The Relationship of Travel Distance to Postoperative Follow-up Care on Glaucoma Surgery Outcomes

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Précis: This study addresses the paucity of literature examining glaucoma patients’ distance from clinic on postoperative follow-up outcomes. Greater distance from clinic was associated with higher likelihood of loss to follow-up and missed appointments.

Purpose: To investigate the relationship of patient travel distance and interstate access to glaucoma surgery postoperative follow-up visit attendance.

Methods and Participants: Retrospective longitudinal chart review of all noninstitutionalized adult glaucoma patients with initial trabeculectomies or drainage device implantations between April 4, 2014 and December 31, 2018. Patients were stratified into groups on the basis of straight-line distance from residence to University of North Carolina at Chapel Hill’s Kittner Eye Center and distance from residence to interstate access. Corrective procedures, visual acuity, appointment cancellations, no-shows, and insurance data were recorded. Means were compared using 2-tailed Student t-test, Pearson χ², analysis of variance, and multivariate logistical regression determined odds ratios for loss to follow-up.

Results: In total, 199 patients met all inclusion criteria. Six-month postoperatively, patients > 50 miles from clinic had greater odds of loss to follow-up compared with patients ≤25 miles (odds ratios, 3.47; 95% confidence interval, 1.24–4.12; P < 0.05). Patients > 50 miles from clinic had significantly more missed appointments than patients 25 to 50 miles away, and patients <25 miles away (P = 0.008). Patients > 20 miles from interstate access had greater distance to follow-up than those ≤10 miles (t(130) = 2.05; P < 0.05). Mean distance from clinic was 12.59 miles farther for patients lost to follow-up (t(137) = 3.29; P < 0.01). Patients with Medicaid coverage had more missed appointments than those with Medicare plans (t(144) = 2.19; P < 0.05).

Conclusions: Increased distance from clinic and interstate access are associated with increased missed appointments and loss to follow-up. Glaucoma specialists should consider these factors when choosing surgical interventions requiring frequent postoperative evaluations.

Key Words: loss to follow-up, postoperative outcomes, proximity to postoperative care, travel distance, appointment cancellations, Medicaid, Medicare

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The current standard of treatment of glaucoma is the reduction of intraocular pressure (IOP) through topical medications, laser, and surgery to maintain quality of life and reduce vision loss. Surgical interventions such as trabeculectomy and tube shunt implantations require frequent follow-up and monitoring to assess their function, evolution, and possible complications.1–4 The American Academy of Ophthalmology’s (AAO) Preferred Practice Pattern Guideline attributes long-term surgical success to follow-up retention, but lack recommendations considering the follow-up demands for each procedure and the adverse outcome risks for patients who may be more susceptible for loss to follow-up because of increased travel distance.2

Following trabeculectomy or tube shunt placement, surgical maturation, evidence of complications, and IOP progress are typically assessed in clinic with frequent postoperative visits. Additional appointments are scheduled at the surgeon’s discretion until expected surgical outcomes have been met.3,5–7 Trabeculectomy, as compared with other glaucoma procedures, typically has more follow-up care and the possible need for medical or procedural intervention or surgical revision.8,9

Investigating the relationship of travel distance to postoperative follow-up care on glaucoma surgery outcomes can enable specialists to make note of patients’ proximity to follow-up care when deciding a surgical treatment intervention.

The purpose of this study is to identify if patients’ distance to the University of North Carolina at Chapel Hill’s Kittner Eye Center is related to surgical follow-up visit attendance. We hypothesize that increased travel distance is associated with increased missed or canceled appointments and loss to follow-up.

METHODS AND PARTICIPANTS

Data Source and Study Population

Institutional Review Board approval with informed consent exemption was granted for this retrospective study. This research adhered to the tenets of the Declaration of Helsinki and authors were trained in human subject research ethics by the Collaborative Institutional Training Initiative...
Program. Through the resources of the North Carolina Translation and Clinical Sciences Institute (NC TraCS), deidentified demographic, clinical, and insurance data from the Carolina Data Warehouse for Health were retrieved. Using the i2b2 application from NC TraCS, we obtained patient data from April 4, 2014 until December 31, 2018 for this longitudinal study. This timeframe allowed us to examine charts of patients who were surgically treated at the Kittner Eye Center of the University of North Carolina at Chapel Hill and compare distances between patient address to clinic.

The Kittner Eye Center is a tertiary academic referral center located in central North Carolina and serves a diverse and widespread patient population traveling from rural North Carolina for glaucoma management.

**Study Design**

Using the i2b2 interface, we specified International Classification of Diseases (ICD) 9 and 10 codes for glaucoma, age, Current Procedural Terminology (CPT) codes for relevant glaucoma surgical procedures, and clinic location. When establishing a patient set, patients with >1 ICD or CPT code were only counted once using i2b2.

The inclusion criteria specified established diagnoses of glaucomas under ICD-9: 365 and ICD-10: H40. Specifically, we included ICD-10 codes for open-angle glaucoma, primary angle-closure glaucoma, glaucoma secondary to eye trauma, glaucoma secondary to eye inflammation, glaucoma secondary to other eye disorders, glaucoma secondary to drugs, other glaucoma, unspecified glaucoma, and glaucoma in diseases classified elsewhere. We also included ICD-9 codes for corticosteroid-induced glaucoma, glaucoma associated with congenital anomalies, dystrophies, and systemic syndromes, glaucoma associated with disorders of the lens, and glaucoma associated with other ocular disorders in addition to all classifications that were transferred to ICD-10.

The exclusion criteria for subjects included ICD-9: 365.0 borderline glaucoma and ICD-10 H40.00 preglaucoma. Patients under 18 years of age or with unknown ages were excluded from the data. Institutionalized patients or those with managed care at skilled nursing facilities, penal systems, retirement communities, or other nursing homes were excluded on the basis of the potential for confounding variables. Patients without listed home addresses or those who transferred care to other institutions or providers were excluded during chart review. Appendix A (Document, Supplemental Digital Content 1, http://links.lww.com/JIG/A427) contains a full list of exclusion and inclusion criteria. Included patients had initial glaucoma surgeries performed from April 4, 2014 to December 31, 2018. The included CPT code for tube shunt placements were as follows: 66180, aqueous shunt to extraocular equatorial plate reservoir, external approach with graft. Trabeculectomy CPT codes were as follows: 66170, fistulization of sclera for glaucoma; trabeculectomy ab externo in absence of previous surgery; 66172, fistulization of sclera for glaucoma; trabeculectomy ab externo with scarring from previous ocular surgery or trauma (includes injection of antibiotic agents); and 66183, insertion of anterior segment aqueous drainage device, without extraocular reservoir, external approach (ie, Ex-PRESS Shunt).

Revision surgery CPTs for both tube shunt placement and trabeculectomy includes: 66185, revision of aqueous shunt to extraocular equatorial plate reservoir, with graft; and 66250, revision or repair of operative wound of anterior segment, any type, early or late, major or minor procedure.

In total, 199 patients met the above inclusion criteria and their charts were reviewed for demographics, initial surgery CPT, surgery date, insurance coverage at the date of service, tube shunt type (if applicable), laterality, attending surgeon, preoperative IOP, and postoperative IOPs at 1 day, 1 week (5 to 9 d), 1 month (3 to 5 wk), 3 months (± 2 wk), and 6 months (± 3 wk). Preoperative uncorrected visual acuity (VA) using Snellen chart examination was compared during chart review to 6 months postoperative VA. An VA decrease of ≥2 lines was classified as “Worsened.” Patients with a decline from counting fingers at six feet to counting fingers at four feet was considered a clinically significant decline. A change from count fingers to hand motion, hand motion to light perception, or light perception to no light perception was also considered clinically significant worsened VA. Visual fields were tested using confrontation for most patients and perimetry was sporadic because of the inconsistent nature and mixed modalities of preoperative and postoperative visual field examinations, these data were not included for statistical analysis.

Number of corrective and revision surgeries were recorded. Additional tube shunt placements or trabeculectomies within the global period, 90 days of the initial surgery, were considered to be corrective procedures. Additional tube shunt placements or trabeculectomies of the same eye beyond 90 days were considered to be surgical treatment for glaucoma disease progression and were not included in the data analysis.

Each participants’ office visit notes and telephone encounters were reviewed across the 6-month follow-up period. “Lost to follow-up” status was designated to patients who missed or did not schedule postoperative follow-up appointments as recommended by the provider and did not return to clinic in the 6-month postoperative period. Those who were suspected of being lost to follow-up were carefully reviewed for any indication of transfer of care to another provider (eg, patient or outside provider requests for records). Patients who transferred care without documented approval or recommendation by the surgeon were considered “lost to follow-up.” Patients who transferred care with the provider’s approval or with the appropriate transfer of records were excluded from the study. If at any point the physician documented that a patient could return to clinic as needed and the patient did not schedule further appointments in the 6-month postoperative period, the patient was not considered lost to follow-up.

Number of patient-initiated canceled/no-show appointments were recorded using comments provided by administrative encounters (eg, lack of transportation) excluding provider or clinic-initiated cancellations (eg, change of operating hours or provider schedule). Patients who canceled appointments and subsequently attended a rescheduled appointment within the time-period for each follow-up interval (eg, 3 mo ± 2 wk) were noted to have “rescheduled” an appointment, and not counted as “missed.” The number of patient-initiated rescheduled appointments was explicitly noted and counted separately from those that were rescheduled from prior no-show appointments.

In addition to the clinical chart review, straight-line (Euclidean) distances from patients’ home addresses to the Kittner Eye Center were measured to create radii of incidence of postoperative complications. Straight-line distance from patients’ home addresses to nearest interstate access was measured to identify groups of patients from rural communities.

**Outcome Measures**

The patient sample was stratified into 3 distance radii groups as follows: 0 to 25 miles, 25.5 to 50 miles, and > 50 miles from home address to Kittner Eye Center. Patients
were secondarily stratified into 3 distance groups from home to interstate access as follows: 0 to 10 miles, 10.5 to 20 miles, and > 20 miles. Distance and canceled or no-show appointments, loss to follow-up status, VA outcomes, were documented and means compared by 2-tailed Student t-test, Pearson χ² analysis, and analysis of variance. Odds ratios (ORs) were estimated using multivariate logistic regression models for distance from Kittner Eye Center and loss to follow-up, and distance to Kittner Eye Center and number of revision/corrective surgeries. Statistics were completed using R software (version 3.6.3; R Foundation for Statistical Computing, Vienna, Austria) and IBM SPSS by the NC TraCS Institute.

RESULTS

Of the 199 patients that met inclusion criteria for the study, distances ranged from 0.5 to 114 miles from home address to Kittner Eye Center. The map of patient radii of distance from Kittner Eye Center to home addresses is presented in Figure 1. The accompanying table in Figure 1 includes information on percentage of patients lost to follow-up, percentage with worsened VA, and average number of missed appointments between groups. Table 1 displays the demographic data and corresponding P-values the entire study population and distance subgroups, <25 miles from Kittner Eye Center, 25 to 50 miles, and >50 miles, respectively. There were no significant differences in demographic proportions between distance groups. Table 2 displays the kind and number of each treatment modality used within each distance subgroup. Table 3 shows the relative percentages of follow-up and VA outcomes for each distance subgroup and surgical treatment modality.

Multivariate logistic regression analyses compared the effect of straight-line distance from home address to the Kittner Eye Center, straight-line distance from home to

| Patients Lost to Follow up | 0–25 Miles | 25.5–50 Miles | > 50.5 Miles |
|----------------------------|------------|--------------|-------------|
| Worsened Visual Acuity     | 13.9%      | 24.6%        | 37.0%       |
| Avg. Missed/Cancelled Appointments | 1.17       | 1.37         | 2.22        |

**FIGURE 1.** Map of population home address radii and 6-month postoperative follow-up data.

**TABLE 1.** Demographic Data of Study Population and Subgroups With P-Values

|                          | Study Population | Patients <25 mi from Kittner Eye Center | 25-50 mi | > 50 mi | P    |
|--------------------------|------------------|----------------------------------------|----------|---------|------|
| N                        | 199              | 115                                    | 57       | 27      | 0.2585 |
| Average age (range)      | 64.94 (22-93)    | 65.93 (22-93)                          | 64.84 (31-93) | 60.89 (32-77) | 0.2585 |
| Average distance from Kittner Eye Center (mi) | 25.83 | 11.99 | 32 | 71.74 | — |
| Sex (n)                  | 100              | 59                                     | 29       | 12      | 0.8089 |
| Females                  | 99               | 56                                     | 28       | 15      | 0.1676 |
| Race                     |                  |                                        |          |         |      |
| Black/African American   | 101              | 60                                     | 28       | 13      | 0.2585 |
| White                    | 77               | 45                                     | 21       | 11      | 0.1676 |
| Asian                    | 3                | 3                                      | 0        | 0       | 0.1401 |
| Other                    | 17               | 7                                      | 8        | 2       | 0.1401 |
| American Indian/Alaskan Native | 1       | 0                                      | 0        | 1       | 0.1401 |
| Ethnicity                |                  |                                        |          |         |      |
| Non-Hispanic/Latino      | 183              | 109                                    | 49       | 25      | 0.1401 |
| Hispanic/Latino          | 16               | 6                                      | 8        | 2       | 0.1401 |
interstate access, number of corrective procedures, number of rescheduled appointments, treatment type, race, ethnicity, age, sex, and VA decline from preoperative appointment on loss to follow-up. ORs for loss to follow-up were calculated for each group. Figure 2 is a plot of ORs and 95% confidence intervals (CIs) for loss to follow-up on the basis of tested patient demographic factors. Treatment type (tube shunt vs. trabeculectomy), sex, age, and race were not significant predictors of loss to follow-up. A full summary of the loss to follow-up OR data can be found in Table 4.

The logistic model revealed that patients living > 50 miles from the Kittner Eye Center had increased odds of loss to follow-up in comparison with those <25 miles away (OR, 3.47; 95% CI, 1.24-9.41; P < 0.05). Patients 25 to 50 miles from the Kittner Eye Center were not more likely to be lost to follow-up compared with those living <25 miles away (OR, 1.58; 95% CI, 0.59-4.11; P = 0.35). Straight-line distance from home to interstate access was associated with significantly increased odds of loss to follow-up when analyzed in a logistic model independent of straight-line distance from home to the Kittner Eye Center (OR, 1.57; 95% CI, 1.01-2.43; P < 0.05). When both distances were analyzed together, only straight-line distance from home to Kittner Eye Center was significant.

In addition, there was incidental evidence that individuals of Hispanic or Latino ethnicity had a marginally elevated, but not statistically significant, OR of being lost to follow-up (OR, 2.93; 95% CI, 0.92-8.72; P = 0.056). Individuals with a reported decrease in uncorrected VA of >2 lines on Snellen chart from their preoperative appointments and their last attended appointments were found to have increased odds of being lost to follow-up (OR, 2.46; 95% CI, 1.16-5.29; P < 0.05). There were no significant differences in the number of appointments scheduled between patients who had worsened VA compared with those who did not have VA decline (P > 0.05). In total, 22 patients underwent at least 1 corrective procedure, which was associated with significantly decreased odds of loss to follow-up (OR, 0.12; 95% CI, 0.065-0.64; P < 0.05). The number of rescheduled appointments did not have the same level of significance for decreasing odds of loss to follow-up (OR, 0.33; 95% CI, 0.069-0.90; P = 0.086).

Pearson χ2 analysis and 2-tailed independent samples Student t-tests were conducted on multiple outcome data between groups of patients living 0 to 25 miles from Kittner Eye Center and those living > 50 miles away. A χ2 test of independence revealed a significant association between distance from Kittner Eye Center and loss to follow-up (P = 0.016). There was no significant difference between the choice of initial surgical treatment (eg, tube or trabeculectomy) in the 3 distance groups from home address to Kittner Eye Center (P = 0.46). A 2-tailed test of proportions indicated no significant difference in proportion of patients undergoing trabeculectomy in each home to Kittner Eye Center distance group (P = 0.133). There was no significant difference in number of corrective procedures done between patients who underwent trabeculectomy versus tube shunt implantation (t140 = 0.96; MD = 0.06; 95% CI, 0.076-0.18; P = 0.34).

Six-months postoperatively, patients residing > 50 miles from Kittner Eye Center were more likely to be lost to follow than patients living ≤25 miles from the eye center (t140 = 2.86; P < 0.01; MD = 0.23; 95% CI, 0.12-0.242). Patients > 20 miles from an interstate access had significantly greater loss to follow-up than those <10 miles from access (t130 = 2.05; MD = 0.14; 95% CI, 0.14-0.26; P < 0.05). One-way analysis of variance with Tukey post hoc analysis revealed a significant difference of means of missed appointments between the 3 distance groups from home address to the Kittner Eye Center. Patients > 50 miles from Kittner had significantly more missed (canceled or no-showed and nonrescheduled) appointments than those 25 to 50 miles and those <25 miles away (P = 0.008). There was no significant difference in means of missed appointments between the 3 distance groups from home address to interstate access (P = 0.91). A comprehensive statistical summary of average missed appointments for both distance groups (first, home address to Kittner Eye Center and second, home address to interstate access) can be found in Table 5. Similarly, Figure 3 displays the percentages of patients in both distance groups who were retained (not lost to follow-up) between each postoperative follow-up visit over the 6-month period. Figure 4 displays the percentages of patients in both distance groups who attended scheduled appointments at each follow-up interval in the 6-month postoperative period. In comparison with Figure 3, this figure illustrates the general follow-up adherence patterns in the study population.

Insurance data were collected and analyzed to investigate the relationship of socioeconomic status (SES) on missed

### TABLE 2. Surgical Treatments Performed in Study Population Distance and Treatment Subgroups

| Procedure Type | n (%)                  |
|----------------|------------------------|
| Ahmed Glaucoma Valve (New World Medical Inc., Rancho Cucamonga, CA) | n = 83 |
| Patients <25 mi from Kittner Eye Center | 51 (61.4) |
| Patients 25-50 mi | 21 (25.3)  |
| Patients >50 mi | 11 (13.3)   |
| Baerveldt Implant (Abbott Medical Optics, Abbott Park, IL) | n = 70 |
| Patients <25 mi | 36 (51.4) |
| Patients 25-50 mi | 21 (30.0)  |
| Patients >50 mi | 13 (18.6)   |
| Trabeculectomy +/- Ex-PRESS Shunt (Optonol Ltd, Neve Ilan, Israel) | n = 46 |
| Patients <25 mi | 28 (60.9) |
| Patients 25-50 mi | 15 (32.6)  |
| Patients >50 mi from Kittner Eye Center | 3 (6.5) |

### TABLE 3. Follow-up and Visual Acuity Outcomes Across Treatment Groups

|                     | Lost to Follow-up (%) | Worsened Visual Acuity (%) |
|---------------------|-----------------------|----------------------------|
| Study population    | 20.1                  | 33.2                       |
| Patients <25 mi from Kittner Eye Center | 13.9                  | 31.3                       |
| Ahmed               | 50.0                  | 52.8                       |
| Baerveldt           | 18.8                  | 25.0                       |
| Trabeculectomy +/- Ex-PRESS | 31.2     | 22.2                       |
| Patients 25-50 mi from Kittner Eye Center | 24.6                  | 35.1                       |
| Ahmed               | 42.9                  | 20.0                       |
| Baerveldt           | 35.7                  | 45.0                       |
| Trabeculectomy +/- Ex-PRESS | 21.4     | 35.0                       |
| Patients >50 mi from Kittner Eye Center | 37.0                  | 37.0                       |
| Ahmed               | 60.0                  | 50.0                       |
| Baerveldt shunt     | 30.0                  | 30.0                       |
| Trabeculectomy +/- Ex-PRESS | 10.0     | 20.0                       |
FIGURE 2. Forest plot of odds ratios for loss to follow-up on the basis of patient characteristics with 95% confidence intervals. *P < 0.10; **P < 0.05.

appointments and loss to follow-up. At the time of surgery, 114 (57.3%) of the 199 patients were enrolled in Medicare plans, 32 (16.1%) North Carolina Medicaid, 38 (19.1%) private or state employee insurance plans, and 15 (7.5%) were uninsured. On average, patients covered by North Carolina Medicaid had significantly more missed appointments than those with Medicare (t(144) = -2.1931; P < 0.05; M = 1.03; MD = 0.35; 95% CI, 0.57-0.87). Patients enrolled in Medicaid also had significantly higher rates of loss to follow-up compared with those with Medicare plans (t(144) = -2.444; P < 0.05; M = 0.38; MD = 0.20; 95% CI, −0.361 to −0.038). Patients with Medicaid were, on average, 12.41 miles farther from the Kittner Eye Center than patients with Medicare plans (P < 0.05; 95% CI, 1.084-23.740). No significant differences in missed appointments, loss to follow-up, or VA outcomes were found between privately insured patients and those with Medicare or Medicaid (P > 0.05).

Patients lost to follow-up were a mean distance of 35.89 miles from Kittner Eye Center, which was significantly higher than those not lost to follow-up (t(197) = 3.29; P < 0.01; M = 25.83; MD = 12.59; 95% CI, 22.8-28.9).

TABLE 4. Multivariate Logistic Regression Analysis of Factors for Loss to Follow-up in Postoperative Glaucoma Patients (n = 199) at a Tertiary Referral Academic Hospital

| Factors                        | Lower | Upper  | OR    | P     |
|--------------------------------|-------|--------|-------|-------|
| Rescheduled appointments       | 0.669 | 0.9    | 0.33  | 0.086*|
| (range, 0-5)                   |       |        |       |       |
| > 50 mi from Kittner           | 1.24  | 4.12   | 3.47  | 0.013**|
| (vs. <25 mi from Kittner)      |       |        |       |       |
| Hispanic/Latino (yes vs. no)   | 0.92  | 8.72   | 2.93  | 0.056*|
| Race                           | 0.71  | 2.70   | 1.37  | 0.35  |
| Corrective procedures          | 0.0065| 0.64   | 0.12  | 0.049**|
| (range, 0-3)                   |       |        |       |       |
| Female sex (yes vs. no)        | 0.29  | 1.34   | 0.626 | 0.23  |
| Worsened visual acuity ≥ 2 lines | 1.16  | 5.29   | 2.46  | 0.0193**|
| (yes vs. no)                   |       |        |       |       |
| Age                            | 0.97  | 1.02   | 0.99  | 0.76  |
| Tube shunt (vs. trabeculectomy) | 0.34  | 2.45   | 0.91  | 0.86  |

OR indicates odds ratios.
*Significance at the 0.1 level.
**Significance at the 0.05 level.

DISCUSSION

This study revealed that a significant proportion of patients located over 50 miles away from our clinic and patients located >20 miles from interstate access were lost to follow-up and had a significantly higher number of missed postoperative appointments. Lower SES (as estimated by Medicaid coverage) was also associated with increased missed appointments in the 6-month postoperative period, and higher rates of loss to follow-up and increased travel distance to clinic. Patients of all distances were equally likely to undergo trabeculectomy or tube shunt placement, and those with corrective procedures were more likely to adhere to the follow-up schedule. In addition, patients who had a decline in VA of ≥2 lines from their preoperative visit had higher odds of being lost to follow-up within the 6-month postoperative period. Because of variable trends in VA after glaucoma surgery, a study examining long-term follow-up is needed to identify the association between functional VA loss and missed appointments.10-12

Analyzing the number of attended rescheduled appointments allowed us to quantify a patient’s likelihood to follow the 6-month postoperative follow-up course commonly seen in preferred practice guidelines, clinic practices, and related studies on surgical glaucoma management.28,11,13 Many patients in this study were instructed to return to care approximately 5 times within the 6-month follow-up period per physicians’ office visit notes. Because of this, there were no significant differences in the number of appointments anticipated to be scheduled for each patient, and missed appointments were the primary dependent variable for each subgroup of patients.

Over 40% of our study population was located >25 miles from the Kittner Eye Center in Chapel Hill, North Carolina suggesting that a large, rural population beyond the Raleigh-Durham metropolitan area is served. Straight-line distance allowed us to reduce potential confounding variables relating to traffic patterns, road closures, individual access to public transport service routes, and patients’ choices for routes to clinic. The
The use of straight-line distance from patients’ addresses to health care services to estimate health outcomes and follow-up data has been validated in multiple meta-analyses, epidemiological, and clinical studies.14–17 Follow-up retention is integral to the long-term goals of glaucoma care, but the data suggest that distance is a barrier for patients. Our study supports the findings of prior interdisciplinary follow-up outcome literature, namely that distance is a significant predictor for loss to follow-up and increased appointment cancellations.8,9,18–24 Our findings expand upon previous literature by suggesting long-term follow-up retention in a 6-month postoperative period is affected by distance to clinic, distance to interstate access, functional VA loss, and SES.

The small sample of patients living > 50 miles from the Kittner Eye Center limits the ability to generalize the statistical results of follow-up outcomes to all patients commuting long distances. Specifically, when distance from interstate access and distance from the Kittner Eye Center were analyzed together in the logistical model, the distance to Kittner Eye Center was a greater predictor of loss to follow-up. This is likely because of the broader range of distances represented in the sample of patients in the “> 50 miles to Kittner Eye Center” distance group (50.5 to 114 miles) compared with the “> 20 miles to interstate access” distance group (20.5 to 34 miles). This result suggests that, while rurality is a predictor of follow-up adherence, straight-line distance to clinic has greater statistical influence. A larger

### TABLE 5. ANOVA Multiple Comparisons of Means of Missed (Canceled or No-Showed, and Nonrescheduled) Appointments Between Distance Groups

| Kittner Distance Group (Mean Missed Appointments) (mi) | Kittner Distance Group Compared (mi) | Mean Difference | SE  | P    | 95% Confidence Interval |
|--------------------------------------------------------|-------------------------------------|----------------|-----|------|------------------------|
| 0-25 (1.17)                                            | 25-50                               | −0.195         | 0.251| 0.719| −0.79 - 0.4            |
| > 50                                                   | 25-50                               | −1.048*        | 0.331| 0.005| −1.83 - −0.27         |
| 25-50 (1.36)                                           | > 50                                | −0.854         | 0.362| 0.05 | −1.71 - 0             |
| > 50                                                   | 0-25                                | 1.048*         | 0.331| 0.005| 0.27 - 1.83           |
| > 50                                                   | 25-50                               | 0.854          | 0.362| 0.05 | 0 - 1.71              |
| Interstate Distance Group (Mean Missed Appointments) (mi) | Interstate Distance Group Compared (mi) | Mean Difference | SE  | P    | 95% Confidence Interval |
| < 10 (1.39)                                            | 10-20                               | −0.01          | 0.277| 0.999| −0.66 - 0.64          |
| 10-20 (1.40)                                           | > 20                                | 0.115          | 0.286| 0.914| −0.56 - 0.79          |
| > 20                                                   | < 10                                | 0.01           | 0.277| 0.999| −0.64 - 0.66          |
| > 20                                                   | > 20                                | 0.125          | 0.335| 0.926| −0.67 - 0.92          |

*The mean difference is significant at the 0.05 level.
ANOVA indicates analysis of variance.

FIGURE 3. Percent of follow-up retention as a factor of distance traveled to Kittner Eye Center and distance to interstate access.
sample of rural patients > 20 miles from interstate access and patients > 50 miles from clinic could help ameliorate this statistical disparity.

Patients’ insurance coverage was noted and analyzed for follow-up adherence outcomes as a metric for retrospectively evaluating SES. We found significant relationships suggesting that patients with financial need-based North Carolina Medicaid coverage were, on average, more likely to be lost to follow-up, and had more missed appointments within the 6-month follow-up period. This is likely a multifaceted issue wherein patients with Medicaid may have to commute a greater distance to access an in-network glaucoma surgeon and may face greater follow-up limitations because of the financial burden of travel. Other possible contributing factors to follow-up nonadherence include barriers such as the inability for patients or caregivers to take time off from work or afford transportation costs and insurance expenses. These systemic predictors of health outcomes are difficult to assuage in a single clinic setting. Conditions such as uncorrectable low vision, dementia, fatigue, and systemic comorbidities significantly impacting patients’ health may also prohibit follow-up adherence, and these barriers should be considered by clinicians considering surgical interventions. In a study in rural China, simple interventions such as text reminders and distribution of free postoperative drops were sufficient to increase postoperative surgical follow-up, indicating either proactive provider-patient interaction and incentivization as effective means to remedy postoperative visit compliance.

Bhargava et al26 examined patients’ views on glaucoma surgery follow-up care and found that they prefer to travel short distances and to be seen by a physician (as opposed to an advanced practice provider). The current body of ophthalmological distance to follow-up literature has examined the attrition rates and clinical characteristics of patients who are lost to follow-up in ophthalmology clinics in developing nations.19–24 Ashaye and colleagues retrospectively examined the specific characteristics of follow-up attrition in a Nigerian glaucoma clinic. They found that male sex, traveling distance, ophthalmic polypharmacy, patients with mild to moderate glaucoma, and those without a significant family history of vision loss were more likely to be lost to follow-up.25 In India, Gupta et al24 found that awareness of glaucoma disease progression, close proximity, and higher monthly income were associated with higher follow-up compliance. They also found that 88% of patients who dropped out incorrectly believed that surgery was curative for glaucoma.

Similar studies examined postoperative complications following cataract procedures in pediatric and adult populations in Mexico, sub-Saharan Africa, India, and South Asia. These have suggested that traveling distance is positively correlated with follow-up attrition.29–24 Prior research has provided an epidemiological framework for this follow-up data study, but the cultural and resource variations between populations warrant a more generalizable sample for glaucoma specialists in the United States. There is a scarcity of United States-based follow-up studies in ophthalmology. In 2005, Lara and colleagues similarly responded to the shortage of published data on factors contributing to patient follow-up adherence in regard to the American Society of Bariatric Surgery’s postoperative follow-up recommendations. They found that travel distance did not affect follow-up attendance at early postoperative appointments; however, they found that 3-month and 9-month postoperative appointment attendance was negatively affected.27 Glaucoma and bariatric surgery both require long-term postoperative monitoring for outcomes and complications. Postoperative follow-up appointment retention studies can help quantify the importance of the follow-up schedule, to what extent access to care affects long-term outcomes, and identify future areas for intervention.

Because of the frequency of required surgical follow-up visits and magnitude of sight-threatening complications that may occur, the surgeon must consider the risks and benefits of surgical treatments for each individual patient. This complexity in surgical glaucoma care warrants further investigation into patient-specific factors that may help the surgeon decide on optimal management. We would suggest that these risks and benefits be weighed against the likelihood of patients maintaining follow-up visits and that the distance a patient must travel to maintain this care is an important factor that should be considered.
Although this retrospective study decreases the potential for observer bias (Hawthorne effect) and examines recent outcomes of a large academic ophthalmology practice, there exist inherent limitations because of the design. Inclusion criteria regarding diagnoses, procedures, and strict home address requirement helped to reduce confounding variables related to treatment plans, and managed medical care. Institutionalized patients (eg, those residing at skilled nursing facilities, assisted living communities, prisons, and psychiatric hospitals) may have greater adherence to follow-up appointments because they have hired professionals to arrange appointment scheduling and transportation. Another limitation of the study was because of bias. One of the treating surgeons suspected the influence of travel distance to follow-up care and therefore tended to choose tube shunt surgery for patients who were located far from the treatment center.

In addition, although there is extensive documentation between provider networks in the electronic health records, it is possible that patients returned to referring providers or initiated care with a different practice. This could potentially result in the inclusion of patients who were analyzed as being lost to follow-up but were still receiving care. The effects of this possibility were moderated statistically through a multivariate logistic regression that would have pushed means toward the null hypothesis, which was rejected. Monitoring uncorrected VA is another limitation of the study. Best-corrected VA may be a more globally representative parameter to measure the evolution of functional ability. Patient presentations for glaucoma surgery may vary from longstanding uncontrolled IOP with gradual VA decline to those with acutely elevated IOP with vision loss independent of the follow-up course.

This study suggests that patients living >50 miles away from follow-up care have increased follow-up cancellation or no-show rates. We speculate that the association between successful follow-up and postoperative outcomes is even more important in the setting of surgical techniques that require close monitoring and more frequent intervention such as trabeculectomy, which should be specifically examined in future investigations. Patients living >50 miles from follow-up care at the treatment center or >20 miles from interstate access were more likely to be lost to follow-up. This finding has important implications for rural populations being treated for glaucoma. In contrast, many patients in the study commuted 20 to 40 miles from other metropolitan areas while having closer access to the interstate, and these populations demonstrated superior follow-up retention. This suggests that patients commuting from rural areas, where there is a paucity of medical care and public transportation, and higher rates of poverty are particularly vulnerable to complications and attrition during the postoperative follow-up period. Patients who underwent corrective procedures within 90 days of the original surgical intervention demonstrated a significantly decreased likelihood of being lost to follow-up. A prospective investigation would enable researchers to contact lost to follow-up patients and their referring providers to identify specific barriers to care and to better understand treatment courses, disease progression, and other reasons for not returning to the Kittner Eye Center.

The results of this study suggest glaucoma specialists should make note of patients’ proximity to follow-up care when deciding a surgical treatment intervention. Further studies can explore specific factors contributing to follow-up attrition, follow-up scheduling guidelines, and potential telemedicine or educational strategies to improve postoperative follow-up retention.

REFERENCES

1. Weinreb RN, Aung T, Medeiros FA. The pathophysiology and treatment of glaucoma: a review. *JAMA*. 2014;311:1901–1911.
2. Prum BE, Rosenberg LF, Gedde SJ, et al. Primary open-angle glaucoma preferred practice pattern (®) guidelines. *Ophthalmology*. 2016;123:P41–P111.
3. Shigeta T, Tomidokoro A, Arai M, et al. Long-term follow-up of visual field progression after trabeculectomy in progressive normal-tension glaucoma. *Ophthalmology*. 2002;109:766–770.
4. Vajaranant TS, Wu S, Torres M, et al. The changing face of primary open-angle glaucoma in the United States: demographic and geographic changes from 2011 to 2050. *Am J Ophthalmol*. 2012;154:303–314; e303.
5. Quaranta L, Riva I, Gerardi C, et al. Quality of life in glaucoma: a review of the literature. *Adv Ther*. 2016;33:99–108.
6. Gedde SJ, Feuer WJ, Shi W, et al. Treatment outcomes in the primary tube versus trabeculectomy study after 1 year of follow-up. *Ophthalmology*. 2018;125:650–663.
7. Saheb H, Gedde SJ, Schiffman JC, et al. Tube Versus Trabeculectomy Study G. Outcomes of glaucoma reoperations in the Tube Versus Trabeculectomy (TVT) Study. *Am J Ophthalmol*. 2014;157:1179–1189; e1172.
8. Murdoch I. Postoperative management of trabeculectomy in the first three months. *Community Eye Health*. 2012;25:73–75.
9. Vijaya L, Manish P, Ronnie G, et al. Management of complications in glaucoma surgery. *Indian J Ophthalmol*. 2011;59(suppl):S131–S140.
10. Alusabali T, Alghamdi AA, Khandekar R. Outcomes of Ahmed valve surgery for refractory glaucoma in Riyadh, Saudi Arabia. *Int J Ophthalmol*. 2015;8:560–564.
11. Kyari F, Abdull MM. The basics of good postoperative care after glaucoma surgery. *Community Eye Health*. 2016;29:29–31.
12. Hirooka K, Nitta E, Ukegawa K, et al. Vision-related quality of life following glaucoma filtration surgery. *BMC Ophthalmol*. 2017;17:66.
13. Tseng VL, Coleman AL, Chang MY, et al. Aqueous shunts for glaucoma. *Cochrane Database Syst Rev*. 2017;7:CD004918.
14. Bliss RL, Katz JN, Wright EA, et al. Estimating proximity to care: are straight line and zipcode centroid distances acceptable proxy measures? *Med Care*. 2012;50:99–106.
15. Kelly C, Hulme C, Farragher T, et al. Are differences in travel time or distance to healthcare for adults in global north countries associated with an impact on health outcomes? A systematic review. *BMJ Open*. 2016;6:e013059.
16. Siedner MJ, Lankowski A, Tsiac AC, et al. GPS-measured distance to clinic, but not self-reported transportation factors, are associated with missed HIV clinic visits in rural Uganda. *AIDS*. 2013;27:1503–1508.
17. Smith AB, Meyer AM, Meng K, et al. The relationship of travel distance with cystectomy access and outcomes. *Urol Oncol*. 2018;36:308.e1–308.e9.
18. Arora KS, Robin AL, Corcoran KJ, et al. Use of various glaucoma surgeries and procedures in medicare beneficiaries from 1994 to 2012. *Ophthalmology*. 2015;122:1615–1624.
19. Kim YK, Jeoung JW, Park KH. Understanding the reasons for loss to follow-up in patients with glaucoma at a tertiary referral teaching hospital in Korea. *Br J Ophthalmol*. 2017;101:1059–1065.
20. Fudemberg SJ, Lee B, Waisbourd M, et al. Factors contributing to nonadherence to follow-up appointments in a resident glaucoma clinic versus primary eye care clinic. *Patient Prefer Adherence*. 2016;10:19–25.
21. Gedde SJ, Schiffman JC, Feuer WJ, et al. Treatment outcomes in the tube versus trabeculectomy (TVT) study after five years of follow-up. *Am J Ophthalmol*. 2012;153:789–803; e872.
22. Angermann R, Rauchegger T, Nowosieki Y, et al. Treatment compliance and adherence among patients with diabetic retinopathy and age-related macular degeneration treated by anti-vascular
endothelial growth factor under universal health coverage. Graefes Arch Clin Exp Ophthalmol. 2019;257:2119–2125.

23. Ashaye AO, Adeoye AO. Characteristics of patients who dropout from a glaucoma clinic. J Glaucoma. 2008;17:227–232.

24. Gupta V, Chandra A, Yogi R, et al. Prevalence and causes of patient dropout after glaucoma surgery. Ophthalmic Epidemiol. 2013;20:40–44.

25. Yang K, Jin L, Li L, et al. Interventions to promote follow-up after trabeculectomy surgery in rural southern China: a randomized clinical trial. JAMA Ophthalmol. 2016;134:1135–1141.

26. Bhargava JS, Bhan-Bhargava A, Foss AJ, et al. Views of glaucoma patients on provision of follow-up care; an assessment of patient preferences by conjoint analysis. Br J Ophthalmol. 2008;92:1601–1605.

27. Lara MD, Baker MT, Larson CJ, et al. Travel distance, age, and sex as factors in follow-up visit compliance in the post-gastric bypass population. Surg Obes Relat Dis. 2005;1:17–21.

28. NC Institute of Medicine. North Carolina county health profiles. Available at: http://nciom.org/map/. Accessed June 9, 2020.