Cataracts are the leading cause of preventable blindness globally and are responsible for approximately 50% of worsening bilateral vision cases among Caucasians, Hispanics, and African Americans in the United States. By 2020, the prevalence of Americans aged >40 years with cataracts in either eye is expected to increase by 50%, from 20.5 million to 30.1 million people, according to US Census estimates for the projected population. Cataract surgery by phacoemulsification is a safe, cost-effective procedure that is associated with few complications. Phacoemulsification is typically performed on an outpatient basis using a local anesthetic.

Cataract surgery improves patients’ vision and quality of life, as evidenced by an immediate improvement in sleep quality and gait speed, in addition to a long-term reduction in hip fractures within a year of surgery. The subsequent improvement in visual acuity has also been associated with significant improvements in daily activities and emotional and social well-being. Cataract surgery has resulted in a significant return on investment to society, as a result of being cost-effective and improving quality of life. In addition, a study reviewing nearly 130,000 cataract surgeries performed over a 22-year period showed a rate of only 1.6% of significant complications.

As the most frequently performed procedure in the United States, phacoemulsification proficiency represents a significant component of ophthalmology residency training. However, development of such skills
Resident-Performed Cataract Surgery

KEY POINTS

- The rate of cataract surgery cancellation is high and some cancellations are preventable.
- This study compared the effect of intervention with mandatory on-site preadmission testing versus usual care on cataract surgery cancellation among residents at Wills Eye Hospital.
- The overall surgery cancellation rate was 14.5% among the 441 patients in the study.
- The intervention cohort was more likely to have preadmission testing and a physical examination than the usual care cohort.
- When analyzed by treatment location, the cancellation rate was 100% with incomplete preadmission testing, 10.9% with preadmission testing by a PCP, and 5.5% with on-site preadmission testing.
- Completing preadmission testing on-site on the day of the initial cataract evaluation resulted in the least surgery cancellations.
- Patients who lived further from the hospital and women who did not have on-site preadmission testing were more likely to cancel cataract surgery than counterparts.
- The per-patient reimbursements were higher in the usual care group than in the intervention group, resulting in no net financial benefit to the clinic for conducting the intervention.
- Increasing patient access to preadmission testing can reduce cataract surgery cancellations, which can lead to improved patient vision and overall health.

is impeded by the steep learning curve associated with surgical training. In a survey of ophthalmology residency program directors in the United States, 10% of the residents were identified as having trouble attaining surgical competency.

An assessment of resident-performed surgeries found significantly higher complication rates than in cases performed by attending physicians, with an incidence of posterior capsule tears and vitreous loss in 5.8% and 2.9% of patients, respectively. Patients in our study could elect to have surgery with a resident or with an attending physician. Another study showed that third-year residents found it particularly difficult to perform nuclear emulsifications (a critical step in cataract surgery); manage capsular bag dialysis; and handle mature, senile cataracts.

Aside from direct surgical practice, ophthalmology residents traditionally train in wet laboratories, where they operate on pig, cow, or cadaver eyes. They also learn through assisting attending surgeons with procedures, and gradually gain expertise by mastering each step separately (step-by-step method) or by performing the entire procedure (one-step method). The use of surgical simulators has increased recently, and several studies have shown that this preparation reduces residents’ frustration with their surgical skills and improves their efficiency.

Complication rates, surgery times, and proficiency have been shown to markedly improve as surgical volume increases, with a 50% decrease in complication rates in resident-performed surgeries after the resident’s first 40 cases. One study that assessed an attending surgeon’s first 1000 cases noted an 8.4% decrease in the incidences of major and minor complications over time. Independent observers who assessed surgical proficiency using the Objective Structured Assessment of Cataract Surgical Skill scoring were consistently able to distinguish surgeons who had performed less than 50 surgeries from those who had performed 50 to 249 surgeries.

A high level of surgical proficiency among residents is often associated with a robust clinical cataract curriculum. The American Board of Ophthalmology recently added surgical skills to the 6 core competencies required of residency programs to maintain accreditation by the Accreditation Council for Graduate Medical Education. Various objective assessments of residents’ surgical skill, such as the Eye Surgical Skills Assessment Test, ensure that residents achieve surgical competence during their training. As a result, residency programs must optimize their number of surgical cases to train more proficient residents and improve communication to reduce cancellation rates.

Despite this, some programs have been unable to provide residents with sufficient experience, because of high rates of surgery cancellations. A study of canceled cataract surgeries at a Boston, MA, ambulatory surgical center over a 2-year period revealed that more than 5% of cancellations occurred less than 24 hours from the scheduled operation. Those cancellations, 41% of which were considered preventable, resulted in an average annual loss of approximately $100,000 and 189.5 hours of lost operating room time. A review of canceled cataract surgeries at 123 Veterans Administration facilities found an average ophthalmic surgery cancellation rate of 9%; 35% of these cancellations were attributed to “patient factors,” with another 28% attributed to inadequate workup. Some patient factors include issues with remembering the scheduled surgery, transportation, or insurance. These factors can be mediated through interventions that allow hospitals to reach their full clinical and economic potentials.

One study has identified the preoperative window as an
important period to improve adherence. Being informed about the surgical and presurgical processes and having questions addressed during preoperative visits have a significant effect on a patient’s level of satisfaction. Same-day surgery cancellations at the Stony Brook University Medical Center Ambulatory Surgery Center in New York decreased from 8% to <3% between 2008 and 2010 after the implementation of a performance improvement project that targeted preoperative instruction.

The resident-run Cataract & Primary Eye Care Service clinic at Wills Eye Hospital requires routine preadmission testing, a physical examination before cataract surgery, and a review of preventive measures to minimize postoperative risk. A previous study by Wills Eye Hospital found that resident-performed cataract surgeries found a cancellation rate of 29.5% for cataract surgery. Of these cancellations, 72% were within 7 days of surgery, which cost the hospital $844,370. In addition to the financial toll, the cancellations resulted in an average loss of 29 surgical cases for each resident over a 1-year period.

An assessment over 1 year of the combined financial and educational toll found Wills Eye Hospital to be operating at 96% capacity. Most important, failure to complete preadmission testing and a physical examination were the most frequently cited reasons for cancellation, which highlights the need for an intervention protocol that could significantly attenuate these rates.

Therefore, we conducted a randomized controlled study to evaluate the effect of mandatory on-site preadmission testing and a physical examination on decreasing resident-performed cataract surgery cancellation rates.

**Methods**

This cluster-randomized controlled trial investigated the effect of an intervention on cataract surgery cancellation rates at the Cataract & Primary Eye Care Service at Wills Eye Hospital. The intervention was comprised of several nonmedical procedures, most notably mandatory same-day preadmission testing and a physical examination with a Wills Eye Hospital–affiliated cardiologist, which was considered on-site preadmission testing. The intervention also included escorting patients to the cardiologist’s office, which was chosen for convenient same-day preadmission testing because this practice is within walking distance to Wills Eye Hospital. Those who could not have same-day preadmission testing because of a scheduling conflict were provided assistance with rescheduling their preadmission testing and physical examination to another date.

Other aspects of the intervention involved reiterating surgery instructions provided by the residents and surgical coordinator, and answering patients’ questions over the phone before cataract surgery. The intervention protocol was a randomized, weekly schedule, along with the usual care protocol, which allowed for a direct assessment of the efficacy of the intervention protocol relative to the current Cataract & Primary Eye Care Service procedure.

The Wills Eye Hospital Institutional Review Board approved the study and waived informed consent. A total of 441 patients who were scheduled for cataract surgery in the resident clinic between January 5, 2015, and November 23, 2015, were randomized, by week, into 2 groups: usual care or intervention. Patients who lived in a nursing home, were on dialysis, were incarcerated, or were younger than age 18 years were excluded from the study. Patients randomized to the usual care group were provided with preadmission testing and physical examination requirements at the time of cataract surgery scheduling, and were instructed to complete preadmission testing and a physical examination with their primary care physician (PCP) within a 30-day window before surgery.

Patients randomized to the intervention group were required to complete same-day, on-site preadmission testing and a physical examination at an affiliated cardiology practice and were escorted to this office by a research assistant. If the patient’s ophthalmology appointment was completed after 4:00 PM, the research assistant scheduled the patient’s preadmission testing visit within 1 week of their scheduled cataract surgery. If an intervention patient’s surgery was scheduled beyond 30 days, the research assistant scheduled his or her preadmission testing and a physical examination within a 30-day window before surgery. However, patients were not excluded if they chose to have the preadmission testing and a physical examination completed by their PCP.

The patients in both groups received a reminder call by the ophthalmology resident or the operating room staff 1 to 2 days before surgery, which was already standard of care at our institution. The patients who canceled surgery without rescheduling were deemed cancellations, and were administered a brief telephone questionnaire to assess their reasons for cancellation.

A password-protected, HIPAA (Health Insurance Portability and Accountability Act of 1996)-compliant database was used to track all phases of the study. The research assistant conducted chart reviews on all patients who had scheduled cataract surgery to determine the patients’ demographics, insurance status, preoperative visual acuity, and surgery details.

**Statistical Analysis**

The patients’ characteristics were summarized by randomization assignment using means, medians, standard deviations, and ranges for continuous variables, and frequencies and percentages for categorical variables. The randomization arms were compared with respect to cate-
Table 1 Covariate Distributions, by Randomization Group

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Total (N = 441)</th>
<th>Intervention (N = 201)</th>
<th>Usual care (N = 240)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female, N (%)</td>
<td>248 (56.2)</td>
<td>111 (55.2)</td>
<td>137 (57.1)</td>
<td></td>
</tr>
<tr>
<td>Male, N (%)</td>
<td>193 (43.8)</td>
<td>90 (44.8)</td>
<td>103 (42.9)</td>
<td></td>
</tr>
<tr>
<td>Age, mean, yrs (SD)</td>
<td>65.5 (12.3)</td>
<td>66.3 (12.2)</td>
<td>64.8 (12.3)</td>
<td></td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African American, N (%)</td>
<td>246 (55.8)</td>
<td>115 (57.2)</td>
<td>131 (54.6)</td>
<td>.43</td>
</tr>
<tr>
<td>Caucasian, N (%)</td>
<td>193 (43.8)</td>
<td>90 (44.8)</td>
<td>103 (42.9)</td>
<td></td>
</tr>
<tr>
<td>Latino/Hispanic, N (%)</td>
<td>19 (4.3)</td>
<td>8 (4.0)</td>
<td>11 (4.6)</td>
<td></td>
</tr>
<tr>
<td>N/A, N (%)</td>
<td>26 (5.9)</td>
<td>13 (6.5)</td>
<td>13 (5.4)</td>
<td></td>
</tr>
<tr>
<td>Other, N (%)</td>
<td>1 (0.2)</td>
<td>0 (0)</td>
<td>1 (0.4)</td>
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</tr>
<tr>
<td>Surgery attended</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No, N (%)</td>
<td>64 (14.5)</td>
<td>25 (12.4)</td>
<td>39 (16.3)</td>
<td>.26</td>
</tr>
<tr>
<td>Yes, N (%)</td>
<td>377 (85.5)</td>
<td>172 (87.6)</td>
<td>201 (83.8)</td>
<td></td>
</tr>
<tr>
<td>Scheduled eye for surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right eye, N (%)</td>
<td>225 (51)</td>
<td>103 (51.2)</td>
<td>122 (50.9)</td>
<td>.93</td>
</tr>
<tr>
<td>Left eye, N (%)</td>
<td>216 (49)</td>
<td>98 (48.8)</td>
<td>118 (49.2)</td>
<td></td>
</tr>
<tr>
<td>History of cataract surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No, N (%)</td>
<td>366 (83)</td>
<td>169 (86.2)</td>
<td>200 (83.3)</td>
<td>.84</td>
</tr>
<tr>
<td>Yes, N (%)</td>
<td>75 (17)</td>
<td>35 (17.7)</td>
<td>40 (16.7)</td>
<td></td>
</tr>
<tr>
<td>Preadmission testing completed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No, N (%)</td>
<td>28 (6.3)</td>
<td>8 (4.0)</td>
<td>20 (8.3)</td>
<td>.062</td>
</tr>
<tr>
<td>Yes, N (%)</td>
<td>413 (93.7)</td>
<td>169 (82.6)</td>
<td>240 (91.7)</td>
<td></td>
</tr>
<tr>
<td>Preadmission testing same day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No, N (%)</td>
<td>315 (71)</td>
<td>107 (53.2)</td>
<td>208 (85.8)</td>
<td></td>
</tr>
<tr>
<td>Yes, N (%)</td>
<td>100 (22.7)</td>
<td>86 (43.8)</td>
<td>13 (5.4)</td>
<td></td>
</tr>
<tr>
<td>Preadmission testing location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-site, N (%)</td>
<td>165 (37.4)</td>
<td>132 (65.7)</td>
<td>33 (13.8)</td>
<td>.001*</td>
</tr>
<tr>
<td>Primary care provider, N (%)</td>
<td>248 (56.2)</td>
<td>61 (30.3)</td>
<td>187 (77.9)</td>
<td></td>
</tr>
<tr>
<td>Visual acuity (LogMAR) in scheduled eye, median (min-max)</td>
<td>0.7 (0-2.70)</td>
<td>0.6 (0-2.70)</td>
<td>0.7 (0.1-2.70)</td>
<td>.36</td>
</tr>
<tr>
<td>Visual acuity (LogMAR) in fellow eye, median (min-max)</td>
<td>0.3 (0-3)</td>
<td>0.3 (0-3)</td>
<td>0.3 (0-3)</td>
<td>.71</td>
</tr>
<tr>
<td>Distance to Wills Eye Hospital, miles, median (min-max)</td>
<td>4.4 (0-173)</td>
<td>4.5 (0-172.9)</td>
<td>4.3 (0-59)</td>
<td>.49</td>
</tr>
</tbody>
</table>

*Clinically significant.
*Data available for 200 patients.
*Data available for 237 patients.
*Data available for 234 patients.

N/A indicates not available. SD, standard deviation.

Cost Analysis

The cost analysis was conducted from the perspective of Wills Eye Hospital and included the main measures of (1) additional reimbursements achieved as a result of the intervention, and (2) a net financial benefit of the intervention versus usual care. The additional reimbursements achieved were calculated by monetizing the procedures completed in the intervention group versus the usual care group. Monetization was performed based on the patient’s primary and secondary insurance plans. The additional reimbursement achieved in the intervention group was compared with our previous study34 by construction of an Excel model with a 1-year time horizon that accounted for payer mix in the previous study versus the interventional study. Reimbursements included the 3 major components of anesthesia, surgeon, and facility.

The net financial benefit of the intervention was calculated based on best practices in applied health economic methods of cost-benefit analysis. Specifically, the cost-benefit analysis enabled the determination of whether the net financial benefit of the intervention was ≥$0 (ie, the cost of the intervention was equal to or exceeded the reimbursements achieved). The intervention costs included 4 direct-cost categories, including physician time in referring patients to mandatory preadmission testing and physical examinations, telephone time of the administrative staff, personnel training on the intervention, and intervention materials. The personnel costs were calculated using wage rates for intervention staff multiplied by time in intervention delivery, documentation, and training. Fringe benefit costs (ie, healthcare, disability, life insurance) were added to personnel costs by the application of the prevailing Wills Eye Hospital fringe benefit rate of 26%.

Results

A total of 441 patients were enrolled and randomized.
in the study, with 201 (45.6%) patients in the intervention group and 240 (54.4%) patients who received usual care. In total, 413 (93.7%) patients completed preadmission testing and a physical examination, and 377 (85.5%) patients attended cataract surgery (Table 1).

Overall, 246 (55.8%) patients were African American and 130 (29.5%) were Caucasian. A total of 248 (56.2%) patients were female. None of the baseline covariates showed evidence of association with the randomization group. The patients’ mean age was 65.5 years (standard deviation, 12.3 years).

Table 2 shows the association of baseline variables with surgery cancellation status. Ethnicity, sex, and distance from Wills Eye Hospital showed potential association in an adjusted model (P < .20) with cancellation in the univariable regression analysis. The final multivariable model for the association of randomization with cancellation after sequentially removing covariates that were not associated with cancellation (P > .20) included sex and distance from Wills Eye Hospital. (We used this study as an opportunity to explore patient factors that correlated with cancellation.)

Patients who lived further away from Wills Eye Hospital were more likely to cancel a cataract surgery than patients who lived closer to the hospital, with a 5% increase in the odds of cancellation for every 5-mile increase in distance (P < .0001; odds ratio [OR], 1.05; 95% confidence interval [CI], 1.03-1.08; Table 3). Female patients were more likely than male patients to cancel cataract surgery (P = .015; OR, 1.74; 95% CI, 1.11-2.71; Table 3). The association between randomization assignment and cancellation remained nonsignificant after adjustment (P = .27; OR, 0.75; 95% CI, 0.45-1.25; Table 3).

During the study, some patients in the usual care group chose to take advantage of on-site preadmission testing and a physical examination, whereas some patients in the intervention group chose to complete preadmission testing and have a physical examination with their PCP. Ultimately, 13.8% of patients in the usual care group completed on-site preadmission testing and 77.9% completed preadmission testing with their PCP. In the intervention group, 65.7% of patients completed on-site preadmission testing and 30.3% of patients completed preadmission testing with their PCP (Table 1). As a result of this divergence from the original preadmission testing location assignments, we also performed an as-treated analysis based on the location where preadmission testing was actually completed. The cancellation rates by location were 100% with incomplete preadmission testing, 5.5% with on-site preadmission testing, and 10.9% with preadmission testing with a PCP (P = .055).

There was a significant difference in the completion of preadmission testing between the patients receiving usual

### Table 2: Association of Covariates with Cataract Surgery Cancellation Status

<table>
<thead>
<tr>
<th>Covariate</th>
<th>No (N = 64)</th>
<th>Yes (N = 377)</th>
<th>Cancellation odds ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention group, N (%)</td>
<td>25 (12.4)</td>
<td>176 (87.6)</td>
<td>0.73 (0.42-1.29)</td>
<td>.28</td>
</tr>
<tr>
<td>Usual care group, N (%)</td>
<td>39 (16.3)</td>
<td>201 (83.8)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age, mean, yrs (SD)</td>
<td>66.2 (9.9)</td>
<td>65.4 (12.6)</td>
<td>1.01 (0.99-1.02)</td>
<td>.54</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female, N (%)</td>
<td>44 (17.7)</td>
<td>204 (82.3)</td>
<td>1.93 (1.14-3.28)</td>
<td>.014^a</td>
</tr>
<tr>
<td>Male, N (%)</td>
<td>20 (10.4)</td>
<td>176 (89.6)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Scheduled eye for surgery, N (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right eye, N (%)</td>
<td>26 (12.4)</td>
<td>197 (87.6)</td>
<td>0.71 (0.38-1.32)</td>
<td>.28</td>
</tr>
<tr>
<td>Left eye, N (%)</td>
<td>36 (16.7)</td>
<td>180 (83.3)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Season</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall, N (%)</td>
<td>17 (19.1)</td>
<td>72 (80.9)</td>
<td>2.23 (0.87-5.71)</td>
<td>.26</td>
</tr>
<tr>
<td>Summer, N (%)</td>
<td>22 (16.8)</td>
<td>109 (83.2)</td>
<td>1.90 (0.77-4.70)</td>
<td>.26</td>
</tr>
<tr>
<td>Winter, N (%)</td>
<td>7 (1.8)</td>
<td>377 (98.2)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>History of cataract surgery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No, N (%)</td>
<td>52 (14.2)</td>
<td>314 (85.8)</td>
<td>0.87 (0.46-1.66)</td>
<td>.68</td>
</tr>
<tr>
<td>Yes, N (%)</td>
<td>12 (10.5)</td>
<td>63 (89.5)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age, mean, yrs (SD)</td>
<td>66.2 (9.9)</td>
<td>65.4 (12.6)</td>
<td>1.01 (0.99-1.02)</td>
<td>.54</td>
</tr>
<tr>
<td>Visual acuity (LogMAR) in affected eye, median (min-max)</td>
<td>0 (0-2.7)</td>
<td>0.7 (0-2.7)</td>
<td>1.15 (0.84-1.58)</td>
<td>.37</td>
</tr>
<tr>
<td>Visual acuity (LogMAR) in nonaffected eye, median (min-max)</td>
<td>0.30 (0-3)</td>
<td>0.30 (0-3)</td>
<td>0.91 (0.52-1.60)</td>
<td>.75</td>
</tr>
<tr>
<td>Distance to Wills Eye Hospital, miles, median (min-max)</td>
<td>5 (0.8-172.9)</td>
<td>4.3 (0-109)</td>
<td>1.01 (1.00-1.02)</td>
<td>.17</td>
</tr>
</tbody>
</table>

^aClinically significant.
^bData available for 373 patients.
^cData available for 370 patients.
^dData available for 376 patients.
CI indicates confidence interval; no available; SD, standard deviation.

### Table 3: Multiple GEE Logistic Regression Model for Cataract Surgery Cancellation (N = 441)

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Level</th>
<th>Odds ratio of cancellation</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>Per 5 miles</td>
<td>1.05 (95% CI, 1.03-1.08)</td>
<td>&lt; .0001^a</td>
</tr>
<tr>
<td>Group</td>
<td>Intervention vs usual care</td>
<td>0.73 (95% CI, 0.45-1.25)</td>
<td>.27</td>
</tr>
<tr>
<td>Sex</td>
<td>Female</td>
<td>1.74 (95% CI, 1.11-2.71)</td>
<td>.015^a</td>
</tr>
</tbody>
</table>

^aClinically significant.
CI indicates confidence interval; GEE, generalized estimating equation.
care and those who had an intervention (P < .001). Those with incomplete preadmission testing were more likely to have been assigned to the usual care group (N = 20) than to the intervention group (N = 8). This may also explain, in part, the association between sex and cancellation that we found in our sample. More female patients did not complete on-site preadmission testing than was expected, and more male patients had on-site preadmission testing (P = .02). All patients with incomplete preadmission testing had their cataract surgery canceled.

Finally, the reasons for surgery cancellation were grouped into sickness, transportation, not having clearance, unable to recall, family situations, insurance, other, and unknown. There was no association between the randomization group and the reason cited for cancellation of cataract surgery (P = .094).

Cost Analysis

Staff time data were collected on a subset of 80 patients as a result of a delay in the initiation of cost analysis from the start of the study (Table 4). The total staff time the research assistant spent was 1489 minutes (ie, 24.8 hours), and the mean staff time spent per patient was 5 minutes. The most time-consuming task in the total and average times throughout the study was walking the patient to and from preadmission testing, which is an approximate 4-minute walk from Wills Eye Hospital (Table 4).

The total staff financial cost of delivering the intervention was $621.45 ($7.77 per patient; Table 5). With the institution’s telephone service cost of 3 cents per minute, the total cost for 252 recorded minutes of telephone time was $7.56 ($0.10 per patient). The total cost of the intervention (staff plus telephone service; 2015 US dollars) was $629.01 ($7.86 per patient).

The cost-benefit analysis revealed the incremental per-patient cost of the intervention to be $7.77, whereas the incremental per-patient reimbursement was $664.79. Reimbursement information was available for 206 (85.8%) patients in the usual care group and 177 (88.1%) patients in the intervention group. Patient randomization did not account for payer type or procedure level (Current Procedural Terminology code 66984 vs 66982). The per-patient reimbursements were greater in the control group than in the intervention group; thus, the intervention did not result in a net financial benefit to the institution.

Discussion

In a previous study conducted at our site regarding resident-performed cataract surgery cancellations, a lack of preadmission testing was the most frequently cited reason for cancellation, which accounted for 35.6% of cancellations.34 Similarly, among patients who were scheduled for ambulatory surgery, Gaucher and colleagues found that 28% of patients had not undergone tests ordered by the surgeon or the anesthetist between 3 and 7 days before the planned date of surgery.33 Furthermore, Argo and colleagues reported that surgeons at sites with lower cancellation rates had higher utilization of preoperative clinic visits.

Prompted by these findings, the patients in our study were randomized to a protocol designed to facilitate preadmission testing and thereby reduce cancellation rates for resident-performed cataract surgery. This was conducted within 30 days of the patients’ scheduled cataract surgery. Overall, the cancellation rate among 441 pa-

### Table 4 Staff Time Spent Delivering the Intervention

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total time, min (N = 80)</th>
<th>Time per patient, mean, min (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk patient to preadmission testing physician</td>
<td>1071</td>
<td>15 (4.79)</td>
</tr>
<tr>
<td>Call to/from clinical staff</td>
<td>113</td>
<td>1 (0.60)</td>
</tr>
<tr>
<td>Call to/from patient</td>
<td>112</td>
<td>2 (1.36)</td>
</tr>
<tr>
<td>E-mail to/from preadmission testing physician</td>
<td>105</td>
<td>1 (0.96)</td>
</tr>
<tr>
<td>Reminder call to patient</td>
<td>27</td>
<td>2 (1.49)</td>
</tr>
<tr>
<td>Other tasks</td>
<td>61</td>
<td>6 (3.50)</td>
</tr>
<tr>
<td>Total staff time</td>
<td>1489</td>
<td>5 (6.10)</td>
</tr>
</tbody>
</table>

4Activities that were categorized as “other” included rescheduling because the patient forgot his or her identification and insurance card, picking up the patient from the preadmission testing physician’s office and walking him or her to the bus stop, and meeting with the patient and arranging for the preadmission testing to be completed on another day.

### Table 5 Cost-Benefit Analysis

<table>
<thead>
<tr>
<th>Cost measure</th>
<th>Intervention, $</th>
<th>Usual care, $</th>
<th>Contrast, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per-patient intervention costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean per-patient staff cost</td>
<td>7.77</td>
<td>0.00</td>
<td>7.77</td>
</tr>
<tr>
<td>Mean per-patient telephone service costs</td>
<td>0.10</td>
<td>0.00</td>
<td>0.10</td>
</tr>
<tr>
<td>Total intervention costs</td>
<td>7.86</td>
<td>0.00</td>
<td>7.87</td>
</tr>
<tr>
<td>Per-patient reimbursements for completed cataract surgeries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean per-patient facility reimbursement</td>
<td>4101.51</td>
<td>4687.86</td>
<td>-586.36</td>
</tr>
<tr>
<td>Mean per-patient surgeon reimbursement</td>
<td>810.57</td>
<td>868.24</td>
<td>-57.66</td>
</tr>
<tr>
<td>Mean per-patient anesthesiology reimbursement</td>
<td>266.80</td>
<td>287.57</td>
<td>-20.77</td>
</tr>
<tr>
<td>Total reimbursements</td>
<td>5178.88</td>
<td>5843.68</td>
<td>-664.79</td>
</tr>
<tr>
<td>Cost-benefit</td>
<td></td>
<td></td>
<td>-672.86</td>
</tr>
</tbody>
</table>

4Contrast in differences between intervention costs and reimbursements.
patients enrolled in the study was 14.5%. This represents a nearly 50% reduction in cancellations from our previous study, which showed a 29.5% cancellation rate.\textsuperscript{34}

Although previous studies have not specified the cancellation rates of resident-performed cataract surgeries, studies focusing on ophthalmic surgeries showed cancellation rates between 5.3% and 21.9%.\textsuperscript{27,35-38} One potential reason for this reduction compared with our previous internal data may be a systemic awareness of the problem and increased counseling from physicians and staff on the importance of obtaining preoperative testing.

We were able to successfully address the lack of preoperative testing, which accounted for approximately 33% of the overall resident-performed cataract surgery cancellations in our institution (and probably a larger portion of the preventable causes); however, many other factors need to be recognized. Patients who lived further away from Wills Eye Hospital were more likely to cancel cataract surgery than those living close to the hospital. Female patients who did not have on-site preadmission testing, as they were assigned to, were also more likely to cancel surgery than male patients.

These findings may enable us to identify patients who are at increased risk for surgery cancellation and, therefore, improve quality of care. However, although these findings revealed a correlation, they do not indicate causality. Moreover, no association was found between cataract surgery cancellation and seasonal timing of surgery (Table 2). By contrast, previous studies had found that cancellation rates were highest among cases scheduled in the winter, particularly in February.\textsuperscript{27} Our data were collected over an 11-month period, which excluded December. Therefore, the timeline of the study accounted for the effects of seasonal timing on surgery cancellation.

According to the American Academy of Ophthalmology Preferred Practice Pattern guidelines, preoperative medical testing should be strongly considered in patients with certain systemic diseases.\textsuperscript{39} However, the American Academy of Ophthalmology does not support preadmission testing as routine care for all patients, because research indicates that routine preadmission testing does not improve surgical outcomes, does not reduce the risk for postoperative complications, and has no effect on procedure cancellation.\textsuperscript{3,13,39,40} Site-specific protocols that are in place at outpatient surgical centers may also dictate whether preoperative testing is required from an anesthesia standpoint. At Wills Eye Hospital, the anesthesia department created standardized guidelines that require all patients who undergo any ocular surgical procedure to have the same preadmission testing.

Several studies have reported success in decreasing surgery cancellations through some form of preadmission testing. For example, Fenschl and colleagues observed significantly fewer surgery cancellations among patients evaluated in an anesthesia preoperative medicine clinic compared with patients who did not attend a clinic visit before surgery (5.3% vs 13%, respectively).\textsuperscript{41} Fernando and colleagues observed a 15% reduction in the cancellation rate of ophthalmic surgeries after the utilization of preassessment forms that evaluated patients’ suitability for surgery and were performed at the time the surgery was scheduled.\textsuperscript{42} In our study, 100% of patients who had incomplete preadmission testing canceled surgery, whereas only 8.7% of patients who completed preadmission testing canceled surgery. The rates of cancellation were 5.4% lower among those who attended on-site preadmission testing compared with those whose preadmission testing was performed by their PCP, although this finding did not reach statistical significance.

We observed the lowest cancellation rates among patients who completed on-site preadmission testing and those who completed preadmission testing on the same day of the initial cataract evaluation. Our patient-centered protocol eliminated the need for an extra visit, which reduced the travel time, parking and transportation fees, and copayment expenses that would have been required. Offering same-day, on-site preadmission testing was very well received by patients and staff, and has since been incorporated into the standard protocol for the institution. Although the cost analysis in this study indicated no financial benefit to the institution for the intervention, which may have resulted from a lack of adjustment for payer type or procedure level between groups, the enhanced quality of care and the increase in opportunity for resident surgical training were enough to make the financial cost of the intervention worthwhile.

Although it has not been studied, another benefit of our intervention is improved preventive medical care for our patients and a potential decreased cost to society. Many patients who elected to use on-site preadmission testing did not have a PCP or had not seen a physician for years. During preadmission testing and physical examination, cholesterol levels, glucose levels, and blood pressure were tested and an electrocardiogram was conducted. These tests detected conditions such as diabetes, hyperlipidemia, and hypertension, which were treated before the patient obtained clearance for surgery. This reduced the patients’ anesthesia-related risk, and theoretically also reduced overall morbidity and mortality over a lifetime. These patients benefited from clinical evaluation and probably cost our society less to care for than if their unknown and uncontrolled medical issues led to an acute hospitalization.

**Limitations**

The limitations of this study include small sample size,
data collection in only 1 ophthalmology clinic, and little patient information regarding reasons for cataract surgery cancellation.

In addition, our study did not address patients’ barriers to attending cataract surgery. Our study sample primarily consisted of underserved individuals from our resident clinic. These individuals may have increased barriers to medical and eye care, including financial and transportation barriers; as a result, their cancellation rates may be higher than cataract surgery cancellation rates in the general population.

Conclusion

As our findings show, by facilitating on-site preadmission testing, we have addressed a major reason for surgery cancellation at our institution. Consequently, ensuring that patients have access to preadmission testing and physical examination by a PCP before cataract surgery may provide more surgical opportunities to ophthalmologists in training, with the ultimate goal of decreasing patients’ visual impairment and improving their health and quality of life. Furthermore, our study’s results indicate the importance of addressing patient barriers to attending surgery, particularly transportation issues, in future studies.

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Author Disclosure Statement

The authors have no conflicts of interest to report.

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