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A Quantitative Study of Correlations between Patient Load with the Usage of Artificial Intelligence Treatment Planning tools (auto planning, adaptive RT, Clear Check, Deformable Dose, Auto-contouring, EZFluence, etc.) A United States Context

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Abstract

Introduction:

Artificial intelligence (AI) is the process of automating tasks that were traditionally done manually. AI can be used throughout the dosimetry treatment planning process for external beam radiation treatments. Artificial intelligence has the opportunity to help reduce treatment planning time and help to increase the quality of treatment plans. The workload of cancer treatment facilities across the United States varies greatly. This study aims to determine if the workload of a treatment facility has an impact upon the usage of artificial intelligence during treatment planning.

Methods:

This study is a qualitative study of 96 survey participants. The survey was created using the Qualtrics program and was distributed through the American Association of Medical Dosimetrists (AAMD) to all of their members. The survey was open for responses for 22 days. The survey consisted of 19 multiple choice, and interval questions. The results of the survey were interpreted using 2-way ANOVA testing and frequency data analysis.

Results:

The results of this study indicated that there is no statistical significance between the average number of patients being simulated weekly at a facility and the usage of artificial intelligence in external, beam treatment planning (P=0.4135, P=0.13, P=0.31, P=0.36, P=0.18, P=0.97). The results also indicated there was no statistical significance between the average number of external beam treatment plans created weekly and the usage of artificial intelligence in treatment planning (P=0.17. P=0.64, P=0.83, P=0.97, P=0.63).

Conclusion:

There was no correlation between the average weekly number of simulated patients or the average number of weekly external beam plans created and the usage of artificial intelligence in treatment planning. Another study with a larger sample size would be beneficial to further examine any possible correlations.

Introduction

Artificial intelligence is a rapidly growing category of computer science. The aim of artificial intelligence is to simulate human intelligence and to mimic actions that normally would be performed by a human[1]. There is potential for artificial intelligence to assist medical dosimetrists with radiation therapy treatment planning (RTTP). Three-dimensional treatment planning systems were introduced to radiotherapy in the early 1990's[2]. This was made possible by the introduction of helical CT scanners[2]. These systems are computer-aided designing or planning software that enhance the treatment planning processes to arrive at the best dose plans for the patients[2]. Currently there are six well-known brand options of treatment planning systems that are being used in the field. A clinical site has the possibility to choose between Brainlab, Elekta, Philips, Prowess, RaySearch, and Varian[3]. Each brand offers a specific software that can be implemented in various steps of planning. The treatment planning process will typically begin with the oncologist defining the gross tumor volume, the clinical target volume, the planning target volume, and the internal target volume. The gross tumor volume (GTV) can be classified as the gross palpable or visible tumor, as stated by the ICRU Report 50[4]. The International Commission on Radiation Units and Measurements (ICRU) Report 50 states that the clinical target volume (CTV) can be described as the GTV with additional surrounding volume of tissue that may contain subclinical or microscopic disease[4]. In addition, the planning target volume (PTV) is designated as the CTV with added margins for geometric uncertainties, such as patient motion, beam penumbra, and treatment setup differences[4]. Lastly, the internal target volume (ITV) is stated as the CTV combined with internal margin that accounts for tumor motion[4]. The process of an oncologist defining these target structures is typically done manually to ensure accuracy. However, developments in artificial intelligence offer an automated way of generating certain target structures, while maintaining or increasing accuracy. There are various brands that offer programs to auto-contour the CTV, and PTC. After the delineation of the target structures by the oncologist, the plan is passed to the dosimetrist.

Classically, the dosimetrist will then proceed to manually contour all of the organs at risk (OAR's) that could possibly receive dose from the treatment. According to the International Commission on Radiation Units and Measurements (ICRU) Report 50, organs at risk are critical structures that may limit the amount of radiation delivered to the tumor volume[4]. The contouring of OAR's is done through a 3D treatment planning system which will illustrate the patient's CT scan that was acquired from the CT simulation. The process entails locating the normal organs and outlining the structure on alternating slices of the CT scan. The slices are then interpolated together in order to have a complete contour of the organ. This can be a quite tedious process, depending on how many organs need to be contoured.

The repetitive action of contouring organs offers an opportunity to incorporate artificial intelligence into treatment planning. There are software options that offer an "auto-countering" experience. One particular type of auto-contouring is atlas segmentation (AS) contouring. The process of atlas segmentation uses a few steps. The target patient must be aligned to a certain template (1) then the contours from the template are then aligned with the anatomical structures of the patient that is being planned (2) next, the selected contours will undergo "label fusion" in which the contours will attempt to match to the patient's anatomy (3) [6]. Elekta offers an atlas-based auto segmentation (ABAS) software[7]. This software claims to be accurate, flexible, simple, and efficient[7]. Another particular program is Limbus AI[5]. Limbus AI is automatic contouring for radiation therapy that claims to be 5-10 times quicker than manual contouring[5].

Auto-contouring aims to help create treatment plans faster when there is a large patient load. Another example of artificial intelligence in dosimetry is auto-planning (AP). Auto-planning would take place during the planning process, after the contours have been finished. AP works in three steps: run a series of scripts in the background (1) automatically generates different auxiliary structures give the prescription dose (2) and automatically optimize the objective function (3)[8]. Varian offers a version of auto-planning titled "Rapid Plan". This database aims to increase treatment planning speed and effectiveness[9]. There are many other programs that offer assistance during the planning process. All of the programs share the same goal to create a more advanced radiotherapy planning system.

External beam radiation is considered the most common form of radiation therapy. Therefore, external beam treatment plans are the most commonly produced[7]. There are essentially three different particles that can be used for external beam therapy: photons, protons, and electrons[7]. The most commonly used particles for externa beam treatment are photons. Photons are the same particle used in x-ray imaging; however, the doses are much lower[7]. During external beam radiation the photons penetrate the skin and travel through the body[7]. For the purposes of this study, only medical dosimetrists who plan external beam photon treatments are considered. The decision was made because photons are the most commonly used. In addition, electron and proton planning can vary greatly compared to photon planning. Therefore, for ease of data analysis, only external beam photon plans will be examined for this study.

As previously stated, there are many opportunities for new development in AI technology to be utilized to help treatment planning become quicker and more effective. Nevertheless, not every site possesses these programs. The need for artificial intelligence could be determined by a clinic's patient workload. It would be helpful if clinic sites had data in which they could determine what artificial dosimetry options would be the most beneficial based on clinic workload and size.

The purpose of this study is to determine if there is an association between which software is being used, and the clinic's workload. The workload of a particular site consists of the number of patients that are simulated, planned for, and treated within a week. Careful consideration must be used when deciding to implement a new software. These programs are often quite expense and require training sessions to understand how to use them to the full capability. The benefit to this study is being able to compare number of patients to software used. By illustrating that there is a correlation, it would be possible for clinics of similar size to have data to use in determining if they should implement the use of artificial intelligence as well.

One way this study is going to determine the workload of a facility is by examining the average number of patients simulated weekly. Having a patient coming in for a CT simulation implies that the patient will be starting a new treatment. Therefore, the number of patients that are simulated weekly can be directly related to the number of new external beam treatment plans that are being generated by the facility. The process of simulating a patient involves the patient laying on the CT scanner table exactly how the treatment will be performed [6.] In addition, this study examines the average weekly number of external beam treatment that are created at the particular facility. The number of external beam plans created was determined to be a good indicator on workload of the facility.

The researcher hypothesizes that there will be a consistent correlation with clinic size and usage of AI programs. In theory, if a clinic treats more patients then AI programs that assist in treatment planning or contouring should be used to help the facility keep up with the patient load. In addition, if a site is slower and perhaps does not generate as many treatment plans then there is ample time to devote to each treatment plan and manually contour and create the fields for that particular patient.

Hypothesis:

Null hypothesis (H0): There is not a correlation between clinic size and workload with utilizing artificial intelligence in dosimetry.

Alternative hypothesis (Ha): There is a correlation between clinic size and workload with utilizing artificial intelligence in dosimetry.

Methods and Materials:

Patient Selection:

This study is a qualitative study comprised of 96 survey responses. The participants of this study are to be at least 18 years of age. The participant's gender, ethnic background, and health status are not relevant information to this particular study and, therefore, will not be included. The study includes participants who are active members of the American Association of Medical Dosimetry (AAMD). It was a requirement that participants of the study are actively creating radiation therapy treatment plans for external beam treatments. The research includes only individuals who create external beam photon treatment plans. There are different planning processes for various types of radiation, therefore, maintaining the focus on external beam photon treatments maintains consistency. The location where the participant works is not a requirement because this study is examining facilities throughout the United States.

IRB:

Documents for Institutional Review Boards (IRB) were submitted to Grand Valley State University (GVSU) for review to obtain approval to conduct the survey. Approval needed to be obtained before the survey could be distributed through the American Association of Medical Dosimetrists (AAMD). A human subject's research protocol was submitted to GVSU. Approval was obtained under Exempt Category 2, GVSU IRB Policy 911.

Survey:

The survey was constructed in the software Qualtrics. The survey consisted of 19 questions around facility workload and treatment planning. The survey began with the participants having to acknowledge that they read the consent form. At the beginning of the survey participants were instructed to only proceed with the survey if they were staff dosimetrists who utilized photon treatment planning. The survey appendix can be seen listed below:

1. Are you at least 18 years of age?
    a. Yes/No
2. Which of the following treatments does your facility perform? Select all that apply.
    a. External Beam Photon/Electron, Brachytherapy, Proton, Other (Please Specify)
3. Identify your primary work setting (where you work most of your hours).
    a. Academic Medical Center, Community Hospital, Freestanding Oncology Center, Other (Please Specify)
4. I would describe the area where this facility is located as:
    a. Urban (a highly populated city, or metropolitan area), Suburban (outlying single-family housing areas that are surrounding larger cities and metropolitan areas), Rural (open country, fewer than 2,500 residents, countryside where farming and natural resources are predominantly used for family income)
5. How many full-time equivalent treatment planning staff members does this facility currently employ?
    a. <1, 1, 2, 3, 4, 5-7, 8-10, 11-15, 16-20, ≥ 21, unsure
6. How many linear accelerators are utilized at this facility?
    a. 1, 2, 3, 4,5, 6, ≥ 7, unsure
7. On average, how many external beam photon patients are simulated within a week-long span?

    a. ≤ 5, 6-15, 16-25, 26-35, 36-45, ≥ 46, unsure

8. On average, how many new photon plans at the facility are generated for treatment within a week-long span?
    a. ≤ 5, 6-15, 16-25, 26-35, 36-45, ≥ 46, unsure
9. On average, how many of the average weekly generated external beam photon new treatment plans at the facility involve advanced treatment planning (e.g., IMRT, VMAT, SBRT, SRS)?
    a. ≤ 5, 6-15, 16-25, 26-35, 36-45, ≥ 46, unsure
10. How would you describe the photon planning workload of this facility?
    a. Light, Somewhat Light, Moderate, Somewhat Heavy, Heavy
11. What treatment planning software does your facility utilize? Select all that apply.
    a. Eclipse, RayStation, Pinnacle, Monaco, Accuray (Cyberknife, Tomotherapy), Other (Please Specify)
12. What is your satisfaction with the treatment planning software that is being used?
    a. Very Satisfied, Somewhat Satisfied, Neutral, Somewhat Dissatisfied, Very Dissatisfied, N/A
13. Please select any artificial intelligence software your facility offers. Select all that apply.
    a. Auto Contouring (e.g. Varian Smartsegmentation, Limbus Contour, Pinnacle Auto-Segmentation with SPICE, eContour, MIM Maestro), Automated 3D Planning Software (e.g. EZFluence, Pinnacle AutoPlanning engine, RayStation Automated Treatment Planning), IMRT/VMAT Automated Planning (e.g. EZFluence, Pinnacle AutoPlanning engine, RayStation Automated Treatment Planning, Hyperarc), Automated Plan Check (e.g. Clear Check, planCheck), Adaptive RT (e.g. Ethos, Pinnacle Dynamic Planning), Scripting (e.g. DoseLab, RIT), None, Other (Please Specify)
14. How often do you use each of the software listed?
    a. Always, Very Often, Sometimes, Rarely, Never, N/A
15. If you answered Rarely or Never, what are the reasons for not utilizing the software on a regular basis?
16. Please rate your satisfaction with your current software.
    a. Very Satisfied, Somewhat Satisfied, Neutral, Somewhat Dissatisfied, Very Dissatisfied, N/A
17. Please rate the following statements (AI stands for Artificial Intelligence):
    a. Strongly Agree, Somewhat Agree, Neutral, Somewhat Disagree, Strongly Disagree
18. What roadblocks are preventing the usage of artificial intelligence at your facility? Select all that apply.
    a. Budget Limitations, Physician Preference, Physicist Preference, Dosimetrist Preference, Access to Training/Education, Quality/Accuracy of Artificial Intelligence, Effort/Time to Integrate into Clinic, Other (Please Specify), N/A
19. Is there anything you'd like to add?

The survey was distributed through the American Association of Medical Dosimetrists (AAMD). The survey questions were finished being constructed and a link was then generated. The link for the Qualtrics survey was copied and emailed to the liaison at the American Association of Medical Dosimetrists (AAMD). The email embedded with the link to the survey was distributed to all AAMD current members. Participants click on the embedded link and they are redirected to Qualtrics to complete the survey. The survey was available to be completed from June 13th, 2021 to July 5th, 2021. The survey was open for responses for 22 days. After the 22 days the survey was closed.

Analysis of Survey Results:

Once all the responses were gathered the data needed to be interpreted. The responses were exported from Qualtrics into SPSS Statistics. In order to interpret the 96 responses, the data needed to be recoded. A variety of two-way ANOVA, Monte Carlo, frequency testing, and one-way ANOVA tests were performed in order to examine any correlations. Two-way ANOVA testing was performed between the average number of patients simulated weekly versus the usage of various artificial intelligence software (see Table 1-Table 11). In addition, a two-way ANOVA test was performed between the average number of weekly photon plans created versus the usage of various artificial intelligence software (see Table 12-Table 23). The participants of the survey were asked to rate their usage of auto-contouring, automated 3D planning, IMRT/VMAT planning, automated plan check, adaptive, RT, and scripting. The participants could pick between always, very often, sometimes, rarely, or never for each of the different artificial intelligence software. When performing data analysis each software needed to be interpreted separately. Auto-contouring, automated 3D planning, IMRT/VMAT planning, automated plan check, adaptive, RT, and scripting were each compared to the average weekly number of patients simulated and compared to the average number of weekly external photon beam treatment plans made. The results were then interpreted for statistical significance.

Results:

The goal of this study was to evaluate any correlations that exist between the workload of a facility and the usage of artificial intelligence during external beam photon treatment planning. The average weekly number of patients simulated and the average number of weekly photon treatment plans created was compared with the usage of different types of artificial intelligence software. Statistical significance was determined as a P-value of < 0.05.

Most Commonly Used Artificial Intelligence Software:

A frequency statistical analysis was performed with data from the question about the usage of artificial intelligence software. Participants were asked to rate the usage of auto contouring, automated 3D planning software, IMRT/VMAT automated planning, automated plan check, adaptive RT, and Scripting. According to the analysis the most commonly used AI software was automated plan check (See Table 24). This was the most common with 20 participants answering “always or very often” to using automated plan check. The satisfaction with automated plan check was evaluated and it was found that the majority were satisfied with automated plan check with 15 participants selecting the “very satisfied” option for automated plan check (See Table 25).

Average Number of Weekly Simulated Patients:

The average number of weekly simulated patients was evaluated using a multiple-choice question where various ranges could be selected. The participants were given the ability to choose between <5, 6-15, 16-25, 26-35, 36-45, ≥46. In order to allow for more meaningful statistical interpretation, the large ranges were condensed to <5, 6-25, 26-45, and ≥46. The survey focused on auto-contouring, automated 3D planning software, IMRT/VMAT automated planning, automated plan check, adaptive RT, and scripting. The participants were asked to rate the usage of the AI software using a scale with always, very often, sometimes, rarely, or never. For the purpose of data analysis, the options were condensed to "always or very often", "sometimes or rarely", and "never". In order to properly analyze the data each artificial intelligence software was compared with the average number of patients simulated within a week individually. (See Table 26).

Auto Contouring:

The average number of external beam photon patients simulated weekly was compared with the usage of auto-contouring (e.g., Varian Smartsegmentation, Limbus Contour, Pinnacle Auto-Segmentation with SPICE, eContour, MIM Maestro) (See Table 1). Auto-contouring is intended to replace manual contouring during the process of treatment planning. A Monte Carlo estimate was conducted (See Table 2). The test revealed a P-value of 0.41 and a 99% lower confidence limit of 0.40 and a 99% upper confidence limit of 0.43 (See Table 2). The P-value of 0.41 indicates there is no statistical significance between the average number of external beam photon patients simulated weekly in comparison to the usage of auto-contouring during treatment planning.

Automated 3D Planning Software:

The average number of external beam photon patients simulated weekly was compared with the usage of automated 3D planning software (e.g., EZFluence, Pinnacle AutoPlanning engine, RayStation Automated Treatment Planning) (See Table 3). Automated 3D planning software is intended to automatically generate a 3D plan based upon various parameters. The process of creating a 3D plan is traditionally done manually. A Monte Carlo estimate was conducted (See Table 4). The test revealed a P-value of 0.14 and a 99% lower confidence limit of 0.13 and a 99% upper confidence limit of 0.15 (See Table 4). The P-value of 0.14 indicates there is no statistical significance between the average number of external beam photon patients simulated weekly in comparison to the usage of automated 3D planning software.

IMRT/VMAT Automated Planning

The average number of external beam photon patients simulated weekly was compared with the usage of IMRT/VMAT Automated Planning (e.g., EZFluence, Pinnacle AutoPlanning engine, RayStation Automated Treatment Planning, Hyperarc) (See Table 5). Intensity-modulated radiation therapy (IMRT) is a more complex form of treatment planning than 3D planning. Automated IMRT planning would essentially replace the manual planning process for IMRT/VMAT treatment plans. A Monte Carlo estimate was conducted (See Table 6). The test revealed a P-value of 0.31 and a 99% lower confidence limit of 0.30 and a 99% upper confidence limit of 0.32 (See Table 6). The P-value of 0.31 indicates there is no statistical significance between the average number of external beam photon patients simulated weekly in comparison to the usage of IMRT/VMAT automated planning.

Automated Plan Check

The average number of external beam photon patients simulated weekly was compared with the usage of Automated Plan Check (e.g., Clear Check, planCheck) (See Table 7). A Monte Carlo estimate was conducted (See Table 8). The test revealed a P-value of 0.36 and a 99% lower confidence limit of 0.35 and a 99% upper confidence limit of 0.38 (See Table 8). The P-value of 0.36 indicates there is no statistical significance between the average number of external beam photon patients simulated weekly in comparison to the usage of automated plan check. Automated plan check was the most used artificial intelligence software among the responses from the survey.

Adaptive RT

The average number of external beam photon patients simulated weekly was compared with the usage of Adaptive RT (e.g., Ethos, Pinnacle Dynamic Planning) (See Table 9). A Monte Carlo estimate was conducted (See Table 10). Adaptive RT can be used for real time planning and adjustments of the treatment plan. The test revealed a P-value of 0.18 and a 99% lower confidence limit of 0.17 and a 99% upper confidence limit of 0.19 (See Table 10). The P-value of 0.18 indicates there is no statistical significance between the average number of external beam photon patients simulated weekly in comparison to the usage of adaptive RT.

Scripting

The average number of external beam photon patients simulated weekly was compared with the usage of Scripting (e.g. DoseLab, RIT) (See Table 11). A Monte Carlo estimate was conducted (See Table 12). The test revealed a P-value of 0.0003 and a 99% lower confidence limit of <.0001 and a 99% upper confidence limit of 0.0007 (See Table 12). The P-value of 0.0003 indicates there is statistical significance. However, it was determined to be a false positive based upon the small sample size of 6 participants. Therefore, there is no correlation between the average number of external beam photon patients simulated weekly in comparison to the usage of scripting.

Average Number of New Photon Plans Created Weekly

The average number of new photon plans created weekly was evaluated using a multiple-choice question where various ranges could be selected. The participants were given the ability to choose between <5, 6-15, 16-25, 26-35, 36-45, ≥46. In order to allow for more meaningful statistical interpretation, the large ranges were condensed to <5, 6-25, 26-45, and ≥46. The survey focused on auto-contouring, automated 3D planning software, IMRT/VMAT automated planning, automated plan check, adaptive RT, and scripting. The participants were asked to rate the usage of the AI software using a scale with always, very often, sometimes, rarely, or never. For the purpose of data analysis, the options were condensed to "always or very often", "sometimes or rarely", and "never". In order to properly analyze the data each artificial intelligence software was compared with the average number new photon plans created weekly. (See Table 26).

Auto-Contouring:

The average number of new photon plans created weekly was compared with the usage of auto contouring (e.g., Varian Smartsegmentation, Limbus Contour, Pinnacle Auto-Segmentation with SPICE, eContour, MIM Maestro) (See Table 13). A Monte Carlo estimate was conducted (See Table 14). The test revealed a P-value of 0.97 and a 99% lower confidence limit of 0.97 and a 99% upper confidence limit of 0.97 (See Table 14). The P-value of 0.97 indicates there is no statistical significance between the average number of new photon plans created weekly and the usage of auto contouring.

Automated 3D Planning Software:

The average number of new photon plans created weekly was compared with the usage of automated 3D planning software (e.g., EZFluence, Pinnacle AutoPlanning engine, RayStation Automated Treatment Planning) (See Table 15). A Monte Carlo estimate was conducted (See Table 16). The test revealed a P-value of 0.0072 and a 99% lower confidence limit of 0.005 and a 99% upper confidence limit of 0.0094 (See Table 16). The P-value of 0.0072 indicates there is statistical significance however, it was determined to be false negative based upon lacking sample size. Therefore, there is no correlation between the average number of new photon plans created weekly and the usage of auto contouring.

IMRT/VMAT Automated Planning:

The average number of new photon plans created weekly was compared with the usage of IMRT/VMAT automated planning (e.g., EZFluence, Pinnacle AutoPlanning engine, RayStation Automated Treatment Planning, Hyperarc) (See Table 17). A Monte Carlo estimate was conducted (See Table 18). The test revealed a P-value of 0.17 and a 99% lower confidence limit of 0.16 and a 99% upper confidence limit of 0.18 (See Table 18). The P-value of 0.17 indicates there is no statistical significance between the average number of new photon plans created weekly and the usage of auto contouring.

Automated Plan Check

The average number of new photons plans created weekly was compared with the usage of automated plan check (e.g., Clear Check, planCheck) (See Table 19). A Monte Carlo estimate was conducted (See Table 20). The test revealed a P-value of 0.64 and a 99% lower confidence limit of 0.63 and a 99% upper confidence limit of 0.65 (See Table 20). The P-value of 0.64 indicates there is no statistical significance between the average number of new photon plans created weekly and the usage of automated plan check.

Adaptive RT

The average number of new photon plans created weekly was compared with the usage of Adaptive RT (e.g., Ethos, Pinnacle Dynamic Planning) (See Table 21). A Monte Carlo estimate was conducted (See Table 22). The test revealed a P-value of 0.83 and a 99% lower confidence limit of 0.82 and a 99% upper confidence limit of 0.83(See Table 22). The P-value of 0.83 indicates there is no statistical significance between the average number of new photon plans created weekly and the usage of adaptive RT.

Scripting

The average number of new photon plans created weekly was compared with the usage of Scripting (e.g. DoseLab, RIT) (See Table 23). A Monte Carlo estimate was conducted (See Table 24). The test revealed a P-value of 0.0001 and a 99% lower confidence limit of <.0001 and a 99% upper confidence limit of 0.0004 (See Table 24). The P-value of 0.0001 indicates there is statistical significance however, based upon sample size it was determined this is a false positive. Therefore, there is no correlation between the average number of new photon plans created weekly and the usage of scripting.

Discussion

The purpose of this study was to determine if there was any correlation between the workload of a treatment facility and the usage of artificial intelligence in external beam photon treatments. Artificial intelligence has been around for years; however, it is getting more attention recently[8]. The possibility of utilizing artificial intelligence software during the treatment planning process for radiation oncology has also been increasing recently. AI has the potential to aide in treatment planning, contouring, and adaptation[8]. Artificial intelligence is able to be combined with a library of patient data to generate automated radiation treatment plans[9]. Even though artificial intelligence can assist in dosimetry, not every radiation oncology facility is implementing AI software. This study distributed a survey throughout the American Association of Medical Dosimetrist (AAMD) to members who are currently planning external beam photon treatments. There was a variety of questions asked about workload and usage of AI. The data was then analyzed. There were no comparisons made between auto-contouring, automated 3D planning, IMRT/VMAT automated planning, automated plan check, adaptive RT, and scripting with the workload of the facility. All the findings were deemed not statistically significant. There was no correlation found between the workload of a facility and the usage of AI in treatment planning. The null hypothesis stated that there is not a correlation between clinic size and workload with utilizing artificial intelligence in dosimetry. Based upon the results we would fail to reject the null hypothesis.

Most Commonly Used Artificial Intelligence Software:

According to the analysis the most commonly used AI software was automated plan check (See Table 24). Automated plan check examples include: Clear Check and planCheck. Automated plan checking programs are intended to improve plan quality, increase efficiency of reviewing plans, and standardize protocols[10]. Automated plan check being the most commonly used AI software amongst participants makes clinical sense. Automated plan check systems do not interfere with contouring or specific planning aspects of the process. Automated plan check programs interpret the dose volume histogram (DVH) quicker and put it into an easy to construe form. This makes it easier for dosimetrists, physicians, and physics to evaluate the plan. Employees who are actively planning external beam photon plans have some resilience incorporating AI into treatment planning because of accuracy. However, automated plan check does not plan aspects of the treatment plan itself. Therefore, it explains why automated plan check was found to be the most commonly used AI software in this study.

Average Number of Weekly Simulated Patients & Average Number of New Photon Plans Created Weekly

The participants of the study were asked about the average weekly number of patients that are CT simulated every week. This was assessed using a multiple-choice technique with different intervals. The average number of simulations performed weekly was deemed to be a good indicator of facility workload. Number of simulations is a good indicator because it shows how often new patients are being brought in and includes current patients who need to be re-simulated for various reasons. When evaluating this data, it was compared to the usage of artificial intelligence. Each AI software was interpreted individually with the average number of weekly simulated patients. The average number of new external beam photon plans created weekly was also examined. This variable was decided to be a good indicator of workload of a facility because it shows how many external beam plans are actually being created. The number of plans being created weekly can attest to how busy a facility is. Therefore, it was evaluated against auto contouring, automated 3D planning, automated IMRT/VMAT planning, automated plan check, adaptive RT, and scripting.

Auto Contouring:

Auto-contouring was one of the AI software was being examined. Automated contouring has been improving and can help with efficiency in treatment planning[11]. Varian Smartsegmentation, Limbus Contour, Pinnacle Auto-Segmentation with SPICE, eContour, MIM Maestro are all examples of different automated contouring programs that are offered. Even though advancements have been made, there are still inaccuracies when using automated contouring. When using automated contouring it was found that the majority of structures required modification of contours before they could be used in planning[11]. Unreliability with auto-contouring may have been an influence in the results of this study. The usage of auto-contouring was compared with the average number of patients simulated weekly. The comparison was found to be statistically insignificant with a P-value of 0.41. There is still some concern when using auto-planning, however, technology is always changing and advancing. The usage of automated contouring was compared to the number of weekly generated external beam photon plans and was found to have no statistical significance with a p-value of 0.97. The lack of significance in this study could be possibly due to the low response rates of the survey that was distributed.

Automated 3D Planning Software:

Automated 3D planning was also evaluated in this study. EZFluence, Pinnacle AutoPlanning engine, RayStation Automated Treatment Planning are some examples of automated 3D planning software that can be used. Automated optimization of 3D plans has the possibility to increase the efficiency and quality of the treatment planning process. Automated 3D planning is most commonly used with breast treatments[12]. EZFluence is a program that can assist in creating a breast plan with field-in-field techniques[12]. EZFluence has been found to help improve dose homogeneity and coverage[12]. When automated 3D planning was compared to the average number of weekly CT simulations there was no correlation found. With a P-value of 0.14 it was deemed not statistically significant. Automated 3D planning in comparison with the average number of external beam photon beams generated produced a p-value of 0.0072. This p-value would indicate there is statistical significance however, it was determined to be false negative based upon lacking sample size. It was be inferred that the lack of significance in this comparison is due to an overall low response rate to the survey from AAMD members.

IMRT/VMAT Automated Planning

The usage of IMRT/VMAT planning was evaluated in this study. Intensity-modulated radiation therapy (IMRT) planning is a more complex form of planning that allows for more uniform dose distribution and high-precision[13]. Volumetric modulated arc therapy (VMAT) is a technique where dose is delivered to the tumor while the machine rotates around the patient[14]. VMAT planning is usually used when the tumor is near sensitive body organs and the dose distribution needs to be greatly controlled[14]. Both IMRT and VMAT are more complex techniques in treatment planning. Often it is preferred to manually plan IMRT/VMAT plans because of the complexity. When IMRT/VMAT automated planning was compared to the average number of weekly simulations performed there was no statistical significance between the two. A p-value of 0.31 shows that there is no significance between the average number of external beam photon patients simulated weekly in comparison to the usage of IMRT/VMAT automated planning. A p-value of 0.17 was determined when IMRT/VMAT automated planning was compared to the average number of external beam photon plans that are generated weekly. The p-value indicates there is no correlation between IMRT/VMAT automated planning and average number of external beam photon plans that are generated weekly.

Automated Plan Check

Automated plan check was found to be the most commonly used AI software between participants of this study. Automated plan check programs take information from the DVH and provide a view of the dose that is easier to interpret[10]. Clear Check and plan check are some examples of automated plan check software. Even though the frequency test showed this was the most commonly used AI system, there was no statistical significance between automated plan check and the average number of external beam photon patients simulated weekly. This can be seen by the P-value of 0.36. Automated plan check in comparison with the average number of external beam photon plans created weekly have a p-value of 0.64. The p-value indicates there was no statistical significance between automated plan check and the number of external beam photon plans created weekly.

Adaptive RT

Adaptive RT was a program that was evaluated in this study. Some examples are adaptive Rt are Ethos and Pinnacle Dynamic Planning. Adaptive radiotherapy planning monitors variations in the target[15]. The GTV can move every day, adaptive planning was created to compensate for a dynamic target[15]. Adaptive RT is essentially planning aimed to give dose to a moving target. The planning can either take place between fractions, prior to a fraction, or during a fraction. Adaptive RT has the possibility to become more accurate than single day pre-treatment CT simulation[15]. Adaptive RT was found to have to statistical significance with the average number of external beam photon patients simulated weekly. The lack of significance was determined by a p-value of 0.18. A p-value of 0.83 was generated when adaptive RT was compared to the average number of external beam photon plans created weekly. Even though the popularity adaptive RT is increasing, the sample size of this study was not large enough to determine any statistical significance.

Scripting

Scripting was also interpreted in this study. Scripting is used in ensuring the accuracy of the linear accelerators[16]. It becomes increasingly useful for the Winston-Lutz (WL) test[16]. The WL test is often performed for stereotactic radiosurgery (SRS) and stereotactic body radiation therapy (SBRT) treatments[16]. SRS and SBRT treatments are delivered at very high doses and require a high degree of accuracy[16]. DoseLab and RIT are examples of scripting programs used. When scripting was compared with the average number of external beam photon patients simulated weekly a p-value of 0.0003 was determined. The P-value of 0.0003 indicates there is statistical significance. However, it was deemed false positive based upon the small sample size of 6 participants. A p-value of 0.0001 was found between scripting and the number of external beam photon plans created weekly. Even though this p-value is significant, based upon sample size it was determined this is a false positive. The lack of sample size in the questions regarding scripting could be possibly related to physics normally performing the testing on the linear accelerators and not the dosimetrists. A recommendation would be to perform a study solely on scripting with more focus into the physics department in order to determine any correlations.

Limitations and future research

Limitations of this study include a low response rate to the survey distributed by the American Association of Medical Dosimetrists (AAMD). The AAMD ha roughly 2,500 members. It was expected to receive about 1,500 responses based upon previous surveys that were distributed through the AAMD. Unfortunately, only 96 responses were received. The survey was distributed during the time period of the annual AAMD meeting. It was hypothesized by the AAMD that due to the overwhelming number of emails sent during the annual meeting it is possible the email containing the link to the survey was overlooked by many members. Due to the small sample size, statistical significance was not able to be determined. A larger sample size would perhaps provide results that were significant. In addition, not every participant answered every question. This created some skewed results and false positive correlations. There was nothing in place in the Qualtrics survey that required every question to be answered. There was also nothing in place to prevent multiple employees from one facility responding to the quiz. As a result, the data could possibly be inaccurate with multiple surveys from one location. In theory, it would only be necessary to have one survey from each facility to indicate workload and AL usage.

Future research could include a larger sample size, protocols that require all survey questions to have a response, and a system that limits the response per facility to one. More research needs to be conducted on this topic in order to determine significant results. These results would then be able to help determine if facilities with varying number of patients would benefit from different artificial intelligence software.

Conclusion

Artificial intelligence is a growing topic. Patients are entitled to receive the most efficient and accurate treatment possible. AI can be utilized in treatment planning to help create treatment plans that are more accurate and efficient[3]. There are several aspects where AI are used to aide treatment planning. Auto-contouring, automated 3D planning software, automated IMRT/VMAT planning, automated plan check, adaptive RT, and scripting are examples are AL used in radiation oncology treatment planning. External beam planning is the most common form of radiotherapy planning[7]. Majority of patients will receive external beam therapy in the form of photons[7]. Therefore, that is the type of planning this study was focused on. The workload of a facility is very important. The workload shows how many plans the facility is generating. The average number of patients simulated weekly and the average number of new external beam photon plans generated weekly were evaluated. The study aimed to explore any possibly correlations between the workload of a facility and any usage of the various AI programs.

This study was conducted using a survey method that was distributed through the American Association of Medical Dosimetrists (AAMD). The members received a link to participate in the survey. The response rate for the survey was low which limited the results.

The study showed that there was no statistically significant relationship between AI software usage and the average number of patients simulated weekly. In addition, there was no statistically significant relationship between AI software usage and the average number of external beam photon plans created over a week-long span. Further research with a larger sample size is needed to be able to determine any correlations that may exist between the workload of a facility and the usage of artificial intelligence in treatment planning.

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Table 1. Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Auto-Contouring

Number of Patients	*Usage of Auto Contouring*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	1 16.67	2 33.33	3 50.00	6
6-25	4 25.00	8 50.00	4 25.00	16
26-45	2 40.00	0 0.00	3 60.00	5

>= 46	4 40.00	4 40.00	2 20.00	10
Total	11	14	12	37
Frequency Missing = 34				

Table 2. Monte Carlo Testing for Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Auto-Contouring

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.4135
99% Lower Conf Limit	0.4008
99% Upper Conf Limit	0.4262
Number of Samples	10000
Initial Seed	615812229

Table 3. Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Automated 3D Planning Software

Number of Patients	*Usage of Automated 3D Planning Software*			
Frequency Row Pct	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	1 25.00	1 25.00	2 50.00	4
6-25	7 53.85	4 30.77	2 15.38	13
26-45	6 85.71	1 14.29	0 0.00	7
>= 46	1 20.00	1 20.00	3 60.00	5
Total	15	7	7	29
Frequency Missing = 42				

Table 2. Monte Carlo Testing for Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Automated 3D Planning Software

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.1379

99% Lower Conf Limit	0.1290
99% Upper Conf Limit	0.1468
Number of Samples	10000
Initial Seed	1533291175

Table 4. Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of IMRT/VMAT Automated Planning

Number of Patients	*Usage of IMRT/VMAT Automated Planning*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	1 20.00	1 20.00	3 60.00	5
6-25	5 38.46	6 46.15	2 15.38	13
26-45	4 57.14	0 0.00	3 42.86	7
>= 46	2 33.33	2 33.33	2 33.33	6
Total	12	9	10	31
Frequency Missing = 40				

Table 5. Monte Carlo Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of IMRT/VMAT Automated Planning

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.3117
99% Lower Conf Limit	0.2998
99% Upper Conf Limit	0.3236
Number of Samples	10000
Initial Seed	1111774388

Table 6. Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Automated Plan Check

Number of Patients	*Usage of Automated Plan Check*			
Frequency Row Pct	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	2 40.00	1 20.00	2 40.00	5
6-25	11 84.62	1 7.69	1 7.69	13
26-45	3 60.00	0 0.00	2 40.00	5
>= 46	4 66.67	1 16.67	1 16.67	6
Total	20	3	6	29
Frequency Missing = 42				

Table 7. Monte Carlo Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Automated Plan Check

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.3646
99% Lower Conf Limit	0.3522
99% Upper Conf Limit	0.3770
Number of Samples	10000
Initial Seed	186131488

Table 8. Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Adaptive RT

Number of Patients	*Usage of Adaptive RT*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	0 0.00	0 0.00	3 100.00	3
6-25	0 0.00	5 71.43	2 28.57	7

26-45	1 20.00	1 20.00	3 60.00	5
>= 46	0 0.00	1 25.00	3 75.00	4
Total	1	7	11	19
Frequency Missing = 52				

Table 9. Monte Carlo Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Adaptive RT

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.1760
99% Lower Conf Limit	0.1662
99% Upper Conf Limit	0.1858
Number of Samples	10000
Initial Seed	191862879

Table 10. Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Scripting

Number of Patients	*Usage of Scripting*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	0 0.00	0 0.00	3 100.00	3
26-25	1 14.29	5 71.43	1 14.29	7
26-45	0 0.00	0 0.00	3 100.00	3
>= 46	5 83.33	0 0.00	1 16.67	6
Total	6	5	8	19
Frequency Missing = 52				

Table 11. Monte Carlo Average Number of External Beam Photon Patients Simulated Weekly Vs. Usage of Scripting

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.0003
99% Lower Conf Limit	<.0001
99% Upper Conf Limit	0.0007
Number of Samples	10000
Initial Seed	760578692

Table 12. Average Number of New Photon Plans Created Weekly vs. Usage of Auto Contouring

Number of Plans	*Usage of Auto Contouring*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	1 33.33	1 33.33	1 33.33	3
6-25	5 25.00	8 40.00	7 35.00	20
26-45	2 40.00	1 20.00	2 40.00	5
>= 46	3 33.33	4 44.44	2 22.22	9
Total	11	14	12	37
Frequency Missing = 34				

Table 13. Monte Carlo Average Number of New Photon Plans Created Weekly vs. Usage of Auto Contouring

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.9700
99% Lower Conf Limit	0.9656
99% Upper Conf Limit	0.9744
Number of Samples	10000
Initial Seed	616110677

Table 14. Average Number of New Photon Plans Created Weekly vs. Usage of Automated 3D Planning Software

Number of Plans	*Usage of Automated 3D Planning Software*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	0 0.00	0 0.00	2 100.00	2
6-25	10 58.82	5 29.41	2 11.76	17
26-45	5 83.33	1 16.67	0 0.00	6
>= 46	0 0.00	1 25.00	3 75.00	4
Total	15	7	7	29
Frequency Missing = 42				

Table 15. Monte Carlo Average Number of New Photon Plans Created Weekly vs. Usage of Automated 3D Planning Software

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.0072
99% Lower Conf Limit	0.0050
99% Upper Conf Limit	0.0094
Number of Samples	10000
Initial Seed	1046184197

Table 16. Average Number of New Photon Plans Created Weekly vs. Usage of IMRT/VMAT Automated Planning

Number of Plans	*Usage of IMRT/VMAT Automated Planning*			
Frequency Row Pct	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*

<=5	2 50.00	0 0.00	2 50.00	4
6-25	4 26.67	7 46.67	4 26.67	15
26-45	5 71.43	0 0.00	2 28.57	7
>= 46	1 20.00	2 40.00	2 40.00	5
Total	12	9	10	31
Frequency Missing = 40				

Table 17. Monte Carlo Average Number of New Photon Plans Created Weekly vs. Usage of IMRT/VMAT Automated Planning

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.1728
99% Lower Conf Limit	0.1631
99% Upper Conf Limit	0.1825
Number of Samples	10000
Initial Seed	796418585

Table 18. Average Number of New Photon Plans Created Weekly vs. Usage Automated Plan Check

Average Number of New Photon Plans Created Weekly vs. Usage Automated Plan Check				
Number of Plans	*Usage of Automated Plan Check*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	2 66.67	0 0.00	1 33.33	3
6-25	12 75.00	2 12.50	2 12.50	16
26-45	2 40.00	1 20.00	2 40.00	5
>= 46	4 80.00	0 0.00	1 20.00	5
Total	20	3	6	29
Frequency Missing = 42				

Table 19. Monte Carlo Average Number of New Photon Plans Created Weekly vs. Usage Automated Plan Check

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.6408
99% Lower Conf Limit	0.6284
99% Upper Conf Limit	0.6532
Number of Samples	10000
Initial Seed	1287261558

Table 20. Average Number of New Photon Plans Created Weekly vs. Usage of Adaptive RT

Number of Plans	*Usage of Adaptive RT*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	0 0.00	0 0.00	2 100.00	2
6-25	1 10.00	5 50.00	4 40.00	10
26-45	0 0.00	1 25.00	3 75.00	4
>= 46	0 0.00	1 33.33	2 66.67	3
Total	1	7	11	19
Frequency Missing = 52				

Table 21. Monte Carlo Average Number of New Photon Plans Created Weekly vs. Usage of Adaptive RT

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.8251
99% Lower Conf Limit	0.8153
99% Upper Conf Limit	0.8349

Number of Samples	10000
Initial Seed	1581522932

Table 22. Average Number of New Photon Plans Created Weekly vs. Usage of Scripting

Number of Plans	*Usage of Scripting*			
Frequency Row	*Always or Very Often*	*Sometimes or Rarely*	*Never*	*Total*
<=5	0 0.00	0 0.00	2 100.00	2
6-25	0 0.00	5 62.50	3 37.50	8
26-45	1 25.00	0 0.00	3 75.00	4
>= 46	5 100.00	0 0.00	0 0.00	5
Total	6	5	8	19
Frequency Missing = 52				

Table 23. Monte Carlo Average Number of New Photon Plans Created Weekly vs. Usage of Scripting

Monte Carlo Estimate for the Exact Test	
Pr <= P	0.0001
99% Lower Conf Limit	<.0001
99% Upper Conf Limit	0.0004
Number of Samples	10000
Initial Seed	2028891864

Table 24. Frequency of Usage of Artificial Intelligence Software

Table	***Frequency of Use***	***Frequency***	***Percent***	***Cumulative Frequency***	***Cumulative Percent***
Auto Contouring	Always or Very Often	11	29.73	11	29.73
Auto Contouring	Sometimes or Rarely	14	37.84	25	67.57
Auto Contouring	Never	12	32.43	37	100.00
Automated 3D Planning Software	Always or Very Often	15	51.72	15	51.72
Automated 3D Planning Software	Sometimes or Rarely	7	24.14	22	75.86
Automated 3D Planning Software	Never	7	24.14	29	100.00
IMRT/VMAT Automated Planning	Always or Very Often	12	38.71	12	38.71
IMRT/VMAT Automated Planning	Sometimes or Rarely	9	29.03	21	67.74
IMRT/VMAT Automated Planning	Never	10	32.26	31	100.00
Automated Plan Check	Always or Very Often	20	68.97	20	68.97
Automated Plan Check	Sometimes or Rarely	3	10.34	23	79.31
Automated Plan Check	Never	6	20.69	29	100.00
Adaptive RT	Always or Very Often	1	5.26	1	5.26
Adaptive RT	Sometimes or Rarely	7	36.84	8	42.11
Adaptive RT	Never	11	57.89	19	100.00
Scripting	Always or Very Often	6	31.58	6	31.58
Scripting	Sometimes or Rarely	5	26.32	11	57.89
Scripting	Never	8	42.11	19	100.00

Table 25. Frequency of Satisfaction with Automated Plan Check (e.g. Clear Check, planCheck)

Scale	*Frequency*	*Percent*	*Cumulative Frequency*	*Cumulative Percent*
Very Satisfied	15	68.18	15	68.18
Somewhat Satisfied	6	27.27	21	95.45
Neutral	1	4.55	22	100.00
Frequency Missing = 49				

Table 26. Usage of Software Vs. Average Number of Patients Simulated Weekly

Table	*Frequency of Use*	*Workload*	*Frequency Count*	*Percent of Row Frequency*
Auto Contouring* Number of Patients Simulated	Always or Very Often	1_<=5	1	9.1
Auto Contouring* Number of Patients Simulated	Always or Very Often	2_6-25	4	36.4
Auto Contouring* Number of Patients Simulated	Always or Very Often	3_26-45	2	18.2
Auto Contouring* Number of Patients Simulated	Always or Very Often	4_>= 46	4	36.4
Auto Contouring* Number of Patients Simulated	Sometimes or Rarely	1_<=5	2	14.3
Auto Contouring* Number of Patients Simulated	Sometimes or Rarely	2_6-25	8	57.1
Auto Contouring* Number of Patients Simulated	Sometimes or Rarely	3_26-45	0	0.0
Auto Contouring* Number of Patients Simulated	Sometimes or Rarely	4_>= 46	4	28.6
Auto Contouring* Number of Patients Simulated	Never	1_<=5	3	25.0
Auto Contouring* Number of Patients Simulated	Never	2_6-25	4	33.3
Auto Contouring* Number of Patients Simulated	Never	3_26-45	3	25.0
Auto Contouring* Number of Patients Simulated	Never	4_>= 46	2	16.7
Automated 3D Planning* Number of Patients Simulated	Always or Very Often	1_<=5	1	6.7
Automated 3D Planning* Number of Patients Simulated	Always or Very Often	2_6-25	7	46.7
Automated 3D Planning* Number of Patients Simulated	Always or Very Often	3_26-45	6	40.0
Automated 3D Planning* Number of Patients Simulated	Always or Very Often	4_>= 46	1	6.7
Automated 3D Planning* Number of Patients Simulated	Sometimes or Rarely	1_<=5	1	14.3
Automated 3D Planning* Number of Patients Simulated	Sometimes or Rarely	2_6-25	4	57.1
Automated 3D Planning* Number of Patients Simulated	Sometimes or Rarely	3_26-45	1	14.3
Automated 3D Planning* Number of Patients Simulated	Sometimes or Rarely	4_>= 46	1	14.3
Automated 3D Planning* Number of Patients Simulated	Never	1_<=5	2	28.6
Automated 3D Planning* Number of Patients Simulated	Never	2_6-25	2	28.6
Automated 3D Planning* Number of Patients Simulated	Never	3_26-45	0	0.0

Automated 3D Planning* Number of Patients Simulated	Never	4_>= 46	3	42.9
IMRT/VMAT Automated Planning* Number of Patients Simulated	Always or Very Often	1_<=5	1	8.3
IMRT/VMAT Automated Planning* Number of Patients Simulated	Always or Very Often	2_6-25	5	41.7
IMRT/VMAT Automated Planning* Number of Patients Simulated	Always or Very Often	3_26-45	4	33.3
IMRT/VMAT Automated Planning* Number of Patients Simulated	Always or Very Often	4_>= 46	2	16.7
IMRT/VMAT Automated Planning* Number of Patients Simulated	Sometimes or Rarely	1_<=5	1	11.1
IMRT/VMAT Automated Planning* Number of Patients Simulated	Sometimes or Rarely	2_6-25	6	66.7
IMRT/VMAT Automated Planning* Number of Patients Simulated	Sometimes or Rarely	3_26-45	0	0.0
IMRT/VMAT Automated Planning* Number of Patients Simulated	Sometimes or Rarely	4_>= 46	2	22.2
IMRT/VMAT Automated Planning* Number of Patients Simulated	Never	1_<=5	3	30.0
IMRT/VMAT Automated Planning* Number of Patients Simulated	Never	2_6-25	2	20.0
IMRT/VMAT Automated Planning* Number of Patients Simulated	Never	3_26-45	3	30.0
IMRT/VMAT Automated Planning* Number of Patients Simulated	Never	4_>= 46	2	20.0
Automated Plan Check* Number of Patients Simulated	Always or Very Often	1_<=5	2	10.0
Automated Plan Check* Number of Patients Simulated	Always or Very Often	2_6-25	11	55.0
Automated Plan Check* Number of Patients Simulated	Always or Very Often	3_26-45	3	15.0
Automated Plan Check* Number of Patients Simulated	Always or Very Often	4_>= 46	4	20.0
Automated Plan Check* Number of Patients Simulated	Sometimes or Rarely	1_<=5	1	33.3
Automated Plan Check* Number of Patients Simulated	Sometimes or Rarely	2_6-25	1	33.3
Automated Plan Check* Number of Patients Simulated	Sometimes or Rarely	3_26-45	0	0.0
Automated Plan Check* Number of Patients Simulated	Sometimes or Rarely	4_>= 46	1	33.3
Automated Plan Check* Number of Patients Simulated	Never	1_<=5	2	33.3

Automated Plan Check* Number of Patients Simulated	Never	2_6-25	1	16.7
Automated Plan Check* Number of Patients Simulated	Never	3_26-45	2	33.3
Automated Plan Check* Number of Patients Simulated	Never	4_>= 46	1	16.7
Adaptive RT* Number of Patients Simulated	Always or Very Often	1_<=5	0	0.0
Adaptive RT* Number of Patients Simulated	Always or Very Often	2_6-25	0	0.0
Adaptive RT* Number of Patients Simulated	Always or Very Often	3_26-45	1	100.0
Adaptive RT* Number of Patients Simulated	Always or Very Often	4_>= 46	0	0.0
Adaptive RT* Number of Patients Simulated	Sometimes or Rarely	1_<=5	0	0.0
Adaptive RT* Number of Patients Simulated	Sometimes or Rarely	2_6-25	5	71.4
Adaptive RT* Number of Patients Simulated	Sometimes or Rarely	3_26-45	1	14.3
Adaptive RT* Number of Patients Simulated	Sometimes or Rarely	4_>= 46	1	14.3
Adaptive RT* Number of Patients Simulated	Never	1_<=5	3	27.3
Adaptive RT* Number of Patients Simulated	Never	2_6-25	2	18.2
Adaptive RT* Number of Patients Simulated	Never	3_26-45	3	27.3
Adaptive RT* Number of Patients Simulated	Never	4_>= 46	3	27.3
Scripting* Number of Patients Simulated	Always or Very Often	1_<=5	0	0.0
Scripting* Number of Patients Simulated	Always or Very Often	2_6-25	1	16.7
Scripting* Number of Patients Simulated	Always or Very Often	3_26-45	0	0.0
Scripting* Number of Patients Simulated	Always or Very Often	4_>= 46	5	83.3
Scripting* Number of Patients Simulated	Sometimes or Rarely	1_<=5	0	0.0
Scripting* Number of Patients Simulated	Sometimes or Rarely	2_6-25	5	100.0
Scripting* Number of Patients Simulated	Sometimes or Rarely	3_26-45	0	0.0
Scripting* Number of Patients Simulated	Sometimes or Rarely	4_>= 46	0	0.0
Scripting* Number of Patients Simulated	Never	1_<=5	3	37.5
Scripting* Number of Patients Simulated	Never	2_6-25	1	12.5
Scripting* Number of Patients Simulated	Never	3_26-45	3	37.5
Scripting* Number of Patients Simulated	Never	4_>= 46	1	12.5