Data Interpretation

---

AAMD 44th Annual Meeting
June 16 – 20, 2018
Hurricane Michael
Cat-5
Wind Speed 161mph
Pressure 919mb
Strongest Possible Conclusions

MedDose Infinity Task Group: “Like you, I wonder what the future of Medical Dosimetry holds”

Anticipate Demands: “Trying to catch up to an impatient society” ….. “Patients are fighting for their lives”

Artificial Intelligence/Automation

Improve Quality
Decrease Cost
Expand Access

The Value of Medical Dosimetrists

Is Data Interpretation the New Future for Medical Dosimetry?
Grand Ballroom A-D

The Dosimetrist’s role in the radiation oncology team includes more and more, the ability to interpret and analyze radiation dose distributions in a biological medium for both normal and malignant cells. Analysis requires a great deal of judgment and insight to assess results quickly and report the details of those results with confidence. The purpose of this session is to refresh our minds regarding the statistical tools that are used in radiation oncology and research as well as to entertain the concept of this potential “new future” for medical dosimetry.

Learner Outcomes:
1. How do we make the strongest possible conclusions with the data resulting from radiation planning?
2. Can we interpret data more efficiently leading to better quality for the patient?
3. The DVH is a great data reduction tool but is it being interpreted correctly?
4. Is it wise to have an understanding of confidence intervals, P values, R values, clinical trial design?
5. Looking ahead, does it make sense to think that some level of analytics should be the responsibility of the medical dosimetrist?
Measuring “Productivity” is not as simple as counting the number of plans generated.

Relative Value Units “RVU’s” and Current Procedural Terminology “CPT’s” can “hide” the efforts of Dosimetrists

Some baseline metrics have to exist to describe what is actually happening and who is doing it.

You simply cannot improve something that has not been quantified or qualified.

Information is only as good as the system used to collect and analyze it.
Simulation: What variables can the Dosimetrist impact during initial set up?

Planning: What tools are available to the Dosimetrist and are they being utilized to show value and generate "individualized, quality patient care"?

Treatment: What steps are involved in which the Dosimetry team can assist and improve Efficiency, Accuracy and Quality? (adaptive planning?)

Follow Up: Can we tie "Plan Metrics" to "Follow Up Outcomes"?

"The treatment planning process is the most impactful and complex aspect of radiation oncology care."

Enhancing treatment planning workflow in radiation oncology.


Background: The treatment planning process is the most impactful and complex aspect of radiation oncology care. In order to provide short turn around times from patient CT simulation to treatment plan QA, requires a level of strain and haste for multiple purposes. We implemented to evaluated 18 months of data to determine the value of Quality Assurance (QA) approvals of nonemergency complex plans (including 3D/TMRT/4acBr/5Br/IMRT) that are not completed by 8:00a the day prior to a patient’s first treatment appointment, and found that this occurred on time 62% of the time. We utilized the ASCO QTP (Quality of Care) approach to brainstorm methods to enhance workflow, and made an action plan that would allow for small Plan-Do-Study-Act cycles to reach our ideal state of > 90% On Time Treatment Plan Delivery. Methods: We utilized LEAN tools from the ASCO QTP program (June 2016 cycle) to determine the most impactful areas for our process. We created a highly detailed flow chart of our work processes. Then we utilized Mosaic scripts to establish baselines for our process measures. Results: From our Ishikawa diagram, the initial most impact was in generate target volume contours after the CT simulation. Our first measure was to visually review the CT simulation process. We established a computer based quality control list (QCL) to enhance the communication process, and provided a "reminder" at the time of simulation of the target contour delivery date. After collection of data points, there was significant improvement in on time delivery (now 89%, and approaching the ideal state), as illustrated by our Run Chart, and a coincident decrease in variability between providers and cases was noted in the ASP ET (within 90% of our target). Our continuous change effort is promising, but further data will enhance our findings. Our next steps are to collect an additional two weeks of data, and initiate another PDSA cycle with a new measure of automated, reminder, from the QCL system. In achieving our goal of improving, making it sustainable, we believe that we will be providing high quality, high value patient care, while enhancing the healthiness of the work environment for our staff.

Journal of Clinical Oncology
An American Society of Clinical Oncology Journal
What is it that all of our processes keep generating?

DATA

Welcome to the world of “Big Data”
The data is real time and needs to be analyzed quickly.

Too much data to be analyzed quickly.

Data comes in many different formats and types.

See you on the beach!

DOSIMETRIST

“One who learns from experience (data) to predict future behavior in order to drive better decisions.”
Dosimetrist = Data Scientist = Statistician

“Fact Based Decision Making”
- Seeing beyond your intuition (gut feeling)
- Focus on the right questions
- Uncover simplicity inside complexity
- Making meaning out of Data (data will not do that on its own)
- Can you predict better than guess?

“Gate Keepers of Reality”

By the way….you are responsible for the decisions that you make!

Data Interpretation

Dr. Ben Nelms: “Hello Statistics, My Old Friend”

“Conventional evaluation of treatment plans which judges a ‘best treatment plan’, using tradition and practical knowledge alone is no longer adequate to evaluate directives that arise in modern practice.”

Descriptive Analytics: describes the past to help make future decisions
-- VMAT decreases the amount of beam on time compared to Static Beam IMRT

Predictive Analytics: identifies patterns and uses statistics to make inferences
-- Knowledge based planning ... forecasting potential outcomes
-- Analysis of Variance “ANOVA”; Causation vs Correlation

Prescriptive Analytics: finding the best course of action once the pattern is identified
-- Make specific recommendations regarding predicted values

*** ALL PAST DATA IS TRAINING DATA ***
ANOVA

Variation / Differences among group “means”
(how different are the groups?)

Causation **vs** Correlation

Does one event cause another event to occur and if so, to what degree or in what direction?
(correlation coefficient is the “r” value)

Whoever masters these concepts, should they be worthy, shall hold the power of .........
Minimum / Maximum

Variance
Mean
Median
Mode

Conformity
Gradient

Standard Deviation
Measures of Central Tendency

- Mean
- Median
- Mode

Cumulative DVH

Gives a running total of all the dose to voxels inside the dose grid
Mean = 96.6  
Median = 96.6  
Mode = 96.7

Gives the number of voxels for each dose point

Mean takes the sum of all the numbers in the data set and then divides by the number of data points  
(expectation of the data set)
Median

the middle number if we lined up all of our data points from smallest to largest (least to greatest)

Mode

the value that appears most often (especially helpful if your not using numeric data)
For Example

Treatment Times:

<table>
<thead>
<tr>
<th>In the Room</th>
<th>Out of the Room</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 9:00am</td>
<td>9:14am</td>
<td>14min</td>
</tr>
<tr>
<td>b) 9:25am</td>
<td>9:40am</td>
<td>15min</td>
</tr>
<tr>
<td>c) 9:45am</td>
<td>10:00am</td>
<td>15min</td>
</tr>
<tr>
<td>d) 10:08am</td>
<td>10:16am</td>
<td>8min</td>
</tr>
<tr>
<td>e) 10:25am</td>
<td>10:35am</td>
<td>10min</td>
</tr>
</tbody>
</table>

Mean

\[
\frac{14+15+15+8+10}{5} = 12.4\text{min}
\]

Median

\[
8, 10, 14, 15, 15 = 14\text{min}
\]

Mode

\[
8, 10, 14, 15, 15 = 15\text{min}
\]

Mean .... Heavily influenced by extremely high or low values

“Measures of Central Tendency tell us about the data set as a whole, but maybe not so much about individual data points.”
Table A2 Total net annual income in 2017 excluding benefits by years of experience – Full-time
MDCB Certified - primary position

<table>
<thead>
<tr>
<th>Salary by Years of Professional Experience</th>
<th>Minimum</th>
<th>First Quartile (25th Percentile)</th>
<th>Second Quartile (50th Percentile)</th>
<th>Third Quartile (75th Percentile)</th>
<th>Maximum</th>
<th>Mean (Average)</th>
<th># Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>First year, not certified</td>
<td>$80,000</td>
<td>$82,500</td>
<td>$93,000</td>
<td>$99,000</td>
<td>$160,000</td>
<td>$91,200</td>
<td>5</td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>$68,224</td>
<td>$89,645</td>
<td>$96,000</td>
<td>$108,500</td>
<td>$172,000</td>
<td>$100,477</td>
<td>141</td>
</tr>
<tr>
<td>5 to 9 years</td>
<td>$56,000</td>
<td>$98,900</td>
<td>$110,000</td>
<td>$121,125</td>
<td>$165,000</td>
<td>$111,592</td>
<td>154</td>
</tr>
<tr>
<td>10 to 19 years</td>
<td>$78,000</td>
<td>$108,000</td>
<td>$117,750</td>
<td>$130,000</td>
<td>$203,000</td>
<td>$120,219</td>
<td>320</td>
</tr>
<tr>
<td>20 years or more</td>
<td>$79,000</td>
<td>$112,328</td>
<td>$125,295</td>
<td>$137,850</td>
<td>$201,000</td>
<td>$127,466</td>
<td>194</td>
</tr>
</tbody>
</table>
Measures of Spread

- Range
- Variance
- Standard Deviation

“How data is spread around the middle”

Normal Distribution Curve
“Gaussian Distribution”
Equal number of data points right to left; Mean = Median = Mode

“Zero Skew”

Minimum Maximum
Mean = 96.6
Median = 96.6
Mode = 96.7

Remember:

“We are trying to find ‘simplicity’ in all of the complexity.”

“Statistics will help to simplify complex data but it can be both truthful and misleading at the same time.”
### Treatment Times:

<table>
<thead>
<tr>
<th></th>
<th>In the Room</th>
<th>Out of the Room</th>
<th>Total Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 9:00am</td>
<td>9:14am</td>
<td></td>
<td>14min</td>
</tr>
<tr>
<td>b) 9:25am</td>
<td>9:40am</td>
<td></td>
<td>15min</td>
</tr>
<tr>
<td>c) 9:45am</td>
<td>10:00am</td>
<td></td>
<td>15min</td>
</tr>
<tr>
<td>d) 10:08am</td>
<td>10:16am</td>
<td></td>
<td>8min</td>
</tr>
<tr>
<td>e) 10:25am</td>
<td>10:35am</td>
<td></td>
<td>10min</td>
</tr>
</tbody>
</table>

If we place the data set in order:
8, 10, 14, 15, 15

We can see that the range is: Minimum = 8; Maximum = 15

### In/Out of Room Treatment Times:

8, 10, 14, 15, 15

Range: Minimum = 8; Maximum = 15
Mean = 12.4; Median = 14; Mode = 15

What if we divide up our data set into “Quartiles”?

1) Find the Median of the Lower Half of your data set
   - Lower Set: 8, 10, 14
     Median = 10

2) Find the Median of the Upper Half of your data set
   - Upper: 14, 15, 15
     Median = 15
Now we can define the “Quartiles” of our data set:

In/Out of Room Treatment Times:
  8, 10, 14, 15, 15
Range: Minimum = 8 ; Maximum = 15

Lower Set : 8, 10, 14  Upper : 14, 15, 15
  Median = 10    Median = 15

1\text{st} Quartile = 8-10  3\text{rd} Quartile = 14-15
2\text{nd} Quartile = 10-14  4\text{th} Quartile = 15

Why?
We are determining just how spread out the data is.

1\text{st} Quartile = 8-10  3\text{rd} Quartile = 14-15
2\text{nd} Quartile = 10-14  4\text{th} Quartile = 15

Now we know that the “Interquartile Range” is: 10 to 15 minutes.
So...go back to the Salary Survey
The “2nd Quartile (50%)” is our Median and we can compare the Median to the Mean = $93,000 and $91,200

Normal Distribution Curve
“Gaussian Distribution”
Equal number of data points right to left; Mean = Median = Mode

In the Salary Survey, the Mean of $91,200 is less than the Median of $93,000 which indicates that our data is “Skewed”.

!!!! In other words, there are lower salary values that are pulling/skewing our data down. !!!!

(which value do you want your employer to know?)
For our simple In/Out Time example ..... 

It’s obvious that we do not have a Symmetric or “Normal” curve “Zero Screw”

Our data set is “Sewed”
Mode is the highest point of the curve
Median is in the Middle of the curve
Mean is towards the lower end of the curve

Mean is less than Median/Mode = there are data points on the lower end of the curve maybe “extreme” data points

Range = 0.2-17.0%,  Mean = 3.5%,  Median = 1.6%,  Mode = 0.5%
Cumulative DVH

Same DVH ... ?Mean, ?Median, ?Mode .... Is there room for more optimization?

Cumulative DVH SRS Brain:
Min = 95.4%
Max = 152.2%
Mean = 121.6%
Median = 120.3%
Mode = 122.5%
STD = 12.2%
Differential DVH SRS Brain:
Min = 95.4%
Max = 152.2%
Mean = 121.6%
Median = 120.3%
Mode = 122.5%
STD = 12.2%

There is another line item utilized in your DVH to help simplify complex data.......

“Standard Deviation”

Definition: The average distance/amount between any point and the mean.

Mathematically it is the square root of the variance.
5 Points listed as distance from the mean:

a) 1.0  b) 2.0  c) 1.3  d) 3.75  e) 2.25

To find the VARIANCE:

“The sum of the squared differences from the mean divided by the number of points.”

So Variance for this set is:

\[
\frac{1^2 + 2^2 + 1.3^2 + 3.75^2 + 2.25^2}{5}
\]

= 5.163 squared units

Standard Deviation = square root of the Variance

\[
\text{std} = 5.163^{1/2} = 2.272 \text{ units}
\]

Just a thought:
Having created a high quality plan, would it be good practice to use gEUD to lower the standard deviation?
So, What now?
If we meet all of the “score card” metrics, should we stop there?

Knowledge Based Planning
Shaded Area = Plan Database
Dashed Lines = Current Plan
Cumulative DVH
Parotid Gland

Min = 2.7%
Max = 96.5%
Mean = 23.5%
Median = 19.3%
Mode = 3.3%
STD = 20.6%

Differential DVH
Parotid Gland

Min = 2.7%
Max = 96.5%
Mean = 23.5%
Median = 19.3%
Mode = 3.3%
STD = 20.6%
Adaptive Therapy: With automation, can we now create “final estimated score card” metrics showing statistical variations around the mean?

End Result Analysis (cumulative)
End Result Analysis (differential)

Initial: Range = 92.5 to 108.5
STD = 2.9
End Result: Range = 92.2 to 110.6
STD = 3.2
As the Medical Profession moves increasingly closer to “quality performance scores” for outcome data, response data, complication data, etc….is dosimetry the right position to quantify that data?

Thank You!