

SPECIAL ARTICLE

Evaluation of a Redesign Initiative in an Internal-Medicine Residency

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ABSTRACT

BACKGROUND

Several organizations have advocated for comprehensive redesign of graduate medical training, but the effect that residency redesign will have on measures of patient satisfaction, resident and intern (trainee) satisfaction, and patient care is unknown.

METHODS

We designed an experimental inpatient-medicine service with reduced resident workload comprising two teams, with each team consisting of two attending physicians, two residents, and three interns. Attending physicians, selected for their teaching prowess, supervised the teams throughout the workday and during bedside team-teaching rounds. This experimental model was compared with a control model comprising two teams, with each consisting of one resident and two interns, plus multiple supervising attending physicians who volunteered to participate. Patients were alternately assigned to the experimental teams and the control teams, subject to limits on the number of patients interns are allowed to admit.

RESULTS

Over a 12-month period, 1892 patients were assigned to the experimental teams and 2096 to the control teams; the average census per intern was 3.5 and 6.6 patients, respectively. Overall satisfaction was significantly higher among trainees on the experimental teams than among those on the control teams (78% and 55%, respectively; $P=0.002$). As compared with the control teams, the experimental teams were not associated with a higher average length of patient stay or readmission rate; adherence to standards for quality of inpatient care was similar in both groups of teams. Interns on the experimental teams spent more time in learning and teaching activities than did interns on the control teams (learning: 20% of total time vs. 10%, $P=0.01$; teaching: 8% of total time vs. 2%, $P=0.006$).

CONCLUSIONS

As compared with a traditional inpatient care model, an experimental model characterized by reduced trainee workload and increased participation of attending physicians was associated with higher trainee satisfaction and increased time for educational activities.

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PHYSICIANS IN TRAINING LEARN THEIR specialty while providing clinical care. The optimal allocation of time to education, training, patient safety, and the provision of care has yet to be established.^{1,2} Studies confirm that extended work hours and increased on-call workload are associated with fatigue-related errors and a lower likelihood of participation in educational activities.³⁻⁶ Although early models for reform were intended to give high priority to effective supervision,^{7,8} the Accreditation Council for Graduate Medical Education (ACGME) has focused on reducing resident work hours, resulting in substantial compression of resident schedules and activities.^{9,10} In the model resulting from the implementation of ACGME standards, continuity between team members is diminished because of shorter, discontinuous schedules. High inpatient volume, rapid throughput of patients, and diminished availability of senior attending physicians have placed additional strains on the teaching and learning environment, leading to concerns about the erosion of the traditional strengths of postgraduate medical education.¹¹⁻²⁰

In response to these concerns, we engaged in a 3-year process to plan and implement an experimental model of inpatient service for our residency program in internal medicine. We conducted an assessment of needs, designed and funded a new teaching service, and implemented and evaluated the model service as a demonstration project, collecting a range of observational data to evaluate teaching, learning, and patient-care outcomes.

METHODS

DESIGN AND FUNDING OF THE EXPERIMENTAL MODEL

We convened a redesign committee comprising faculty and residents, reviewed annual surveys of feedback from residents and interns (hereafter referred to as trainees), and sponsored a series of focus groups with trainees and nonphysician staff. To address trainees' requests for additional feedback, increased time for learning, and increased time with attending physicians and to enhance collaboration and communication, the committee designed a model called the Integrated Teaching Unit (ITU). The elements of the ITU model included the participation of two attending physicians, a reduced clinical load and decreased call frequency for trainees, faculty development to enhance bedside teaching and feedback, geograph-

ic regionalization of care within the hospital (i.e., the grouping of patients into one care unit), creation of multidisciplinary teams, development of a postdischarge follow-up clinic, and rationalization of rotation schedules to keep teams together for 4-week periods. Project funding was secured from the Department of Medicine and the hospital. The institutional review board for Partners HealthCare approved the study.

Each of the two attending physicians, who were board-certified in medicine, supervised a trainee team comprising two residents (postgraduate year 2 or 3) and three medical interns (postgraduate year 1). Attending physicians who had received superior ratings for their teaching ability were recruited from a pool of hospitalists, internists, and medical specialists to join the ITU teams, with one hospitalist plus one internist or specialist assigned to each team. Each of the two attending physicians served as the physician of record for approximately half the patients cared for by the team. The two attending physicians supervised daily bedside rounds together with the multidisciplinary team for 2 scheduled hours each morning; at least one of these physicians remained available throughout the workday and met with the team to conduct additional teaching and to review progress at day's end. Each attending physician participated in an individual faculty development meeting with the service director to review the roles and responsibilities each would assume on the team. These meetings focused on strategies to optimize bedside teaching quality and on the expectations for teaching and feedback to residents and interns. Salaried hospitalists received their usual salary; other ITU attending physicians were compensated for their time, prorated at 80% of their annual salary, and fringe benefits. Patient billing forms were completed by attending physicians; collections were handled by the department.

To maximize resident leadership in the presence of increased supervision, residents were oriented to the expectation that they would lead the daily walk rounds. Interns were instructed to use the residents as their first point of contact for questions. Each team of trainees started and completed the 4-week rotation at the same time, as did most attending physicians. Individual feedback to interns and residents was provided at least every 2 weeks. Each intern admitted patients overnight every sixth night, leaving by noon the next day. Residents supervised interns every fourth

night until 10 p.m. and were covered thereafter by a night resident. Each team cared for a maximum of 15 patients.

GENERAL MEDICAL SERVICE TEAMS

The two ITU teams were compared with two general medical service (GMS) teams that continued to operate on the basis of the traditional team structure of the hospital. GMS teams comprised one resident and two medical interns; attending physicians of record were drawn from a pool of hospitalists and physicians in practice and were not paid beyond their hospitalist salary or private patient billing. One attending physician was assigned to teaching and met with the teams three times a week for approximately 5 hours but had little or no responsibility for patients under the team's care. The residents and interns made rounds independently of attending physicians and nurses and discussed decisions about patient care with the attending physician daily. Interns admitted patients every fourth night until 10 p.m. Residents supervised their interns every other night until 7 p.m. and were covered thereafter by a night resident.

PATIENT AND TEAM ASSIGNMENTS

Patients eligible for the study included all patients admitted to either inpatient-medicine teaching service (ITU or GMS). These patients were alternately assigned by an admissions coordinator in a nonselective process to one of four medicine teams (two ITU teams and two GMS teams). Patients were assigned to one of the two on-call teams without regard to payer or diagnosis until a team reached its capacity. Interns and residents were assigned to ITU and GMS teams by the scheduling office before the new service was established. Both the ITU and GMS teams adhered to the ACGME-defined limits on duty hours and admissions.

SETTING

The experimental model was implemented at the Faulkner Hospital in Boston, a community teaching hospital affiliated with the Brigham and Women's Hospital internal-medicine residency program. The hospital has 72 inpatient-medicine beds located on one floor. Additional telemetry monitors were installed to facilitate the grouping of patients into team-based care units.

DATA COLLECTION AND EVALUATION

Hospital administrative data provided information on patients' age, race or ethnic group, primary and secondary diagnoses, and length of stay, as well as on in-hospital deaths and readmissions. Length of stay was defined as the number of days from admission to the medicine service to discharge from the hospital. The national hospital inpatient quality measures were extracted by independent coders who were unaware of the team assignments. Only the inpatient quality measures subject to the influence of the inpatient-medicine care team were evaluated. Patients' charts were abstracted for the cause of death by two independent physician-reviewers who were unaware of the team assignments; disagreements were resolved by means of consensus. An independent observer recorded intern activity on an iPaq pocket PC device running Timer Pro (Applied Computer Services). Activity categories included direct patient care (examining and interviewing patients and discussing their care with team members), indirect care (reviewing the chart, writing notes, and performing order entry), education (teaching and learning), and other tasks. Trainees and attending physicians were invited to complete an online survey at the end of each rotation to determine satisfaction. Surveys were mailed by Press Ganey Associates to all patients after discharge.²¹

STATISTICAL ANALYSIS

We examined differences in baseline health and demographic characteristics between patients assigned to the ITU teams and those assigned to the GMS teams, using Student's *t*-test for continuous variables and Fisher's exact test for discrete variables. For length of stay, we performed a multivariate regression analysis. Outcome was coded as 1 if the observed length of stay was greater than the adjusted standardized length of stay for the diagnosis-related group, and 0 if not. The model variables included in the analysis were age (years), sex (female, yes or no), race (white, yes or no), and service group (ITU group, yes or no). Analysis of survey responses was performed with the use of Student's *t*-test, with Fisher's exact test used for dichotomized responses. Time-motion data were analyzed assuming an exponential distribution. Analysis was performed with the use of SAS software, version 9.1.2.

RESULTS

CHARACTERISTICS OF INPATIENTS

Over a 12-month period, 1892 medical inpatients were assigned to the two ITU teams and 2096 were assigned to the two GMS teams. There were no significant differences between the patients assigned to the ITU teams and those assigned to the GMS teams in terms of age, sex, payer, or distribution of diagnoses (Table 1). The ITU teams were at their census limit of 15 patients on 15% of days.

TRAINEE ACTIVITIES

Forty-five trainees spent time on an ITU team and a GMS team, 53 on an ITU team only, and 17 on a GMS team only. Interns on the ITU and GMS services worked similar median numbers of hours per week (62.5 and 61.7 hours, respectively; $P=0.82$), but the average patient census per intern was significantly lower on the ITU teams than on the GMS teams (3.5 vs. 6.6 patients, $P<0.001$). During 90 hours of direct observation, ITU interns spent more time in educational activities (including self-directed learning and attendance at didactic sessions and conferences) than GMS interns (20.2% of total time vs. 10.4%, $P=0.01$), more time teaching (8.3% vs. 2.5%, $P=0.006$), and less time in indirect patient care (36.9% vs. 44.5%, $P=0.03$); GMS interns spent a similar amount of total time in direct patient care (12.4% vs. 15.5%, $P=0.34$) and a greater amount of time with each patient (3.5% and 2.4% of total time per patient, respectively; $P=0.12$). During the observed times, interns on ITU teams and those on GMS teams spent similar amounts of time moving between different parts of the hospital and on administrative and other tasks.

TRAINEE, ATTENDING, AND PATIENT SATISFACTION

Surveys were returned by 62 of 75 GMS trainees (83% response rate) and 98 of 118 ITU trainees (83% response rate). Six residents completed additional surveys after a second rotation on an ITU team, and these additional responses were included in the analysis. Resident and intern satisfaction was significantly higher on the ITU teams than it was on the GMS teams (Table 2). Trainees on the ITU teams were significantly more likely to agree that the rotation was closest to their ideal training experience, to have enjoyed the rotation,

to have learned new physical examination skills, to have received feedback from attending physicians, and to have participated in more patient follow-up than usual as compared with trainees on GMS teams. Satisfaction did not differ between interns and residents on the same type of team.

Surveys were returned by 41 of 47 ITU attending physicians (87.2%); 70.7% felt the model was closest to their ideal teaching experience, 82.9% felt that their teaching skills were well used, 90.2% liked the dual attending-physician model, and 92.6% felt they had learned from their co-attending physician.

Patient satisfaction surveys were received by mail from 418 patients treated by an ITU team (22.1% response rate) and 465 patients treated by a GMS team (22.2% response rate). Patient satisfaction did not differ significantly between ITU and GMS teams; the overall satisfaction rates were 85.6% and 85.9%, respectively ($P=0.88$), and the rates of patient satisfaction with their physicians were 83.2% and 82.7%, respectively ($P=0.74$).

QUALITY AND EFFICIENCY OF CARE

The average length of stay was 4.10 days for patients treated by an ITU team and 4.61 days for those treated by a GMS team ($P=0.002$); it is not known whether the half-day difference is clinically important. The difference in length of stay remained significant after adjustment for age, diagnosis, sex, and race (odds ratio for a longer stay than expected in the group of patients treated by an ITU team, as compared with a GMS team, 0.21; 95% confidence interval, 0.09 to 0.33; $P<0.001$). There were no significant differences between the ITU and GMS teams in the 30-day readmission rate (6.9% and 8.0%, respectively; $P=0.19$) (Table 1) or the discharge location (see Table A in the Supplementary Appendix, available with the full text of this article at NEJM.org).

The causes of death did not differ significantly between patients treated by ITU teams and those treated by GMS teams (Table 1), nor were there significant differences in the teams' composite scores on the relevant national hospital inpatient quality measures for pneumonia (three measures, 68.0% for the ITU teams and 71.9% for the GMS teams; $P=0.54$), acute myocardial infarction (four measures, 100% for both groups), or heart failure (four measures, 92.7% and 95.9%, respec-

Table 1. Patient Characteristics and Outcomes.

| Variable | ITU Group | GMS Group | P Value |
|--|-----------|-----------|---------|
| No. of patients | 1892 | 2096 | |
| Female sex — % | 58.0 | 60.0 | 0.13 |
| Race or ethnic group — %† | | | |
| White | 78.0 | 80.7 | 0.11 |
| Black | 14.1 | 13.3 | |
| Hispanic | 4.9 | 3.8 | |
| Other | 3.0 | 2.2 | |
| Age — yr | 68.9±17.6 | 69.6±17.2 | 0.22 |
| Insurance — % | | | 0.29 |
| Private | 37.7 | 39.6 | |
| Medicare | 32.3 | 33.2 | |
| Medicaid | 25.9 | 23.5 | |
| None | 4.0 | 3.7 | |
| Diagnostic category — % | | | 0.1 |
| Cardiovascular | 17.2 | 15.1 | |
| Pulmonary | 15.8 | 15.0 | |
| Gastroenterologic | 12.7 | 15.2 | |
| Renal | 8.3 | 7.3 | |
| Injury or poisoning | 4.6 | 6.0 | |
| Endocrine | 5.4 | 5.1 | |
| Infectious disease | 5.2 | 4.1 | |
| Dermatologic | 4.5 | 4.2 | |
| Rheumatologic | 3.2 | 3.6 | |
| Psychiatric | 3.0 | 3.4 | |
| Oncologic | 3.1 | 2.4 | |
| Neurologic | 2.1 | 2.5 | |
| Hematologic | 1.7 | 2.2 | |
| Other | 13.1 | 14.0 | |
| Mean daily census — no. of patients/ intern | 3.5 | 6.6 | <0.001 |
| Length of stay — days | 4.1±0.09 | 4.6±0.10 | 0.002 |
| Readmissions within 30 days — % | 6.9 | 8.0 | 0.19 |
| Deaths — no. (%) | 26 (1.4) | 48 (2.3) | |
| Cause of death — no. (%) | | | 0.89 |
| Cancer | 8 (30.8) | 15 (31.3) | |
| Pneumonia | 5 (19.2) | 12 (25.0) | |
| Heart disease | 4 (15.4) | 7 (14.6) | |
| Sepsis | 4 (15.4) | 6 (12.5) | |
| Other | 5 (19.2) | 8 (16.7) | |

* Plus-minus values are means ±SD for age and means ±SE for length of stay.

GMS denotes general medical service, and ITU integrated teaching unit.

† Race or ethnic group was reported by patients.

tively; $P=0.23$) (Table B in the Supplementary Appendix).

EXTENT OF STRUCTURAL REORGANIZATION

Most of the elements of the ITU design were successfully introduced. Geographic regionalization of care within the hospital was achievable at low census but could not be implemented without extending emergency-room waiting periods when the hospital census was high. A postdischarge follow-up clinic was discontinued after it was found that the clinic complicated the transition from inpatient care to follow-up with the primary care physician and interrupted team activities.

DISCUSSION

The educational mission of residency training has become increasingly strained by the dependency of academic institutions on financial incentives that maximize throughput. Our residents and interns articulated a need for increased opportunities to pursue subjects in depth, engage in reflection, be thorough, spend more time with patients, and participate in discussions with teachers and mentors. This need has dominated medical education from the beginning of the modern era, and it is these opportunities that allow residency to be an educational experience rather than an exercise in technical training.

The process of planning, designing, implementing, and evaluating a model inpatient service that would provide these opportunities within regulatory constraints was complex and challenging. Many aspects of the initiative were successful. However, some planned elements of the original ITU design, including the regionalization of patient care and the development of a robust follow-up clinic, were not. Nevertheless, our observations support the use of some or all of the elements of our model in other residency programs. Overall, our findings suggest that as compared with a typical model of inpatient care that adheres to the ACGME-defined maximal admission and work-hour limits, an educationally driven service with two carefully selected attending physicians, a decreased resident workload, and increased resident supervision with multidisciplinary teams was associated with an increase in time spent in educational activities and increased trainee satisfaction without having a negative effect on the quality of care.

Table 2. Resident and Intern Survey Responses.*

| Response | ITU Respondents (N=104) | GMS Respondents (N=62) | P Value |
|--|----------------------------|---------------------------|---------|
| I agree with this statement — % in agreement | | | |
| I enjoyed the rotation | 77.9 | 54.8 | 0.002 |
| This rotation was closest to an ideal training experience | 41.4 | 6.4 | <0.001 |
| I learned new physical-examination skills | 77.9 | 30.6 | <0.001 |
| I received feedback from my attending physician | 85.6 | 30.6 | <0.001 |
| I learned a lot from this activity this month — % in agreement | | | |
| Attending morning reports | 95.1 | 58.3 | <0.001 |
| Listening to attending physicians on rounds | 83.6 | 66.1 | 0.009 |
| Preparing teaching topics | 78.9 | 74.4 | 0.59 |
| Attending peer-led didactic sessions | 80.0 | 44.1 | <0.001 |

* A total of 98 residents and interns completed surveys, including 6 residents who each completed an additional survey after a second rotation on an ITU team; the percentages shown are based on the total of 104 surveys completed. A total of 62 residents and interns in the GMS group completed surveys. GMS denotes general medical service, and ITU integrated teaching unit.

A reduced workload and census cap could have created an incentive for trainees to extend the length of patients' stay. However, this did not seem to be the case, since patients assigned to our experimental teams did not have longer stays; indeed, the length of stay for these patients was shorter than that for the patients assigned to the traditional teams, but given the potential for bias in patient assignments, we cannot be sure of the validity of this finding.

Although few studies have assessed comprehensive redesign of team structure and function, several studies have shown that enhancement of team interaction and reductions in workload can reduce the number of tests ordered and the number of medication errors and can increase patient safety and the efficiency of care.²²⁻²⁶ Our study builds on the efforts of these earlier investigators to understand the effects of microsystem organization and team functioning on safety by addressing performance factors that have received insufficient attention to date. When their workload was reduced, the trainees in our program increased the time they spent with each of their patients, on teaching, and on attending available educational activities; they also reported high degrees of satisfaction with their inpatient team experience and additional educational attainment.

Many factors must be considered in evaluating the implications of our findings. An open educational intervention has the potential to be subject

to a diverse array of confounding factors. It is not possible to identify which component of the intervention was the primary driver for the measured differences, although we speculate that our findings are more likely to be explained by several intersecting factors than by any single component. The expanded availability of clinician-educators who were compensated for their time is likely to have contributed to the identified differences found. The amount of supervision and feedback that was provided may also have influenced behavior and satisfaction. Members of the ITU and GMS teams spent a similar amount of time at the bedside, but ITU interns had a significantly lower patient census, meaning that the time they spent per patient at the bedside was greater (by almost 50%). The increased amount of time available for reflection may also have improved care, communication, and satisfaction. In addition, for the team members on the traditional service, the proximity of another team with greater resources may have diminished their enthusiasm or engagement and magnified the differences in satisfaction between the team types.

Our findings could reflect the results of a Hawthorne effect, the improvement in performance that is related to the subject's knowledge that he or she is being studied, since the structured intervention was obvious to participants.²⁷ However, the extended duration of the trial and the exposure of both the intervention and con-

trol teams to the observation would be expected to mitigate any Hawthorne effect. Although there were no detectable differences in the demographic characteristics of the patients assigned to the two groups or the case mix, it is possible that the detected differences in outcomes were due to the nonrandom assignment of patients between the teams.

On the basis of our observations and the qualitative responses from participants, we speculate that the participation of two attending physicians on the team was an important factor that led to greater satisfaction on the part of the attending physicians and the trainees and increased opportunities for feedback, exchange of ideas, and sharing of teaching styles.²⁸ These interactions between attending physicians may have been enhanced by the fact that each pair consisted of a hospitalist and either a primary care physician or a medical specialist. The presence of two attending physicians on bedside rounds created opportunities for debate and provided greater insights into clinical thinking, an experience that can lead to greater learning.²⁹ Survey and anecdotal responses from members of the ITU teams suggest that trainees used the additional time available for reflection and critical self-appraisal, which have been shown to improve learning and could have contributed to improved satisfaction.³⁰

The opportunity for residents to teach in the type of learning environment provided by the experimental model is likely to have contributed to increased satisfaction and learning.

Staffing a team model in the manner described in this report is associated with increased costs. Although our findings and those from other studies suggest the potential for financial savings as a result of the efficiencies gained by such an inpatient care team in general medicine at an academic teaching hospital, future work will need to define the suitability and sustainability of such services for community and other major teaching centers.^{31,32} Our study shows that an educationally centered program, constructed to address the educational needs of trainees, can be successfully introduced without adversely affecting the quality of care. Our findings therefore support many of the recommendations made by educational leaders and the Institute of Medicine for the reform of graduate medical education.^{1,2}

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