Advanced Radiology Reporting and Analytics with *rScriptor*

vRad results after 10 million radiology reports

Introduction

rScriptor, a product of Scriptor Software, is a vendor neutral, cloud-based radiology reporting system that creates, validates, normalizes and analyzes radiology reports. It integrates with virtually any voice recognition system to create high-quality radiology reports from disorganized dictations. At the heart of *rScriptor* is a sophisticated Natural Language Processing (NLP) engine that was specifically designed to process radiology reports.

This software was licensed to vRad in January of 2014 and since this time has been used to create more than 10 million radiology reports. From the initial roll-out period to present Scriptor Software and vRad have worked together to improve both report quality and radiologist workflow. This whitepaper describes the results of this effort.

Interface and Installation

rScriptor is a client/server application that resides on the radiologist's workstation and interfaces with virtually any voice recognition or word processing software through the use of the computer's clipboard. It copies an unformatted and disorganized dictation from the voice recognition system to the computer's clipboard, reorganizes it into a detailed and complete radiology report, uses NLP to validate the report (checks for errors, billing/coding/MIPS compliance and completeness) and then pastes the report from the clipboard back into the dictation window. At this point the radiologist can dictate additional information, correct any errors or omissions found by *rScriptor* and then sign the report.

It is important to note that unlike other software applications that post-process radiology reports looking for errors and billing/coding/MIPS deficiencies, *rScriptor* identifies these problems *before* the report is signed. This gives the radiologist the opportunity to correct any reporting errors and prevents these errors from appearing in the final report.

With *rScriptor* a practice measures how many reporting errors or deficiencies were *avoided* rather than how many were made. This information along with other data is used to generate reports that document the continuous quality improvements made by a practice over time. These reports can be generated on a weekly, monthly or quarterly basis and provide a practice with the hard data they need to document the value the practice brings to the healthcare system. This information is becoming increasingly important as healthcare continues its transition from a volume-based payment system to a value-based system.

rScriptor installation is as simple as placing the software on the radiologist's desktop. No software integration is required. A very small Graphical User Interface (GUI) is visible on the workstation or can be minimized. Interaction with *rScriptor* can be performed using the GUI, hotkeys or voice commands.

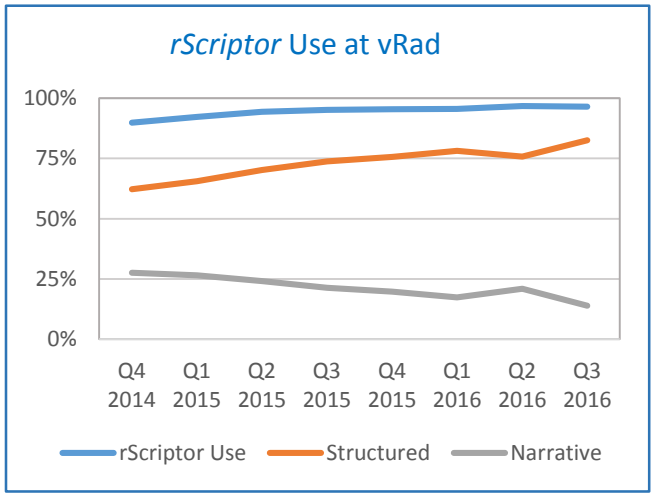
Roll-out

After thorough testing of *rScriptor* at vRad in late 2013, roll-out to approximately 350 radiologists began in January 2014 and continued for approximately 9 months. Each radiologist received one-on-one training from a vRad trainer on the use of the software. The message to the radiologists regarding *rScriptor* was simple (paraphrasing): "The medical leadership feels this software will be helpful in regards to report quality, billing/coding compliance and error reduction and would like all radiologists to learn how to us it."

A key component to this message was that the radiologists were not required to change the way they were dictating. If they were accustomed to creating narrative radiology reports they were welcome to continue dictating these reports and rScriptor would simply fill in the objective portions of the report for them (procedure title, technique, indication, etc.). If they wanted to create structured reports (those with a uniform structure but also with itemized anatomical descriptions) they were welcome to use *rScriptor*'s structured reporting capabilities.

Structured Reporting

After the initial roll-out period the number of structured radiology reports, narrative reports and reports not created by *rScriptor* were measured. This was done automatically based upon information contained in the signed reports. The percentage of radiologists dictating structured reports increased from less than 20% prior to *rScriptor* to 62% immediately following roll-out. Since that time the percentage of vRad reports which are structured has increased further to 82%. The percentage of reports created by *rScriptor* has also increased from approximately 90% after roll-out to greater than 96% in Q3 of 2016.



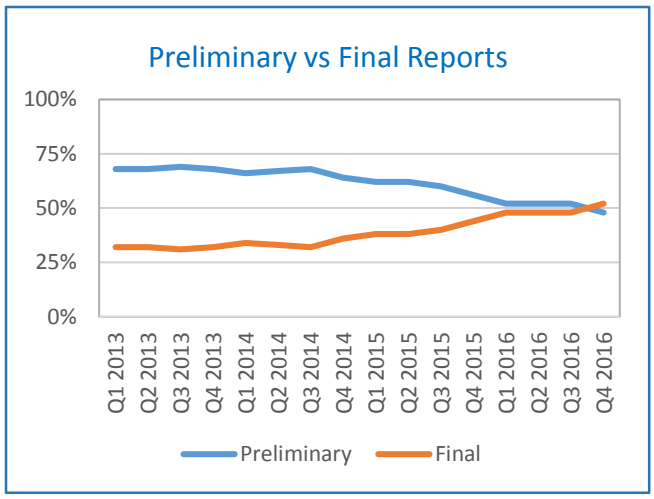
Why were the majority of radiologists transitioning from narrative reporting to structured reporting when they were not required to do so? Because most found it more efficient to dictate only the positive findings of a structured report rather than both the positive and negative findings of a narrative report. *rScriptor* also allowed them to dictate both the Findings and Impression sections *simultaneously*, something that was not possible with narrative reporting. Finally, many radiologists found they preferred structured reporting over narrative reporting when they were given a tool that could easily produce either type of report.

The transition to structured reporting was well-received by the referring physicians. By the end of 2016, 114 clients requested that they receive only structured reports while there was not a single client request to receive only narrative reports.

Preliminary vs Final Reports

As a teleradiology practice vRad provides its clients with the option of receiving preliminary reports (those that are later over-read by the onsite radiologist) or final reports (those that vRad bills directly). Historically the preliminary reports were brief and focused on the more significant findings while the final reports were complete and were in a form ready for billing. With the introduction of *rScriptor* the differences between preliminary and final reports largely disappeared. There was sometimes less detail in the findings section of the preliminary report and comparison studies were not always available for preliminary studies but otherwise the reports were very similar.

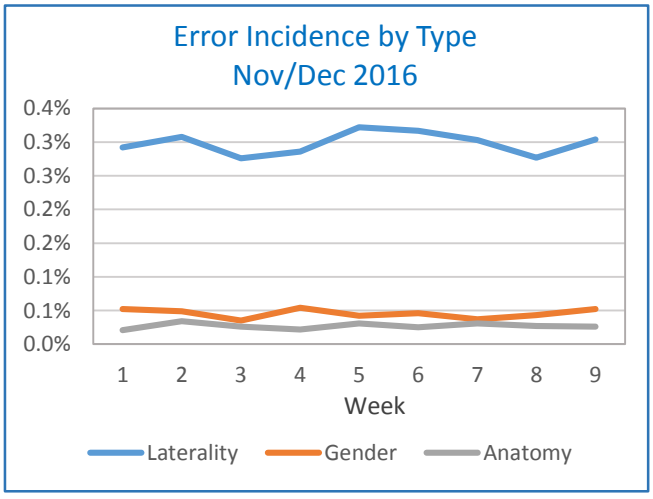
The radiology practices receiving preliminary reports took notice of this change. Many who had been over-reading a more abbreviated preliminary report for years were now receiving final quality reports. It no longer made



sense to spend time over-reading these reports when the reports were of sufficient detail to be billed directly. This was one of several factors that allowed vRad to transition from a teleradiology practice where the majority of reports dictated were preliminary reports to one where (for the first time in Q4 of 2016) the majority were final reports.

Error Reduction

At the time of report creation *rScriptor* validates each report by checking for several common reporting errors. These errors fall into the categories of laterality (e.g. left mentioned in a right extremity report), gender (e.g. hysterectomy in a male) or anatomical description (e.g. metatarsal mentioned in an upper extremity study) errors. We looked at the number of error messages displayed to the radiologists for the last 9 weeks of 2016.

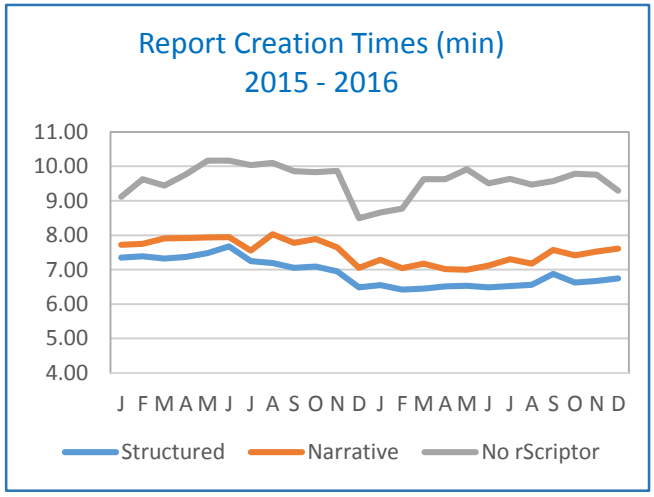


As this chart demonstrates, these types of errors occur at a steady rate over time. A workflow in which errors are identified after they have occurred in the hopes of teaching the radiologists not to make the same errors in the future will in general not be effective. It is necessary to identify these errors before they appear in the final report so that they can be corrected. This is the workflow built into *rScriptor*.

Although the impact is difficult to quantify, many radiologists have found that structured reporting itself has helped them ensure they have completely reviewed all of the patient's anatomy. The structured report acts as a "checklist" of sorts at the end of the review process.

Productivity

To evaluate the impact of *rScriptor* on radiologist productivity we looked at all reports created at vRad in 2015 and 2016 and divided each report into one of three categories: structured reports created in *rScriptor*, narrative reports created in *rScriptor* and reports in which *rScriptor* was not used. All reports were created using the same vRad Picture Archiving and Communication System (PACS) interface and dictation system. The time between when the case was opened and when the report was



signed was averaged for each calendar month. The chart demonstrates that at no time did *rScriptor* decrease the productivity of the radiologists. On average radiologists using *rScriptor* to create structured reports required 6.9 minutes for each report, those dictating narrative reports

using *rScriptor* required 7.5 minutes and those not using *rScriptor* required 9.6 minutes.

rScriptor's ability to write large portions of the report automatically (such as report title, technique, report headings, anatomical structure titles, procedure codes, etc.), its ability to fill in negative findings in structured reports and its ability to support the simultaneous dictation of the Findings and Impression sections is most likely responsible for the differences in productivity.

vRad's efforts have also increased productivity through the development of a standardized method to pass relevant information to *rScriptor* such as the patient history, contrast type and volume, comparison exam descriptions, standardized procedure names and many other relevant pieces of information. This information is passed to *rScriptor* via a macro inserted into the top of the dictation window. Although this data can be supplied by the radiologist at the start of each dictation, the ability to automatically insert it into the report allows the radiologist to focus on dictating the findings only and eliminates the need to dictate all of the objective data required for a complete radiology report.

Billing and Coding

One of the challenges of any radiology practice is satisfying the myriad of billing, coding and reporting requirements which are now commonplace in all of medicine. For an organization like vRad this is especially difficult due to the sheer size of the company with 400+ radiologists serving more than 2000 health care organizations in all 50 states. The ability of *rScriptor* to perform billing and coding validation on every report before it is signed has been very helpful in achieving maximum reimbursement.

To make this possible *rScriptor* is continually updated to keep pace with changes made by the Centers for Medicare & Medicaid Services (CMS), Current Procedural Terminology (CPT) and International Classification of Disease (ICD) coding systems. *rScriptor* report templates satisfy both the CPT coding system but also the more detailed ICD-10 coding system. Report template updates are sent out to all practices as soon as a CMS, CPT or ICD-10 coding system change goes into effect. The structured reporting capability of *rScriptor* also ensures that all required anatomy for a particular exam is mentioned in the report.

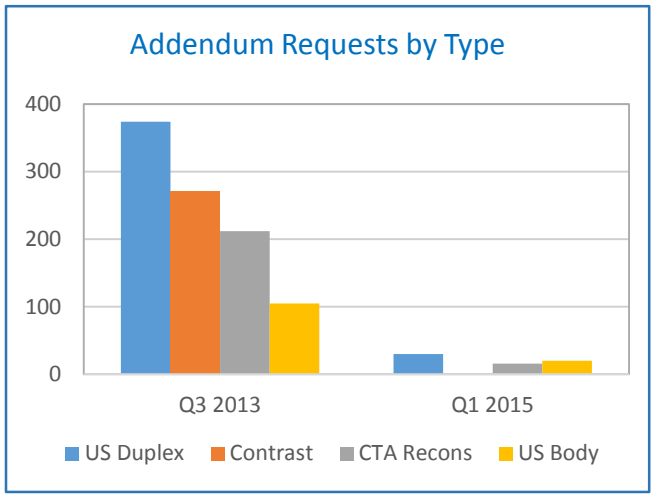
If information is missing for a particular exam and that information is required for proper billing/coding, a simple order correction window is displayed allowing the radiologist to provide that information via check boxes or by providing the necessary numerical values. A typical example is a CTA Chest report. In order to bill for a CTA exam either three-dimensional (3-D) reformatted images or Maximum Intensity Projected (MIP) images must be present in the study. Otherwise it is down-coded to a CT Chest exam. In order to avoid any inadvertent down-coding and subsequent loss of revenue *rScriptor* will check the order to see if either type of reformatted image is mentioned in the order. If not specified it will ask the radiologist if these images are present and if so will add that information to the Technique section of the report. The result is that the radiology practice avoids the all too common problem of under-coding and loss of revenue that to some degree affects all radiology practices.

The order correction window is also commonly launched by the radiologists themselves when they discover the order is incorrect or does not include all of the procedures which are present in the study.

To determine the magnitude of the problem under-coding or incorrect coding poses to vRad we looked at all reports dictated with *rScriptor* in December of 2016. We found that the order correction window opened automatically by *rScriptor* or was launched by the radiologist 27,044 times or for 6.2% of the reports. Preventing such a large number of documentation errors from appearing in the final reports allowed vRad to avoid the incorrect billing of a large number of exams.

rScriptor was also able to identify health care facilities which routinely send problematic orders. In December of 2016 *rScriptor* identified a single site that sent 983 orders that required radiologist intervention to correct the order. It was also able to identify the specific data which was incorrect or missing in these orders. The ability to identify specific sites that require attention is very helpful in optimizing the workflow from order entry to signed report.

Like most radiology practices, vRad sends documentation deficiencies in reports back to the radiologists for addenda. We looked at the number of addenda requests for the four most common report deficiency types in the quarter before *rScriptor* testing (Q3 2013) and in the quarter after roll-out and widespread use (Q1 2015). The requests fell into four categories: inadequate Technique section for Duplex US exams, failure to mention if contrast was present on a CT or MR exam, failure to mention the presence of MIP or 3-D reconstructed images on a CTA exam and failure to include all of the relevant anatomy on an US exam.



As the chart demonstrates there was a 93.1% decrease in the need for addenda following widespread use of *rScriptor* at vRad. The decline corresponds almost exactly with the percentage of reports created with *rScriptor* in Q1 2015 (approximately 92%). The addenda requests that remained were primarily due to the 8% of radiologists who were still not using *rScriptor* or who removed portions of the *rScriptor* report which were required for proper billing and coding.

PQRS and ICD-10

Just as *rScriptor* can identify billing/coding problems within a report, it can also detect Physician Quality Reporting System – PQRS (in 2017 called the Merit-Based Incentive Payment System - MIPS) and ICD-10 errors or deficiencies within reports. Many of these are not errors in the order or in the Technical section of the report such as those described in the preceding paragraphs. They are instead problems with the way in which the radiologist described a specific finding in the report or recommended follow-up for a finding.

For example, the 2016 PQRS measure #195 requires that the description of an internal carotid artery (ICA) stenosis use the NASCET method (for cross-sectional exams) or an indirect velocity method (for duplex ultrasound exams). *rScriptor* uses its NLP engine to verify that either there was no stenosis described in the report or that the stenosis measured followed the PQRS measure #195 guidelines. If not, a message is displayed to the radiologist giving them instructions on how to correct the description to meet this PQRS requirement.

In December of 2016 *rScriptor* found 4187 ICD-10 and 248 PQRS deficiencies in vRad reports. These were corrected before the reports were signed and therefore never contributed to the practice's PQRS failure rate. The warning messages also educate the radiologists on what is required by PQRS and ICD-10. Over time they change the way in which they report these findings and the number of warning messages for the same measure tends to decrease. This information is collected and used in *rScriptor* analytics reports to provide hard data of process improvements made by the radiology practice over time.

Acuity of Findings

rScriptor automatically assigns one of five levels of acuity to every finding in the report: Negative, Incidental, Positive, Acute or Critical. The radiologist can change the acuity level of any finding by adding a "modifier" word to any dictated finding. They do this while dictating the finding and do not have to take their eyes off of the images to change the acuity level. The modifier word itself does not appear in the final report. With the acuity levels set the Impression section of the report can be (optionally) ordered based upon acuity with the most acute findings appearing at the top of the Impression.

Every radiology report can also (as an option) be automatically searched for critical findings. The *rScriptor* NLP algorithm understands not only whether a critical finding was mentioned but also if it was mentioned in the negative (i.e. a specific statement was made that the finding was not present), is a follow-up exam describing a

change or if what would normally be a critical finding is not critical due to information found elsewhere in the report (using the knowledge of a radiologist).

For example, the description of a pneumothorax can be assigned an acuity level anywhere between Negative and Critical depending on the description:

Negative: There is no pneumothorax.

Positive: There is a tiny residual pneumothorax in the left lung apex. A chest tube is in place.

Critical: 30% left-sided pneumothorax.

The NLP algorithm in *rScriptor* understands the differences between each of these statements and can assign the appropriate acuity level automatically.

Critical Findings Workflow

rScriptor can be configured to activate the critical findings workflow of any radiology practice. It will activate this workflow (through interactions with other software on the workstation) when either *rScriptor* detects the presence of a critical finding in the report (through the use of NLP) or the radiologist indicates that there is a critical finding in the report. If a practice does not use software to manage critical findings *rScriptor* will simply warn the radiologist when it detects a critical finding that was not marked critical by the radiologist. This acts as a reminder to directly communicate this critical finding to the responsible caregiver.

Each radiology practice decides what findings are considered critical in their practice and only those findings are marked as critical at the time the report is created. This process is intended to help a practice maximize the quality of care they provide and comply with the Joint Commission's National Patient Safety Goal 2 (NPSG-2) requirement for verbal communication of critical diagnoses. This data is collected for use in rScriptor analytics reports to provide evidence of the quality of care provided by the radiology practice.

Customization

rScriptor comes preconfigured with over 200 report templates that expand to more than 1000 templates based upon the presence or absence of contrast, the laterality, the ultrasound probe type (when applicable) the age of the patient and several other factors. These report templates can be customized by both the radiology practice and by the individual radiologists as needed.

Additionally, *rScriptor* reports can be formatted differently for different health care organizations served by the radiology practice. For example, if a particular Orthopedic practice wants to receive double-spaced reports with the Impression at the top of the report *rScriptor* can automatically format the reports in this fashion. Other sites without specific formatting requirements will be formatted in the default manner chosen by the practice. The radiologists do not need to change how they dictate. *rScriptor* takes care of the formatting requirements for each site.

rScriptor can also handle special content requests made by health care organizations. For example, one of the facilities that vRad serves asked that the radiologists always comment on the location of the markers placed on the patient for an MR Thoracic Spine exam. Prior to *rScriptor* that would have been very difficult to accommodate with 400+ radiologists reading for 2000+ different facilities. But *rScriptor* can easily accommodate this request and if there is no mention of a marker for this facility and this exam type it will issue a message to the radiologist asking them to mention the marker locations.

Knowledge Base

Radiologists commonly use tabulated data or flowcharts when reading certain types of radiology reports. For example, velocity tables in arterial US exams, trauma grading scales for solid organ or vascular injuries or ACR incidental findings flowcharts for certain cross-sectional or ultrasound findings. This information is either committed to memory when encountered frequently or looked up when encountered infrequently. It is readily available in textbooks and on the Internet but can be frustrating to locate when one requires it for a radiology report.

rScriptor has addressed this problem by incorporating much of this information into a "Knowledge Base" allowing instant access to this data from the *rScriptor* GUI. ACR incidental findings follow-up guidelines, Trauma grading tables, vascular tables, PIOPED II criteria, Merit-Based Incentive Payment System measures for radiology, etc. are all immediately available for review.

All of the ACR incidental findings guidelines have been converted from flowchart form into a series of questions that the radiologist answers through button selections on the GUI. At the end of these questions (typically 3-6 questions) they are presented with the ACR guidelines recommendation for that particular finding. The appropriate recommendation can then be automatically inserted into their report with or without the associated journal article reference mentioned as part of the recommendation. *rScriptor* also provides the radiologist with immediate access to this journal article should they wish to review the article before making a recommendation.

In December of 2016 there were 8,011 pages of the *rScriptor* Knowledge Base reviewed by vRad radiologists. Approximately 59% of these were to access ACR incidental findings follow-up guidelines, 10% to review trauma grading tables and 6% to review vascular tables. 1573 ACR incidental findings guideline recommendations were directly inserted into vRad reports in this month alone.

Normalization

vRad is one of the leaders in radiology data normalization and benchmarking through the development of their patented Radiology Data Processing Standardization Techniques and Radiology Patient Care (RPC) Indices. vRad and Scriptor Software expanded upon their normalization system to add "body focus" modifiers to each normalized exam name allowing this CPT based system to expand to the more detailed ICD-10 coding system.

For radiology practices without access to a data normalization tool, *rScriptor* manages the data normalization process for them using its own proprietary data normalization algorithms. For example, *rScriptor* understands that a "CT Head without contrast" is the same as a "CT Brain WO" which is the same as a "CT Head/Brain W/O". It has the ability to *learn* new exam titles that it has not seen in the past and assign these to the proper radiology report templates in the future. The end result is a normalized set of data that follows both the CPT and ICD-10 coding systems. This data is collected along with a wealth of other information as described earlier in this report.

Normalization also extends to the Findings level of each report within *rScriptor*. For example, the anatomical sections of the radiology reports are standardized across all modalities and all exams. Even narrative reports are processed internally within *rScriptor* to place findings in the anatomical sections of what would be the equivalent structured report. This allows data in narrative reports to be available for data analytics. Acuity levels for all findings are also standardized and assigned for each anatomical structure in the report.

Because *rScriptor* is vendor neutral, data is collected and normalized independent of the PACS or voice recognition system utilized at a particular location. For example, a radiology practice may be reading from 5 different locations with 3 different PACS systems and 2 different voice recognition systems all of which are incapable of sharing data. With *rScriptor* the variety and number of PACS and voice recognition systems is irrelevant. It collects normalized data from all systems simultaneously.

Analytics

The large collection of detailed and normalized data collected by *rScriptor* during the report creation process is used to provide a radiology practice with a wide variety of useful reports. These *rScriptor* reports can be generated at any frequency and fall into the broad categories of volume, quality and technical measures.

Volume measures are those most commonly used in radiology practices today and include the number of exams read by a radiology practice by modality, day of week, time of day, facility, referring physician or radiologist. They are very useful in the management of a radiology practice.

Quality measures collected by *rScriptor* include the number and types of errors *prevented* in reports, count of

MIPS-compliant reports, number of MIPS deficiencies prevented in reports, count of ICD-10 deficiencies prevented in reports, number and types of Medicare coding errors corrected, critical findings counts and types, number of ACR incidental findings guideline recommendations inserted into reports and number of ACR incidental findings-compliant reports dictated. *rScriptor* analytics give a practice the hard data needed to demonstrate the quality of care they provide to the patients they serve.

Technical measures collected by *rScriptor* include the operating systems and versions in use by the radiologists, domain and server names, CPU architecture, total RAM available on these workstations and percentage of RAM in use.

Conclusions

Due to its vendor neutral and cloud-based design, *rScriptor* can create, validate, normalize and analyze data from *all facilities* served by a radiology practice. This eliminates the problem of data interoperability which would otherwise prevent data from disparate PACS and voice recognition systems from being shared. Detailed analytics are performed on this data automatically and at any desired frequency.

The analytics reports are designed to not only provide details on case volumes but also on the quality of care a radiology practice provides to their respective healthcare facilities. The ability to analyze and document quality measures is becoming increasingly important as practices transition from a volume-based payment system to a quality-based system.

This whitepaper describes the impact *rScriptor* had on radiology reporting at vRad during calendar years 2014 through 2016. The improvements cited were due to a combined efforts of both Scriptor Software and vRad with the goal of maximizing report quality and value for the patients and health care systems vRad serves.

vRad results for 2014 through 2016 demonstrate:

- 10,769,405 reports (8,480,074 of which were structured reports) were created with *rScriptor*
- Percentage of final reports has increased from 34% to 53% over this time period
- 93% reduction in the need for addenda

vRad results for December 2016 demonstrate:

- *rScriptor* prevented 1651 potential reporting errors
- Documented 1573 ACR incidental follow-up recommendations inserted into reports
- Corrected 27,044 orders that arrived with incorrect or incomplete information
- Generated 2891 Medicare report deficiency warnings
- Generated 248 PQRS (now called MIPS) report deficiency warnings
- Generated 4187 ICD-10 report deficiency warnings
- Documented 8011 Knowledge Base pages accessed

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