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# Computer Applications

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## Computerized schedules – one solution to variable workstyles

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*A computerized scheduling program was developed to provide hospital anaesthetic coverage and yet still satisfy the complex workstyles of 30 anaesthetists. Hospital commitments required ten anaesthetists available each weekday and four each weekend day for after-hours coverage of the intensive care units and operating rooms. The workstyles included part-time arrangements, limited calls by some individuals, and calls restricted to certain anaesthetists with specific areas of expertise. Rules were defined to limit the proximity of late calls to avoid fatigue and computer software was developed. For each scheduling period, the program assists in making daily call assignments based on each anaesthetist's availability and a priority ranking system. It is flexible enough to allow personal preferences. The number and distribution of all calls scheduled are counted. When the assignments are completed, differences are reconciled. For two years, this program has proved superior to previous manual systems for scheduling this group of anaesthetists with variable workstyles.*

### Key words

ANAESTHESIA: scheduling, computers; STATISTICS: schedules.

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The increasing difficulty of manually scheduling 30 anaesthetists for 24-hour coverage of operating rooms, intensive care units, and an obstetrical suite, led to the development of a computerized call schedule program. Although software was available for scheduling, none was suitable to match our hospital call requirements and the many different workstyles of our anaesthesia group.<sup>1-4</sup>

Workstyle variations in this group include part-time arrangements, limited calls by senior and administrative partners, and calls in the intensive care units and the cardiovascular/trauma operating rooms which are restricted to certain anaesthetists with specific areas of expertise. In this group, these variations have a high priority. They satisfy the many different personal requirements of 30 anaesthetists. The program assists in assigning hospital calls and incorporates these different workstyles. Overnight and late calls are distributed to avoid fatigue. The number of calls scheduled is fairly proportioned and is dependent on each individual's workstyle. Calls worked which differ from those assigned are reconciled.

There were three alternatives in developing a computerized system. The first involved a system to track and total calls assigned manually but this would not assist in preparing a call list. The second, totally automated, generated a completed schedule after all call rules and doctor commitments were programmed. However, fixed rules could not be formulated for every situation or for each individual doctor's preferences. The third alternative, our system, assists in assigning calls to doctors based on their availability, a priority ranking system, and personal preferences. Assignments are made for daily calls in the operating rooms, weekly rotations in two intensive care units and absent days for two part-time groups. All assignments completed are tracked.

### Methods

In order to computerize, we defined the rules for hospital

coverage, group organization, call assignments, and the different centres where assignments are scheduled. Computer software was developed.

#### *Hospital coverage*

Anaesthesia for obstetrical and surgical cases after 16:00 hours requires a first call anaesthetist who stays in the hospital overnight and a second call anaesthetist who is available for emergency cases. One of these must have expertise in trauma and cardiovascular anaesthesia. These two calls are assigned seven days per week. Six other anaesthetists (calls three to eight) are available five weekdays after 16:00 hours to continue surgical cases. Third call goes home the latest and eighth call the earliest. Two other anaesthetists provide 24-hour coverage for the medical surgical, and cardiovascular intensive care units on a weekly basis. In total, ten anaesthetists are assigned calls each weekday and four each weekend day.

#### *Group organization*

For each scheduling quarter, approximately thirteen weeks, the number of calls which an individual must be assigned for fair proportioning is calculated. Not all individuals in the group are equal. Less than one third take a normal 100 per cent assignment of operating room calls. Ten are involved in part-time arrangements and take a reduced number of all calls. These include a group of four individuals who each work three of every four weeks (A group, 75 per cent of calls), a group of five individuals who each work four out of five days a week (B group, 80 per cent of calls), and one anaesthetist who works three days a week (60 per cent of the regular call assignments). Four doctors do not take all eight calls. One works no third through eighth calls to compensate for administrative time. The anaesthetist who supervises the Pain Clinic takes no third or fourth calls, and two senior anaesthetists take no first or weekend calls. The nine anaesthetists who cover the two intensive care units on a weekly rotation are also scheduled differently. They do not take operating room calls during their intensive care week, take no weekend first or second calls, and are assigned only 60 per cent of the regular operating room calls. Only half the group does major trauma and cardiovascular cases.

#### *Call assignments*

Excessive "on call" hours in close proximity are avoided by a few simple rules. Calls are not scheduled the day following a late night (calls two and three) or the Monday following a week in the intensive care unit. No calls are scheduled the day before or two days after a first call. No high calls (one, two, three, four) are assigned the evening prior to a single requested holiday. A weekend call is not assigned when a doctor's holiday falls on either a Monday or a Friday. We complete one schedule each thirteen

weeks (four/year; A,B,C,D quarters). Operating room calls, intensive care unit rotations, and A and B group absent days are distributed evenly over each of these quarters.

#### *Task centres*

There are five specific groups or task centres which must be scheduled. These include the two intensive care groups (medical surgical-M and cardiovascular-C) which are staffed by a weekly rotation, the two job sharing arrangements (groups A and B) where one member of each group is scheduled to be absent each day, and the operating room group which has eight calls each day and two on weekends. One anaesthetist can belong to more than one of these task centres.

#### *Computer software*

The program is written in "Revelation," a data base system made up of entry templates and programs written in R/BASIC. "Revelation" can be run on networked personal computers as well as larger mini computers and mainframes. The system uses algorithms on a calendar basis in assigning calls required to fulfil daily shift requirements and takes into account past call records. The selection of a doctor for a specific call on a particular day depends on his availability and a priority ranking system. Lack of availability is determined by holidays, no call requests, workstyle arrangements and rules which define days for no call assignments following previous overnight first or late second and third calls. Priority is based on the number of days from the last previous call and the total number of calls left to be scheduled for fair proportioning. The scheduling system is menu-driven and incorporates several features to ensure user friendliness. The user does not need previous computer experience. The author, and user, at this hospital has no formal training in computers or data processing. The software required extensive time for development and testing by an outside data processing firm (HKA Data Processing Limited).<sup>\*</sup> The knowledge obtained in setting up this computer project may be useful for future anaesthetic applications.<sup>4</sup>

#### **Results**

To operate the program the user simply follows the menus from "Rules" to "Backup" (Figure 1).

#### *Rules*

The "Rules" menu defines all fixed program rules (eg., the four scheduling quarters per year). Rules for each of the individual task centres are listed on the menu. At present, a change in these rules requires program changes but future adaptations will allow user options.

<sup>\*</sup>HKA Data Processing Limited, 455 Cochrane Drive, Units 16-18, Markham, Ontario, L3R 9R3.

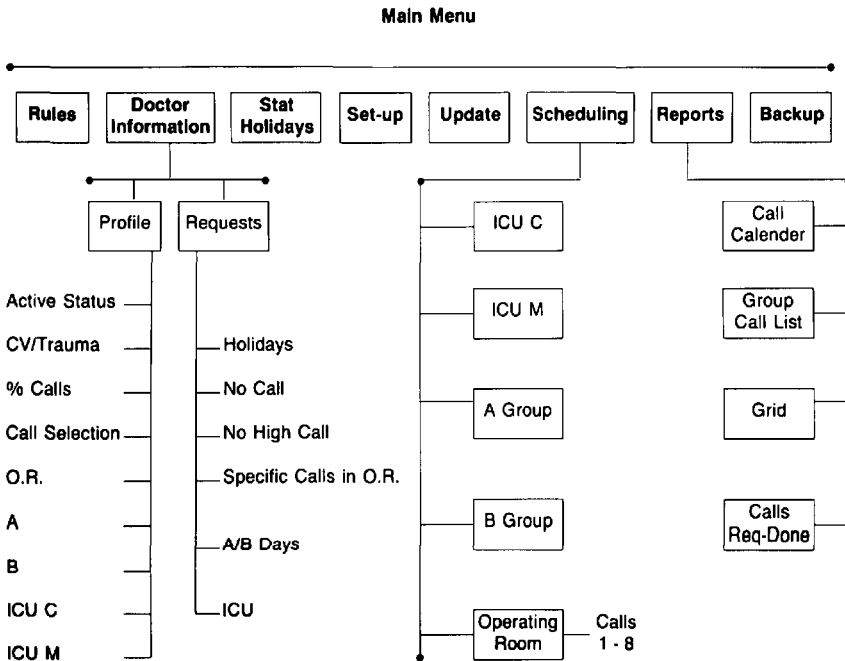


FIGURE 1 *Main menu* The menu system for computerized scheduling. Main menus completed from left to right, lead to a final printed call schedule.

#### *Doctor information*

This file is made up of two parts. Both the "Profile" and "Request" menus are data entry files which can be altered from quarter to quarter by the user. The "Profile" of each doctor determines his activity status. Active doctors will be assigned calls, inactive doctors are not scheduled. The cardiovascular/trauma call is an option. Each individual is assigned to one or more of the five task centres, the operating rooms (OR), groups (A,B) or intensive care units (C,M). The type of calls assigned in the operating rooms (one to eight) and their percentage (100 per cent for a full-time anaesthetist) are specified for each doctor. "Requests" for each doctor including holidays, days for no calls, and no high calls in the operating rooms (one to four) are keyed at this stage. Specific assignment requests within each task centre can be entered, for example, a request for a first call in the operating room on a specific day.

#### *Stat holidays*

The "Stat Holidays" menu must be completed so that

weekend rules are extended over a three-day period of a long weekend.

#### *Set up*

Once "Doctor Information" has been completed, a new scheduling quarter (A,B,C,D) to include only the active doctors can be created. The "Setup" menu will compute the number of intensive care unit weeks, A and B group absent days and operating room calls which need to be assigned over the scheduling quarter. To achieve fair proportioning it calculates the number of assignments required for each doctor for each of the task centres based on his requested percentage.

#### *Update*

The "Update Final Call Menu" allows the reconciliation of calls completed which differ from those which were scheduled in the previous quarter. If an individual is sick on the day of his assigned call, the doctor who worked this call will receive a credit. The program then recalculates calls required in the new quarter to account for these

changes. Therefore, the final number of calls required in each new quarter is the sum of the new quarter calls required, the calls unassigned from any previous quarters, and any of these updated calls.

**Scheduling**

Each of the task centres can now be scheduled. Those which are the most complex are scheduled first. Coverage for the two intensive care units (C,M) is assigned first because this task centre requires an individual who is available for an entire week. The program lists the intensive care unit doctors who are available for the entire week (i.e., they have no holidays and no other requests). Of those available the one who has done the fewest number of weeks in the unit over the year and who has the longest time period from his last unit week is shown as the first priority for selection. Absent weeks for members of the A group are scheduled next, followed by the absent days for the members of the B group. Again the doctor who is available and has the highest priority is selected. This system also tracks which days of the week the B group absent days are assigned. In this way, the premium Monday or Friday absent days are equalized throughout the year.

Doctors' operating room calls (one to eight) are also chosen according to availability and priority. For any quarter, calls may be assigned by date (from the start to the completion of the quarter) or by call number (all the first calls, then all the second calls etc.).

**Example**

Consider assigning a second call on a particular day (Wednesday, November 2, 1988) (Figure 2). The initials of all the active doctors are listed by the program. For this day and this second call, the initials of those doctors who are available are highlighted. If the first call for this day is assigned to a doctor without cardiac and trauma expertise only those doctors with this area of expertise will be available for this second call. The number of unscheduled second calls yet to be assigned during this quarter for fair proportioning is shown for each individual. The number of second calls already assigned during this quarter is also shown. To assist in choosing one of the available doctors, a priority ranking (numbers, letters) of these doctors is computed and listed beside each doctor's initials. There are two factors which determine priority. First, the doctor who has the most number of days between this proposed call and his last assigned second call will be listed as "number one." The doctor who was assigned this call most recently receives the lowest priority of those available (the largest priority number). Second, the individual who has the most second calls unscheduled has top priority and is listed as "letter A." These priority

Operating Room Call Scheduling				
Call 2	Wednesday Nov 2, 1988	Doctor....		
Priority	Name	Unscheduled	Assigned	Same Day
	SA	.06	4	
	ZB	-.57	4	AAB
	SB	.59	4	B
	GB	-.35	3	AB
1A	RF	1.65	1	A
	PC	.83	1	B
	RD	.43	5	AB
	HF	1.06	5	
	GG	.65	3	
2B	CI	.41	4	AB
	AK	.06	4	A
	BK	.06	4	AB
3C	MK	.31	2	
	MKu	.00	0	
	PL	.06	5	
	SL	.00	0	
	PLo	.38	3	B
	DM	.64	4	A
	DMc	-.35	4	BB
	DMk	-.35	3	A
	JM	-.35	4	
	WN	-.13	3	B
	SO	.06	5	B
	KR	.06	4	A
	KRs	.06	3	AB
	HS	-1.35	5	A
	JW	-.05	3	A

FIGURE 2 Operating room call scheduling Operating room call assignment for second call Wednesday, November 2, 1988. The initials of all doctors are shown under the column "Name." Those highlighted are doctors available to do this call. "Unscheduled" refers to the number of calls which are still required to be scheduled during this period for fair proportioning. "Assigned" is the number of second calls which have already been assigned during this quarter. The A's and B's noted under "Same Day" are the number of second calls assigned on a Wednesday during the A and B quarterly periods. A single A and B signify that one second call has already been assigned during each of the A and B quarters. The "priority" numbers and letters, 1A, 2B and 3C beside each available doctor's initials determines that doctor RF (1A) is the best choice for this call.

rankings (letters A-Z) are weighted by the percentage of calls taken by an individual. If an individual has less than 0.5 second calls unscheduled during this quarter, his priority ranking is highlighted also. The user chooses which priority ranking, either number or letter, is the most appropriate. Obviously, a doctor given a "1A" priority is the best choice for any assignment. To avoid repeated calls on the same day of the week, the number of calls assigned on this day are listed for each quarter and the entire year. If a choice by priority ranking leads to an excessive number of calls on this particular day of the week, a second individual can be chosen.

Each time a doctor is chosen for an intensive care unit week, an A or B absent day or an operating room call, a personal scheduling summary shows his assignments for a

	Scheduling Summary			Doctor RF			
	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Week 1	2	*	*	3	*	*	*
Week 2	*	5	*	6	H	*	*
Week 3	H	*	⊙	*	8	*	*
Week 4	1	*	*	4	7	*	*
Week 5	M	M	M	M	M	M	M

FIGURE 3 Scheduling summary Five week-scheduling summary of all assignments for doctor RF. The days (Mon-Sun) are noted on the horizontal and weeks (one to five) on the vertical. The proposed call is shown circled in the middle of the summary on a Wednesday in the third week. Numbers are operating room calls, "M" the medical surgical intensive care unit rotation and "H" holidays.

five week period (Figure 3). The summary addresses the problem of subjective personal preferences which cannot be computerized. Some doctors do not mind certain call sequences (e.g., calls on two successive weekends) whereas others may object. The user can reject a proposed call when the resulting sequence of calls will be unacceptable to an individual doctor and then schedule a second priority doctor.

Unavailable doctors are included on the scheduling lists. The user can assign them the call, although the program will give a message as to why they are not available. It will then allow the user to override the availability rule.

### Reports

These are generated for a specific time period or for a specific doctor. A "Call Calendar" for each scheduling quarter is printed for each doctor listing his operating room calls, holidays, A and B absent days, and rotations in the intensive care units. The "Group Call List" records the names of doctors assigned to operating room calls (one to eight) and the intensive care unit rotations for an entire quarter. The "Grid," a spreadsheet format for each month, lists doctors down the page and days of the month across the page. All calls, requests, and holidays for specific days are noted beside the doctor and under the day. A blank space beside a doctor's name under a specific day indicates no assigned calls or requests for this particular day. Therefore, this doctor is available if someone needs to switch a scheduled call. "Calls Required And Done" generates a report showing how many operating room calls, intensive care unit weeks, holidays, weekends, and A and B absent days have been scheduled over a specific time period and compares these numbers with those required for fair proportioning. Over a one-year period all calls scheduled should approximate all calls required. If they do not, discrepancies are carried over to the following year.

### Backup

All information for a year's scheduling is stored on a hard disk. In the "Backup" menu, data from each scheduling quarter can be transferred to a floppy disk for easy future access.

### Discussion

This computerized system has been used for the last two years to schedule calls in the operating rooms and the two intensive care units for this complex group. The advantages of this system over a previous manual system include better distribution and proportioning of assigned calls, easier and more complex tracking, improved handling of personal requests and preferences, fuller reports, and minimal time to update and reschedule. Complex workstyles and part-time arrangements which are encouraged by our department to satisfy each individual's lifestyle are accommodated in the scheduling assignment.

It is unlikely that any one software package will be suitable for all departments of anaesthesia (e.g., the length of scheduling periods or the different task centres). In future, options will be added to the software to make it more adaptable for scheduling other equally complex medical groups. These changes will also allow users to modify the rules as hospital commitments and anaesthetic workstyles change. The priority ranking system will become more sophisticated. This will allow the development of a partially automated program where the computer assigns the calls and generates a proposed call schedule. As well, if calls worked were paid at a defined rate, this program could be linked to a payroll system.

To date the costs, both time and money, have exceeded our previous very limited manual system. These costs are justified, because no manual system or human scheduler could handle all the complexities in this group of 30 anaesthetists. Now that the program is functioning the time required to complete the schedules is much less than with the old manual method. This system proves that almost any hospital requirements and any anaesthetist's workstyle can be accommodated by a computerized program.

### References

- 1 Larson TC, Larson SL, Harle TS. Computer-assisted scheduling of radiology resident call. *Invest Radiol*, 1986; 21: 424-6.
- 2 Becher GE, Wortman RL, Silver J. Computerized house officer schedules at the University of Michigan. *J Med Educ*, 1982; 57: 308-15.

- 3 Okada M. Prolog-based system for nursing staff scheduling implemented on a personal computer. *Comput Biomed Res*, 1988; 21: 53-63.
- 4 Zissos A, Strunin L. Computers in anaesthesia. *Can J Anaesth*, 1985; 32: 374-84.

#### Résumé

*Nous avons élaboré un logiciel informatique permettant d'élaborer une liste de garde tenant compte des divers intérêts de 30 anesthésistes. Pour couvrir les interventions qui se prolongent et les soins intensifs, il fallait assurer la disponibilité de dix anesthésistes après les heures régulières la semaine et de quatre la fin de semaine. Or, certains anesthésistes travaillent à temps partiel, d'autres font moins de gardes et certains secteurs demandent une expertise particulière. Pour éviter la fatigue, un système de priorité assure un espacement minimum entre les journées qui se prolongent et permet au logiciel de distribuer à l'avance les gardes de chaque jour selon les disponibilités et les préférences de chacun. A la fin d'une période, le logiciel peut compenser pour tout changement apporté à la liste initiale. En usage depuis deux ans, ce système informatisé s'est avéré supérieur aux anciens systèmes manuels et satisfait tout un groupe d'anesthésistes aux besoins variés.*