Published in final edited form as:

Crit Care Med. 2017 July ; 45(7): 1138–1144. doi:10.1097/CCM.0000000000002319.

Simulation of a Novel Schedule for Intensivist Staffing to Improve Continuity of Patient Care and Reduce Physician Burnout

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Abstract

Objective—Despite widespread adoption of in-house call for ICU attendings, there is a paucity of research on optimal scheduling of intensivists to provide continuous on-site coverage.

Overnight call duties have traditionally been added onto 7 days of continuous daytime clinical service. We designed an alternative ICU staffing model to increase continuity of attending physician care for patients while also decreasing interruptions to attendings' non-clinical weeks.

Design—Computer-based simulation of a one-year schedule.

Setting—A simulated ICU divided into 2 daytime teams each covered by a different attending and both covered by 1 overnight on-call attending.

Subjects—Simulated patients were randomly admitted on different service days to assess continuity of care.

Interventions—A Shared Service schedule was compared to a standard 7 Days On schedule. For the 7 Days On schedule, an attending covered a team for 7 consecutive days and off-service attendings cross-covered each night. For the Shared Schedule, 4 attendings shared the majority of

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Conflicts of Interest: Dr. Landrigan has served as a paid consultant to Virgin Pulse to help develop a Sleep and Health Program. Dr. Landrigan has consulted with and holds equity in the I-PASS Institute, which seeks to train institutions in best handoff practices and aid in their implementation. In addition, Dr. Landrigan has received monetary awards, honoraria, and travel reimbursement from multiple academic and professional organizations for teaching and consulting on sleep deprivation, physician performance, handoffs, and safety, and has served as an expert witness in cases regarding patient safety and sleep deprivation. The other authors have no potential conflicts of interest to disclose.

daytime and nighttime service for 2 teams over 2 weeks, with recovery periods built into the scheduled service time.

Measurements and Main Results—Continuity of care as measured by the Continuity of Attending Physician Index (CAPI) increased by 9% with the Shared Schedule. Annually, the Shared Service Schedule was predicted to increase free weekends by 3.4 full weekends and 1.3 weekends with either Saturday or Sunday off. Full weeks without clinical obligations increased by 4 weeks. Mean time between clinical obligations increased by 5.8 days.

Conclusions—A Shared Service schedule is predicted to improve continuity of care while increasing free weekends and continuity of uninterrupted non-clinical weeks for attendings. Computer-based simulation allows assessment of benefits and tradeoffs of the alternative schedule without disturbing existing clinical systems.

Keywords

personnel staffing and scheduling; continuity of patient care; professional burnout; health manpower; computer simulation; intensive care unit

INTRODUCTION

Support for critical care attending presence in ICUs 24 hours per day, 7 days per week (“24/7”) to enhance patient safety (1, 2) has led a growing number of large academic medical centers to implement in-house overnight ICU attending staffing models (3-5). Because overnight shifts are typically disconnected from traditional 7-day weeks of daytime clinical service, cross-covering physician overnight staffing decreases continuity of attending physician care for patients. From intensivists’ perspective, in-house overnight calls interrupt administrative and academic time. Weekend calls increase the total number of weekends required to be at the hospital and away from personal interests. Burnout has been increasing among intensivists and has been receiving increasing attention, as evidenced by the recent joint statement of the Critical Care Societies Collaborative (6). Workload has been identified as a primary risk factor for burnout (6). Unfortunately, little research has been done on ways to decrease or mitigate the effect of time spent in the hospital and on how to optimize scheduling for 24/7 in-house intensivist coverage (7, 8).

Using computer-based modeling, we compared the typical “7 Days On” schedule (an attending is on service for 7 consecutive days with nights covered by in-house non-service attendings) to a novel “Shared Service” schedule where two attendings share overnight and daytime service obligations over a 2-week block. We hypothesized that the Shared Service schedule would increase continuity of attending physician care for ICU patients while also increasing contiguous academic or administrative time and free weekend days. We used computer-based simulation to study the impact of this Shared Service schedule on a typical academic ICU.

MATERIALS AND METHODS

Design of Schedules

For the purpose of this simulation, we modeled staffing for an ICU with 2 daytime attendings, each covering 1 of 2 patient teams, and with a single overnight attending covering both teams, regardless of the modeled schedule. Number of patients covered by an attending was thus consistent between both modeled schedules. We counted each overnight call as 1.5 days of service to account for decreased productivity on post-call days. We included all daytime and overnight service in the maximum annual service total for each faculty member. Because service week assignments usually differ among attendings based on non-clinical obligations (e.g., research, education, administration), we distributed annual service time using week equivalents (service days divided by 7) as follows: 25% of faculty were assigned a target of 13 weeks, 25% targeted 15 weeks, 25% targeted 17 weeks, and 25% targeted 19 weeks. We designed the Shared Service schedule with the aim that total amount of service be equivalent to the traditional 7 Days On schedule. We estimated that in order to adequately staff such a unit, 12 full-time intensivists would be required.

Details of the Schedules

For the 7 Days On schedule (Figure 1A), one attending covered each of 2 patient care teams during the day for 7 consecutive days. Attendings on daytime service did not provide overnight service during that week. For the Shared Service schedule (Figure 1B), two attendings divided daytime coverage evenly for each of 2 teams (4 attendings total) during 2-week blocks. Overnight coverage was provided by 1 of 4 on-service attendings whenever possible, with 2 non-service attendings included in the overnight schedule to minimize extended shifts. Each overnight was followed by a post-call day free of service. In addition to post-call days, each on-service faculty member had at least 2 full, non-post-call days completely free from clinical duties, with one of these days a weekend day. Consecutive service days were limited to 4. Under both schedules, attendings were not assigned daytime service in adjacent blocks.

Simulation and Data Analysis

Model schedules were programmed based on the descriptions above and 1,000 replications of 1-year service and call assignments were evaluated to assess stochastic variation in the random assignment of clinical responsibilities. Attendings from the 12-member simulated faculty were assigned randomly to be on service based on the rules described above and otherwise limited only by the maximum service time assigned to that attending. Calls were randomly assigned among candidate attendings when not explicitly dictated by the Shared Service schedule.

To examine the impact of the new schedule on continuity of care, we simulated patients with varying lengths of stay (LOS) and tracked which attending cared for the patient on each shift. For each LOS under each schedule, we simulated 1,000 patients admitted on a random day of a hypothetical 2-week 7 Days On or Shared Service schedule. Our measure of continuity was the Continuity of Attending Physician Index (CAPI), calculated as the number of 12-hour shifts in the patient's ICU stay divided by the number of unique

attendings who cared for the patient. It is the inverse of a previously published index of continuity in nursing care that has been applied to ICUs (9).

From a unit-wide perspective, we calculated the mean number of different attendings who had at least one clinical assignment each week. Our outcomes of interest for simulated attendings were: 1) clinical service time; 2) number of weeks completely free of clinical service, including both daytime and overnight service; 3) mean number of days between service obligations; and 4) number of weekends free from service. Weekends were considered completely free of clinical service only if an attending was not post-call or on-call on both Saturday and Sunday; otherwise the weekend was considered partly free if the attending was not post-call or on-call on either Saturday or Sunday but had one of those obligations on the other weekend day. A week was considered completely free of clinical service if no daytime service was assigned that week; if any overnight call was assigned only on Friday or Sunday; and if the attending had at least a partly free weekend.

In sensitivity analyses, we modified the Shared Service schedule so that 4 cross-covering attendings allowed for decreased service time during a 2-week block for 2 of the on-service attendings (Figure 1C). We also considered the impact of eliminating all 24-hour calls by adding an additional night-float attending (Figure 1D). We reran the same analyses using these modified schedules.

All simulation and analyses were performed in R version 3.2.4 (10). We grouped attendings according to their number of weeks of assigned clinical service and compared outcomes of interest between the 7 Days On and Shared Service schedules using two-way analysis of variance. A p-value less than 0.05 was considered statistically significant. This study was exempt from ethics review since it was based on simulated data.

RESULTS

Continuity of care was influenced by timing of a patient's admission during an attending's service week (e.g., a patient admitted on the last day of an attending's service by definition had lower continuity than a patient admitted on an attending's first day) and the patient's LOS. On average, CAPI was 9% higher (95% confidence interval (CI) 8% – 10%, $p < 0.0001$) with the Shared Service schedule versus the 7 Days On schedule.

The mean number of different attendings required weekly to staff the simulated ICU was 4.9 (95% CI 4.9 – 4.9) under the Shared Service schedule and 7.1 (95% CI 7.1 – 7.1) under the 7 Days On schedule. With the Shared Service schedule, mean number of 2-week blocks that attendings were scheduled for service varied between 7.0 (95% CI 7.0 – 7.0) and 10.2 (95% CI 10.2 – 10.3) per year, depending on the attending's protected non-clinical time. Under the 7 Days On schedule, mean scheduled uninterrupted weeks on service ranged from 6.0 (95% CI 6.0 – 6.0) to 11.1 (95% CI 11.1 – 11.1) weeks. By design, number of overnight calls outside of service weeks was higher under the 7 Days On schedule. Thus, the predicted total amount of clinical service per intensivist over the academic year, including nights on call, was similar overall under both schedules ($p = 1.0$; Figure 2).

The Shared Service schedule was predicted to result in additional time off from clinical service (Figure 2). Attendings could be expected on average to gain 3.4 full weekends (95% CI 3.3 – 3.4, $p < 0.0001$) and 1.3 partial weekends (95% CI 1.2 – 1.3, $p < 0.0001$) free annually. In addition, we found average gains of 4.1 weeks annually (95% CI 4.1 – 4.2, $p < 0.0001$) completely free from any clinical obligations. Mean time between clinical obligations increased by approximately 5.8 days (95% CI 5.7 – 5.8, $p < 0.0001$) under the Shared Service schedule.

In a sensitivity analysis, we modified the Shared Service schedule to reduce service time for 2 of the on-service attendings each 2-week block by adding more cross-covering overnight attendings (Figure 1C). This resulted in on average 2.2 fewer completely free weekends (95% CI 2.1 – 2.2, $p < 0.0001$) but 4.3 additional partially free weekends (95% CI 4.3 – 4.4, $p < 0.0001$) annually as compared to the base case Shared Service schedule. Attendings under this schedule also had on average 1.9 fewer weeks (95% CI 1.9 – 2.0, $p < 0.0001$) completely free of clinical assignments as compared to the base case Shared Service schedule. Using more cross-coverage under the modified Shared Service schedule reduced the average improvement in CAPI to 4.0% (95% CI 3.0% – 5.0%, $p < 0.0001$) compared to the 7 Days On schedule. Nonetheless, these outcomes all remained significantly improved as compared to the 7 Days On schedule.

We tested the effect of eliminating 24-hour calls by adding an additional attending for each 2-week block with exclusively overnight clinical duties (Figure 1D). Consequently, the average number of free weekends was slightly less than under the 7 Days On schedule (Figure 3). This alternate schedule had the advantage of eliminating randomly assigned cross-covering overnight call. Continuity of care was thus as much as 26% higher (95% CI 24% – 28%, $p < 0.0001$) compared to the 7 Days On schedule for shorter LOS but decreased for longer LOS so that at a simulated LOS of 25 days CAPI was 6% lower (95% CI 5% – 6%, $p < 0.0001$) compared to the 7 Days On schedule. As compared to the base case Shared Service schedule, gains in number of free weeks and time between clinical service were overall maintained, and mean number of days between clinical service assignments actually increased by 2.2 (95% CI 2.1 – 2.3, $p < 0.0001$).

DISCUSSION

In a simulated academic ICU, a Shared Service schedule, in which the majority of overnight in-house coverage is provided by attendings who are also “on-service” during daytime, is predicted to increase the number of weeks attendings are free of clinical obligations and increase the number of weekend days off that attendings could spend on personal pursuits. These benefits would be achieved while increasing continuity of patient care and with the same number of attending staff working the same number of clinical weeks. In fact, the average number of attendings needed during any particular week was decreased under the Shared Service schedule, increasing scheduling flexibility. A computer-based simulation allowed us to study potential impact of the Shared Service schedule prior to disturbing existing systems of care.

An increasing number of ICUs have in-house overnight intensivist staffing (3-5, 11). While some studies have shown that increased continuity of care improves outcomes such as ICU length of stay, family satisfaction, and errors (9, 12, 13), the impact of overnight intensivist staffing on patients may depend on the particular staffing model used to fill additional attending shifts. Our Shared Service schedule ensures 24-hour intensivist coverage while maximizing continuity of care, which may enhance the benefits of overnight attending presence.

Attention to particular staffing models that allow for high-intensity coverage while minimizing negative impacts on critical care physicians is important (14). The Shared Service schedule aims to address two potential challenges of 24/7 intensivist staffing: productivity and burnout. The ability to provide attendings with uninterrupted time for research, teaching, and administration is critical in academic medical centers (15-18), and fragmentation of research time negatively affects academic productivity (19). Thus, the Shared Service schedule is predicted to increase academic productivity by ensuring that protected time would generally not be interrupted by overnight calls.

Because all off-service weekends and more off-service weeks would be free of clinical duties, we believe the Shared Service schedule could reduce physician burnout. Burnout syndrome, characterized by exhaustion, depersonalization, and reduced personal accomplishment (6), appears to be increasing among physicians generally (7) and has been found to be present in almost half of intensivists (20). Burnout may lead to post-traumatic stress disorder, alcohol abuse, or suicidal ideation (6). Burnout may also contribute to intensivists leaving the profession or poorer work performance (6). The Shared Service schedule may promote improved work-life balance by increasing amount of time between clinical duties and number of weekends off, both of which have been associated with decreased burnout and depression (12, 20, 21).

During each 2-week block of the Shared Service schedule, each attending is required to remain in the hospital for one extended 24-hour period. Attending physicians who obtain limited sleep may be at increased risk of making medical errors (22). Thus, we designed the Shared Service schedule to minimize extended shifts, although we did not eliminate them altogether given our competing aim of minimizing cross-coverage and in recognition of the fact that many attendings would regardless be working (perhaps in offices or laboratories) prior to an overnight shift. In addition, attendings in ICUs staffed by trainees or physician extenders are more likely than trainees to get at least some sleep even when in-house overnight. As there have been calls to limit attending work hours similarly to trainee work hours limitations (23), we considered a potential modification of the Shared Service schedule that eliminated 24-hour periods on service by adding a “night float” attending. Our analysis demonstrated the feasibility of this approach while highlighting the variable impact on continuity, weekends off, and amount of time from the last non-working week.

Different scheduling models has been an area of intense debate among hospitalists (24, 25). There have also been simulation studies of staffing to match patient volumes, particularly in trauma and emergency department setting (26-29). However, to our knowledge, there have

not been other quantitative studies of the impact of staffing models on physician outcomes and on continuity of care.

Assessing the potential impact of various scheduling alternatives without disrupting the existing care delivery system is an advantage of computer-based simulation. Many industries rely on simulation to inform decision-making regarding resource scheduling, as such methods allow optimization of interventions and testing of new concepts in compressed time (30). Simulation has been increasingly applied to the study of health technologies and systems (31-34). Our modeling approach is flexible and rapidly adaptable for considering various scheduling alternatives as further recommendations and regulations are promulgated.

Several limitations of this study should be noted. First, the impacts on patients and intensivists described in this study are hypothetical, and prospective studies implementing such a schedule are necessary to validate the real-world impact of this simulation. We did not explicitly study the projected impact of the Shared Service schedule on sleep, and further research directly assessing changes in attending sleep patterns is needed. Some may perceive the intensity of time on service under the Shared Service schedule, which requires combined daytime and nighttime coverage, to be an added burden as compared to the more traditional shift schedule. Adaptation of the schedule to different units (e.g., with differing number of teams) and different attending groups may be necessary. We demonstrate in a sensitivity analysis that one particular customization of the Shared Service schedule, in which 2 additional cross-cover overnight shifts were added, may decrease some of the overnight burden for particular attendings while maintaining many of the benefits of this scheduling model. Future prospective studies of schedule implementation should directly assess attending fatigue, performance, and burnout as outcome measures, as well as the effect of staffing patterns on patient outcomes.

CONCLUSIONS

An alternative Shared Service schedule for intensivist staffing eliminates most off-service clinical responsibilities and is thus predicted to increase academic productivity and reduce burnout while increasing continuity of patient care. By using computer-based simulation, we were able to optimize and quantify potential costs and benefits of the proposed schedule prior to implementation. We conclude that simulation is a valuable adjunct to assess potential impact of scheduling interventions on patient and provider outcomes.

Acknowledgments

Support for this project came from the Department of Anesthesiology, Perioperative, and Pain Medicine at Boston Children's Hospital.

Source of Funding: Dr. Geva was supported by grant T32HD040128 from the NICHD/NIH.

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Figure 1. Schematic of 2 weeks of staffing under the 7 Days On (A) and Shared Service (B – D) schedules

See text for details of schedule design. Individual attendings are designated by different letters. Non-service attendings are denoted by italicized lowercase letters. Rows 1 and 2 in each figure represent the daytime coverage for each of two teams and the “call” attending covering the entire simulated ICU overnight. Days of the week are shown across the top of the figure. Translucent columns marked with “x” denote adjacent weeks in which different attendings are on service. The second, third, seventh, and eighth rows show the activity of each of the on-service attendings each day. S = service; C = on call; SC = service + call; PC = post-call; O = off.

Figure 2. Outcome measures for attendings stratified by amount of assigned clinical time

Bars represent mean across 1,000 replications for each schedule and error bars represent 1 standard deviation above the mean. All differences between the Seven Days On and Shared Service schedules are significant ($p < 0.0001$) except for total weeks of service ($p = 1.0$).

Figure 3. Outcome measures for attendings with alternate Shared Service schedule

Gray bars represent results for an alternate Shared Service schedule in which 24-hour calls were eliminated (Figure 1D). Bars represent mean across 1,000 replications for each schedule and error bars represent 1 standard deviation above the mean. All differences between the Seven Days On and alternate Shared Service schedules are significant ($p < 0.0001$) except for total weeks of service ($p = 1.0$).