telic event. It does not show duration but expresses a conclusive end-point. Different from *result in*, *is* expresses an ILS or a condition lasting "for an indefinite time but may eventually cease to exist" (Radden & Dirven, 2007, p. 191).

5. RESULTS AND DISCUSSION

The present study examined the modals commonly used in medical abstracts and their functions relating to the abstract structure as well as their relation with grammatical aspects in terms of meanings. The results of the present study are presented and discussed according to the two research objectives.

Research Objective 1: to explore the modals used in medical abstracts and their functions

Each modal was used to portray various types of modality in different parts of the medical abstracts to construct various meanings. Table 1 presents the distribution of each modal in various positions of the abstract structure, and the details of each modal are provided thereafter.

Table 1

The Distribution of Each Modal in Various Positions of the Abstract Structure

	Abstract Structure		
	Beginning	Body	Final Part
can	36.49%	27.03%	36.49%
could	5.88%	5.88%	88.24%
may	38.46%	19.23%	42.31%
might	25%	12.5%	62.5%
must	-	25%	75%
should	-	10%	90%
will	20.69%	27.59%	51.73%
would	-	50%	50%

5.1 Predominant use and differences among modals

5.1.1 The modal *Can*

The modal *can* was applied in the beginning, body, and final part of the medical abstracts. For this modal, 36.49% were used in the beginning section to provide background information. Another 36.49% were used in the body to indicate the gap of the literature or to express the purpose of the study. Finally, the remainder, 27.03%, was applied in the ending part interpreting what was found and providing implications or recommendations. Examples are presented in Table 2.

In the beginning section, the modal *can* was used in sentences expressing opportunity VDM, ability VDM, deontic PM, and existential QDM. First, opportunity VDM, ability VDM, and existential VDM were portrayed when the modal *can* emphasized (1) the characteristics of non-human agents (e.g. cells and bacteria), (2) the chance that some negative circumstances may occur (e.g. particular infections or diseases and

compromised quality of life), (3) positive possibilities (e.g. genetics providing insights into disease), and (4) questions relating to treatment. Next, deontic PM was portrayed when the achievement of treatment was mentioned as the prioritized goal (e.g. talking about how an intervention can be used for treatment success). Additionally, when this modal was used in the same sentence with another modal (i.e. *may*), EM was expressed.

As for the body, *can* was applied to portray similar types of modality as those expressed in the beginning section, except for EM, which wasn't found at all in this section of the abstract. The modal *can* was used to raise a question not only in the beginning section but also in the body when the authors pointed out a significant question not addressed in the existing literature. Moreover, teleological PM was also expressed with the use of *can* in the body when the authors mentioned a particular way to achieve a particular effect. This type of modality is different from deontic PM portrayed with the modal *can* since deontic PM involves an action that should be done for patients. In other words, the benefits of patients were stated more explicitly instead of focusing only on technical steps.

In the final part, the medical writers ended their abstracts with discussion, implications, or recommendations. The modal *can* was used to express similar types of modality as those expressed in the beginning and the body, except for EM and teleological PM, none of which were found in ending sentences. Regarding priority modality, the fact that deontic PM, not teleological PM was chosen for the final part is consistent with the content of this part relating to suggesting what should be done, not elaborating on the details concerning treatment strategies. Interestingly, universal QDM was found in the final part with the use of *can* while it was not found in the other two parts of abstract. Further research might investigate the use of universal QDM in medical abstracts to see whether there is any potential tradition of generalization relating to the structure of the abstract.

Consistent with Krairerg and Mallikamas (2014), context plays an important role in determining the meaning of *can* since it could be interpreted as portraying both opportunity VDM and ability VDM. However, in the present research material, when negative and interrogative forms were applied with the present tense (i.e. *cannot* and

Table 2

Examples of Modality Portrayed with Can in Different Parts of Medical Abstracts

Abstract Structure	Modality	Example	Function
Beginning	Opportunity VDM	Early and late effects of chest radiation *can* lead to radiation-induced heart disease, including pericardial disease, myocardial fibrosis, cardiomyopathy, coronary artery disease, valvular disease, and arrhythmias, in the setting of myocardial fibrosis (Curigliano et al., 2016).	Providing background information
	Ability VDM	How *can* we treat cancer more effectively? (Schneider, Schmidt-Supprian, Rad, & Saur, 2017).	Raising a question concerning the ability to treat cancer more effectively
	Existential QDM	Endometrial carcinomas *can* be classified into several histological subtypes, including endometrioid, serous and clear cell carcinomas (Urick & Bell, 2019).	Providing background information concerning potential subtypes of endometrial carcinomas
Body	Opportunity VDM	However, in modern times, chronic social threats *can* drive the development of sleep disturbances in humans, which *can* contribute to the dysregulation of inflammatory and antiviral responses (Irwin, 2019).	Indicating the chance of negative outcomes to emphasize the need to look into the issue
	Ability VDM	*Can* targeting of these interactions significantly improve patient outcomes? (Steeg, 2016)	Pointing out the gap in the existing literature

Abstract Structure	Modality	Example	Function
	Existential QDM	The mechanisms of antigen uptake, the nature of the antigen processing compartments and the lifetime of cell surface peptide-MHC class II complexes *can* vary depending on the type of APC (Roche & Furuta, 2015).	Emphasizing the need to look into the issue
	Deontic PM	Even patients who are not cured with initial therapy *can* often be salvaged with alternate chemotherapy combinations, the novel antibody-drug conjugate brentuximab, or high-dose autologous or allogeneic hematopoietic stem cell transplantation (Shanbhag & Ambinder, 2018).	Emphasizing the need to look into the issue
	Teleological PM	Functional genomic annotations from these cell types and states *can* then be used to resolve candidate genes and causal variants (Gutierrez-Arcelus, et al., 2016).	Providing further information concerning the topic, elaborating on what can be done to achieve particular effects
Final Part	Opportunity VDM	Such discoveries *can* often advance knowledge for all cancers (DeSantis, et al., 2017).	Discussing the possibility that what was discovered can advance knowledge relating to the issue
	Deontic PM	…women *can* increase their chances of having a healthy baby by reducing their risk for getting an infection during pregnancy ("Announcement: National," 2017).	Discussing what women can do for their babies' wellbeing.
	Universal QDM	These dosage systems *cannot* be identical by descent … (Graves, 2016).	Discussing the fact that is applied for all the cases of such dosage systems

Can…infinitive?), the meaning seems no longer ambiguous. For example, it is quite clear that *can* in the following statements is involved with ability VDM: "Haploinsufficiency is emerging as a critical aspect of gene essentiality: approximately 3,000 human genes *cannot* tolerate loss of one of the two alleles" (Bartha et al., 2018) and "How *can* we treat cancer more effectively?" (Schneider et al., 2017). Further research is needed regarding this matter.

5.1.2 The modal *Could*

The modal *could* was mostly used in the final part (88.24%) whereas 5.88% were used in the beginning section, and the other 5.88% were applied in the body. In the beginning area, this modal was applied to provide background information, portraying ability VDM.

When past tense is applied with *could*, which describes "a habitual past ability" or "an ability to do something on one particular past occasion" (Wallwork, 2013, p. 88) and which is "not used to make speculations" (p. 90), this clearly portrays ability VDM, not opportunity VDM (e.g. "The term 'undruggable' was coined to describe proteins that *could not* be targeted pharmacologically" (Dang et al., 2017)).

Next, in the body, *could* was also used together with *would* to express EM (e.g. "What *could not* be anticipated at the outset was how discovery of the mechanisms regulating the activation and function of cytotoxic T cells *would* lead to new developments in cancer immunotherapy" (Golstein & Griffiths, 2018)). Finally, this modal was used in the final part of the abstract to express opportunity VDM (e.g. "Therefore, monitoring wildlife cancers *could* offer interesting and novel insights into potentially unique non-age-related mechanisms of carcinogenesis across species" (Pesavento et al., 2018)). Moreover, several ending sentences were composed with the modal *could* to portray deontic PM. Sentences with *could* portray deontic PM when they concern what could be done to achieve the goal of helping or saving people (e.g. "A substantial portion of cancer cases and deaths *could* be prevented by broadly applying effective prevention measures, such as tobacco control, vaccination, and the use of early detection tests" (Torre et al., 2015)).

5.1.3 The modal *May*

The modal *may* was included in the final part (42.31%), the beginning (38.46%), and the body (19.23%). At the beginning of the abstracts, this modal mostly expressed existential QDM elaborating on the particular characteristics of someone or something so as to provide background information to readers (e.g. "Physicians from a wide range of specialties *may* be involved in either the referral to or the placement of brachytherapy" (Chargari et al., 2019) indicating that some physicians from a diverse range of specialties are involved in either of these two tasks).

In addition, as Vihla (1999) asserts, *may* can be used to show dynamic possibility. In the present study most of the cases of *may* expressing dynamic possibility are considered as depictions of existential QDM. For example, in one of the beginning sentences, "Patients *may* experience adverse cardiovascular events related to their cancer treatment or as a result of an exacerbation of underlying cardiovascular disease" (Curigliano et al., 2016), *may* shows that not *all* but *some* patients would experience adverse events. The modal does not seem to emphasize that *all* the patients have the potential to get worse but rather emphasizes the possible cases of *some* patients.

Next, an opening sentence with the use of this modal portrays EM when it concerns speculation about a past event (e.g. "As modern and ancient DNA sequence data from diverse human populations accumulate, evidence is increasing in support of the existence of beneficial variants acquired from archaic humans that *may* have accelerated adaptation and improved survival in new environments — a process known as adaptive introgression" (Racimo et al., 2015)). In addition, *may* in an opening sentence portrays deontic PM when it concerns an act for helping someone get better conditions (e.g. Persons with type 1 diabetes require insulin for survival; insulin *may* be given as a daily shot or continuously with an insulin pump (Bullard et al., 2018)).

In the body, the modal *may* was used to point out the gap in the existing literature or indicate the need to conduct the study. These body sentences, with the use of *may*, expressed EM (e.g. "However, in modern times, such interactions between inflammation and the brain appear to drive the development of depression and *may* contribute to non-responsiveness to current antidepressant therapies" (Miller & Raison, 2016)) and existential QDM (e.g. "Genes identified as essential in human

cell lines or knockout mice *may* be distinct from those in living humans" (Bartha et al., 2018)).

Similar to those in the body, sentences in the final part, composed with *may*, portrayed EM (e.g. "Together with longitudinal studies, this approach *may* yield pivotal insights into how autoimmunity is triggered" (Gutierrez-Arcelus et al., 2016)) and existential QDM (e.g. "In this review, we present the evidence relating to specific early life exposures that affect future allergy development, and discuss how these exposures *may* promote either tolerance or allergic sensitization" (Reynolds & Finlay, 2017)).

5.1.4 The modal *Might*

The major use of the modal *might* was applied in the final part (62.5%). For this modal, 25% were used at the beginning whereas the other 12.5% were used in the body.

Similar to the modal *may*, the modal *might* appearing at the beginning of the abstracts portrayed existential QDM (e.g. "A small proportion of diabetes cases *might* be types other than type 1 or type 2, such as maturity-onset diabetes of the young or latent autoimmune diabetes in adults" (Bullard et al., 2018) demonstrating that some diabetes cases are neither type 1 nor type 2). In addition, when used with a particular phrase emphasizing speculation, such as be supposed to, the modal *might* in an opening sentence portrayed EM (e.g. "One mechanism by which sleep is proposed to provide a survival advantage is in terms of supporting a neurally integrated immune system that *might* anticipate injury and infectious threats" (Irwin, 2019)).

In the body, *might* was used to portray EM (e.g. "However, progress is being made to 'drug' many of these targets, and therefore more appropriate terms *might* be 'difficult to drug' or 'yet to be drugged'" (Dang et al., 2017)). Next, the use of *might* in the final part of the abstracts was mainly linked to opportunity VDM and deontic PM. For example, when used with *can* and *could*, *might* can be part of the sentence portraying opportunity VDM, as in "Nicotine exposure during adolescence, a critical period for brain development, *can* cause addiction, *might* harm brain development, and *could* lead to sustained tobacco product use among youths" (Singh et al., 2016). Moreover, when a recommendation concerned the safety of others, deontic PM was expressed (e.g. "Public health authorities and employers *might* consider

results from relevant absenteeism surveillance analyses when developing prevention messages and in pandemic preparedness planning" (Groenewold et al., 2019)).

Furthermore, it is also worth comparing *may* and *might*. Despite Yamazaki's (2001) claim that *may* and *might* do not differ in terms of the level of certainty, in the present study, *may* was used in 15.52% of the modalized sentences, whereas *might* was used in only 4.6%. The present results are in accordance with Biber et al., (1999) arguing that *may* is more commonly applied than *might* in academic writing to depict possibility. These medical writers chose meanings based on their findings, which were related to certain evidence. Therefore, this is probably related to the conclusion that "*might* is slightly weaker than *may*" (Glasman-Deal, 2010, p. 163).

5.1.5 The modal *Must*

No use of the modal *must* was discovered in the beginning. This could be explained by the function of the opening sentences which is to present the current problem or situation, not to elaborate what should or must be done. For this modal, 75% was applied in the final part, and the other 25% in the body. This modal was found to be associated with only two types of modality: deontic PM and teleological PM. To illustrate, *must* was applied to portray teleological PM in the body as in "However, AID *must* be tightly controlled in B cells to minimize off-target mutations, which *can* drive chromosomal translocations and the development of B cell malignancies, such as lymphomas" (Casellas, 2016) emphasizing what must be done to achieve a particular outcome. Teleological PM was also seen in the final part, as in, for example, "Furthermore, efforts to target this pathway *must* consider the influence of the tumour microenvironment" (Röhrig & Schulze, 2016). Different to the depiction of teleological PM, deontic PM was portrayed when a final-part sentence, with the modal must, concerned social welfare, such as the allocation of health-care resources in the statement "This perspective presents key methodological, technical, practical and organizational challenges that *must* be considered by decision-makers responsible for the allocation of health-care resources to obtain robust and timely information about the relative cost-effectiveness of the increasing numbers of emerging genomic tests" (Payne et al., 2018).

5.1.6 The modal *Should*

For the modal *should*, 90% appears in the final part whereas the other 10% are in the body. Similar to *must*, no use of *should* was applied in opening sentences which are supposed to provide information concerning the present issues, not recommendations.

In the body, *should* was used to portray teleological PM, elaborating on more details (e.g. "In response to this single case of Ebola, initial health care worker active monitoring protocols needed modification to improve clarity about what types of exposure *should* be monitored" (Yacisin et al., 2015) indicating the need to monitor particular types of exposure to achieve the goal of being able to deal with an Ebola case effectively).

As for the final part of the abstracts, *should* was applied to portray deontic PM, providing recommendations (e.g. "Physicians *should* be supported by adequately resourced health services to respond effectively to the range of clinical and broader patient needs identified through the routine use of tools to facilitate communication" (Licqurish et al., 2019) emphasizing the support that physicians should obtain). *Should* was also used to portray teleological PM, providing recommendations concerning how to achieve a particular goal (e.g. "Here, we discuss these differences and emphasize that sex is a biological variable that *should* be considered in immunological studies" (Klein & Flanagan, 2016) discussing a variable that should be considered to achieve a particular goal which is more important than the action of consideration itself). Furthermore, in the final part, *should* was also used to express EM, showing the speculation about the future direction or possible benefits (e.g. "Therefore, a better understanding of the processes that regulate ferroptosis sensitivity *should* ultimately aid in the discovery of novel therapeutic strategies to improve cancer treatment" (Friedmann Angeli et al., 2019)).

5.1.7 The modal *Will*

For the modal *will*, 51.73% appear in the final part of the abstracts, 27.59% in the body, and 20.69% in the beginning. Considering that epistemic modality has been regarded as the indication of the speaker's "judgment of the truth of the statement" (Yang et al., 2015, p. 1), *may* was expected to dominate the realm of epistemic modality (Alonso-Alemida & Cruz-Garcia, 2011). Nevertheless, in this study *will*

was the most frequently used to express this type of modality. This *might*, on the surface, look surprising since *will* is usually associated with an expression of certainty not equivalent to hedging. However, the results are consistent with the findings of Hardjanto (2016) treating *will* as a hedge in his study and saying that "*will* is more commonly used to express epistemic meaning than non-epistemic meaning" (p. 43).

In order to provide background information and further details highlighting problematic trends and projections that underline the necessity for conducting the study, the majority of opening and central sentences composed with *will* portrayed EM (e.g. "In 2018, there *will* be approximately 22,240 new cases of ovarian cancer diagnosed and 14,070 ovarian cancer deaths in the United States" (Torre et al., 2018) and "A critical next step *will* be to identify the in vivo and ex vivo immunophenotypes that are affected by risk variants" (Gutierrez-Arcelus et al., 2016)).

Similar to the usage in the beginning and body, in the final part the major use of *will* was associated with the portrayal of EM showing future direction (e.g. "Investigation, recognition and in-depth biological understanding of these differences *will* be vital for the design of next-generation clinical trials and the implementation of molecularly guided cancer therapies in the future" (Schneider et al., 2017)).

Besides EM, deontic and universal QDM were also portrayed with the modal *will*. For instance, when the determiner *any* was used with the modal *will*, as in "*Any* condition leading to high levels of DNA damage *will* result in replication stress, which is a source of genome instability and a feature of pre-cancerous and cancerous cells" (Gaillard et al., 2015), universal QDM is portrayed. *Any* and *will* indicate that *every* condition like this will lead to this particular result. Additionally, when the goal of saving others is shown, deontic PM is expressed. For example, when the modal *will* is used with the modal *should* as in "International travelers *should* consider a pretravel consultation with travel health specialists; rabies preexposure prophylaxis is warranted for travelers who *will* be in rabies endemic countries for long durations, in remote areas, or who plan activities that *might* put them at risk for a rabies exposures" (Murphy et al., 2019), the highlight is not on what will happen but on what should be done for the safety of oneself and others.

5.1.8 The modal *Would*

For the modal *would* in the research material, 50% appeared in the body of the abstracts, providing more details concerning the topic. The other 50% were in the final part dealing with interpreting the results and indicating implications.

Regarding *would* as the past tense form of *will*, according to Hardjanto (2016), this was also found to indicate epistemic modality more than non-epistemic modality and to be typically applied in conditionals. This is consistent with the data of the present study. *Would* was used in an if-conditional to depict epistemic modality as in, for example, "The combined cancer death rate dropped continuously from 1991 to 2015 by a total of 26%, translating to approximately 2,378,600 fewer cancer deaths than *would* have been expected if death rates had remained at their peak" (Siegel et al., 2018) providing further information relating to the topic. Moreover, since *would* tends to show "the hypothetical alternative of will," (Hardjanto, 2016, p. 44), *would* in "Thus, a deeper understanding of the complex networks of interactions that ncRNAs coordinate *would* provide a unique opportunity to design better therapeutic interventions" (Anastasiadou et al., 2018), which was stated to discuss implications, implies less confidence or commitment on the part of the speaker than the use of *will*.

Next, the percentages of the modals commonly used to portray each type of modality are presented in Table 3. The results revealed that *can* ranked top in four modal categories (i.e. deontic PM, teleological PM, ability VDM, and opportunity VDM) and second in the existential QDM group. The predominant presence of *can*, 43.1% of all the modalized sentences, is consistent with Muangsamai's (2018) findings indicating that *can* was the most commonly used modal among health and medical science writers.

Table 3

The Percentages of Modals Applied for Each Type of Modality in the Selected Medical Abstracts

			Dynamic Modality	
	Episte	Priority Modality	Volitional Dynamic Modality	Quantificational Dynamic

	mic Modality	(PM)			(VDM)			Modality (QDM)	
		Deontic PM	Bou le-tic PM	Teleo lo-gical PM	Abil ity VD M	Oppor tu-nity VDM	Dispos i-tional VDM	Existe n-tial QDM	Univ er-sal QDM
can	2.08%	37.93 %	-	28.57 %	93.5 5%	67.65%	-	40%	20%
could	4.17%	13.79 %	-	14.29 %	6.45 %	23.53%	-	-	-
may	33.33%	3.45 %	-	-	-	2.94%	-	45%	-
might	4.17%	6.9%	-	-	-	5.88%	-	10%	-
must	-	6.9%	-	28.57 %	-	-	-	-	-
should	6.25%	17.24 %	-	28.57 %	-	-	-	-	-
will	41.67%	13.79 %	-	-	-	-	-	5%	80%
would	8.33%	-	-	-	-	-	-	-	-

However, this is contrary to Alonso-Alemida and Cruz-Garcia's (2011) conclusion that *may* is the most frequently used, constituting 35% of the cases in their analyzed medical abstracts. In their study, *can* came second at about 15%. Vihla (1999) and Hardjanto (2016) analyzing modals in medical texts state that *may* and *might* are typically used to indicate epistemic meaning, while the epistemic use of *can* and *could* is rare (Vihla, 1999). Alonso-Alemida and Cruz-Garcia (2011) consider the predominant use of *may* appropriate for writing a medical abstract, stating that it serves the purpose of elaborating on key points in a very limited space without having to provide description and justification.

The materials Alonso-Alemida and Cruz-Garcia's (2011) analyzed were published between 1998-2008 whereas those of the present study were released between 2015-2019. It is possible that from the late 90s to the late 2010s, some medical writers have moved from the trend of using

may to a tendency towards the use of *can* in the abstract to put the highlight on the evidence rather than emphasizing the speaker's judgement. Although *may* and *can* show possibilities, *may* indicates the speaker's assessment of potentiality, which relies on the speaker's judgment of the truth value (Evans & Green, 2006; Portner, 2009; Radden & Dirven, 2007; Sweetser, 1990). Discussing epistemic modality in medical research articles, Yang et al. (2015) illustrate being "implicitly subjective" with the use of *may* (6). Regarding this aspect, it differs from *can* associated with potentialities coming from speaker-external sources, as Radden and Dirven (2007) put it, "from intrinsic qualities of a thing or circumstances" (246). Two examples from the present research material are provided below:

(a) "Outbreaks of hepatitis C virus (HCV) infections *can* occur among hemodialysis patients when recommended infection control practices are not followed" (Muleta et al., 2016).

(b) "We then present our view on how progestogens *may* be safely and effectively used in treating breast cancer" (Carroll et al., 2017).

In terms of sentential modality, (a) depicts opportunity VDM; (b) portrays epistemic modality. While *can* in (a) indicates the intrinsic nature of this virus and the opportunity of being infected dependent on the circumstances related to control practices, *may* in (b) shows the writers' evaluation of potentiality, which relies on their judgment of the reality of a state of affairs. In other words, as Wallwork (2013) summarizes, *can* portrays "a characteristic behavior"; it shows that "things are possible but do not necessarily happen" *should* particular conditions be met (85). On the other hand, *may* in (b) is used to depict "speculation" (Wallwork, 2013), which is also reflected through the phrase "We then present our view on…"

Some scholars assert *can* demonstrates a higher level of certainty than *may* (Martikainen, 2018, p. 920; Wallwork, 2013, p. 86). Considering this assertion, it can be argued that the results concerning the prominent

use of *can* could also illustrate the trend toward the portrayal of greater certainty. However, regarding this point, further investigation specifically concerning the selection of modals for opportunity VDM is needed.

Despite the weight on the speaker's judgment, the use of *may* does not indicate the lack of evidence but mixes together "an evidential and the epistemic reading" (Alonso-Almeida and Cruz-Garcia, 2011, p. 70). Nevertheless, the tendency towards *can* possibly demonstrates the increased weight on evidence per se.

Moreover, in the present study, *can* was found to be able to fit more types of modality than *may,* which could be one of the reasons why *may* was not the most predominant in this study. *May* was not applied to depict teleological PM, ability VDM, or universal QDM, but *can* could fit these three categories. To illustrate, in terms of showing quantity, while *may* is unlikely to be used to express universal QDM, *can* in the negative form is possible for this type of modality. Since *cannot* expresses impossibility whereas *may not* suggests possibility, it is reasonable to see only *cannot* in the realm of universal QDM (e.g." These dosage systems *cannot* be identical by descent but were probably constructed from elements of ancient silencing mechanisms that are ubiquitous among vertebrates and shared throughout eukaryotes" (Graves, 2016) indicating the characteristics of all the dosage systems). Nevertheless, both *may* and *can* are possible for the expression of existential QDM. Additionally, Muangsamai (2018) also found that while *may* was not used to provide background knowledge, present the methodology, or recommend further studies, *can* was found to be a communicative tool for these three purposes.

In addition, since deontic PM and teleological PM are similar in terms of having a prioritized goal that is more significant than the action itself, the modals used for these two were similar (i.e. *can, could, must, should*). However, despite the similarity, deontic PM was the more outstanding modality in the research material. The difference between these two types of modality in the research material is that deontic PM concerns social obligation or the duty to save lives (e.g. "Thus, in contrast to the growing burden, a substantial proportion of liver cancer deaths *could* be averted, and existing disparities *could* be dramatically reduced, through the targeted application of existing knowledge in prevention, early detection, and treatment, including improvements in vaccination against hepatitis B virus, screening and treatment for chronic hepatitis C

virus infections, maintaining a healthy body weight, access to high-quality diabetes care, preventing excessive alcohol drinking, and tobacco control, at both the state and national levels" (Islami et al., 2017)).

Slightly unlike deontic PM, teleological PM focuses on how to achieve a particular goal but social obligation is not implied in the statement (e.g. "Functional genomic annotations from these cell types and states *can* then be used to resolve candidate genes and causal variants" (Gutierrez-Arcelus et al., 2016)). The fact that uses of deontic PM outnumbered those of teleological PM in this study could imply that the ultimate goal of saving patients and improving social welfare is also suggested in medical abstracts. This is consistent with Vihla's (1999) claim that deontic modals representing "the practical side of medicine" (119) are frequently applied in professional directive texts.

Regarding modal choices, *may, might,* and *will* were not chosen for any sentences portraying teleological PM but only for deontic PM (e.g. "Persons with type 1 diabetes require insulin for survival; insulin *may* be given as a daily shot or continuously with an insulin pump" (Bullard et al., 2018)). Whereas Muangsamai (2018) revealed that *should* and *must* "were very rarely found in the medical reports" (p. 240) of New Scientist, in the present material these two modals were frequently found to portray deontic PM and teleological PM. The difference could have arisen from the different sets of audiences. Deontic modals are more commonly used in professional than in popular texts (Vihla, 1999). Since the target audience of New Scientist is a general audience, not medical professionals like the target of the selected academic journals, the more frequent use of *should* and *must* in the present material is not surprising. Vihla (1999) asserts that deontic *can* and *may* are less commonly used than deontic *should* and *must* showing necessity or obligation. In contrast, in the present research, *can* was the most frequently used modal to express deontic PM, at 37.93%. However, Vihla (1999) discusses medical texts in general including handbooks and textbooks and does not specifically focus on abstracts. It can be inferred that while *should* and *must* emphasizing strong norms of action or introducing "professional rules" (Vihla, 1999, p. 119) are popular choices for directive texts, the tendency towards *can* expressing deontic PM in medical abstracts indicates its suggestive nature and the trends towards providing possible ways to achieve the desired outcomes. Additionally, while *must* was only limited to the portrayal of deontic PM and

teleological PM, *should* was used for these two types of modality plus epistemic modality.

Research Objective 2: to explore the relation of the modals used in medical abstracts and other grammatical patterns, namely tense and aspect, voice, reality status, and situation type in terms of meanings

The five grammatical elements most commonly applied in the verb strings of the sentences with modals in the research material are shown in Table 4. It was found that the medical writers portrayed epistemic modality the most in the abstract, accounting for 28.29% of all the sentential modalities. Opportunity VDM contributed 19.08%, and ability VDM ranked third at 17.76%.

Table 4

The Top Five Grammatical Elements Used in the Verb Strings of the Modalized Sentences

	Sentential Modality	Tense and Aspect	Voice	Reality Status	Situation Type
1	epistemic modality 28.29 %	present simple 79.88%	active-direct 79.88%	potential reality 46.75 %	act 31.27 %
2	opportunity VDM 19.08 %	future simple 11.15%	passive 20.12%	immediate reality 40.25 %	activity 21.05 %
3	ability VDM 17.76 %	past simple 3.1%	-	projected reality 9.6 %	indefinite lasting state 20.43 %
4	deontic PM 15.79 %	past perfect 2.48%	-	known reality 3.41 %	accom-plishment 15.79 %
5	existential QDM 11.84 %	present perfect 2.17%	-	-	achievement 10.22 %

As hypothesized, medical texts typically deal with experts' assumptions based on evidence indicating opportunities or possibilities. This was reflected through the use of the top three types of modality portrayed in the material. Some examples of the top three are provided below:

> (1) Epistemic modality (e.g. "Therefore, a better understanding of the processes that regulate ferroptosis sensitivity *should* ultimately aid in the discovery of novel therapeutic strategies to improve cancer treatment" (Friedmann Angeli et al., 2019).
>
> (2) Opportunity VDM (e.g. Accumulating evidence suggests that environmental experiences that occur during the first months of life *can* influence the risk of allergic sensitization" (Reynolds & Finlay, 2017).
>
> (3) Ability VDM (e.g. "…approximately 3,000 human genes *cannot* tolerate loss of one of the two alleles" (Bartha et al., 2018).

Next came deontic PM at 15.79%. This type of modality is possibly required in medical writing since medical fields are usually associated with what *should* or *should not* be done so as to treat patients or save lives. In other words, medicine is the science designed for individual and social wellbeing, which highlights an obligation, for the good of patients and society (e.g. "Physicians *should* be supported by adequately resourced health services to respond effectively to the range of clinical and broader patient needs identified through the routine use of tools to facilitate communication" (Licqurish et al., 2019)). The fifth-ranked was existential QDM, accounting for 11.84% of all the sentential modalities. Existential modality fits tentative defining and categorization, useful for medical messages acknowledging other possibilities (e.g. "Endometrial carcinomas *can* be classified into several histological subtypes, including endometrioid, serous and clear cell carcinomas" (Urick & Bell, 2019)).

5.2 Relationships with other grammatical aspects

As shown in Table 4, in terms of tense and aspect, present simple ranks first at 79.88%. This is unsurprising given modalized sentences in the medical abstracts typically deal with generalization or physiological facts. The next tenses that follow are future simple and past simple at 11.15% and 3.1%, respectively. The predominance of the present simple is consistent with Salager-Meyer's (1992) results supporting the claim that scientific writers use the present tense "to emphasize the relevance of their own study and to enhance its generalizability" (102), which is linked to the function of the conclusion stage. As for the future simple, it was applied only in the stage providing background information and, as previously discussed, was found to express epistemic modality. Despite its rarity, the past simple was mostly used as part of the background stage showing what happened at a particular point in time (e.g. "The term 'undruggable' *was coined* to describe proteins that *could not be targeted* pharmacologically" (Dang et al. 2017)).

Regarding voice, active-direct voice was far more outstanding in the modalized sentences, constituting 79.88% of all the verb strings, compared to passive voice which was adopted in 20.12%. This is consistent with Fryer's (2012 as cited in Muangsamai, 2018) findings showing that in all moves of the medical texts the active form outnumbered the passive choice. Interestingly, in the present research material, most modalized passive-voice strings are used to portray deontic PM (e.g. "A substantial portion of cancer cases and deaths *could be prevented* by broadly applying effective prevention measures, such as tobacco control, vaccination, and the use of early detection tests" (Torre et al., 2015)).

Additionally, according to Muangsamai (2018), "the agentless passive is used for generalizations" (240). This was found in the present material through the depiction of existential QDM (e.g. "Outbreaks associated with untreated recreational water *can be caused* by pathogens, toxins, or chemicals in fresh water (e.g., lakes, rivers) or marine water (e.g., ocean)" (Graciaa et al., 2018), in which *can* and the passive form are used for categorization based on causes).

As for reality status, as expected, potential reality was the most outstanding, at 46.75% since only modalized sentences were analyzed and modals usually portray potential reality. The second most dominant

was immediate reality typically related to the use of present simple, which was used as part of many modalized sentences (e.g. "Together with longitudinal studies, this approach *may* yield pivotal insights into how autoimmunity *is triggered* (Gutierrez-Arcelus et al., 2016)).

In terms of situation type, since medical messages are typically related to the causal relationships of what causes, prevents, or treats particular diseases, most verb strings in the modalized sentences were composed with bounded events (i.e. act (31.27%), activity (21.05%), accomplishment (15.79%), achievement (10.22%)). Indefinite lasting states appeared in 20.43% of the verb strings showing the background information of how things were or would be (e.g. "In 2018, there *will be* approximately 22,240 new cases of ovarian cancer diagnosed and 14,070 ovarian cancer deaths in the United States" (Torre et al., 2018)) and being part of the conclusion stage (e.g. "Improving health care provider training and expertise in exercise counseling and incorporating prompts into electronic medical records *are* potential strategies to facilitate counseling for exercise that can help adults manage their arthritis and comorbid conditions" (Hootman et al., 2018)). The progressive aspect was scarcely discovered in the abstracts but was found to form accomplishing activity (0.62%), iterative activity (0.31%), and culminating activity (0.31%). Further research could explore whether any particular situation types could influence how medical writers make their choices.

6. CONCLUSIONS

In English for Science and Technology (EST) writing, typical linguistic description cannot be used to effectively explain the special functions of modals (Salager-Meyer, 1992, p. 105). Modals were discovered to function variously in different parts of medical abstracts, with the highest number in the final part of the abstract structure. In the majority of the abstracts analyzed in this study, the focus was no longer on the speculation of the author but on the evidence and circumstances. Focusing on potentiality based on evidence and circumstances is probably a more engaging way of communication, as Vihla (1999) states, possibility expressions demonstrate reliability; the text does not assert more than what is justified. Modals are also related to the choices of other grammatical aspects in the verb strings of modalized sentences. In the material the present simple was the most dominant choice showing

relevance and enhancing generalizability. The active-direct voice was found more often than the passive voice although passive voice is typically tied to the use of generalization. Potential reality was the most outstanding showing the possibility associated with modals. Bounded events were mainly used for the verb strings of modalized sentences, and indefinite lasting states were commonly used in the background stage and conclusion stage. Importantly, communicators and readers need to be aware that one modal can express different meanings when it is used in different contexts.

The findings and information proposed in this study add to the variety of modal typologies in the literature. Although scholars do not reach a consensus when dealing with the types of modals, variety means there is a greater chance for exploring all the possibilities. Hopefully, this research study may lead to a better understanding of modals used in medical abstracts and help communicators choose their words wisely. Effective selection means knowing the meanings you would like to portray and why you choose particular modals, not merely memorizing patterns which might not fit your context. Besides benefiting medical writers and scholars who would like to publish or present their works in international contexts, this study also has pedagogical implications. EST, as well as EAP and ESP, instructors can use the research findings to help enhance their students as competent communicators. Ultimately, what labels are used with any modals does not matter as much as how you understand them and why you choose any particular word to create a meaning.

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