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Patients' Needs and Preferences Regarding Radiology Test Results on Patient Portals

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PATIENTS' NEEDS AND PREFERENCES REGARDING RADIOLOGY TEST RESULTS ON PATIENT PORTALS

by

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ABSTRACT

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Introduction and significance: Radiology exams are an important part of health care. To enhance the quality of health care, health care services need to be delivered in ways that meet patients' needs and preferences. Patients were found to be interested in the timely receipt of radiology test results. One of the easiest and fastest ways to deliver radiology test results to patients is via online patient portals. It seems, however, that the method of providing radiology test results through patient portals has not reached its full maturity; it still needs a great deal of improvement. Therefore, participation of the end-readers (i.e., the patients) in the shape of radiology test results on patient portals is crucial. Moreover, making the radiology test results readily available to patients can encourage them to be more involved in their health care. To the best of our knowledge, this is the first study that covers this topic from this angle. The findings of this study can be used to improve the quality of health care services by making radiology test results on the patient portal meet patients' needs and preferences. **Objective:** The aim of this study was to investigate the needs and preferences of patients regarding radiology test results delivered via patient portals. **Method:** This study used a cross-sectional, quantitative approach design using a questionnaire survey with close-ended questions. The distribution method used for this study was a self-administered questionnaire, on paper and

online. The sample size of this study was 615 participants. There were three main research questions that this study aimed to answer: 1. Is there a relationship between patients' level of education and how much they understand from the radiology report? 2. Does health literacy have a main role in patients' understanding of the radiology report? 3. Does adding a statement at the end of the radiology report in lay terms summarizing the content of the report improve patients' understanding of the report? In addition, this study also explored the following issues: 4. How much do patients understand from a typical radiology report? 5. Which type of radiology reporting do patients prefer (structured versus free-text)? 6. Do patients think that the type of radiology reporting affects their understanding of the report? **Data analysis:** The collected data were analyzed using the Pearson Chi-square test with Cramer's V, Spearman's correlation test, Fisher's exact test, and Wilcoxon signed rank test with effect size. **Results:** No relationship was found between patients' level of understanding of a radiology report and health literacy or level of education. An association was found between health literacy and level of education, where people with a lower level of education tended to have limited health literacy. No correlation was found between laypersons' level of understanding of a typical spine MRI report and gender, age, race, previous radiology exam experience, or native language. There also was no correlation between laypersons' level of understanding of a typical brain MRI report and gender, race, native language, or previous radiology exam experience. However, there was a very weak relationship between laypersons' level of understanding of a typical brain MRI report and age, where elderly people tended to not understand the typical brain MRI report. Most of the participants (69%) wanted to receive their radiology test results through the online patient portal. Most of the participants (61%) also preferred the structured radiology

report to the free-text report. Sixty one percent of the participants thought that the type of radiology reporting affected their level of understanding, around 75% of whom preferred structured radiology reporting. Most of the participants did not understand the typical radiology reports (Mdn=2). Most of the participants understood the MRI report with the patient summary statement (Mdn=4). The vast majority of the participants (84%) thought that adding a summary statement at the end of the radiology report summarizing the content of the report in lay terms was a good method for improving their understanding of the report. The Wilcoxon signed rank test revealed that adding a summary at the end of a radiology report summarizing the content of the report in lay terms can significantly enhance the participants' level of understanding of the reports with a very large effect size ($Z = 17.271$, $p < 0.001$, $r = 0.723$ for the spine MRI report and $Z = 17.239$, $p < 0.001$, $r = 0.721$ for the brain MRI report). **Conclusions:** Most patients will not understand their radiology report regardless of their level of education and their health literacy skills. Adding a summary at the end of the radiology report in lay terms summarizing the content of the report significantly improves patients' understanding of the report. Structured radiology reporting is the preferred type of reporting for most patients, and most of them think that the type of radiology report affects their level of understanding of the report.

Keywords: patient portal, radiology test results, radiology image, radiology report, health literacy, summary statement, radiology reporting type

To my parents, Mr. Abdulaziz Almanaa and Mrs. Norah Abu Ghanem.

Heartfelt thanks go to my advisor, Dr. Timothy B. Patrick

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LIST OF ABBREVATIONS

HITECH	Health Information Technology for Economic and Clinical Health
HIT	Health Information Technology
MRI	Magnetic Resonance Imaging
CT	Computed Tomography
HIPAA	Health Insurance Portability and Accountability Act
ACR	American College of Radiology
RSNA	Radiological Society of North America
CAD	Computer-Assisted Detection
CADx	Computer-Assisted Diagnosis
ROI	Region of Interest
TOFHLA	Test of Functional Health Literacy in Adults
REALM	Rapid Estimate of Adult Literacy in Medicine
NLP	Natural Language Processing

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Chapter I: Introduction

Preface

Radiologic imaging exams are a major part of health care services. They are utilized to help health care providers in diagnosing and treating medical conditions. Without radiologic imaging exams, many diagnostic and therapeutic procedures would have been very painful and invasive. With the help of these radiologic imaging exams, diagnostic and therapeutic procedures that are not painful and/or are minimally invasive are available.

The final step of the radiologic imaging exam is the production of a radiology report. It used to be in a hard copy, which could make them prone to errors, missing information, or misreading due to unclear handwriting. The advancements in technology in health care accelerated the transition of radiology reports from paper-based reports to electronic-based reports. There are several benefits of this transition, some of which may include the reduction of errors and misspellings, the decrease of information loss, and the facilitation of report delivery to patients.

It is critical that patients become more engaged in their health care to improve the quality of their care. Making the radiology test results readily available to patients might encourage them to be more involved in their health care. One of the easiest ways to deliver radiology test results to patients is via online patient portals.

Online patient portals are the electronic gateway to medical records, which may involve radiology test results. The proliferation of patient portals has facilitated the delivery of

radiology test results to patients, which made the patients the end-readers of the radiology test results, images, and reports, as well as the referring physicians. However, the availability of radiology test results to patients via patient portals could raise some issues that might affect health care quality. Therefore, health care services should meet patients' needs and preferences in order to improve the quality of care.

Background

I. Patient Portals

The Health Information Technology for Economic and Clinical Health (HITECH) Act was enacted to promote the adoption and meaningful use of health information technology (HIT), including patient portals.[1,2] Meaningful Use is intended to improve care coordination and promote patient and family engagement.[3-5]

A patient portal is an online website or application that gives patients secure, real-time, self-service access to their health information whenever and wherever they want as long as they have an internet connection.[6-9] Some of the patient portal features include showing recent physician visits, discharge summaries, immunization records, medications, allergies, and test results, including radiology test results.[8-10] Through patient portals, patients will be more engaged in their health care, which might improve health care efficiency, enhance patient-provider interaction, reduce costs, and improve health outcomes.[7,9,11,12] It has been shown that radiology test results are one of the most frequently accessed features in the patient portal.[13,14]

Health care providers should provide instructions on how a patient registers for a patient portal account. Once registered, the patient should be able to sign in to his or her account and use all the features of the online patient portal. Without a doubt, providing radiology test results through patient portals is an important feature of patient portals. As soon as the results are uploaded into the patient portal, the patient is notified about the availability of the results. The patient then can look at the results conveniently via the portal without the need to call the health care provider or visit the doctor's office to know the results.

II. Radiology Images and Reports

Radiology procedures can be utilized for both diagnostic and therapeutic purposes.[15] The therapeutic radiology procedures, also known as radiation therapy, are used to treat cancer by damaging cancer cells' DNA with high-energy radiation in order to destroy their ability to divide and grow.[15] Radiation therapy might be used as a standalone therapy for cancer or in conjunction with chemotherapy or surgery. Radiation therapy can cause damage to healthy cells as well as to cancer cells; therefore, diagnostic medical imaging exams may be utilized to help accurately target the radiation to the cancer area.[15]

Diagnostic medical imaging exams, such as magnetic resonance imaging (MRI), computed tomography (CT), ultrasound, or x-ray exams, are an important part of health care that has led to enhancements in the diagnosis and treatment of many health conditions. Medical imaging is a technology that provides images of the internal organs of the body to allow physicians to examine, diagnose, and treat medical conditions.[16] It has evolved rapidly with the help of technological and computing advances.[17]

One of the most important advances in medical imaging is decision support systems. There are two types of decision support systems in medical imaging that led to better health care quality.[18] First, computer-assisted detection (CAD) helps radiologists locate the areas, called regions of interest (ROIs), in the image where abnormalities are suspected; then the radiologists assess their medical significance.[19] The second type of decision support system is computer-assisted diagnosis (CADx). In CADx, suspicious ROIs in the image, which have been identified by either the radiologist or a CAD system, are given to the system to evaluate them and provide the likely diagnoses.[18] When radiologists interpret images and write radiology reports with the help of decision support systems, they should not abrogate their clinical judgment, they should use decision support systems as supplementary and subservient to their clinical judgment.[20]

After the patient undergoes a medical imaging exam, the images are analyzed and interpreted by a radiologist, who generates a radiology report of the findings and recommendations based on his or her clinical judgment.[21-23] The radiology report is the formal documentation of the results of a radiologic exam and an important way of communicating between the radiologist and the referring physician.[22-25] However, with the proliferation and advancement of online patient portals, patients are also becoming the end-readers of the reports.[26,27]

III. Radiology Test Results on the Patient Portal

Health Insurance Portability and Accountability Act (HIPAA) provides patients with the right to securely access their personal health information.[28] The American College of Radiology

(ACR), in light of this legal obligation, recommends that radiology reports be made readily available to patients. Moreover, ACR suggests the utilization of online patient portals to achieve this.[29]

In the new era of technology, it is much easier to share radiology test results with patients. This is due to the conversion from paper-based reports and traditional film images to fully digital radiology reports and images.[30] In the past (and still today in a few practices), radiologists would hang traditional film images on light boxes to see through the images and report their findings on paper. This could complicate the process of image sharing with the patient. Nowadays, radiologists can see radiological images, interpret them, and generate reports digitally, which facilitates the process of radiology image and report sharing with the patient because everything is fully digital and ready to be shared electronically with the patient via online patient portals.[31]

The number of patients who access radiology test results through online patient portals is growing and will continue to grow with the development of health information technology.[32,33] It appears to be that most patients prefer their radiology reports to be delivered through online patient portals.[34,35] Not only is the patient portal the preferred method of receiving radiology reports, but most patients, as shown in one study, reported that the ability to access radiology reports via the patient portal was important.[36] Figure 1.1 shows a typical framework of radiology test results on the patient portal.

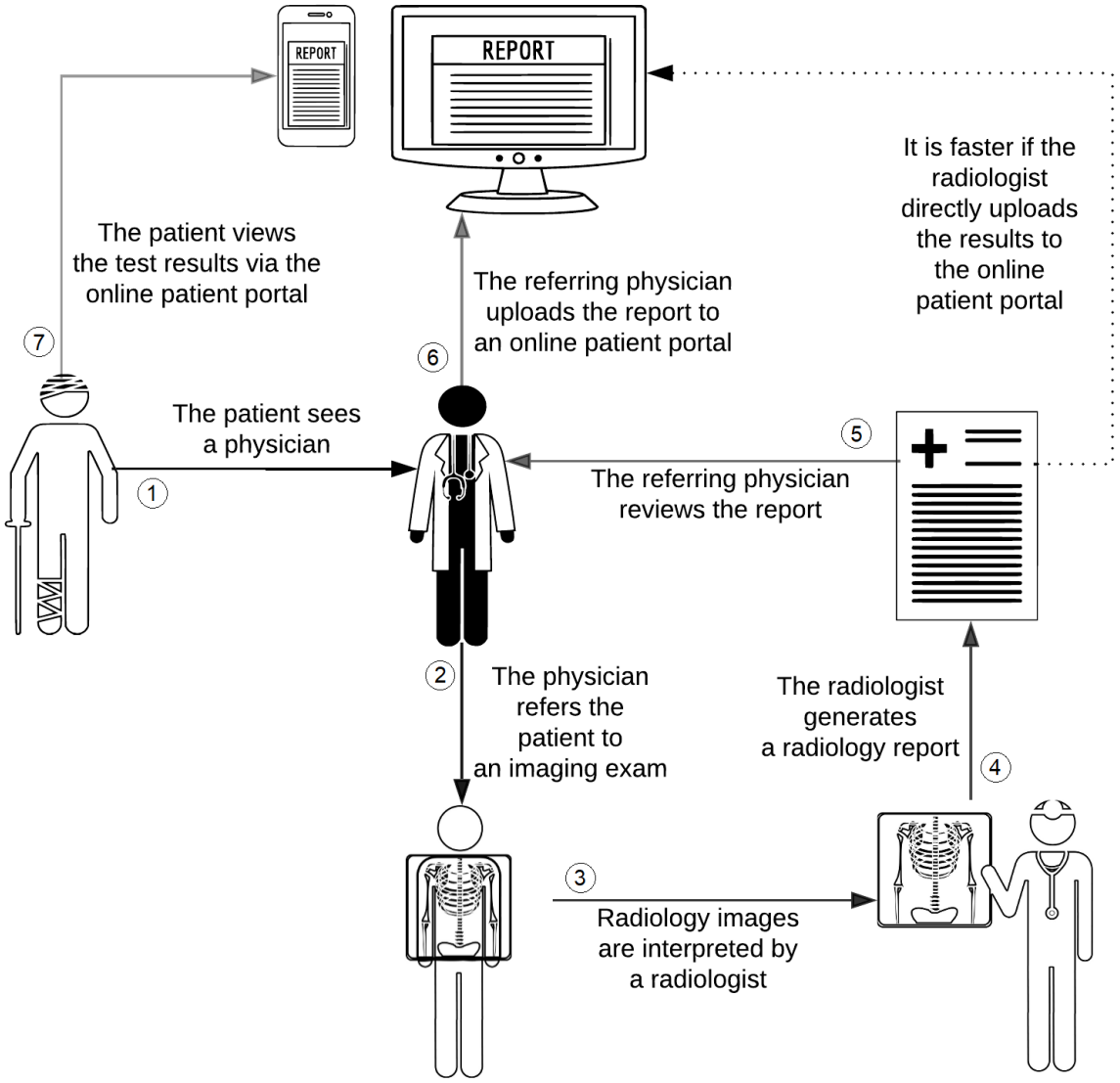


Figure 1.1: Typical Framework of Radiology Test Results on the Patient Portal

Significance of the Study

To enhance the quality of health care, health care services need to be delivered in ways that meet patients' needs and preferences.[37] The recent movement toward patient-centered

care has affected the shape of the radiology test results.[38,39] This is in part due to the increase in patient access to online patient portals. Patients are becoming the end-readers of the radiology reports alongside with the referring physicians.[27,38] Patients' access to their radiology test results empowers them and makes them more informed and engaged in their health care.[40,41] The benefits of allowing patients to access to their radiology test results through patient portals have been well studied.[7,9,11,12,40,42-47] However, needs and preferences of patients with regard to the radiology test results delivered via an online patient portal is an area that still needs further study.[32,33,35,48]

It seems that patient access of radiology test results through patient portals has not reached its full maturity and it still needs a great deal of improvement. Therefore, participation of the end-readers in shaping the use of radiology test results on the patient portals is crucial. From the findings of the social media analysis (please refer to chapter II), 70% of the posts related to the radiology test results ask for an interpretation for the results. Patients find the radiology test results difficult to understand.[26] Several methods have been proposed in the literature to resolve this issue,[26,49-51] some of which have not been examined. Moreover, radiology reports can be either a free-text report or a structured report, and patients' preference regarding this matter has not been investigated.

Traditionally, radiology reports are made available on the patient portal after the referring physician reviews them and communicates them to the patient.[52,53] This process takes time, and waiting for radiology test results can cause anxiety for patients.[35,44,54] Patients prefer immediate access to their radiology test reports.[34,35,55] This could be done if the radiologists make the reports readily available on the patient portal as soon as they create them.[56,57]

However, this could cause issues in the complexity, clarity, and difficulty of the radiology report for the patients.[26,40,58] Adding a summary of the findings at the end of the report in lay terms[26] could be one of the simplest, affordable, and effective methods to improve patients' understanding of the radiology report and satisfy their needs. Its effectiveness has not been investigated; it was covered in this study.

Adding a patient summary statement as a method to improve patients' understanding of their radiology report is different from the other methods in several aspects. First, this method is affordable and cost-effective when compared with other methods that require more technology involvement, such as linking unclear terms in a radiology report to reference databases. Second, adding a summary of the findings as a method to enhance patients' understanding of the radiology report does not raise security concerns. Unlike linking unclear terms in the report to reference databases, adding a summary of the findings does not require an interface between the patient portal and an external reference database, which solve the security concerns. Third, adding a summary of the findings would minimally disrupt the workflow of the radiologist. Other methods, such as creating two reports for every exam, an original report and another one presented in lay terms, would seriously disrupt the radiologist's workflow and decrease his or her productivity. Finally, adding a summary of the findings would not affect the critical information in the report. Other methods, such as rewording the report in understandable language for a layperson, would result in critical information loss and failure to fulfill the main purpose of the report. Therefore, it appears to be that adding a summary of the findings at the end of the report to improve patients' understanding is an ideal method.

To the best of our knowledge, this is the first study focused on investigating patients' needs and preferences regarding radiology test results on the patient portal from this angle. Several aspects covered in this study include the role of health literacy in patients' understanding of their radiology report, the effectiveness of adding a summary of the content of the report in lay terms as a method to improve patients' understanding of their report, and patients' preference for type of radiology reporting. Findings of this study can be used to improve the quality of health care services by making radiology test results on the patient portal meet patients' needs and preferences.

Aims of the Study

The aim of this study was to investigate the needs and preferences of the patients regarding the radiology test results delivered via patient portals. There were three main objectives of this study:

- Determine the association between patients' level of education and how much they can understand from the radiology report.
- Examine the role of health literacy in the patients' understanding of the radiology report.
- Investigate whether adding a statement at the end of the radiology report in lay language summarizing the content of the report enhances patients' understanding of the report.

In addition, the following objectives were explored in this study:

- Investigate how much patients understand from a typical radiology report.

- Investigate patients' preferences regarding the type of radiology reporting (i.e., whether patients prefer free-text or structured reports).
- Determine whether patients think that the type of radiology reporting (free-text or structured) affects their level of understanding of the report.

Definition of Terms

Patient Portal: an online website or application that gives patients secure, real-time, self-service access to their health information whenever and wherever they want as long as they have an internet connection.[6-9]

Radiation Therapy: a type of radiology procedure used to treat cancer by damaging cancer cells' DNA with high-energy radiation in order to destroy their ability to divide and grow. Radiation therapy might be used as a standalone therapy for cancer or in conjunction with chemotherapy or surgery.[15]

Diagnostic Medical Imaging: a technology that provides images of the internal organs of the body to allow physicians to examine, diagnose, and treat medical conditions.[16]

Health Literacy: the degree to which a person is able to gain, communicate, process, and comprehend basic health information, instructions, and services required to make proper health decisions.[59]

Radiology Report: a formal documentation of the results of a radiologic exam and an important form of communication between the radiologist and the referring physician.[22-25]

Free-Text Radiology Report: a type of radiology report in which radiologists write their findings and recommendations in an unrestricted format.[50]

Structured Radiology Report: a type of radiology report written in an organized style, which can enhance readability, reduce errors, eliminate omissions of important information, facilitate scientific research, and improve the visibility of critical information.[60-62]

Chapter II: Literature Review and Social Media Analysis

Literature Review

Literature Search Strategy

To conduct the literature review, Google Scholar, PubMed, and Ovid were searched for studies related to the topic of this paper. Only articles written in the English language were included in the review. To include as many studies as possible in the review, there was no constraint applied to the publication date. Moreover, the reference lists of the included articles were searched to find studies that might be related to the topic of this paper. The feature "similar articles" in PubMed also was used to find studies that may be related to the topic of this paper. The keywords used in the search were as follows: ("patient portal" OR "personal health record" OR "PHR") AND ("images" OR "imaging" OR "radiologic" OR "radiology" OR "radiologic report" OR "radiology report" OR "report") AND ("patient preferences" OR "patient perspective" OR "patient").

Patients and Radiology Test Results on Patient Portals

I. Advantages and Disadvantages of the Utilization of Patient Portals to Access Radiology Test Results

With the increase of patient portal adoption and patients' increasing interest in accessing their radiology test results,[38] there is a high demand for the availability of radiology test results on the patient portal. A 2016 study[32] showed that radiology reports were viewed by 51% of patients, a 16% increase over the results of a 2006 study[13] that revealed 35% of patients

viewed their radiology reports. When patients are given access to their health information, including radiology test results, they become more informed and engaged in their health care,[40,41] which results in several benefits.[7,9,11,12,40,42-47] Conversely, when patients have limited access to their radiology test results, this may subvert the efforts of the patients to be more engaged in effective patient-physician partnerships for decision-making.[63]

The benefits of allowing patients to access and review their health information include better adherence to therapy,[11,12,42,43] better preparation for next clinic visits,[40,44-46] better self-education about their health,[40,44-46] empowerment in patient-physician partnerships,[44] getting results fast,[47] and minimization of delays in care.[44-46] When patients are provided with secure online access to their health information via the patient portal, they do not need to wait for office hours to have questions answered. Consequently, their test results are delivered faster and the patients can then educate themselves and enrich their knowledge about their health status. The patient-physician relationship becomes closer as the patients are able to review their provider's notes whenever they need to, which might lead to greater patient compliance and better clinical outcomes.

Accompanying the previously mentioned advantages of allowing patients to access and review their health information, however, there are some disadvantages. The disadvantages of accessing radiology test results via patient portals might include the complexity of the contents, a misunderstanding of the report, and the anxiety and stress of the patients.[40,47,64,65] The contents of the radiology test results can be complex for laypeople. A layperson might not be able to read his or her radiological images and make sense out of them. Moreover, radiology

reports can be very difficult to interpret for a layperson, which could result in misunderstanding the report; thus, the patient becomes anxious and stressed.

II. When Results Should be Provided and from Whom

Traditionally, radiology reports are made available on the patient portal after the referring physician reviews them and communicates the results to the patient.[52,53] This process takes time, and waiting for radiology test results can cause anxiety for patients.[35,44,54] Patients expect to receive their radiology test results within 1 to 3 days after the exam, and they will contact their providers to ask about the results in 1 to 5 days.[54] Most patients prefer immediate access to their radiology test reports.[34,35,55] This could be done if the radiologists make the reports readily available on the patient portal as soon as they generate them.[56,57] However, this process can raise several problems relating to the complexity, clarity, and difficulty of the terms in the report,[26,40,58] which will be discussed in detail later. Figure 1.1 explains more about this process.

When it comes to from whom patients prefer to receive their radiology test results, the literature showed conflicted answers.[34,44,52,53,66,67] For example, in a study conducted by Schreiber, Leonard, and Rieniets (1995), the vast majority of the patients (87% - 92%) wanted to receive their radiology test results from the radiologist rather than their referring physician, regardless of whether the results were normal or abnormal.[53] On the other hand, in another study conducted by Kuhlman, Meyer, and Krupinski (2012), most of the patients (73% - 77%) wanted to receive their radiology test results from their ordering physician, regardless of whether the results were normal or abnormal.[52] The results of another study revealed that

patients were fairly evenly split with regard to from whom they preferred to receive their radiology test results.[44]

It is unclear why there are discrepancies in the findings of the studies pertaining to whom patients would prefer to provide radiology test results to them. It might be due to the methodology of the study, the location where the study was conducted, the time when the study was done, or other unmentioned reasons. Lack of awareness of the role of the radiologist was noticed in patients, and this could play a major role in the preference of patients with regard to who delivers their radiology test results to them.[34,52] It seems that many patients are uncertain as to whether radiologists are physicians.[52,68,69] When patients were asked about the role of the radiologist, 40% of the respondents did not answer correctly and thought that a radiologist is a technician or a nurse.[52]

Patients were found to be interested in the timely receipt of radiology test results.[35,44,52,56,66,70] In some cases, it appears to be that receiving radiology reports in a timely manner is more important than who delivers the results.[52,66] In other words, patients prefer to receive their radiology test results from whoever is faster. However, both radiologists and referring physicians are concerned that when patients are granted immediate and direct access to their radiology test results via patient portals, it will increase patient anxiety, which will result in more demands on the time of the physician caused by more consultative requests from patients.[71,72] Moreover, radiologists and referring physicians are concerned that patients may not be able to understand the terms and context of the radiology reports.[65,71]

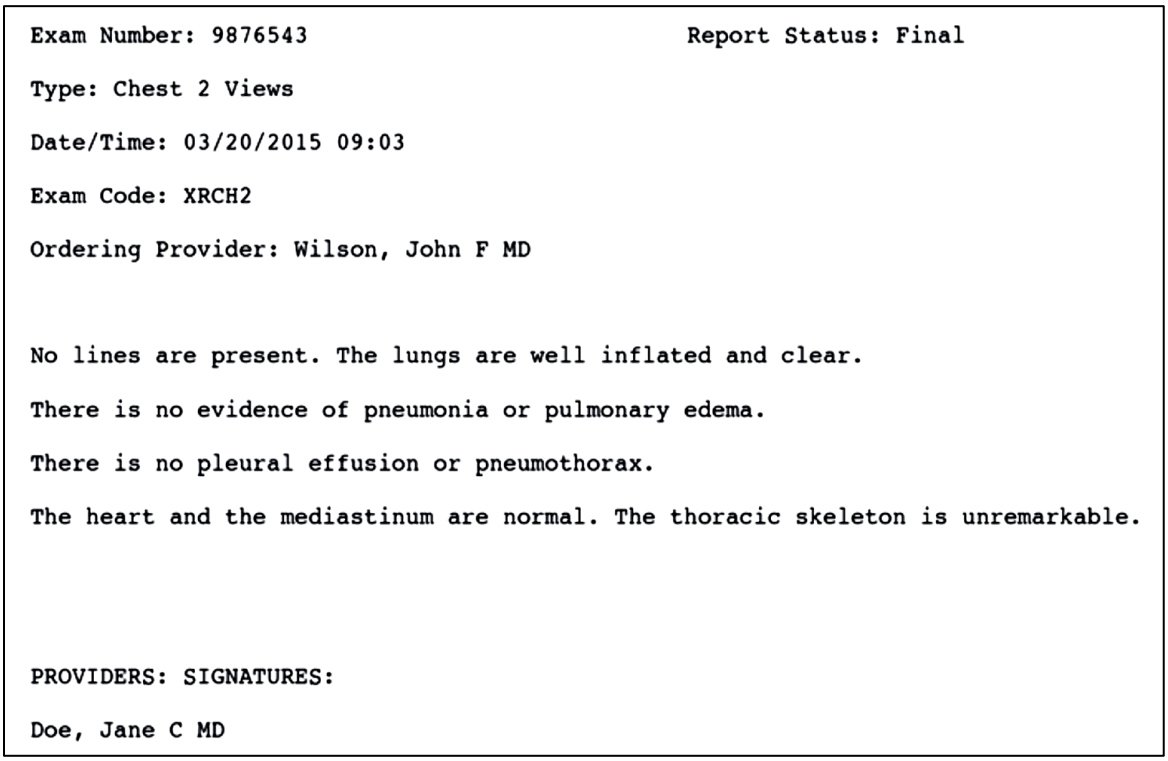
III. Language Used in Radiology Reports

Although radiology test results are one of the most frequently accessed features in the online patient portal,[13,14] they are one of the most difficult pieces of information in medical records for lay patients to understand.[26,73] This could be due to the level of patients' health literacy, the complexity of the language used in the radiology report, and the complexity of radiologic images.[26,40,58,64,65,74]

Health literacy is defined as the degree to which a person is able to gain, communicate, process, and comprehend the basic health information, instructions, and services required to make proper health decisions.[59] The level of patients' health literacy could be the obstacle of understanding the radiology test results, as the average American adult can read only at the level of seventh to eighth grade.[75-77] Low literacy skills can result in adverse health outcomes.[78] It is recommended that health information be written at or below a sixth grade level for an average American adult to understand.[79,80] Therefore, attention to the health literacy aspect of the radiology test results may help optimize patient health and satisfaction.[49]

Even patients with well-developed literacy skills may not be able to understand their radiology test results, especially the radiology report.[26,80] This is in part because of the unclear or technical language of the contents of the radiology reports.[26,40,47,58,71] The radiology report can be very complex and difficult for a layperson to understand, which could result in unnecessary anxiety and stress.[65,71,81,82] People usually expect the worst when they are in pain. The word "tear," as an example, is regularly used in an MRI report to describe a degenerative disease, which is often a benign condition of aging, but a layperson may interpret this word as meaning there is major damage that requires immediate attention and repair.[83] To show a real-

world example, in the chest radiographic examination report, Figure 2.1 (adopted from Mityul, Gilcrease-Garcia, Mangano, Demertzis, Gunn [50]), there are several terms that might be difficult to understand for a layperson even though this report looks simple and easy to understand. It appears that no study has been conducted to investigate the relationship between health literacy and patients' understanding of the radiology report.



Exam Number: 9876543 Report Status: Final

Type: Chest 2 Views

Date/Time: 03/20/2015 09:03

Exam Code: XRCH2

Ordering Provider: Wilson, John F MD

No lines are present. The lungs are well inflated and clear.

There is no evidence of pneumonia or pulmonary edema.

There is no pleural effusion or pneumothorax.

The heart and the mediastinum are normal. The thoracic skeleton is unremarkable.

PROVIDERS: SIGNATURES:

Doe, Jane C MD

Figure 2.1: Chest X-Ray Examination Report

The radiology report may contain medical terms, anatomical words, names of diseases, or terms used to express the level of certainty. Usually a medical background is required to comprehend the content of radiology reports. Several methods have been proposed to increase patients' understanding of radiology reports, discussed in the next section.

IV. Ways to Increase Patients' Understanding of Radiology Reports

Patients have expressed a strong preference for radiology reports to be in lay language

in order for them to understand the reports.[26,35,44] It is not practical for radiologists to generate two reports to every imaging study. However, adding a sentence at the end of the report summarizing the essential findings in lay language might be practical and would minimally disrupt the workflow of the radiologist.[26] After the radiologist writes all parts of the report, he or she would add a statement at the end of the report that briefly explains the content of the report. This statement should be written in a way that is understandable for a layperson, which should be at or below a sixth grade level.[79,80] Writing the summary statement in a way that is not easy to understand would defeat its purpose, waste the radiologist's time, and might confuse the patient and cause anxiety. Figure 2.2 (adopted from Gunn, Gilcrease-Garcia, Mangano, Sahani, Boland, Choy [26]) shows a sample of a radiology report with an added simple statement in lay language at the end of the report. The effectiveness of adding a summary at the end of the report as a method to improve the patients' understanding of the radiology report has not been studied and needs further research.

EXAMINATION: Chest, two view

HISTORY: 50 year old male with congestive heart failure presenting with shortness of breath.

FINDINGS:

Comparison is made to the prior study dated 12/12/2012.

There is mild pulmonary edema and small bilateral pleural effusions. There is no pneumothorax. There is no confluent pulmonary opacity to suggest pneumonia. There is unchanged cardiomegaly. The mediastinum is otherwise normal.

IMPRESSION:

1. New mild pulmonary edema and bilateral small effusions.
2. Stable cardiomegaly.

PATIENT SUMMARY STATEMENT:

There is a small amount of fluid accumulating in the lungs.

Figure 2.2: Chest X-Ray Report with a Sentence at the End in Lay Language

Another method that could be done to increase patients' understanding of the radiology report is by "rewording" the report in understandable language for a layperson.[49] By doing so, the radiologist would not need to write two reports, one for the referring physician and one for the patient; instead, the radiologist would need to reword for lower reading level.[49] In other words, the radiologist needs to choose words understandable to a layperson. This method might not be easy to apply, because there are many terms in the radiology report that cannot be reworded and they usually do not have synonyms. Furthermore, this could disrupt the radiologists' workflow, because the radiologist is used to writing in a particular style that might be difficult to change. The time needed to write a "reworded" report would be very long, because the radiologist would think about every word before he or she writes it. The radiologist would be required to ensure that the words that he or she chooses to use in the report are suitable for laypeople as well as the referring physician.

Patients' understanding of their radiology report also may be improved by linking the terms in a radiology report to reference databases.[26,50,84-86] This could be done by a system or an application that parses the radiology report for technical or medical words, terms, or phrases and then automatically cross-references them against reference databases. The system or the application, which is bundled in the online patient portal, then displays the technical or medical words, terms, or phrases with embedded hyperlinks. Once the patient hovers over or clicks on the words, terms, or phrases, the system or the application displays a simple explanation or a lay language definition as a pop-up balloon or a new small window.[85,86] Figure 2.3 (adopted from Gunn, Gilcrease-Garcia, Mangano, Sahani, Boland, Choy [26]) shows a sample of a radiology report that is liked to a reference database to enhance patients' understanding of the radiology report.

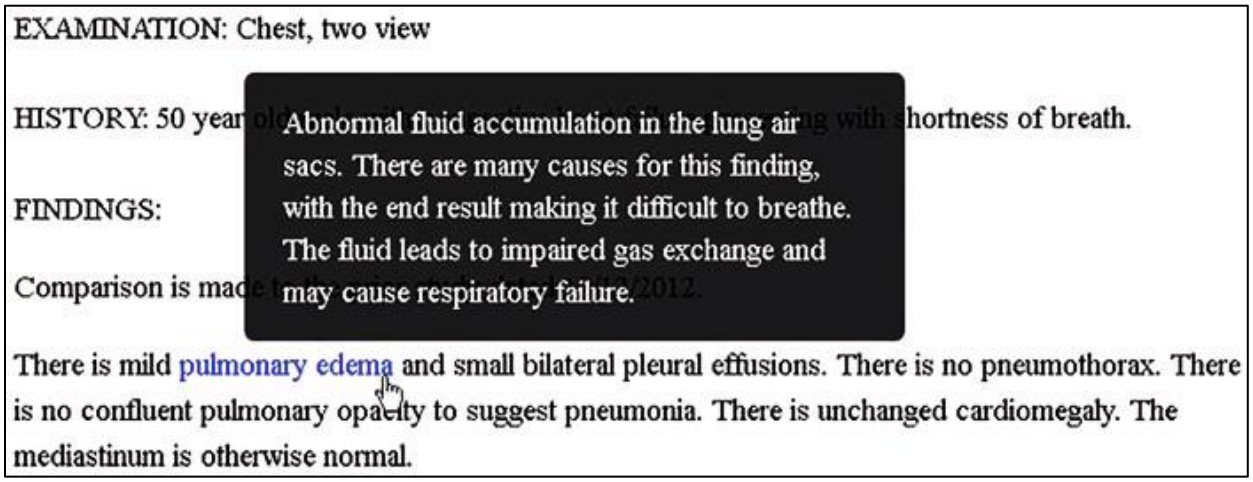


Figure 2.3: Sample of a Radiology Report Liked to a Reference Database

One of the biggest issues of this suggested method is how to find a reference database that contains a simple explanation of the difficult terms in the report. Creating a reference database for all domains (e.g., knee MRI, head CT, and chest X-ray) from the scratch would cost a great deal of money, and it would take time to construct and collect the terms that need to be

explained to a layperson. Available databases, such as RadiologyInfo.org and RadiologyExplained.com, might not be good references, as they are meant for medical professionals, they are too difficult for laypeople to read, or their authors are not identified, which makes them unreliable.[87,88]

Linking words and terms in the radiology report to a reference database could give rise to other issues, for instance, how to identify which terms should be classified as unclear.[26] The task of identifying the terms that need to be clarified by linking them to a reference database is difficult. Moreover, security concerns might arise when an interface between the patient portal and an external reference database is established. Issues and concerns that accompany linking the unclear terms in the radiology report to a reference database should be resolved and satisfied to ensure the success of this method.

It has been shown that when medical information is accompanied by images or illustration pictures, patients' attention, recall, and comprehension of medical concepts is improved.[89,90] Moreover, showing patients illustration pictures specifically related to their conditions might give them better understanding of the causative links between their symptoms and treatments.[91] Studies showed that many patients expressed interest in seeing their radiologic images,[34,44,92] which suggests that patients think that including images or illustrations may enhance their understanding of the radiology test results.[86] This is because they can refer to the visuals when they face difficulties understanding some anatomical words. An example of an illustration included in a radiology report is shown in Figure 2.4 (adopted from Cook, Oh, Kahn [86]).

CONTRAST: None.

COMPARISON: Left knee radiographs from 11/5/2014.

FINDINGS:

Fluid: Large effusion.

medial collateral ligament
Ligament in the inner side of the knee W

posterior horn extending to the inferior to the undersurface with edema in the underlying tibial plateau.
- Medial collateral ligament: Edema surrounding the ligament in keeping with a grade 1 sprain.
- Cartilage: Intact.

Lateral compartment:
- Lateral meniscus: Radial tear of the posterior horn with a displaced fragment into the

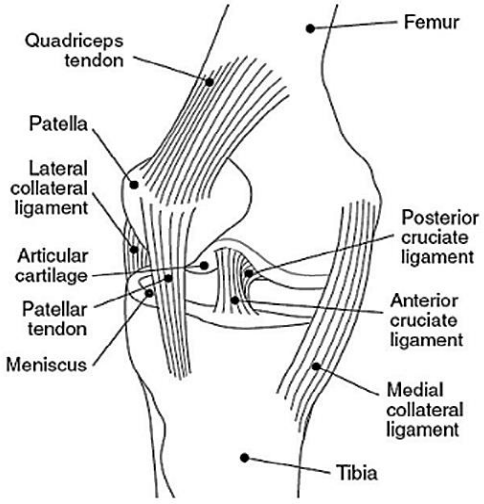


Figure 2.4: An Example of an Illustration Picture Included in a Radiology Report

This method of improving patients' understanding of their radiology test results might result in an increase in consultative questions from patients. Some patients might find difficulties in understanding their radiologic images or the visuals included in their radiology test results. As a result, the number of questions about the radiology test results asked by the patients might increase.

In addition, words used in provider–patient interactions have strong effects on patients, including non-adherence to treatment, confusion, and anxiety.[49,85,93] Patients and radiologists do not have same perceptions of the meaning of some words used in the radiology report.[85] The misinterpretation of terms in the radiology report by patients is problematic.[58] Terms used to express the level of certainty in the radiology reports can be easily misinterpreted.[51] For example, in one study,[85] the phrase "probably metastatic disease" was interpreted by patients as high level of certainty of metastatic disease. Radiologists, on the other hand, interpreted the same phrase as low level of certainty of metastatic disease, which could cause confusion and anxiety for the patients. On the contrary, the phrase "consistent with metastatic disease" was interpreted by radiologists as a high probability of true metastatic disease, but patients interpreted the same phrase as much less probability of metastatic disease.[85]

It is important that both the writer and the reader of the radiology report understand the meaning behind specific phrases, terms, and words and agree on them in order for information to be accurately passed along.[94] Uses of words such as "possibly" would raise the question "how much possibility?", because "possibly" is a vague word and could lead to confusion.[51] The meaning of most of the words or terms that are used to express the level of certainty, such as probably, possibly, and less likely, cannot be agreed on because they are subject to individual interpretation. The meaning of textual-based expressions to convey the radiologists' level of confidence in their findings can even vary from one radiologist to another.[95]

One possible way to minimize the variability in the interpretation of the words and terms used to show the level of certainty in the radiology reports is by providing a

percentage.[51,95] It is easier to understand "how much possibility?" of something in the report when it is written in a percentage. For instance, the reader of a radiology report can understand that the possibility of metastatic disease is higher when the radiologist writes "60% chance of metastatic disease" compared with "30% chance of metastatic disease"; however, the reader cannot figure out how much the possibility of metastatic disease is when the radiologist writes "possibly metastatic disease," which leads to confusion. Using a percentage to express the level of certainty gives the patient a clear idea about how confident the radiologist is in the radiology report. Both the radiologist and the patient can agree on the meaning of the numbers because, for example, 70% always will be greater than 40%, but there will be disagreement on the meaning of the textual-based certainty expressions.

Another possible approach that could be used to minimize the variability in the interpretation of the terms used to show the level of certainty in the radiology reports is by using a well-defined lexicon of certainty terms.[96] Table 2.1 shows an example of a well-defined lexicon of certainty terms, which is adopted from Panicek, Hricak.[96] However, this lexicon of certainty terms has been created for radiologists, so it might need some modifications to make it easier for laypersons to understand. It is not logical to expect all patients to know about the existence of the lexicon of the certainty terms. Therefore, the lexicon of the certainty terms must be always included in the radiology report to show patients the level of certainty of the terms used in the report.

Consistent with	>90%
Suspicious for/Probable/Probably	~75%
Possible/Possibly	~50%
Less likely	~25%
Unlikely	<10%

Table 2.1: Example of a Well-Defined Lexicon of Certainty Terms

This method might not be better than expressing the level of certainty in a percentage for several reasons. First, if a radiologist uses a percentage to express his or her confidence level for a diagnosis, the radiologist will be able to choose from a large range of numbers (i.e., the radiologist can choose any number from 1 to 100). Therefore, the radiologist will be able to show accurately how certain he or she is. On the other hand, a lexicon of certainty terms, such as the one in Table 2.1, will provide only a limited range of certainty terms (e.g., only five certainty terms) that a radiologist has to choose from, which might not reflect precisely how confident the radiologist is. Second, the utilization of a lexicon of certainty terms to express the level of certainty is a process of indirectly using a percentage to show the level of certainty. Therefore, why not just simplify the process and use a percentage to express the level of certainty from the beginning? Using a lexicon of certainty terms instead of a percentage might increase the complexity of the radiology report. Third, it seems that all of the available lexicons

of certainty terms were created for radiologists; there is no lexicon of certainty terms has been generated for patients.

V. Structured Versus Free-Text Reports

The radiology report can be a free-text (narrative) report or a structured report.[97] Free-text reports have been used as a way to write radiology reports for over a century.[97,98] In free-text reports, radiologists write their findings and recommendations in an unrestricted format.[50] This type of report writing allows radiologists to selectively describe the findings they find significant and omit information they find insignificant to the clinical context. Moreover, this type can be faster for radiologists because during dictation, they do not need to look away from the images to fill out blanks in another screen.[18,50] However, the excessive variability in language and style of free-text reports can be problematic for patients because it can cause miscommunication between the radiologist and the patient.[50] Another issue with the free-text report is that the radiologist may unintentionally understate important findings.[18,50] An example of a free-text report is shown in Figure 2.1.

Structured reports are a type of radiology reports written in an organized style. Structured radiology reports have several advantages when compared to free-text reports. They can enhance readability, reduce errors, eliminate omissions of important information, facilitate scientific research, and enhance the visibility of critical findings.[60-62]

Structured reports also have their downsides, however, which might include a reduction in the radiologists' productivity due to dwell time (i.e., the radiologists' productivity decreases as a result of the increased visual attention on the templates and not keeping their eyes on the

images),[99] an unnecessary increase in the report length due to including unnecessary information, and unsuitability for complicated cases.[60] Table 2.2 summarizes the benefits and limitations of structured radiology reports (adopted from Ganeshan, Duong, Probyn, Lenchik, McArthur, Retrouvey, Ghobadi, Desouches, Pastel, Francis [100]).

Benefits	Limitations and Challenges
Disease-specific report templates can improve report clarity and quality, and ensure consistent use of terminology across practices.	Radiologists may be resistant to change.
Checklist style reports can reduce diagnostic errors (such as failing to report incidental renal cell carcinoma in a magnetic resonance spine performed for back pain).	Learning curve associated with new reporting style may negatively impact radiology workflow and productivity.
Can reduce grammatical and nongrammatical digital speech recognition errors	Potentially increased error rates if used improperly (eg, failing to remove the prepopulated phrase of "normal gallbladder" in a patient who is status post cholecystectomy).
Ensures completeness of radiology report documentation and thereby improves radiology reimbursement	Interruption of visual search pattern may increase reporting time.
May be financially rewarding under the new Medicare Merit-based Incentive Payment System	Including unnecessary or irrelevant information in a template report may negatively impact the coherence of the report and its subsequent comprehension by referring physicians.
Positively impacts research in radiology by facilitating data mining	
Provides opportunities for quality improvement	
Can help promote evidence-based medicine by integrating clinical decision support tools with radiology reports	

Table 2.2: Benefits and Limitations of Structured Reporting

There are three levels of structured reporting of radiologic studies.[99] At the basic level, the structured report is displayed with headings, such as clinical history, indication, examination protocol, radiological findings, and impression. In the second level, the "findings" section includes subheadings for organs and organ systems. The third level has the previous characteristics and requires the utilization of a standardized language. Figure 2.5 shows a

sample of each level of structured reporting (adopted from Ganeshan, Duong, Probyn, Lenchik, McArthur, Retrouvey, Ghobadi, Desouches, Pastel, Francis [100]).

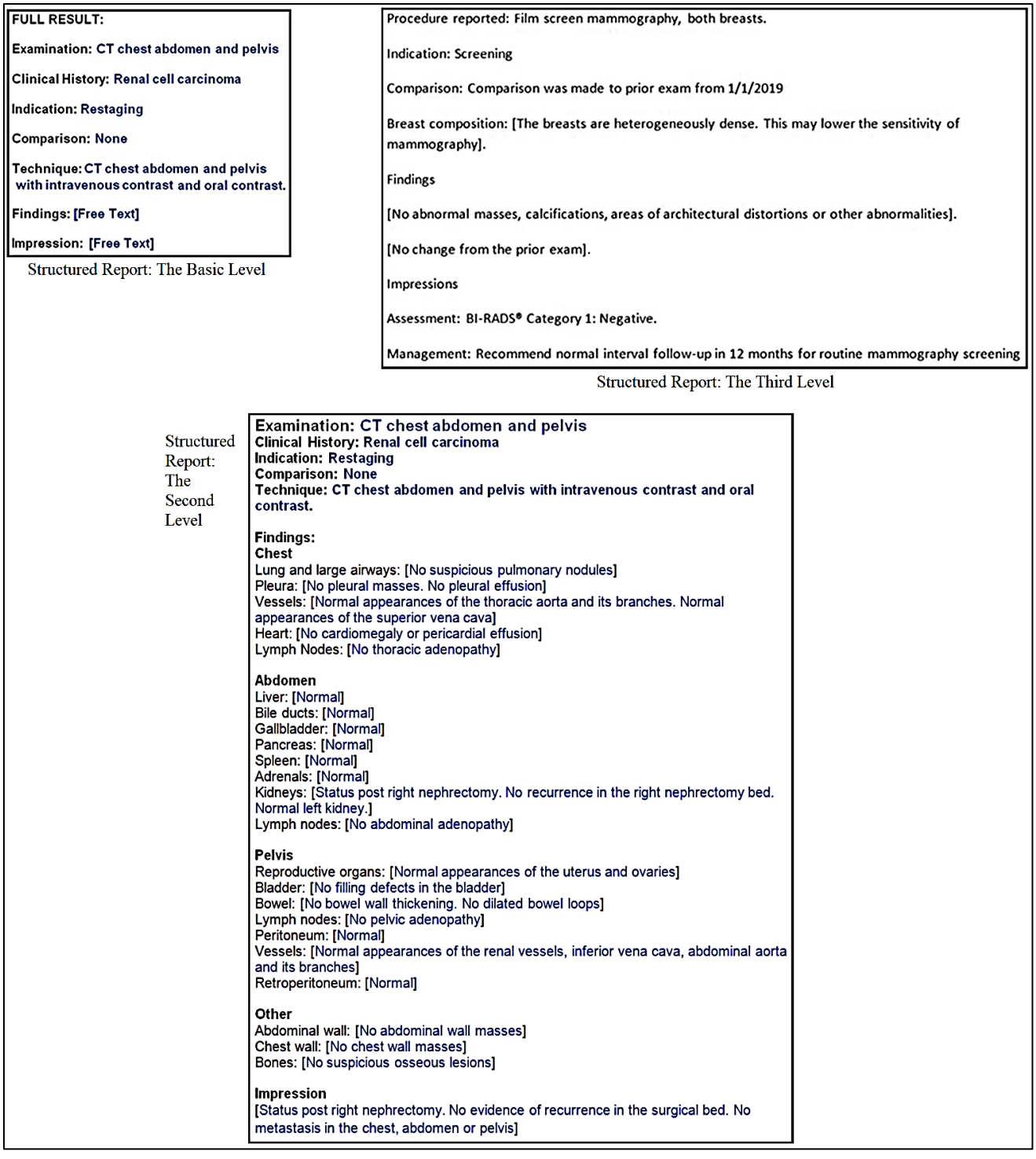


Figure 2.5: A Sample of Each Level of Structured Reporting

The utilization of a standardized radiology lexicon in structured reporting is the most important level among the three levels of structured reporting. That is because this is how most advantages of structured reporting are realized.[101] A standardized radiology lexicon, such as RadLex, created by Radiological Society of North America (RSNA), provides a way of describing the findings of radiologic studies in clear, concise, consistent, and unambiguous language.[18,50,102] A standardized lexicon also can facilitate radiology research, reduce errors, and enable decision support.[18,103] The main concern of using a standardized lexicon in structured reporting is that the available standardized radiology lexicons have been generated predominantly for health care providers, and might not be suitable for laypersons.[88]

Radiology structured reporting is preferred by both radiologists and referring physicians.[104-108] The radiologists and the referring physicians find structured reporting helpful in reducing errors related to the report, increasing their productivity, and decreasing report turnaround time.[109] Structured reporting is also preferred by researchers because it can improve data mining and facilitate scientific research.[108,110] However, it appears that no study has been done to investigate preferences of the patients regarding the style of the radiology report (i.e., whether patients prefer a free-text radiology report or a structured radiology report).[33] Further research is needed in this area to find out which type of radiology report patients prefer.

VI. Recommendations for a Good Radiology Report

The quality of a radiology report is essential for fulfilling its ultimate purpose, which is improving the quality of health care. There are several recommendations for designing and creating e a good radiology report. Here are some of them:

- The report should be clear and consistent.[111,112]
- Whenever possible, the report should describe a precise diagnosis.[113]
- The report should be concise and brief, if possible.[112] This is because detailed health information can cause stress.[40]
- The completeness of the radiology report is crucial.[72,97] The report should contain as much significant information as possible and omit information that is deemed clinically irrelevant or insignificant.
- A standardized structured reporting should be used as per the health care providers' preferences.[97,114] Patients' preferences regarding the type of radiology reporting have not been studied.
- Radiologists should avoid excessive jargon or medical terms as much as possible.[72]
- The report should be carefully proofread to correct errors in spelling and grammar.[72]
- The level of certainty in the report should be conveyed in straightforward language, such as in a percentage.[51,72,95]
- Radiologists should pay more attention to the timeliness of the report creation.[52,66,112]
- Radiologic images and/or illustrations should be included in the radiology report when possible.[44,86,89-91]

Summary and Conclusions

Online patient portals are evolving rapidly to adjust to the needs and preferences of patients. They have the potential to decrease errors, enhance communication between health care providers and their patients, and promote informed decision-making. There is a high

demand for radiology test results to be entered into online patient portals so patients can review their results whenever and wherever they wish. Well-implemented portals can improve patient understanding of their radiology test results, which in return, encourages them to take a greater role in their own health care. It appears that the method by which radiology test results are provided via online patient portals has not reached its full maturity and still needs a great deal of improvement.

Radiology test results used to be communicated to referring physicians only, and the referring physicians delivered the results to their patients. Delivering the results directly from the radiologist to the patient via the patient portal has created many issues and concerns. Health care providers have concerns pertaining to the potential for misunderstanding of the medical language, increased anxiety, and increased phone calls. On the other hand, although patients are concerned about their privacy, they want their radiology test results to be received through the patient portal promptly and in clear and understandable language.

Several methods have been proposed to overcome the issues raised by delivering radiology test results through the patient portal. Some of the proposed methods include writing a summary statement at the end of the report, rewording the report in understandable language, linking terms in the report to reference databases, including images or illustration pictures in the report, using a percentage to show level of certainty, and using a standardized structured reporting that a layperson can understand. However, this area still needs further research to ensure that the needs and preferences of the patients are satisfied in order to improve the quality of health care.

Social Media Analysis Study

Introduction to the Social Media Analysis Study

One of the biggest concerns about receiving radiology test results via patient portals is that patients do not always understand their results.[26,73] When patients face difficulties understanding their results, they will probably consult whatever online medical information sources are readily accessible to find answers to their questions.[71] There are several good online patient education resources, such as RadiologyInfo.org, that patients may consult. However, these websites do not satisfy patients' questions and concerns because they lack specifics and exceed the recommended readability level.[87,88] Therefore, many patients seek help by posting their concerns and questions on social media. Analyzing the posts in social media will provide insight into the type of questions patients ask, which in return might help in identifying patients' needs pertaining radiology test results.[115]

Methodology of the Social Media Analysis Study

A thematic analysis was performed on 563 posts collected from four different online websites: medhelp.org, reddit.com, patient.info, and answers.yahoo.com. Software called "Octoparse"[116] was used to extract the data from these websites. Keywords used in the search include "radiology, radiological, radiologic, report, image, imaging, scan, exam, test, results, Computed Tomography, CT, CAT, Ultrasound, US, U/S, Magnetic Resonance Imaging, MRI, Nuclear Medicine, PET, PET/CT, X-ray, Fluoroscopy, Angiography." The initial number of posts collected was 1,355. Four different pieces of information were extracted from the posts: the title, the content of the post, the year it was posted, and the number of responses to the post.

The 1,355 posts were manually reviewed to ensure that only relevant posts were included in the analysis. Seven hundred ninety two posts were excluded for lack of relevance, leaving 563 posts. Most of the excluded posts were questions about the risks of ionizing radiation, questions about how to prepare for a radiology scan, questions about the technique of a radiology exam, questions about the side effects of contrast agents, questions about lab test results, or posts that described patients' experience during a radiology scan. Only posts focusing on radiology test results were included in the analysis.

The included posts were analyzed and categorized under four themes: request for interpretation, request for recommendations, request for information about diagnosis or illness, and expression of feelings. A brief explanation of each theme with two sample posts is below:

1. Request for interpretation: includes posts that contained requests to interpret a radiology report or part of it or interpret a radiology image. This involved requests to translate a word, a term, or a phrase in the radiology report. The following are two samples of posts that were included in this theme: "*Can someone please explain to me in layman's terms what this means? C5-6 Bulge/shallow broad based protrusion greater to the right…*" and "*I have the reports from two MRI's, one for my Cervical Spine … and I do not understand what they mean and I was hoping that you could help translate them into layman's terms so it will be easier for me to understand what it means.*"
2. Request for recommendations: posts included in this theme asked for recommendations or advice for next steps after receiving radiology test results.

Samples are as follows: "*I am a 29 y/o Male and my MRI results showed mild disc desiccation at C3/4. What are the likely treatment/follow-up care I could be looking at?*" and "*Hi, had an MRI, after it was suggested during an eye exam to check for grave or … the findings were bilateral and symmetrical optic nerve thickening with …. Based on this what should I be doing next and what type of MD should I seek out for help … thanks.*"

3. Request for information about diagnosis or illness: this theme includes posts that asked for more information about the radiology test results or request for answers based on previous experience. In other words, these posts asked for more explanation of current diagnosis or illness to gain better understanding about the patient's current health. The difference between this theme and "Request for Interpretation" theme is that in this theme, the person who posted the post, understood the report or the image but wanted more information about his or her current health status. The following two posts are samples of posts included in this theme: "*My Dr ordered a CT scan of my lungs. I was a previous smoker. It showed 2 nodules and 'old' scar tissue from pneumonia… Anyone ever had this problem…. Does pneumonia scar tissue mimic anything else? Thank you!*" and "*Hello. My dad has recently had a CT scan… they have found multiple small pulmonary modules, some of which have cavitated in his Chest, Abdomen and Pelvis …. I am just wondering that due to them being in the main three areas of his body whether this is likely to be cancer as it seems to be the way it has spread. …He also has portal vein thrombosis. How serious is this? Many thanks.*"

4. Expression of feelings: this theme includes posts that asked for emotional support or simply expressed positive or negative feelings, such as sad, worried, terrified, or happy. Here are two sample posts: "*Good news … so no cancer…*" and "*I am a 23 year old male with no symptoms of a brain tumor. Recently … after a CT scan, the radiologist said to have found a mass on my brain… I am terribly scared and nervous, and I have no idea who I should trust…*"

Social Media Analysis Results

The analysis of the included posts revealed the following findings: The average of responses to the posts was 0.65, which is a very low response rate. Nearly half of the posts (47%) contained zero response (No response) as shown in Figure 2.6. Around 39% of the posts contained only one or two responses, and 14% of the posts contained more than two responses. The distribution of the posts over the years 2006 to 2019 is shown in Table 2.3. Finally, and most importantly, as shown in Figure 2.7, the thematic analysis of the posts revealed that 70% of the posts fall under theme 1 (Request for Interpretation), 8% of them fall under theme 2 (Request for Recommendations), 15% of the posts fall under theme 3 (Request for Information about Diagnosis or Illness), and 7% of the posts fall under theme 4 (Expression of Feelings). Under theme 4, only three posts expressed positive feelings; 33 posts expressed negative feelings.

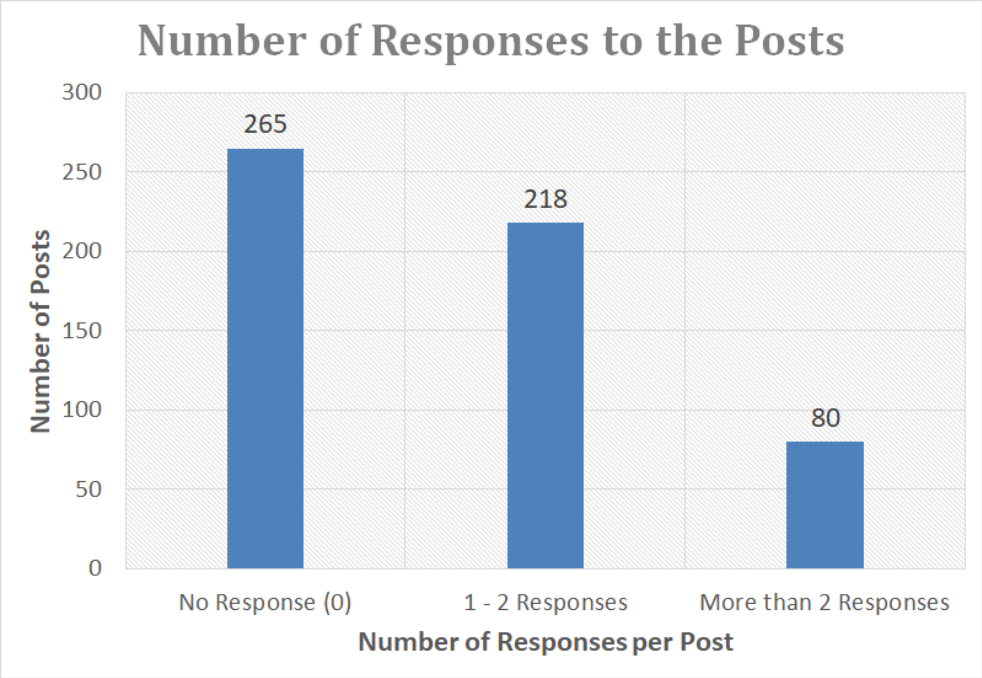


Figure 2.6: Number of Responses per Post

Number of Posts	Year Posted
1	2006
7	2007
24	2008
17	2009
23	2010
75	2011
39	2012
60	2013
66	2014
49	2015
72	2016
55	2017
72	2018
3	2019

Table 2.3: Distribution of Posts over the Years

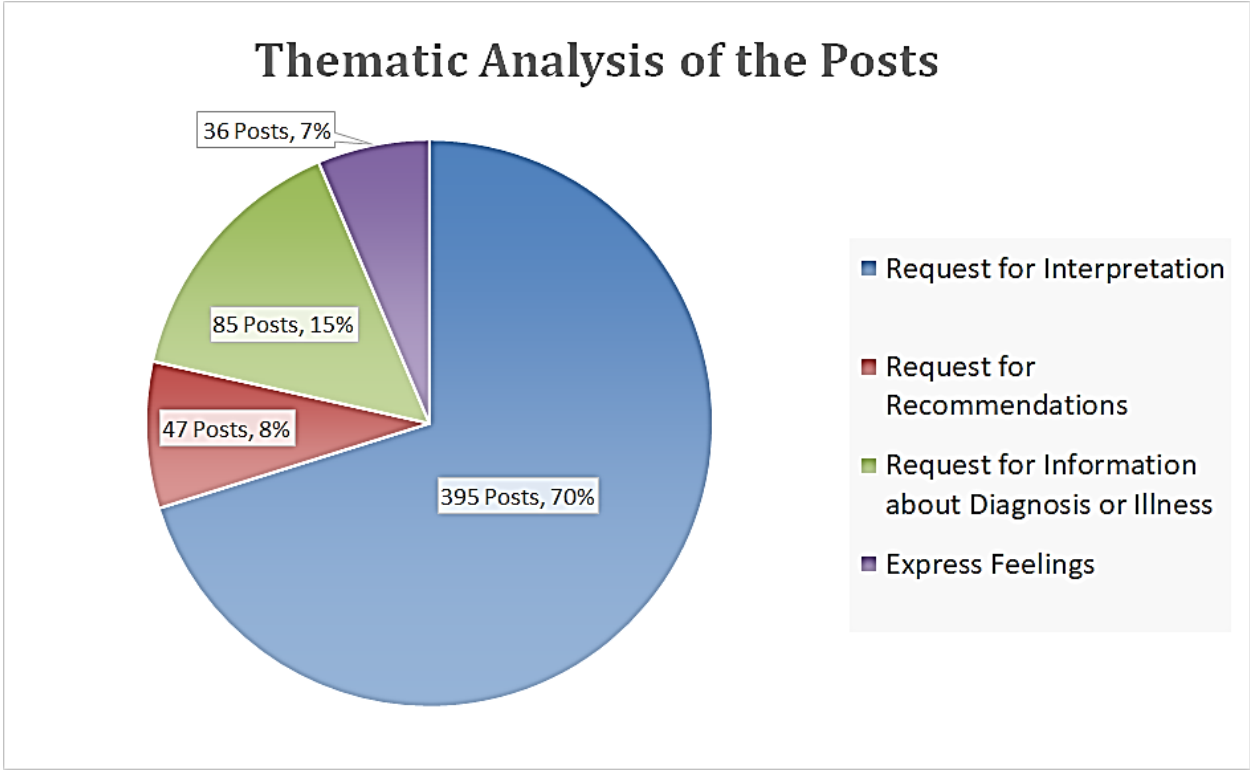


Figure 2.7: Thematic Analysis of the Posts

Words analysis was performed on the included posts using the following website "https://www.online-utility.org/text/analyzer.jsp." The words analysis was conducted only on the content of the posts, not on the title of the posts. This is because the words in the title are most probably repeated in the content of the posts. The most mentioned modality is MRI as shown in Table 2.4. The most mentioned body parts are the spine and the brain. Each one of them is mentioned over 200 times in the posts. This includes the main body part, spine and brain, and their smaller anatomical structures, such as lumbar spine, thoracic spine, white matter, and pituitary gland.

Top Four Mentioned Modalities	Occurrences
MRI	463
CT	189
X-Ray (Radiography)	140
Ultrasound	116

Table 2.4: Top Four Mentioned Modalities in the Posts

Discussion and Conclusions of the Social Media Analysis Study

The response rate to the posts indicates that around half of the people who post questions about radiology test results in social media will not have their questions answered. This could make the person who posted the question become anxious and stressed while waiting for someone to respond. Moreover, the very low response rate indicates that the questions about radiology test results, which are the main scope of all the posts, are very difficult to answer. Only few people might be able to answer these kinds of questions, people with a medical background, for instance.

The distribution of the posts over the years 2006 to 2019 suggests that posts regarding radiology test results are regularly active. Posts about the radiology test results increased in recent years (after 2011 until 2018). There are only three posts in 2019, but this is because the analysis was conducted by the end of January 2019, and there is a very high chance that the number of posts regarding radiology test results will significantly rise at the end of 2019.

The thematic analysis of the posts showed that 70% of the people who posted a question about radiology test results were asking for an interpretation of the results (theme 1). Among the 70% of people who posted requests for an interpretation, 91% were asking for an interpretation of a radiology report or part of it, and only 9% were asking for an image

interpretation. This strongly implies that there is an issue with the current way of writing the radiology report from the point of view of laypeople. This supports the findings of previous studies that the contents of the radiology reports can be complex and difficult for a layperson to understand.[26,40,47,58,64,65,71] Posts that requested either recommendations or more information about the diagnosis or illness (themes 2 and 3) represent 23% of all the posts. Radiology reports, as suggested by the analysis, miss these important pieces of information. The radiologists should include in the report clear information about the recommendations or advice about next steps. Moreover, a link to a reliable patient education resource should be included in the report to explain more about the diagnosis or illness.

The analysis of the words in the posts revealed that most posts were about the results of the MRI scans of the spine (e.g., cervical spine, lumbar spine, and thoracic spine) and the brain. This finding suggests that the information in the results of MRI spine exams and MRI brain exams are one of the most difficult types of radiology results for a layperson to understand. Therefore, two radiology reports, one brain MRI report and one spine MRI report, were used to test the effectiveness of a method (adding a summary at the end of the report in lay terms) to improve patients' understanding of the radiology report.

The new trend toward patient-centered care and patient access to their health information via patient portals has placed new demands on health care providers to consider the lay recipients of the radiology reports.[117] The radiology reports must be designed in a way that is suitable for laypersons as well as referring physicians in order to increase patients' engagement in their health care, and, consequently, enhance the quality of the health care.

Chapter III: Methodology

Research Questions

There are three main research questions that this study aimed to answer:

1. Is there a relationship between patients' level of education and how much they understand from a radiology report?
2. Does health literacy have a main role in patients' understanding of the radiology report?
3. Does adding a statement at the end of the radiology report in lay terms summarizing the content of the report improve patients' understanding of the report?

In addition, this study also explored the following issues:

4. How much do patients understand from a typical radiology report?
5. Which type of radiology reporting do patients prefer (i.e., do patients prefer free-text reports or structured reports?)?
6. Do patients think that the type of radiology reporting (free-text or structured) affects their level of understanding of the report?

Study Design and Its Appropriateness

Study design depends greatly on the nature of the research. For this study, a cross-sectional, quantitative approach design using a questionnaire survey with close-ended questions was chosen for several reasons. The main advantage of a cross-sectional study design is that it can be carried out in a short time frame and it measures cause and effect at the same

time.[118] To address the research questions, a quantitative approach design was used through a survey research method. The quantitative approach was selected because it allows for greater objectivity of results, eliminates data collection biases, provides results easy to analyze, and accelerates the research process.[119] This can improve the accuracy and credibility of the study.[119] Moreover, the quantitative approach design is used to evaluate the relationship between independent and dependent variables,[120] which made it appropriate for this study.

A qualitative approach design was not chosen because the data collection in this design is time-consuming.[121] Furthermore, the qualitative approach design usually requires a small and selective sample, so the generalizability of the results is usually limited.[121,122] The results of this design also cannot be generalized because they are not tested to determine whether they are by chance or whether they are statistically significant.[123] The present study required a large number of participants, from whom the data were collected, to produce findings that can be generalized.

The survey research method allows researchers to collect a variety of data—including beliefs, characteristics, opinions, attributes, previous experiences, and behaviors of participants—and then quantitatively investigate it.[119,124-126] Since the scope of this study was the needs and preferences of the patients regarding radiology test results delivered via patient portals, the survey research method was the most appropriate one to facilitate data collection directly from study participants. Moreover, the use of a survey as the instrument of this study allowed the collection of data from a large number of participants, which also a cost-effective and time-efficient method.[126,127]

Survey research can be conducted using questionnaires or interviews.[128,129] A questionnaire with close-ended questions was used for this study. Questionnaires can reduce bias and encourage more honest answers by providing anonymity, which might not be achieved with interviews.[119,130] Questionnaires also can help in collecting high-quality, usable data and in increasing response rates.[130,131] A questionnaire with open-ended questions was not suitable for this study because that type of questionnaire is usually used for narrative and qualitative studies.[132] Moreover, open-ended questions require more time and effort to answer for the participants, and more time and effort to analyze for the researcher. Meanwhile, closed-ended questions are easier to answer for the participants, and they are easier to analyze for the researcher.[133]

The distribution method used for this study was a self-administered questionnaire, on paper and on the web. This method provided flexibility for participants to decide when and where to complete the survey.[134] Moreover, this method of distribution allowed the questionnaire to be distributed over a wide geographic area, and it allowed participants to maintain their anonymity, which in return reduced bias.[127,128] Self-administered questionnaires also can save time, cost, and effort for the researcher.[135]

Study Sample

The study design, as mentioned earlier, was a cross-sectional, quantitative approach design using the survey research method. To generalize the findings, it was important to ensure that the sample size is adequate.[136] An inadequate sample size could yield findings that are not significant statistically, which means that the results of the study cannot be generalized to the

target population.[136] Therefore, it is crucial to determine the adequate, or minimum, sample size of a study. The basic rule is the larger the sample size, the better, and the lesser the likelihood that the results of the study will be biased.[119,137]

This study was focused on the needs and preferences of patients regarding the radiology test results delivered via patient portals. The population of this study was all individuals over 18 years old who might use the patient portal to view their radiology test results. There are several formulas and statistical techniques provided in the literature to calculate the appropriate sample size for a study, most of which depend on the population size. For this study, the population size was unknown and could not be estimated. The only thing known about the population size was that it was large. What was noticed in all formulas and rules of sampling is that as the population size increases, the sample size increases. However, this increase is at a diminishing rate and eventually will remain constant at around 380, beyond which there will be little to be gained compared to the cost, effort, and time.[138,139]

As mentioned before, the potential population size of this study was very large, beyond 5,000. As suggested by Gay and colleagues, when a population size exceeds 5,000, a sample size of 400 will be adequate.[140] Israel also suggests a sample size of 400 for a population size more than 100,000 with ± 5% precision level and 95% confidence level.[141]

Based on the statements above, the target sample size of this study should be 400. However, oversampling is suggested to ensure that the target sample size is reached, to generate data that is reliable, and to increase the precision of the study findings.[142,143] Therefore, oversampling was used to increase the target sample size by 25%, to 500. This was

the minimum sample size for this study, but the researcher recruited as many participants as possible within the constraints of the study. As a result, the number of completed questionnaires (in both paper-based and web-based questionnaires) was 656.

The inclusion criteria of the study sample were as follows:

- All individuals at least 18 years-old.
- Unique participants, which meant participants filling in the questionnaire for the first time.
- Being able to understand the English language. This was because the reports used in this study were in English.
- Individuals with no medical background.
- Participants who have basic computer skills. This was because the concentration of this study was about the radiology test results delivered through patient portals, so basic computer skills were required.

Distribution Methods

The questionnaire was distributed in two forms, paper-based and web-based. The web-based questionnaire was designed using Google Forms.[144] There are several advantages to using Google Forms, including the ability to include pictures in the questions, the ability to skip questions based on the answer, the ability to choose the question type, the ability to access the survey via any technological means (e.g., smart phones, tablets, and computers), and the ability to use it free of charge. In addition, the responses are collected automatically, and they can be easily exported as an Excel file.[145] It is important to pay attention to the physical appearance of

the survey, such as the general theme look and the progress bar,[134] to make the design of the survey attractive to the participants. These features are also available in Google Forms. A sample of a flyer used to recruit participants is shown on Figure 3.1.

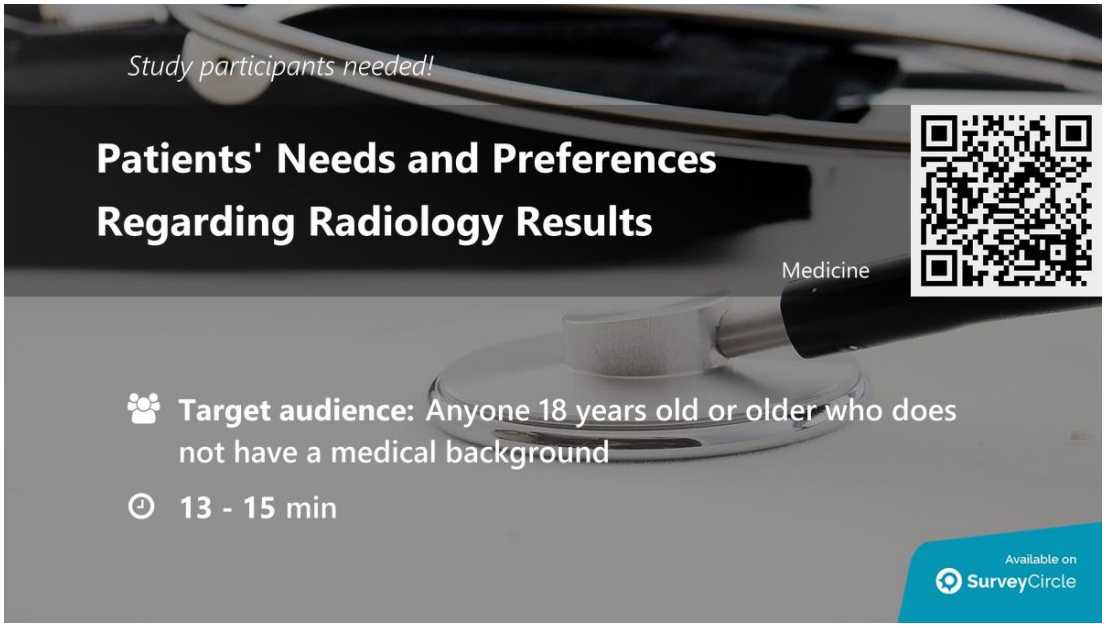


Figure 3.1: Sample of a Flyer used for Recruitment

The web-based questionnaire was distributed on several social media websites, which included:

- Twitter: The questionnaire was distributed in multiple trending hashtags.
- Reddit.com: The researcher posted several requests to fill out the questionnaire in several subreddits such as “r/SampleSize.”
- Answers.yahoo.com: The researcher posted several requests to fill out the questionnaire.
- WhatsApp groups: The researcher sent several requests to fill out the questionnaire in more than six WhatsApp groups.

- Telegram groups: The researcher sent several requests to fill out the questionnaire in several Telegram groups.
- SurveyCircle: The researcher posted the questionnaire on the website looking for participants.

It is worth mentioning that there were some websites that did not allow the distribution of the questionnaire, some of which included:

- Medhelp.org: The website team removed the post of the request to fill out the questionnaire. They asked the researcher to submit the questionnaire for a review, which was done. However, the researcher did not receive any response from the website team.
- Patient.info: The researcher submitted a post requesting to fill out the questionnaire, and the post was sent for moderation. The researcher never received the approval.

To increase the sample size, a paper-based questionnaire was also distributed.[146] The paper-based questionnaire was distributed in several locations at different times. Locations that the questionnaire was distributed in included the university campus, public libraries, several Starbucks locations, and shopping centers. When possible, approval was obtained from the administration of the location before the distribution of the questionnaire. During the recruitment phase, the researcher provided information to potential participants about the study and gave them the choice to take the survey either on paper or online by scanning a QR code that led to the web-based survey.

Survey Design

There was no established questionnaire focused on the topic of this study found in the literature. Therefore, a questionnaire has been created based on the literature review and the social media analysis study to answer the research questions of the present study. Some questions have been adopted from other scientific published questionnaires with some modifications[26,147-153] and the rest were created.

There are several texts in the literature that offer guidance on how to construct a good questionnaire. Wildemuth summarized a few of the suggestions.[134] They are as follows:

- Only questions that can be answered should be asked.
- Only questions necessary to answer the research objectives should be asked.
- To prevent any misinterpretation, use complete sentences to ask the questions in the questionnaire.
- Use simple language that is understandable for laypersons.
- Avoid using words or terms that can be misconstrued as subordinating, biased, aggressive, or offensive.
- Questions should not be very specific or too broad.
- Do not ask double-barreled questions.
- Do not require each question to be answered before participants can move on to the next question.

All these suggestions were incorporated into the questionnaire except the last suggestion. The participants were in control of the extent of their participation, and they could

quit whenever they wished. Moreover, they were informed about their ability to quit the survey whenever they wanted from the first page of the questionnaire. However, all the questions in the questionnaire needed to be answered in order to continue with the survey. This was the case in the web-based questionnaire to eliminate uncompleted submissions, but not in the paper-based questionnaire because it was not possible.

The questionnaire was divided into three main sections. All the questions in the questionnaire were close-ended. The first section, about demographic information, contained eight questions. In this section, the researcher asked questions about gender, level of education, age, race, English proficiency, computer proficiency, and whether the participant had a medical background. There was no question about ethnicity, which determines whether an individual is of Hispanic origin or not.[154] This was because this question would not add much value to the study, and it would add unnecessary time to the survey. Moreover, according to the census bureau of the United States,[155] people who identify themselves as Hispanic may be of any race, so there was not much information missed by not adding an ethnicity question. The responses regarding the English skills were scored on a 5-point Likert-like scale.[156] The rest of the questions in the first section had multiple-choice answers, from which the participants chose the most accurate answers.

The second section was designed to assess the health literacy of the participants. Reliable and valid health literacy assessment tools, such as Test of Functional Health Literacy in Adults (TOFHLA)[157] and Rapid Estimate of Adult Literacy in Medicine (REALM)[158], are available. However, including these tools in this study was not practical for several reasons. First, health literacy is not the main scope of this study. Second, these tools are lengthy and time-consuming

for the researcher and the participants. Finally, these types of health literacy tests may cause participants to feel embarrassed or ashamed about their difficulties reading.[159,160] Therefore, for this study, it was more feasible to use a one-item literacy screening test that had been tested and validated to rapidly identify in a non-threatening way participants with limited health literacy skills.[149] The response to the following question can detect limited health literacy: "*How confident are you filling out medical forms by yourself?*" This single health literacy screening question has been validated for detecting inadequate health literacy.[149-153] The participants answer this screening question using a 5-point Likert-like scale: 1- Extremely, 2- Quite a bit, 3- Somewhat, 4- A little bit, and 5- Not at all. If the participants score 3 or greater in this question, this indicates inadequate health literacy.[149]

The third section consisted of 15 questions. All of the questions were answered using a 5-point Likert scale,[156] a 5-point Likert-like scale, or a Yes/No/Not Sure scale. The first four questions (numbers 10, 11, 12, and 13) asked the participants whether they had had a previous radiology exam, whether they had had the chance to read their radiology report, how easy it was to understand the report, and whether they preferred to receive their radiology test results online via the patient portal.

Questions 14 to 22 were about how much the participants can understand from a typical radiology report before and after adding a summary of the content of the report. The reports in questions numbers 14 and 18 were from "www.mtsamples.com." These reports were about MRI spine and brain exams because they are the most difficult to interpret for a layperson, as suggested by the social media analysis (please refer to chapter II). The factors that played a main role in choosing the two reports involved: the type of the report (i.e., the report

must be about MRI spine or MRI brain), the length of the report (i.e., the report should not be too long or short), the difficulty of the report (i.e., the report should be a typical report and not very difficult or simple), and the availability of the report.

Two radiologists helped in choosing the two reports. Moreover, they helped in adding the summary at the end of the reports in questions 16 and 20. When a disagreement occurred in any part of the statement, the radiologists resolved it by reaching a consensus through discussion.

Because there was a chance that some participants might not accurately self-report their level of understanding of the report, one question was added after every self-report question to objectively assess the participants' level of understanding of the report (i.e., questions 15, 17, 19, and 21). These were comprehension questions that asked about substantial parts of the report. The two radiologists helped write these comprehension questions.

The radiology reports were presented to the participants twice, one without the patient summary statement (i.e., questions 14 and 18) and one with it (i.e., questions 16 and 20); then their level of understanding of the reports was measured for comparison. Since there were two repeated measurements on a single sample, there was a chance of a performance increase in the second report, the one with the patient summary statement, due to the practice developed by reading the report without the patient summary statement. Therefore, a note was added in the instructions for questions 16 and 20 to eliminate the effect that might develop by reading

the same report twice. The note clearly stated that "There is **NO NEED** to read the report again. Please **SKIP** to the end of the report and read the patient summary statement."

Finally, questions number 23 and 24 asked about which type of radiology reporting the participants prefer and whether they think the type of reporting affects their level of understanding of the report. The report in question 23 was from "https://openi.nlm.nih.gov." The preliminary survey is shown in Appendix A and the final draft of the survey instrument is shown in Appendix B.

Validity and Reliability of the Instrument

It is important to evaluate the survey instrument prior to administering it to the sample of the study to ensure that the instrument is valid and reliable.[134] The validity of a questionnaire is defined as the extent to which an instrument can accurately measure what it sets out to measure.[161] Its reliability is defined as the extent to which an instrument can produce consistent results on repeated measurements.[161]

There are several methods to evaluate a survey instrument before to administering it to a study sample. Wildemuth suggested two approaches to ensure that a questionnaire is valid and reliable, pretesting or pilot testing.[134] Pretesting means that the questionnaire is reviewed by either experts or a small group of the target sample. This can reveal any issue with the instrument, such as misleading questions or incomplete response categories. In this study, the questionnaire was reviewed and evaluated by two radiologists and a clinical assistant professor at University of Wisconsin-Milwaukee (UWM). Then the questionnaire was administered to a small group of the target sample. Although Wildemuth suggested using one of the

approaches—pretesting by either experts or a small group of the target sample—the questionnaire was pretested by both.

After the radiologists and the clinical assistant professor pointed out all the problems they found, the issues were resolved. The instrument then was administered to a small group of the target sample (N=6), and the evaluators were asked to think aloud as they responded to the questions. This method is also called the participatory pilot survey, in which the participants are aware that they are taking a pilot survey, and they are asked to provide their feedback about it.[162] The researcher took notes on all the comments of the evaluators and incorporated them in the questionnaire. This approach can ensure that the questions in the questionnaire are being interpreted correctly and that the questions are measuring what they are intended to measure.[134]

Pilot testing also was used after pretesting to ensure that the instrument was valid and reliable. Pilot testing means administering the questionnaire to a small sample other than the sample that was used for the final draft of the survey.[134] This method is also called the undeclared pilot survey, in which the participants take the survey as if it is the final survey. This means that the participants do not know that they are taking a pilot survey.[162] The pilot testing was used to ensure that all the remaining problems were resolved. As recommended by Converse and Presser,[162] the participatory pilot survey was conducted first, then the undeclared pilot survey was done. The sample size in the pilot testing (the undeclared pilot survey) was 25 participants. The process of developing the survey is shown in Figure 3.2. The reliability of the instrument was also statistically analyzed by calculating the Cronbach's alpha for the pilot survey, which is one of the most common approaches for checking the reliability of a

questionnaire.[163] Furthermore, the reliability of the survey was also analyzed by calculating Guttman's Lambda 2 for the pilot survey, which is another statistical approach to check the reliability of a questionnaire.[164]

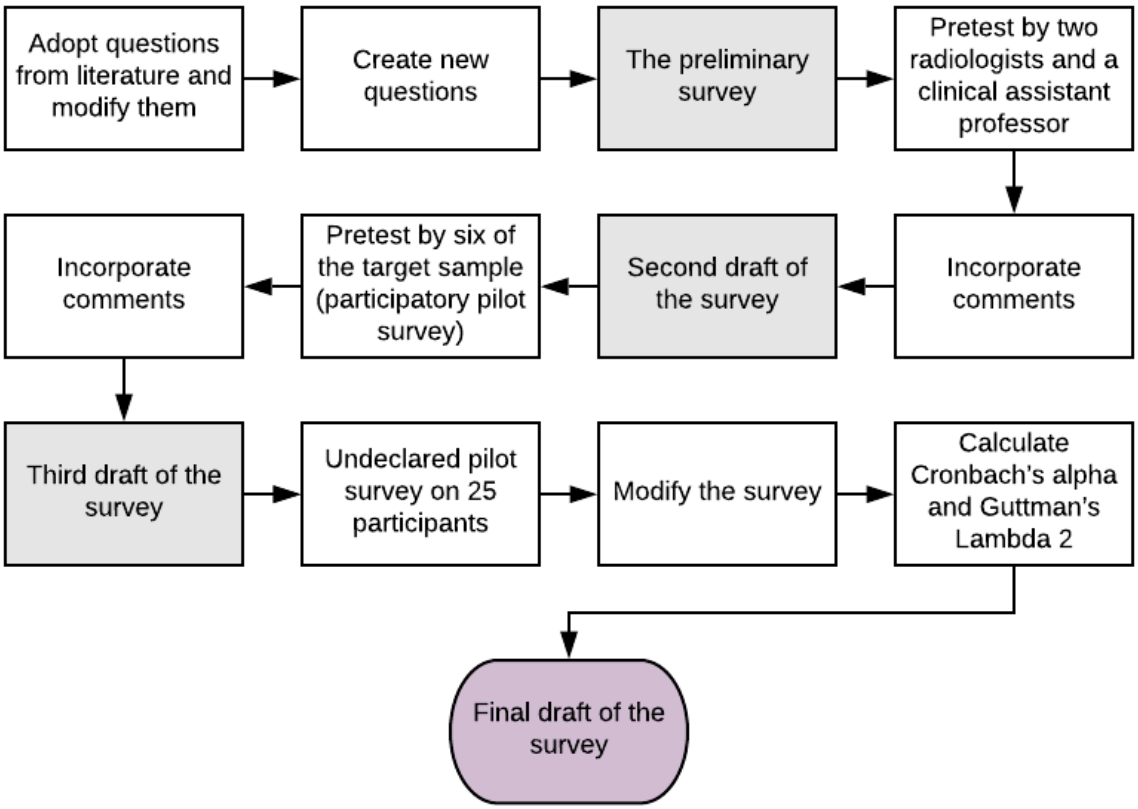


Figure 3.2: Survey Development Process

Data Analysis

Prior to data analysis, a pre-analysis data screening should be conducted.[165] The pre-analysis data screening can ensure that the collected data is accurate and the data will yield accurate results.[165] Therefore, as part of this study, a pre-analysis data screening of missing data was conducted. A suggested method for dealing with missing data is to remove the missing data from the dataset.[165,166]

A non-experimental research design was used in this study. According to Mertler and Reinhart,[165] the basic difference between experimental and non-experimental research designs is the level of control over the independent variables. In the experimental research design, the researcher has control over the levels of the independent variables. For example, if a researcher conducts an experiment to investigate the impact of two treatments, the researcher would randomly divide the participants into groups. Some groups would receive the treatments and the other would be the control group, which would not receive the treatments. In this case, the researcher has controlled the independent variable and decided which group received which treatment.

In non-experimental research design, such as surveys, the researcher cannot manipulate the levels of the independent variables. The researcher may define the independent variables, but he or she cannot assign respondents or participants to the various levels of independent variables. This is because the participants already belong to one of the independent variable levels. For instance, if a researcher wants to study how males and females differ from each other with regard to their scores in a test, the gender of the participants could be defined but could not be manipulated by the researcher. In this case, all participants entered in the study would be already categorized into one of the levels of the independent variables, male or female. As a result, in a non-experimental research design, the researcher can conclude that the independent variables and dependent variables are related, but he or she cannot draw causal inferences from the results of the study.[165] On the other hand, when a researcher conducts an experimental research design, the researcher can draw conclusions based on the findings with respect to causality.[165] Therefore, the researcher should choose a statistical

analysis that suits the design of the study. The main factor that helps in determining the statistical test that should be used in analyzing a collected data is the type of variables and the number of independent and dependent variables.[165]

The collected data was analyzed with SPSS version 26. An alpha level of 0.05 for all statistical tests in this study was used. First, a descriptive analysis was conducted to describe the sample of the study. This included gender, level of education, age, race, English proficiency, computer proficiency, and medical knowledge. These were expressed in percentages and frequencies, such as a one-way frequency table. The central tendency, the median (Mdn), and the interquartile range (IQR) were also measured.

There are several options for investigating possible associations between the variables in research questions 1 and 2. A good test that can be conducted to evaluate relationships between ordinal variables is Spearman's correlation test.[165,167] A major advantage of this non-parametric test is that it can show relationships between variables even if their relationship is not linear. The degree of relationship between two ordinal variables in this test is expressed as a correlation coefficient ranging from -1.00 to +1.00. A test value near zero indicates no relationship, and if there is a relationship, a value near +1.00 or -1.00 will be obtained.[165,168] Pearson's correlation, which is a parametric test, could not be conducted on the data of this study because this test measures the relationships between continuous (interval or ratio) variables.[167] The differences between non-parametric and parametric tests are shown in Table 3.1, adopted from Fowler, Cohen, and Jarvis.[168] Therefore, the Spearman's correlation test was used to answer research questions 1 and 2.

Non-parametric tests	*Parametric tests*
May be used with actual observations, or with observations converted to ranks	Are used only with actual observations
May be used with observations on nominal, ordinal and interval scales	Generally restricted to observations on interval scales
Compare medians	Compare means and variances
Do not require data to be normally distributed or to have homogeneous variance; i.e. they are 'distribution free'	Require data to be normally distributed and to have homogeneous variance
Are suitable for data which are counts	Counts must usually be transformed
Are suitable for derived data, e.g. proportions, indices	Derived data may first have to be transformed

Table 3.1: Differences between Non-Parametric and Parametric Tests

In research question 1, "Is there a relationship between patients' level of education and how much they understand from a radiology report?", the independent variable is "education level" and the dependent variable is "understanding level". Both variables are ordinal because the possible values for the independent variable are "8th grade or less, high school graduate or GED, associate's degree, bachelor's degree, and graduate degree", and the possible values for the dependent variable are "no understanding, understand a little, understood about half, mostly understood, and complete understanding".

In research question 2, "Does health literacy have a main role in patients' understanding of the radiology report?", the independent variable is "health literacy" and the dependent variable is "understanding level". The independent variable has 5 values: "1- Extremely, 2- Quite a bit, 3- Somewhat, 4- A little, and 5- Not at all." Scores 3 or greater indicate limited health literacy skills, and scores 1 or 2 indicate good health literacy skills.[149-153] The dependent

variable is “understanding level” with 5 values: “no understanding, understand a little, understood about half, mostly understood, and complete understanding”.

Another statistical test that was used in addition to Spearman’s correlation test to answer research questions 1 and 2 was Fisher’s exact test.[169,170] McDonald recommends using the Fisher's exact test when the sample size is less than 1,000, because this test is more accurate than the chi-square test or G-test.[169] This test is appropriate for answering research questions 1 and 2. However, it is most commonly used for 2×2 tables, so the variables needed to be converted to dichotomous variables, meaning that the values of the variables were grouped into two categories. Therefore, the values of the independent variable in research question 1, level of education, were grouped into two categories. The values “8th grade or less, high school graduate or GED, associate's degree” were grouped into “Low Education Level” and the values “bachelor's degree and graduate degree” were grouped into “High Education Level.” In research question 2, the independent variable, health literacy, was converted into “Limited Health Literacy Skills” (for scores 3, 4, or 5) and “Good Health Literacy Skills” (for scores 1 or 2).

The values of the dependent variable in research questions 1 and 2, understanding level, were also grouped into two categories. The values “no understanding, understand a little, and understood about half” were grouped into one category “No understanding” and the values “mostly understood and complete understanding” were grouped into one category “Understood”. In the Fisher’s exact test, the null hypothesis is evaluated,[171] which was in research question 1: there is no association between the level of education and the level of understanding of the radiology report. The null hypothesis in research question 2 was there is no association between health literacy and the level of understanding of the radiology report.

In research question 3, “Does adding a statement at the end of the radiology report in lay terms summarizing the content of the report improve patients’ understanding of the report?”, the Wilcoxon signed rank test[172] was used. This test is utilized to compare two repeated measurements on a single sample when data is ordinal.[173,174] It was conducted to compare participants’ understanding of the radiology reports before and after adding the patient summary statement of the content of the report in lay terms at the end of the report. The paired *t*-test could not be used in this study because this test is used to compare two sample means, appropriate for a continuous variable.[173] Other tests that can compare between paired samples when the data is ordinal include the Mann–Whitney test, Kruskal–Wallis test, and Friedman's test. However, these tests were not suitable for answering this research question. This was because Mann–Whitney test is used to compare two separate (independent) samples[173]; meanwhile, in this study, the two measurements were taken from the same sample. The Kruskal–Wallis test also has the same issue as the Mann–Whitney test, and it is used for three or more samples.[175] The Friedman's test is used when the data is ordinal, but it compares three or more paired samples,[176] which was not the case in the present study because there were only two paired samples.

In the Wilcoxon signed rank test, the null hypothesis is evaluated.[173,174] The null hypothesis for research question 3 was there is no difference between the patients’ understanding of a radiology report before and after adding the patient summary statement (the median difference is zero). On the other hand, the alternative hypothesis was there is difference between the patients’ understanding of the radiology report before and after adding the patient summary statement (the median difference is not zero $\alpha = 0.05$). In other words,

the alternative hypothesis was that adding a patient summary statement at the end of a radiology report can improve patients' level of understanding of their report. Not only was the statistical significance calculated, the practical significance was also calculated to see how much the patient summary statement affected the patients' level of understanding of their report. To do so, the effect size was calculated, which is a quantitative measure of the strength of the effect of an intervention.[177,178]

Relative frequencies (percentages), frequencies, or graphs[174] were used to answer research questions 4, 5, and 6, "How much do patients understand from a typical radiology report?", "Which type of radiology reporting do patients prefer (i.e., do patients prefer free-text reports or structured reports?)?", and "Do patients think that the type of radiology reporting (free-text or structured) affects their level of understanding of the report?".

Ethical Procedures

Before the distribution of the questionnaire, the approval from the University of Wisconsin-Milwaukee Institutional Review Board (IRB) was obtained (IRB # 20.073). No identifiable information was collected from the participants of this study.

In the paper-based survey, the participants were given an informed consent form before they started the questionnaire. Moreover, they were informed that their participation in the study was completely voluntary and anonymous. The participants were informed that the information they provided would be kept confidential. The participants also were informed of their right to withdraw from the study whenever they wished with no consequences. The general nature of the study was explained in the informed consent form. No signature was

obtained from the participants. However, when the participants returned the completed questionnaire, that was considered an indication of their consent to participate in the study.

In the web-based survey, the participants were informed about their rights and the general nature of the study in the first web page. At the end of the same page, the participants had the choice to proceed with the questionnaire or quit by answering a question about whether they wished to continue with the questionnaire. Their agreement to proceed with the questionnaire indicated consent and their willingness to participate in the study.[179]

Chapter IV: Results

Validity and Reliability of the Questionnaire

First, some of the questions in the survey were adopted from the literature with minor modifications. Moreover, other questions in the survey were developed with the help of three experts, the two radiologists and the clinical assistant professor at UWM. The experts also pretested all the questions in the survey and provided their feedback to the researcher. After incorporating their comments, the questionnaire then was pretested by six of the target sample (participatory pilot survey). After the questionnaire was modified, the researcher conducted an undeclared pilot survey on 25 respondents. The questionnaire then was modified and the final version of the survey was drafted. The phases that the survey passed through during its development ensured that it was valid and reliable.[134,162] Figure 3.2 shows the phases of the survey development process.

The reliability of the questionnaire was analyzed using Cronbach's alpha. It does not make sense to perform the Cronbach's alpha test on the questionnaire as a whole, as the larger number of questions will increase the value of Cronbach's alpha.[180] Therefore, the questionnaire was divided into several scales. There are three sections in the questionnaire. The first section is about demographic information, so the Cronbach's alpha test was not performed on this section. The Cronbach's alpha test also was not conducted on the second section, which was about health literacy, for two reasons. First, the second section consists of only one item, and the Cronbach's alpha test cannot be done on only a single item.[181] Second, as mentioned earlier, this single health literacy screening item has been validated for detecting

inadequate health literacy[149-153]; therefore, there was no need to perform the Cronbach's alpha test on this section. The third section of the questionnaire was divided into three scales, which are Understanding Level without the Summary Statement (4 items), Understanding Level with the Summary Statement (5 items), and Type of Reporting Preference (2 items). Table 4.1 shows the values of Cronbach's alpha on each scale. A Cronbach's alpha value of 0.7 or higher is considered acceptable.[180]

Scale	Cronbach's Alpha Value
Understanding Level without the Summary Statement	0.766
Understanding Level with the Summary Statement	0.749
Type of Reporting Preference	0.709

Table 4.1: Cronbach's Alpha Values for Each Scale

Since there is "a fundamental limitation in estimating the degree of error of a scale: a researcher will never know with certainty the exact value of a test's reliability in any given situation."[182] Therefore, another reliability test, Guttman's Lambda 2, was also performed on the third section of the questionnaire. Guttman's Lambda 2 test is preferable to Cronbach's alpha because it produces more accurate estimates of the reliability than Cronbach's Alpha.[183,184] A value of more than 0.7 is considered indicative of good reliability.[164,185] Table 4.2 shows the values of Guttman's Lambda 2 on each scale of the questionnaire.

Scale	Guttman's Lambda 2 Value
Understanding Level without Summary Statement	0.771
Understanding Level with Summary Statement	0.779
Type of Reporting Preference	0.709

Table 4.2: Guttman's Lambda 2 Values for Each Scale

Sample Size

The number of the collected paper-based surveys was 193. Meanwhile, the number of the web-based surveys was 485. The total number of obtained questionnaires was 678, of which 22 were deleted because they were uncompleted or completely unanswered. All of the deleted surveys were from the paper-based surveys. There was no uncompleted or completely unanswered survey in the web-based surveys. This was because all the questions in the web-based survey needed to be answered in order to continue with the questionnaire. As a result, the web-based survey did not allow uncompleted submissions.

The total number of completed questionnaires, from both paper-based and web-based surveys, was 656. Forty-one of the respondents were excluded from the study because they did not meet the inclusion criteria. They were as follows: two respondents had no computer skills, 36 respondents had a medical background, and three respondents reported that they do not have good English skills. Therefore, the total number of completed questionnaires that were included in the analyses was 615. Figure 4.1 briefly explains the steps taken in order to achieve the total number of completed questionnaires included in the analyses.

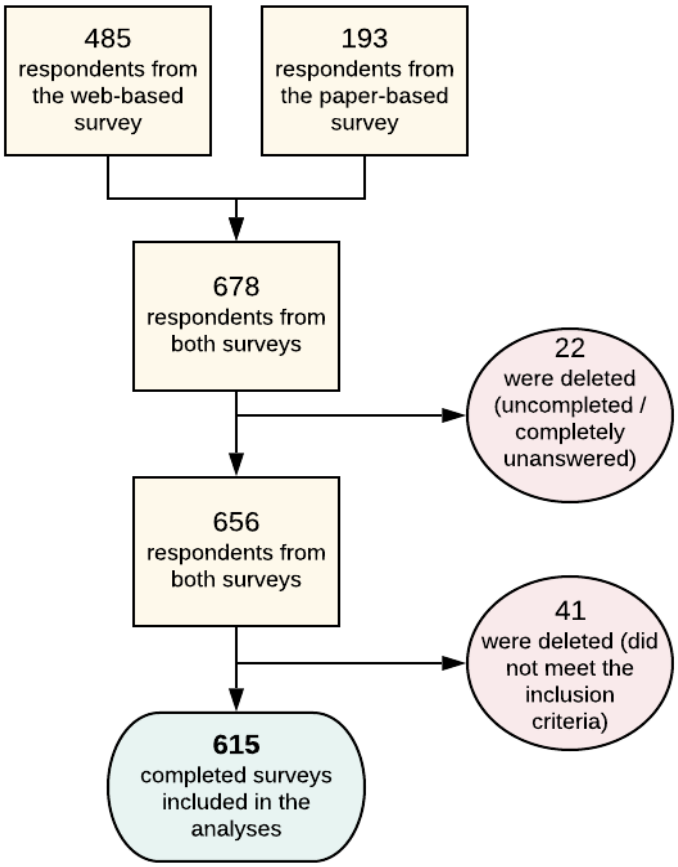


Figure 4.1: Steps to the Final Number of Surveys Included in the Analyses

Description of the Sample

More than half of the respondents were female (55%), 44.39% of them were male, and only 0.49% of them reported their gender as "Other." In terms of age, approximately three-quarters of the respondents were between ages 18 and 44 (74.47%), 10.57% of the respondents were between 45 and 54, 6.83% of the respondents were between 55 and 64, and 8.13% of the respondents were over 64. In terms of education, most of the participants were high school graduates or had a General Educational Development (GED) diploma (39%), more than a quarter of the participants had obtained a bachelor's degree (27.48%), 13.17% of the

respondents had obtained an associate's degree, 10.08% of the respondents had obtained a graduate degree, and 9.92% of the respondents had an eighth grade education or less.

In terms of race, around half of the respondents were white (49.76%), 11.38% of the participants were black or African American, 7.48% of the participants were Asian, 0.65% of the participants were American Indian or Alaska Native; only one participant was Native Hawaiian or other Pacific Islander (0.16%), and 30.57% of the participants reported their race as "Other." Furthermore, most of the participants were native English speakers (N=537). Out of the 78 respondents who reported that English is not their first language, 45 of them reported that their English skills are extremely good, and 33 of them reported that their English skills are good (please refer to Figure 4.2). More details about the sample characteristics are shown in Table 4.3.

Characteristic	Percentage (%)	Frequency (N)
Gender		
Female	55.12%	339
Male	44.39%	273
Other	0.49%	3
Level of Education		
8th grade or less	9.92%	61
High school graduate or GED	39.35%	242
Associate's degree	13.17%	81
Bachelor's degree	27.48%	169
Graduate degree	10.08%	62
Age		
18 - 24	30.24%	186
25 - 34	26.02%	160
35 - 44	18.21%	112
45 - 54	10.57%	65
55 - 64	6.83%	42
Over 64	8.13%	50
Race		
White	49.76%	306
Black or African American	11.38%	70
Asian	7.48%	46
American Indian or Alaska Native	0.65%	4
Native Hawaiian or Other Pacific Islander	0.16%	1
Other	30.57%	188
Native English Speaker		
Yes	87.32%	537
No	12.68%	78
Total	**100%**	**615**

Table 4.3: Demographic Information of the Sample

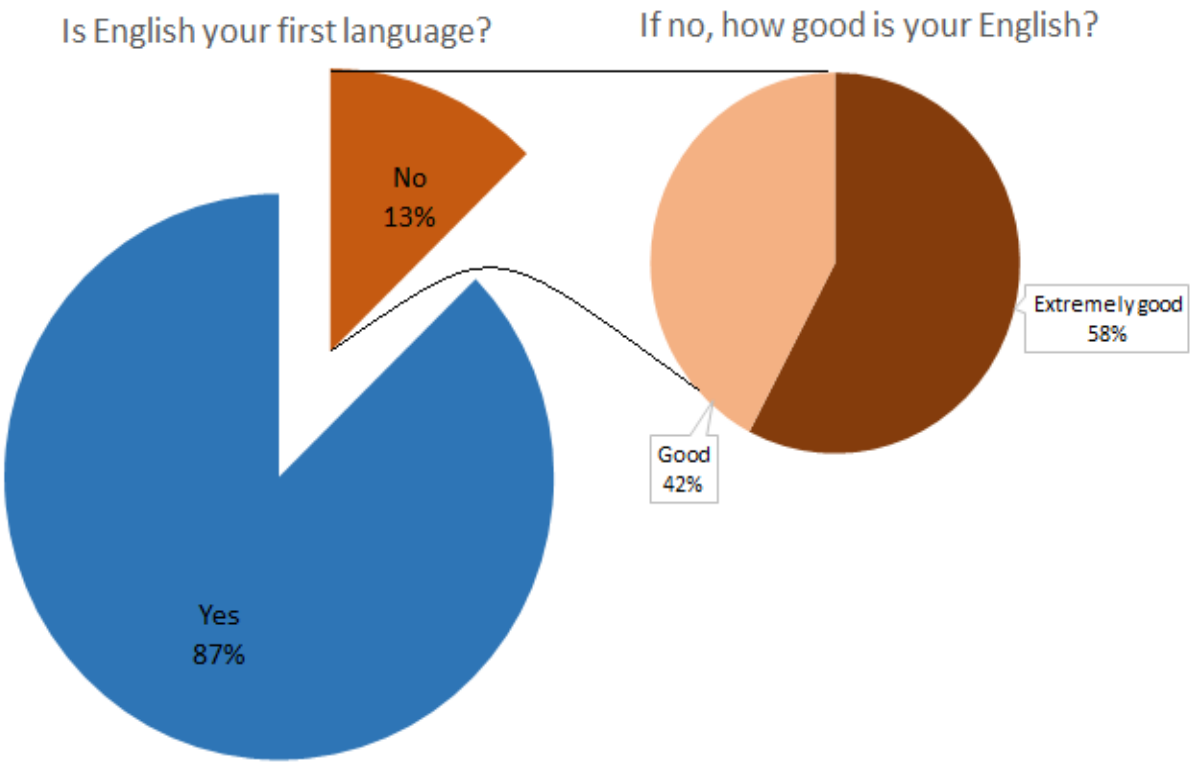


Figure 4.2: English Proficiency

Health Literacy

The second section of the questionnaire was designed to assess the health literacy of the respondents. Health literacy is defined as the degree to which a person is able to gain, communicate, process, and comprehend the basic health information, instructions, and services required to make proper health decisions.[59] A single health literacy screening question, "How confident are you filling out medical forms by yourself?", was answered by the 615 participants in the study. The participants answered this screening question using a 5-point Likert-like scale: 1- Extremely, 2- Quite a bit, 3- Somewhat, 4- A little bit, and 5- Not at all. If the participant scored 3 or greater in this question, this indicated inadequate health literacy.[149]

Approximately half of the respondents reported that they are extremely confident filling out medical forms by themselves (47.15%). Moreover, 36.75% of the participants feel quite a bit confident filling out medical forms by themselves. The respondents who reported that they are somewhat and a little bit confident filling out medical forms by themselves were 11.87% and 2.93%, respectively. Only 1.30% of the respondents reported that they are not at all confident filling out medical forms by themselves, as shown in Figure 4.3. Therefore, 16.1% of the study sample have limited or inadequate health literacy skills; meanwhile, 83.9% of the study sample have well-developed health literacy skills.

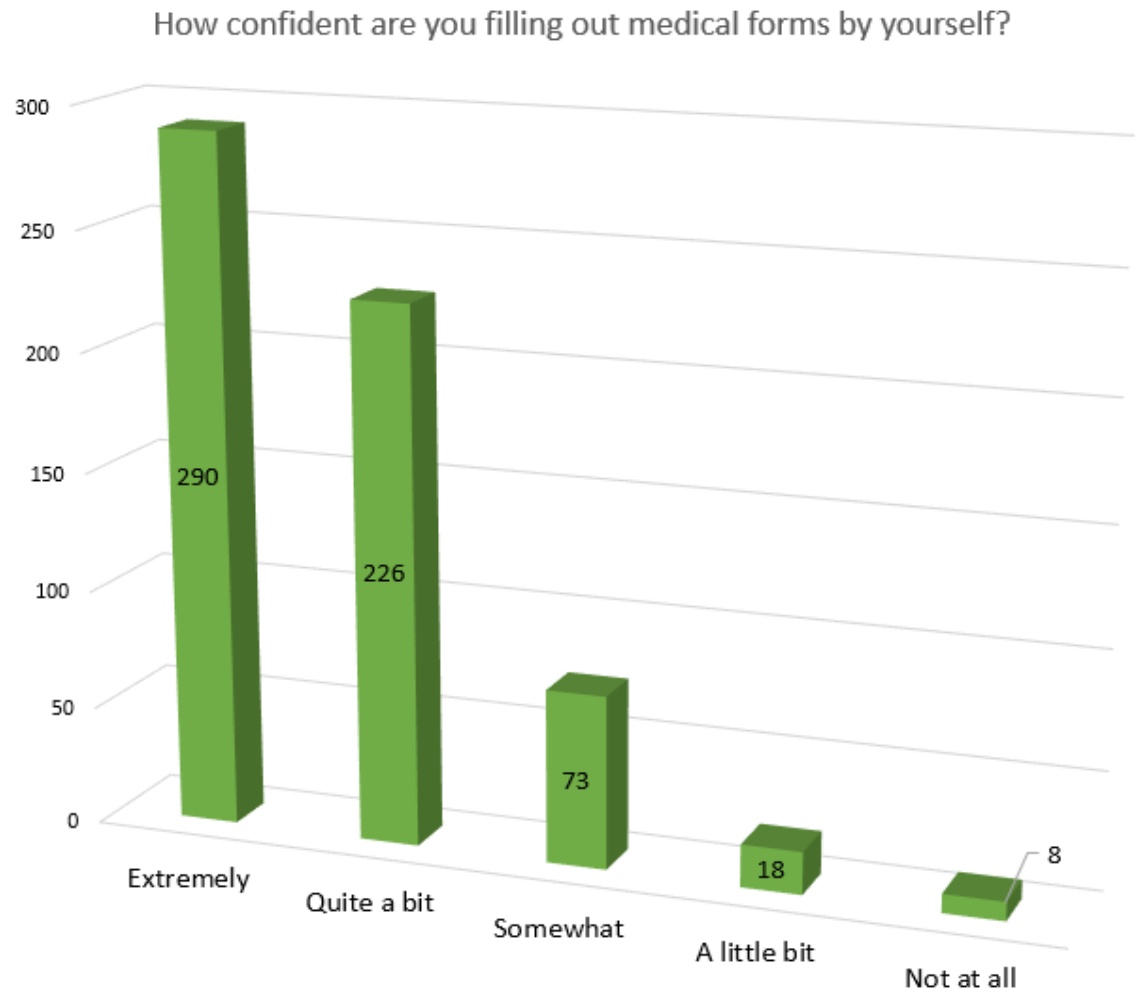


Figure 4.3: Responses to the Single Health Literacy Screening Question

Previous Experience Regarding Radiology Test Results

More than half of the respondents had had a radiology medical exam done on them before (N=327). Out of the 327 participants who had a radiology medical exam done before, 143 had the chance to read their radiology report, as shown in Figure 4.4.

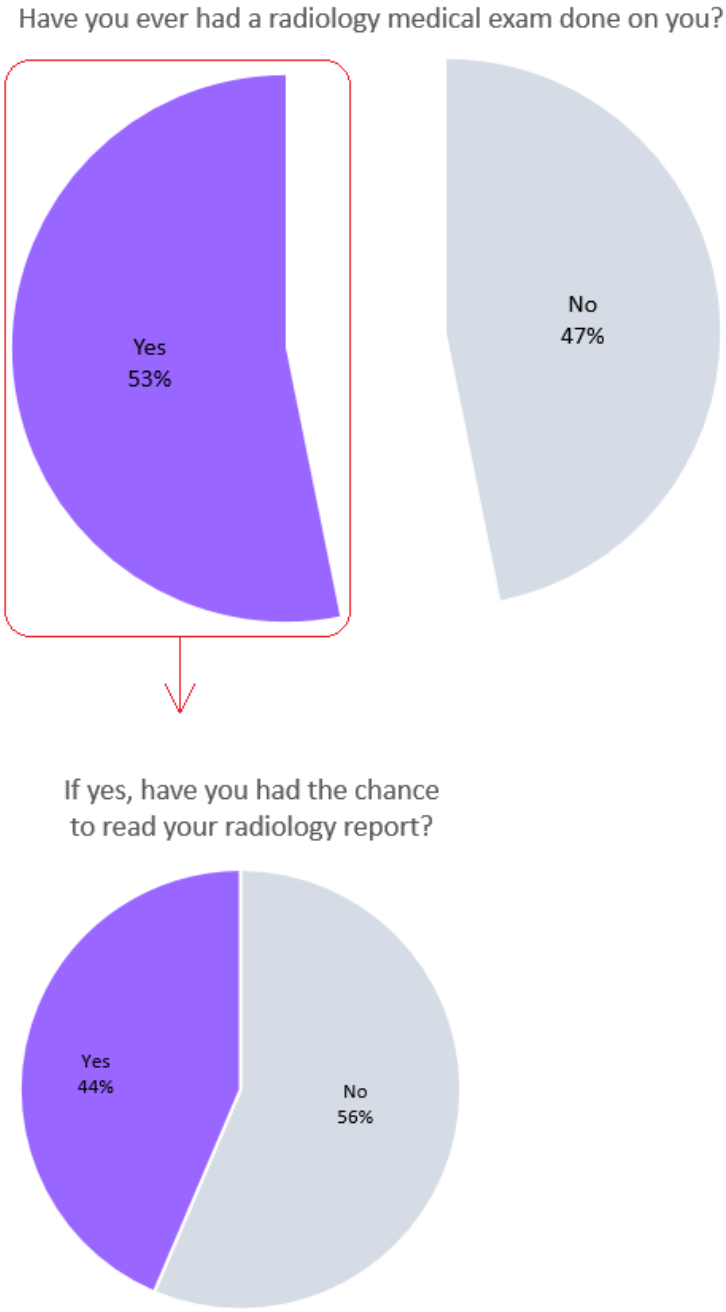


Figure 4.4: Percentage of Participants who had a Radiology Exam and the Chance to Read their Report

When asked about how easy it was to understand their radiology report, 38 participants answered very difficult, 42 participants answered somewhat difficult, 25 participants answered neither easy or difficult, 29 participants answered somewhat easy, and only 9 participants answered easy, as shown in Figure 4.5.

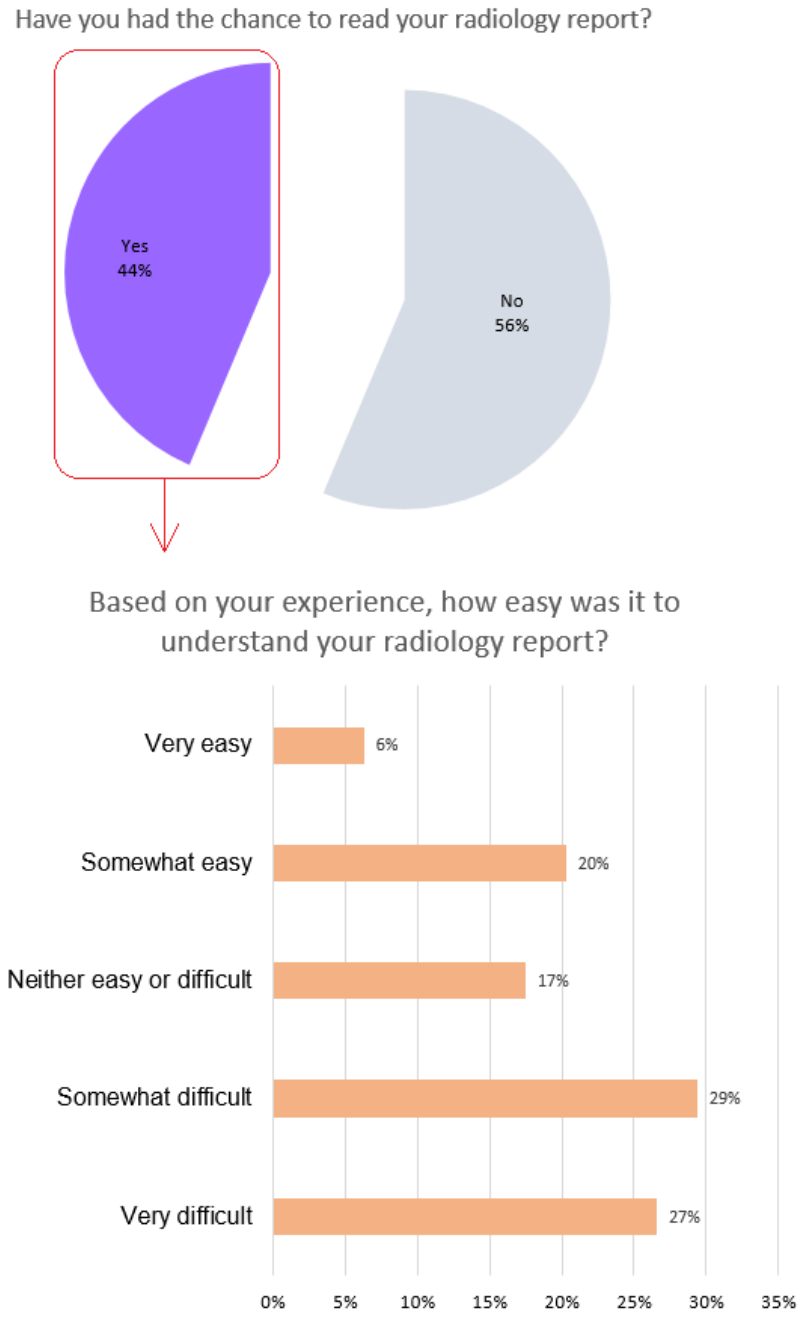


Figure 4.5: Participants' Experience Regarding their Radiology Report

This means that approximately three-quarters (73%) of the participants who had a radiology exam before and had the chance to read their radiology report did not find it easy to understand their radiology report ("1= Very difficult" to "5=Very easy", N=143, Mdn=2, IQR=3).

Laypersons' Preference Regarding the Method of Receiving Radiology Test Results

One item in the questionnaire asked the participants about whether they prefer to receive their radiology test results online via the patient portal. The vast majority of the respondents answered yes (N=422), 104 participants were undecided, and only 89 participants answered no, as shown in Figure 4.6.

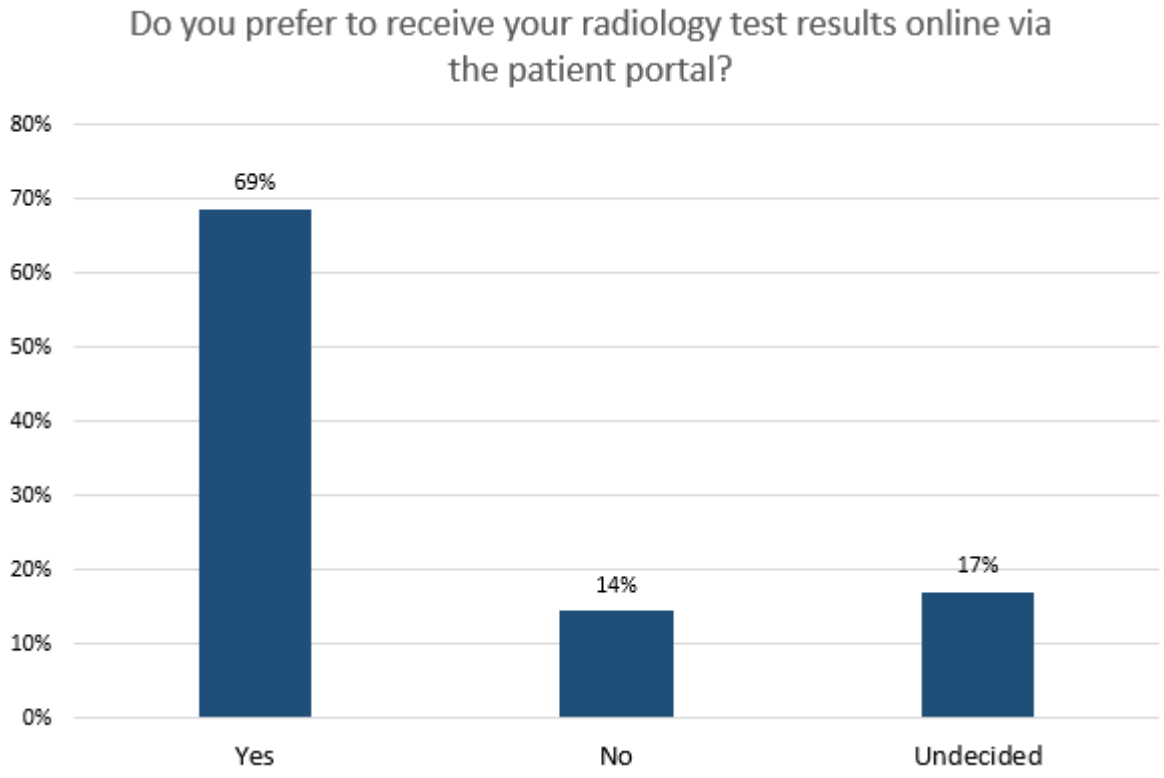


Figure 4.6: Participants' Preference Regarding the Method of Receiving Radiology Results

Laypersons' Level of Understanding of a Typical Radiology Report

The participants' level of understanding of a typical radiology report was measured by exposing the participants to two typical radiology reports and then asking them to self-report their level of understanding. The reports were about MRI spine and MRI brain exams because they are the most difficult to interpret for a layperson, as suggested by the social media analysis (please refer to chapter II). Because there was a chance that some participants might not answer the self-report questions accurately, one question was added after every self-report question to objectively assess the participants' level of understanding of the report. These were comprehension questions that asked about substantial parts of the report.

The answer to the comprehension question can show whether the participant really understood the report or not. If a participant reported that he or she "mostly understood" or "complete understanding" of the radiology report but failed to correctly answer the comprehension question or answered "not sure" to the comprehension question, then they were excluded from the analyses because they did not really understand the report. This was done to ensure that the results were as accurate as possible.

On the other hand, if a participant reported that he or she "no understanding", "understand a little", or "understood about half" of the radiology report but answered the comprehension question correctly, then they were included in the analyses for two reasons. First, the participants might have answered the comprehension question correctly by chance through guessing. Second, this study aimed to improve the patients' understanding of their

radiology report; therefore, if the participants did not feel that they understood the radiology report, this means that they still needed improvement in understanding the radiology report.

For the two typical radiology reports, the participants were presented with a simulated hypothetical clinical scenario. They were asked to imagine being the person in the described situation. Then they were asked to review the radiology report, which was presented in typical medical language, and self-report their level of understanding of the report. The participants were reminded to use their current knowledge and to not consult other resources for definitions. These two questions were answered using a 5-point Likert-like scale: “No understanding”, “Understand a little”, “Understood about half”, “Mostly understood”, and “Complete understanding.”

In the first typical radiology report, which was about a spine MRI exam, out of the 615 participants, 581 participants were included in the analysis. Thirty-four participants were excluded from this part of the analysis because they reported that they either completely or mostly understood the report but failed to correctly answer the comprehension question. Thirteen percent of the participants totally did not understand the report, 40% of them understood a little, 29% understood about half of the report, 14% of them mostly understood the report, and only 4% participants completely understood the report, as shown in Figure 4.7. It seems to be that most of the participants did not understand the typical spine MRI report (“1=No understanding” to “5=Complete understanding”, N=581, Mdn=2, IQR=1).

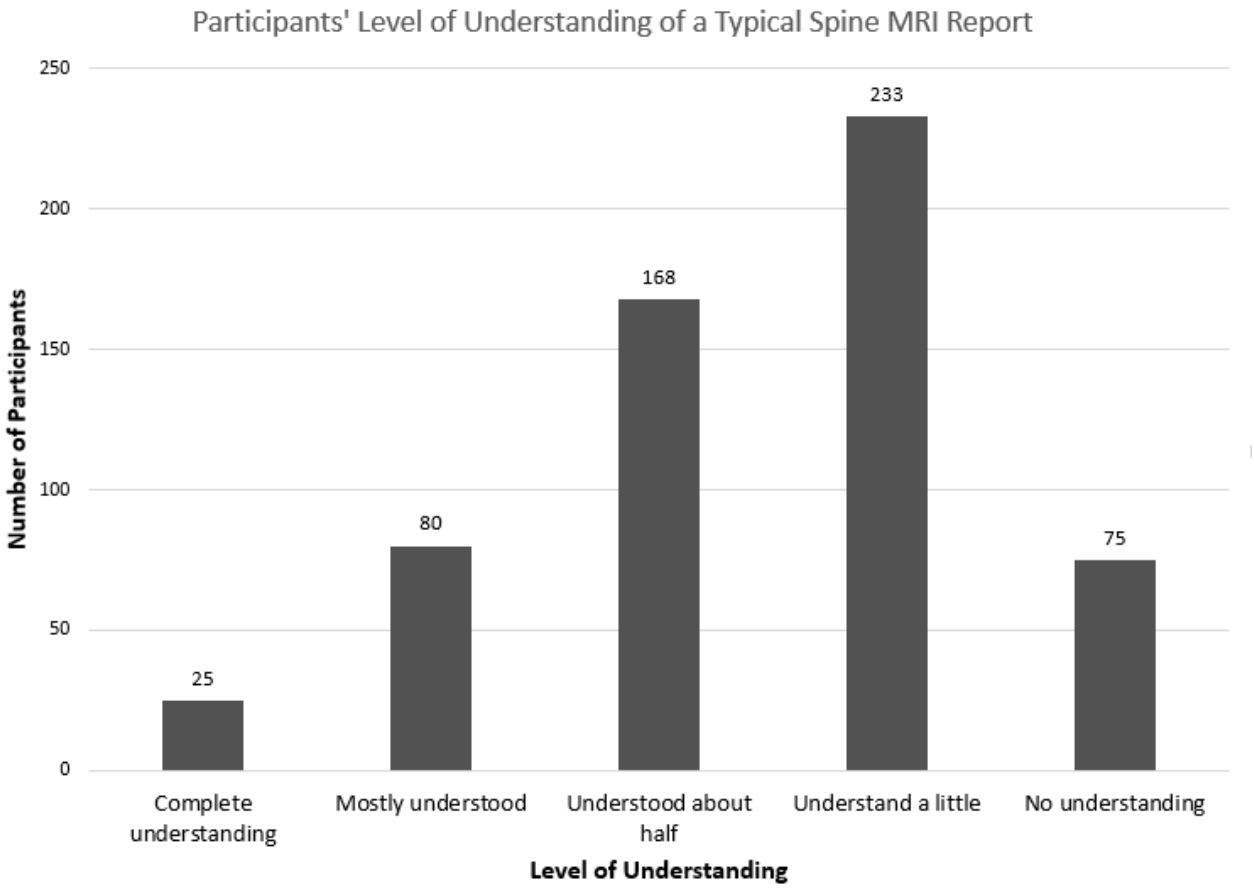


Figure 4.7: Participants' Level of Understanding of a Typical Spine MRI Report

Participants' level of understanding of the second typical radiology report, which was about a brain MRI exam, was also analyzed. The number of participants who were included in this part of the analysis was 586. Twenty-nine participants were excluded from this part of the analysis for the same previously mentioned reasons: they reported that they either completely or mostly understood the report but failed to correctly answer the comprehension question. Out of the 586 participants, 23% of them completely did not understand the report, 41% of them understood a little, 26% understood about half of the report, 7% of them understood most of the report, and only 3% of the participants completely understood the report, as shown in Figure 4.8. It appears to be that most of the respondents also did not understand the typical

brain MRI report (“1=No understanding” to “5=Complete understanding”, N=586, Mdn=2, IQR=1).

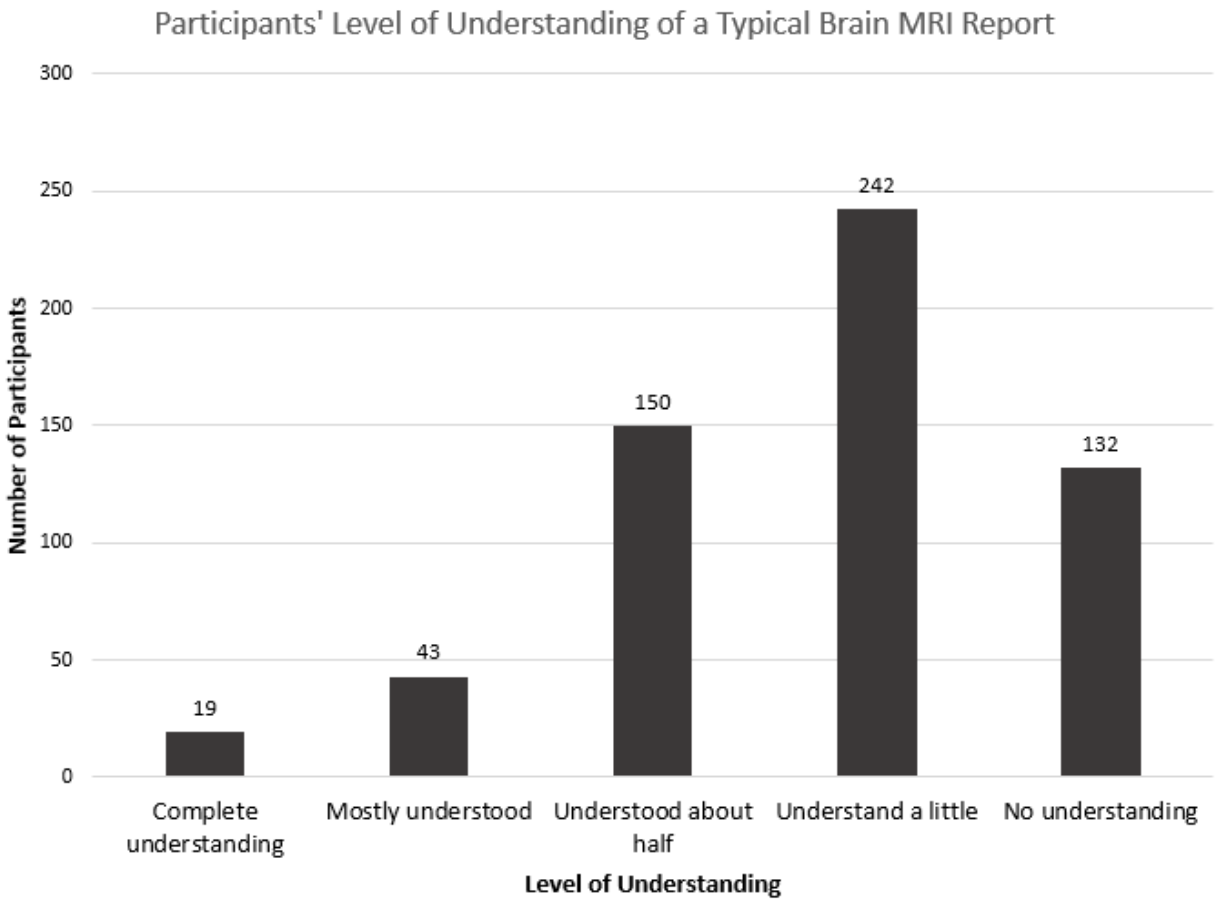


Figure 4.8: Participants' Level of Understanding of a Typical Brain MRI Report

Laypersons’ Level of Understanding of a Radiology Report with a Patient Summary Statement

For the two radiology reports with the intervention, the participants were again presented with the same reports but with a summary statement at the end of the radiology reports. The participants were informed that the content of the report was same as the report previously presented to them. They also were instructed to not read the report again and skip

to the end of it and read only the patient summary statement. As a reminder, the participants were asked to use their current knowledge and to not consult other resources for definitions. These two questions also were answered using the 5-point Likert-like scale: “No understanding”, “Understand a little”, “Understood about half”, “Mostly understood”, and “Complete understanding.” A comprehension question was also added after every self-report question to objectively assess the participants’ level of understanding of the report after adding the summary statement at the end of the report.

For the same reasons mentioned in the previous section, if the participants answered that they completely or mostly understood the radiology report but failed to correctly answer the comprehension question, they were excluded from this part of the analysis. However, if they answered that they completely did not understand, understood a little, or understood about half of the radiology report but answered the comprehension question correctly, they were included in the analyses.

The number of participants included in the analysis of the first radiology report with the patient summary statement, which was about the spine MRI exam, was 585. The 30 participants that were excluded from the analysis reported that they either completely or mostly understood the report but failed to correctly answer the comprehension question. Out of the 585 participants, 32% of them completely understood the report, 42% of them mostly understood the report, 15% understood about half of the report, 9% of them understood a little of the report, and only 2% of them completely did not understand the report, as shown in

Figure 4.9. Most of the participants understood the spine MRI report with the patient summary statement (“1=No understanding” to “5=Complete understanding”, N=585, Mdn=4, IQR=2).

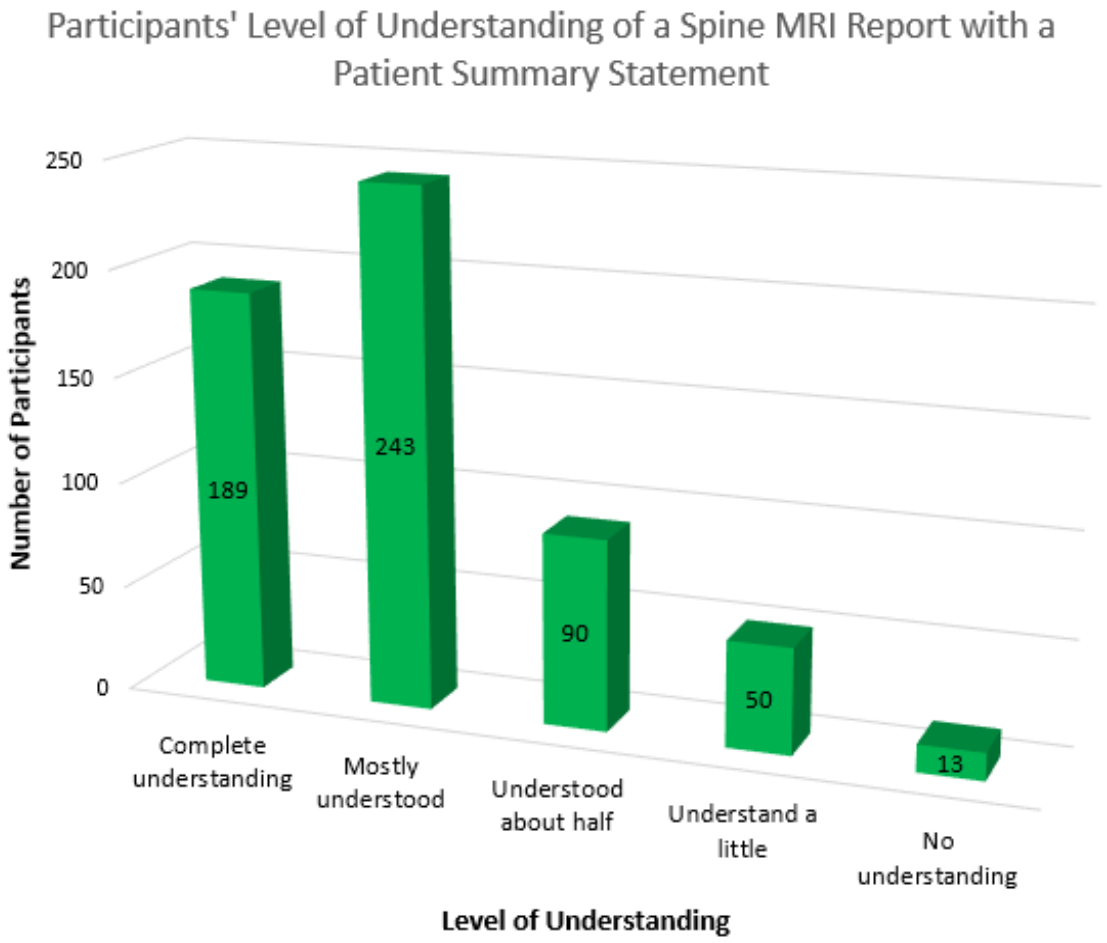


Figure 4.9: Participants' Level of Understanding of a Spine MRI Report with a Patient Summary Statement

Participants’ level of understanding of the second radiology report with the patient summary statement, which was about the brain MRI exam, is shown in Figure 4.10. The number of participants who were included in this part of the analysis was 589. Twenty-six participants were excluded from this part of the analysis because they reported that they either completely or mostly understood the report but failed to correctly answer the comprehension question. Out of the 589 participants, 38% of them completely understood the report, 32% of them understood most of the report, 16% understood about half of the report, 11% of them

understood a little of the report, and only 4% of the participants completely did not understand the report. From these results, it seems that most respondents reported that they understood the brain MRI report with the patient summary statement ("1=No understanding" to "5=Complete understanding", N=589, Mdn=4, IQR=2).

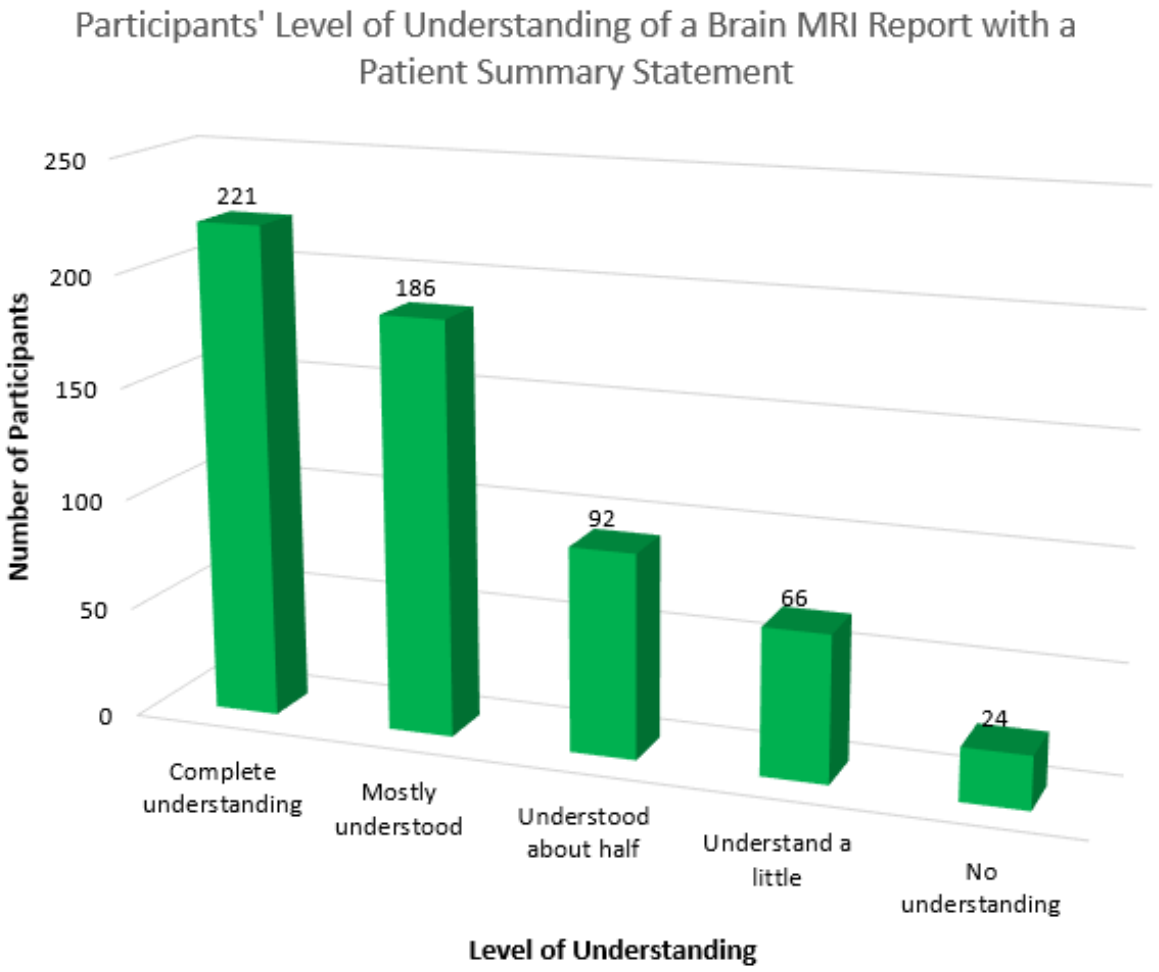


Figure 4.10: Participants' Level of Understanding of a Brain MRI Report with a Patient Summary Statement

The participants' responses to the question that asked about whether they think that adding a summary statement at the end of the radiology report summarizing the content of the report in lay terms was a good method for improving their understanding of the report were analyzed. The responses of the participants were reported in a Likert-scale ranging from "Strongly agree" to "Strongly disagree." Out of the 615 participants, 514 thought that adding a patient summary statement was a good method for improving their understanding of the report; meanwhile, only 28 participants did not think that adding a patient summary statement was a good method for improving their understanding of the report, as shown in Figure 4.11. The findings revealed that vast majority of the respondents indicated agreement with the idea that adding a patient summary statement is a good method for improving their understanding of the radiology report ("1=Strongly agree" to "5= Strongly disagree", N=615, Mdn=1, IQR=1).

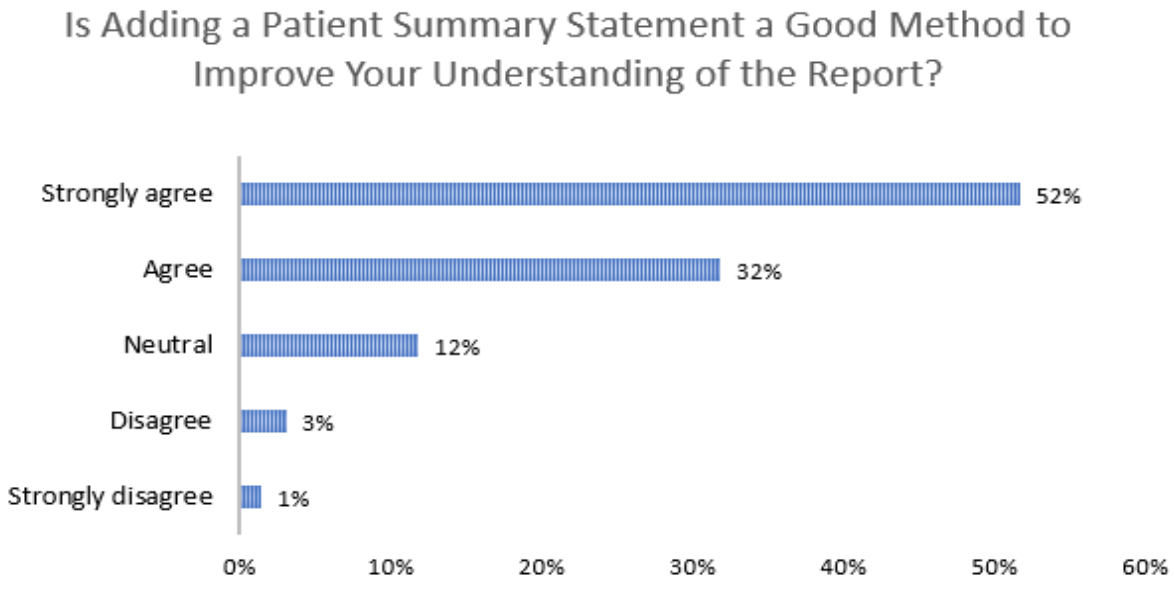


Figure 4.11: Participants' Support for the Patient Summary Statement

Laypersons' Preference Regarding the Type of Radiology Reporting

When it comes to the type of radiology reporting (i.e., either a free-text radiology report or a structured radiology report), most of the participants preferred the structured report (N=377) over the free-text report (N=144). Only 94 participants reported that they did not have a preference regarding the type of the radiology reporting, as shown in Figure 4.12. When asked whether they thought that the type of the radiology reporting affected their level of understanding of the report, 61% of the participants agreed that the type of radiology reporting affected their level of understanding, 19% of them disagreed, and 20% of the participants neither agreed nor disagreed, as shown in Figure 4.13. This means that most of the participants thought that the type of the radiology reporting affected their level of understanding of the report ("1=Strongly agree" to "5= Strongly disagree", N=615, Mdn=2, IQR=2).

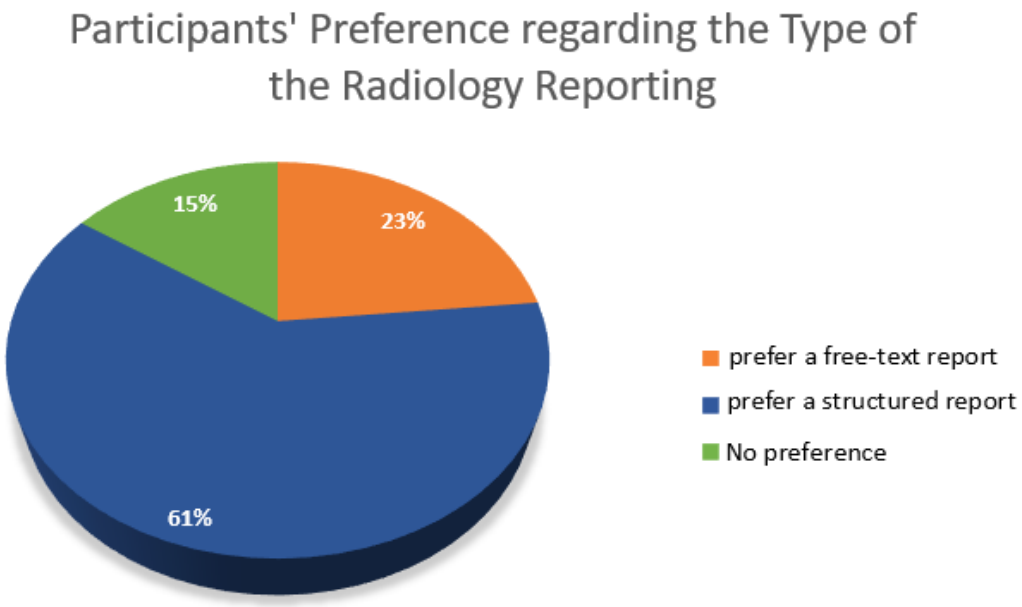


Figure 4.12: Participants' Preference Regarding the Radiology Reporting Type

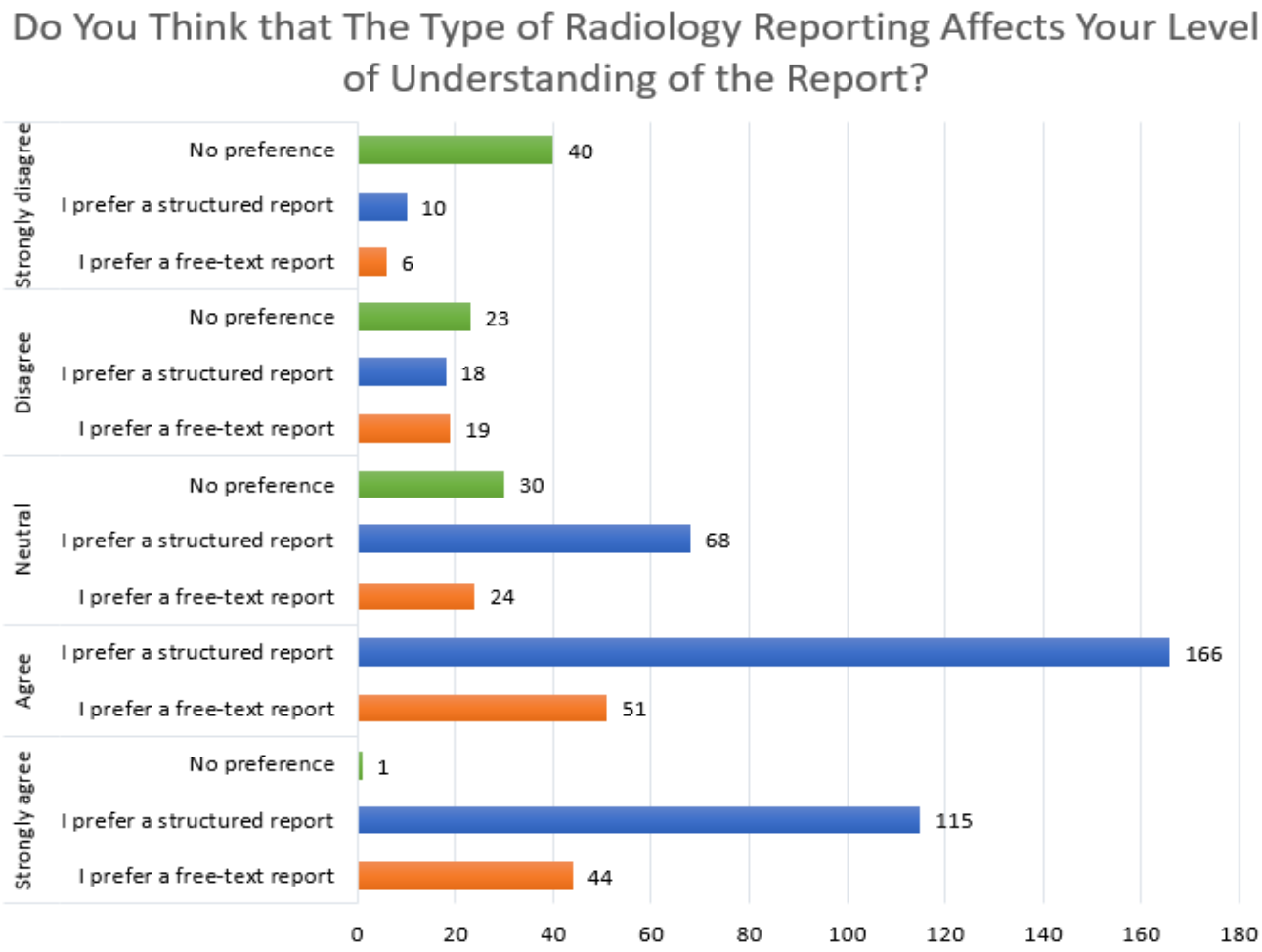


Figure 4.13: Participants' Preference Regarding Reporting Type and whether it affects Their Level of Understanding of the Report

Bivariate Analysis

The Pearson Chi-square test is a powerful statistical tool that is utilized to discover whether there is an association between two categorical variables.[186] In this study, it was conducted to discover relationships between nominal variables. If a relationship between two nominal variables was statistically significant (i.e., $P \leq 0.05$), the practical significance (i.e., how much the variables are associated) was reported. Cramer's V correlation test is used to measure how much the variables are associated when the variables are nominal and the cross-tabulation table is larger than 2x2;[187-190] therefore, it was used in the current study. The value of Cramer's

V test falls between 0 and +1, where a value of 0, or very close to 0, means no association, and a value of +1 indicates a perfect association.[187-190] Interpretation of the Cramer's V correlation coefficient values is shown in Table 4.4, adopted from Lee.[191]

Value of Cramer's V Coefficient	***Interpretation of Association***
0.00 – 0.10	Negligible
0.10 – 0.20	Weak
0.20 – 0.40	Moderate
0.40 – 0.60	Relatively strong
0.60 – 0.80	Strong
0.80 – 1.00	Very strong

Table 4.4: Interpretation of the Cramer's V Correlation Coefficient Value

Before assessing the relationship between a nominal variable (e.g., the preference method of receiving radiology test results) and an ordinal variable (e.g., level of education), the ordinal variable was grouped into fewer categories and converted into a nominal variable. That was done to help interpret the results and simplify the table of the frequency distribution, which could make it easier for both the researcher and the reader to understand.[134] Consequently, the Pearson Chi-square test with Cramer's V correlation coefficient (if the Chi-square was significant) was used to assess the correlation between the nominal variable and the ordinal variable that was converted into a nominal variable.

The level of education values were grouped into two categories: (Low Education Level for "8th grade or less, high school graduate or GED, and associate's degree" and High Education Level for "bachelor's degree and graduate degree"). The values of the age variable were grouped into three categories: (18-34 for "18-24 and 25-34", 35-54 for "35-44 and 45-54", and Over 54 for "55-64 and Over 64"). The values of the health literacy variable were grouped into

two categories: (Good Health Literacy Skills for scores “1 and 2” and Limited Health Literacy Skills for scores “3, 4, and 5”). Finally, the understanding level of the radiology report values were grouped into two categories: (No understanding for “no understanding, understand a little, and understood about half” and Understood for “mostly understood and complete understanding”). Although the race is a nominal variable, the values “American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, and Other” were grouped into one category, “Other.” This was because all the expected values for “American Indian or Alaska Native” and “Native Hawaiian or Other Pacific Islander” were less than 5.

The Spearman’s correlation test was used to measure the strength and direction of correlation between two ordinal variables.[165,168] The numerical value of the Spearman’s correlation coefficient, r_s, can be any number between +1 and -1. A value of +1 indicates a perfect positive correlation and a value of -1 indicates a perfect negative correlation.[165,168] The closer the Spearman’s correlation coefficient value is to -1 or +1, the greater is the strength of the association. Meanwhile, when the value of the Spearman’s correlation coefficient is 0, or near 0, this indicates lack of association.[165,168] A guide to the interpretation of the values of the Spearman’s correlation coefficient is shown in Table 4.5, adopted from Fowler, Cohen, and Jarvis.[168]

Value of coefficient r_s (positive or negative)	*Meaning*
0.00 to 0.19	A very weak correlation
0.20 to 0.39	A weak correlation
0.40 to 0.69	A modest correlation
0.70 to 0.89	A strong correlation
0.90 to 1.00	A very strong correlation

Table 4.5: A Guide to the meaning of the Spearman's Correlation Coefficient

The Chi-square test was used to assess the association between the preference method of receiving radiology test results and gender, level of education, age, race, native language, health literacy, and previous radiology exam experience. Table 4.6 shows the findings of this assessment.

	Do you prefer to receive your radiology test results online via the patient portal?			
	Yes % (N)	**No % (N)**	**Undecided % (N)**	**Marginal Row Total % (N)**
Gender (N = 612)				
Female	67% (227)	16% (54)	17% (58)	100% (339)
Male	70% (192)	13% (35)	17% (46)	100% (273)
Pearson Chi-square $X^2(2)= 1.261$, $P= 0.532$				
Level of Education (N = 615)				
Low Education Level	63% (240)	17% (64)	21% (80)	100% (384)
High Education Level	79% (182)	11% (25)	10% (24)	100% (231)
$X^2(2)= 18.283$, $P< 0.001$, Cramer's V correlation coefficient (φ_c) = 0.172				
Age (N = 615)				
18 – 34	71% (244)	12% (43)	17% (59)	100% (346)
35 – 54	75% (132)	13% (23)	12% (22)	100% (177)

Over 54	50% (46)	25% (23)	25% (23)	100% (92)
$X^2(4)= 19.724, P= 0.001, \varphi_c= 0.127$				
Race (N = 615)				
White	72% (220)	13% (39)	15% (47)	100% (306)
Black or African American	51% (36)	23% (16)	26% (18)	100% (70)
Asian	76% (35)	7% (3)	17% (8)	100% (46)
Other	68% (131)	16% (31)	16% (31)	100% (193)
$X^2(6)= 13.993, P= 0.030, \varphi_c= 0.107$				
Native English Speaker (N = 615)				
Yes	69% (369)	14% (74)	18% (94)	100% (537)
No	68% (53)	19% (15)	13% (10)	100% (78)
$X^2(2)= 2.288, P= 0.319$				
Health Literacy (N = 615) (How confident are you filling out medical forms by yourself?				
Good Health Literacy Skills	76% (392)	12% (60)	12% (64)	100% (516)
Limited Health Literacy Skills	30% (30)	29% (29)	40% (40)	100% (99)
$X^2(2)= 81.667, P< 0.001, \varphi_c= 0.364$				
Previous Radiology Exam Experience (N=615)				
Yes	58% (191)	20% (66)	21% (70)	100% (327)
No	80% (231)	8% (23)	12% (34)	100% (288)
$X^2(2)= 34.695, P< 0.001, \varphi_c= 0.238$				

Table 4.6: Bivariate Analysis of the Preference Method of Receiving Radiology Test Results and Gender, Level of Education, Age, Race, Native Language, Health Literacy, Previous Radiology Exam

The findings of the Chi-square test and the Cramer's V correlation test indicated that there was a significant weak correlation between the preference method of receiving radiology test results and level of education ($X^2(2) = 18.283$, $P < 0.001$, $\varphi_c = 0.172$), where people with high education level were more in favor of receiving their radiology test results via the online

patient portal. The test also found that there was a significant weak correlation between the preference method of receiving radiology test results and age ($X^2(4) = 19.724$, $P = 0.001$, $\varphi_c = 0.127$). People who were aged 35 – 54 years old were more likely to support the idea of receiving their radiology test results through the online patient portal. Moreover, the test revealed that there was a significant moderate association between the preference method of receiving radiology test results and health literacy ($X^2(2) = 81.667$, $P < 0.001$, $\varphi_c = 0.364$). It seems that people with good health literacy skills were more supportive of the idea of receiving their radiology test results through the online patient portal. There was also a significant moderate association between the preference method of receiving radiology test results and prior radiology exam experience ($X^2(2) = 34.695$, $P < 0.001$, $\varphi_c = 0.238$). Participants who had not had radiology exams done before were more in favor of receiving their radiology report through the patient portal.

The results of the Chi-square test showed that the relationship between the preference method of receiving radiology test results and race was statistically significant ($X^2(6) = 13.993$, $p = 0.030$), but the value of the Cramer's V correlation coefficient was very low ($\varphi_c = 0.107$). This means that the relationship was negligible (please refer to Table 4.4) and was not worth mentioning. The results of the test also revealed that there was no correlation between the preference method of receiving radiology test results and gender or native language.

The Chi-square test was also done to assess the association between health literacy and gender, race, and native language. Table 4.7 shows the results of this assessment. The test found no correlation between health literacy and gender, race, or native language.

	Health Literacy (How confident are you filling out medical forms by yourself?)		
	Good Health Literacy Skills % (N)	**Limited Health Literacy Skills % (N)**	**Marginal Row Total % (N)**
Gender (N = 612)			
Female	82% (278)	18% (61)	100% (339)
Male	86% (235)	14% (38)	100% (273)
X^2(1)= 1.852, *P*= 0.174			
Race (N = 615)			
White	86% (262)	14% (44)	100% (306)
Black or African American	81% (57)	19% (13)	100% (70)
Asian	83% (38)	17% (8)	100% (46)
Other	82% (159)	18% (34)	100% (193)
X^2(3)= 1.373, *P*= 0.712			
Native English Speaker (N = 615)			
Yes	85% (456)	15% (81)	100% (537)
No	77% (60)	23% (18)	100% (78)
X^2(1)= 3.222, *P*= 0.073			

Table 4.7: Bivariate Analysis of Health Literacy and Gender, Race, and Native Language

The Spearman's correlation test was conducted to see if there was any relationship between health literacy and level of education or native language, as shown in Table 4.8.

	Health Literacy (How confident are you filling out medical forms by yourself?)					
	1- Extremely % (N)	**2- Quite a bit % (N)**	**3- Somewhat % (N)**	**4- A little bit % (N)**	**5- Not at all % (N)**	**Marginal Row Total % (N)**
	Good Health Literacy Skills		**Limited Health Literacy Skills**			
Level of Education (N = 615)						
8th grade or less	36% (22)	46% (28)	13% (8)	5% (3)	0% (0)	100% (61)
High school graduate or GED	43% (105)	33% (80)	18% (43)	3% (8)	2% (6)	100% (242)

Associate's degree	42% (34)	41% (33)	12% (10)	4% (3)	1% (1)	100% (81)
Bachelor's degree	57% (97)	34% (57)	7% (11)	2% (3)	1% (1)	100% (169)
Graduate degree	52% (32)	45% (28)	2% (1)	2% (1)	0% (0)	100% (62)
Spearman's correlation coefficient (r_s)= -0.161, P< 0.001						
Age (N = 615)						
18 – 24	27% (79)	30% (68)	44% (32)	28% (5)	25% (2)	100% (186)
25 – 34	26% (76)	27% (60)	22% (16)	22% (4)	50% (4)	100% (160)
35 – 44	23% (66)	18% (40)	7% (5)	6% (1)	0% (0)	100% (112)
45 – 54	12% (34)	9% (20)	11% (8)	11% (2)	13% (1)	100% (65)
55 – 64	6% (18)	5% (12)	11% (8)	22% (4)	0% (0)	100% (42)
Over 64	6% (17)	12% (26)	5% (4)	11% (2)	13% (1)	100% (50)
r_s= -0.037, P= 0.365						

Table 4.8: Bivariate Analysis of Health Literacy and Level of Education and Age

The test indicated that there was no relationship between health literacy and age. However, as per the guide in Table 4.5, there was a significant negative very weak association between health literacy and level of education (r_s = -0.161, p < 0.001), where people with lower level of education tended to have limited health literacy skills.

The Chi-square test was done to evaluate the association between laypersons' level of understanding of a typical spine MRI report and gender, race, native language, and previous radiology exam experience, as shown in Table 4.9. The test showed that there was no relationship between laypersons' level of understanding of a typical spine MRI report and gender, race, or native language. The test revealed that there was a statistically significant association between laypersons' level of understanding of a typical spine MRI report and

previous radiology exam experience ($X^2(1) = 4.788$, $P = 0.029$). However, the value of the Cramer's V correlation coefficient was extremely low ($\varphi_c = 0.091$); thus, the relationship was negligible.

	Laypersons' Level of Understanding of a Typical Spine MRI Report		
	No understanding % (N)	**Understood % (N)**	**Marginal Row Total % (N)**
Gender (N = 578)			
Female	80% (255)	20% (65)	100% (320)
Male	84% (218)	16% (40)	100% (258)
$X^2(1) = 2.222$, $P = 0.136$			
Race (N = 581)			
White	80% (230)	20% (57)	100% (287)
Black or African American	82% (53)	18% (12)	100% (65)
Asian	83% (33)	18% (7)	100% (40)
Other	85% (160)	15% (29)	100% (189)
$X^2(3) = 1.586$, $P = 0.663$			
Native English Speaker (N = 581)			
Yes	81% (410)	19% (95)	100% (505)
No	87% (66)	13% (10)	100% (76)
$X^2(1) = 1.426$, $P = 0.232$			
Previous Radiology Exam Experience (N = 581)			
Yes	79% (234)	21% (64)	100% (298)
No	86% (242)	14% (41)	100% (283)
$X^2(1) = 4.788$, $P = 0.029$, $\varphi_c = 0.091$			

Table 4.9: Bivariate Analysis of Laypersons' Level of Understanding of a Typical Spine MRI Report and Gender, Race, Native Language, and Previous Radiology Exam Experience

The results of the Spearman's correlation test also revealed that there was no correlation between laypersons' level of understanding of a typical spine MRI report and age, as shown in Table 4.10.

	Laypersons' Level of Understanding of a Typical Spine MRI Report					
	No understanding % (N)	**Understand a little % (N)**	**Understood about half % (N)**	**Mostly understood % (N)**	**Complete understanding % (N)**	**Marginal Row Total % (N)**
Age (N = 581)						
18 - 24	12% (20)	43% (75)	25% (43)	18% (31)	2% (4)	100% (173)
25 - 34	13% (19)	35% (52)	32% (47)	13% (20)	7% (11)	100% (149)
35 - 44	7% (8)	38% (41)	37% (40)	11% (12)	6% (7)	100% (108)
45 - 54	17% (10)	32% (19)	28% (17)	18% (11)	5% (3)	100% (60)
55 - 64	14% (6)	57% (24)	17% (7)	12% (5)	0% (0)	100% (42)
Over 64	24% (12)	45% (22)	29% (14)	2% (1)	0% (0)	100% (49)
r_s= -0.077, P= 0.063						

Table 4.10: Bivariate Analysis of Laypersons' Level of Understanding of a Typical Spine MRI Report and Age

The Chi-square test was also conducted to see if there was any association between laypersons' level of understanding of a typical brain MRI report and gender, race, native language, or previous radiology exam experience. The test revealed that there was no relationship between laypersons' level of understanding of a typical brain MRI report and gender, race, native language, or previous radiology exam experience, as shown in Table 4.11.

	Laypersons' Level of Understanding of a Typical Brain MRI Report		
	No understanding % (N)	**Understood % (N)**	**Marginal Row Total % (N)**
Gender (N = 583)			
Female	88% (287)	12% (38)	100% (325)
Male	91% (234)	9% (24)	100% (258)
X^2(1)= 0.864, P= 0.353			
Race (N = 586)			
White	90% (262)	10% (29)	100% (291)
Black or African American	84% (53)	16% (10)	100% (63)
Asian	83% (35)	17% (7)	100% (42)

Other	92% (174)	8% (16)	100% (190)
X^2(3)= 4.562, *P*= 0.207			
Native English Speaker (N = 586)			
Yes	89% (456)	11% (54)	100% (510)
No	89% (68)	11% (8)	100% (76)
X^2(1)= 0.000, *P*= 0.987			
Previous Radiology Exam Experience (N = 586)			
Yes	88% (266)	12% (38)	100% (304)
No	91% (258)	9% (24)	100% (282)
X^2(1)= 2.461, *P*= 0.117			

Table 4.11: Bivariate Analysis of Laypersons' Level of Understanding of a Typical Brain MRI Report and Gender, Race, Native Language, and Previous Radiology Exam Experience

The results of the Spearman's correlation test revealed that there was a statistically significant (p = 0.005) but a very weak negative correlation (r_s = -0.116) between laypersons' level of understanding of a typical brain MRI report and age, where elderly people tended to not understand the typical brain MRI report, as shown in Table 4.12.

	Participants' Level of Understanding of a Typical Brain MRI Report					
	No understanding % (N)	**Understand a little % (N)**	**Understood about half % (N)**	**Mostly understood % (N)**	**Complete understanding % (N)**	**Marginal Row Total % (N)**
Age (N = 586)						
18 - 24	19% (35)	43% (77)	25% (45)	9% (16)	4% (8)	100% (181)
25 - 34	20% (29)	39% (58)	29% (43)	7% (10)	5% (7)	100% (147)
35 - 44	22% (24)	41% (44)	26% (28)	8% (9)	3% (3)	100% (108)
45 - 54	15% (9)	48% (29)	25% (15)	10% (6)	2% (1)	100% (60)
55 - 64	40% (17)	38% (16)	19% (8)	2% (1)	0% (0)	100% (42)
Over 64	38% (18)	38% (18)	23% (11)	2% (1)	0% (0)	100% (48)
r_s= -0.116, *P*= 0.005						

Table 4.12: Bivariate Analysis of Laypersons' Level of Understanding of a Typical Brain MRI Report and Age

The Relationship between Laypersons' Level of Understanding of a Typical MRI Report and their Level of Education

To assess the relationship between laypersons' level of understanding of a typical MRI report and their level of education, the Spearman's correlation test and Fisher's exact test were done. The results, as presented in Table 4.13, Table 4.14, Table 4.15, and Table 4.16, revealed that there was no association between laypersons' level of understanding of a typical MRI report and their level of education (r_s = -0.045, P = 0.281 for the spine MRI report) and (r_s = -0.030, P = 0.473 for the brain MRI report). The Fisher's exact test statistic values were 0.579 and 0.407 for the level of understanding of typical spine and brain MRI reports, respectively, and level of education. These results were not significant at $p < 0.05$, which means we failed to reject the null hypothesis.

	Participants' Level of Understanding of a Typical Spine MRI Report					
	No understanding % (N)	**Understand a little % (N)**	**Understood about half % (N)**	**Mostly understood % (N)**	**Complete understanding % (N)**	**Marginal Row Total % (N)**
Level of Education (N = 581)						
8th grade or less	14% (8)	59% (34)	22% (13)	5% (3)	0% (0)	100% (58)
High school graduate or GED	14% (33)	36% (83)	30% (68)	15% (35)	5% (11)	100% (230)
Associate's degree	11% (8)	33% (24)	30% (22)	21% (15)	5% (4)	100% (73)
Bachelor's degree	12% (19)	40% (63)	30% (48)	13% (20)	6% (9)	100% (159)
Graduate degree	11% (7)	48% (29)	28% (17)	11% (7)	2% (1)	100% (61)
r_s= 0.045, P= 0.281						

Table 4.13: The Results of the Spearman's Correlation Test of Laypersons' Level of Understanding of a Typical Spine MRI Report and their Level of Education

	Participants' Level of Understanding of a Typical Brain MRI Report					
	No understanding % (N)	**Understand a little % (N)**	**Understood about half % (N)**	**Mostly understood % (N)**	**Complete understanding % (N)**	**Row Total % (N)**
Level of Education (N = 586)						
8th grade or less	28% (16)	41% (24)	29% (17)	0% (0)	2% (1)	100% (58)
High school graduate or GED	21% (50)	39% (91)	27% (63)	9% (20)	5% (11)	100% (235)
Associate's degree	22% (16)	39% (28)	25% (18)	13% (9)	1% (1)	100% (72)
Bachelor's degree	19% (31)	46% (74)	25% (41)	6% (9)	4% (6)	100% (161)
Graduate degree	32% (19)	42% (25)	18% (11)	8% (5)	0% (0)	100% (60)
r_s= -0.030, *P*= 0.473						

Table 4.14: The Results of the Spearman's Correlation Test of Laypersons' Level of Understanding of a Typical Brain MRI Report and their Level of Education

		Participants' Level of Understanding of a Typical Spine MRI Report		
		No understanding (N)	**Understood (N)**	**Marginal Row Total (N)**
Level of Education	**Low Education Level (N)**	293	68	361
	High Education Level (N)	183	37	220
	Marginal Column Total (N)	476	105	**Grand Total=** 581
	Two-sided Fisher's exact test, *P* = 0.579			

Table 4.15: The Results of the Fisher's Exact Test of Laypersons' Level of Understanding of a Typical Spine MRI Report and their Level of Education

		Participants' Level of Understanding of a Typical Brain MRI Report		
		No understanding (N)	**Understood (N)**	**Marginal Row Total (N)**
Level of Education	**Low Education Level (N)**	323	42	365
	High Education Level (N)	201	20	221
	Marginal Column Total (N)	524	62	**Grand Total=** 586
	Two-sided Fisher's exact test, *P* = 0.407			

Table 4.16: The Results of the Fisher's Exact Test of Laypersons' Level of Understanding of a Typical Brain MRI Report and their Level of Education

The Relationship between Laypersons' Level of Understanding of a Typical MRI Report and their Health Literacy Skills

Spearman's correlation test and Fisher's exact test were also conducted to measure the correlation between laypersons' level of understanding of a typical MRI report and their health literacy skills. The results of both tests showed that there was no association between laypersons' level of understanding of a typical MRI report and their health literacy skills. Table 4.17 and Table 4.18 show the results of the Spearman's correlation test. The values of the Spearman's correlation coefficient were (r_s = -0.035, P = 0.396) and (r_s = -0.027, P = 0.518) for the level of understanding of typical spine and brain MRI reports, respectively, and health literacy. The results of the Fisher's exact test are presented in Table 4.19 and Table 4.20. The Fisher's exact test statistic values were 0.252 and 0.105 for the level of understanding of typical

spine and brain MRI reports, respectively, and health literacy. These results were not significant at $p < 0.05$, which means we failed to reject the null hypothesis

		Participants' Level of Understanding of a Typical Spine MRI Report					
		No understanding % (N)	**Understand a little % (N)**	**Understood about half % (N)**	**Mostly understood % (N)**	**Complete understanding % (N)**	**Marginal Row Total % (N)**
Health Literacy (N = 581) (How confident are you filling out medical forms by yourself?							
Good Health Literacy Skills	1- Extremely	11% (31)	38% (105)	34% (92)	12% (34)	4% (12)	100% (274)
	2- Quite a bit	14% (30)	43% (90)	25% (51)	13% (27)	5% (10)	100% (208)
Limited Health Literacy Skills	3- Somewhat	11% (8)	38% (28)	26% (19)	22% (16)	3% (2)	100% (73)
	4- A little bit	22% (4)	39% (7)	22% (4)	11% (2)	6% (1)	100% (18)
	5- Not at all	25% (2)	38% (3)	25% (2)	13% (1)	0% (0)	100% (8)
	r_s= -0.035, P= 0.396						

Table 4.17: The Results of the Spearman's Correlation Test of Laypersons' Level of Understanding of a Typical Spine MRI Report and their Health Literacy Skills

	Participants' Level of Understanding of a Typical Brain MRI Report					
	No understanding % (N)	**Understand a little % (N)**	**Understood about half % (N)**	**Mostly understood % (N)**	**Complete understanding % (N)**	**Marginal Row Total % (N)**
Health Literacy (N = 586) (How confident are you filling out medical forms by yourself?						

Good Health Literacy Skills	1- Extremely	18% (49)	45% (123)	27% (74)	6% (16)	3% (9)	100% (271)
	2- Quite a bit	28% (61)	37% (81)	24% (53)	6% (14)	4% (8)	100% (217)
Limited Health Literacy Skills	3- Somewhat	21% (15)	40% (29)	21% (15)	15% (11)	3% (2)	100% (72)
	4- A little bit	22% (4)	33% (6)	33% (6)	11% (2)	0% (0)	100% (18)
	5- Not at all	38% (3)	38% (3)	25% (2)	0% (0)	0% (0)	100% (8)
	r_s= -0.027, P= 0.518						

Table 4.18: The Results of the Spearman's Correlation Test of Laypersons' Level of Understanding of a Typical Brain MRI Report and their Health Literacy Skills

		Participants' Level of Understanding of a Typical Spine MRI Report		
		No understanding (N)	**Understood (N)**	**Marginal Row Total (N)**
Health Literacy	**Limited Health Literacy Skills (N)**	77	22	99
	Good Health Literacy Skills (N)	399	83	482
	Marginal Column Total (N)	476	105	**Grand Total=** 581
	Two-sided Fisher's exact test, P = 0.252			

Table 4.19: The Results of the Fisher's Exact Test of Laypersons' Level of Understanding of a Typical Spine MRI Report and their Health Literacy Skills

		Participants' Level of Understanding of a Typical Brain MRI Report		
		No understanding (N)	**Understood (N)**	**Marginal Row Total (N)**
Health Literacy	**Limited Health Literacy Skills (N)**	83	15	98
	Good Health Literacy Skills (N)	441	47	488
	Marginal Column Total (N)	524	62	**Grand Total=** 586
	Two-sided Fisher's exact test, *P* = 0.105			

Table 4.20: The Results of the Fisher's Exact Test of Laypersons' Level of Understanding of a Typical Brain MRI Report and their Health Literacy Skills

Laypersons' Level of Understanding of a Radiology Report before and after Adding the Patient Summary Statement

As mentioned earlier, the answer to the comprehension questions can show whether the participant really understood the report or not. Therefore, if the participants reported that they mostly or completely understood the radiology report but failed to correctly answer the comprehension question or answered "not sure" to the comprehension question, then they were excluded from the analyses. When the participants were excluded from the dataset of the level of understanding of the report before adding the summary statement, then they were also excluded from the dataset of the level of understanding of the report after adding the summary, and the vice versa was done too. This was done because the Wilcoxon signed rank test is used to compare two repeated measurements on a single sample.[173,174]

Thirty-four participants were excluded from the dataset of the level of understanding of the spine MRI report before adding the summary statement. In addition, 30 participants were excluded from the dataset of the level of understanding of the spine MRI report after adding the summary statement. Out of the 34 and 30 participants that were excluded, 19 were mutual events, meaning that the same participant was excluded from both datasets. Therefore, only 45 participants were excluded from the analysis of the level of understanding of the spine MRI report before and after adding the summary statement, leaving 570 participants.

The Wilcoxon signed rank test was used to test the hypothesis that adding a patient summary statement at the end of a radiology report can improve patients' level of understanding of their report. First, the test was conducted to compare the participants' level of understanding of the spine MRI report before and after adding the patient summary statement. The Wilcoxon signed rank test showed that there was a significant difference (Z = 17.271, $p < 0.001$) between scores given for the participants' level of understanding of the spine MRI report before adding the patient summary statement compared to after adding the patient summary statement, as presented in Table 4.21. The median score for the participants' level of understanding of the spine MRI report before adding the patient summary statement was 2 compared to 4 for their level of understanding of the report after adding the patient summary statement ("1=No understanding" to "5=Complete understanding"). The effect size, which measured how much the patient summary statement affected the participants' level of understanding of the report, was calculated. The equation to calculate the effect size by converting a Z-score into the effect size estimate (r), given by Rosenthal,[192] is as follows: $r = Z/\sqrt{N}$ where Z is the Z-score and N is the sample size. Therefore, the effect size$(r) =$

$17.271/\sqrt{570} = 0.723$. This value is considered very large according to Cohen's classification for effect sizes.[193-195] Thresholds for interpreting effect sizes based on Cohen's classification for effect sizes are shown in Table 4.22, adopted from Cohen[193]; Ellis[194]; and Field[195].

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Participants' Level of Understanding of a Typical Spine MRI Report and Participants' Level of Understanding of a Spine MRI Report with the Patient Summary Statement equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .001.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	570
Test Statistic	94321.500
Standard Error	2639.777
Standardized Test Statistic	17.271
Asymptotic Sig.(2-sided test)	.000

Table 4.21: Wilcoxon Signed Rank Test Results of Participants' Level of Understanding of a Spine MRI Report before and after Adding the Patient Summary Statement

Effect Size Meaning	Effect Size
Small effect	0.1
Medium effect	0.3
Large effect	≥ 0.5

Table 4.22: Thresholds for Interpreting Effect Sizes based on Cohen's Classification for Effect Sizes

Second, 29 participants were excluded from the dataset of the level of understanding of the brain MRI report before adding the summary statement. Moreover, 26 participants were excluded from the dataset of the level of understanding of the brain MRI report after adding

the summary statement. Out of the 29 and 26 participants that were excluded, 12 were mutual events. Therefore, only 43 participants were excluded from the analysis of the level of understanding of the brain MRI report before and after adding the summary statement, leaving 572 participants.

The Wilcoxon signed rank test was also done to compare the participants' level of understanding of the brain MRI report before and after adding the patient summary statement. The test revealed that there was a significant difference (Z = 17.239, p < 0.001) between scores given for the participants' level of understanding of the brain MRI report before adding the patient summary statement compared to after adding the patient summary statement, as shown in Table 4.23. The median score for the participants' level of understanding of the brain MRI report before adding the patient summary statement was 2 compared to 4 for their level of understanding of the report after adding the patient summary statement ("1=No understanding" to "5=Complete understanding"). The effect size$(r) = 17.239/\sqrt{572} = 0.721$, which is also considered very large according to Cohen's classification for effect sizes (please refer to Table 4.22).

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between Participants' Level of Understanding of a Typical Brain MRI Report and Participants' Level of Understanding of a Brain MRI Report with the Patient Summary Statement equals 0.	Related-Samples Wilcoxon Signed Rank Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .001.

Related-Samples Wilcoxon Signed Rank Test Summary

Total N	572
Test Statistic	92578.000
Standard Error	2607.162
Standardized Test Statistic	17.239
Asymptotic Sig.(2-sided test)	.000

Table 4.23: Wilcoxon Signed Rank Test Results of Participants' Level of Understanding of a Brain MRI Report before and after Adding the Patient Summary Statement

Based on the results of the Wilcoxon signed rank tests, which were performed on the participants' level of understanding of the spine and brain MRI reports before and after adding the patient summary statement, the null hypothesis was rejected. This means that adding a patient summary statement at the end of a radiology report can significantly improve patients' level of understanding of their report.

Chapter V: Discussion and Conclusions

This study aimed to investigate the needs and preferences of the patients regarding to radiology test results delivered via patient portals. There were, particularly, three main objectives of this study: to determine the relationship between patients' level of education and how much they can understand from a radiology report, to examine the role of health literacy in the patients' understanding of the radiology report, and to investigate whether adding a patient summary statement at the end of the radiology report in lay language summarizing the content of the report enhances patients' understanding of the report. The current study also covered other aspects of the needs and preferences of patients regarding to radiology test results delivered through patient portals, such as how much patients understand from a typical radiology report, patients' preferences regarding the type of radiology reporting, and whether patients think that the type of radiology reporting affects their level of understanding of the report.

Implications of the Findings and Comparison with Previous Studies

This study indicated that 16.1% of the study sample had limited or inadequate health literacy skills. This percentage is slightly lower than the results of a systematic review, done by Paasche-Orlow et al., of 85 studies, which was 26%.[196] This could be due to the differences in the characteristics of the sample between the current study and the studies that were systematically reviewed. Paasche-Orlow and his colleagues stated in their paper that the sample of the reviewed studies did not provide a nationally representative sample.[196] For example, Paasche-Orlow and his colleagues reported that 37% of subjects in the reviewed

studies did not complete high school and 55% of all subjects were black.[196] Meanwhile, nationally, only 12% of the population did not complete high school and 13% of the population is black.[197,198] These percentages are much closer to the sample characteristics of the current study, with 10% and 11% for participants who did not have at least high school or GED and black or African American participants, respectively.

There was no relationship found between health literacy and gender, age, race, or native language. Patients with limited health literacy skills can be difficult to identify by only looking at their gender, age, race, or native language, as indicated by the results of this study. Weiss recommends overcoming the difficulty of identifying patients with limited health literacy skills can be done by providing easy-to-understand information to all patients.[80] This recommendation is feasible when the health care provider wants to deliver health information to a patient and the health information is intended for the patient. For instance, when a health care provider prescribes a medication to a patient and the provider wants to deliver some information to the patient about the drug, such as the dosage and the side effects, the provider can simplify the information because it is intended for the patient. However, this might not be applicable to radiology test results, especially radiology reports. This is because the radiology reports are meant to be delivered to the referring physicians. In addition, there are many words and terms in the radiology report that cannot be simplified and there are no synonyms for them. Moreover, simplifying the radiology report might result in loss of critical information and, therefore, failure to fulfill the main objective of the report.

Expectedly, there was an association between health literacy and level of education, where people with a lower level of education tended to have limited health literacy skills. It is

important to differentiate between level of education and health literacy. Level of education measures how many years a person attended school, but it does not measure how much the person learned in school.[80] In other words, not all people with a high level of education have good health literacy skills. On the contrary, some people with low education level have good health literacy skills. The findings of this study suggest that low education level is one of the factors that can be used to predict patients with limited health literacy skills. However, it cannot be the only factor to identify patients with limited health literacy skills.

There was no correlation found between laypersons' level of understanding of a typical spine MRI report and gender, age, race, or native language. There was an association found between laypersons' level of understanding of a typical spine MRI report and previous radiology exam experience, but the association was very weak and negligible. The findings of the study also revealed that there was no correlation between laypersons' level of understanding of a typical brain MRI report and gender, race, native language, or previous radiology exam experience. However, there was a very weak relationship between laypersons' level of understanding of a typical brain MRI report and age, where elderly people tended to not understand the typical brain MRI report.

Based on the previously mentioned findings, it seems that the laypersons' level of understanding of a typical MRI report is not associated with any previously stated factors. That is because even the existing relationship between laypersons' level of understanding of a typical MRI report and previous radiology exam experience and age were either very weak or negligible. It appears to be that the radiology report is not easy to understand for people of any gender, age, and race. Furthermore, whether the person is a native English speaker or not

would not help him or her to understand his or her radiology report. Likewise, people with previous radiology exam experience also would not understand their radiology report more than people without previous radiology exam experience.

The vast majority of the participants (69%) in this study wanted to receive their radiology test results through the online patient portal. These results are consistent with the previous studies.[34,35] It is important to note that not all the remaining 31% of the participants were against the idea of receiving their radiology test results online via the patient portal. Only 14% of the respondents did not prefer to receive their radiology results through the patient portal. The other 17% of the participants were undecided. The association was evaluated for the preference of receiving radiology test results online via the patient portal with gender, level of education, age, race, native language, health literacy, and previous radiology exam experience. No relationship was found between the preference for receiving radiology test results online via the patient portal and gender or native language. However, there was a correlation found between the preference of receiving radiology test results online via the patient portal and race, but it was extremely weak and negligible.

On the other hand, it was found that an association exists between the preference of receiving radiology test results via the online patient portal and education level, age, health literacy, and previous radiology exam experience. It might be expected that people with a high education level, people aged 35 – 54 years old, and people with good health literacy skills were more in favor of receiving their radiology test results via the online patient portal. People with high education level might have good computer skills,[199,200] which could make them more in favor of receiving their radiology test results via the online patient portal. The factor of age was

grouped into three groups before the Chi-square test was conducted. If the age was ungrouped, the distribution of the age in terms of the preference of receiving radiology test results via the online patient portal is shown in Figure 5.1. It is clear that younger respondents were more supportive of the idea of receiving radiology test results through the online patient portal than older respondents. This could be because younger people tend to use the internet more than the older people.[201] Therefore, they are more confident using the internet to receive their radiology test results. Finally, the reason why people with good health literacy skills were more in favor of receiving their radiology test results via the online patient portal could be because they think that they are more capable of reading and understanding their radiology test results than people with limited health literacy skills. As a result, they may think that their results received via the online patient portal might be sufficient and they would not need to communicate with their health care provider.

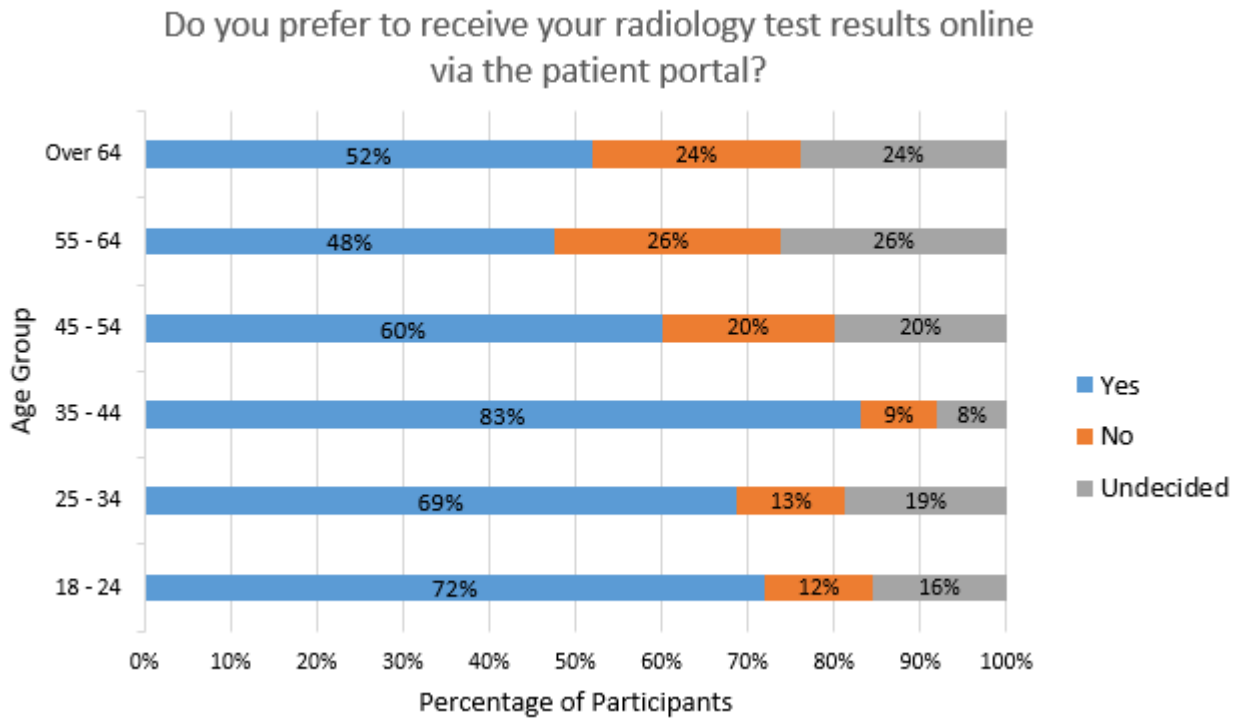


Figure 5.1: Distribution of Age in terms of the Preference of Receiving Radiology Test Results via the Online Patient Portal

Interestingly, people who had not undergone radiology exams before were more in favor of receiving their radiology report through the patient portal. It is unclear why people with a previous radiology exam experience were less in favor of receiving their radiology report via the online patient portal. It could be because some of the participants did not have a good experience with the online patient portal. The online patient portal is a rapidly evolving technology, but it is still in its infancy and it needs a great deal of enhancement.[202] A previous study showed that patients did not understand what features were available in the patient portal.[202] Moreover, many patients stated that the patient portal was confusing and the medical jargons in the portal were difficult to understand.[202-204] Therefore, participants with a previous radiology exam experience may have had a bad experience with the online patient portal that affected their preference of receiving their radiology test results via the patient portal.

The results of this study also showed that most of the participants (61%) preferred the structured radiology report to the free-text report. In a previous study conducted by Gassenmaier and his colleagues,[62] it was found that referring physicians prefer the structured radiology report over the free-text report. The current study confirms that patients also prefer the structured radiology report. The participants in the current study were not asked (because of the time that could be added to the survey) about what specifically they liked about the structured radiology report, which could be investigated in future research. However, the participants were asked whether they think the type of radiology reporting affects their level of understanding of the report. Sixty-one percent of the participants thought that the type of

radiology reporting affects their level of understanding, around 75% of whom preferred structured radiology reporting.

The results of Gassenmaier et al. study revealed that structured reporting can enhance quality and readability for physicians.[62] This could be the reason the participants in the current study thought that the type of radiology reporting affected their level of understanding. The layout of the structured reports are, indeed, more appealing and the information is more clearly organized,[62] which could improve readability and facilitate locating critical information for patients. In the structured report, the information is divided into headings (e.g., clinical history, findings, and impression). It is easier for the patient to locate important information by looking at the headings. For instance, a patient can easily find the findings of the exam by looking at the findings section or the impression section of the report. The patient does not need to read through the whole report to find the information that he or she is looking for.

The structured report at its basic or second level can be suitable for a layperson if the language used in the report is simple and clear. However, the third level of structured radiology reporting requires the use of a standardized lexicon. The utilization of a standardized lexicon can be problematic for patients because the available standardized radiology lexicons have been created predominantly for health care providers, which might not be suitable for laypersons.[88] The structured radiology report used in this study was at the basic level. Therefore, it did not contain any standardized lexicons.

In the current study, out of the number of participants who had had a radiology exam before and had the chance to read their radiology report, around three-quarters (73%) did not

find it easy to understand their report. These findings are consistent with the social media analysis study (please refer to chapter II) as well as the previous studies,[26,40,47,58,64,65,71] which indicate that the radiology report can be complex and difficult for a layperson to understand. The radiology report contains medical terms, anatomical words, names of diseases, or terms used to express the level of certainty of the radiologists, which can be complicated and confusing. It is essential to have a medical background to understand the content of the radiology report. The radiology report *as is* should not be released via the patient portal to the patients. Most of the patients will not be able to comprehend their report; as a result, they will be more anxious and stressed.[47]

Most of the participants did not understand the typical MRI reports, with only 18% (for the spine MRI report) and 10% (for the brain MRI report) of the participants reporting that they understood the MRI reports. In other words, out of ten patients receiving their radiology reports via the patient portal, only one or two patients will understand the report. The findings of the study provide a strong indication that a layperson will not probably understand his or her radiology report as is. This could be due to the readability level, the language, and jargon used in the radiology report.[26,40,58] The findings of this study also support the results of the social media analysis (please refer to chapter II), which indicated that the majority of the posts (70%) asked for an interpretation of the radiology report. The radiology report in its current form is meant to be for referring physicians and is too difficult for a layperson to understand.

Two statistical tests, the Spearman's correlation test and the Fisher's exact test, were conducted to understand the relationship between patients' level of education and how much they understand from a typical radiology report. The results of the Spearman's correlation test

showed that there was no association between participants' level of education and their level of understanding of a radiology report. The results of the Fisher's exact test also was consistent with the results of the Spearman's correlation test, that is, there was no relationship between participants' level of education and their level of understanding of a radiology report. This means that even well-educated people might not be able to understand their radiology report.

The Spearman's correlation test and the Fisher's exact test were also conducted to see if there was a correlation between patients' health literacy skills and how much they understood from a typical radiology report. Interestingly, the findings of both tests revealed that no association was found between patients' health literacy skills and how much they understood from a typical radiology report. The findings strongly suggest that even people with good health literacy skills might not be able to comprehend their radiology report.

The results of the current study provide a strong confirmatory indication that there is no correlation between patients' level of understanding of their radiology report and their level of education or their health literacy skills. The radiology report can be as difficult to understand for well-educated, health-literate patients as it is for patients with a low education level and limited health literacy skills. The findings seems to suggest that the issue is not related to the patients' education level or their health literacy skills, but rather it is about the way the radiology report is written. The level of complexity and difficulty of the radiology report is so high that it is difficult even for a well-educated and health-literate person to understand. It appears to be that there is a need for a method to improve patients' understanding of their radiology report.

In this study, a method to improve patients' understanding of their radiology report, which is adding a patient summary statement, was investigated. Most of the participants understood the MRI reports when the patient summary statements were added at the end of the reports. The patient summary statement summarized the content of the radiology report in simple and easy-to-understand language. The vast majority of the participants (84%) thought that adding a summary statement at the end of the radiology report summarizing the content of the report in lay terms was a good method for improving their understanding of the report.

Alongside the subjective perspectives that the participants provided about the patient summary statement as a method to improve their understanding of the radiology report, the objective information was obtained by conducting the Wilcoxon signed rank test and the effect size. The difference of the laypersons' level of understanding of an MRI report before and after adding a patient summary statement is clear, as shown in Figure 5.2. The findings of the Wilcoxon signed rank test revealed that there was a significant difference between scores given for the participants' level of understanding of the MRI reports before adding the patient summary statement compared to after adding the patient summary statement. Adding a patient summary statement at the end of a radiology report summarizing the content of the report in lay terms can significantly enhance the participants' level of understanding of the reports. The effect size was very large, which means the improvement of the participants' level of understanding of the radiology reports was very large. Therefore, adding a patient summary statement is an effective method for improving patients' understanding of their radiology report.

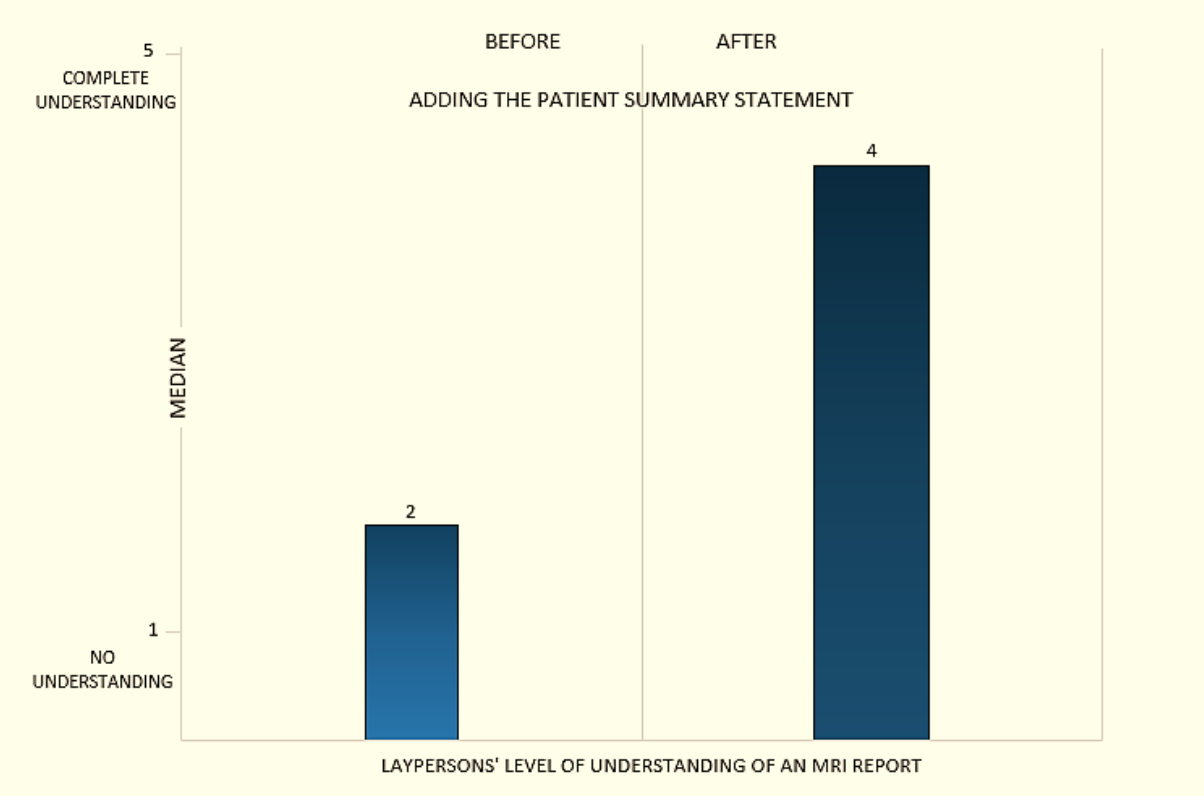


Figure 5.2: Laypersons' Level of Understanding of an MRI Report before and after Adding the Patient Summary Statement

Recommendations

Based on the results of the current study, it seems that adding the patient summary statement at the end of the radiology report summarizing the content of the report is an effective and efficient method for significantly improving the patient's level of understanding of the report. To make the full use of the patient summary statement, radiologists should pay attention to important aspects when writing the statement. Several aspects that the radiologists should consider are mentioned in the following paragraphs.

The findings of this study suggest that even well-educated and health-literate patients can face difficulties understanding their radiology report. Therefore, radiologists should not assume that their patients will understand their radiology report based on their level of

education or health literacy skills. The patient summary statement should be written in simple and plain language that a layperson can understand. Moreover, the radiologists should avoid using professional medical terms as much as possible in the patient summary statement.[72] Even medical terms that sound simple and easy to understand for someone who has a medical background might be difficult to understand for a layperson. For instance, in one study that investigated how much medical terminology patients understand, some participants defined the word ”chronic” as serious, deadly, or strong.[205] In the same study, around 57% of the subjects did not know the word “triglyceride,” and 62% of them did not know the term “edema”.[205]

Radiologists should also consider that not all patients are familiar with the locations and functions of the internal organs. Anatomical words can be very challenging to a layperson. For example, in one study, participants showed lack of knowledge of simple anatomy; only 20.2% and 42.1% of the participants were able to locate the stomach and the heart, respectively.[206] Therefore, when the radiologists write the patient summary statement, they should simplify their explanation about anatomical words as much as possible.

When generating a radiology report, the radiologists should pick the structured reporting type. This is because, as per the results of the current study, patients prefer the structured radiology report to the free-text report. Furthermore, they also think that the type of the radiology reporting affects their level of understanding. The level of the structured report, however, should be at its basic or second level, because the third level requires the use of a standardized lexicon. As mentioned before, the problem with the third level of structured

reporting is that the available standardized radiology lexicons have been mainly generated for health care providers, not for laypersons.[88]

The patient summary statement should be concise and brief, but complete and comprehensive. Radiologists should make the statement as short as they can, because long and detailed health information might cause stress to the patients.[40] This does not mean excluding any important information from the statement; but the statement should contain as much significant information as possible and omit information deemed insignificant. The completeness of the statement is important in order to give the patient the full picture of the content of the report. The patient summary statement should be free from spelling and grammar mistakes, because such mistakes might make the statement looks vague and confusing. When radiologists want to express their level of certainty in the statement, they should write it in percentages instead of using textual-based expressions such as “probably” and “possibly”.[51,72,95] The textual-based expressions used to express the radiologists’ level of confidence in their findings make the statement ambiguous and might lead to confusion and anxiety for patients.[51,85]

Limitations of the Study

Despite the several strengths of this study, some limitations should be noted. One of the limitations is that there is no standard or systematic way of writing the patient summary statement. This means that the patient summary statement is written solely based on the radiologists’ opinion, which might differ from radiologist to radiologist. However, since radiologists are the persons who write the report based on their clinical judgment and opinion,

it is up to them to decide what the best is for their patients when they write the patient summary statement. They should decide what type of information they consider important and include it in the statement, decide what type of information they consider insignificant and omit it from the statement, and choose the type of words that they consider simple and easy to understand for a layperson. Radiologists, however, should follow the recommendations mentioned in the previous section to maximize the benefits of the patient summary statement.

The current study used two repeated measurements on a single sample, which might have resulted in improved performance in the second measurement, due to the practice developed by participants of reading the report twice. However, to eliminate the effect that might develop by reading the same report twice, a note was added in the instructions of the questions for the second measurement. The note clearly instructed the participants to not read the report again and skip to the end of the report and read only the patient summary statement.

Future Work

The current study covered patients' needs and preferences regarding radiology test results on patient portals. There are several suggestions for future extensions to the current work. In this study, a method to improve patients' level of understanding of their radiology report was investigated. However, radiologists' point of view regarding adding the patient summary statement as a method to improve patients' level of understanding of their radiology report was not studied. In future research, this part of the topic could be explored in depth. One of the aspects that could be examined is whether radiologists will accept this method or

not. Furthermore, it is unknown how disruptive this method is to radiologists, so that also can be studied in future research.

Another suggestion that can extend the current study is investigating whether patients prefer the third level of structured radiology reporting when compared with the basic or second level. The structured radiology report used in this study was at the basic level, and participants preferred it to the free-text radiology report. The second level of structured radiology reporting is the same as the basic level except that the "findings" section in the second level includes subheadings for organs and organ systems. Therefore, for future research, the patients' perspectives pertaining the third level of structured radiology reporting can be investigated.

The findings of this study showed that people with a previous radiology exam experience, unexpectedly, were less in favor of receiving their radiology report via the online patient portal. This could be studied in future research, especially the reasons why they were less in favor of receiving their radiology report via the online patient portal. Once the causes are revealed, it is then, possible to search for solutions to overcome this issue.

Finally, the patient summary statement is written manually by the radiologists. In future research, ways to convert the manual method of writing the patient summary statement into semi-automated, then fully automated, approaches, via natural language processing (NLP) for example, could be researched. This was not investigated in this study because the effectiveness of the patient summary statement had not been studied before. Therefore, it was all the more necessary to study how effective this method is first before the transmission to an automated method of writing the patient summary statement.

Conclusions

Patients have the right to access their personal health information as per HIPAA regulations.[28] Based on this legal obligation, the ACR suggests that radiology reports be made readily available to patients via the online patient portal.[29] Most patients also prefer immediate access to their radiology test reports[34,35,55] through the online patient portal.[34,35] This could be achieved if the reports were made readily available on the patient portal directly from the radiologists.[56,57] However, this process can raise several issues, such as patient anxiety, due to the complexity and difficulty of the terms used in the report.[26,40,58]

The current practice of writing the radiology report, indeed, is not suitable for laypersons, as patients are becoming the end-readers of the radiology reports alongside their referring physicians.[27,38] Most patients will not understand their radiology report regardless of their level of education and their health literacy skills. There is a need for a method that is affordable and effective to fill in this gap and overcome this problem. Adding a patient summary statement at the end of the radiology report in lay terms summarizing the content of the report will significantly improve patients' understanding of the report.

There are two type of radiology reporting, free-text and structured radiology reporting. Radiologists have been using the free-text reporting as a way to create the radiology reports for more than a century.[97,98] However, most patients prefer the structured radiology report over the free-text radiology report. Most of them also think that the type of radiology report affects their level of understanding of the report.

It is necessary that health care services are delivered in ways that meet patients' needs and preferences to improve the health care quality.[37] This study provided in-depth insight into several aspects of the needs and preferences of the patients regarding radiology test results delivered through online patient portals. There is still a room to extend this study to cover other aspects of the needs and preferences of patients pertaining to the radiology test results delivered via patient portals to achieve the ultimate goal, which is enhancing the quality of health care.

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Appendix A: The Preliminary Survey

Dear participant,

My name is Mansour Almanaa and I am a PhD student at the University of Wisconsin-Milwaukee (UWM). I am conducting a study for my dissertation to investigate patients' needs and preferences regarding radiology test results on patient portals. The purpose of this study is to better understand what patients' needs and preferences pertaining to their radiology test results on patient portals in order to improve health care services.

If you are 18 years old or older, I would appreciate your assistance in completing this questionnaire, which may take approximately 15 minutes to complete. If you agree to complete this questionnaire, please answer the questions and return the questionnaire to the distributor. Your responses will be completely anonymous and will be used only for the research purposes.

If you have any questions, please contact me at malmanaa@uwm.edu. Thank you for your participation in this study.

Sincerely,

Mansour Almanaa

Please answer the following questions to the best of your ability by checking the box that best represents your answer.

Section 1 – Demographic information

The aim of this section is to gather unidentifiable demographic information of the participants.

1. What is your gender?
- ☐ Male
- ☐ Female

2. What is the highest level of education that you have completed?
- ☐ 8th grade or less
- ☐ High school graduate or GED
- ☐ Associate's degree
- ☐ Bachelor's degree
- ☐ Graduate degree

3. What is your age group?
- ☐ Less than 18
- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ Over 64

4. Are you a native English speaker?
- ☐ Yes
- ☐ No

5. If English is not your first language, how good is your English skills?
- ☐ Extremely good
- ☐ Good
- ☐ Neutral
- ☐ Bad
- ☐ Extremely bad

6. You have the computer skills necessary to use a secure website like an online patient portal.
- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

7. You have a good medical background.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

Section 2 – Health Literacy

This section is intended to measure the level of the participants' ability to deal with health information.

8. How confident are you filling out medical forms by yourself?

- 1- Extremely
- 2- Quite a bit
- 3- Somewhat
- 4- A little bit
- 5- Not at all

Section 3 – Radiology Test Results on an Online Patient Portal

The purpose of this section is to investigate the participants' level of understanding of the radiology report before and after adding a statement at the end of the report.

9. Have you ever had a radiology medical exam done on you?

- Yes
- No

10. Based on your experience, how easy was it to understand your radiology report?

- Very difficult
- Somewhat difficult
- Neither easy or difficult
- Somewhat easy
- Very easy

11. Do you prefer to receive your radiology test results online via the patient portal?

- Yes
- No

12. When possible, you would like to view your radiology images with the radiology report on the patient portal.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

13. Including your radiology images with the radiology report on the patient portal will help you understand your health problems.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

14. On a scale ranging from “No understanding” to “Complete understanding”, please rate your level of understanding of the following radiology report.

CLINICAL INFORMATION
Injury

COMPARISON
None

TECHNIQUE
MRI thoracic spine was examined in the AP, lateral and swimmer's projections.

FINDINGS
There is mild chronic-appearing anterior wedging of what is believed to represent T11 and 12 vertebral bodies. A mild amount of anterior osteophytic lipping is seen involving the thoracic spine. There is a suggestion of generalized osteoporosis. The intervertebral disc spaces appear generally well preserved. The pedicles appear intact.

IMPRESSION
1. Mild chronic-appearing anterior wedging of what is believed to represent the T11 and 12 vertebral bodies.
2. Mild degenerative changes of the thoracic spine.
3. Osteoporosis.

- ☐ No understanding
- ☐ Understand a little
- ☐ Understood about half
- ☐ Mostly understood
- ☐ Complete understanding

15. The information in this report is more confusing than helpful.
- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

16. The main issue with this report is unclear language and complexity.
- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

17. On a scale ranging from “No understanding” to “Complete understanding”, please rate your level of understanding of the following radiology report.

CLINICAL INFORMATION
Injury

COMPARISON
None

TECHNIQUE
MRI thoracic spine was examined in the AP, lateral and swimmer's projections.

FINDINGS
There is mild chronic-appearing anterior wedging of what is believed to represent T11 and 12 vertebral bodies. A mild amount of anterior osteophytic lipping is seen involving the thoracic spine. There is a suggestion of generalized osteoporosis. The intervertebral disc spaces appear generally well preserved. The pedicles appear intact.

IMPRESSION
1. Mild chronic-appearing anterior wedging of what is believed to represent the T11 and 12 vertebral bodies.
2. Mild degenerative changes of the thoracic spine.
3. Osteoporosis.

PATIENT SUMMARY STATEMENT:
No trauma-related injury observed. There are age-related changes and a decrease in the bone density of the spine.

- ☐ No understanding
- ☐ Understand a little
- ☐ Understood about half
- ☐ Mostly understood
- ☐ Complete understanding

18. On a scale ranging from “No understanding” to “Complete understanding”, please rate your level of understanding of the following radiology report.

CLINICAL INFORMATION
Dyspnea

COMPARISON
None

TECHNIQUE
MRI of the head performed without and with 12 ml of IV gadolinium (Magnevist).

FINDINGS
There are no abnormal/unexpected foci of contrast enhancement. There are no diffusion weighted signal abnormalities. There are minimal, predominantly periventricular, deep white matter patchy foci of FLAIR/T2 signal hyperintensity, the rest of the brain parenchyma appearing unremarkable in signal. The ventricles and sulci are prominent, but proportionate. Per T2 weighted sequence, there is no hyperdense vascularity. There are no calvarial signal abnormalities. There is no significant mastoid air cell fluid. No significant sinus mucosal disease per MRI.

IMPRESSION
1. No abnormal/unexpected foci of contrast enhancement; specifically, no evidence for metastases or masses.
2. No evidence for acute infarction.
3. Mild, scattered, patchy, chronic small vessel ischemic disease changes.
4. Diffuse cortical volume loss, consistent with patient's age.
5. Preliminary report was issued at the time of dictation.

- ☐ No understanding
- ☐ Understand a little
- ☐ Understood about half
- ☐ Mostly understood
- ☐ Complete understanding

19. The information in this report is more confusing than helpful.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

20. The main issue with this report is unclear language and complexity.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

21. On a scale ranging from “No understanding” to “Complete understanding”, please rate your level of understanding of the following radiology report.

CLINICAL INFORMATION
Dyspnea

COMPARISON
None

TECHNIQUE
MRI of the head performed without and with 12 ml of IV gadolinium (Magnevist).

FINDINGS
There are no abnormal/unexpected foci of contrast enhancement. There are no diffusion weighted signal abnormalities. There are minimal, predominantly periventricular, deep white matter patchy foci of FLAIR/T2 signal hyperintensity, the rest of the brain parenchyma appearing unremarkable in signal. The ventricles and sulci are prominent, but proportionate. Per T2 weighted sequence, there is no hyperdense vascularity. There are no calvarial signal abnormalities. There is no significant mastoid air cell fluid. No significant sinus mucosal disease per MRI.

IMPRESSION
1. No abnormal/unexpected foci of contrast enhancement; specifically, no evidence for metastases or masses.
2. No evidence for acute infarction.
3. Mild, scattered, patchy, chronic small vessel ischemic disease changes.
4. Diffuse cortical volume loss, consistent with patient's age.
5. Preliminary report was issued at the time of dictation.

PATIENT SUMMARY STATEMENT:
There are age-related changes appearing as a moderate decrease of blood supply to the small blood vessels in the brain; otherwise, normal study.

- No understanding
- Understand a little
- Understood about half
- Mostly understood
- Complete understanding

22. Adding a statement at the end of the report summarizing the content of the report in lay terms is a good method to improve your understanding of the report.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

23. There is no need for the details in the report because the summarizing statement at the end of the report explains the content of the report in lay terms and this is enough.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

24. Which type of the radiology reporting do you prefer of the two reports shown below?

Final Report	**Final Report**
Exam Number: XXXXX A 35-year-old male with a complaint of chest pain. There are no medical history. The chest x-ray images show normal cardiac contours. The lungs are clear and there are no pleural effusions. There is no evidence of pneumonia or pulmonary edema. No radiopaque foreign bodies are present. No acute cardiopulmonary disease.	**Exam Number:** XXXXX **Indication:** 35-year-old male with chest pain **Comparison:** No previous exam **Technique:** PA and lateral chest x-ray **Findings:** The cardiac contours are normal. The lungs are clear and there are no pleural effusions. There is no evidence of pneumonia or pulmonary edema. No radiopaque foreign bodies are present. **Impression:** No acute cardiopulmonary disease.
Free-Text Report	Structured Report

- ☐ Free-text report
- ☐ Structured report

25. The type of radiology reporting affects your level of understanding of the report.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

Appendix B: The Final Draft of the Survey

Dear participant,

My name is Mansour Almanaa and I am a PhD student at the University of Wisconsin-Milwaukee (UWM). I am conducting a study for my dissertation to investigate patients' needs and preferences regarding radiology test results on patient portals. A patient portal is an online website or application that gives patients secure, real-time, self-service access to their health information whenever and wherever they want as long as they have an internet connection. Radiology test results, which consist of radiology images and reports, are some of the information that is delivered via the patient portal. The practice of delivering radiology test results through patient portals has not reached its full maturity and still needs a great deal of improvement. The purpose of this study is to better understand what patients' needs and preferences are that pertain to their radiology test results on patient portals in order to improve health care services.

I would appreciate your assistance in completing this questionnaire, which may take approximately 15 minutes to complete. Please only complete this questionnaire once. If you agree to complete this questionnaire, please answer the questions as thoughtfully and honestly as possible and return the questionnaire to the distributor. Your participation in this questionnaire is completely voluntary. If you do not wish to participate, simply discard the questionnaire. If you decide to participate in this questionnaire, you may withdraw at any time. There are no negative consequences, whatever you decide. There are no direct benefits to participating in this study. Your responses will be completely anonymous and will be used only for the research purposes.

Please complete this questionnaire only if you are 18 years old or older, able to understand the English language, do not have a medical background, and have basic computer skills.

For questions about your rights as a research participant, complaints, or problems: Contact the UWM Institutional Review Board (IRB) at 414-229-3173 or irbinfo@uwm.edu.

If you have any questions or need additional information, please contact me at malmanaa@uwm.edu. Thank you for your time and help.

Sincerely,

Mansour Almanaa

Please answer the following questions to the best of your ability by checking the box that best represents your answer. Select only one answer per question. Please remember that the information you provide will be treated in a confidential manner.

Section 1 – Demographic information

The aim of this section is to gather unidentifiable demographic information of the participants. The information collected will be used to compare the groups of respondents.

1. What is your gender?
- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Prefer not to answer

2. What is the highest level of education that you have completed?
- ☐ 8th grade or less
- ☐ High school graduate or General Educational Development (GED)
- ☐ Associate's degree
- ☐ Bachelor's degree
- ☐ Graduate degree

3. What is your age group?
- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ Over 64

4. What do you consider to be your racial background?
- ☐ White
- ☐ Black or African American
- ☐ Asian
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Other

5. Is English your first language?
- ☐ Yes (Skip to question 7)
- ☐ No

6. If English is not your first language, how good are your English skills (Please rate your answer on a scale ranging from “Extremely good” to “Extremely bad”)?

- ☐ Extremely good
- ☐ Good
- ☐ Neutral (neither good nor bad)
- ☐ Bad
- ☐ Extremely bad

7. Do you have the computer skills necessary to use a secure website like an online patient portal?

- ☐ Yes
- ☐ No

8. Do you have a medical background (e.g., have any clinical training or earned a health-related degree)?

- ☐ Yes
- ☐ No

Section 2 – Health Literacy

This section is intended to measure the level of the participants’ ability to deal with health information.

9. How confident are you filling out medical forms by yourself?

- ☐ 1- Extremely
- ☐ 2- Quite a bit
- ☐ 3- Somewhat
- ☐ 4- A little bit
- ☐ 5- Not at all

Section 3 – Radiology Test Results on an Online Patient Portal

The purpose of this section is to investigate the participants' level of understanding of the radiology report before and after adding a statement at the end of the report. This section is also intended to determine the participants' preference regarding the radiology reporting type.

10. Have you ever had a radiology medical exam done on you, such as X-Ray, CT, MRI, Nuclear Medicine, Ultrasound, etc.?

- ☐ Yes
- ☐ No (Skip to question 13)

11. Have you had the chance to read your radiology report?

- ☐ Yes
- ☐ No (Skip to question 13)

12. Based on your experience, how easy was it to understand your radiology report?

- ☐ Very difficult
- ☐ Somewhat difficult
- ☐ Neither easy or difficult
- ☐ Somewhat easy
- ☐ Very easy

13. Do you prefer to receive your radiology test results online via the patient portal?

- ☐ Yes
- ☐ No
- ☐ Undecided

14. Please imagine that you are at home, and you log onto the online patient portal and pull up this report on the evening of the day that you had your MRI done on your back after a fall injury. Please rate your level of understanding of the following radiology report on a scale ranging from "No understanding" to "Complete understanding." (Please use your current knowledge and do not search definitions).

CLINICAL INFORMATION
Injury

COMPARISON
None

TECHNIQUE
MRI thoracic spine was examined in the AP, lateral and swimmer's projections.

FINDINGS
There is mild chronic-appearing anterior wedging of what is believed to represent T11 and 12 vertebral bodies. A mild amount of anterior osteophytic lipping is seen involving the thoracic spine. There is a suggestion of generalized osteoporosis. The intervertebral disc spaces appear generally well preserved. The pedicles appear intact.

IMPRESSION
1. Mild chronic-appearing anterior wedging of what is believed to represent the T11 and 12 vertebral bodies.
2. Mild degenerative changes of the thoracic spine.
3. Osteoporosis.

- ☐ No understanding
- ☐ Understand a little
- ☐ Understood about half
- ☐ Mostly understood
- ☐ Complete understanding

15. According to the radiology report in question 14, are there changes in the structure of the spine caused by trauma?

- ☐ Yes
- ☐ No
- ☐ Not sure

16. In the report below, a statement that summarizes the content of the report (from question 14) has been added at the end of the report. There is **NO NEED** to read the report again. Please **SKIP** to the end of the report and read the patient summary statement. After reading this statement, on a scale ranging from "No understanding" to "Complete understanding," please rate your level of understanding of the following radiology report. (Please use your current knowledge and do not search definitions).

CLINICAL INFORMATION
Injury

COMPARISON
None

TECHNIQUE
MRI thoracic spine was examined in the AP, lateral and swimmer's projections.

FINDINGS
There is mild chronic-appearing anterior wedging of what is believed to represent T11 and 12 vertebral bodies. A mild amount of anterior osteophytic lipping is seen involving the thoracic spine. There is a suggestion of generalized osteoporosis. The intervertebral disc spaces appear generally well preserved. The pedicles appear intact.

IMPRESSION
1. Mild chronic-appearing anterior wedging of what is believed to represent the T11 and 12 vertebral bodies.
2. Mild degenerative changes of the thoracic spine.
3. Osteoporosis.

PATIENT SUMMARY STATEMENT:
No trauma-related injury was observed. There are age-related changes and a decrease in the bone density of the spine.

- ☐ No understanding
- ☐ Understand a little
- ☐ Understood about half
- ☐ Mostly understood
- ☐ Complete understanding

17. Does the radiology report in question 16 show that there is a spinal fracture?
- ☐ Yes
- ☐ No
- ☐ Not sure

18. Please imagine that you are at home, and you log onto the online patient portal and pull up this report on the evening of the day that you had your MRI done on your head after you suffered from a shortness of breath. On a scale ranging from “No understanding” to “Complete understanding,” please rate your level of understanding of the following radiology report. (Please use your current knowledge and do not search definitions).

CLINICAL INFORMATION
Dyspnea

COMPARISON
None

TECHNIQUE
MRI of the head performed without and with 12 ml of IV gadolinium (Magnevist).

FINDINGS
There are no abnormal/unexpected foci of contrast enhancement. There are no diffusion weighted signal abnormalities. There are minimal, predominantly periventricular, deep white matter patchy foci of FLAIR/T2 signal hyperintensity, the rest of the brain parenchyma appearing unremarkable in signal. The ventricles and sulci are prominent, but proportionate. Per T2 weighted sequence, there is no hyperdense vascularity. There are no calvarial signal abnormalities. There is no significant mastoid air cell fluid. No significant sinus mucosal disease per MRI.

IMPRESSION
1. No abnormal/unexpected foci of contrast enhancement; specifically, no evidence for metastases or masses.
2. No evidence for acute infarction.
3. Mild, scattered, patchy, chronic small vessel ischemic disease changes.
4. Diffuse cortical volume loss, consistent with patient's age.
5. Preliminary report was issued at the time of dictation.

- ☐ No understanding
- ☐ Understand a little
- ☐ Understood about half
- ☐ Mostly understood
- ☐ Complete understanding

19. Does the radiology report in question 18 show changes in the brain or in the blood supply to the brain?

- ☐ Yes
- ☐ No
- ☐ Not sure

20. In the report below, a statement that summarizes the content of the report (from question 18) has been added at the end of the report. There is **NO NEED** to read the report again. Please **SKIP** to the end of the report and read the patient summary statement. After reading this statement, on a scale ranging from "No understanding" to "Complete understanding," please rate your level of understanding of the following radiology report. (Please use your current knowledge and do not search definitions).

CLINICAL INFORMATION
Dyspnea

COMPARISON
None

TECHNIQUE
MRI of the head performed without and with 12 ml of IV gadolinium (Magnevist).

FINDINGS
There are no abnormal/unexpected foci of contrast enhancement. There are no diffusion weighted signal abnormalities. There are minimal, predominantly periventricular, deep white matter patchy foci of FLAIR/T2 signal hyperintensity, the rest of the brain parenchyma appearing unremarkable in signal. The ventricles and sulci are prominent, but proportionate. Per T2 weighted sequence, there is no hyperdense vascularity. There are no calvarial signal abnormalities. There is no significant mastoid air cell fluid. No significant sinus mucosal disease per MRI.

IMPRESSION
1. No abnormal/unexpected foci of contrast enhancement; specifically, no evidence for metastases or masses.
2. No evidence for acute infarction.
3. Mild, scattered, patchy, chronic small vessel ischemic disease changes.
4. Diffuse cortical volume loss, consistent with patient's age.
5. Preliminary report was issued at the time of dictation.

PATIENT SUMMARY STATEMENT:
There are age-related changes appearing as a moderate decrease of blood supply to the small blood vessels in the brain; otherwise, normal study.

- ☐ No understanding
- ☐ Understand a little
- ☐ Understood about half
- ☐ Mostly understood
- ☐ Complete understanding

21. Does the radiology report in question 20 reveal any tumors or hemorrhages (bleeding) in the brain?

- ☐ Yes
- ☐ No
- ☐ Not sure

22. Please rate your answer on a scale ranging from “Strongly agree” to “Strongly disagree.” Adding a statement (i.e., Patient Summary Statement) at the end of the report summarizing the content of the report in lay terms is a good method to improve your understanding of the report.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

23. Between the following two types of radiology reports, which one do you prefer? (Please note that the content in both reports is the same).

Final Report	**Final Report**
Exam Number: XXXXX A 35-year-old male with a complaint of chest pain. There are no medical history. The chest x-ray images show normal cardiac contours. The lungs are clear and there are no pleural effusions. There is no evidence of pneumonia or pulmonary edema. No radiopaque foreign bodies are present. No acute cardiopulmonary disease.	**Exam Number:** XXXXX **Indication:** 35-year-old male with chest pain **Comparison:** No previous exam **Technique:** PA and lateral chest x-ray **Findings:** The cardiac contours are normal. The lungs are clear and there are no pleural effusions. There is no evidence of pneumonia or pulmonary edema. No radiopaque foreign bodies are present. **Impression:** No acute cardiopulmonary disease.
Free-Text Report	Structured Report

- ☐ I prefer a free-text report
- ☐ I prefer a structured report
- ☐ No preference

24. Based on your response to question 23, please rate your answer on a scale ranging from “Strongly agree” to “Strongly disagree”. The type of radiology reporting (free-text or structured) affects your level of understanding of the report.

- ☐ Strongly agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly disagree

Curriculum Vitae

Name: Mansour Abdulaziz Almanaa

Education

Name of University	Country	City	Name of College	Major	Degree of Scientific Qualification	Month and Year of Graduation
King Saud University	Kingdom of Saudi Arabia	Riyadh	College of Applied Medical Sciences	Radiological Sciences	Bachelor of Science	July 2009
Thomas Jefferson University	The United States of America	Philadelphia, Pennsylvania	School of Health Professions	Radiologic and Imaging Sciences	Master of Science	August 2013
Indiana University - Purdue University Indianapolis	The United States of America	Indianapolis, Indiana	School of Informatics and Computing	Health Informatics	Master of Science	May 2017
University of Wisconsin - Milwaukee	The United States of America	Milwaukee, Wisconsin	College of Engineering and Applied Science	Biomedical and Health Informatics	Doctor of Philosophy	May 2020

Honors

- Member of Lambda Nu (A national honor society for the radiologic and imaging sciences, Pennsylvania Gamma Chapter).
- Member of the Golden Key International Honour Society (Indiana University - Purdue University Indianapolis Chapter).
- Member of the Honor Society of Phi Kappa Phi (University of Wisconsin - Milwaukee Chapter).