Published in final edited form as:

Pharmacotherapy. 2016 June ; 36(6): 590–597. doi:10.1002/phar.1757.

Relationship between Medication Adherence and Distance to Dispensing Pharmacies and Prescribers Among an Urban Medicaid Population with Diabetes Mellitus

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Abstract

Study Objective—To determine whether a relationship exists between medication adherence to angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin II receptor blockers (ARBs) and distance to dispensing pharmacies and prescribers among an urban, public aid population with diabetes mellitus.

Design—Retrospective cohort study using claims data.

Data Source—Illinois Department of Healthcare and Family Services database.

Patients—A total of 6532 patients aged 18–64 years with diabetes who had at least one prescription fill for an ACEI or ARB, and had continuous Medicaid coverage in the greater Chicago area in 2009.

Measurements and Main Results—Medication adherence, defined as proportion of days covered (PDC) ≥ 0.8 , to ACEIs and ARBs and its association with distances between patients and their pharmacies and prescribers was assessed. Of the 6532 patients included in the analyses, 2930 (45%) had PDC levels ≥ 0.8 . No significant differences were observed between patients who were adherent versus those who were nonadherent in distance to pharmacy (median 1.39 vs 1.35 miles, $p=0.15$) or distance to prescriber (median 4.39 vs 4.48 miles, $p=0.80$). In a multivariate regression model including age, sex, race-ethnicity, number of pharmacies, number of prescribers, distance to pharmacy, and distance to prescriber, a greater number of prescribers was associated with higher adherence (2 prescribers vs 1 prescriber: odds ratio [OR] 1.396, 95% confidence interval [CI] 1.233–1.580; 3 prescribers vs 1 prescriber: OR 2.208, 95% CI 1.787–2.727).

Conclusion—ACEI or ARB adherence was not associated with distances to pharmacies and prescribers.

Keywords

Medication Adherence; Diabetes Mellitus; Angiotensin-Converting Enzyme Inhibitor; ACEI; Angiotensin II Receptor Blocker; ARB; Health Services Accessibility; Transportation

Diabetic nephropathy is the leading cause of end-stage renal disease in the United States.¹ Angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin II receptor blockers (ARBs) are known to delay the progression of diabetic nephropathy.^{2–4} For this reason, the American Diabetes Association clinical practice guidelines recommend ACEI/ARB therapy for patients with diabetes mellitus and hypertension and/or albuminuria.⁴⁶ Additionally, most older adults with diabetes have other clinical indications for ACEI/ARB therapy, based on risk factors including cardiovascular disease, hyperlipidemia, and smoking.⁵

The renal protective effect of ACEIs/ARBs is conferred with long-term use of these medications, independent of blood pressure reduction.⁶ However, suboptimal use is prevalent due to underprescribing and poor medication adherence. In the National Ambulatory Medical Care Survey (2007–2010), only 28–32% of adults with diabetes received a prescription for an ACEI or ARB.⁷ Among public aid recipients in Illinois with diabetes and an at least one indication for an ACEI or ARB, only 47% of those aged 18–64 years filled at least one ACEI or ARB prescription over a year.⁸ Similarly, among older adults, 51–60% of high-risk patients filled a prescription for an ACEI/ARB medication at least once during a 3–6-month time frame.^{9,10} In addition, a population-based cohort study in Canada found that adherence over 2 years was 64% for ACEIs and 36% for ARBs.¹¹ In comparison, retrospective and prospective studies of oral hypoglycemic agents have shown adherence rates of 36–93%.¹² Generally, nonadherence is associated with numerous factors that can be grouped into five overarching domains: socioeconomic status, health care systems, health condition, therapy, and patient-related factors.¹³ Although individual patient-level factors are frequently addressed in adherence research,¹⁴ the influence of geographic and environmental contextual factors that may influence the ability to see prescribers and fill medications has not received equal attention in terms of adherence.^{15–17}

Travel burden is a specific environmental factor that may function as an indirect barrier to adherence. Although findings are mixed, there is evidence suggesting that travel burden, defined as longer travel time or longer distance to reach health care providers, may contribute to decreased health care utilization and fewer prescription refills.^{17–20} Among those with diabetes, less adherence to primary care appointments is associated with poorer glycemic control,¹⁹ possibly influenced by low medication adherence.²⁰ Travel distances to pharmacies may also affect medication fills and, therefore, medication adherence.^{17,21}

Travel distance to pharmacies may represent a higher burden to ethnic-racial minorities compared to nonminorities. A recent study in Chicago revealed that the number of pharmacies was lower and distance to pharmacies was greater for residents in segregated minority communities than in segregated white and integrated communities.²² In this study, the average distance to the nearest pharmacy was longer for racial-ethnic minorities;

however, the impact of this distance on actual medication fills obtained was not explored empirically.

In addition, there is related evidence showing greater travel burden among racial-ethnic minority groups to receive health care.¹⁷ In one cross-sectional study, urban African-Americans and other minorities were more likely to report a trip for medical or dental care taking at least 30 minutes of travel time.²³ Furthermore, African-Americans had greater travel burdens despite controlling for socioeconomic status and mode of transportation. Potentially, travel distance is an independent risk factor for reduced medication adherence, also likely associated with race-ethnicity, income, and likelihood of living in a population-dense environment.

This study is among the first, to our knowledge, to investigate whether a relationship exists between ACEI and ARB adherence and distance to pharmacies and prescribers using individual-level data among an urban, public aid population with diabetes.

Methods

Using claims data, patients with diabetes mellitus, defined as having an *International Classification of Diseases, Ninth Revision* (ICD-9) code 250.xx, were identified who were enrolled in the State of Illinois public aid program in 2008 or 2009 (169,609 patients). The sample was further limited to those aged 18–64 years who were public aid eligible for all 365 days of the fiscal year and who lived in the greater Chicago area (defined as Cook County and adjoining counties [30,629 patients]). Individuals aged 65 years and older were excluded because many were insured by Medicare.

Prescription claims data for this sample included medication name, date filled, number of days supplied, pharmacy filling the prescription (with address), and prescriber of medication (with address). The numbers of pharmacies and prescribers represented the total unique pharmacies and prescribers for each enrollee (each pharmacy and prescriber has a unique identifier). We generated a comprehensive list of all brand-name and generic ACEIs and ARBs available in the United States. This list included all formulary antihypertensive medications in the Illinois public aid preferred drug list as well as nonpreferred agents.

Adherence was defined based on proportion of days covered (PDC) with a listed ACEI or ARB as reflected in prescriptions filled in the 2009 calendar year.^{24,25} When medications were switched from an ACEI to an ARB and vice versa, PDC was calculated by using days supplied for either medication in the numerator. The PDC calculation assumes that patients are taking the medication as prescribed and that any prescription fill falling completely within the time period of interest is fully utilized by the patient. Any medication fills whose coverage falls outside of this time period is truncated at the completion of this period, thus precluding a fill at the end of the study from falsely elevating the PDC. The first prescription fill of 2009 was designated as the index date for the PDC time interval. The PDC ranges from values between zero and one, and adherence was defined as PDC of 0.8 or higher, which is a common threshold used by the Pharmacy Quality Alliance.²⁶

The majority of enrollee addresses (composites of house number and name, city, state, and ZIP code) were geocoded via ESRI's ArcGIS Online Geocoder Service (ESRI, Redlands, CA) as longitude and latitude coordinates.²⁷ Enrollees with post office box numbers were excluded. Less than 1% of enrollee addresses contained only a facility name (e.g., group home), the address of which was located by using Google Maps. Prescriber and pharmacy addresses were identified in a similar fashion. Distances were calculated by using Euclidean (straight line or "as-the-crow-flies") distance between enrollee and prescriber and between enrollee and pharmacy.^{28,29} When multiple unique prescribers or pharmacies were present for a given enrollee during the calendar year, a weighted average was computed based on number of fills (distances were given weight proportional to number of fills). We excluded enrollees where patient-prescriber or patient-pharmacist distances exceeded the 98th percentile for distance to pharmacy (23 miles) and prescribers (32 miles).

Race-ethnicity of the patients was obtained from the Illinois Department of Health and Family Services, which used the following categories: Caucasian, African-American, Hispanic, Asian-American/Pacific Islander, and other or unknown. Hispanics were further identified as Spanish speaking or non-Spanish speaking based on their self-reported language preference when they enrolled in public aid. A previous study of Illinois Medicaid enrollees showed differences in adherence based on language preference.¹⁷

Pharmacy-specific descriptive data were obtained through the National Council for Prescription Drug Programs dataQ Pharmacy Database. A self-designated "provider type code" indicated the type of pharmacy; we included community/retail pharmacies. If the primary, secondary, or tertiary code included the code "mail order pharmacy," the enrollee was excluded from analyses.

A secondary analysis excluded nonpersistent individuals (354 patients [5.4%]) for whom there were no prescription fills for at least 90 days (a prespecified limit on the number of days allowed between refills, or "permissible gap"³⁰). However, as the findings from both analyses (with and without the nonpersistent patients) were very similar, we included the nonpersistent patients in the final results.

Statistical Analysis

Statistical analyses were performed by using SAS software, versions 9.4 and 9.2 (SAS institute, Inc., Cary, NC), and R package rms for model validation. Basic descriptive statistics were reported. We included p values from Mann-Whitney tests for quantitative variables and χ^2 tests for categorical variables. A pairwise two-sample Mann-Whitney test controlling for the type I error rate^{31,32} was used to compare the distance to pharmacy across race-ethnicity groups. Logistic regression models were used to evaluate the relationship of medication adherence (PDR = 0.8) with average distance to pharmacy and average distance to prescriber. Age, sex, interaction between age and sex, race-ethnicity and language, number of prescribers (1, 2, 3, or more), and number of pharmacies (1, 2, 3, or more) were also included in the models. The adjusted McFadden, Nagelkerke, and Tjur pseudo R^2 statistics for logistic regression were used as measures of predictive power. The Hosmer-Lemeshow test was used to assess goodness of fit.³³ In addition, we calculated the

overfitting-corrected index³⁴ via bootstrapping. The index exceeded 0.97, indicating no evidence of overfitting.

Results

A total of 6532 individuals with at least one prescription fill for an ACEI or ARB who met all criteria (diabetes diagnosis, age 18–64 years, Medicaid eligible for 365 days, Chicago area resident, travel distances within 98th percentile, and non-mail order pharmacy use) and were included for the final analyses (Table 1). Of these patients, 2930 (45%) were considered adherent (PDC = 0.8). Adherent enrollees were older than nonadherent enrollees (54.3 vs. 50.6 years, $p < 0.0001$), but these groups did not significantly differ by sex (66.0% vs. 65.8% female, $p = 0.88$). Nonadherent enrollees were more likely to have a racial-ethnic minority background ($p < 0.0001$). Adherent enrollees filled prescriptions from more prescribers (33.4% of adherent patients vs. 26.0% of nonadherent patients had two or more prescribers, $p < 0.0001$). There was no significant difference in distance to pharmacy between adherent and nonadherent patients (median 1.39 miles for adherent patients vs. 1.35 miles for nonadherent patients, $p = 0.15$). Similarly, there was no significant difference in distance to prescriber (median 4.39 miles for adherent patients vs. 4.48 miles for nonadherent patients, $p = 0.80$). Most of the enrollees used one unique pharmacy (81.5%), and this did not significantly differ between adherent and nonadherent enrollees ($p = 0.98$). Overall, most prescriptions (99%) contained between 28 and 31 days' supply of an ACEI or ARB.

Enrollees with prescriptions written from multiple prescribers had longer average travel distances. The mean $\pm$ SD distance to prescriber was 6.2 ± 6.2 miles for enrollees with one prescriber, 7.0 ± 5.8 miles for those with two prescribers, and 8.4 ± 5.4 miles for those with three or more prescribers. Hispanic patients (both Spanish speaking and non-Spanish speaking) had shorter average distances to prescribers compared with other racial-ethnic groups (Table 2).

Table 3 shows the mean distance to pharmacy by racial-ethnic group. The average distance to pharmacy was greater for Caucasians and African-Americans compared with both Spanish-speaking and non-Spanish-speaking Hispanics. Significant differences were present for Caucasian vs. Spanish-speaking and non-Spanish-speaking Hispanics ($p < 0.0001$), African-American vs. Spanish-speaking and non-Spanish-speaking Hispanics ($p < 0.0001$), and Spanish-speaking Hispanics vs. other or unknown races or ethnicities ($p = 0.01$).

Table 4 shows odds ratios of the logistic regression model of adherence. African-Americans (OR 0.545, 95% confidence interval [CI] 0.476–0.623), Spanish-speaking Hispanics (0.539, 95% CI 0.442–0.656), and non-Spanish-speaking Hispanics (0.691, 95% CI 0.568–0.840) were less likely to be adherent compared with Caucasians. Having more prescribers was associated with greater adherence (2 prescribers vs 1 prescriber: OR 1.396, 95% CI 1.233–1.580; 3 prescribers vs 1 prescriber: OR 2.208, 95% CI 1.787–2.727). Older enrollees were more likely to be adherent than younger enrollees, and this relationship was stronger for women than men. Number of pharmacies, distance to pharmacy, and distance to prescriber were not associated with adherence.

Discussion

Among adult public aid enrollees with diabetes in the greater Chicago area, distances to pharmacies and prescribers were not associated with ACEI or ARB fill adherence. Similar to previous studies, we did detect lower adherence among racial-ethnic minority groups.⁸ Together, these results suggest that variation in geographic locations and relative proximity of pharmacies and prescribers is unlikely to contribute to these racial-ethnic differences in medication adherence among Medicaid enrollees. Given the number of personal barriers to medication adherence in inner-city populations, distance to pharmacy and prescriber may not be of particular relevance.

In low-income populations, the availability of transportation is likely more important than distance travelled. For example, Tierney et al showed that in an inner-city public aid population, lower reimbursement for transportation to visit providers resulted in decreased refills of medication.³⁵ Consequently, having travel barriers to health care providers may result in fewer encounters and missed appointments. In diabetes care, patients with high levels (> 30%) of missed provider appointments have been shown to have poorer refill adherence²⁰ and higher all-cause mortality.³⁶ Fewer provider visits results in reduced monitoring (e.g., blood glucose level and blood pressure) and fewer adjustments to medications, resulting in a greater risk of poor control. Likewise, more frequent provider visits and better continuity of care are associated with better adherence with chronic disease medication.³⁷ Provider visits offer opportunities for medication adjustments, prescription refills, education, monitoring, and self-management reinforcement, which collectively contribute to better health outcomes.

Although a longer distance to travel to a pharmacy may appear as a barrier, the evidence is mixed. In one study of an indigent, rural population, travel distance to a pharmacy had no relationship with medication adherence.³⁸ In urban areas, the ability to travel a longer distance to pharmacies may reflect better access to a vehicle or driver, a pharmacy in more frequently visited location (e.g., grocery store), or more convenient access via public transportation (e.g., bus or train stop).²¹ In Chicago, many lower-income census tracts have longer distances to pharmacies than higher-income tracts.²² However, adherence patterns depend on where prescriptions are filled, which may not represent the geographically closest pharmacy. In fact, in our study, the mean distance to pharmacy was 2.7 miles (median 1.4 miles), greater than mean 0.5–0.8 mile of proximal retail pharmacies in low-income neighborhoods.²² Additionally, Caucasians and African-Americans traveled further to pharmacies than Hispanics. This would support the lack of influence of distance to pharmacy on adherence. Theoretically, co-location of pharmacy and prescriber together could benefit patients receiving convenient refills of chronic disease medications (“one-stop shopping”). Yet, in a study of co-located providers/pharmacies, co-location was not associated with improvement in cardiovascular risk factor control.³⁹

We found that the greater the number of unique prescribers identified, the greater the number of filled ACEI/ARB medications. This may reflect greater disease burden, specialty care, health care utilization,⁴⁰ and receipt of care for complex, chronic conditions rather than simply visiting multiple primary care providers. This finding is in contrast to other studies

that found that a greater number of prescribers contributed to fragmented care and worse medication adherence.^{41,42} However, these studies differed in that they included analyses of prescription claims data from a single pharmaceutical benefit manager (CVS Caremark)⁴¹ and VA health care system.⁴² In the current study, we investigated predominantly middle-aged, low-income patients who typically receive care through federally qualified health centers and safety net providers. Although Illinois is transitioning many of these patients to public aid managed care, they previously experienced substantial fragmented care. Still, more complexity of care remains common in public aid populations, generally provides an additional challenge to chronic disease care, and may help justify disease management programs.

In this study, the number of unique pharmacies used to fill prescriptions was not associated with medication adherence. This is in contrast to what has been found in other studies examining adherence-related factors including medication complexity.^{41,43} This might reflect the homogeneous population of Medicaid enrollees younger than 65 years old. It also suggests that consolidation of prescriptions in one pharmacy, although convenient, may have a lesser impact among Medicaid recipients on obtaining continued refills than previously thought.

This study has several strengths. This retrospective cohort study applied a multivariate regression analysis involving an adequate sample of urban Medicaid enrollees. This is among the first studies to incorporate measured distances between individuals and their prescribers and pharmacies using individual-level fill data to investigate medication adherence. Few studies consider travel burden and location in researching adherence patterns.¹⁷ Further studies are needed to understand the potential existence and relevance of “pharmacy deserts” previously reported in Chicago.²²

There are a number of limitations to this study. First, despite referencing the dataQ database, mail-order pharmacy services may not have been completely removed from the analyses. We addressed this by limiting the pharmacy/enrollee distances at the 98th percentile, removing distant out-of-state pharmacies from the data analyzed. There is evidence that mail-order options improve diabetes medication adherence.⁴⁴ Next, we lacked information on mode of transportation (e.g., car, bus, train) used by patients. Distance data do not fully capture actual burden of travel, which also varies depending on available routes and locations. For example, a longer distance to a pharmacy or physician may be less burdensome if located along a convenient public transportation line. A similar distance may be more burdensome to travel if multiple public transit transfers were required. Third, the data do not reflect choice and availability of pharmacies or providers who see patients with public aid insurance. Traveling longer distances to receive health care or refill medication may represent necessity or choice. Fourth, the claims data analyzed reflect medication refills but not actual medication use by patients. The data do not account for medication sharing and hoarding, which might underestimate use. Fifth, due to variability in diagnostic codes related to cardiac and kidney disease, we did not account for more specific indications of ACEI/ARB use, such as microalbuminuria or congestive heart failure, or relative or absolute contraindications of therapy (e.g., angioedema or hyperkalemia). Still, the risks of ACEIs/ARBs remain low, and studies consistently demonstrate underuse of these medications.^{9,10}

Sixth, we did not adjust for other factors known to influence refill behaviors, including beliefs about medication or complexity of therapy (number of unique medications and doses). The analyses focused on ACEI/ARB use, and adherence to other therapeutic classes and refill timing for different medications likely vary.⁴⁵ Finally, the data include Medicaid enrollees from the greater Chicago area in Illinois only, and results may not be generalizable to other populations. Very likely, there are different, complex, and challenging travel barriers observed in rural populations.

Conclusion

We found that distances to pharmacies and prescribers were not associated with higher ACEI/ARB adherence in an urban, public aid patient population with diabetes. Although location and proximity may be of lesser importance, travel burden may influence medication refill patterns, medication adherence, and, ultimately, cardiovascular risk factor control. Further research investigating these relationships appears warranted, as well as studies of strategies that address travel burden and its impact on medication adherence.

Acknowledgments

Samina Syed was funded by an Institutional National Research Service Award grant (T32 DK080674). Claudia Lora was funded by a National Institutes of Health grant (K23 DK091313). Ben Gerber, Lisa Sharp, and Michael Berbaum were funded by a National Institutes of Health grant (R01 DK091347). The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States government.

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Table 1

Characteristics of the 6532 Study Patients

Characteristic	Nonadherent Group (n=3602)	Adherent Group (n=2930)	p Value
Race-ethnicity			
Caucasian	565 (15.7)	717 (24.5)	<0.0001
African-American	1963 (54.5)	1323 (45.1)	
Asian-American/Pacific Islander	119 (3.3)	140 (4.8)	
Hispanic (Spanish speaking)	363 (10.1)	278 (9.5)	
Hispanic (Non- Spanish speaking)	381 (10.6)	287 (9.8)	
Other or unknown	211 (5.9)	185 (6.3)	
Age (yrs)	50.58 ± 10.01	54.26 ± 8.03	<0.0001
Female	2370 (65.8)	1933 (66.0)	0.88
No. of pharmacies			
1	2938 (81.6)	2385 (81.4)	0.98
2	534 (14.8)	440 (15.0)	
3	130 (3.61)	105 (3.6)	
No. of prescribers			
1	2664 (74.0)	1951 (66.6)	<0.0001
2	746 (20.7)	722 (24.6)	
3	192 (5.3)	257 (8.8)	
Distance to pharmacy (miles)	1.35 [0.59–3.14]	1.39 [0.62–3.31]	0.15
Distance to prescriber (miles)	4.48 [2.07–9.31]	4.39 [2.02–9.23]	0.80

Data are no. (%) of patients, mean ± SD values, or median [interquartile range] values.

Table 2

Distance to Prescriber by Racial-Ethnic Group for the 6532 Patients

Race-Ethnicity	No. of Patients	Mean $\pm$ SD Distance (miles)	Median (IQR) Distance (miles)	99% CI
Caucasian	1282	7.18 $\pm$ 6.34	5.00 (2.51–9.99)	6.73–7.64
African-American	3286	6.83 $\pm$ 6.11	4.88 (2.09–10.01)	6.55–7.10
Asian-American/Pacific Islander	259	7.11 $\pm$ 6.85	4.83 (2.20–10.13)	6.01–8.22
Spanish-speaking Hispanic	641	5.03 $\pm$ 5.51	3.33 (1.52–5.96)	4.47–5.59
Non-Spanish-speaking Hispanic	668	5.37 $\pm$ 5.40	3.59 (1.81–6.88)	4.83–5.91
Other or unknown	396	6.18 $\pm$ 5.77	3.99 (1.98–8.68)	5.43–6.93

IQR = interquartile range; CI = confidence interval.

Table 3

Distance to Pharmacy by Racial-Ethnic Group for the 6532 Patients

Race/Ethnicity	No. of Patients	Mean $\pm$ SD Distance (miles)	Median (IQR) Distance (miles)	99% CI
Caucasian	1282	3.06 $\pm$ 4.04	1.50 (0.65–3.54)	2.77–3.35
African-American	3286	2.90 $\pm$ 3.68	1.47 (0.66–3.46)	2.74–3.07
Asian-American/Pacific Islander	259	2.28 $\pm$ 3.25	1.21 (0.57–2.53)	1.76–2.80
Spanish-speaking Hispanic	641	2.05 $\pm$ 2.93	0.95 (0.48–2.25)	1.75–2.35
Non-Spanish-speaking Hispanic	668	2.40 $\pm$ 3.31	1.19 (0.52–2.80)	2.07–2.73
Other or unknown	396	2.58 $\pm$ 3.39	1.39 (0.56–3.26)	2.14–3.03

IQR = interquartile range; CI = confidence interval.

Table 4Logistic Regression Model of Adherence (PDC ≥ 0.8)^a for the 6532 Patients

Variable	OR (95% CI)	p Value
Distance to pharmacy	1.014 (0.999–1.029)	0.07
Distance to prescriber	0.994 (0.985–1.002)	0.16
Age ^b		
Female	1.055 (1.047–1.063)	<0.0001
Male	1.026 (1.016–1.035)	<0.0001
No. of pharmacies (reference = 1)		
2	0.920 (0.795–1.064)	0.26
3 or more	0.812 (0.612–1.076)	0.15
No. of prescribers (reference = 1)		
2	1.396 (1.233–1.580)	<0.0001
3 or more	2.208 (1.787–2.727)	<0.0001
Race-ethnicity (reference = Caucasian)		
African-American	0.545 (0.476–0.623)	<0.0001
Asian-American/Pacific Islander	0.981 (0.697–1.209)	0.54
Spanish-speaking Hispanic	0.539 (0.442–0.656)	<0.0001
Non-Spanish-speaking Hispanic	0.691 (0.568–0.840)	<0.0001
Other or unknown	0.705 (0.559–0.889)	0.003

PDC = proportion of days covered; OR = odds ratio; CI = confidence interval.

^aModel-fit statistics.^bDue to a significant age-by-sex interaction (p value<0.0001), odds ratios for age were computed for female and male.Pseudo R² statistics for logistic regression: Nagelkerke = 0.086, Tju r= 0.063, McFadden = 0.050.

Hosmer-Lemeshow goodness-of-fit test: p=0.72.