

Methods of Radiology Reports Generation and Patterns of Associated Musculoskeletal Symptoms: A Cross-Sectional Multi-Center Study

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Abstract

Objectives This study aimed to investigate the association between the methods used to generate radiology reports and the prevalence of musculoskeletal symptoms among radiologists. Additionally, we investigated the factors associated with the use of such methods. **Methods** An online survey was sent to radiologists practicing in hospitals in the Eastern Province of Saudi Arabia. The survey addressed demographic characteristics, work environment, and methods used to generate radiology reports and included an evaluation of musculoskeletal symptoms using the Nordic Musculoskeletal Questionnaire. Results were analyzed descriptively using the Chi-square test and logistic regression analysis. **Results** The survey was completed by 198 radiologists (111 men and 87 women), including residents (40.9%), specialists (27.3%), and consultants (31.8%). Most participants (71.2%) were aged below 40 years. In total, 140 (70.7%) participants had experienced musculoskeletal symptoms in the week preceding the survey. The most popular method used to generate radiology reports was typing using a keyboard, with 64.1% of participants using this method, followed by a handheld dictation device (49.5%). Radiologists with limited years of practice more frequently generated reports via keyboard typing, particularly those with <1-year of experience (35.8%). A multivariable logistic regression analysis revealed that radiologists who used handheld dictation devices were at higher risk of developing musculoskeletal symptoms. **Conclusions** Musculoskeletal symptoms are common among radiologists. Radiologists who use handheld dictation devices were particularly likely to report experiencing musculoskeletal symptoms. These devices were less commonly used among radiologists with fewer years of experience.

Background

In modern daily clinical practice, healthcare providers often spend more time performing clerical duties and preparing clinical documentation than attending to patients [1]. Growing multidisciplinary care and the rise in medicolegal issues necessitate the maintenance of comprehensive and accurate medical records, which may underlie the trend of increasing documentation duties. The management of health-related information has evolved such that all information pertinent to the patient is integrated into a single electronic record that can be shared and accessed among interdisciplinary professionals. These records also serve as primary data sources for clinical research.

Radiologists spend long hours reading and analyzing an increasing number of radiographs and scans, and they communicate their interpretations in the form of radiology reports. A radiology report is part of the patient's medical record that reflects the radiologist's contribution to patient care. The use of the Picture Archiving and Communication System (PACS) has revolutionized the practice of clinical radiology. This system is associated with increased productivity and diagnostic accuracy, as well as an improved workflow [2 3]. Despite these advantages, PACS has led to a decrease in face-to-face interactions between clinicians and radiologists, because radiological images and radiology reports are now easily available to clinicians anytime and anywhere [4 5]. Therefore, a greater emphasis is laid on the radiology report, which is the primary work product of the radiologist and has to satisfy the expectations of the referring clinician.

Handwriting, keyboard typing, handheld dictation devices, and telephone dictation are among the several methods used to generate radiology reports. However, there is limited information regarding what methods used by radiologists for report generation and factors associated with the use of these methods. Furthermore, although several studies have demonstrated a high prevalence of musculoskeletal discomfort among radiologists [5–7], no previous study has investigated the methods used to generate radiology reports and their effects on the musculoskeletal symptoms. Krupinski et al. have reported that fatigue and discomfort experienced by radiologists interfere with diagnostic accuracy [8–10]. Such erroneous diagnostic interpretations can negatively affect patient care and result in litigation and distress to radiologists [11].

Therefore, our study aimed to investigate the association between the methods used to generate radiology reports and the prevalence of musculoskeletal symptoms among radiologists. Additionally, we investigated the factors associated with the use of such methods.

Methods

Study design

The survey was designed using the QuestionPro survey software (Seattle, WA, USA). An online survey format was selected for our study, as it is easily accessible, saves time, and is cost-effective. The survey was designed to be taken anonymously—with no personal identification data requested or stored—and could be completed in approximately 5 min.

A cover letter describing the purpose of the study, informing participants of the voluntary nature of their participation, and assuring their anonymity was provided along with the survey. The participants were encouraged to contact the research investigator for any queries pertaining to the study, using the provided contact information.

The survey was comprised of 20 questions that covered the following areas: (1) background demographic information, including age, sex, years of experience, and institution of current practice; (2) workload-related data, including the number of hours spent per day in interpreting and reporting radiological images, and the type of imaging studies usually reviewed; (3) methods used to generate radiology reports; and (4) musculoskeletal symptoms that had been identified to have resulted from working as a radiologist. The standard Nordic Musculoskeletal Questionnaire was used to determine the body regions affected by musculoskeletal symptoms, as it is a valid and reliable screening and surveillance tool [12]. The symptoms were measured as work-related symptoms (aches, pain, or discomfort) that were present in the 7 days preceding the survey.

A pilot study was conducted with a group of 30 radiologists to assess the clarity of the questions and time needed to complete the survey. After the pilot study, no major changes were made to the questions.

Each invited radiologist received a unique link to the online survey so that the survey could not be filled more than once from the same link. This ensured that the survey would not be compromised by duplicate responses or responses from individuals not included in the target population. Anonymity of the respondents' identity was maintained using the QuestionPro respondent anonymity assurance feature.

Study participants

This cross-sectional study was designed to investigate the methods used by radiologists to generate radiology reports and evaluate the effects of these methods on work-related musculoskeletal symptoms among clinical radiologists, including residents, specialists (junior staff), and consultants (staff) practicing across all hospitals in the major cities of the Eastern Province of Saudi Arabia. The survey began on April 28, 2019, and was open to respondents for 14 days.

We sent a personalized message with a link to the online survey to all members (n = 110) of a WhatsApp (Facebook, Menlo Park, CA, USA) group of radiology residents practicing in the Eastern Province. The link to the survey was also sent to radiology specialists and consultants whose contact information was available to the investigators. A reminder message was sent three days later.

Additionally, a paper-based survey questionnaire was distributed to the radiology departments of hospitals in the surveyed region to reach radiologists whose contact information was unavailable with the investigators. Investigators visited those departments a week later to collect the completed surveys.

Ethical considerations

The study was approved by the Institutional Review Board. Informed consent of the participants in the study was implied, when the participants either completed the survey electronically, or returned the completed paper-based survey. All information pertaining to the survey was provided in the covering letter. Therefore, their acceptance and completion of the survey was considered as acknowledgement of informed consent.

Statistical analysis

Data obtained were compiled using the QuestionPro platform and analyzed using the IBM SPSS for Windows software, version 25 (IBM Corp., Armonk, NY, USA). Descriptive statistics, such as percentages and frequency distributions of different characteristics, were used as appropriate. The Chi-square test and multiple logistic regression were used for data analysis. Multivariate logistic regression analysis was performed to identify the factors associated with methods used to generate radiology reports. Odds ratios (OR) with 95% confidence intervals (CI) were calculated using the full model fit. For the logistic regression analysis models, candidate variables were selected based on biological plausibility and risk factors previously identified in the literature. An α of 0.05 was considered statistically significant.

Results

Characteristics of participants

A total of 198 participants (an overall response rate of 75.3%), including residents (40.9%), specialists (27.3%), and consultants (31.8%), completed the survey, of whom 56.1% were men, and 43.9% were women. The majority of the participants were in the 30–39 (40.4%) or < 30 years (30.8%) age groups. In addition, 36.4% of the participants had 1–5 years of experience, and 33.9% had over 10 years of experience. Most participants (94.4%) were right-handed, and 57.6% reported spending seven to nine hours per day interpreting and reporting on radiological images (Table 1).

Table 1
Characteristics of the participants

Characteristics		Number of Participants (%)	
Age (years)	< 30	61	(30.8)
	30–39	80	(40.4)
	40–49	35	(17.7)
	50–59	15	(7.6)
	≥ 60	7	(3.5)
Gender	Male	111	(55.1)
	Female	87	(43.9)
Professional Rank	Resident	81	(40.9)
	Specialist	54	(27.3)
	Consultant	63	(31.8)
Years of Practice	Less than 1	20	(10.1)
	1 to 5	72	(36.3)
	6 to 10	37	(19.7)
	More than 10	67	(33.8)
Institution	Public	157	(79.3)
	Private	41	(20.7)

Methods used to generate radiology reports

The most popular method used to generate radiology reports was typing using a keyboard, with 64.1% of participants using this method, followed by a handheld dictation device (49.5%). Substantially fewer participants wrote the report by hand (9.1%) or used headphone dictation (6.1%) or telephone dictation (2.5%). Most participants (71.2%) consistently used only one method to generate reports.

Associations with the methods used to generate radiology reports

There was a significant association between participant age and keyboard typing as a form of generating radiology reports ($\chi^2 = 30.57$; $P < 0.0001$). This method was used by most participants in the age group of < 30 years (86.9%). Participant experience, in years, was also significantly and inversely associated with keyboard typing ($\chi^2 = 16.61$; $P = 0.0023$). Overall, 90%, 83.3%, 61.6%, and 35.8% of participants with < 1 year, 1–5 years, 6–10 years, and > 10 years of experience, respectively, preferably used keyboard typing over other forms of generating radiology reports. Professional rank was significantly associated with keyboard typing ($\chi^2 = 47.56$; $P < 0.0001$). For instance, 85.2% of residents, 72.2% of specialists and 30.2% of consultants typically used keyboard typing. More women (75.9%) used keyboard typing than men (55.0%).

Additionally, the use of handheld dictation devices to generate radiology reports was significantly associated with the number of years of experience ($\chi^2 = 11.73$; $P = 0.0195$) and professional rank ($\chi^2 = 10.99$; $P = 0.0267$), but not with the participant age ($\chi^2 = 1.25$; $P = 0.8698$). Unlike keyboard typing, this method was least commonly used by radiologists with < 1 year of experience (30%). However, most radiologists with > 5 years of experience (58.5%) reported using this method.

Radiologists who spent the majority of time interpreting ultrasound scans were more likely to provide handwritten radiology reports (OR = 4.794; $P = 0.0026$). In contrast, all radiologists who spent most of their time interpreting magnetic resonance imaging scans used handheld dictation devices for the generation of radiology reports ($P = 0.0019$).

A multivariate analysis confirmed the association between keyboard typing and age, years of experience, and professional rank. It also confirmed the association of use of handheld dictation devices with years of experience, and professional rank (Table 2).

Table 2
Factors related to methods of radiology report generation

		Handwriting		Handheld Dictation Device		Keyboard Typing	
		OR	(CI)	OR	(CI)	OR	(CI)
Age (years)	< 30	1.00		1.00		1.00	
	30–39	1.21	(0.35–4.12)	1.11	(0.56–2.23)	0.22	(0.09–0.56)
	40–49	0.77	(0.14–4.32)	1.28	(0.54–3.05)	0.05	(0.02–0.16)
	50–59	3.14	(0.48–20.65)	1.24	(0.38–4.01)	0.10	(0.02–0.39)
	≥ 60	2.93	(0.24–35.73)	1.25	(0.24–6.50)	0.17	(0.03–1.06)
Gender	Male	1.00				1.00	
	Female	0.70	(0.24–2.02)	0.90	(0.51–1.60)	2.39	(1.23–4.64)
Professional Rank	Resident	1.00		1.00		1.00	
	Specialist	0.69	(0.16–3.06)	1.01	(0.43–2.34)	0.28	(0.10–0.80)
	Consultant	0.30	(0.05–1.87)	3.19	(1.17–8.69)	0.06	(0.02–0.19)
Years of Experience	Less than 1	1.00		1.00		1.00	
	1 to 5	1.18	(0.21–6.55)	1.69	(0.58–4.96)	0.54	(0.11–2.78)
	6 to 10	0.56	(0.06–5.06)	5.19	(1.50–18.00)	0.11	(0.02–0.59)
	More than 10	0.54	(0.05–5.35)	3.53	(0.91–13.71)	0.03	(0.00–0.17)

Associations between musculoskeletal symptoms and methods used to generate radiology reports

The majority of the participants (70.7%) reported experiencing musculoskeletal symptoms in at least one part of the body in the seven days preceding the survey. Their musculoskeletal symptoms varied depending on the affected area: a substantial proportion of the participants reported to have experienced lower back (42.4%), neck (40.9%), or shoulder (32.3%) symptoms during this seven-day period, while

24.7% experienced wrist/hand pain (Table 3). A multivariate analysis revealed that women were 2.69 times (CI 1.37–5.29) more susceptible to experiencing musculoskeletal symptoms.

Table 3
Musculoskeletal symptoms among participants

Body Part		Symptoms in the Past 7 days	
		N	(%)
Any Part	No	58	(29.3)
	Yes	140	(70.7)
Neck	No	117	(59.1)
	Yes	81	(40.9)
Shoulders	No	134	(67.7)
	Yes	64	(32.3)
	Right	18	(9.1)
	Left	13	(6.6)
	Bilateral	33	(16.7)
Elbows	No	180	(90.9)
	Yes	18	(9.1)
	Right	13	(6.6)
	Left	4	(2.0)
	Bilateral	1	(0.5)
Wrists/Hands	No	149	(75.3)
	Yes	49	(24.8)
	Right	35	(17.7)
	Left	6	(3.0)
	Bilateral	8	(4.0)
Upper Back	No	142	(71.7)
	Yes	56	(28.3)
Lower Back	No	114	(57.6)
	Yes	84	(42.4)
Hips/Thighs/Buttocks	No	165	(83.3)
	Yes	33	(16.7)
Knees	No	171	(86.4)

	Yes	27	(13.6)
Ankles	No	187	(94.4)
	Yes	11	(5.6)

Overall, a significantly higher incidence of musculoskeletal symptoms was noted among radiologists who used handheld dictation devices ($P = 0.0161$) in the seven days preceding the survey. Those who used handheld devices, in particular, had a higher tendency to experience elbow ($P = 0.0431$) or wrist/hand pain ($P = 0.0263$). In contrast, radiologists who provided handwritten radiology reports experienced wrist/hand symptoms less often in the seven days preceding the survey ($P = 0.0478$).

A multivariate analysis was used to separately examine each method used to generate radiology reports while controlling for factors that were significant in the univariate models. According to this analysis, participants who used handheld dictation devices had higher risk of developing musculoskeletal symptoms (OR 2.33; CI 1.21–4.50). Particularly, they had 2.97 (CI 1.00–4.50) and 2.27 (CI 1.14–4.50) times higher tendencies of experiencing elbow or wrist/hand symptoms, respectively. However, the analysis did not confirm a significant negative association between handwriting and wrist/hand symptoms (OR 0.18; CI 0.02–1.39).

Discussion

This cross-sectional study showed that keyboard typing and the use of handheld dictation devices were the most common methods used by radiologists to generate radiology reports; nearly 50% of the participants in this study reported using handheld dictation devices. Radiology residents and particularly those with limited years of experience were least likely to use handheld devices to generate radiology reports. We first postulated that this may be attributed to the limited availability of such handheld dictation devices within institutions and limited access to such devices for radiologists. However, we performed sensitivity analyses in the two largest hospitals within our study region, wherein all radiologists had unrestricted access to handheld dictation devices. Interestingly, the sensitivity analyses confirmed our original findings.

In our view, radiologists with limited experience are unfamiliar with the use of dictation devices for report documentation and prefer the conventional and familiar method of keyboard typing. Dictated audio files can be transcribed manually or using speech recognition technology, which involves automatic conversion of spoken voice into digital text. Traditionally, a transcriptionist listens to the voice-recorded report and transcribes the audio recording to create a text file. This preliminary document is rechecked by the radiologist to approve the final version of the report. This process often causes significant delays in delivering the final report to the referring clinician. While this manual transcription method is considered obsolete in the current practice, it is still being used in a limited number of institutions in the surveyed region.

Speech recognition technology has been used for radiology reporting since 1981 [13]. Technological innovations in continuous speech recognition software that offers high accuracy have led to the widespread use of this technology in radiology reporting and overall medical documentation [14]. Speech recognition technology exhibits a learning curve and its use requires training. Reports generated by experienced users need minimal editing because the error rate in such reports is lesser than that in reports generated by new/inexperienced users who require greater time and effort to edit and proofread documents [15]. This technical difficulty could explain why radiology residents do not usually prefer this method for report generation. However, several studies have reported that speech recognition technology reduces the documentation time and cost and report turnaround time [16–18].

In our cohort, a small number of radiologists reported providing handwritten radiology reports. This finding was expected as the majority of hospitals in the surveyed region utilized electronic records almost universally for their medical services. Hence, the low rate of radiologists handwriting reports does not necessarily reflect a low preference of radiologists for this method since they are mandated to document reports electronically. The use of handwritten radiology reports is technology-independent and perceived as cost-effective, and may be more timely than other alternatives. Moreover, handwritten documentations are sometimes illegible, which can result in misdiagnosis and complications, and are susceptible to loss. Furthermore, handwritten documentations cannot be electronically analyzed, and do not facilitate efficient information sharing [19].

Additionally, this study demonstrated a high prevalence (70.7%) of musculoskeletal symptoms among radiologists. This observation is consistent with previous studies that reported similar findings [5 7 20]. The most commonly affected regions were the lower back and neck. Although such complaints are common among the general population and are thus not easily attributed to the occupational environment alone, they are probably related to the prolonged sitting times of radiologists [5]. Consistent with the results of a previous study among radiologists [20], we found that more than half of the participants spent 7–9 hours a day working in front of computers, interpreting and reporting imaging findings. In this study, we considered the symptoms present among radiologists in the last seven days preceding the survey, as this could provide more reliable information and minimize memory recall bias.

Robertson et al. conducted an analysis of the work environment of radiologists and demonstrated that the typical work of radiologists involved complex, prolonged pointing and handheld device activities [21]. The study also found that, in comparison to non-radiologists, radiologists spent more time using a mouse (69% vs. 42%) and less time using a keyboard (2% vs. 22%) during PACS-related activities. The researchers suggested that the use of alternative input devices and hands-free dictation systems could minimize the repetitive movements of radiologists and improve the safety of their work environment during the interpretation of radiological images in PACS. In our study, because of the limited number of radiologists who use headphone dictation, we could not evaluate the effect of hands-free dictation devices on the prevalence musculoskeletal symptoms.

It is essential for radiologists to pay careful attention to ergonomic factors of their work environment. It has been demonstrated that the use of ergonomic devices and ergonomic training can help in reducing the susceptibility to work-related musculoskeletal symptoms [7]. Good ergonomic knowledge is of paramount importance. A previous study reported that radiologists with good ergonomic knowledge experienced significantly less lower back pain than did those with poor knowledge [22].

The current study is the first to investigate the association between methods used to generate radiology reports and musculoskeletal symptoms among radiologists. Moreover, our study included all hospitals in major cities of the Eastern Province, which is the largest governorate in Saudi Arabia. However, the present study has certain limitations. The musculoskeletal symptoms were self-reported. Although self-reports enable convenient and quick collection of data, they may also introduce bias such that those who experienced musculoskeletal symptoms were more likely to respond than those who did not. In addition, the present study was a cross-sectional survey; therefore, causality could not be assessed directly. Furthermore, complaints of musculoskeletal symptoms are common in the general population, and a comparison group would have enabled a more accurate evaluation of work-related musculoskeletal symptoms among radiologists. Lastly, the study did not explore the reasons for using the methods available to generate the radiology reports.

Conclusion

Musculoskeletal symptoms are common among radiologists. Various methods are used by radiologists to generate radiology reports. Radiologists who use handheld dictation devices were more susceptible to musculoskeletal symptoms. These devices were less commonly used among radiologists with fewer years of experience. The results of this study may serve as a resource for developing interventional strategies to address musculoskeletal symptoms among radiologists.

List Of Abbreviations

CI: Confidence Interval

CT: Computed Tomography

OR: Odd Ratio

PACS: Picture Archiving and Communication Systems

Declarations

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Ethics approval and consent to participate

The study was approved by the Institutional Review Board at the Imam Abdulrahman bin Faisal University (IAU IRB No. 2019-01-240). Informed consent of the participants in the study was implied, when the participants either completed the survey electronically or returned the completed paper-based survey. All information pertaining to the survey was provided in the covering letter. Therefore, their acceptance and completion of the survey was considered as acknowledgement of informed consent.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

Conceptualization: AH, MS, and OA; Data analysis: AH; Methodology: HS and OA; Writing-original draft: HS and MS; Writing-review & editing: AH, EK, and OA; Supervision: OA. All authors read and approved the final manuscript.

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