Using a Corpus-Assisted Discourse Studies Approach to Analyse Gender: A Case Study of German Radiology Reports[1]

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Abstract: This paper explores how a Corpus-Assisted Discourse Studies (CADS) approach can be utilised to investigate representations of gender as well as potential gender bias in radiology reporting, which constitutes a form of professional, medical discourse. The database collected for this purpose consists of three specialised German sub-corpora (332,901 cranial, thoracic, and whole-body computed tomographies, with more than 61 million tokens), which were extracted from a larger medical corpus called *MedCorpInn* that was built as part of an interdisciplinary project conducted jointly by the University of Innsbruck and Innsbruck Medical University. As a basic premise, CTs are assumed discursive, linguistic events, which are influenced by social and institutional factors. They represent an essential everyday communicative practice among radiologists and referring doctors and they function both as documentation and as a legal record of imaging procedures. To investigate whether there are differences and/or subtle similarities (Taylor 2018; Brezina 2018) in the largely standardised reports on female vs on male patients, a CADS-approach focusing on gender is applied. Keywords, collocation, and concordance techniques will be introduced and used to explore how male and female patients are discussed in the medical discourse studied here. Research into internal clinical communicative practices could also be of interest from the perspective of gender medicine.
Keywords: healthcare communication, discourse studies, medical discourse, language and gender, gender bias

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Medical activities are largely based on linguistic practices that serve various communicative purposes in everyday clinical practice – for example, conversations between doctors and patients, protocols, phone calls, reports, etc. Setting out from the constructivist perspective of discourse linguistics, language is assumed to be a social practice with which knowledge is socially negotiated and constituted (Spitzmüller, Warnke 2011: 53). Thus, such communicative practices can be described as social and discursive events influenced by different social and institutional factors. Some of these practices have been subjected to linguistic research, particularly since the emergence of sociolinguistics and discourse analysis in the 1980s, when drivers such as power and social and institutional factors were increasingly integrated into linguistic research on medical communication (Menz 2010: 2). At the same time, biases along the lines of different social factors have been shown to be largely present in medicine, particularly by studies on gender-sensitive medicine, in which perspectives on gender-specific differences pose new challenges to the constitution of medical knowledge.

This paper asks whether traces of such biases can be found on the linguistic surface of a corpus of German-language radiology reports by using a Corpus-Assisted Discourse Studies (CADS) approach. When speaking of bias, it is important to stress that this should not be understood as something that individuals do on purpose; on the contrary, biases are considered to appear rather unintentionally, as they refer to the 'ways that humans unknowingly draw upon assumptions about individuals and groups to make decisions about them. This type of cognition occurs involuntarily, automatically, and beyond one's awareness' (Allen, Garg 2016: 1428).

First, a brief literature review will discuss corpus and discourse linguistic research on healthcare in relation to gender. In this first part, I also briefly introduce the basic concepts of Corpus Linguistics (CL) and Discourse Studies that form the methodology of the case study, which discusses whether there are differences and/or similarities in the reports on female vs male patients that may indicate a gender bias. As Baker suggests, linguistic corpora bring us closer to meanings and thus can be used as 'a more robust way of pointing out biases' (Baker 2014: 11). Of course, in a comparison of radiology reports written on female vs male patients, differences are to be expected, as gender-specific organs, pathologies, and examinations play an essential role in these texts. However, the analysis will focus on whether there are also unexpected differences (i.e. differences that cannot be clearly attributed to medical gender specificity) and similarities and how these can be traced by means of a CADS analysis. Preliminary findings will be situated within the respective discursive frameworks.

Research on healthcare communication and gender

In the last few decades, trends towards specialised, patient-tailored treatment have had a strong impact on various medical disciplines and the consideration of the genomic, biochemical, and behavioural levels of patients in healthcare aimed at optimising patient care (Goetz, Schork 2018). The shift from an initially merely technical, disease-oriented approach to more individualised forms of medical care has challenged the idea of the conventional, asymmetrical doctor-patient setting, and calls for more collaborative methods of patient involvement have become prevalent, as can be seen in many recent models of shared decision-making (Elwyn et al. 2012), which are considered to have positive effects on patient satisfaction and subsequently on outcomes. The inclusion of socio-demographic factors is thus an important desideratum when analysing medical communication: there have been a number of investigations on the impact of macro-structural social categories (Menz 2010) on healthcare communication, such as migration/multilingualism, the role of interpreters (Bührig, Meyer 2004), and ethnic minority patients (Hagiwara et al. 2019), but also factors such as status (Menz, Al-Roubaie 2008) or age (Lalouschek 1995). Attention has also been turned to gender: The impact of gender on medical communication has been studied both from qualitative and quantitative perspectives in doctor-patient communication (West 1984; Wodak 1981; Sieverding, Kendel 2012; Menz 2010), in pain descriptions (Menz, Lalouschek 2006; Jaworska, Ryan 2018), and in online patient feedback (Baker, Brookes 2021). To the best of my knowledge, however, there are no studies on the communication among healthcare professionals themselves, as peer interaction among clinical staff members has in general not yet been extensively studied and is difficult to access. At the same time, a growing body of medical publications have emerged that highlight the importance of the relationship between language and discrimination and characterise medical communication as prone to perpetuating different forms of systemic bias. Within the field of Computational Linguistics and Natural Language Processing (NLP) in particular, there has been growing research on how to uncover and quantify pervasive bias in clinical texts (Feldman et al. 2019; Beach et al. 2021). While most of the research in this area focuses on automated, machine-learning tools, there is almost no substantial linguistic or discourse analytic research that could qualitatively expand the quantitative view of such language data. Before giving some examples of how Corpus and Discourse Studies are intertwined in researching health communication, I would like to briefly outline some of the main concepts of these linguistic disciplines, as they also serve the underlying methodology of this work.

Methodological framework: Corpus Linguistics and Discourse Studies

Contemporary developments in the Digital Humanities and computer sciences provide new approaches and insights into large amounts of naturally occurring, authentic language data, and computational methods have influenced almost every area of linguistics. Corpus linguistics represents one of the most widely used methodologies and offers a broad range of specialist, digital methods for analysing large collections of machine-readable texts (McEnery, Hardie 2012). Such collections are referred to as corpora (from Latin *corpus*), which typically consist of the data, the metadata describing those data, and linguistic annotations, which add further linguistic information to the raw data, such as a part of speech (Lemnitzer, Zinsmeister 2015: 13). There are two main types of corpora: they are either general or specialised. While general corpora are usually designed to represent language broadly (e.g. different text genres), specialised corpora focus on language in more specific domains (e.g. a corpus on tweets on a certain topic). Both these types of corpora can be used to study large-scale language use with techniques 'affording a reliable means of identifying trends and patterns in communication' (Crawford, Brown, Harvey 2014: 75). Such trends and patterns in communication can also be understood as indicators for the exploration of discourse. Following the German corpus pragmatics proposed by Scharloth and Bubenhofer (2011), it can be assumed that linguistic research can relate recurrent linguistic patterns to cultural or social phenomena. Such patterns can be interpreted as resulting from the recurrent linguistic actions of the institutions in which they are produced (Scharloth, Bubenhofer 2011: 196). CL tools make it possible to calculate these patterns of language use ('Sprachgebrauchsmuster', Bubenhofer 2009), for example, with keywords and collocations (these techniques are explained in the case study section), which can subsequently be interpreted through the lens of discourse analysis.

For the present analysis, I also rely on the CADS approach proposed by Partington (2008). This approach basically combines quantitative, statistical CL methods with methods typically involved in qualitative Discourse Analysis (i.e. an in-depth analysis of particular segments of discourse) in order to understand the discourse under study as best as possible. The basic methodology involves a comparative approach, where, first, depending on the research question, an appropriate target corpus and second, a suitable reference corpus is selected or compiled. Different kinds of comparisons are feasible – for example, by contrasting print papers with scientific papers or by focusing on the diachronic dimensions or other circumstances of a certain type of text.

The next step is to calculate the frequency and keyword lists by comparing

the target with the reference corpus, as 'it is only possible to both uncover and evaluate the particular features of a discourse type by comparing it with others' (Partington 2008: 194). Such key items can then be analysed in more detail by applying quantitative and qualitative methods. In Discourse Studies it is moreover considered fruitful to take into account 'corpus-external data both to try and interpret and explain our data and also as a means of identifying areas for analysis' (Partington, Taylor, Duguid 2013: 10).

Since corpus linguistic computer programs offer both quantitative and qualitative approaches to data, they are suitable for such an endeavour. Researchers can study quantitative information on the frequency counts of linguistic features; they can also focus more closely on the individual contexts of words (concordances) to investigate their data. Quantitatively derived results can be subjected to statistical tests that provide useful insights into how significant or how strong the investigated associations are (Brezina 2018). Of course, such insights would be impossible to obtain just by working with the data manually.

Corpus and Discourse studies on health: a short overview

There is a growing strand of research that is conducted on healthcare corpora in digital contexts, such as online platforms for advice-seeking and advice-giving, online support groups, or online patient feedback (Brookes 2020; Hunt, Brookes 2020). In these contexts, Corpus and Discourse Studies can reveal, inter alia, how illness or healthcare are experienced and talked about and how these insights may be used to optimise respective communication practices. For example, Demmen et al. (2017) analysed corpora of semi-structured interviews and online forum contributions exchanged between patients, family carers, and health professionals to evaluate the use of metaphors of violence in care contexts. Digital contexts related to health have been explored both quantitatively and qualitatively in German as well – for example, in terms of the discursive constructions of 'normality' in online bereavement fora (Schütte 2021) or in relation to discursive conceptualisations and stereotypes associated with HIV/AIDS in the discussion posts in an online forum on medical topics (Knuchel 2021).

CL studies on conversation analysis also allow for the practical application of findings, which can in turn be used for data-driven learning approaches. Adolphs et al. (2004) investigated a corpus of phone calls to the UK's 'NHS Direct' health advisory service in order to describe the features of this kind of interaction, some of the findings of which were used to train the advisors. Another promising research topic is the study of health and illness narratives. Bubenhofer (2018) examined narrative patterns in 14,000 birth reports written in German by mothers in internet fora in order to determine typical

patterns of language use and the corresponding social implications. By investigating an English corpus of health and illness narratives, Jaworska and Ryan (2018) found that patients' descriptions of chronic pain varied along the lines of gender: women referred to pain more frequently and had a wider lexical repertoire for pain reporting, while men were more likely to use fewer descriptors and focused more on painkillers. There are also studies focusing diachronically on the representation of illnesses: Ilg (2021) investigated the German term *Schizophrenie* ('schizophrenia') from the time it was coined in 1908 up to the 21st century by examining its contexts and how it has changed towards becoming an everyday evaluative linguistic expression. Iakushevich (2021) conducted a discourse linguistic analysis of how depression is constructed in the quality media in Germany between 1954 and 2015.

Corpora of internal clinical texts, however, are hard to find, especially in German. An exception is the FRAMED (Freiburg Annotated Medicine Text) corpus compiled by Hahn and Wermter (2004), which includes various medical texts from the University Hospital of Freiburg (discharge letters, pathological and histological findings, surgical protocols, and non-clinical medical texts). Due to anonymity requirements, this corpus is not publicly accessible. However, research on internal clinical discourse could provide new insights into how communication patterns are used and, if necessary, how they could be optimised in their specific context. The context examined in this study is described in the following sections, which shed light on radiology reporting as a discursive practice and introduce the data set used in the case study.

Case study: corpus-assisted research with CTs in relation to gender

Radiology reporting

Radiology reports play an indispensable role in everyday clinical work routines. They are the most important form of communication between radiologists and referring doctors and function both as elementary documentation and as a legal record of imaging procedures such as ultrasound, magnetic resonance imaging, computed tomography, angiography, X-ray, fluoroscopy, etc. These reports are largely standardised and usually contain a descriptive part, in which clinical, anamnestic information is given and the images are described, and an interpretative part, where the findings are discussed and evaluated. The content of the texts generally covers a broad spectrum of specific topics, including statements on the detection or examination of tumours, diseases, internal bleeding, bone fractures, and injuries or on how a specific anatomic object has changed and is medically interpreted. Radiology reports also suggest which next steps need to be taken and are thus important for determining the further course of examination and treatment.

The reports studied here are written in German and therefore exhibit a number of characteristics of the specialised medical language that is used by professionals in this context. For example, there is a large number of Germanised, (pseudo)Greco-Latin terms and ad hoc forms; these specific characteristics are consistent with those observed in early research on medical terminology (Wiese 1984). Because of their usefulness in communication, ellipses, abbreviations, and different writing variants also occur frequently in the texts.

In addition to these linguistic features, it is necessary to mention some contextual features that influence radiology reports as discursive events. In their introduction to CL, Perkuhn et al. (2012) emphasise that all observations made in a corpus depend not only on the domain of language but also on random influences. This is true for the domain investigated here as well: it needs to be borne in mind that radiology reporting takes place in a highly institutionalised system. Thus, these texts are embedded in institutional agendas, such as time and financial resources, but also in legal requirements. Additional factors, such as individual preferences (e.g. for a certain writing style), are likely to come into play as well that may be manifested in the texts but cannot easily be traced using a quantitative approach alone. The analysis of such institutional discourse, according to Ribeiro et al. (2014), has 'implications for the understanding of how social life is organised' (p. 403). Thus, analysing radiology reports can be helpful to understand these texts as discursive and social events that are influenced by a range of different social and institutional factors. Hence, a CADS approach seems useful because it allows for instances of this specialised, internal clinical discourse to be studied using both CL and DA methods. At the same time, this also points to the limitations of this study: There are many different factors that may potentially interact in medical reporting language use (e.g. age, type of insurance, provenience, etc.) and findings need to be carefully considered within their context.

Data and corpus design

For this study, three specialised sub-corpora were selected as the data base: cranial, thoracic, and whole-body computed tomographies (CTs) written in German were extracted from the large *MedCorpInn* corpus. This corpus contains 5,002,933 radiology reports written in German and was compiled as part of an ongoing interdisciplinary project initiated in 2019 conducted jointly by the Medical University of Innsbruck and the University of Innsbruck (Project Homepage: www.medizinwort.at). The texts were provided by the Department of Radiology and the Department of Neuroradiology at the University Hospital of Innsbruck. The corpus can be divided into more than 300 different sub-corpora depending on the type of examination and the anatomic

objects or regions investigated. To the best of my knowledge, no CL or CADS analysis has ever been conducted on CTs. They represent the real-life language use of a specific, clinical context to which it is usually difficult to gain access.[2]

The three selected sub-corpora are the largest ones among CT imaging procedures and are only representative for the specialist discourse of radiology reporting in the context of the mentioned clinics. In total, 332,901 texts (more than 61 million tokens) written between 2007 and 2019 were extracted. Table 1 illustrates the composition of the corpus.

Table 1: Corpus composition: number of texts and tokens per sub-corpus

Corpus	**Number of texts**	**Number of tokens**
Cranial CTs (total)	173,959	20,997,353
Female patients	81,177	9,650,293
Male patients	92,753	11,338,060
Thoracic CTs (total)	86,938	17,403,742
Female patients	39,179	7,754,456
Male patients	47,755	9,649,286
Whole-body CTs (total)	72,004	22,716,068
Female patients	29,491	9,139,921
Male patients	42,510	13,576,147
Total	332,901	61,117,163

Source: *MedCorpInn* corpus.

The data are unstructured but enriched by structured metadata, including 39 different categories that provide either demographic information (e.g. the patient's gender, age) or information on medical procedures (e.g. indication, referral etc.). For this paper, the selection criterion by which corpus queries were filtered is the patient's gender. As already mentioned, other variables might have an impact on reporting as well, and this must be kept in mind when interpreting the findings.

As these data are sensitive, they had to be meticulously anonymised over the course of work on the project by adhering to the data confidentiality rules (§6 DSG, current version) that were approved by the ethical review committee of the Medical University of Innsbruck. Neither the full corpus nor its sub-corpora can be made publicly accessible.

[2] Because project cooperation was already established with the Medical University of Innsbruck, it was possible to obtain these kinds of data.

The text structure as well as the texts themselves were processed in Python 3 and with R statistical software.[3] For this case study, the CTs were tokenised using the *Quanteda* R package (Benoit et al. 2018), which by default preserves symbols, numbers, and punctuation. The latter were removed from the count. The CTs vary in their length but tend to be short; on average, they range from 120 to 320 tokens per text.

The current study

As mentioned above, this case study seeks to explore a large number of CTs focusing on gender. The research question underlying this section is: To what extent are male and female patients discussed similarly and differently in the internal clinical discourse of radiology reporting? How and to what extent can such differences and similarities be interpreted? CL techniques such as keywords, collocation, and concordance are used to answer these questions.

Baker (2014) suggests that one of the first questions to ask when looking at gender bias in corpora is what items are being used to refer to gender identity (p. 78). This can be accomplished by querying the corpus for the occurrences of gendered lexical items that are expected to be used frequently. Another option is keywording, which is a useful corpus technique for finding, as Gabrielatos (2018) puts it, 'a way in to the texts' (p. 227) of the investigated corpus. In the following case study, keywording will first be used to find references to gender identity in terms of persons, and second to explore what other items relating to gender repeatedly appear in the sub-corpora and may be of interest to explore further.

Keywording

Keywording is utilised to help researchers focusing on lexical items that are characteristic of a particular target corpus in comparison with a reference corpus, without having to identify them manually or on the basis of pre-defined subjective categories. According to Egbert et al. (2020: 29), the primary goal of keywording is 'to identify a set of words that is especially characteristic of a type of discourse, or that provides insights into the 'aboutness' of that discourse domain'. Different measures have been established for calculating keywords (for an overview, see Brezina 2018) and make it possible to take a close look at linguistic items that differ when observed in a frequency comparison. Such items can then be further observed using techniques such as collocation and concordance (see the next section).

[3] For a more detailed description of challenges and issues in corpus building of the *MedCorpInn* corpus, see Irschara et al. (2022).

In order to generate 'candidate key items' (CKIs – a term coined by Gabrielatos 2018), i.e. items that are typical for the radiology discourse under investigation in relation to the patients' gender, the three CT corpora were split up into reports on female (FCTs) and on male patients (MCTs), as illustrated in Table 1. To calculate keywords, frequency lists for both corpora are generated for each type of examination and then statistically compared. Regarding both the amount of text and the number of tokens, the corpora consisting of reports on female patients are smaller; however, the average text length is almost identical.[4]

The analysis was conducted using the ProtAnt software tool, which is designed to identify prototypical texts in a corpus by ranking them according to the number of keywords they contain. This tool can also be used to calculate a complete set of keywords for the corpus being studied (Anthony, Baker 2015: 278). The following measures in ProtAnt were chosen to first identify the CKIs:

- Significance measure: Log-Likelihood (LL, 4-term, with a threshold of $p < 0.05$ with a 3.84 Bonferroni correction, which raises the threshold required for an item to be key)
- Effect size measure: %DIFF statistics (which considers the normalised frequencies of the investigated items in the two corpora; see Gabrielatos, Marchi 2012)

The discussion of which statistic measure works best for finding key items of interest is still open (Brezina 2018: 85). LL is among the most commonly used significance tests for the detection of keyness but has been criticised for being sensitive to corpus size and word frequencies: in a large corpus, high significance can be attributed even to small differences (Garbielatos, Marchi 2012). While statistical significance testing indicates how probable it is that a resulting difference or relationship is not due to chance or sampling error, effect size statistics indicate how strong the difference or relationship is (Brezina 2018: 12).

Once calculated, candidate key items (ranked by their effect size) were examined manually, first to find nouns referring to persons and second to discover further potentially interesting individual keywords as repeated patterns in the sub-corpora. It is necessary to mention here that the selection of individual keywords varies greatly depending on the research aim – for example, their selection can be determined by a certain statistical threshold and/or by focusing only on the top N keywords;

[4] Cranial CTs display an average of between 118 and 122 tokens per text, thoracic CTs display an average of between 198 and 202 tokens per text, and whole-body CTs include 310–319 tokens. The reason why there are fewer female CT reports (when generally there are a few more female patients in the whole *MedCorpInn* corpus) cannot be explored in this paper.

keywords are often grouped into or associated with specific topics of interest (Gabrielatos 2018: 237), which is the case in this study. As this case study focuses on how male and female patients are discussed, nouns referring to persons were extracted first. The following terms were identified among the top 300 keywords for each sub-corpus:

Table 2.1: Keywords per sub-corpus (target corpus: FCTs), ranked by keyness

Female patients	Rank	Keyword	Effect (%DIFF)	Keyness (LL)
Cranial CTs	2	*Patientin* ('patient-FEM')	5915.93	6,950.53
	133	*Intensivpatientin* ('ICU patient-FEM')	9299.14	62.15
Thoracic CTs	1	*Patientin* ('patient-FEM')	61.97	16,942.42
	256	*Intensivpatientin* ('ICU patient-FEM')	107.01	69.52
	292	*Raucherin* ('smoker-FEM')	99.54	64.67
Whole body CTs	2	*Patientin* ('patient-FEM')	8,135.27	11,218.76
	289	*Intensivpatientin* ('ICU patient-FEM')	7,920.98	49.16

Source: *MedCorpInn* corpus.

As Table 2.1 shows, the terms *Patientin* ('patient-FEM') and *Intensivpatientin* ('ICU patient-FEM') appear in all the sub-corpora as keywords. The %DIFF score indicates equal normalised frequencies at a value of '0', while a value of '100' indicates double frequency and every increase of '100' raises the difference by one. Thus, most of the reported effect sizes indicate rather high differences, which, of course, is to be expected since the target corpora consist of texts referring to female patients.

Keywords were also calculated for the sub-corpora of reports on male patients (by using reports on female patients as the reference corpora), as shown in Table 2.2.

Table 2.2: Keywords per sub-corpus (target corpus: MCTs), ranked by keyness

Male patients	Rank	Keyword	Effect (%DIFF)	Keyness (LL)
Cranial CTs	2	*Patienten* ('patient-MASC')	25,422.08	2,502.32
	6	*Patient* ('patient-MASC')	266.97	1,218.55
	289	*Intensivpatient* ('ICU patient-MASC')	300.54	34.90
Thoracic CTs	1	*Patienten* ('patient-MASC')	469.97	5,698.28
	4	*Patient* ('patient-MASC')	659.60	2,648.33
	180	*Studienpatient* ('study patient-MASC')	4,480.69	58.75
Whole body CTs	4	*Patienten* ('patient-MASC')	370.95	3,233.30
	11	*Patient* ('patient-MASC')	355.02	1,354.83

Source: *MedCorpInn* corpus.

Overall, there are more mentions of 'male patient(s)' than 'female patient(s)' (with a frequency of 909.75 vs 885.97 per million words, inflected forms included), but this difference is only at a low level.

While *Patient(en)* ('patient(s)-MASC') is key in all sub-corpora, the male equivalent to the above-mentioned *Raucherin* ('smoker-FEM') does not appear in the keyword list. Hence, is smoking mentioned in the findings only when women are involved? In this case, the metadata do not reveal any further information: whether a patient smokes or not cannot be readily deduced from the structured metadata and is only found in the free text, i.e., in the actual data. A manual corpus query reveals that the term *Raucher* ('smoker-MASC') also appears in reports on women. As an example, consider the following sentence: *Patientin ist Raucher seit dem 15. Lebensjahr*, which can be translated as 'Patient [feminine form] has been a smoker [masculine form] since the age of 15'. This can be explained by the use of the (pseudo-)generic masculine, which is a grammatical masculine form used to refer not only specifically to a group of men but also 'generically' to a mixed group (of both men and women or of irrelevant/indeterminate gender). This form has been criticised by feminist linguists in German-speaking areas since the 1980s as (re)producing a male bias. Research has shown that so-called generic nouns referring to persons are not interpreted generically, but rather gender specifically (for an extensive overview, see Kotthoff, Nübling 2018). In the sub-corpus consisting of thoracic CTs on women, *Raucherin* ('smoker-FEM') occurs almost as often[5] as *Raucher* ('smoker-MASC'), which explains why this noun does not appear key in reports on male patients. This raises the question as to whether so-called generic masculine forms are used in the rest of the corpus as well. A close reading

[5] *Raucherin* ('smoker-FEM') occurs with a frequency of 9.17 per million words, and *Raucher* ('smoker-MASC') with a frequency as high of 9.8 per million words.

of individual stretches of text in the corpus that contain the lemmas *Patientin* ('patient-FEM') and *Patient* ('patient-MASC') shows that 7.8% of the references to female patients in the FCTs are written in the generic masculine. With the terms *Intensivpatient* ('ICU patient-MASC') and *Intensivpatientin* ('ICU patient-FEM'), the generic form is used even more often as it occurs in 41.7% of the references to female patients in FCTs. Within MCTs, the compound *Studienpatient* ('study patient-MASC') referring to patients participating in clinical studies can be found – here, no generic use can be traced. In the whole corpus, 'study patient-MASC' appears 2.9 times more often than 'study patient-FEM' does (1.88 vs 0.65 fpmw), which could be related to the underrepresentation of women in clinical trials, something that is widely reported by medical researchers (Vitale et al. 2016).

These observations show that when researching nouns referring to persons in our texts, generic uses must be taken into account. Such uses are problematic as they evoke the cognitive effect of readers being less likely to interpret these forms as feminine – generically intended words cannot be unambiguously assigned to female patients, which may cause ambiguity in the reporting itself.

As outlined above, in the second step of this analysis the different CKI lists were manually reviewed to detect keywords that occurred repeatedly in the sub-corpora and might be of further interest. Intuitively, some keywords that appeared only in the FCTs and that related to *pain* caught my interest – for example, *Kopfschmerzen* ('headache'), *Schmerz* ('pain'), or *Thoraxschmerzen* ('thoracic pain') as outlined in Table 3. Pain experiences as well as pain descriptions are known to differ by gender and represent an essential linguistic practice. This pattern may be of particular interest in relation to our research question.

Table 3: Keywords indicating pain (FCTs), ranked by keyness

Corpus	Rank	Keyword	Effect (%DIFF)	Keyness (LL)
Cranial CTs	42	*Schmerzen* ('pain')	46.02	222.20
	140	*Kopfschmerz* ('headache')	47.38	79.96
Thoracic CTs	309	*Thoraxschmerzen* ('thorax pain')	1.53	65.60
	340	*Schmerz* ('pain')	1.35	59.5
	624	*Thoraxschmerz* ('thorax pain')	1.49	31.31

Source: *MedCorpInn* corpus.

The frequencies of the mentioned keywords including the word 'pain' indicate statistically significant differences, though in thoracic CTs with very low effects. When considering the whole data set, pain-related keywords (as lemmatised forms, i.e.

canonical word forms including inflectional forms) appear significantly more often in reports on female patients as illustrated in Table 4.

Table 4: Frequencies of the lemmas 'pain', 'thoracic pain' and 'headache'

lemma	Female patients (FCTs)		Male patients (MCTs)		LL	%DIFF
	abs. frequency	fpmw	abs. frequency	fpmw		
Schmerz ('pain')	3,418	128.7	3,553	102.7	88.06	25.26
Thoraxschmerz ('thoracic pain')	1,303	49.00	1,163	33.64	86.74	45.88
Kopfschmerz ('headache')	4,683	176.4	1,074	109.18	699.10	80.73

Source: *MedCorpInn* corpus.

The differences in the use of these lemmas turn out to be highly significant (LL, a p-value of 0.01 as the minimum significance threshold), especially concerning the term 'headache', for which the largest effect is measurable. The effects are at a rather low but still well measurable level.

Considering the current state of research, the occurrence of these keywords related to 'pain' could indicate a tendency among women to address pain more frequently, as Hoffmann and Tarzian (2001) reported in an extensive literature review on gendered experiences of pain; similar results are reported by Jaworska and Ryan (2018) for a corpus of online narratives concerning chronic and terminal illness. Thus, it is conceivable that if descriptions of pain are more common in female patients, such descriptions are more frequently mentioned in the reports. A close reading reveals that occurrences of 'pain' are mostly found at the beginning of the text, i.e. in the first part of the report containing the anamnesis, which is the only section of the text likely to contain traces of interaction between doctor and patient, whereas the rest of the report essentially contains a description and interpretation of the CT image. Here, a contributing factor could be the doctors' gender as well: Several meta-analyses suggest that female doctors facilitate a more open exchange and patient-centred approach (Jefferson et al. 2013) and that patients thus report pain more often when encountering a female doctor. However, for reasons of anonymisation, the doctors' gender cannot be determined in this case study.

The resulting keywords are somewhat isolated and only provide a quick overview of some salient themes in our study corpus. Nevertheless, we do not know why they appear nor how they are contextualised – all we know is that they are significantly more frequent in texts for female patients. To gain further insights, they need to

be investigated in a more detailed manner that takes into account the context in which they appear. As an illustrative example, I will now only focus on collocates of the lemma *Schmerz* ('pain'), as pain descriptions play a significant role in medical reporting and are an essential diagnostic tool. Of course, a more detailed analysis would be needed to investigate and compare related keywords as well, such as the above-mentioned compounds *Thoraxschmerz* ('thorax pain') and *Kopfschmerz* ('headache').

Collocation and concordance

Collocation techniques underline the importance of context and the notion that meaning is not contained within a word itself but depends largely on the context in which it occurs (McEnery, Hardie 2012: 123). As 'actual words in habitual company' (Firth 1957: 14), collocation refers to the phenomenon whereby certain words tend to occur with unusual frequency in the immediate proximity of other words. Corpus linguists measure relationships between collocates and their 'node words' (a word under investigation) in order to thoroughly understand a word's meaning and/or its usage patterns. For this purpose, various approaches have been established that traditionally focus on the following three criteria: (1) distance, (2) frequency, and (3) exclusivity (Brezina et al. 2015: 140). Distance describes the span between a node word and its collocates, defining how many words to the left and to the right should be included in the calculation. Moreover, it is used to set a minimum frequency threshold for words to be counted as collocates. While the frequency criterion identifies how typical a word association is, the exclusivity criterion highlights rather unique or unusual combinations. Ultimately, the measure we decide to apply shapes the resulting collocations.

To explore collocations in more detail, researchers often use concordancing, which makes it feasible to read every single occurrence of a study word in context with the respective collocate. Thus, a predefined context can be scanned to learn how collocates are used; as such, concordancing is a helpful tool for qualitative in-depth corpus analysis.

For this case study, I decided to search for collocates of the headword *Schmerz* ('pain') for both MCTs and FCTs to examine how collocates are used to refer to male vs female patients. Therefore, I used a span of five words to the left and five words to the right of the node words (L5 > R5), which is a standard collocational span in CL. The minimum threshold was set to five, which means that a word should co-occur with the investigated headword at least five times within the pre-defined span in order to be defined as collocate. Regarding statistical metrics, I chose the cubed MI score (MI^3), which indicates the association strength of collocations (with higher scores

denoting stronger associations) and gives weight to frequency, whereas classical MI scores rather emphasise exclusivity.[6]

As next step, a comparison of collocations was conducted in order to obtain information about differences, but also about the similarities (Taylor 2018), between the collocates surrounding 'pain' in the different corpora. Overall, 509 collocates were found in reports on female patients and 536 in reports on male patients.[7] One first result is that the collocates are largely identical for both corpora and have similar items and effect sizes – there is an overlap of 82.15% of the collocates surrounding the word we investigated in both corpora. This may be due to the fact that, as stated above, radiology reporting makes use of a standardised lexical repertoire. Some of the shared collocates can be grouped into:

- adjectival (and at times metaphorical) collocates indicating the intensity of the pain, e.g. *stark* ('strong'), *zunehmend* ('increasing'), *heftig* ('severe'), *akut* ('acute'); the quality of the pain experience, e.g. *stechend* ('stabbing'), *krampfartig* ('crampy'), *kolikartig* ('colic-like'); the localisation, e.g. *thorakal* ('thoracic') or *abdominell* ('abdominal');
- temporal references, e.g. *seit* ('since'), *aktuell* ('current'), *jetzt* ('now'), *plötzlich* ('suddenly'), *heute* ('today'), *seither* ('since then'), *Woche* ('week'), *Stunden* ('hours'), etc.;
- or nouns referring either to the cause of the pain, e.g. *Sturz* ('fall'), *Skisturz* ('ski crash'), *Autounfall* ('traffic accident'), *Fraktur* ('fracture'); to further symptoms, e.g. *Atembeschwerden* ('breathing difficulties'), *Husten* ('cough'), *Fieber* ('fever'), *Gewichtsverlust* ('weight loss'); or to the affected anatomic object, e.g. *Lymphknoten* ('lymph node'), *Schulter* ('shoulder').

Many of these collocates add semantic information to 'pain' and seem to fit in traditional categories established from a medical perspective, as outlined by Reisigl (2010) in a systematic overview of German pain descriptions.[8]

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[6] Brezina et al. (2015: 150) emphasise that MI^3 has the advantage of fewer typos and ad-hoc spellings or abbreviations being ranked – both of which are common in the investigated reports.

[7] The overlap of 82.15% was calculated after manually removing some collocates that displayed inflected forms of the same item - for example, the adjectival collocate *linksthorakal* ('left thoracic') occurred in different cases which were thus not considered unique. Abbreviations were removed manually if the abbreviated lexical item was found in both collocation lists.

[8] In this publication, Reisigl also discusses the difficulty patients have classifying their subjective experiences of pain into medically pre-defined categories. Another extensive overview of linguistic constructions of pain in German is provided by Overlach (2008).

As for unique collocates, an almost identical amount was found in both corpora (91 collocates in FCTs, 96 collocates in MCTs, i.e. 187 unique collocates in total). I only considered the top 50 (as an arbitrary delimitation) of the remaining unique collocates for each patient group and categorised them manually into semantic domains, some of which were established by Jaworska and Ryan (2018: 111) in their CL analysis of pain narratives with a focus on gender.[9]

Before the (at times ambiguous) collocates were categorised into semantic domains, they were carefully checked regarding their context in order to determine how best to categorise them. Some collocates could be considered appropriate for more than one category – for example, *Läsion* ('lesion') could also be ranked in the *cause of pain* category as well as *injury*. However, the semantic categorisation is intended to make it easier to discern potential differences. Table 5 represents the semantic categories of the collocates surrounding the lemma 'pain' found in MCTs, and Table 6 shows those found in FCTs.

Table 5: The semantic categorisation of the top 50 collocates of the lemma *Schmerz* ('pain'), MCTs

Pain intensity/ Quality	*stärkste* ('strongest'), *kolikartig* ('colic-like'), *bewegungsabhängig* ('movement-dependent'), *steigende* ('rising')
Body parts	*Mundöffnung* ('mouth opening'), *Augenbraue* ('eyebrow'), *Handgelenk* ('wrist'), *Milz* ('spleen'), *Unterlippe* ('lower lip'), *Ellbogen* ('elbow'), *Nasenwurzel* ('nasal root')
Symptoms	*Nachtschweiß* ('night sweats'), *Schüttelfrost* ('chills'), *fieberhaft* ('feverish'), *Diarrhoe* ('Diarrhoea')
Cause of pain	*Fahrradsturz* ('bicycle fall'), *Verkehrsunfall* ('traffic accident'), *Schläge* ('beating'), *Raufhandel* ('scuffle'), *C2-Abusus* ('C2-abuse'), *Sturzgeschehen* ('falling')
Injury	*Läsion* ('lesion'), *Rippenfraktur* ('rib fracture'), *Hämatom* ('haematoma'), *Platzwunde* ('laceration')
Medical condition	*Dünndarmkarzinoid* ('small bowel carcinoid'), *Angina* ('angina'), *metastasierend* ('metastatic'), *rezidivierend* ('recurrent'), *Sensibilitätsstörung* ('sensory disturbance'), *Mastoiditis* ('mastoiditis')
Medical treatment & examination	*Biopsie* ('biopsy'), *Thoraxröntgen* ('chest X-ray'), *Vendal* (name of an opioid pain medication), *operiert* ('operated')

[9] The categories I adopted are: *body parts*, *quantifiers*, *time references* and *people* (Jaworska and Ryan 2018: 111); owing to the small number of unique collocates referring to pain qualities, these were not further distinguished into *sensory*, *affective*, and *evaluative qualities* the way the cited authors did.

Diagnosis	*Nachweis* ('detection'), *Diagnose* ('diagnosis'), *Frakturausschluss* ('fracture exclusion'), *beurteilbar* ('evaluable'), *anamnestisch* ('anamnestic'), *unverändert* ('unchanged'), *Antibiose* ('antibiosis'), *laborchemisch* ('laboratory-chemical'), *Entzündungswerte* ('inflammatory findings'), *erfolgt* ('occurs')
Quantifiers	*gering* ('low'), *hoch* ('high')
Time references	*früh* ('early'), *nun* ('now')
Communication	*berichtet* ('reports')
People	---

Source: *MedCorpInn* corpus.

Table 6: The semantic categorisation of the top 50 collocates of the lemma *Schmerz* ('pain'), FCTs

Pain intensity/ quality	*Chron* (abbreviation for 'chronic'), *chronisch* ('chronic'), *neuropathisch* ('neuropathic'), *heftigste* ('most severe'), *verstärkt* ('increased'), *subjektiv* ('subjective')
Body parts	*Mammae* ('mammae'), *Nacken* ('neck'), *Rücken* ('back'), *Wange* ('cheek'), *Ovarii* ('ovarii'), *Körper* ('body'), *Oberbauch* ('upper abdomen'), *Mittelbauch* ('middle abdomen'), *Knie* ('knee'), *Scapula* ('scapula'), *Nasenrücken* ('nasal bridge')
Symptoms	*Kurzatmigkeit* ('shortness of breath'), *Entzündungszeichen* ('inflammatory signs'), *cephalea* ('cephalea')
Cause of pain	*gestürzt* ('fell')
Injury	*Jochbogenfraktur* ('zygomatic arch fracture'), *Monokelhämatom* ('monocular haematoma')
Medical condition	*Aortenaneurysma* ('aortic aneurysm'), *Sepsis* ('sepsis'), *Myelom* ('myeloma'), *Parästhesien* ('paraesthesias'), *Harnwegsinfekt* ('urinary tract infection'), *Geröllzysten* ('boulder cysts'), *Pleuraerguss* ('pleural effusion')
Medical treatment & examination	*Ultravist* (name of a contrast medium), *Extraktion* ('extraction'), *Hormontherapie* ('hormone therapy'), *Clopidogrel* (name of a medication to reduce the risk of stroke), *Pille* ('pill')
Diagnosis	*abgrenzbar* ('delineable'), *normal* ('normal'), *Aufklärung* ('clarification'), *Hinweis* ('indication'), ärztlich ('medical'), *Untersuchung* ('examination'), *Raumforderung* ('mass'), *Stad* ('stadium'), *therapieresistent* ('therapy-resistant')
Quantifiers	*nur* ('only'), *viele* ('many')
Time references	*seitdem* ('since then'), *weiterhin* ('continuously'), *bisher* ('thus far')
Communication	---
People	*Patientin* ('patient-FEM')

Source: *MedCorpInn* corpus.

The resulting categories include collocates referring to pain intensity and quality, symptoms, causes of pain, injuries, and medical conditions; the majority of the collocates concern body parts, medical treatment, examination, and diagnosis. There are a small number of quantifiers and time references that relate to the pain experience. Most of the unique collocates can be classified to a similar extent in the semantic domains outlined and even though being key only in FCTs, 'pain' has a high proportion of the same collocates in both corpora. The *cause of pain* category varies between the two genders in terms of frequency, as in the MCTs there are more items than in the FCTs and the former relate more to concrete situations such as accidents, beatings, or intoxication, while for female patients the only collocate in this category is the more general past principle *gestürzt* ('fallen'). This is consistent with the notion that risky behaviour is more common among men, something that gender medicinal research has been highlighting and has explained with gendered stereotypes and role expectations, such as risky behaviour being associated with masculinity (Sieverding, Kendel 2012).

Concerning the category *pain intensity/quality*, there are two superlatives that mark high pain intensity, i.e., *stärkste* ('strongest') in the MCTs, *heftigste* ('most severe') in the FCTs; other qualifiers focus on sensory qualities of pain, such as *kolikartig* ('colic-like') in the MCTs or *neuropathisch* ('neuropathic') in the FCTs. Here, an interesting difference is that the adjective 'chronic' occurs both as an abbreviation and fully written out in reports on female patients. The concordances prove that this collocate appears mostly in the immediate vicinity of 'pain': the sequence 'chronic pain' is found in 84 out of 102 cases where these items collocate. Thus, descriptions of chronic pain appear significantly more often among female patients, which in turn is consistent with the findings of clinical trials showing that women are in general more likely to suffer from chronic pain (Bartley, Fillingim 2013). This is true also for migraine and chronic tension-type headache, which, as mentioned above, appears as a keyword in cranial CTs referring to female patients.

In terms of linguistic activities, the only unique collocate referring directly to the act of describing pain is the communication verb *berichtet* ('reports'), occurring in reports on male patients.[10] Here, I also searched for inflected forms of this collocate (e.g. 'reported'), but such collocates were not found in any of the corpora. Concordancing demonstrates that in most of the occurrences (21 out of 25), *berichtet* ('reports') is used in the context of documenting that a patient is *not* reporting any pain or discomfort from the examination, mostly in the context of *Aufklärungs-* or *Abschlussgespräch* ('informative' or 'final consultation').

[10] Other collocates falling in this category can be found in both corpora – for example, the verbs *klagt* and *beklagt* (both can be translated as 'complains') ranked in the top 100 collocates.

In the FCT corpus, no unique collocates referring to such linguistic activities were found. However, the collocate *subjektiv* ('subjectively') was detected in texts on female patients and was first classified within the *pain intensity/quality* category. However, a close reading suggests that this collocate might be placed in the *communication* category, as it behaves similarly to 'reporting': the female patient's perspective is presented, but it is presented as subjectively perceiving, not actively reporting, as the following examples show (emphasis added):

[1] Keine akute Einblutung. *Subjektiv* wieder vermehrt Schmerzen hinter den Augen.
('No acute internal bleeding. *Subjective* increased pain behind the eyes again.')
[2] Übelkeit, Obstipation, *subjektiv* starke Bauchschmerzen.
('Nausea, constipation, *subjectively* severe abdominal pain.')
[3] Fibröse Dysplasie, subjektiv Schmerzen bei klinisch unauffälligem Befund.
('Fibrous dysplasia. *Subjective* pain with clinically unremarkable findings.')
[4] Stechende Schmerzen *subjektiv* kurzatmig, dzt. Schub von Morbus Crohn.
('Sharp pain, *subjectively* short of breath, current episode of Crohn's disease.')
[5] Unterleibsschmerzen, Übelkeit, *subjektive* Verschlechterung der Dyspnoe.
('Abdominal pain, nausea, *subjective* worsening of dyspnoea.')
[6] Seither Kopfschmerzen und *subjective* Riechstörung.
('Since then pain and subjective olfactory disturbance.')

In 67% of the concordance lines in which this collocation occurs (58 occurrences in total), it is used to refer directly to pain and the pain's quality, as outlined in examples 1–3. Thus, doctors state whether pain is prevalent at all, and additionally, they document how women 'subjectively' report on the pain itself (*increased*, *stronger* pain; *pulsating* pain). In most of the other concordance lines, pain is listed as a symptom and 'subjective' is used to describe a specific complaint, such as shortness of breath, memory lapses, swellings, dizziness or vision loss (see lines 4–6). A few descriptions also include quotation marks – for example, *subjektiv 'grippig'* or *subjektiv 'Gedächtnisaussetzer'* ('subjectively "flu-like"' or 'subjective "memory lapses"'), whereby direct quotations are incorporated into the reports. In an NLP study, Beach et al. (2021) classify occurrences of quotation marks in medical records as markers of disbelief, but this cannot simply be transferred to this context; quotation marks do carry a distancing function, but can also be used, for example, to make a report more patient-oriented by including direct quotes. Since only a few such examples are available, no general tendencies can be identified here.

Although the investigated collocational pattern does not occur in findings on male patients, descriptions of how male patients subjectively classify certain health-related complaints (e.g. references to subjective gait disturbance or shortness of breath)

can be detected in MCTs; pain, however, does not appear in the collocation span. A comparison of the frequencies shows that the lemmatised adjective *subjektiv* ('subjective', the abbreviated form was manually included) occurs significantly more often (LL 24.29, %DIFF 69.88, p-value of 0.01) in reports on women. This collocational pattern might raise the question why something as subjective as the experience of pain is subjectivised twice and whether this could possibly be interpreted as a form of mitigation or relativisation: 'subjectively' could be classified as a distancing marker expressing a distancing attitude of the speaker to the subject matter (cf. the term *Distanzindikator* by Helbig/Buscha (2017: 435) which is used to describe a subclass of modal words). This would be in line with research in the field of the impact of gender on oral descriptions of pain that has shown that women tend to downplay their pain or relativise it in doctor-patient interactions – for example, by using diffusivity markers more often and expressing doubts that their pain description may just be a subjective impression (Menz et al. 2002). At the same time, the medical context must be included: Medical dictionaries (Reiche 2003: 1789; Pschyrembel 2020: 1754) refer to the distinction between 'subjective' and 'objective symptoms', which seems to be common in that *subjective* refers to symptoms that are only subject to the patient's experience, while *objective* symptoms include those that are somehow obvious 'from the outside', such as easily recognisable fractures or injuries also perceptible to the doctor. On the other hand, an examination of the use of 'objective' would be interesting, but this word form occurs very few times. A few examples that are consistent with the cited medical literature can be identified (emphasis added):

[1] Hören *subjektiv* u. *objektiv* recht gut.
('Hearing *subjectively* and *objectively* quite good.')
[2] *Subjektiv* und *objektive* respiratorische Verschlechterung.
('*Subjective* and *objective* respiratory deterioration.')
[3] Starkes Spannungsgefühl in der rechten Hemisphäre. *Obj.* Schwellung.
('Strong feeling of tension over right hemisphere. *Objectively* swelling.')

It thus appears that this pattern is also grounded in medical practice. However, the absence of a communication verb in the unique collocates of the FCTs suggests a subtle difference at the linguistic level of how patients' reporting is conveyed in the anamnestic sections of the reports.

In order to provide a larger picture of the 'subjectively vs objectively' pattern, a more detailed analysis beyond the collocational span would be of interest.

Conclusion

In this case study, a CADS approach with a focus on gender was used to examine a corpus of 332,901 thoracic, cranial, and whole-body CTs written in German (2007–2019). These texts were analysed to investigate to what extent male and female patients are discussed similarly and differently in this internal clinical discourse, which represents an important communicative practice between radiologists and referring doctors.

A keyword analysis was used first to identify nouns referring to persons and second to explore which other lexical items that occur repeatedly in the sub-corpora might be interesting in relation to gender. Among the top 300 keywords, there are some similar references to persons (e.g. 'patient', 'ICU patient'); however, manual analysis reveals that in almost all cases, female patients are referred to using both the pseudo--generic masculine and the gender-specific feminine form. As generic words are interpreted in a male-biased manner, it needs to be assumed that this language use pattern has a disadvantageous effect on the kind of precise communication desired in medical reporting. The only exclusion is the compound *Studienpatient* ('study patient-MASC'), which only appears in reports on male patients and is thus being used gender specifically, a likely explanation for which is the fact that women are often excluded from clinical trials.

A further manual categorisation of the candidate key items occurring repeatedly in the sub-corpora resulted in several keywords referring to *pain* (e.g. *pain, thoracic pain, headache pain*) in reports on female patients, which led to a collocation comparison of the node word *pain* for reports on both female and male patients. This analysis revealed a large overlap between collocates (over 82% shared collocates), indicating a high level of similarity regarding language use patterns of pain descriptions in both corpora. The remaining unique collocates were manually grouped into semantic domains, which yielded in an equal distribution of collocates within each of the groups. The collocate 'subjective' was found only in reports on female patients and raised the question why subjectivity is particularly emphasised in women's reports. A study of medical literature showed that this collocational pattern is likely rooted in medical practice, as there is a practical distinction between *subjective* and *objective* symptoms. At the same time, it is found that 'subjectively' behaves similarly to 'reporting', which is the only communication verb found in the unique collocates in MCTs. Thus, the female patient's perspective is conveyed by what they subjectively perceive rather than by what they actively report, which points to a subtle but measurable difference.

On a methodological level the case study shows that a combination of quantitative and qualitative methods can be fruitful when investigating similarities as well as differences, and that results cannot be interpreted straightforwardly but require

further contextualisation. Some limitations must be kept in mind; for example, one limitation of this study is that only very frequent keywords were considered, which could lead to less frequent but still relevant keywords being overlooked. Furthermore, narrative and less standardised medical text types could be of interest, in which medical reports form one part of various other text sections (e.g. doctors' letters).

Considering the similarities, which outweigh the differences in this study overall, one important result is that bias as suggested by the medical literature might not be overtly documented on the linguistic surface of the investigated reports, but it may lie in other (discursive) practices of which, however, we have no written evidence. This in turn raises questions for medicine – for example, whether biases emerge in other areas such as waiting times or the allocation of appointments. More research concerning gender bias in healthcare communication can thus generate further impulses that might also be relevant from the perspective of gender medicine.

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