



Original contribution

# Cost impact of unexpected disposition after orthopedic ambulatory surgery associated with category of anesthesia provider<sup>☆</sup>



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## Abstract

**Study Objective:** To provide estimates of the costs and health outcomes implications of the excess risk of unexpected disposition for nurse anesthetist (NA) procedures.

**Design:** A projection model was used to apply estimates of costs and health outcomes associated with the excess risk of unexpected disposition for NAs reported in a recent study.

**Setting:** Ambulatory and inpatient surgery.

**Patients:** Base-case model parameters were based on estimates taken from peer-reviewed publications when available, or from other sources including data for all hospital stays in the United States in 2013 from the Healthcare Cost and Utilization Project Web site. The impact of parameter uncertainty was assessed using 1-way and 2-way sensitivity analyses.

**Interventions:** Not applicable.

**Measurements:** Major complication rates, relative risks of complications, anesthesia costs, costs of complications, and cost-effectiveness ratios.

**Main Results:** In the base-case model, there were on average 2.3 fewer unexpected dispositions for physician anesthesiologists compared with NAs. Overall, anesthesia-related costs (including the cost of managing unexpected dispositions) were estimated to be about \$31 higher per procedure for physician anesthesiologists compared with NAs. Alternative model scenarios in the sensitivity analysis produced estimates of smaller additional costs associated with physician anesthesia administration, to the point of cost savings in some scenarios.

**Conclusions:** Provision of anesthesia for ambulatory knee and shoulder procedures by physician anesthesiologists results in better health outcomes, at a reasonable additional cost, compared with procedures with NA-administered anesthesia, at least when using updated cost-effectiveness willingness-to-pay benchmarks.

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## 1. Introduction

The role of certified registered nurse anesthetists (NAs) in the provision of anesthesia services for surgery in the United States has grown over the last few decades, with NAs augmenting or substituting for anesthesiology services provided by physician anesthesiologists [1]. Based on calculations using the National Plan and Provider Enumeration System database containing all National Provider Identifier (NPI) numbers, as of December 2016, there were 48,647 unique NPIs for active NAs and 46,851 NPIs for active physicians listing anesthesiology as a primary specialty, with an additional 3,117 listing anesthesiology-pain medicine as a primary specialty [2].

Although NAs generally have been shown to safely and effectively provide a range of anesthesiology services under the supervision of physician anesthesiologists [3-8], the rising role of NAs in the provision of anesthesia care has sparked some concern about the potential impact of the quality of anesthesia services [4,9,10]. For example, in a study examining performance managing a set of simulated intraoperative emergencies, Henrichs et al. [4] found that board-certified physician anesthesiologists achieved a modestly higher mean overall performance score than NAs ( $66.6\% \pm 11.7\%$  vs  $59.9\% \pm 10.2\%$ ;  $P < .01$ ). Similarly, Silber et al. [9] found higher rates of death and failure-to-rescue when anesthesia care was not directed by physician anesthesiologists (odds ratio for death, 1.08;  $P < .04$ ; odds ratio for failure-to-rescue, 1.10;  $P < .01$ ), but no statistically significant difference in complication rates (odds ratio for complication, 1.00;  $P < .79$ ). This corresponds to 2.5 excess deaths/1000 patients and 6.9 excess failures-to-rescue (deaths) per 1000 patients with complications.

In a recent study focused on outcomes for ambulatory surgical procedures, Memtsoudis et al. [11] examined whether patient characteristics, ambulatory facility type, anesthesia provider and technique, procedure type, and temporal factors impact the outcome of unexpected disposition after ambulatory knee and shoulder surgery. Unexpected disposition was defined as either an admission to a hospital or death following ambulatory surgery, but death as an outcome was too rare to be analyzed as a separate end point. Their results indicated that a factor independently increasing the risk for unexpected disposition was the type of anesthesia provider. Specifically, the reported relative risk for unexpected disposition for anesthesia provided by NAs vs physician anesthesiologists was 1.38 ( $P < .01$ ) for knee procedures and 1.79 ( $P < .01$ ) for shoulder procedures.

Although the literature indicates a lower risk of unexpected disposition after ambulatory knee and shoulder surgery when anesthesia is provided by physician anesthesiologists compared with NAs, the cost impact or cost-effectiveness of this reduction is largely absent from the literature. The objective of present study is to fill this gap by using estimates of the excess risk of unexpected disposition after ambulatory knee and shoulder surgery associated with anesthesia administered

by NAs compared with physician anesthesiologists (reported by Memtsoudis et al.) to generate estimates of the cost and effectiveness implications of unexpected dispositions. Estimates of resource costs and health-related quality of life obtained from the literature are used to project the differences in overall costs for anesthesia administered by NAs compared with physician anesthesiologists in relation to differences in treatment effectiveness (ie, outcomes). Outcomes are estimated alternatively as “hospitalizations avoided” or “quality-adjusted life-years (QALYs) gained” from fewer unexpected dispositions with physician administered anesthesia.

## 2. Materials and methods

Base-case model parameters are derived from estimates in published peer-reviewed studies when available, but in some instances when no specific data from the literature are available, reasonable assumptions are used for base-case parameters. The impact of parameter uncertainty is assessed using both 1-way and 2-way discrete sensitivity analyses for key model parameters.

The base-case model parameters relating to rates of serious complications for ambulatory knee and shoulder surgery are reported in Table 1, along with their sources. The base-case parameter estimates relating to the relative risk of unexpected disposition are taken from the study by Memtsoudis et al. To facilitate subsequent cost analysis, we specify a ratio of 1 physician anesthesiologist for 4 NAs (1:4 ratio) to represent the mix for the nonspecific physician/NA team category in the study by Memtsoudis et al. Studies by Lovald et al. [12], Gill et al. [13], and Martin et al. [14] provide additional detail about the likelihood of serious complications, including death. However, the base-case model assumes no differences in rates for “other” serious complications associated with type of anesthesia provider.

Similarly, base-case cost parameters and their sources are reported in Table 2. Estimates of professional service costs by type of anesthesia provider are taken from Hogan et al. [15], inflated to 2014 dollars using the Consumer Price Index—all items [16]. Gonano et al. [17] provide base-case parameter estimates for anesthesia supply costs, which are assumed to be the same for all types of anesthesia providers.

The base-case value of the cost of an unexpected admission is derived from data for all hospital stays in the United States in 2013 from the Healthcare Cost and Utilization Project (HCUP) Web site [18]. After excluding all neonatal and maternal hospital stays, HCUP’s online database query tool, H-CUPNet (<http://hcupnet.ahrq.gov/>), generated an estimated mean length of stay (LOS) of 4.9 days for 2013, with a mean cost per stay of \$12,539 in 2013 dollars (\$12,742 after inflated to 2014 dollars). Simply dividing the mean total cost per stay by the mean LOS yields an estimate of \$2600 per inpatient day. To be conservative, for our base-case cost estimate, we assume that the mean LOS for unexpected hospitalizations

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