Using JMP to Perform Bayesian Calculations

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Abstract

Title: Using JMP to Performa Bayesian Calculations
Background: Accreditation Council for Graduate Medical Education states that "Residents must have sufficient training in…endotracheal intubation" and that achieving 80% likelihood to successfully intubate the *next* patient is a good rule of thumb.
Methods: To assess the likelihood that a resident has achieved this level of competency during residency training, JMP 9.0 (Cary, NC) was used to create a Bayesian program to determine on the basis of a provider's prior intubation experiences the likelihood that they behaved like a novice (probability to intubate = 30%) or a competent provider (probability > 80%). Validation of the approach was achieved by comparing the prior Bayesian likelihoods of intubation competency to subsequent intubation outcomes.
Results: An 80% likelihood that the provider was competent demonstrated an 80% or higher intubation success rate on subsequent intubation attempts. Unfortunately, most of the residents had not attained this level of competency during the period of study.
Conclusion: A Bayesian approach to the assessment of intubation competency can accurately predict the outcome of subsequent intubation events. Future studies will be required to determine if new training techniques (video assisted) can significantly improve the learning curve.

Background

Accreditation Council for Graduate Medical Education states that: "Residents must have sufficient training in endotracheal intubation" but the definition or description of what constitutes 'sufficient training' is vague. Observational studies examining the success versus total opportunity rates of residents indicates only 50% success. Since what happened in the past is less important than what may happen during future intubation events, current thinking has been to adopt a standard that proficiency is achieved when the resident is 80% likely to successfully intubate their *next* patient.
To address this new standard will require a different approach to the statistical analysis of intubation proficiency.

Methods

Bayes Theorem:
What is the probability that a provider is Proficient (P(Pro))?

P(Pro|S) * P(S) = P(S|Pro) * P(Pro) (Bayes Theorem)

Where:
P(Pro|S) = Probability of Proficiency given a Success
P(S) = Probability of Success
P(S|Pro) = Probability of Success given a Proficient provider (80%)
P(Pro) = Probability that that a provider is Proficient

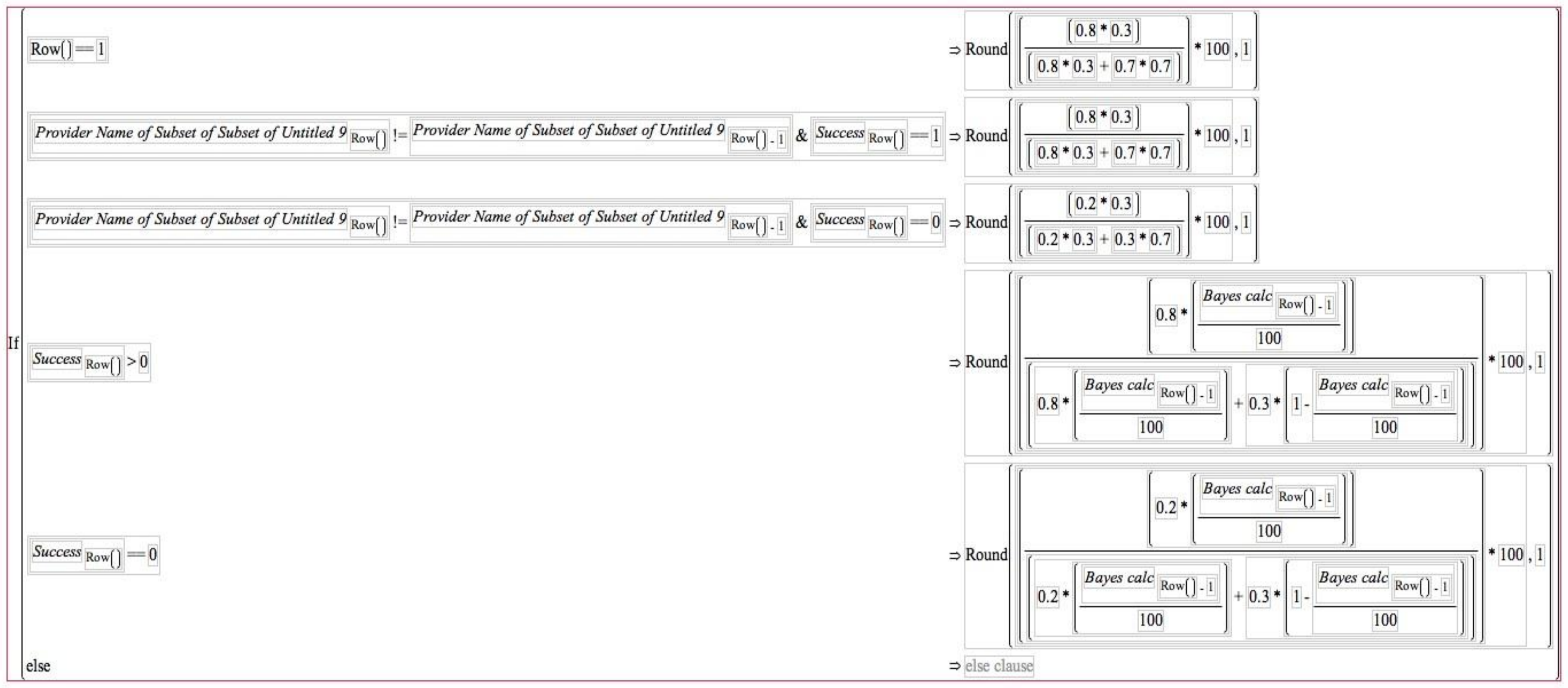
Probability of a successful intubation:
80% of the Proficient (Pro), by definition
30% of the Novices (N), based on prior observations (empiric prior)

Sample Calculation
Assume: From prior observations, the likelihood that the resident was Proficient or a Novice was 50/50: i.e.: P(Pro) = 0.50 and P(N) = 0.50.

If the intubation is successful, then P(S) is 1.0 and the new probability that the resident is proficient (P(Pro)) is:
P(Pro|S) = (0.80 * 0.5) / 1.0 = 0.40; and conversely, that the resident is a novice (N):
P(N|S) = P(S|N) * P(N) = 0.30 * 0.5 = 0.15

Dividing by the sum of these joint probabilities to obtain posterior probabilities, i.e.,
P'(Pro) = 0.40 / (0.40+0.15) = 0.73 (up from 0.5) and
P'(N) = 0.15 / (0.40+0.15) = 0.27 (down from 0.5)

Constructing Bayes Theorem Using JMP 9.0 (Cary, NC)



Results

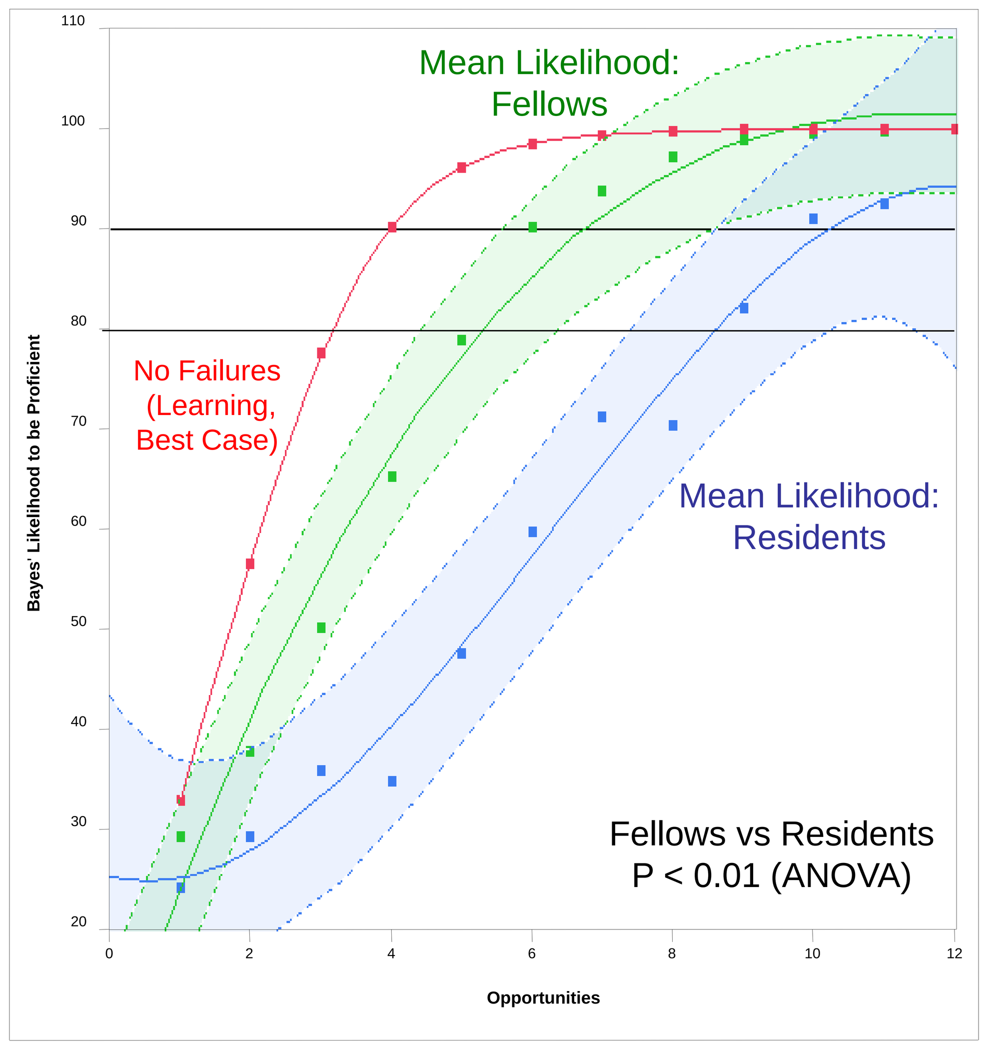


Figure 1: To demonstrate an 80% likelihood that the Intubator is Proficient, new residents require about 10 intubation opportunities whereas Fellows (former residents) require less than 6 opportunities.

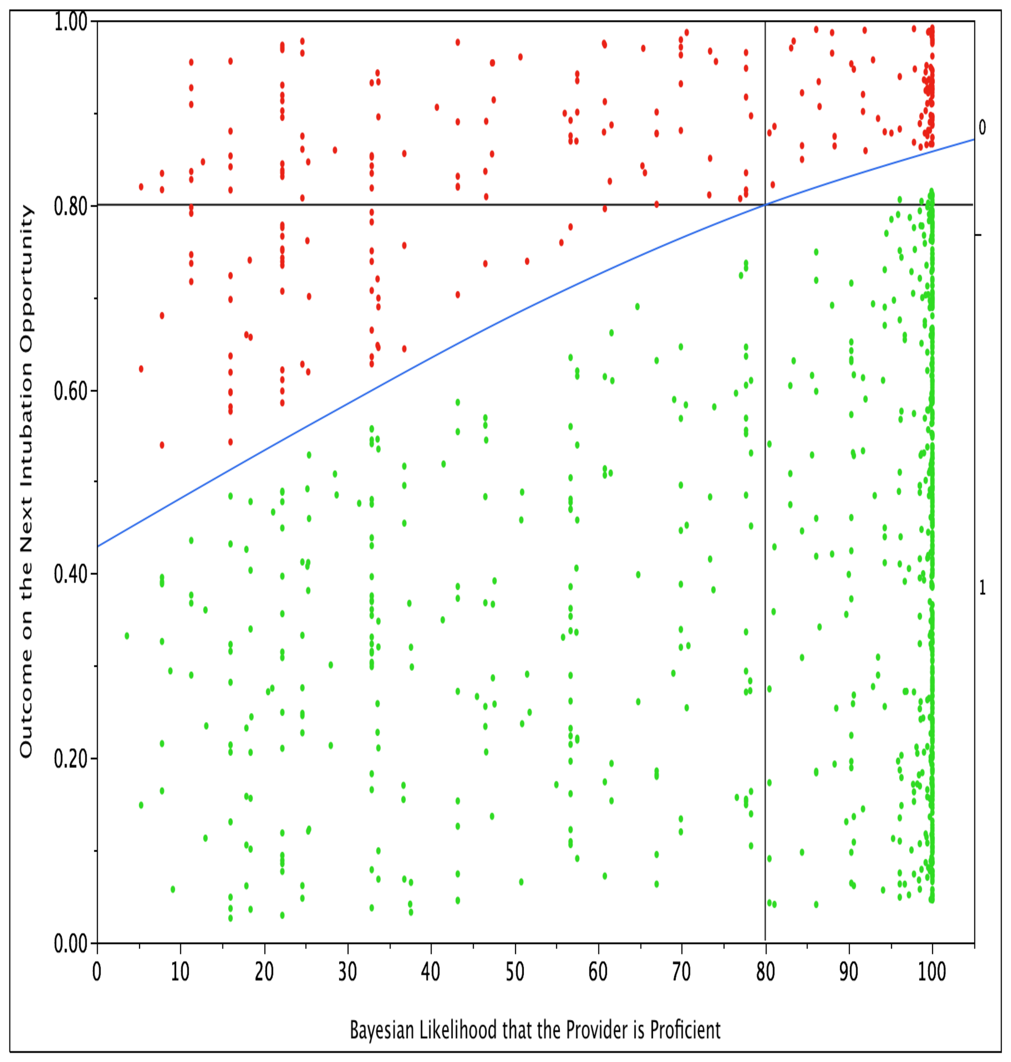


Figure 2: Validation of the Bayesian approach: When the prior Bayesian likelihood of Proficiency was 80% or higher, the subsequent intubation success rate was 80%.

Conclusions

Acquisition of intubation skills is achieved through an 'epiphany' rather than incremental process. There typically exists a 'latency period' during which the novice intubator struggles to 'see what they are looking at'. However, once the visual cues are established, skill is acquired rapidly.

In the evaluation of learning skills, use of the Bayesian approach has several advantages over traditional statistical analysis which require, among other factors, independence of prior events. These findings, together with national reductions in resident duty hours, suggest that new training techniques will have to be developed if future practitioners are to be competently skilled in the art of neonatal intubation.

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