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Comprehensive Analysis to Uncover Determinants of Patient Appointment Compliance in Ophthalmology at the Kresge Eye Institute

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INTRODUCTION

- The patient-physician relationship is an essential component of effective healthcare.¹
- Several studies have researched the importance of appointment compliance (AC) in addressing health care interventions and reducing mortality risk. One study found AC to be 58% and highlighted effective strategies such as mailed or telephoned reminders in bettering patient arrival¹. Another research paper compared appointment non-adherence in AA with severe, uncontrolled hypertension².
- Our retrospective study, which is focused on patients who sought care at Kresge Eye Institute (KEI) in Detroit, Michigan, is aimed to elaborate on factors impacting AC and continuity of care. The Detroit metropolitan area has a diverse population, with a wide range of demographics, and stratified income brackets.⁴ This provided the necessary framework needed to properly assess patient appointment compliance.
- The demographic data utilized in this study included: KEI clinic locations and providers, physician specialty, the chronological rank of appointments within a patient's appointment history, age, race, insurance, zip code, appointment month, and gender.
- This data provided by KEI offers insight into the factors contributing to appointment compliance and continuity of care.

References

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- African-Americans with Severe, Poorly Controlled Hypertension. PLoS ONE, 9(8). doi: 10.1371/journal.pone.0103090 4. Miller, A.J., et al., *Predictors of repeated "no-showing" to clinic appointments*. Am J Otolaryngol, 2015. **36**(3): p. 411-4.

METHODS

- The Institutional Review Board of Wayne State University approved the study protocol (IRB-20-04-2048)
- Retrospective analysis was performed across all appointments scheduled from 01/2014-12/31/2018 at any of KEI's 24 out-patient Michigan location.
- Patient arrival to appointment, denoted as compliant (CO), and cancellation/no-show to appointment, classified as non-compliant (NC), across KEI clinic sites
- Chi-square test was performed to compare categorical and binary characteristics between CO and NC groups for patient gender, race, and insurance type, scheduling location, appointment month, provider, and physician specialty.
- Mann-Whitney U test assessed relative distribution of continuous characteristics (including patient age and appointment rank) across CO and NC appointments.
- The appointment rank variable was used as an indicator of the patient's relationship length with KEI at each appointment relative to all the appointments in a patient's appointment history.
- Logistic regression, in regards to AC, was performed to control for covariates • Receiver operating characteristic (ROC) curves with area under curve (AUC) values and Hosmer-
- Lemeshow goodness of fit tests were generated from logistic regression analyses to demonstrate the predictive accuracy and fit of our model.
- A geographical map of the entire population of appointments scheduled at KEI was generated using Microsoft® Excel Version 15.11.2, showing relative frequency of appointments according to each associated patient's residential zip code.

Figure 1. Procedure for Sample S

	Total Number of Appointments (N= 836,384)	
alaction		
election	Number of Appointments, including no-shows, cancellations, and arrivals (N= 829,034)	
	Number of Appointments including, testing, pediatric, and	
	spontaneous appointments (N= 630,188)	
	Number of Appointments Included in Analysis (N= 597,364)	

Comprehensive Analysis to Uncover Determinants of Patient Appointment Compliance in Ophthalmology at the Kresge Eye Institute

 Excluded (N= 7,350) Zip codes other than 48XXX and 49XXX
Excluded (N= 198,846) appointment cancellations

Excluded testing (N= 12,804), pediatric (N= 9,442), and spontaneous (N= 10,578) appointments

		F	RES	ULTS				
Table 1. Distribution of Demographic,Administrative, and AppointmentCharacteristics among compliant and non-				Table 2. Summary of ContinuousAppointment Characteristics				
	appointments	-	JII-					
	Non-compliant	Compliant	p-value			Mean	Range	Med (IQR)
	n= 124,504 (20.84%)	n= 472,860 (79.16%)			СО	59.61	0.002-116	62.97 (50.54-
Demographic Characteristics				Age	co	55.01	0.002-110	
Female sex, No. (%)	73,650 (59.23 %)	283,316 (59.92%)	<0.0001	(years)				72.86)
Race (distribution of 5 categori	es with highest frequency)		<0.0001		NC	51.88	0.008-118	54.87 (40.91-
African American/Black	91,335 (73.36%)	273,168 (57.77%)						65.20)
Asian	1,725 (1.39%)	9,098 (1.92%)			All	58.01	0.002- 118	61.36 (48.09- 71.52)
Caucasian/White	12,612 (18.13%)	151,108 (31.96%)						
Hispanic or Latino	2,408 (1.93%)	8,951 (1.90%)						71.527
Middle Eastern	3,697 (2.97%)	14,489 (3.06%)						
Age, Mean (IQR)	51.88 (40.91-65.20)	59.61 (50.54-72.86)	<0.00001	Appt Rank	CO	10.10	1-175	6 (2-13)
Ophthalmic specialty (distribut	ion of 5 categories with highest frequ	ency)	<0.0001		NC	7.58	1-143	4 (2-9)
Comprehensive	24,781 (19.90%)	104,399 (22.08%)			All	9.58	1-175	5 (2-12)
Retina	16,208 (13.02%)	112,797 (23.84%)						- (/
Resident or Fellow	30,169 (24.23%)	79,533 (16.82%)						
Glaucoma	18,040 (14.49%)	76,563 (16.19%)		Percent	CO	70.37%	4.17-100%	71.43% (25.00- 83.33%)
Cornea	9,596 (7.71%)	32,498 (6.87%)		Compliance				
Administrative Characteristics				(%)	NC	27 909/	0-95.83%	40.00% (17.65
Appointment Location (distribu	ition of 3 categories with highest freq	uency)	<0.0001	(***	NC	37.80%	0-95.83%	40.00% (17.65-
KEI General	44,898 (36.06%)	167,810 (35.49%)						57.14%)
Residents	33,005 (26.51%)	84,524 (17.88%)			All	63.58%	0-100%	66.67% (50.00- 80.00%)
KEI Southfield	6,594 (5.30%)	40,909 (8.65%)						
Appointment Month (distributi	on of 3 categories with highest freque		<0.0001					
March	11,105 (8.92 %)	42,631 (9.02%)						-1
June	10,997 (8.83%)	41,176 (8.71%)		Total Number	CO	19.53	1-175	14 (6-26)
April	10,457 (8.40 %)	40,623 (8.59 %)		of	NC	12.73	1-175	7 (3-17)
Scheduling Provider		<0.0001	Appointments					
Primary Insurance Types (distribution of 3 categories with highest frequency)			<0.0001	<pre><0.0001 per Patient's</pre>	All	18.12	1-175	12 (5-24)
Medicare Associated	38,185 (31.14%)	209,484 (44.41%)		Entire History				
Molina Associated	15,038 (12.26%)	33,033 (7.00%)						
Blue Cross Blue Shield Associat	ed 11,742 (9.57%)	67,811 (14.38%)						
Appointment Characteristics								
appt rank number, Mean (IQR)	7.58 (2-9)	10.10 (2-13)	<0.00001			0	•	

Figure 2. Frequency of Appointments per Ophthalmic Specialty. The total n= 597,364 appointments was categorized across the indicated ophthalmic

subspecialties seen at the KEI clinic.

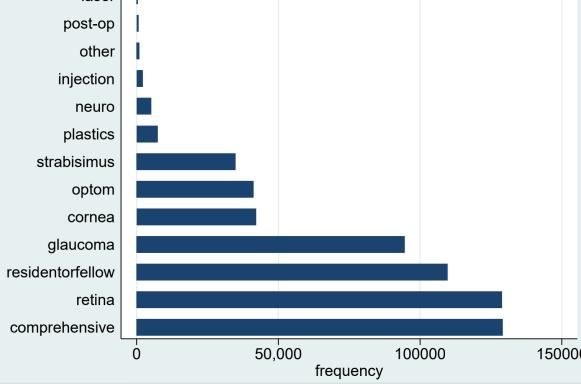




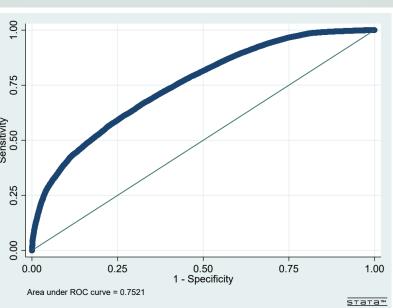
Figure 4. Appointment frequency across each zip code.

he total n = 829,034 appointments were mapped across each Michigan based zip code using Microsoft Excel (see Methods section). The enlarged area represents metro Detroit. Four observations in our analysis were Michigan based, but had an unspecified zip code listed in the EMR at that particular appointment.

Color	Range	No. Appointments	%	No zip codes.	Mean
Red	10,001+	407,723	0.492	22	18,532.86
Orange	5,001 to 10,000	146,870	0.177	21	6,993.81
Yellow	2.501 to 5.000	132 874	0 160	40	3 321 85

Ι.	Color	Range	No. Appointments	%	No zip codes.	Mean
	Red	10,001+	407,723	0.492	22	18,532.86
	Orange	5,001 to 10,000	146,870	0.177	21	6,993.81
	Yellow	2,501 to 5,000	132,874	0.160	40	3,321.85
	Green	501 to 2,500	114,448	0.138	81	1,412.94
	Blue	101 to 500	18,418	0.022	75	245.57
	Purple	1 to 100	8,697	0.010	397	21.91
	total		829,030	100%	636	

Figure 5. Receiver operating characteristic curve and associated **AUC for logistic** regressions (Table 3) across all appointments.



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Figure 3. Frequency of Appointments per racial category.

The total n = 597,364 appointments was categorized across the indicated racial categories seen at the KEI.

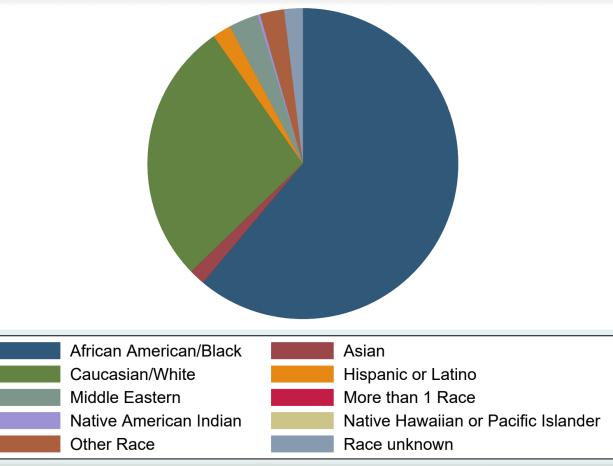


Table 3. Comprehensive multiple logistic regression across initial appointments.

*Appointment compliance is the outcome (dependent) variable and race, age, sex, specialty, appointment location, month, and appointment rank are the predictors. Also, please note that 75 insurance categories have been omitted for table length, but can be found in the supplementary materials.

Predictor*	Odds ratio	P-value	95% CI			
Patient Race						
African American		reference category				
Race Unknown	0.10	<0.0001	0.09-0.12			
Asian	1.89	<0.0001	1.54-2.33			
Caucasian/White	2.82	<0.0001	2.59-3.07			
Hispanic/Latino	1.58	<0.0001	1.44-1.73			
Middle Eastern	1.65	<0.0001	1.48-1.84			
More than 1 race	2.34	< 0.0001	1.74-3.15			
Native American Indian	1.55	0.066	0.97-2.46			
Native Hawaiian or Pacific Islander	2.82	0.162	0.66-12.08			
Other Race	0.68	< 0.0001	0.60-0.77			
Specialty						
Comprehensive		referenc	e category			
Cornea	0.93	0.050	0.87-1.00			
Resident or Fellow	1.03	0.735	0.89-1.19			
Glaucoma	0.93	0.037	0.87-1.00			
	5.94	0.088				
Injection	5.94		0.77-46.03 bservation			
Laser	1.00	,				
Neuro	1.83	<0.0001	1.51-2.22			
Optometry	0.47	<0.0001	0.35-0.65			
Other	0.50	0.276	0.14-1.75			
Plastics	0.83	0.141	0.66-1.06			
Post-op			bservation			
Strabismus	0.91	0.059	0.83-1.00			
Retina	1.04	0.49	0.94-1.15			
Appointment Location						
KEI General	Detroit clinic loco	ation as reference catego	pry			
Bingham Farms	2.03	<0.0001	1.80-2.29			
Clinton Township	7.41	< 0.0001	3.48-15.81			
Dearborn	2.71	<0.0001	2.13-3.46			
Hutzel Warren	3.00	< 0.0001	2.41-3.74			
KEI Dearborn Oakwood	0.92	0.064	0.84-1.00			
KEI Dearborn Optometry	1.72	< 0.0001	1.24-2.38			
KEI Adult Muscle	0.80	0.022	0.66-0.97			
KEI Sinai Grace	1.88	<0.0001	1.33-2.67			
KEI Sinai Grace Ophthalmology	0.77	<0.0001	0.69-0.87			
KEI Well Eye Care	1.13	0.434	0.83-1.55			
Lake Orion	5.78	<0.0001	4.52-7.40			
Novi	7.43	<0.0001	3.57-15.49			
OR Boarding	163.32	<0.0001	23.33-1143.21			
Port Huron	1.86	<0.0001	1.44-2.40			
Residents	1.15	0.095	0.98-1.34			
Southfield	1.98	<0.0001	1.80-2.18			
Taylor	1.56	<0.0001	1.29-1.89			
Troy	2.27	<0.0001	1.84-2.81			
KEI Well Eye Clinic	2.01	<0.0001	1.41-2.86			
Ypsilanti	6.51	<0.0001	4.04-10.48			
Appointment Month						
January month as reference category						
February	1.14	<0.0001	1.07-1.21			
March	1.31		1.21-1.42			
April	1.37		1.29-1.48			
May	1.35		1.27-1.44			
June	1.26		1.18-1.35			
July	1.31		1.21-1.43			
August	1.40		1.30-1.51			
September	1.26		1.16-1.36			
October	1.32		1.23-1.42			
November	1.30		1.20-1.41			
December	1.29		1.19-1.39			
December			1.17-1.37			
Number of Observations	Model Char		6.452			
Number of Observations			6,152			
Prob> chi			00001			
Pseudo R2		0.1610				
Area under ROC curve		0.75				

CUMALATIVE CHARACTERISTICS:

- Percent compliance was calculated according to each patient's entire appointment history and the mean was found to be 70.37% (Table 2).
- There were more than 13 ophthalmic specialties represented as is summarized in **Figure** 2 with the corresponding frequencies.
- The mean patient age across all appointments was 58.01 years (SD: 20.07 years) with a range of <1 year to 118 years (IQR: 48.09-71.52 years) (**Table 2**).
- While more than ten racial categories were represented, 61.02% of appointments at KEI were for African American patients. The frequency of racial demographics is highlighted in **Figure** 3
- patients.
- of appointments per patient zip code (Figure 4).

DEMOGRAPHIC CHARACTERISTICS:

- appointments, which are summarized in Table 1.
- to NC appointments (Table 1 and 2).
- analyzed (p<0.0001; **Table 1**)

CLINIC AND ADMINISTRATIVE CHARACTERISTICS:

- differed concerning AC (p<0.0001; **Table 1**).
- (p<0.00001; Table 1) than NC appointments.

REGRESSION ANALYSIS:

- categories were determined based on the greatest frequency.
- in **Figure 5**.
- AUC to be equal to 0.75 (Table 3 and Figure 5).
- (OR: 2.82; 95% CI:2.59-3.07; p<0.0001).

- appointment month, and physician specialty.

- for the assessment of patient care and overall satisfaction.

Cumulatively, 79.16% (472,860) of all appointments (Table 1) were compliant.

For sex distribution, the majority (59.77%; 356,966) of appointments were those of female

The patient zip code associated with each appointment was used to determine the distribution

Patient demographic and clinical characteristics are described relative to AC across all

Patient gender had significant differences between CO and NC groups (p<0.0001) with female patients representing a significantly greater portion of all compliant appointments. CO appointments were associated with significantly (p<0.00001) older patients as compared

AC was found to have a significantly different distribution across the 10 racial categories

The distribution of the 24 associated clinic locations and appointment month significantly

Also, the distribution of primary insurance types across more than 200 possible insurance types and ophthalmic specialty differed significantly with respect to AC (p<0.0001). • CO appointments were associated with a significantly higher appointment rank

Multiple logistic regression analysis was performed to control for covariates and build a model which the greatest predictive accuracy possible from the data available.

Our model features the categorical contribution of each racial group, ophthalmic specialty, clinic location, primary insurance type, and appointment month relative to AC. Reference

The results of the model are found in **Table 3** with an associated ROC curve and AUC

Multiple logistic regression revealed age, male sex, appointment rank, appointment month, race, specialty, and clinic location to be significantly associated with AC with the

Across all racial categories reported relative to African Americans, appointments associated with patient's whose race was unknown had the lowest odds of compliance (OR: 0.10; 95%) CI: 0.09-0.12; p<0.0001) and appointments of Caucasians had the highest odds of compliance

CONCLUSIONS

• This investigation found the distribution of AC, defined by the CO and NC groups, to be significantly different across patient gender, race, age at appointment, clinic location, and

• In future analyses, additional metrics, such as driving distance, access to transportation, and patient satisfaction, could increase the predictive accuracy of our model.

• A follow-up study can be performed to overcome this limitation and analyze subsets and more patient-specific characteristics (employment status, education,

household income, history of mental illness, non-ophthalmological comorbidities and primary method of transportation) that could, perhaps, contribute to non-compliance.

• Hence, the comprehensive dataset reveals potential factors that affect AC and can be used to improve the quality of patient care. This study has applicability to other institutions, allowing