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# *Analysis of Strategies to Decrease Postanesthesia Care Unit Costs*

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*Background:* **The goal of this study was to identify interventions that anesthesiologists can make to decrease total costs of a postanesthesia care unit (PACU).**

*Methods:* **Data were collected retrospectively from patients who underwent ambulatory surgery at our tertiary care center.**

*Results:* **Supplies and medications accounted for only 2% of PACU charges. Personnel costs, which depend on the peak number of patients in the PACU, accounted for almost all PACU costs. If nausea and vomiting could have been eliminated in each patient who suffered this complication, without causing sedation, the total time to discharge for all patients would have been decreased by less than 4.8% (95% confidence interval < 7.3%). Arrival rates to and times to discharge from the PACU followed triangular and log-normal distributions, respectively. Computer simulations, using published times to discharge for drugs with "faster recovery," such as propofol, showed that the use of these drugs would only decrease PACU costs if operating rooms were consistently scheduled to run later each day. Such earlier discharge also might be beneficial if used at night, but only if the PACU could close after a single patient leaves. However, reasonably achievable decreases in the times to discharge for all patients undergoing general anesthesia are unlikely to substantively decrease PACU costs. In contrast, arranging an operating room schedule to optimize admission rates would greatly affect the number of PACU nurses needed.**

*Conclusions:* **Anesthesiologists have little control over PACU economics *via* choice of anesthetic drugs. The major determinant of PACU costs is the distribution of admissions. (Key words: Computer simulation. Cost analysis. Nausea. Pharmacoeconomics. Postanesthesia care unit.)**

COST containment and reduction have become major goals in health care. To decrease costs, hospital managers need to know the principal determinants of cost. However, these determinants are not always obvious, despite widespread beliefs. Poor understanding of the individual factors comprising the total cost of providing care for surgical patients may hamper efforts to decrease costs. The goal of this study was to use a patient database and computer simulation to test putative ways to significantly decrease costs of caring for patients in an ambulatory postanesthesia care unit (PACU). We tested three hypotheses: (1) greater use of short-acting anesthetics would decrease PACU costs; (2) elimination, by some hypothetical method, of nausea and vomiting would decrease PACU costs; (3) operating room scheduling practices can be adjusted to reduce PACU costs.

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## Materials and Methods

### *Data Collection and Descriptive Statistics*

All patients included in the study had their surgery at a tertiary care center, the University of Iowa Hospitals (UIHC). Data were collected retrospectively from the UIHC Hospital Information Systems' computer database.

The first of two groups of patients used in the study was examined to estimate the percentage of PACU charges accounted for by supplies and pharmacy charges. The 36 patients who underwent surgery at the UIHC Ambulatory Surgical Center on November 1 and 2, 1993, and were not scheduled to be admitted, were used. We chose these dates arbitrarily. For convenience, only 2 days were used in the analysis, because a relatively small sample size was large enough to draw clinically relevant conclusions. Also, charges, not costs, were collected. Charges do not necessarily reflect actual costs. However, relative (percentage of total) charges are accurate proxies for relative costs within the same institution.[1] This is how we used charges. We did not use a more sophisticated methodology, because the results were so extreme. All PACU charges for these 36 patients were for nursing time, supplies, such as intravenous tubing, or pharmacy items, such as droperidol.

The second group of patients was used to analyze for factors that controlled PACU time. The 258 patients who had surgery at the UIHC Ambulatory Surgical Center from November 1 to 30, 1993, and were not scheduled to be admitted, were included. All patients in the first group were also patients in the second group. Again, the dates were selected arbitrarily. PACU admission and discharge times, type of anesthesia, and antiemetic use were recorded. A patient was considered to have nausea if he/she received an antiemetic. Therefore, because some patients may have received an antiemetic prophylactically in the PACU, our methodology intentionally overestimated the actual rate of nausea and/or vomiting. During Mondays and Tuesdays, our ambulatory operating rooms start at 8 AM; other days, they start at 7 AM. Therefore, 1 h was subtracted from arrival times for patients who had their surgery Monday or Tuesday. Times to discharge from the PACU to home were recorded as mean ± SD.

### *Statistical Analysis of Patient Data*

Effect of nausea on the mean time to discharge was tested by a one-sided Student's *t* test with separate variances.[2] Confidence intervals on the percentages of PACU charges attributed to medications and supplies were found with the use of the standard method for a two-sided confidence interval of a population mean.[3] The observed statistical distribution of times to discharge was compared to a log-normal distribution using Lilliefors test.[4]

### *Computer Simulations*

We quantified the role played by postoperative nausea and vomiting on the total time to discharge for all patients. To do this, we simulated the effect that reducing the rate of nausea or vomiting to zero would have on the total time to discharge. This could be done, for example, with a putative hypothetical totally effective prophylactic, antinausea, antiemetic, and nonsedating therapy. In particular, the sum of time to discharge for all patients was first obtained. Times to discharge for individual patients who suffered documented nausea and/or vomiting were then reduced to the median time to discharge. Next, the sum of times to discharge was recomputed. The reported statistic was the percentage decrease in the sum of times to discharge, which we believe to be a reasonable indication of the effect of nausea and vomiting. Approximate one-sided upper 95% confidence intervals were found using the bootstrap percentile method, using 2,000 bootstrap simulations.[5] During the arbitrarily chosen study period, there was one unexpected admission, which was for nausea and vomiting. Because this patient had a time to discharge (195 min) that was similar to that of other patients with nausea and/or vomiting, we included the patient in the analysis. On no days did our PACU stay open later than planned.

We also performed computer simulations to examine the effect that decreasing time to discharge would have on the peak number of patients in our PACU. To do so, we used a statistical property of the observed log-normal distribution of times to discharge.[6] In particular, the time needed for 95% of the patients to be discharged was estimated by calculating the exponential of the upper 95% confidence limit on the logarithms of the times to discharge, assuming a constant population variance of the log times to discharge. A 95% confidence limit on the peak number of patients in the PACU was found by taking the smallest integer greater than or equal to the product of admission rate and the time required for 95% of the patients to leave.

The effect of the time of arrival throughout the day on the peak number of patients in the PACU was considered. First, we determined the observed distribution of arrival times. To do so, we divided arrival times into half-hour blocks, starting at 7 AM. Of the 258 ambulatory patients, 178 had general anesthesia. We included only patients who had general anesthesia, so that the results of these simulations could be compared easily to results of the other simulations. We counted the number of the 178 patients who arrived at each half-hour increment. Second, we used the measured distribution of arrival times to find an appropriate theoretical distribution. In particular, the triangular distribution that best matched the observed arrival times was found by using nonlinear absolute values regression.[6,7] Third, we used computer simulation to project the effect of changing the distribution of arrival times on the peak number of patients in the PACU. To do this, we convoluted the triangular arrival distribution with specified constant times to discharge.[6] The peak numbers of patients in the PACU were found by taking the smallest integer greater than or equal to the calculated numbers of patients.

## Results

### *Significance of Supplies and Medications on PACU Charges*

We recorded the percentages of PACU charges accounted for by supplies and medications among am-

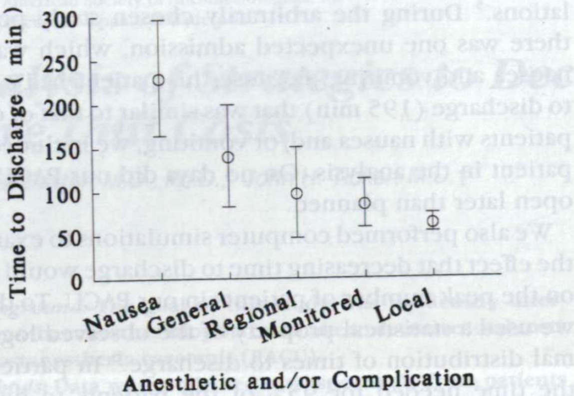


**Fig. 1. Effect of anesthetic on time to discharge. Ambulatory patients had general, regional, monitored, or local anesthesia. Nausea = the subset of patients having general anesthesia who received antiemetics and/or had nausea or vomiting postoperatively; general = patients having general anesthesia who neither received antiemetics nor reported nausea or vomiting postoperatively. Times to discharge were recorded as mean ± SD.**

bulatory surgery patients. The remainder of the charges were for time, *i.e.,* personnel costs. Our ambulatory surgery patients received few medications and required few anesthesia and recovery room supplies after they left the operating rooms. Supplies and medications accounted for only 2% (95% confidence interval 0–3%) of PACU charges. Charges for costs of personnel accounted almost entirely for the remainder.

### *Effect of Nausea on Time to Discharge*

Ambulatory patients (n = 258) who had general (n = 178), regional (n = 19), monitored (n = 34), or local (n = 27) anesthesia care had progressively shorter times to discharge, respectively (fig. 1).‡ As expected, among patients who had general anesthesia, the 8% who required postoperative antiemetics (labeled "nausea" in fig. 1) stayed longer than those who did not (labeled "general" in fig. 1; 230 ± 66 min, n = 14, *versus* 141 ± 58 min, n = 164, respectively; $P < 0.0001$; fig. 1).§ We simulated the effect that a hypothetical therapy that could prevent nausea in all patients would have had on the total time to discharge for all ambulatory patients. Eliminating nausea and vomiting would have resulted in a projected decrease in total time to discharge of only 4.8% (95% confidence interval < 7.3%). This analysis assumed that preventing and treating nausea would not affect time to discharge for patients without nausea. We deliberately assumed that the putative hypothetical antiemetic would be totally effective and have no sedative properties, an unlikely ideal. Therefore, the estimate of 4.8% would overestimate the real benefit in reduction of time to discharge, if the putative antiemetic had sedation as a side effect.

### *Statistical Distribution of Times to Discharge*

The two factors that affected the actual number of patients in the PACU at a given time of day were the hourly admission rates and the times to discharge. We examined the statistical distribution of times to discharge among ambulatory patients who had general anesthesia. The distribution was consistent with a log-normal distribution ($P = 0.149$, testing the null hypothesis that the distribution was log-normal; fig. 2, left).

### *Simulation of Anesthetic's Effect on How Late Ambulatory Surgery Can Remain Open*

Decreasing the time to discharge could permit admissions to the PACU later in the day, without requiring that the PACU stay open later and, thus, without increasing costs. We studied how the mean times to dis

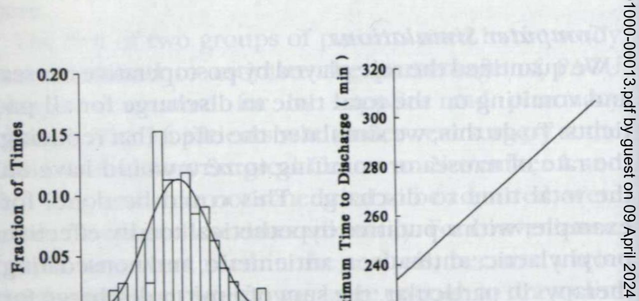


**Fig. 2. Statistical distribution of time to discharge. Histogram (*left*) shows statistical distribution of base 10 logarithm of time to discharge among 178 ambulatory patients who had general anesthesia. The best-fit normal distribution curve has been drawn (*left*). Effect of changing time to discharge was simulated (*right*) using properties of the observed (*left*) log-normal distribution of times to discharge. Maximum time to discharge = time needed for 95% of patients to leave the PACU. The line (*right*) was drawn directly from the observed (*left*) statistical distribution.**

‡ These retrospective data should not be used to conclude that using monitored anesthesia care would decrease time to discharge and thus save money. When patients are randomized to different types of anesthesia, differences may disappear.[8]

§ This can be compared to 7% in a recent study that interviewed 1,017 patients 24 h after they had undergone outpatient procedures (Anesthesiology News 20:4, 1993).

charge affected the times required for nearly all (95%) of the patients to leave. This required simulating the times required for the last patient who arrived to leave, because that patient would be reasonably expected to be the last to leave. The times to discharge followed a log-normal distribution (fig. 2, left). From the standard mathematical properties of log-normal distributions, the time for 95% of the patients to leave would be proportional to the mean time to discharge (fig. 2, right).

The simulation results (fig. 2, right) were used to project the effect that using drugs with an effect that rapidly dissipates, such as desflurane or propofol, more often might have on the time needed for the last patient to leave the PACU. For example, from the ambulatory surgery literature, use of propofol instead of thiopental for induction can be expected to decrease the mean time to discharge by 21 min.[9] Use of propofol instead of isoflurane for maintenance similarly has been reported to decrease mean time to discharge by 22 min.[10] For purposes of projection, we assumed that propofol would decrease the mean time to discharge by 22 min. We also assumed that, for an additional 50% of days (over and above what was given), the last patient of the day was given propofol. The value of 50% was chosen as an arbitrary overestimate of the actual possible increase, because most of our patients receive propofol anyway. Among our patients who had general anesthesia, with or without nausea, the mean time to discharge was 148 min ($n = 178$). Thus, from the simulation results (fig. 2, right), for 95% of days, additional use of propofol would decrease the time for the last patient who has general anesthesia to leave by $100 \times 0.5 \times 22/148 = 7\%$. Suppose that this patient was being taken care of at night or during a weekend and therefore was the only patient in the PACU. Also assume that two nurses must be present when the PACU is open. Then, decreasing the time to discharge by 7% would decrease PACU costs by $2 \times 7 = 14\%$.

### *Simulation of Anesthetic's Effect on Peak Number of PACU Patients*

Decreasing time to discharge might reduce costs by permitting a decrease in the number of PACU personnel. PACU care requires a sufficient number of nurses to be present at any time to care for the patients. This means that the number of personnel required depends on the peak number of patients in the PACU during the day. PACU costs depend, predominantly, on peak PACU census, not average daily census.

Peak PACU census was estimated using the measured statistical distribution of actual times to discharge (fig. 2, left). We did two simulations, one for an admission rate of three patients per hour (fig. 3, left) and a second for an admission rate of one patient per hour (fig. 3, right). As shown in the preceding paragraph, the actual times to discharge followed a log-normal distribution (fig. 2, left). From the mathematical properties of log-normal distributions, the peak number of patients in the PACU would be proportional to the mean time to discharge, assuming that fractions of patients could be present. Equivalently, the percent change in the peak number of patients in the PACU (vertical axes) would equal the percent change in the mean time to discharge (horizontal axes). Suppose there could be fractions of patients. Then, both lines in figure 3 would be straight and have a slope of 1.

The lines plotted in figure 3 change step-wise, because there cannot be fractions of patients. For example, consider the case of one admission per hour (fig. 3, right). Using the measured times to discharge for patients undergoing general anesthesia, the peak number of patients in the PACU turns out to be 4.44 patients. Decreasing the time to discharge by 15% decreased the peak number of patients to 3.77 patients (*i.e.*, by $100 \times (4.44 - 3.77)/4.44 = 15\%$). However, the peak numbers of patients used to generate the figure were five and four, respectively, because there cannot be fractions of patients. The observed effect of decreasing the time to discharge by 15% would be a $100 \times (5$

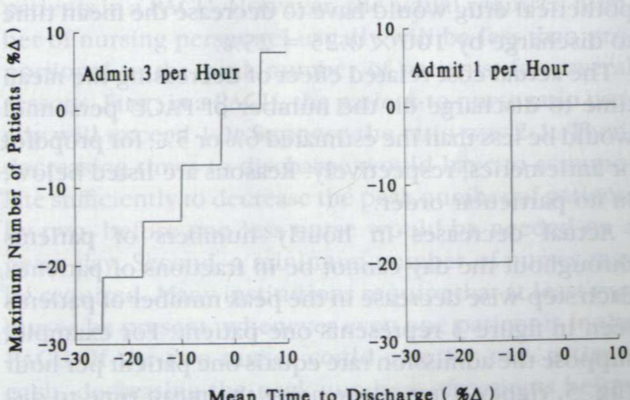


**Fig. 3. Effect of time to discharge on number of patients in a PACU. The peak number of patients in a PACU was simulated. One (*right*) or three (*left*) patient(s) were admitted each hour. Mean time to discharge = percent change in mean time to discharge from observed mean of 148 min; maximum number of patients = 95% confidence limit on percent change in peak number of patients in PACU. Each step-wise decrease in peak number of patients represents one patient.**

– 4)/5 = 20.0% decrease in the peak number of patients, as the plot shows.

We used the proportionality to estimate the effect of using more propofol (as a prototype short-acting drug) on the peak number of patients in the PACU. We made four assumptions: (1) based on the literature cited above, propofol decreases mean time to discharge by 22 min; (2) as in our ambulatory PACU (fig. 1), 70% of the patients receive general anesthetics; (3) an additional 50% of the patients receiving general anesthesia can be given propofol; and (4) as in our ambulatory PACU (fig. 1), the mean time to discharge for all patients equals 128 min. Then, for 95% of days, the drug theoretically could decrease the peak number of patients in the PACU by, at most, $100 \times 0.7 \times 0.5 \times 22/128 = 6\%$. To decrease the peak number of patients in the PACU by a more significant amount, *e.g.*, 25%, propofol would have to decrease the mean time to discharge by $0.25 \times 128/(0.7 \times 0.5) = 90$ min.

We can use this method of analysis to estimate the effect that eliminating nausea and vomiting would have on the peak number of patients in the PACU. We found above that eliminating nausea and vomiting would result in a decrease in total time to discharge of 4.8% among all ambulatory patients. Therefore, for 95% of the days, giving a hypothetical totally effective prophylactic, antinausea, antiemetic, and nonsedating therapy to all patients could decrease the peak number of patients in the PACU by, at most, $100 \times 0.048 = 5\%$. To decrease the peak number of patients in the PACU by a more significant amount, *e.g.*, 25%, the hypothetical drug would have to decrease the mean time to discharge by $100 \times 0.25 = 25\%$.

The actual cost-related effect of decreasing the mean time to discharge on the number of PACU personnel would be less than the estimated 6% or 5%, for propofol or antiemetics, respectively. Reasons are listed below, in no particular order.

Actual decreases in hourly numbers of patients throughout the day cannot be in fractions of patients. Each step-wise decrease in the peak number of patients seen in figure 3 represents one patient. For example, suppose the admission rate equals one patient per hour (fig. 3, right). Then, decreasing the mean time to discharge by 30% would not give a greater decrease in the required number of personnel than would have been achieved by decreasing the mean time to discharge by 10%. Likewise, for a small PACU, using more propofol will not decrease the peak number of patients. The predicted 6% decrease in the peak number of patients must amount to at least one patient for there to be a benefit. Therefore, use of 50% more propofol is not projected to decrease the peak number of patients, unless the peak exceeds 100 4 6 = 17 patients.

For the simulation above, we assumed that patients arrive one at a time at a constant rate, with the maximum time between admissions. If patients arrived in a "bolus," *i.e.*, at nearly the same time, the effect of pharmacologically decreasing time to discharge on the peak number of patients would be weaker. If all of the day's patients arrived in rapid succession, then we project that decreasing the time to discharge would not affect the number of nurses needed in our PACU.

### *Effect of Operating Room Schedule on Peak Number of PACU Patients*

The actual rates of admission of ambulatory patients after general anesthesia at the UIHC Ambulatory Care Center PACU were calculated from recorded arrival times. At 7 AM, when the ambulatory operating rooms open, the PACU admission rate was zero (fig. 4, left). The peak admission rates occurred around 9 AM. The last patient arrived about 4 PM. A triangular distribution can represent the observed arrival rates fairly well (fig 4, right). We plot admission rate rather than absolute PACU census, because the latter depends on both admission rate and time to discharge.

We used the triangular distribution (fig. 4, right) to study how the admission rate affects the peak number of patients in the PACU. We made two assumptions. First, we arbitrarily considered two groups of simulated

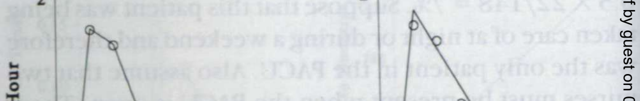


**Fig. 4. Observed distribution of admission times. Admission rates (circles) were calculated from observed times of arrival of 178 ambulatory surgery patients after general anesthesia. (*Left*) Circles were connected by straight lines, to show the raw data. (*Right*) Best-fit triangular distribution was fitted to the observed arrival times.**

patients. Namely, one group stayed in the PACU for 100 min (fig. 5, left), and the others stayed 150 min (fig. 5, right). These times to discharge compare to observed means of 128 and 148 min for all patients and general anesthesia patients, respectively. Second, we assumed that 25 patients arrived each day. Times of hypothetical peak admission rates were varied from 7 AM to 4 PM, in roughly half-hour increments. Data for all of these times of peak admission are shown in figure 5. In addition, for each time of the hypothetical peak admission rate, the time that the last patient arrived was varied from the time of the peak admission rate itself to as late as 4 PM. At each combination of time of peak admission rate and time of the last patient's arrival, the peak number of patients who would be in the PACU was calculated and plotted (fig. 5). Variation in the times of the peak admission rates had less effect than did changes in arrival times of the last of the 25 patients (fig. 5). In fact, changing the hypothetical time of peak admission had so little effect that most of the data in figure 5 overlap. Consequently, the figure appears to show many fewer points than the hundreds of simulations generated.

In sharp contrast to the pharmacoeconomic projections above, our simulations show that arranging an

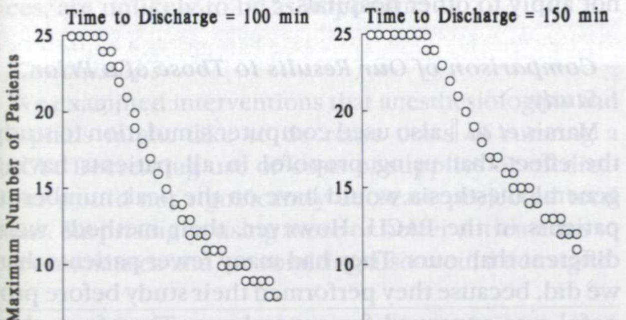


**Fig. 5. Effect of arrival time on number of patients in a PACU. Triangular distributions of admission rates were used to study how admission rate affects the peak number of patients in a PACU. Patients stayed in PACU for 100 (*left*) or 150 (*right*) min. Twenty-five patients arrived each day. Time of the peak admission rate was varied from 7 AM to 4 PM, in roughly half-hour increments. For each time of peak admission rate, time that the last patient arrived was varied from the time of the peak admission rate to 4 PM. At each of the 378 combinations of time of peak admission rate and time that the last patient arrived, peak number of patients in the PACU was calculated (circles). Because data overlap, fewer data are shown than are present.**

operating room schedule to adjust admission rates would greatly affect the number of PACU nurses needed. For example, suppose that the last patient arrived around 9 AM. The peak admission time would have been between 7 AM and 9 AM, *i.e.,* all the patients would have arrived in rapid succession. Comparing figure 5 left and right, decreasing the time to discharge would not substantively affect the peak number of patients. The peak number of patients would equal the daily admission total of 25. In contrast, consider the opposite scenario. Suppose that the last patient arrived near 4 PM. Then, the peak admission time would be between 7 AM and 4 PM, and the patients would have arrived at a much slower hourly rate throughout the day. The peak number of patients would be nearly 70% less than the maximum possible 25 (fig. 5). If the patient-to-nurse ratio were 2 to 1, decreasing the peak number of patients by 70% would decrease PACU costs by 35%. The peak expected patient load is the major determinant of PACU cost, because of staffing requirements.

## Discussion

### *Relationship of Number of Nurses to Peak Number of Patients*

Because supplies and medications accounted for only 2% of PACU charges, personnel costs accounted for almost all PACU charges. To find ways to decrease the number of personnel needed to run a PACU, we simulated effects of interventions on the peak number of patients in a PACU. However, the actual required number of nursing personnel usually will be less than proportional to the peak number of patients, for several reasons. First, in a PACU, the patient-to-nurse ratio usually will exceed 1:1. Suppose the ratio was 2:1. Then, decreasing times to discharge would have to accumulate sufficiently to decrease the peak number of patients by two, before one less nurse would be needed on a given day. Second, a minimum number of nurses may be required. Many institutions require that at least two nurses be present, whenever even one patient is in the PACU. If the two nurses could care for two patients each, decreasing the peak numbers of patients below four would not further decrease the number of nurses. Third, decreases in peak numbers of patients achieved by using more of a drug, such as propofol, likely would vary from day to day. Unless nursing hours can be adjusted, these daily variations will decrease the staffing benefit of decreasing mean times to discharge.

Changing any or all of these nursing policies could decrease PACU costs. For example, increasing the patient-to-nurse ratio would significantly decrease personnel requirements, especially for a large PACU. At our ambulatory PACU, we have a much higher patient-to-nurse ratio than 2:1, once patients are wide awake. We did not quantitatively examine the benefit of a higher patient-to-nurse ratio in this study, because we considered the results to be obvious. The higher the ratio, the lower will be the PACU costs. Alternatively, consider elimination of the minimum number of nurses requirement. The cost decrease would be particularly significant for very small PACUs, or a large one late in the day when only one or two patients remain. We did not quantitatively examine the cost benefit, because we doubt that this strategy would be implemented. We and our PACU nurses consider this standard necessary to maintain a high quality of patient care.

*Limitations of the Study*

This study introduces methodology but does not provide specific detailed information that could be used to manage a PACU. For example, many hospitals could hire part-time nurses. We did not do detailed simulations that would include such specifics. Instead, we tried to address major principles to identify determinants of PACU costs. We deliberately made simplifications, to focus our attention on issues, not details. Using our results, hospitals can focus analyses of their PACU costs on what matters: the distribution of admissions.

We included one result that is based on our individual data and so may not hold universally. At the UIHC Ambulatory Surgical Center, hypothetically eliminating nausea would not significantly decrease PACU costs. This result may not hold at all institutions, because it depends, at least in part, on actual case mix. For example, if an ambulatory care center has a practice consisting of mostly strabismus surgeries and gynecologic laparoscopies, the incidence of nausea and/or vomiting probably would be higher than the 8% at our Ambulatory Surgical Center. Therefore, at that center, eliminating nausea and vomiting might significantly decrease costs. Our result implies that eliminating nausea and vomiting, although of considerable medical and humane interest, would not necessarily affect costs. We could not find any basis to assume that preventing nausea and/or vomiting saves money, based on our ambulatory surgery practice, which, incidentally, includes many strabismus surgeries and gynecologic laparoscopies.

*Cost Analysis* Versus *Time Analysis*

Our pharmacoeconomic analyses show that using more or better antiemetics or short-acting drugs would not decrease time to discharge sufficiently to significantly decrease the peak number of patients in the PACU. Without a decline in peak census, increasing the use of these drugs is unlikely to substantively decrease PACU costs. We can conclude this because personnel costs accounted for almost all PACU charges. We did not do a direct cost analysis of these drugs, balancing the decline in the peak number of patients in the PACU with the greater cost of the newer antiemetics and short-acting anesthetics. By focusing only on time, we intentionally overestimated the cost benefit of these drugs. Although using them more frequently may not substantively decrease PACU costs, they may increase perioperative costs sufficiently to cause an overall increase in costs. We decided against doing a direct cost comparison in actual dollars, because the results would depend on our labor costs, and so would not apply to other hospitals.

*Comparison of Our Results to Those of a Prior Study*

Marais *et al.*‖ also used computer simulation to study the effect that using propofol in all patients having general anesthesia would have on the peak number of patients in the PACU. However, their methods were different than ours. They had many fewer patients than we did, because they performed their study before propofol was approved for general use. Therefore, they could not identify the statistical distribution of times to discharge, *i.e.*, the appropriate theoretical distribution. Instead, they used their measured times to discharge as an empiric distribution, from which they generated, by computer simulation, times to discharge for many patients.

Despite differences in methodologies, our results were the same. In their study, which compared propofol to thiopental and isoflurane in a wide range of adult patients having general anesthesia, the mean time to discharge was 14% shorter in the propofol group. We simulated the effect of changing the mean time to

‖ Marais ML, Maher MW, Wetchler BV, Korttila K, Apfelbaum JL: Reduced demands on recovery room resources with propofol (Diprivan) compared to thiopental-isoflurane. Anesthesiology Review 16:29–40, 1989.

discharge on the peak number of patients present in the PACU for 95% of days (fig. 3).# They found that using propofol decreased the number of patients present in the PACU 95% of the time from seven to six (their table 4). This decrease equals $(7 - 6)/7 = 14\%$. Reanalysis of their data gives our result (fig. 3). A decrease in the time to discharge (14%) causes a proportional decrease in the peak number of patients (14%).

### *Physical Number of PACU Beds*

Our results can be applied when a PACU is designed and the number of beds must be chosen. For example, a traditional rule of thumb is that an operating room suite needs 1.5–2.0 PACU beds for each operating room. Our results may help identify whether a planned operating room would need a small or large PACU, relative to the number of operating rooms. In particular, the number of PACU beds needed must exceed the peak number of PACU patients throughout the day. We found that the major determinant of the peak number of patients was the operating room schedule. Therefore, when predicting capacity requirements at a new operating room suite from data at other hospitals, the focus should be on expected differences among operating room scheduling practices. Differences among expected times to discharge, reflecting anesthesia practices, are unlikely to be as important.

### *Conclusions*

We examined interventions that anesthesiologists and hospitals might take to decrease costs of running a PACU. Decreasing use or costs of supplies or medications would not significantly decrease projected total costs. Surprisingly, using more or better antiemetics to prevent nausea and/or vomiting also would not significantly decrease costs. In fact, if they are expensive, they are likely to increase costs. Newer drugs, such as propofol or desflurane, decrease time to discharge for ambulatory patients. Using these drugs would save money if used to permit operating rooms to run later while still permitting the patients to leave the hospital that day. Such agents might be beneficial when used after hours or at any time the PACU could close once no patients were in it. However, practically achievable decreases in time to discharge may not significantly decrease the peak number of patients in a PACU throughout the day. Expanding the use of drugs with rapidly dissipating effect for all patients having general anesthesia is unlikely to significantly decrease PACU costs. Anesthesiologists have little control over PACU economics *via* choice of anesthetic drugs. We conclude that the major determinant of PACU costs is, by far, the distribution of admissions.

# Marais *et al.* did not use our 95% of days criteria. Instead, they used a $(600 - 10)/600 = 98\%$ criteria. We compared their results to ours using our 95% criteria, based on simulation results presented in their table 4. Their standard errors of the mean number of minutes per day with more patients in the postanesthesia care unit than the 95% maximum value exceeded their simulated mean number of minutes. Therefore, we did not use a criteria stricter than the 95% value.

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