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Abstract

Objective: To determine if a non-sedated magnetic resonance imaging (MRI) strategy for infants with congenital hearing loss is less costly than a sedated MRI.

Study Design: Cost-minimization economic evaluation and database analysis.

Methods: A decision tree was created to analyze two different MRI strategies. The reference strategy utilized a sedated MRI. The alternative strategy included a non-sedated MRI with an assumed failure rate requiring a subsequent sedated MRI. Diagnostic efficacy for both MRI approaches were assumed equal. Monte Carlo and sensitivity analysis was completed to determine the optimal strategy and cost threshold for a minimum non-sedated MRI failure rate. Charge data was obtained for anesthesia charges, and for MRI brain imaging.

Results: The average charge of moderate sedation for an MRI was \$1,366., and an MRI brain with and without contrast was \$981. Mean charges for a sedated MRI strategy were higher than that of a non-sedated MRI strategy (\$2,344.1 versus \$1,213.8. When varying the probability of a successful non-sedated MRI, a non-sedated MRI strategy is less costly than a sedated MRI strategy if the success rate is greater than 42%.

Conclusions: From a charge perspective, a non-sedated MRI strategy is less costly than a sedated MRI strategy if the success rate of the non-sedated MRI exceeds 42%. These results suggest there may be an economic advantage to providing a non-sedated MRI for infants with congenital hearing loss. Further work to compare the efficacy of non-sedated MRI versus sedated MRI is needed to rigorously evaluate cost-effectiveness of a non-sedated MRI strategy.

Introduction

Congenital sensorineural hearing loss in children is a relatively common condition with an incidence as high as 1.1-1.4 per 1,000 neonates screened in the United States. Identifying hearing loss in children is important as untreated hearing loss can result in compromised cognitive development and psychosocial health, as well as decreased quality of life. A key component of the evaluation of congenital hearing loss is the requisition of computed tomography (CT) and/or magnetic resonance imaging (MRI) studies that can potentially identify abnormalities amenable to treatment.

The American College of Radiology (ACR) has identified the CT temporal bone without contrast as the most appropriate test for congenital sensorineural hearing loss in recently published guidelines, but expert opinion has also maintained a role for MRI. Performing a MRI in young children can be challenging given the need for limited movement during image acquisition, and procedural sedation is one method to mitigate patient movement. Given the potential for patient harm and extra resources required for sedation during MRI imaging, we developed an economic evaluation comparing a non-sedated MRI strategy to a traditional sedated MRI for congenital hearing loss.

Table 1. Published failure rates for non-sedated MRI protocols.

Study Author	MRI	Child Age	Immobilization	Failure Rate
Haney et al.	Multiple	Neonatal	Vacuum Immobilizer	3%
Windram et al.	Cardiac MRI	Neonatal	Vacuum Immobilizer	0%
Neubauer et al.	MRI Brain	Pre-Term	Vacuum Immobilizer	7.2%
Ibrahim et al.	MRI Brain	Neonatal	Vacuum Immobilizer	37.5%

Methods and Materials

We designed a cost-minimization economic evaluation for a MRI in young children to evaluate congenital and childhood sensorineural hearing loss with or without the use of a sedation. A decision tree was created to analyze two different MRI strategies (Figure 1):

- The cost of the sedated MRI: anesthesia charge *plus* MRI protocol charge.
- The cost of the non-sedated MRI strategy: MRI protocol charge alone.
- The alternative strategy included a non-sedated MRI with an assumed failure rate requiring a subsequent sedated MRI.

Charge data obtained for moderate sedation anesthesia charges (CPT for "anesthesia for non-invasive imaging or radiation therapy"), and MRI brain with and without contrast imaging (Table 2).

Monte Carlo simulations with 10,000 random walks were completed with each charge variable assumed to have a 10% standard deviation. In order to determine break even points for cost-minimization related to each variable, multiple sensitivity analyses were completed.

Figure 1. Cost minimization decision tree.

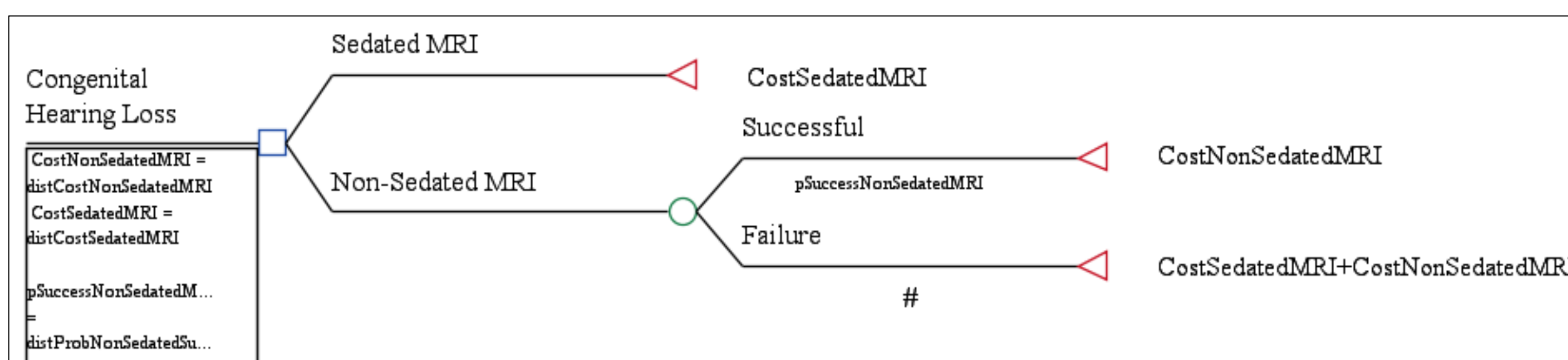


Table 2. Decision tree input variables.

Variable Name	Variable Description	Mean (Std. dev)
CostSedatedMRI	Distribution of Sedated MRI Cost	\$2,345.63 (\$234.00)
CostNonSedatedMRI	Distribution Non-Sedated MRI Cost	\$980.00 (\$98.00)
ProbNonSedatedSuccess	Distribution of Non-sedated MRI Success (%)	0.90 (0.02)

Results

A cost-minimization analysis comparing a sedated MRI to a non-sedated MRI strategy was performed with the above charge data integrated into our model. A Monte Carlo simulation was completed with 10,000 random walks which determined mean charges:

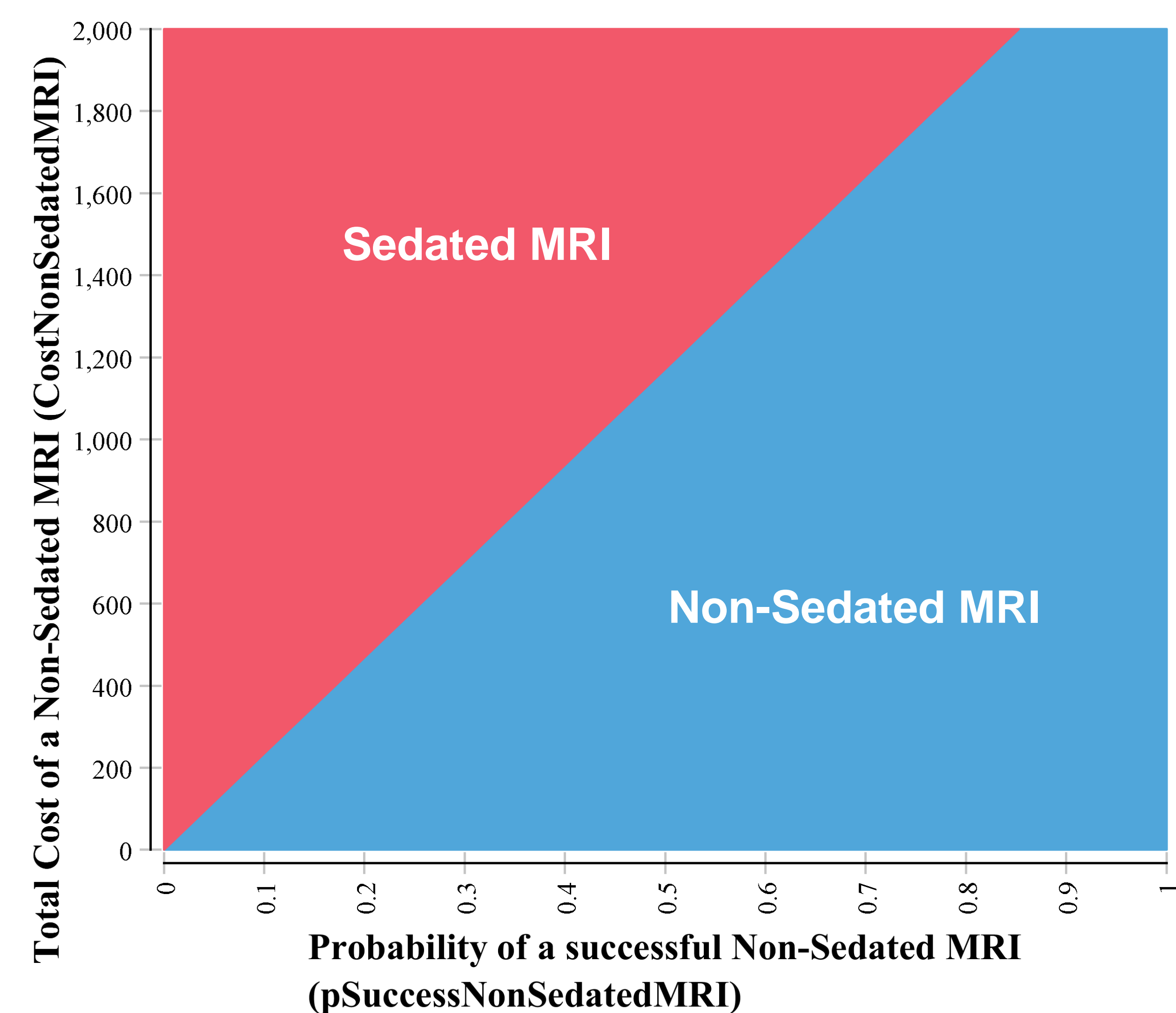
- Sedated MRI strategy: **\$2,344.09** USD; +/- \$231.96
- Non-sedated strategy: **\$1,213.78** USD; +/- \$110.71

The non-sedated MRI strategy dominated the sedated MRI strategy in cost-minimization. The incremental cost difference between the two strategies was \$1,131.08 USD.

One- and two-way sensitivity analyses were performed:

- When the probability of a non-sedated MRI success was varied, a non-sedated MRI strategy is less costly than a sedated MRI strategy if the success rate is **greater than 42%**.
- When both the cost and success of a non-sedated MRI strategy were varied, the non-sedated MRI strategy was least costly (Figure 2).
- As the cost of a non-sedated MRI increased and the success decreased, the sedated MRI strategy became dominant.
- With the probability of non-sedated MRI success constant at 50%, a two-way sensitivity analysis demonstrated the roving break-even threshold when varying costs of a sedated MRI and non-sedated MRI strategy. As the cost of a non-sedated MRI increased, a sedated MRI strategy became dominant.

Figure 2. Two-way sensitivity analysis demonstrating the roving break-even threshold when varying both the cost and probability of a successful non-sedated MRI.



Discussion

- A key component of completing the evaluation of pediatric congenital hearing loss is the requisition of appropriate imaging, as CT or MRI studies can potentially identify abnormalities.
- Completing an MRI in children can be difficult given the requirement for the patient to limit motion for an extended period of time.
- Moderate sedation during MRI imaging has been used, but not without risks including apnea, hypoventilation and hypoxemia stemming from respiratory depression.
- Utilizing sedation requires added resources including close patient monitoring by an experienced anesthetic team with full resuscitative capabilities.
- Strategies for preventing or mitigating patient movement during imaging have been developed including MRI-compatible immobilizers and incubators, rapid image acquisition and motion stabilization techniques, 'feed-and-sleep,' vacuum-bag immobilizer.
- Limitations of this analysis include the use of charges instead of cost.
- Our model cannot provide guidance for an imaging approach specifically for any specific patient population, indication for imaging, or patient age.

Conclusions

- A non-sedated MRI strategy is less costly than a sedated MRI strategy if the success rate of the non-sedated MRI exceeds 42%.**
- There may be an economic advantage to providing a non-sedated MRI for infants with congenital hearing loss from a third party payer perspective.
- A major barrier to the success of performing a non-sedated MRI is patient immobility, especially in young children who are unable to remain still for the time required for MRI image acquisition. Strategies to mitigate patient movement without procedure sedation have been developed with good outcomes.
- Further head-to-head comparative investigations are needed to compare the efficacy of non-sedated MRI versus a sedated MRI in order to rigorously evaluate cost-effectiveness of a non-sedated MRI for congenital hearing loss.

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