Hospital Teaching Intensity, Patient Race, and Surgical Outcomes

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Objectives: To determine if the lower mortality often observed in teaching-intensive hospitals is because of lower complication rates or lower death rates after complications (failure to rescue) and whether the benefits at these hospitals accrue equally to white and black patients, since black patients receive a disproportionate share of their care at teaching-intensive hospitals.

Design: A retrospective study of patient outcomes and teaching intensity using logistic regression models, with and without adjusting for hospital fixed and random effects.

Setting: Three thousand two hundred seventy acute care hospitals in the United States.


Main Outcome Measures: Thirty-day mortality, in-hospital complications, and failure to rescue (the probability of death following complications).

Results: Combining all surgeries, compared with nonteaching hospitals, patients at very major teaching hospitals demonstrated a 15% lower odds of death (P < .001), no difference in complications, and a 15% lower odds of death after complications (failure to rescue) (P < .001). These relative benefits associated with higher resident-to-bed ratio were not experienced by black patients, for whom the odds of mortality and failure to rescue were similar at teaching and nonteaching hospitals, a pattern that is significantly different from that of white patients (P < .001).

Conclusions: Survival after surgery is higher at hospitals with higher teaching intensity. Improved survival is because of lower mortality after complications (better failure to rescue) and generally not because of fewer complications. However, this better survival and failure to rescue at teaching-intensive hospitals is seen for white patients, not for black patients.

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OUTCOMES ARE GENERALLY better in hospitals with higher teaching intensity, but it is unclear how this benefit is achieved. Lower risk-adjusted mortality at teaching hospitals might result from the prevention of some complications, prevention of death after a complication has occurred, both, or even one effect offsetting the other. While teaching hospitals are generally larger and have more advanced technology, greater volume, and better nurse staffing (attributes that may aid in both preventing complications and successfully treating complications), it is by no means clear whether all patients benefit equally from these attributes.

This study first examines surgical outcomes to determine whether differences in complication and failure-to-rescue rates explain observed differences in mortality rates between more and less teaching-intensive hospitals. As a measure of death after complications, failure to rescue provides an important test of how well hospitals do in treating patients who develop complications. We then examine how race is associated with outcomes at hospitals with higher or lower teaching intensity, as black patients both compose a disproportionate share of patients at teaching-intensive hospitals and obtain a disproportionate share of their surgical care at more teaching-intensive hospitals.

See Invited Critique at end of article

STUDY SAMPLE

A description of the data set and the selection/exclusion criteria has been previously reported in the Resident Hours Study, which examined all Medicare patients admitted to short-term general nonfederal acute care hos-
EXAMINING THE RESIDENT-TO-BED RATIO

In Table 2, we display the associations between the resident-to-bed ratio and other hospital characteristics often associated with better patient outcomes.3,4,11,17,18 Larger resident-to-bed ratios were associated with higher proportions of hospitals with characteristics traditionally associated with better outcomes. In this report, we use the resident-to-bed ratio as a marker for a type of hospital, that is, as a proxy for the hospital characteristics associated with teaching intensity. Our models do not determine whether residents themselves cause the differences we observe.

Table 1. Patient Characteristics by Race and Teaching Hospital Intensity: Nonteaching (RB=0) vs Very Major Teaching (RB > 0.6)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Black and White Patients</th>
<th>Black Patients</th>
<th>White Patients</th>
<th>RB=0</th>
<th>RB &gt; 0.6</th>
<th>RB=0</th>
<th>RB &gt; 0.6</th>
<th>RB=0</th>
<th>RB &gt; 0.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>4 495 261</td>
<td>2 271 230</td>
<td>114 448</td>
<td>28 899</td>
<td>2 080 165</td>
<td>199 686</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y, mean</td>
<td>76.37</td>
<td>76.57</td>
<td>75.32</td>
<td>74.91</td>
<td>76.66</td>
<td>75.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, %</td>
<td>38.40</td>
<td>37.45</td>
<td>33.83</td>
<td>34.98</td>
<td>37.66</td>
<td>44.30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of comorbid conditions, mean</td>
<td>2.12</td>
<td>2.11</td>
<td>2.10</td>
<td>2.76</td>
<td>2.60</td>
<td>2.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HTN, %</td>
<td>58.46</td>
<td>57.52</td>
<td>59.32</td>
<td>72.87</td>
<td>73.49</td>
<td>57.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COPD, %</td>
<td>18.94</td>
<td>19.40</td>
<td>16.18</td>
<td>16.38</td>
<td>15.40</td>
<td>16.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus, %</td>
<td>17.68</td>
<td>17.13</td>
<td>16.74</td>
<td>28.57</td>
<td>26.40</td>
<td>14.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHF, %</td>
<td>11.87</td>
<td>12.07</td>
<td>10.23</td>
<td>15.82</td>
<td>14.13</td>
<td>11.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVD, %</td>
<td>7.75</td>
<td>7.23</td>
<td>9.37</td>
<td>11.91</td>
<td>11.30</td>
<td>9.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal failure, %</td>
<td>3.20</td>
<td>3.16</td>
<td>2.93</td>
<td>8.38</td>
<td>6.58</td>
<td>2.81</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; HTN, hypertension; PVD, peripheral vascular disease; RB, resident-to-bed ratio.

*P values that test differences between race (black vs white) or RB (0 vs >0.6) were all highly significant, and all were at the P<.001 level except for comparing black patients in hospitals with an RB of 0 vs hospitals with an RB of more than 0.6 for high blood pressure (P=.03), male sex (P<.001), and peripheral vascular disease (P=.004). Because of the large sample size, most small and large differences are statistically significant, but the small differences may not be clinically significant.

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For each outcome measure in Table 3, we provide results for each surgical category separately and then for the combined group. There were 4,658,934 patients in the mortality and complication models, but only 2,021,314 in the failure-to-rescue model because the failure-to-rescue analysis included only those who had a complication or died. For patients with similar comorbidities and procedures at hospitals with high teaching intensity (resident-to-bed ratio of 0.6 residents per bed) vs no residents (resident-to-bed ratio = 0), the fitted odds of death were 15% lower (95% confidence interval [CI] = 13%-16%) for the combined surgery group, with similar findings for subgroups. Results fitting a random-effects model using individual hospital indicators were similar. Adding income (as defined by median income in the patient’s zip code) to the combined surgery random-effects model did not change these results, suggesting that the observed differences between teaching-intensive and nonteaching hospitals are not reflecting unequal access by income level.
In contrast, the associations between the resident-to-bed ratio and complication rates indicated no consistent relationship, with odds ratios (ORs) overlapping 1.0. However, similar to mortality, failure-to-rescue rates were consistently lower in hospitals with higher resident-to-bed ratios. Hospitals of high teaching intensity (resident-to-bed ratio = 0.6) compared with nonteaching hospitals (resident-to-bed ratio = 0) were associated with 14% (95% CI, 12%-15%) lower odds of failure to rescue for combined surgery, with again similar findings for subgroup analysis. The random-effects model also produced similar results.

**CRUDE (UNADJUSTED) OUTCOMES BY RACE AND TEACHING INTENSITY**

In Table 4, we can see that black patients had higher mortality rates and higher complication rates than white patients. White patients displayed a lower odds of death at teaching-intensive hospitals vs nonteaching hospitals (OR, 0.92; 95% CI, 0.90-0.95), whereas black patients displayed a slightly increased but statistically insignificant odds of dying at the teaching-intensive vs nonteaching hospital (OR, 1.03; 93% CI, 0.97-1.09). For both white and black patients, there was a modest reduction in complications at the teaching-intensive hospitals. Finally, whereas white patients displayed a reduction in failure-to-rescue rates in the teaching-intensive hospitals vs the nonteaching hospitals (OR, 0.94; 95% CI, 0.92-0.97), black patients displayed an increased failure-to-rescue rate (OR, 1.06; 95% CI, 1.00-1.12). Figure 1 displays the unadjusted results. For both black and white patients, rates of death were lower in the higher-teaching-intensity hospitals than in the nonteaching hospitals, although differences for black patients were far smaller than for white patients when comparing nonteaching with teaching-intensive hospitals. We compared the relative advantage of teaching intensity for black patients by calculating the odds of an outcome between the higher- vs lower- (resident-to-bed ratio > 0.6) teaching-intensive hospitals vs nonteaching hospitals. We used the random-effects model to account for the heterogeneity among hospitals.

**ADJUSTED OUTCOMES BY RACE AND TEACHING INTENSITY**

Model 1 in Table 5 includes resident-to-bed ratio and race and their interactions. In model 1, in the first row of Table 5,
the mortality model tests whether the odds of dying for black patients were higher or lower than for white patients in hospitals without residents (resident-to-bed ratio = 0). The adjusted odds of dying were 0.96 (95% CI, 0.95-0.98) for black patients compared with white patients in hospitals with resident-to-bed ratios of 0.6 vs 0. We then compared the odds of dying in a highly teaching-intensive hospital (resident-to-bed ratio = 0.6) with a hospital with a resident-to-bed ratio of 0. For combined surgery, for white patients, the odds of dying in a highly teaching-intensive hospital (resident-to-bed ratio = 0.6) with a hospital with a resident-to-bed ratio of 0.6 vs 0.6 is still 1.18 (95% CI, 1.12-1.24). The 2 models with fixed or random hospital effects produced mostly similar results.

We found, as have others,1,3,11,32,33 that hospitals with higher teaching intensity appear to have lower risk-

<table>
<thead>
<tr>
<th>Model</th>
<th>OR Comparison</th>
<th>Mortality (95% CI); P Value</th>
<th>Complication (95% CI); P Value</th>
<th>Failure to Rescue (95% CI); P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>For RB = 0, black vs white patients</td>
<td>0.96 (0.95-0.98); &lt;.001</td>
<td>1.13 (1.10-1.16); &lt;.001</td>
<td>1.24 (1.18-1.30); &lt;.001</td>
</tr>
<tr>
<td>For white patients, RB = 0 vs 0</td>
<td>0.83 (0.81-0.84); &lt;.001</td>
<td>0.99 (0.97-1.01); .19</td>
<td>1.18 (1.12-1.24); &lt;.001</td>
<td></td>
</tr>
<tr>
<td>For blacks patients, RB = 0.6 vs 0</td>
<td>1.04 (0.99-1.09); .11</td>
<td>0.99 (0.97-1.01); .19</td>
<td>1.18 (1.12-1.24); &lt;.001</td>
<td></td>
</tr>
<tr>
<td>Models 2, 3, and 4 interaction terms</td>
<td>RB = 0.6 vs 0</td>
<td>black race</td>
<td>black race</td>
<td>black race</td>
</tr>
<tr>
<td>Model 2</td>
<td></td>
<td>1.25 (1.20-1.31); &lt;.001</td>
<td>0.99 (0.97-1.01); .44</td>
<td>1.24 (1.18-1.30); &lt;.001</td>
</tr>
<tr>
<td>Model 3: hospital fixed effects</td>
<td>RB = 0.6 vs 0</td>
<td>black race</td>
<td>1.13 (1.07-1.19); &lt;.001</td>
<td>0.98 (0.96-1.01); .16</td>
</tr>
<tr>
<td>Model 4: hospital random effects</td>
<td>RB = 0.6 vs 0</td>
<td>black race</td>
<td>1.18 (1.12-1.24); &lt;.001</td>
<td>0.98 (0.96-1.01); .19</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; OR, odds ratio; RB, resident-to-bed ratio.

Separate models using general surgery, orthopedics, or vascular surgery without and with adjustment for the individual hospitals (a fixed-effects approach) produced mostly similar results, as did a random-effects model including individual hospitals. In this Table, we report models for the combined surgery group only. Separate models using general surgery, orthopedics, or vascular surgery without and with adjustment for the individual hospital (a fixed-effects approach) produced mostly similar results.
adjusted mortality after major surgery than less teaching-intensive hospitals. Previous studies have shown similar or higher postoperative complication rates at teaching hospitals than at nonteaching hospitals. We now demonstrate that the lower mortality rates in surgical cases are mediated by fewer deaths among patients who experienced complications (lower failure to rescue) and not by lower rates of complications. Moreover, this finding does not change when adjustments are made for zip code level income, suggesting that lower failure-to-rescue rates in this population are not generated by unequal access to higher teaching-intensity hospitals by patients of different incomes.

It is therefore of interest to find, when using data from the entire Medicare population in the United States, that black patients, unlike white patients, do not experience lower surgical mortality and failure-to-rescue rates at teaching-intensive hospitals. It appears that black patients fare about equally well in teaching and nonteaching hospitals, whereas white patients have significantly better risk-adjusted mortality and failure to rescue at teaching hospitals than at nonteaching hospitals.

Why does this racial disparity in mortality and failure to rescue exist? This disparity is smaller, though still substantial, in the model with a separate fixed effect for each hospital. This indicates that some, but by no means all, of the disparity stems from black patients going to teaching hospitals with similar resident-to-bed ratios but worse mortality and failure-to-rescue rates than their white counterparts (a similar effect was reported by Lucas et al and Barnato et al). However, our study found that the within-hospital disparities are large, significant, and more substantial than those observed in previous work.

In earlier work, we also studied racial differences in the length of surgery for comparable procedures and found lower-income black Medicare patients had surgery that took on average 29 minutes longer than white patients of similar income (P < .001). In part, this was because black patients tended to go to teaching hospitals that had longer procedure times. However, even when adjusting for the individual hospital, procedure time remained significantly longer in black patients, but now by 7 minutes (P < .001). Inside some very major teaching hospitals, the black-white difference was not apparent, while in others, the difference was more than 16 minutes for comparable surgery. The observed racial disparities in adjusted procedure length raise questions as to whether there are potential differences in who provides care to these populations at teaching-intensive hospitals.

Why do racial differences in failure to rescue occur within hospitals is not well understood, but there are many possibilities. Chan et al report that black patients were 22% (P < .009) more likely to experience a delay in initiating defibrillation than their white counterparts, with arrests occurring in unmornitred beds more often than in white patients (P < .001). Are black patients being monitored in the same way as their white counterparts? In search of a more general cause, Balsa and McGuire have described a process of “statistical” discrimination in which unintentional actions potentially based on poor communication may lead to disparities in outcomes. This could be exacerbated in time-pressured environments in which relatively inexperienced providers deliver much of the care. Unintentional differences in communication might lead to less appropriate or less accurate monitoring of black patients or less involvement in their care by personnel who could make a difference in reducing failure to rescue. In our previous work, we considered the possibility that the differences in surgical procedure length between whites and black patients may be because of different levels of involvement of physicians in training in black vs white patients. How does the difference in income between black and white patients relate to the disparity in failure to rescue? This is a complex issue because these are Medicare, non–health maintenance organization patients and, in principle, income should not be a factor in care, though gaps between principle and practice might occur. We did
adjust for median income within the zip code of residence, and after adjustment, teaching-intensive hospitals still had lower failure-to-rescue rates than nonteaching hospitals in white patients but not black patients, suggesting that the apparent benefit of teaching intensity is not an artifact of unequal income.

It also was interesting that at nonteaching hospitals, black patients actually had slightly lower overall adjusted mortality than white patients, although the crude mortality rates were higher for black patients than white patients in nonteaching hospitals. We would not want to make too much of our finding since the coefficient on the race difference in nonteaching hospitals was small (an OR of 0.96) and recent work by Volpp et al and Polsky et al reports that black patients were noted to have lower 30-day mortality than white patients for a number of conditions, but this reversed with longer follow-up.

There are limitations to our study. Although we report on a very large sample size based on Medicare claims data, the trade-off is that these records do not contain medical record–based data. For example, we do not have details on the sequencing or severity of complications and do not know whether subgroups in this study had a different distribution of complications that may partially explain our findings. Relying on claims data, and not medical record review, does leave open the possibility that racial differences in mortality and failure to rescue may be because of unmeasured severity. However, our study compared white patients at less teaching-intensive hospitals with white patients at more teaching-intensive hospitals and the same for black patients. Hence, for our severity adjustment to be inadequate, even after our extensive risk adjustment, white patients entering teaching hospitals would need to be in better health than white patients entering nonteaching hospitals, but blacks entering teaching hospitals would need to be in the same health as black patients entering nonteaching hospitals. If black patients were sicker than white patients in the same unmeasured ways on admission to all hospitals, this by itself would not produce the pattern of mortality and failure-to-rescue rates that we found.

In conclusion, teaching-intensive hospitals with high resident-to-bed ratios have lower risk-adjusted mortality rates after major surgery than hospitals with lower ratios or without residents. This better survival is mainly because of better failure-to-rescue rates after postoperative complications. However, on average, while white patients have lower mortality and failure-to-rescue rates at teaching-intensive hospitals, black patients do not.

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