Hamish Hwang, MD, FRCSC, FACS, Anise C. Barton, MD, FRCSC

Computer randomized scheduling for general surgery: A novel tool for resource sharing at two regional hospitals in British Columbia

Fair and transparent distribution of resources can serve recruitment and retirement needs and address both surgeon unemployment and burnout.

ABSTRACT: General surgery is a resource-dependent hospital-based specialty. Lack of resources has an impact on a hospital's ability to recruit new surgeons. At the same time, many surgeons experience burnout as a result of increasing workload. A novel computer scheduling system was developed in the early 2000s at the Royal Inland Hospital in Kamloops, BC, to allow the resources for seven full-time-equivalents to be shared among eight surgeons. In 2009 a computer program was created to assist in scheduling. The scheduling system and computer program were later adapted for use at the Vernon Jubilee Hospital to allow the resources for five full-time-equivalents to be shared among seven surgeons filling six positions (two surgeons shared one position). Days and nights on call as well as operating room time, endoscopy time, and minor surgery time were all allocated using the scheduling system. Surgeons chose a full-time-equivalent fraction such as 1.0 or 0.75, and all activities were assigned in proportion. A study was then undertaken to identify "undesirable" scheduling events before and after implementation of the system, such as allotting OR time to a surgeon on call and having OR time cancelled because of a statutory holiday. At Vernon Jubilee Hospital undesirable events were identified for the 12 months before and the 12 months after implementation of the computer randomized scheduling system on 1 July 2014. At Royal Inland Hospital manual scheduling in 2008 was compared with computer randomized scheduling in 2010. A *P* value of greater than .05 was considered significant. There were 61 undesirable events before implementation at Vernon Jubilee and 19 after, for a mean (SD) of 10.2 (8.2) preimplementation events and 3.2 (1.2) postimplementation events per surgeon (*P* < .05). At Royal Inland there were 52 undesirable events before implementation and 65 events after, for a mean (SD) of 6.5 (3.9) preimplementation events and 8.1 (2.9) postimplementation events per surgeon (*P* = ns). In both hospitals precious resources were shared in a fair and transparent way and the experience suggests that a randomized computer scheduling system can improve surgeon well-being by providing greater scheduling flexibility. This flexibility allows for more options when recruiting a new surgeon to a hospital with fixed resources and helps a late-career surgeon wind down a practice in preparation for retirement. Given the resource constraints and increasing demand for general surgical services in BC and Canada, further study on scheduling and resource sharing is needed.

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Dr Hwang is a general surgeon at Vernon Jubilee Hospital and a clinical instructor in the Faculty of Medicine at the University of British Columbia. Dr Barton is a general surgeon at Royal Inland Hospital in Kamloops and a clinical instructor in the Faculty of Medicine at the University of British Columbia.

The practice of general surgery has traditionally been a hospital-based specialty and requires hospital resources. In BC 65% of hospitals have an immediate need to recruit general surgeons but are unable to do so because of insufficient hospital resources.[1] Despite a current shortage and growing need for general surgeons because of an aging population,[1,2] 28.3% of Canadian graduates in general surgery are unable to find a job placement. This is happening in part because of fewer positions being advertised and restricted access to resources such as hospital beds and operating room (OR) time.[3] Few studies have been published on the use of scheduling systems to address resource restrictions and workload pressures. In fact, a MEDLINE search revealed no published studies at all on this topic even though insufficient resources and resulting difficulties with recruitment are very relevant and topical.[1-3]

The number of hours worked and the number of nights on call per week have a substantial impact on surgeons and are strongly related to burnout.[4,5] Burnout occurs in 24% to 40% of American surgeons and is the single greatest predictor of dissatisfaction with career and specialty choice.[6,7] Among Canadian surgeons, on-call burden and lack of access to OR resources are the main contributors to job dissatisfaction.[8] Unfortunately, the lack of hospital resources in Canada not only increases workload and burnout, it exacerbates the problem by preventing the recruitment of new surgeons. The constraints many surgeons work under has made it increasingly difficult to balance being a spouse, a parent, and a surgeon,[9] a goal important to both female and male surgeons.[10]

The surgeons at Royal Inland and Vernon Jubilee agreed that proportional scheduling of on call and all resources was the fairest approach.

Novel scheduling system introduced

Royal Inland Hospital in Kamloops is a regional tertiary care hospital with a catchment area population of 225 000 in the interior of British Columbia. In the early 2000s several surgeons had quit or retired for multiple reasons, and the remaining surgeons were being overworked. As a result, a new system was introduced whereby seven full-time positions were shared among eight surgeons. This allowed for recruitment of new surgeons who agreed to work a fraction of a full-time-equivalent (FTE) so that the total work time still equaled 7.0 FTEs. On-call duties, OR time, endoscopy time, and minor surgery time were all allocated proportionally according to each surgeon's FTE fraction. This was done manually until 2009, when a computer program was created to assist in the scheduling using a randomization algorithm.

The Vernon Jubilee Hospital is a regional hospital that serves a catchment area population of 130 000 in the North Okanagan Valley. In 2013, one of the five general surgeons there experienced a life-threatening medical condition that was directly attributed to workload and stress when two of his colleagues were away. This led to hiring a sixth surgeon and sharing existing resources. Because of the rigidity of the manual scheduling system used, where each surgeon "owned" an OR day and an on-call day, many members of the department were dissatisfied. Word of the novel scheduling system being used in nearby Kamloops and the satisfaction of the surgeons there led to the adaptation of the computer program for the Vernon site so that resources for five FTEs could be shared among six positions filled by seven surgeons (two surgeons shared one position). This meant giving up the concept of an "owned" OR day. The transition to the new system occurred on 1 July 2014.

The screenshot in **Figure 1** shows a sample 1-month schedule and some of the menus used by the computer program. For both hospitals, activities were divided into on call (CA), operating room (OR), minor surgery (MS), and endoscopy (EN). In the adaptation of the program used by Royal Inland, minor treatment (MT) slots were also included.

The program was instructed not to schedule surgeons in the OR when

they were on call or on the day after they were on call (post-call), but this could be overridden manually. Surgeons could choose whether they preferred to be scheduled for a full day of activities post-call or not. Each surgeon could also change his or her allocation fraction (e.g., 1.0, 0.75, 0.5), but with the understanding that all activities would then be assigned proportionally.

The scheduling system introduced at both regional hospitals in the study considers the "no call" and "away" dates submitted by each surgeon and assigns activities only during the time the surgeon is available. The program generates schedules 1 month at a time. Once the parameters are entered for each month the program generates a million schedules (or more if desired) by randomly assigning activities for each surgeon in keeping with the rules on various dates. If the same activity (i.e., CA, OR, EN, MS, or MT) for the same surgeon is scheduled on dates that are close together, the activity is assigned a high score (less desirable), and if the same activity is scheduled on dates that are farther apart, the activity is assigned a low score (more desirable). The two high-priority activities (CA and OR) are calculated together, and the 10 schedules with the lowest scores for CA and OR assignments are then used to schedule the remaining activities (EN, MS, MT). The program also takes into account the activities of each surgeon over the previous *n* months (*n* is chosen by the user), so that the desired weighting is achieved over a reasonable time period. The scores are added up for all activities and surgeons and 10 schedules with the lowest overall scores can then be viewed. The best of the 10 schedules is selected and adjustments are made manually if necessary.

In our study we defined a traditional scheduling system as one where a full-time surgeon has regular days assigned for specific purposes: OR, on call, endoscopy, and minor surgery. This was in place in Kamloops before 2000 and in Vernon before 1 July 2014. The application of the traditional system varies between regions and hospital sites. At some sites the schedule rotates on a yearly basis, but at other sites it is fixed. At many sites on-call responsibilities are not allocated in proportion to OR time and access to other resources. The surgeons at both Royal Inland and Vernon Jubilee agreed that proportional scheduling of on call and all resources was the fairest approach. If surgeons chose a 0.75 FTE fraction for on call they also had to accept being allocated a 0.75 fraction of OR time, endoscopy time, and minor surgery time. Accepting this allocation, which may be paradigm changing at some hospitals, is required if a computer randomized scheduling system is going to work.

Study methods and results

At Vernon Jubilee Hospital scheduling was analyzed for the 12 months before implementation of the scheduling system on 1 July 2014 and the 12 months after implementation.

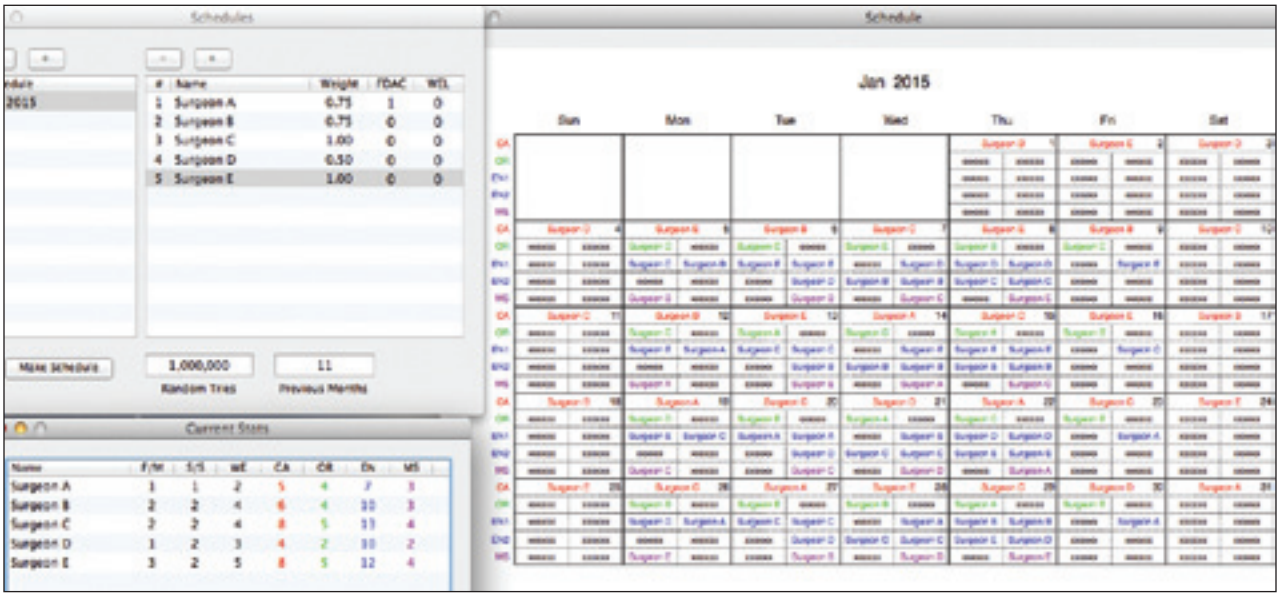

Figure 1. Screenshot of the computer randomized scheduling program used at two regional hospitals in BC.

Undesirable events considered included surgeons being scheduled in the OR while on call, being scheduled in the OR post-call, being scheduled for a full day of activities post-call, and having OR or endoscopy time cancelled as a result of a statutory holiday. At Royal Inland Hospital scheduling was analyzed for the year 2008 and the year 2010 because the exact date for conversion to the computer randomized scheduling system during 2009 could not be determined.

Continuous variables were compared using the paired Wilcoxon signed rank test. Calculations were made using an Internet-based statistical calculator.[11] A *P* value of greater than .05 was considered significant.

In the year before conversion to the scheduling system at Vernon Jubilee, there were 61 undesirable events: OR time scheduled when a surgeon was on call (22 events), OR time scheduled post-call (6 events), full days scheduled post-call (13 events), and OR/endoscopy activities cancelled because of a statutory holiday (20 events). In the year after conversion there were 19 events: OR time scheduled when a surgeon was on call (2 events), OR time scheduled post-call (5 events), and full days scheduled post-call (12 events). After conversion no OR/endoscopy activities were cancelled because of a statutory holiday. Vernon Jubilee Hospital had a mean (SD) of 10.2 (8.2) preimplementation events and 3.2 (1.2) postimplementation events per surgeon ($P < .05$). **Figure 2** shows the change in the number of events for each surgeon. Prior to implementation of computer scheduling there were 0 to 25 undesirable events per surgeon, whereas after implementation there were only 2 to 5 events per surgeon.

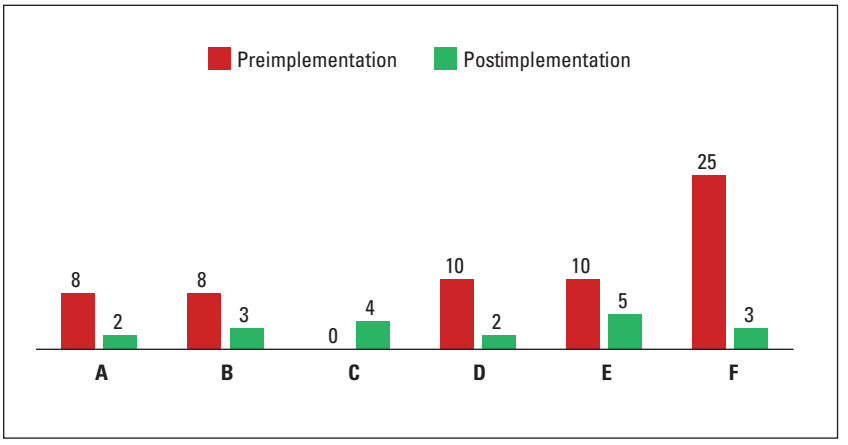

Figure 2. Undesirable events per surgeon (A to F) at Vernon Jubilee Hospital before (pre) and after (post) implementation of computer randomized scheduling.

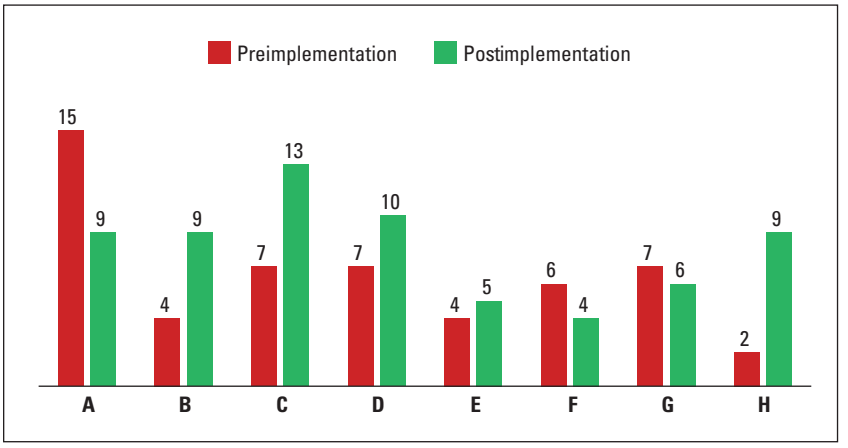

Figure 3. Undesirable events per surgeon (A to H) at Royal Inland Hospital before (pre) and after (post) implementation of computer randomized scheduling.

At Royal Inland the difference between the number of events before and after implementation was less dramatic, probably because the comparison was different than in Vernon, comparing a manual approximation of a randomized schedule to a computer-randomized schedule. In 2008 there were 52 events: OR time scheduled when a surgeon was on call (2 events), OR time scheduled post-call (27 events), and full days scheduled post-call (23 events). There were no activities cancelled because of statutory holidays. In 2010 there were 65 events: OR time scheduled when a surgeon was on call (4 events), OR time scheduled post-call (39 events), and full days scheduled post-call (22 events). No activities were cancelled because of statutory holidays. Royal Inland Hospital had a mean (SD) of 6.5 (3.9) preimplementation events and 8.1 (2.9) postimplementation events per surgeon (P = ns). **Figure 3** shows the change in the number of events for each surgeon.

Figure 4 shows simplified pre-implementation and postimplementation schedules at Vernon Jubilee, with only on-call and operating room assignments included. In the preimplementation schedule each surgeon,

except for the most recent recruit (see dark red slots), has the same on-call day and OR day, barring away days. In the postimplementation schedule, on-call and OR days are randomly assigned after away days are taken into account.

Benefits of computer scheduling

When surveyed, 85% of surgeons at the two hospitals said the computer scheduling system achieved fair distribution of both on-call and procedural time. Undesirable scheduling events were significantly reduced and evenly distributed at Vernon Jubilee after implementation. At Royal Inland, there was little difference in the number of undesirable scheduling events after implementation, which could be because the conversion to the new paradigm had already occurred years beforehand and was simply made more convenient by the computerized system. In addition, many surgeons at Royal Inland Hospital chose to override the program and be assigned a full day of activities after being on call. At Vernon Jubilee Hospital no surgeons exercised this option. The computer program allows the flexibility for each individual surgeon to choose to work a full day post-call or not.

The experience at both hospitals suggests scheduling can improve surgeon well-being by allowing for more flexibility in holiday time and days off, though at the sacrifice of last-minute changes. One surgeon commented: "I prefer this system. The division of resources is transparent and equal, which eliminates a major source of disputes I have witnessed at other sites. Although time off has to be planned early, surgeons are not 'punished' for taking time away with stacked call or loss of OR time."

Dividing a fixed pie into smaller slices is the new reality for general surgery.[1] Traditional scheduling systems only allow surgeons to work full time, half time (if he or she shares a practice with a colleague), or retire and do locums. Dividing resources into more diverse fractions is laborious,

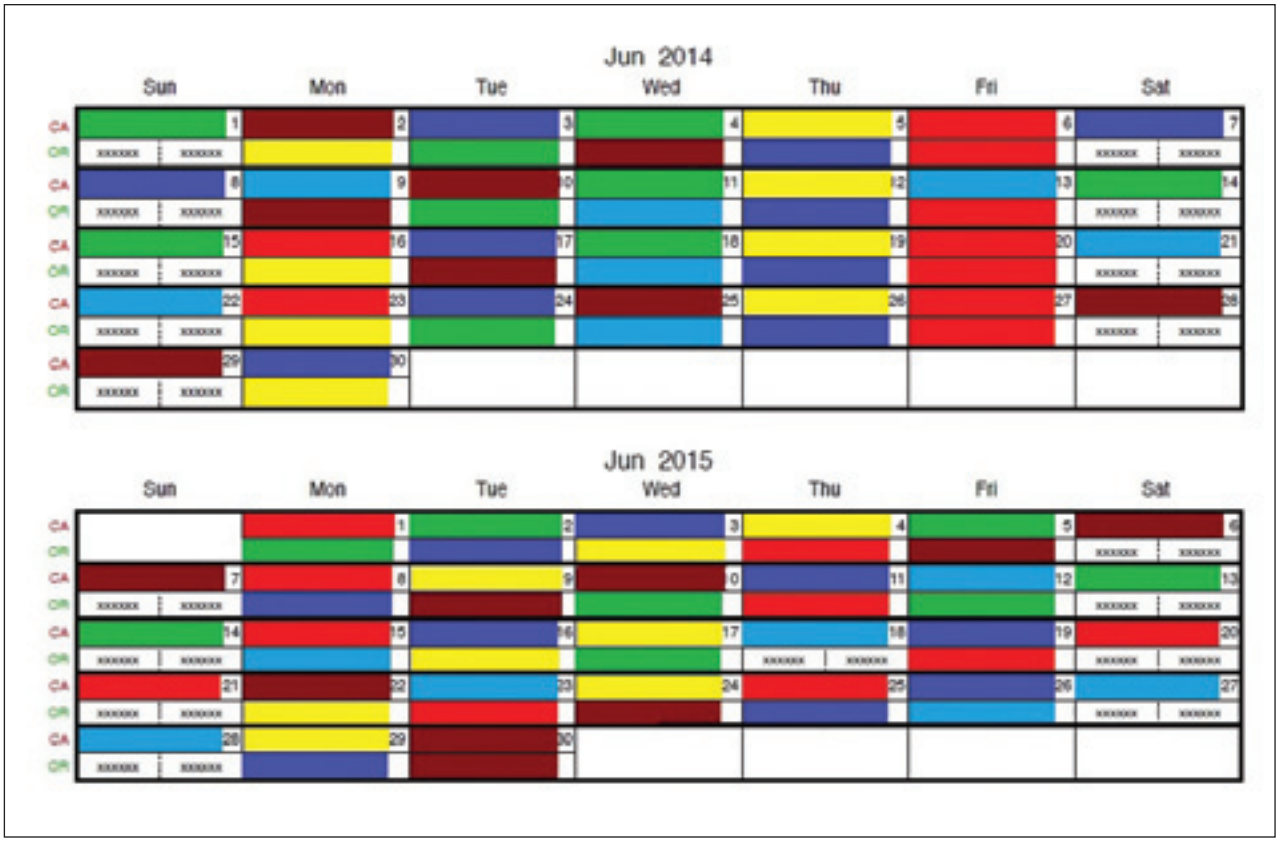

Figure 4. Vernon Jubilee Hospital schedules before (Jun 2014) and after (Jun 2015) implementation of computer-randomized scheduling, with each schedule showing operating room (OR) and on-call (CA) assignments for six surgeons represented by different colors, and time when no surgeon is scheduled represented by "xxxxxx."

and transparency is difficult to achieve when calculations have to be done manually. With a computer program doing all the heavy lifting, FTE fractions of any size can be used to allocate resources. The fractions of each surgeon can be rebalanced as often as needed. As well, the program can be used to calculate whether allocation is in line with the assigned fractions and can thus improve transparency.

In the case of Vernon Jubilee Hospital, resources for five FTEs were divided among six positions filled by seven surgeons. Two semi-retired surgeons shared one 0.83 position, two surgeons each had 0.92, two other surgeons each had 0.83, and the newest recruit started with 0.67 (0.83 + 0.92 + 0.92 + 0.83 + 0.83 + 0.67 = 5). After 6 months the 0.83 position shared by the two semi-retired surgeon was reduced to 0.67 and a third semi-retired surgeon joined this position. This allowed the newest surgeon to increase his fraction to 0.83.

Summary

Fairly dividing resources into FTE fractions with a computer randomized scheduling system can serve the recruitment and retirement needs of each unique community hospital and address both surgeon unemployment and burnout. Moreover, being able to provide options for scheduling time off when needed or half-days off after on-call days may also improve surgeon well-being. Given the resource constraints in Canada and BC, increasing surgeon workload, and the need to recruit new surgeons, further study on innovations in scheduling is needed to balance resource management with surgeon well-being.

Further study on innovations in scheduling is needed to balance resource management with surgeon well-being.

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Competing interests

None declared.

References

1. Hwang H, Karimuddin AA. Dividing the pie into smaller slices: A qualitative and quantitative analysis of the general surgery workforce in British Columbia, 1992-2012. BCMJ 2013;55:26-32.
2. Katz A, Bogdanovic B, Ekuma O, et al. Physician resource projection models. Winnipeg, MB: Manitoba Centre for Health Policy; 2009. p. 43-50.
3. Fréchette D, Hollenberg D, Shrichand A, et al. What's really behind Canada's unemployed specialists? Too many, too few doctors? Findings from the Royal College's employment study – 2013. Ottawa, ON: Royal College of Physicians and Surgeons of Canada; 2013.
4. Balch CM, Shanafelt TD, Dyrbye L, et al. Surgeon distress as calibrated by hours worked and nights on call. J Am Coll Surg 2010;211:609-619.
5. Guest RS, Baser R, Li Yuelin, et al. Cancer surgeons' distress and well-being, II: Modifiable factors and the potential for organizational interventions. Ann Surg Oncol 2011;18:1236-1242.
6. Shanafelt TD, Balch CM, Bechamps GJ, et al. Burnout and career satisfaction among American surgeons. Am Surg 2009;250:463-471.
7. Kuerer HM, Breslin T, Shanafelt TD, et al. Road map for maintaining career satisfaction and balance in surgical oncology. J Am Coll Surg 2008;207:435-442.
8. Ahmed N, Conn LG, Chiu M, et al. Career satisfaction among general surgeons in Canada: A qualitative study of enablers and barriers to improve recruitment and retention in general surgery. Acad Med 2012;87:1616-1621.
9. Murtha Y. Perspectives of being spouse, parent, and surgeon. J Orthop Trauma 2013;27:S12-S13.
10. Kwong A, Chau WW, Kawase K. Work-life balance of female versus male surgeons in Hong Kong based on findings of a questionnaire designed by a Japanese surgeon. Surg Today 2014;44:62-72.
11. Statistics Online Computational Resource. Los Angeles: UCLA Department of Statistics; 2015. Accessed 1 January 2015. www.socr.ucla.edu/SOCR.html.

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