Appointment "no-shows" are an independent predictor of subsequent quality of care and resource utilization outcomes

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BACKGROUND: Identifying individuals at high risk for suboptimal outcomes is an important goal of healthcare delivery systems. Appointment no-shows may be an important risk predictor.

OBJECTIVES: To test the hypothesis that patients with a high propensity to "no-show" for appointments will have worse clinical and acute care utilization outcomes compared to patients with a lower propensity.

DESIGN: We calculated the no-show propensity factor (NSPF) for patients of a large academic primary care network using 5 years of outpatient appointment data. NSPF corrects for patients with fewer appointments to avoid over-weighting of no-show visits in such patients. We divided patients into three NSPF risk groups and evaluated the association between NSPF and clinical and acute care utilization outcomes after adjusting for baseline patient characteristics.

PARTICIPANTS: A total of 140,947 patients who visited a network practice from January 1, 2007, through December 31, 2009, and were either connected to a primary care physician or to a primary care practice, based on a previously validated algorithm.

MAIN MEASURES: Outcomes of interest were incomplete colorectal, cervical, and breast cancer screening, and above-goal hemoglobin A1c (HbA1c) and low-density lipoprotein (LDL) levels at 1-year follow-up, and hospitalizations and emergency department visits in the subsequent 3 years.

KEY RESULTS: Compared to patients in the low NSPF group, patients in the high NSPF group (n=14,081) were significantly more likely to have incomplete preventive cancer screening (aOR 2.41 [2.19–.66] for colorectal, aOR 1.85 [1.65–.08] for cervical, aOR 2.93 [2.62–3.28] for breast cancer), above-goal chronic disease control measures (aOR 2.64 [2.22–3.14] for HbA1c, aOR 1.39 [1.15–1.67] for LDL], and increased rates of acute care utilization (aRR 1.37 [1.31–1.44] for hospitalization, aRR 1.39 [1.35–1.43] for emergency department visits).

CONCLUSIONS: NSPF is an independent predictor of suboptimal primary care outcomes and acute care utilization. NSPF may play an important role in helping healthcare systems identify high-risk patients.

KEY WORDS: No-show; Identification of high-risk patients; Health disparities; Psychosocial issues in healthcare.

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INTRODUCTION

Achieving performance targets and reducing acute care utilization for patients is an increasingly important goal for healthcare delivery systems. Identifying individuals at risk for suboptimal care and high resource utilization represents the first step in designing interventions to improve outcomes. Patients who often miss or "no-show" for their outpatient appointments may represent one easily identifiable high-risk group.

Prior work has demonstrated an association between no-shows to appointments and poor clinical outcomes in specific subgroups (e.g., patients with diabetes,[1,2] and patients with HIV infections).[3–6] However, limited data are available on the prospective outcomes of patients with frequent no-shows among large primary care populations. We investigated the hypothesis that primary care patients that have a high propensity to no-show will have suboptimal clinical outcomes and higher rates of acute care utilization compared to those with a lower propensity to no-show.

METHODS

Study setting and population

We analyzed the relationship between patient propensity for no-show and subsequent clinical and acute care utilization outcomes in a large academic primary care network that encompasses 15 primary care practices, including 4 community health centers. We identified 140,947 adult patients who visited the Massachusetts General Hospital (MGH) practice-based research network (PBRN) between January 1, 2007, and December 31, 2009, and were either connected to a primary care physician or to a primary care practice based on a previously validated algorithm.[7,8]

No-show propensity factor

For each patient, we calculated the no-show propensity factor (NSPF), a measure that transforms the number of a patient's

arrivals and no-shows into a score that represents appointment adherence.[9] Using 5 years (2005–2009) of MGH outpatient primary care and specialty clinic appointment data, we calculated the no-show propensity factor using the following formula:

$$\mathrm{NSPF} = \ln\left[\frac{\left(\frac{(N_S \times N_R) + H_N}{N_S + H_A + H_N}\right)}{N_R}\right],$$

\fleqno

where H_A equals the number of outpatient arrivals in the past 5 years, H_N equals the number of outpatient no-shows in the past 5 years, N_R equals the average no-show rate of the study cohort in the past 5 years, and N_S equals the NSPF smoothing factor, which was set to 10 to correct for those with a low number of overall appointments in order to avoid undue weighting of no-show visits in such patients. We then divided patients into three groups based on NSPF percentile: 1) patients with a percentile rank ≥ 90 (high NSPF), 2) patients with a percentile rank ≥ 75 and < 90 (intermediate NSPF), and 3) patients with a percentile rank < 75 (low NSPF). Mean no-show rates were 31.8 % in the high NSPF group, 17.8 % in the intermediate NSPF group, and 2.4 % in the low NSPF group.

To examine the robustness of the NSPF, we performed calculations using 1 year (2009) and 3 years (2007–2009) of appointment history, since some health systems may not have access to 5 years of outpatient appointment data. We also calculated NSPF using 5 years (2005–2009) of primary care appointment history only, since primary care practices may not have access to specialist visit data. Finally, we classified NSPF risk groups using a 5 % lower cutoff (e.g., ≥ 85 % for high NSPF, ≥70 and <85 % for intermediate, and <70 % for low NSPF) to assess whether our findings were stable at different thresholds.

Patient characteristics

We obtained information on patient characteristics from the MGH-PBRN electronic data repository from 2009. We derived patient demographic variables (age, gender, self-reported race or ethnicity, language, and insurance status) from registration information. We derived median household income, a neighborhood-level marker of socioeconomic status, from Census Block Group data based on geographic information system codes from patient addresses. We calculated the Charlson Comorbidity Index, based on patient age and a weighted algorithm of 16 diagnoses.[10,11] We derived diagnoses of depression and alcohol-related problems using the International Classification of Diseases-Ninth Revision codes and diagnoses noted in the problem list of the outpatient electronic medical record system. We determined the number of hospital admissions to MGH using billing data and the number of emergency department (ED) visits using the ED electronic data repository.

Outcome variables

Clinical quality outcomes. We assessed the association between NSPF and the prevalence rate of incomplete preventive cancer screenings (colorectal, cervical, and breast cancer) and above-goal chronic disease control measures (low-density lipoprotein [LDL] and hemoglobin A1c [HbA1c]) at 1-year follow-up (2010) among eligible patients. We defined eligibility and incomplete preventive cancer screening as follows: 1) no colonoscopy within the prior 10 years or CT colonography/sigmoidoscopy/barium enema within the prior 5 years among patients aged 52–75 years without prior total colectomy, 2) no Papanicolaou (Pap) smear within the prior 3 years among women aged 21 to 64 years, and 3) no mammography within the prior 2 years in eligible women aged 42 to 69 years. We defined suboptimal chronic disease control as the most recent test result in the subsequent year (2010): 1) LDL ≥ 130 mg/dl among patients with diabetes and/or vascular disease (coronary artery disease, peripheral vascular disease, and cerebrovascular disease) and 2) HbA1c ≥ 9 % among patients with diabetes.

Utilization outcomes. We assessed the association between NSPF and counts of 1) admissions to any inpatient service at MGH or 2) MGH ED visits in the subsequent 3 years (2010–2012).

Statistical analysis

We compared patient characteristics in the low NSPF group to the intermediate and high NSPF groups using chi-squared tests to compare proportions and Wilcoxon rank-sum tests to compare means. We used logistic regression models to evaluate the association between NSPF and subsequent clinical outcomes, comparing high NSPF and intermediate NSPF groups to the low NSPF group. We used zero-inflated Poisson (ZIP) regression models to evaluate the association between NSPF and subsequent utilization outcomes. All regression models were adjusted for number of outpatient appointments within the prior 5 years (base model). Using a "change-in-estimate" strategy,[12] we included patient factors in regression models if they altered the measure of association (odds ratio or relative rate) by ≥ 5 % (model 1). Although the change-in-estimate strategy is a common method of selecting confounders, the approach depends on arbitrary thresholds and may not account for all confounding. Therefore, we also ran logistic and ZIP regression models adjusting for all patient factors (model 2). Next, we evaluated the association between NSPF calculated using primary care appointment history only and all outcomes of interest. Finally, we assessed the association between all outcomes of interest and NSPF calculated with 1 year and 3 years of outpatient appointment history and using a 5 % lower cutoff. We did not impute missing data, because the level of missing data was less than 4 % for all regression variables. All statistical analyses were conducted using SAS version 9.3 software (SAS Institute, Cary, NC, USA).

RESULTS

Patient and PCP characteristics within NSPF groups

There were significant differences among patients based on NSPF risk group (Table 1). Compared to patients in the low NSPF group, patients in the intermediate and high NSPF groups were younger, more likely to be non-white, have limited English proficiency, be insured by Medicaid or uninsured, live in neighborhoods with low median household income, and have a diagnosis of depression or alcohol use disorder ($p < 0.001$ for all).

Unadjusted clinical and utilization outcomes

Compared to eligible patients in the low NSPF group, eligible patients in the intermediate and high NSPF groups had greater unadjusted rates of incomplete preventive cancer screening and above-goal chronic disease control measures at 1-year follow-up (Fig. 1). In addition, compared to patients in the low NSPF group, patients in the intermediate and high NSPF groups had higher unadjusted rates of acute care utilization in the subsequent 3 years (Fig. 2).

Adjusted risk for suboptimal clinical and utilization outcomes

Compared to eligible patients in the low NSPF group, eligible patients in the high NSPF group were significantly more likely to have incomplete colorectal, cervical, and breast cancer screening, and above-goal LDL and HbA1c after controlling for all patient characteristics. The direction and significance of the effect was similar for all clinical outcomes in all models (Table 2).

Compared to patients in the low NSPF group, patients in the high NSPF group had increased rates of ED visits and hospitalization in the subsequent 3 years, after controlling for all patient characteristics. The direction and significance of the effect was similar for all clinical outcomes in all models (Table 2).

Compared to patients in the low NSPF group, patients in intermediate NSPF group were more likely to have suboptimal clinical outcomes; the magnitude was smaller, but the direction and significance of the effect was similar in all models and for all outcomes (Table 2).

We calculated NSPF based only on patient primary care appointment history, and findings were similar to NSPF calculated based on visit history for all outpatient appointments (Appendix Table 3). When NSPF was calculated based on 1 year and 3 years of outpatient appointment history, findings were similar to NSPF calculated based on 5 years of data, but the magnitude of association was smaller for all outcomes except cervical cancer screening and LDL control (Appendix, Table 4). When the cutoff for high, intermediate, and low NSPF groups was shifted lower by 5 %, the magnitude of the effect for all outcomes except chronic disease control measures gradually decreased, but the direction and significance remained the same (Appendix, Table 5).

DISCUSSION

We examined the association between patients' propensity to no-show for outpatient visits and subsequent clinical quality and resource utilization outcomes. NSPF was a strong independent predictor of lower preventive cancer screening and chronic disease control rates at 1-year follow-up, and higher rates of ED visits and hospitalizations in the subsequent 3 years. In a setting of increasing emphasis on population health management, our findings have policy and care delivery implications, given the importance of identifying patients at increased risk of adverse clinical outcomes for targeted intervention. The disparities in rates of cancer screening and

Table 1 Baseline characteristics of patients in the three no-show propensity groups

	Low (n = 105,699)	Intermediate (n = 21,167)	High (n = 14,081)
Demographics			
Mean age, years	51.6	45.8	44.0
Male*, %	42.2	44.9	41.5
Non-white, %	16.0	32.9	43.7
Non-English speaking, %	6.3	15.9	18.6
Medicaid, free care or self pay, %	8.8	17.9	29.7
Mean neighborhood median household income, $	63,755	53,789	45,839
Comorbidities			
Depression, %	10.5	16.1	25.2
Alcohol-related diagnosis, %	1.2	2.3	4.4
Mean Charlson score†, n	2.8	2.6	2.7
Healthcare utilization			
Mean number of outpatient appointments in 5 years, n	21.4	23.8	33.0
Mean no-show rate in 5 years, %	2.4	17.8	31.8
Hospitalizations per 1,000 patients in 2009, n	80.9	96.9	135.9
Emergency department visits per 1,000 patients in 2009, n	132.1	228.9	390.1
Receive primary care at a community health center, %	23.2	42.1	55.4

*Note: Comparisons of these characteristics in the low NSPF group vs. the intermediate and high NSPF groups are all significant at the $p < 0.001$ level except: *male, % for the low vs. high group ($p = 0.17$) and †mean Charlson score for low vs. high group ($p = 0.02$).*

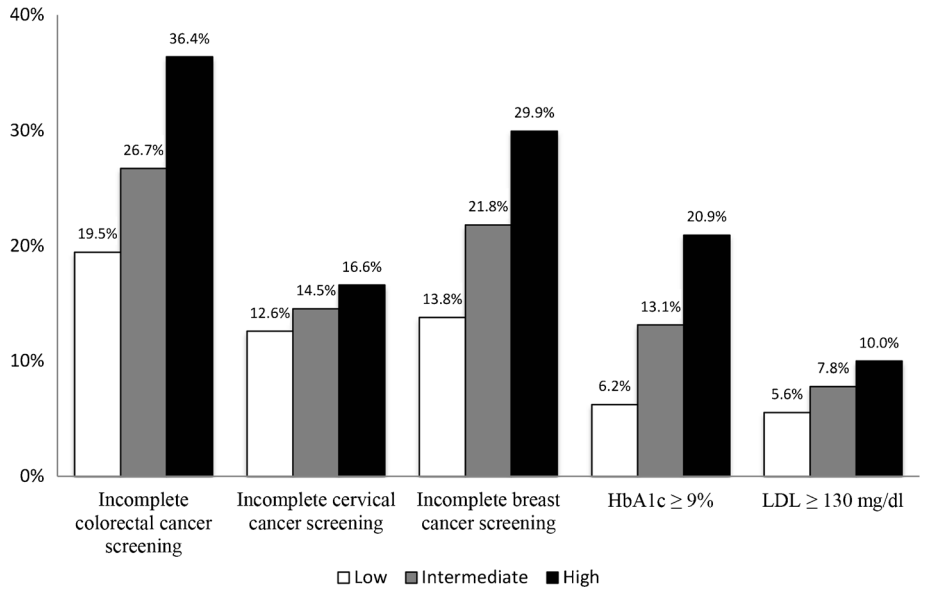

Fig. 1 Unadjusted rates of clinical outcome measures among patients in the three no-show propensity groups. Abbreviations: HbA1c hemoglobin A1c, LDL low-density lipoprotein. Note: Comparisons of these characteristics in the low NSPF group vs. the intermediate and high NSPF groups are all significant at the p < 0.001 level.

chronic disease control among NSPF groups make patients with high NSPF a logical and easily identifiable choice for population management interventions. Patient navigator programs,[13,14] could use NSPF to identify patients at risk for incomplete cancer screening, while primary care-embedded health coaches[15,16] could target patients with chronic diseases and high NSPF to improve disease control. Patients in the high NSPF group had 40–50 % increased rates of ED utilization and hospitalization in the subsequent 3 years, suggesting that high NSPF may serve as an important predictor for future acute care utilization. To the extent that no-shows are a marker for poor care engagement and gaps in care, identifying patients with a high propensity to no-show may help healthcare systems select patients who are at high risk for preventable hospitalizations and ED use, offering additional opportunities for care improvement and cost reduction. NSPF could serve as an especially valuable tool for complex care management programs, whose success largely depends on identifying patients who are not only high-cost (e.g., unnecessary hospital and ED utilization), but also have gaps in care that can be met by the program (e.g., poor engagement with primary care).[17,18]

The two- to threefold higher rates of incomplete preventive cancer screening and suboptimal chronic disease management

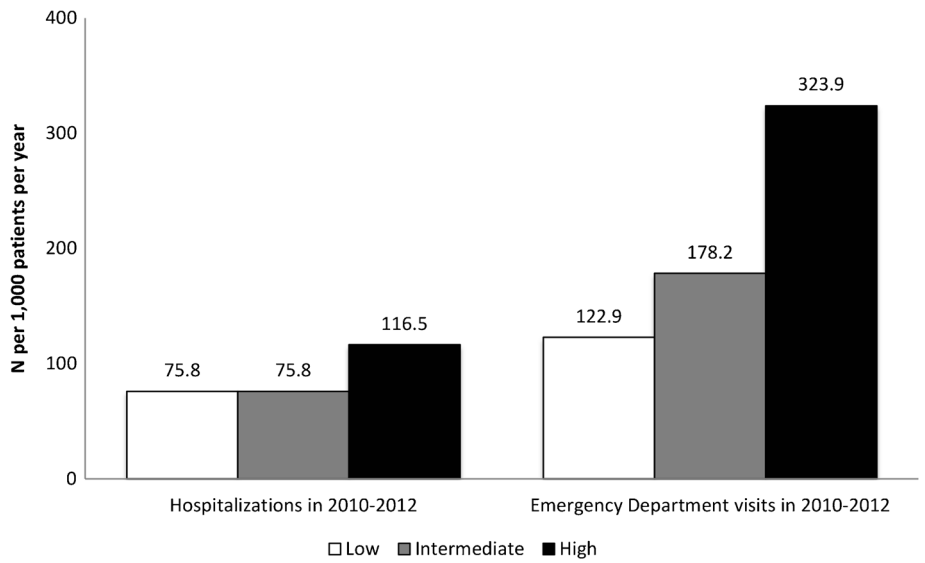

Fig. 2 Unadjusted rates of acute care utilization among patients in the three no-show propensity groups. Note: Comparisons of these characteristics in the low NSPF group vs. the intermediate and high NSPF groups are all significant at the p < 0.001 level, except hospitalizations for the low vs. intermediate group (p = 0.12).

Table 2 Association between no-show propensity and preventive cancer screening, chronic disease control outcomes, and acute care utilization

	Base model[1]	Model 1[2]	Model 2[3]
	aOR [95 % CI]	aOR [95 % CI]	aOR [95 % CI]
Preventive cancer screening			
Incomplete colorectal cancer screening			
High vs. low	2.83 [2.62–3.06]	2.63[4] [2.42–2.85]	2.41 [2.19–2.66]
Intermediate vs. low	1.61 [1.51–1.72]	1.54[5] [1.44–1.65]	1.45 [1.34–1.57]
Incomplete cervical cancer screening			
High vs. low	1.71 [1.58–1.84]	1.76[6] [1.63–1.92]	1.85 [1.65–2.08]
Intermediate vs. low	1.28 [1.19–1.37]	1.39[7] [1.29–1.49]	1.39 [1.25–1.55]
Incomplete breast cancer screening			
High vs. low	3.10 [2.85–3.37]	3.54[8] [3.18–3.93]	2.93 [2.62–3.28]
Intermediate vs. low	1.85 [1.71–.99]	1.85[5] [1.71–1.99]	1.75 [1.58–1.94]
Chronic disease control			
Above-goal low-density lipoprotein			
High vs. low	1.94 [1.66–2.27]	1.38[9] [1.17–1.64]	1.39 [1.15–1.67]
Intermediate vs. low	1.47 [1.26–1.72]	1.20[9] [1.02–1.41]	1.20 [1.01–1.43]
Above-goal hemoglobin A1c			
High vs. low	3.98 [3.42–4.63]	2.67[9] [2.26–3.15]	2.64 [2.22–3.14]
Intermediate vs. low	2.29 [1.94–2.71]	1.76[10] [1.47–2.10]	1.70 [1.42–2.04]
Acute care utilization	aRR [95 % CI]	aRR [95 % CI]	aRR [95 % CI]
Emergency department utilization			
High vs. low	1.65 [1.61–1.69]	1.54[11] [1.49–1.58]	1.39 [1.35–1.43]
Intermediate vs. low	1.20 [1.17–1.24]	1.21[12] [1.17–1.25]	1.15 [1.12–1.19]
Hospitalization			
High vs. low	1.31 [1.02–1.26]	1.50[13] [1.44–1.58]	1.37 [1.31–1.44]
Intermediate vs. low	1.03 [0.99–1.08]	1.21[14] [1.16–1.27]	1.10 [1.04–1.15]

aOR adjusted odds ratio, aRR adjusted risk ratio, CI confidence interval
[1] *Adjusted for number of appointments*
[2] *Adjusted for confounders selected with "change in estimate" approach*
[3] *Adjusted for all covariates*
[4] *Adjusted for number of appointments and neighborhood median income*
[5] *Adjusted for number of appointments*
[6] *Adjusted for number of appointments, race, and insurance*
[7] *Adjusted for number of appointments and race*
[8] *Adjusted for number of appointments, race, and Charlson Comorbidity Index*
[9] *Adjusted for number of appointments, age, and race*
[10] *Adjusted for number of appointments, age, and income*
[11] *Adjusted for number of appointments, age, race, insurance, neighborhood median income, and number of ED visits in 2009*
[12] *Adjusted for number of appointments, age, neighborhood median income, Charlson Comorbidity Index, and number of ED visits in 2009*
[13] *Adjusted for number of appointments, age, insurance, and number of ED visits in 2009*
[14] *Adjusted for number of appointments, age, and number of hospitalizations in 2009*

in the high NSPF group is not only clinically significant, but also has important financial implications. Pay-for-performance programs,[19] as well as care coordination payments and shared savings programs that are contingent upon achieving quality metrics,[20,21] are examples of payment approaches that use preventive cancer screening and chronic disease management goals as benchmarks for quality. Addressing the needs of patients in higher NSPF risk groups may represent a valuable opportunity to improve the care of patients, while yielding financial benefits through improved attainment of quality metrics.

Many claims-based risk assessment tools[22,23] are available to predict future use of health resources. Predictive models have been evolving and improving in accuracy,[24] but they are limited by the fact that they rely mainly on chronic disease diagnoses.[25] Patient complexity and risk for suboptimal outcomes, however, is not only defined by comorbidities, but also by socioeconomic, cultural, and behavioral characteristics of patients.[26–29] The fact that patients in the high NSPF group were young, non-white, with limited English proficiency, and had lower socioeconomic status and higher burden of behavioral health problems such as depression and alcohol use disorder, suggests that NSPF may serve as a proxy for psychosocial complexity. Use of NSPF may thus help health systems find high-risk patients not otherwise identified by traditional predictive modeling tools that depend on comorbidities, particularly among younger patients. Future studies should look at the potential contribution of no-show propensity factor in risk prediction algorithms.

NSPF may be applicable in many practice settings, as it uses appointment history from scheduling systems and is easily calculated. Our analyses demonstrate that calculating NSPF with primary care appointment history alone, with fewer years of data, and using different cutoffs for classifying the three NSPF groups, produced consistent results. However, we found that using more years of appointment data and higher NSPF cutoffs to define high risk had a stronger relationship with clinical and utilization outcomes. Therefore, NSPF may serve as a valuable risk stratification tool to help practices focus their interventions on the highest-risk subgroup.

Study limitations included our inability to examine visit history and outcomes occurring outside of our health system. To the extent that patients who are frequent appointment no-shows have a suboptimal level of engagement and are thus more likely to use out-of-system resources, this may represent a conservative bias. Data on cancer screening results are more likely to be incomplete for the high NSPF group, introducing a potential bias away from the null. However, we obtained data on cancer screening results from a variety of sources, including non-MGH facilities that are part of the Partners HealthCare network as well as insurer billing data from non-Partners sites for patients with managed care contracts. In addition, the algorithms for capturing cancer screening measures have been rigorously validated via chart review, and have shown high sensitivity and specificity. Our findings may not be generalizable to patients in other primary care networks, but our network includes a variety of practice types, including community health centers. Finally, given the observational nature of the study, we cannot rule out any residual confounding. However, we adjusted for many important potential confounders using a multivariate modeling approach, and demonstrated a strong independent association between NSPF and all outcomes.

In summary, our study demonstrates that a patient's propensity to no-show for outpatient appointments is a strong independent predictor of incomplete preventive cancer screening and suboptimal chronic disease management in the following year, and acute care utilization in the subsequent 3 years. The no-show propensity factor may help primary care practices identify high-risk psychosocially complex patients for targeted population management interventions to improve care, achieve performance targets, and reduce acute care utilization.

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Conflict of Interest: *The authors have no potential conflicts of interest.*

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APPENDIX

Table 3 Association between no-show propensity calculated using primary care appointment history only and incomplete preventive cancer screening, above-goal chronic disease control measures, and acute care utilization

	Base model[1]	Model 1[2]	Model 2[3]
	aOR [95 % CI]	aOR [95 % CI]	aOR [95 % CI]
Preventive cancer screening			
Incomplete colorectal cancer screening			
High vs. low	2.00 [1.85–2.16]	2.00[4] [1.85–2.16]	1.90 [1.73–2.08]
Intermediate vs. low	1.31 [1.22–1.40]	1.31[4] [1.22–1.40]	1.27 [1.17–1.37]
Incomplete cervical cancer screening			
High vs. low	1.71 [1.59–.84]	2.03[5] [1.82–2.27]	2.01 [1.79–2.25]
Intermediate vs. low	1.16 [1.07–.26]	1.24[6] [1.15–.34]	1.24 [1.10–1.38]
Incomplete breast cancer screening			
High vs. low	2.69 [2.48–2.93]	2.69 [2.48–2.93]	2.65 [2.38–2.97]
Intermediate vs. low	1.39 [1.29–.51]	1.39 [1.29–1.51]	1.33 [1.20–1.47]
Chronic disease control			
Above-goal low-density lipoprotein			
High vs. low	1.60 [1.35–1.90]	1.22[7] [1.02–1.46]	1.24 [1.02–1.50]
Intermediate vs. low	1.38 [1.19–1.60]	1.27[8] [1.10–1.47]	1.25 [1.07–1.46]
Above-goal hemoglobin A1c			
High vs. low	3.20 [2.73–3.76]	2.24[7] [1.89–2.65]	2.17 [1.82–2.59]
Intermediate vs. low	1.63 [1.39–1.91]	1.45[8] [1.24–1.71]	1.34 [1.13–1.58]
	aRR [95 % CI]	aRR [95 % CI]	aRR [95 % CI]
Acute care utilization			
Emergency department utilization			
High vs. low	1.47 [1.43–1.51]	1.36[9] [1.32–1.41]	1.22 [1.18–1.26]
Intermediate vs. low	1.27 [1.23–.30]	1.11[10] [1.08–1.14]	1.07 [1.04–1.10]
Hospitalization			
High vs. low	1.14 [1.09–1.19]	1.29[11] [1.23–1.35]	1.12 [1.07–1.18]
Intermediate vs. low	1.09 [1.05–1.14]	1.07[11] [1.03–.11]	0.99 [0.95–1.03]

aOR adjusted odds ratio, aRR adjusted relative risk
[1] *Adjusted for number of appointments*
[2] *Adjusted for confounders selected with "change in estimate" approach*
[3] *Adjusted for all covariates*
[4] *Adjusted for number of appointments*
[5] *Adjusted for number of appointments, age, race, insurance, and Charlson Comorbidity Index*
[6] *Adjusted for number of appointments, and race*
[7] *Adjusted for number of appointments, age, and race*
[8] *Adjusted for number of appointments, and age*
[9] *Adjusted for number of appointments age, insurance, Charlson Comorbidity Index, and number of ED visits in 2009*
[10] *Adjusted for number of appointments, income, and number of ED visits in 2009*
[11] *Adjusted for number of appointments, age, and number of hospitalizations in 2009*

Table 4 Association between no-show propensity calculated using 1 year and 3 years of appointment history and incomplete preventive cancer screening, above-goal chronic disease control measures, and acute care utilization after adjusting for all covariates

	1 year	3 years	5 years
	aOR [95 % CI]	aOR [95 % CI]	aOR [95 % CI]
Preventive cancer screening			
Incomplete colorectal cancer screening			
High vs. low	1.95 [1.78–2.14]	1.95 [1.77–2.14]	2.41 [2.19–2.66]
Intermediate vs. low	1.26 [1.15–1.39]	1.27 [1.16–1.40]	1.45 [1.34–1.57]
Incomplete cervical cancer screening			
High vs. low	1.95 [1.74–2.20]	1.94 [1.72–2.18]	1.85 [1.65–2.08]
Intermediate vs. low	1.29 [1.13–1.47]	1.29 [1.13–1.48]	1.39 [1.25–1.55]
Incomplete breast cancer screening			
High vs. low	2.60 [2.30–2.91]	2.60 [2.33–2.90]	2.93 [2.62–3.28]
Intermediate vs. low	1.42 [1.26–.60]	1.41 [1.25–1.59]	1.75 [1.58–1.94]
Chronic disease control			
Above-goal low-density lipoprotein			
High vs. low	1.43 [1.19–1.73]	1.44 [1.20–1.73]	1.39 [1.15–1.67]
Intermediate vs. low	1.16 [0.96–1.39]	1.16 [0.97–1.40]	1.20 [1.01–1.43]
Above-goal hemoglobin A1c			
High vs. low	2.19 [1.84–2.61]	2.17 [1.82–2.59]	2.64 [2.22–3.14]
Intermediate vs. low	1.45 [1.20–1.74]	1.44 [1.20–1.73]	1.70 [1.42–2.04]
	aRR [95 % CI]	aRR [95 % CI]	aRR [95 % CI]
Acute care utilization			

(continued on next page)

Table 4. (continued)

	1 year	3 years	5 years
	aOR [95 % CI]	aOR [95 % CI]	aOR [95 % CI]
Emergency department utilization			
High vs. low	1.18 [1.15–1.22]	1.19 [1.16–1.23]	1.39 [1.35–1.43]
Intermediate vs. low	1.06 [1.02–1.09]	1.04 [1.01–1.08]	1.15 [1.12–1.19]
Hospitalization			
High vs. low	1.10 [1.05–1.16]	1.11 [1.06–1.17]	1.37 [1.31–1.44]
Intermediate vs. Low	1.04 [0.99–1.09]	1.02 [0.97–1.06]	1.10 [1.04–1.15]

aOR adjusted odds ratio, aRR adjusted relative risk

Table 5 Association between no-show propensity factor and incomplete preventive cancer screening, above-goal chronic disease control measures, and acute care utilization after adjusting for all covariates using lower cutoffs

	5 % Lower cutoff	Original cutoff
	aOR [95 % CI]	aOR [95 % CI]
Preventive cancer screening		
Incomplete colorectal cancer screening		
High vs. low	2.12 [1.95–2.30]	2.41 [2.19–2.66]
Intermediate vs. low	1.36 [1.23–1.49]	1.45 [1.34–1.57]
Incomplete cervical cancer screening		
High vs. low	1.79 [1.61–1.99]	1.85 [1.65–2.08]
Intermediate vs. low	1.32 [1.16–1.50]	1.39 [1.25–1.55]
Incomplete breast cancer screening		
High vs. low	2.62 [2.37–.90]	2.93 [2.62–3.28]
Intermediate vs. low	1.64 [1.45–1.85]	1.75 [1.58–1.94]
Chronic disease control		
Above-goal low-density lipoprotein		
High vs. low	1.27 [1.08–1.50]	1.39 [1.15–1.67]
Intermediate vs. low	1.29 [1.06–1.58]	1.20 [1.01–1.43]
Above-goal hemoglobin A1c		
High vs. low	2.36 [2.01–2.77]	2.64 [2.22–3.14]
Intermediate vs. low	1.67 [1.35–2.07]	1.70 [1.42–2.04]
	aRR [95 % CI]	aRR [95 % CI]
Acute care utilization		
Emergency department utilization		
High vs. low	1.33 [1.29–1.37]	1.39 [1.35–1.43]
Intermediate vs. low	1.13 [1.09–1.18]	1.15 [1.12–1.19]
Hospitalization		
High vs. low	1.30 [1.24–1.36]	1.37 [1.31–1.44]
Intermediate vs. low	1.08 [1.02–1.14]	1.10 [1.04–1.15]

aOR adjusted odds ratio, aRR adjusted relative risk