A Randomized, Controlled Trial Evaluating the Impact of a Computerized Rounding and Sign-Out System on Continuity of Care and Resident Work Hours

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BACKGROUND: Adoption of limits on resident work hours prompted us to develop a centralized, Web-based computerized rounding and sign-out system (UWCores) that securely stores sign-out information; automatically downloads patient data (vital signs, laboratories); and prints them to rounding, sign-out, and progress note templates. We tested the hypothesis that this tool would positively impact continuity of care and resident workflow by improving team communication involving patient handovers and streamlining inefficiencies, such as hand-copying patient data during work before rounds ("prerounds").

STUDY DESIGN: Fourteen inpatient resident teams (6 general surgery, 8 internal medicine) at two teaching hospitals participated in a 5-month, prospective, randomized, crossover study. Data collected included number of patients missed on resident rounds, subjective continuity of care quality and workflow efficiency with and without UWCores, and daily self-reported prerounding and rounding times and tasks.

RESULTS: UWCores halved the number of patients missed on resident rounds (2.5 versus 5 patients/team/month, $p = 0.0001$); residents spent 40% more of their prerounds time seeing patients ($p = 0.36$); residents reported better sign-out quality (69.6% agree or strongly agree); and improved continuity of care (66.1% agree or strongly agree). UWCores halved the portion of prerounding time spent hand-copying basic data ($p < 0.0001$); it shortened team rounds by 1.5 minutes/patient ($p = 0.0006$); and residents reported finishing their work sooner using UWCores (82.1% agree or strongly agree).

CONCLUSIONS: This system enhances patient care by decreasing patients missed on resident rounds and improving resident-reported quality of sign-out and continuity of care. It decreases by up to 3 hours per week (range 1.5 to 3) the time used by residents to complete rounds; it diverts prerounding time from recopying data to more productive tasks; and it facilitates meeting the 80-hour work week requirement by helping residents finish their work sooner. (J Am Coll Surg 2005;200:538–545. © 2005 by the American College of Surgeons)

In the new era of limited resident work hours, residents must transfer care of their patients to cross-covering and night float housestaff with increasing frequency.[1,2] This "sign-out" process has historically been an unstructured event with great variation in information content.[3] Even before introduction of the 80-hour work week, inadequate communication between resident teams when handing off patient care duties was cited as a problem.[4] Factors contributing to this problem include errors in communication and decision making and disruptions to patient plans.[5,6] Consequently, much effort is directed toward improving patient care continuity.[7] At the same time, work hour limits increase workflow pressure on housestaff and reinforce the need to implement systems that reduce rework and redundancy. Faced with these challenges, our institution undertook a number of process improvements, including development of a computerized rounding and sign-out system, "UWCores." This

Competing interests declared: None.

Drs Van Eaton and Lober have filed a Provisional Patent Application in the US Patent Office as application No. 60,582,434: "Method and System for Managing Healthcare Provider Rounding and Sign-out Information." No financial or licensing arrangements regarding the system herein described currently exist with any organization.

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application provides a centralized system for resident management of inpatient team lists and patient information used during rounding and sign-out.[8] Previously, we reported that our system was quickly embraced by inpatient housestaff as a popular method for managing inpatient lists and organizing work.[8]

We felt it important to accurately determine the impact of our computerized rounding and sign-out system on continuity of inpatient care and resident ward work efficiency before we could recommend a wider application of the system. To that end, we carried out a prospective, randomized, crossover study, in which a total of 161 residents participated (21% of our resident population), representing two specialties: general surgery and internal medicine.

METHODS

Intervention design

The University of Washington Computerized Rounding and Sign-Out system, "UWCores," is a secure application that uses the World Wide Web and a database to deliver information to any authorized user on any Internet-connected workstation capable of secure authentication and encryption. This includes all hospital workstations and most residents' homes. The system provides a centralized computer application where residents may organize patient lists and enter detailed sign-out information and "to do" lists about their patients. It permits residents to add patients to other team lists when cross-covering admitting or consulting duties. It allows residents to enter and update their own notes about diagnoses, problems, allergies, and medications. It produces sign-out reports and rounding lists that organize patients by team and reproduces recent vital signs and laboratory values automatically downloaded from the hospital clinical information systems. The planning and design of UWCores is described in detail elsewhere.[8] The goals for this system were to:

1. Improve patient care by providing a flexible, centralized system for resident-entered patient information to enhance sign-out communication quality
2. Facilitate transition to an 80-hour work week for residents by organizing patient information and downloading clinical data from hospital information systems to improve workflow efficiency
3. Change the nature of resident tasks—to decrease time spent recopying patient data to notes and lists, and increase time spent in direct patient care activities

Study design

Two hospitals in the UW Medicine system were selected for this study: the University of Washington Medical Center, which is a 450-bed tertiary care university hospital (owned and operated by UW Medicine) and Harborview Medical Center (HMC), which is a 368-bed Level I adult and pediatric trauma center (owned by King County and managed and operated by UW Medicine). The system was implemented at both hospitals simultaneously on June 23, 2003. All inpatient care teams were invited to use the system for a 6-week run-in period. During that time, residents familiarized themselves with the system, and it was modified to better fit resident team needs. At the end of the run-in period, all resident-run inpatient internal medicine and general surgery teams at both hospitals were using the system. The study population of resident teams was then selected: at University of Washington Medical Center, four general internal medicine teams, two general surgery teams, and one surgical oncology/vascular surgery team; at HMC, four general internal medicine teams, two general surgery/trauma teams, and one thoracic surgery/vascular surgery team. At any one time, these teams comprised about 30 internal medicine residents, and about 22 general surgery residents. Over the course of the entire study, because of resident rotation schedules, a total of 161 residents participated.

A prospective, randomized crossover study design was used (Fig. 1). The study period began June 23, 2003, and ended November 17, 2003. This time span was divided into the 6-week prerandomization run-in period (June 23 to August 5, 2003) and a 14-week randomized crossover study period (August 6 to November 17, 2003). After randomization, half of the study teams retained use of the UWCores system (intervention group), and the remaining teams were removed from the system (control group). Teams in the control group returned to their previous patient list management systems, which may have been individual written lists, cards, or a team-developed computerized spreadsheet. On September 26, 2003, the two groups were crossed over by restoring UWCores to those without it, hence converting control group teams to intervention group teams, and removing it from those previously using it, hence converting intervention group teams to control group teams. On November 17, 2003, the study ended and use of the new system was returned to all residents.

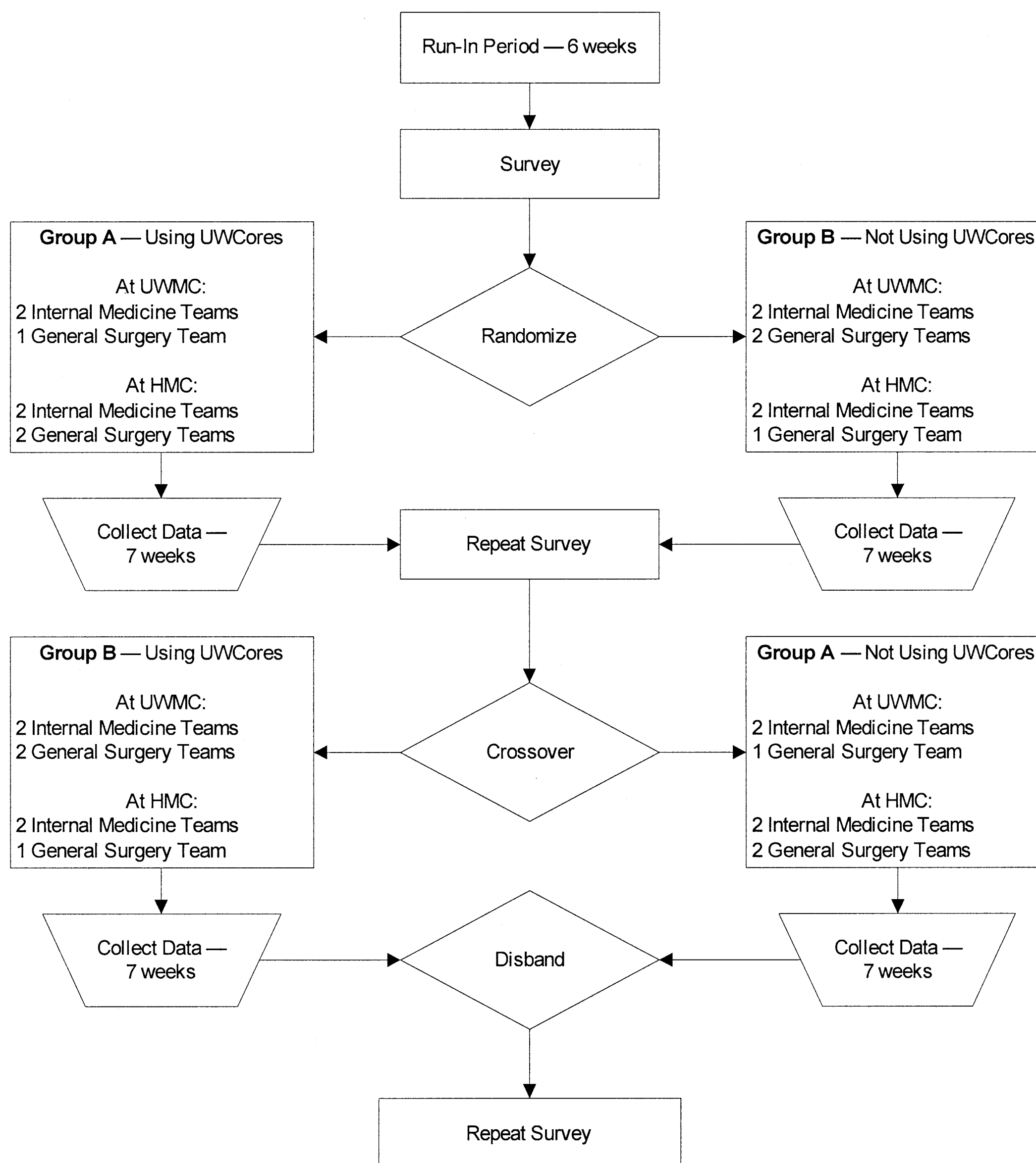

Figure 1. Algorithm of the Web-based computerized rounding and sign-out system (UWCores) crossover study design. HMC, Harborview Medical Center; UWMC, University of Washington Medical Center.

Outcomes measures

At our institution, junior residents perform the majority of data-gathering before resident rounds ("prerounds") and the bulk of the daily ward work. On internal medicine services, subinterns and PGY1 residents were counted as junior residents. On general surgical services, subinterns, PGY1 residents, and PGY2 residents were counted as junior residents.

Continuity of care

Rarely, a patient is not seen during the course of regular resident rounds because the team runs out of time before clinic, scheduled operations, or teaching conferences—or because a cross-covering team does not inform the primary team of an overnight admission. This study measured the self-reported number of patients initially missed on AM resident rounds for either of these reasons. Because our residents report that seeing patients before rounds and discussing overnight events is very important to continuity of care, we measured the self-reported amount of time spent at the bedside before rounds by junior residents. Finally, subjective data were collected about resident assessment of the system's impact on continuity of care (Table 1).

Workflow efficiency

To determine the system's effect on resident workflow efficiency, we measured self- and observer-reported time spent by junior residents during prerounds. In addition, we interviewed junior residents about the nature of their daily ward work and their subjective impression about the typical timing of that work. All study group residents were asked to report whether they thought the system helped them finish their daily ward work sooner (Table 1).

Data collection

This study was approved by the University of Washington Human Subjects Division. Daily during the randomized study period, the first author telephoned the second-call resident on each of the 14 participating teams 2 to 4 hours after rounds and asked a standard set of questions about prerounding and rounding events that day.

Continuity of care

During the daily after-rounds phone calls, the second-call resident for each team reported whether and why any patients were missed on resident rounds. Patients missed on resident rounds because they were away from their rooms were not counted. Three times during the study, participants were directed by email to complete an anonymous, 16-question World Wide Web–based survey, the relevant portions of which are shown in Table 1. The survey was administered before randomization, at crossover, and at the end of the study. Using a five-point Likert scale, respondents evaluated the system's impact on continuity of care.

Workflow efficiency

Among the resident self-reported data gathered during the daily telephone calls was the overall time spent prerounding by the team's junior residents. Twice during the study period, junior residents were interviewed about ward work. They completed a short questionnaire in which they itemized the amount of time spent on various tasks during prerounds. Junior residents self-reported the nature and timing of typical ward work tasks that occur both during prerounds and during the rest of the day.

Statistical methods

Preliminary statistician input was used to design the study arms, length of study periods, and type of data to collect. Residents at our institution continued to rotate among the hospitals and teams included in this study during our data collection. Our analysis treated the team as the unit of randomization and individual resident performance with and without UWCores cannot be reliably reported.

Table 1. The World Wide Web–Based Survey Portion Used for This Study

1. I am associated with this service: general surgery, internal medicine, other discipline
2. I am a: medical student, resident R1–R2, resident > R2, attending, other level
3. Yesterday my team used UWCores: yes, no
4. Yesterday I spent this many minutes prerounding (time spent before rounds editing patient list, gathering patient data): < 15, 16–30, 31–45, 46–60, > 60
5. Yesterday I spent this much time rounding (time spent seeing patients with team, making decisions about care): < 30 min, 31–60 min, 61 min–1.5 h, 1.6–2 h, > 2 h
6. My team is more efficient on rounds when we use UWCores. Strongly disagree, disagree, no change, agree, strongly agree
7. I finish my work sooner when my team uses UWCores. Strongly disagree, disagree, no change, agree, strongly agree
8. Sign-out quality is better between teams that use UWCores when compared with teams that do not. Strongly disagree, disagree, no change, agree, strongly agree
9. Resident-to-resident communication about patients is better between teams that use UWCores when compared with teams that do not. Strongly disagree, disagree, no change, agree, strongly agree
10. Patient continuity of care is better between teams that use UWCores when compared with teams that do not. Strongly disagree, disagree, no change, agree, strongly agree
11. Cross-covering residents adhere to patient plans better when caring for UWCores-using team patients. Strongly disagree, disagree, no change, agree, strongly agree

Continuity of care

A patient was considered "missed" on resident rounds by a resident team when an overnight admission or transfer by a cross-covering team was not communicated to the primary team in time for rounds, or the team ran out of time on rounds and had to see the patient later. These are rare events, and were compared as a count per team, per month. The number of patients missed per team, per month during resident rounds was compared between intervention and control groups using a Poisson regression model. Mean times spent seeing patients before rounds were compared using a Welch Two Sample *t*-test. Likert five-point survey results for sign-out quality and improved continuity of care are reported as descriptive data.

Workflow efficiency

If prerounding or rounding times were unobtainable, or if the team had previously planned to skip the task for that day (eg, prerounding was canceled because all team

junior residents had the day off), those data were recorded as "n/a" and ignored during statistical analysis. Mean junior resident prerounding times, mean team rounding times, and mean times spent hand-copying vital signs and laboratory values before rounds were compared using a Welch Two Sample *t*-test. Subjective reporting of the nature and timing of typical ward work tasks and the Likert five-point survey results about residents finishing work sooner are reported as descriptive data.

RESULTS

Characteristics of study groups

The study period was 103 days, and there were 14 resident teams in the study, for a total of 1,442 telephone calls. The first author made successful contact and collected prerounding times, rounding times, and patient volumes in 1,365 of those calls (94.6%). The characteristics of the study teams by hospital and service are shown in Table 2.

Continuity of care

Use of UWCores reduced the overall number of patients missed on resident rounds by half (from 5 to 2.5 patients/team/month, $p = 0.0001$). In addition, the data suggest that residents spent 40% more of their prerounding time seeing and talking with patients, but the difference was not statistically significant ($p = 0.36$). There was no significant difference when surgical residents were compared with medical residents. Resident assessment of sign-out quality and continuity of care improved over the course of the study. In response to the statement "Sign-out quality is better between teams that use UWCores when compared with teams that do not," respondents at randomization replied 28.3% no change, 50.0% agree, and 13.0% strongly agree. After concluding the study, respondents replied 12.5% no change, 28.6% agree, and 41.1% strongly agree. In response to the statement "Patient continuity of care is better between teams that use UWCores when compared with teams that do not," respondents at randomization replied 23.9% no change, 47.8% agree, and 13.0% strongly agree. After concluding the study, respondents replied 16.1% no change, 30.4% agree, and 35.7% strongly agree.

Workflow efficiency

Use of UWCores reduced the mean portion of prerounding time spent hand-copying vital signs and laboratory values data from 24% to 12% ($p < 0.0001$). Use of UWCores shortened overall team rounds by 1.5 minutes per patient ($p = 0.0006$). Again, no significant difference between surgical and medical residents was present. Because 8,018 patients were rounded on by the intervention group (Table 2), that group saved 200 hours from rounds alone during this 103-day study. At Harborview Medical Center, the average general surgery census was 23 patients during this study; surgical residents in the study group there each saved 4 hours per week from rounds alone. Subjectively, residents reported in their surveys an average time savings of 45 minutes per day for junior residents and 30 minutes per day for senior residents. In addition, residents reported a trend toward completing more ward work tasks earlier in the day when UWCores was used (Table 3). The majority of residents reported finishing their work sooner with UWCores compared with those without it (82.1% agree or strongly agree).

DISCUSSION

Since its inception, UWCores has quickly become accepted by resident and attending physicians.[8] This prospective, randomized, crossover study measured the impact of this new tool on continuity of patient care and resident workflow efficiency. We demonstrated that our computerized system for rounding and sign-out improves continuity of care by decreasing patients missed on resident rounds, by increasing the portion of prerounding time spent directly at the bedside, and by improving resident-reported quality of sign-out. We demonstrated that the system improves workflow efficiency by reducing the amount of prerounding time spent recopying data, by decreasing the amount of time needed to complete rounds, and by helping residents finish their work sooner. In addition, we discovered some unanticipated effects of our system from numerous subjective reports obtained during data collection. The most common reports concerned changes to the nature and timing of resident tasks, and improvements to the flow of rounds by eliminating backtracking.

Continuity of care

An important finding of this investigation is the beneficial impact of a computerized rounding and sign-out system on the number of patients initially missed during resident work rounds. We found that patients were missed on resident work rounds when resident teams had not been told of

Table 2. Characteristics of the Study Population

Characteristics	Both hospitals	Harborview Medical Center	University of Washington Medical Center
No. of teams	14	7	7
Medicine	8	4	4
Surgery	6	3	3
No. of patients rounded on	15,587	10,224	5,363
Medicine	6,567	3,652	2,915
Surgery	9,020	6,572	2,448
Average daily team census	11	15	8
Medicine	8	9	7
Surgery	16	23	8
	Both groups	**Using UWCores**	**Not using UWCores**
No. of patients rounded on	15,587	8,018	7,569
Medicine	6,567	3,393	3,174
Surgery	9,020	4,625	4,395
Average daily team census	11	12	11
Medicine	8	9	8
Surgery	16	16	16

an overnight admission by cross-cover, or when a team ran out of time and had to see and discuss the patient informally later. Our system decreases this event in two ways: by improving communication and by streamlining rounds. Communication is improved by enabling cross-covering residents in the emergency department to quickly and easily add new admissions directly to the primary service's team list. This way, incoming teams the following morning need to rely less on residents remembering to communicate overnight admit events. Instead, new admits are already on each team's rounding list for the morning. This can prompt incoming residents to seek out the overnight team to discuss the admission in more detail. Rounds are streamlined by automatically organizing each team's rounding list by patient room number, and providing the residents' notes about diagnoses, problems, and plans on that same sheet, together with recent basic clinical data. This centralization of sign-out information and provision of selected clinical data in sign-out has been shown to reduce preventable adverse events in a case-control study of another computerized sign-out system.[9] Here, we show both subjective and objective improvement in continuity of care. As the study progressed, resident users increasingly attributed improved overall sign-out quality to our computerized system. This observation supports a previous small study that found implementation of computerized sign-out increased the percentage of residents who felt they received the components of sign-out they considered important from 14% to 100%.[10]

Workflow efficiency

Time savings is of particular concern among residency programs now that housestaff are limited to an 80-hour work week. We measured a time savings on rounds of 1.5 minutes per patient. This modest daily time savings becomes important on busy surgical services, where the daily patient census may sometimes stay at 30 patients for a week. For those services, efficiency becomes vital and UWCores can save 5 hours per week for each resident. The discrepancy between observed time savings and survey-reported subjective time savings is likely re-

Table 3. Resident-Reported Subjective Timing of Ward Work Tasks

	Without UWCores	With UWCores
Prerounding time	Update list	Update list
	↓	Copy data
	Copy data	See patients
	↓	↓
	↓	Write progress notes
	See patients	Review medications
Rounds occur	See patients	Review medications
	Write progress notes	Review test results
After rounds	Review medications	Review consult notes
	Review test results	Call consults
	Review consult notes	Order studies
	Call consults	Organize discharges
	Order studies	
	Organize discharges	

lated to our findings that residents spent nearly the same amount of time prerounding as before, but reported finishing more tasks in that time, and finishing their day's work sooner. We did not assess the time of day when residents felt they had finished their work, which would have perhaps offered a complex but valuable outcome measure.

Previous investigations of computerized methods for managing inpatient sign-out information have primarily evaluated usability and design.[11,12] Studies that evaluate continuity of care or time factors involved in computerized rounding or sign-out tools are rare. One evaluation of electronic sign-out systems and workflow reported that use of a hand-held computer for managing a ward rounding list and sign-out information was considered time-neutral by users, but timing of ward work tasks was not evaluated.[13]

Unanticipated effects

An important finding of our study is a change in the nature of tasks undertaken before rounds (Table 3). We expected a substantial decrease in amount of time spent prerounding by junior residents because UWCores would eliminate time spent hand-copying vital signs and laboratory values before rounds. Despite shortening those recopying tasks, there was no overall reduction in total prerounding time. Instead, residents reported shifting this time savings to other patient care tasks. The largest shift occurred on the internal medicine services, where junior residents reported that the system enabled them to spend more time seeing patients before rounds, and to nearly complete their daily progress notes. That shift was smaller among the surgical group, possibly because the patient-fluid input and output data reported by our system was limited to total values at the time of the study, and surgical residents still needed to hand-copy more detailed values; surgical resident workflow on many services include examining the patient as a team on rounds, rather than by the junior resident beforehand; and surgical residents usually created their progress notes entirely during rounds on many services and that practice changed little with introduction of UWCores. The largest benefit to the surgical services was the ability to centralize a patient list that automatically sorts patients by location on printed reports. Although our study did not measure this effect, residents reported a noticeable improvement in rounding workflow as a result of reduced backtracking through the wards and other difficulties in locating patients from hand-maintained patient lists.

Study limitations

There are a number of potential limitations with this study. Residents in the control group may have had artificially longer prerounding times if it took longer than 1 day to convert back to an older method of patient-list management and recreate manual patient lists. We mitigated this effect by providing copies of older list systems to study teams in the days before randomization and crossover. This study relies heavily on estimates of junior resident prerounding time as reported by colleagues who were likely to be offering a best-guess estimate much of the time. This should impact differences between groups little, because the number of observations is large and estimating is likely to be similar in both arms. The process of gathering detailed information about how residents collect, manage, and share patient data may have brought unusual scrutiny to areas of patient care continuity and ward work efficiency. Such focus may have had, by itself, an independent effect on continuity efforts by residents and on workflow efficiency. Again, this effect should be shared across both arms of the study and impact our measured differences little. In addition, the study was tightly administered over a short period of time to decrease data collection errors; it was carefully administered by the first author, who personally contacted each study participant to obtain these data. Finally, the unit of randomization was teams, not individual residents, because of the team-oriented nature of both inpatient care and the UWCores system. This meant that it was not possible to control exposure of individual residents to UWCores in the control or intervention groups, or before and after crossover.

Many residents reported after the study that they had secretly maintained lists in UWCores at the time they were in the control group and supposed to be using other methods. Although these residents did not benefit from team use of UWCores, they could have used the system's automated data collection and note template features inappropriately when in the control arm. This would mean that the magnitude of difference in observed times between the two arms is actually greater than reported here, and it is a testament to the perceived value of the system among the housestaff.

Finally, the general applicability of our results relies on availability of an institutional source of computerized patient data, which may not be available at all teaching hospitals. It is worth noting that these data are of distinct categories, such as census, laboratory results, and clinical observations, and that the value of each category appears to be independent of the others. The most basic features favored by housestaff—a centralized patient list and sharing of resident-entered data among users and printed report types—could be implemented in the absence of any electronically available data.

In conclusion, an increasing body of knowledge suggests that longstanding, traditional methods of gathering patient data, organizing it, and communicating it among primary team members and cross-covering physicians may not support high patient care standards in a health-care system with increasing patient complexity, shorter work hours, and increased distribution of care. Using the widespread support for this project from the School of Medicine, hospital administration, faculty, and housestaff, we developed a tool that uses modern techniques to address a new challenge of modern medical care. Although systems like UW-Cores cannot replace an interactive sign-out conversation among care providers, they can assist clinicians by supporting improved information organization and detail. This prospective, randomized, crossover study showed that a well-designed computerized system for rounding and sign-out enhances patient care by decreasing patients missed on resident rounds, by increasing time spent directly at the bedside, and improving resident-reported quality of sign-out and continuity of care. It decreases time spent by residents hand-copying data during prerounds and helps them finish their work sooner, and so it facilitates meeting the 80-hour work week requirement and allowing residents to use this time for more direct and effective patient care.

Author Contributions

Study conception and design: Van Eaton, Horvath, Lober
Acquisition of data: Van Eaton
Analysis and interpretation of data: Van Eaton, Rossini
Drafting of manuscript: Van Eaton, Horvath, Lober
Critical revision: Horvath, Pellegrini
Statistical expertise: Rossini
Supervision: Horvath, Pellegrini

REFERENCES

1. Barden CB, Specht MC, McCarter MD, et al. Effects of limited work hours on surgical training. J Am Coll Surg 2002;195:531–538.
2. Griffith CH III, Wilson JF, Rich EC. Intern call structure and patient satisfaction. J Gen Intern Med 1997;12:308–310.
3. Lee LH, Levine JA, Schultz HJ. Utility of a standardized sign-out card for new medical interns. J Gen Intern Med 1996;11: 753–755.
4. Lofgren RP, Gottlieb D, Williams RA, Rich EC. Post-call transfer of resident responsibility: its effect on patient care. J Gen Intern Med 1990;5:501–505.
5. Petersen LA, Brennan TA, O'Neil AC, et al. Does housestaff discontinuity of care increase the risk for preventable adverse events? Ann Intern Med 1994;121:866–872.
6. Goldman L, Pantilat SZ, Whitcomb WF. Passing the clinical baton: 6 principles to guide the hospitalist. Dis Mon 2002;48: 260–266.
7. Wakefield DS, Cyphert ST, Murray JF, et al. Understanding patient-centered care in the context of total quality management and continuous quality improvement. Jt Comm J Qual Improv 1994;20:152–161.
8. Van Eaton EG, Horvath KD, Lober B, Pellegrini CA. Organizing the transfer of patient care information: the development of a computerized resident signout system. Surgery 2004;136:5–13.
9. Petersen LA, Orav EJ, Teich JM, et al. Using a computerized sign-out program to improve continuity of inpatient care and prevent adverse events. Jt Comm J Qual Improv 1998;24:77–87.
10. Ram R, Block B. Signing out patients for off-hours coverage: comparison of manual and computer-aided methods. Proc Annu Symp Comput Appl Med Care 1992:114–118.
11. Frazer TS. "Doctor's notes": a computerized method for managing inpatient care. Fam Med 1988;20:223–224.
12. Reider J, Norton P. Computerized sign-out: a web-based solution. Proc Annu Symp Comput Appl Med Care 1998:1060.
13. Young RJ, Horsley SD, McKenna M. The potential role of IT in supporting the work of junior doctors. J R Coll Physicians Lond 2000;34:366–370.