Health Facilities and Services Review Board

Real Travel Time in Illinois

Report Prepared for Policy Review

By

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Acknowledgments

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Report Summary

Background: The Illinois Administrative Code, in Parts 1110 and 1125, requires the Board to consider 30-minute or 45-minute travel times between proposed new and existing health care facility locations. These rules have been in place many years and needed to be updated, as traffic infrastructures and conditions may have drastically changed. In addition, travel time is not constant for a pair of points, but varies with traffic conditions. Therefore, basing the rule on travel distance (instead of travel time) will provide more accuracy for applicants and application review.

Objectives: (1) Estimate the average real travel time in three areas of Illinois, i.e., Chicago, Metropolitan Chicago (Metro area), and the remainder of the state (Rural area); (2) convert average real travel time to average travel distance; and (3) compute a distance multiplier for each area.

Data and Methods: This study, consistent with Section 1100.510, used Mapquest.com estimated travel time between two selected points of 10-mile distance. Starting points were random points and ending points were existing health care facilities. The size of sample of pair of points was 30 for Chicago, 20 for Metro, and 20 for Rural. We collected travel times for each pair of points every 15 minutes from 6:30am to 7:00pm on different weekday in September and November, 2016 and February, 2017. Mapquest.com updates the travel time for each street every 3-4 minutes, based on the posted speed limits on the road and the actual moving speeds of traffic. The actual speed of traffic is measured by app GPS data from MapQuest partner INRIX, which can detect speed changes and interruptions in traffic. We analyzed the data using IMB SPSS Statistics 20. We first evaluated the assumptions of no difference between round-trip and weekdays' travel time and the normality of sample measures and means distributions undergrounding the Central Limit Theorem. The assumption of no difference between round-trip travel times was met while the assumption about weekday travel time was not met. This finding directed us to collect one-way data at different days of the week to avoid unnecessary duplication while accounting for differences between days. The normality assumptions were also met, giving us strong confidence that our estimates means, standard errors, and confidence intervals are the best estimates of the true values in each study area.

Results: The average travel time for 10-mile drive was 30.50 ±0.19 minutes in Chicago area, 18.17 ± 0.096 minutes in Metro regions, and 14.360 ± 0.06 minutes in Rural area. The corresponding average distances for 30-minute travel time, was 10.48 ± 0.071 miles for Chicago, 17.01 ± 0.095 miles for Metro area, and 21.24 ± 0.08 miles for Rural area. For 45-minute travel time, the average distance was 15.72 ± 0.11 miles for Chicago, 25.52 ± 0.14 miles for Metro, and 31.86 ± 0.12 miles for rural areas. The travel distance distribution was closely normally distributed in Chicago and Metro area; however it was highly skewed in rural areas. Therefore, we suggest using the means values for Chicago and Metro areas and the median values for the Rural area in rule making. We used the mean travel distance of 10.48 miles in Chicago, 17.01 miles in Metro area, and the median value of 21.43 miles in the Rural area to compute the final distance multipliers. Rural area taking as the reference, the distance multiplier was 0.49 ± 0.007 for Chicago area, 0.79 ± 0.009 for Metro area, and 1 for Rural area. These multipliers suggest that on average, travel distance is nearly twice shorter in Chicago and one-time-and-a-quarter shorter in Metro area for a fixed drive time (i.e. 30 min or 45 min), compared to the Rural area.

Recommendations: We recommend the use of the 30-minute travel distance estimates for rule making. The analysis shows that these estimates are reliable, valid, and robust. Therefore, adjustment factors that reflect new data should be picked from the range 0.483 – 0.496 for Chicago and 0.785 – 0.799 for Metro area. The factors can be rounded for simplicity of rule making and in reference to current practical applications of the rule.

Introduction

The Illinois Certificate of Need (CON) program currently requires, in 77 Ill. Adm. Code 1100.510(d), a determination of travel time using MapQuest, Inc. and the application of an adjustment factor to determine the travel time based on the location of a proposed facility. Other rules require the Board and applicants to look at a 30 or 45-minute travel time. For instance, applications may require the Board to consider utilization of existing or approved healthcare facilities within a 45-minute travel of the proposed project size when considering service accessibility. *See* 77 Ill. Adm. Code 1110.530(c)(5)(A)(v), 630(c)(5)(A)(v), 730(c)(5)(A)(v), 1430(c)(5)(A)(v) *and* 1125.570(a)(5).

The assumptions about 30 or 45-minute travel time built in the current rules were established many years ago. The purpose of this study is to account for changes that have occurred in transportation infrastructures and urbanization since then. The mandatory use of MapQuest.com to map nearby facilities when preparing CON applications (77 Ill. Adm. Code 510(d)) also motivates the revision of the travel time criteria in the CON rules.

The issue arises that MapQuest has transitioned into using real-time traffic data to derive its travel times. The possible improvement of the accuracy of the average travel times conflicts with the variance of the travel times throughout the time of day, as traffic patterns shift. For example, a facility creating a map of nearby facilities at 5:00 PM might end up with a more condensed area than one creating the same map at 10:00 AM. Acknowledging these factors that impact travel time estimates, the Health Facilities and Services Review Board aims to implement distance standards, instead of time standards, in order to reflect a more consistent rule of travel time requirements used in CON application review.

This report uses MapQuest traffic data to estimate average travel time and distance for the three CON defined areas, which include (1) Chicago, (2) Chicago Metro, Winnebago, Sangamon, Champaign, and Peoria, and (3) the rural areas (remaining areas of the state) of the state. We draw a sample of 10-mile routes from each area and use repeated measures method to collect the data, as travel time may change throughout a day

and between days due to road conditions, weather, and travelers' schedules. We analyzed the data using IMB SPSS Statistics 20. We first evaluate the assumptions of no difference between round-trip and weekdays' travel time to guide the data collection for the estimation and the normality of sample measures and means distributions undergrounding the Central Limit Theorem to ensure that our sample means are the best estimates of the true values in each area.

The next sections in this report cover the methodology—which includes theoretical approach, sampling, data collection, and data analysis methods—the results—which include the hypothesis testing and the mean, standard error, and confidence interval estimates—discussions, recommendation, and conclusion. We hope the findings of this study will help review the current CON rules on travel time.

Methodology

Theoretical Background

In this study, we use repeated measures method to improve the accuracy of the estimate of the "true value" of the travel time and distance's mean, standard error, and confidence interval of the mean in each of the three study areas (Chicago, Metro, and Rural). Travel time changes throughout the day and from day to day; therefore, measuring this variable several times in a day and over different days of the week is crucial in this study. Repeated measures design allows measuring a dependent variable of a sample under a number of different conditions over time (Frison, & Pocock, 1992; Scheiner & Gurevitch, 2001). We use this method in the logic of the Central Limit Theorem (CLT), which provides that the mean of the means obtained from *all (or infinite)* random samples of sufficiently large finite size would equal the true population mean (Henk, 2004; Hoeffding & Robbins,1948; Kellstedt & Whitten, 2013). In the case of finite number of samples, the sample means should be normally distributed, their mean is the best approximation of the true population mean, and their standard deviation is the standard error of their mean to the true population mean. Repeated measure method designed with the CLT logic is therefore more robust than a single measure method in estimating a population mean.

Sampling and Data Collection

Sampling. Following the CLT logic, we selected a random sample of streets in each study area and repeatedly measure the time it takes (travel time) to go from point A (a health facility address in most cases) to point B (a random location) at different times of the day. The starting points were randomly selected and the ending points were chosen to have an approximate distance of 10 miles. The areas which were assumed to vary in travel times per mile were outlined in 77 Ill. Adm. Code 1100.510(d), where part 1 defines the City of Chicago, part 2 defines the Greater Chicago Metropolitan Area including DuPage, Will, Kendall, Kane, McHenry, Lake, and Grundy, Winnebago, Peoria, Sangamon, and Champaign Counties (hereafter referred to as "Metro"), and part 3 defines other areas, including rural areas and most of Southern Illinois. The distance from point A to B was 10 miles for each location to control for distance-differential bias. The sample sizes are 30 for Chicago area, 20 for Metro area, and 20 for Rural area, which are sufficient for performing statistical tests (e.g., normality test, and test of equal variance) needed in this study. We repeated measuring the travel time every 15 minutes from 6:30 am to 7 pm on each sample street for a total of 51 measures in a day. The period of 6:30 am to 7 pm capture both the peak time and non-peak times in a typical day. We repeated the measures every 15 minutes for convenience.

Data Collection. We used mapquest.com real time travel time estimate as measure in this study. Mapquest.com estimates travel time based on the posted speed limits on the road and the actual moving speeds of traffic. The actual speed of traffic is measured by app GPS data from MapQuest partner INRIX, which can detect speed changes and interruptions in traffic. MapQuest updates traffic and road conditions every 3 to 4 minutes (MapQuest, 2017).

We collected a first series of data to test the significance of daily and back-and-forth variations of travel time on the same route. A total of 4 streets randomly selected from each original sample (as previously defined) were used to collect extensive data each day over 3 weeks. The Metro area's sample streets were located in Rockford, Peoria, Champaign-Urbana, and Springfield and that of the rural were located in Marion, Olney, Macomb, and Streator. The Chicago's sample streets had Mercy Medical on Pulaski as the end point. The starting points were selected in the north, south, east, and west of the health care facility. The Chicago streets data was collected every 15 minutes on Mondays and Tuesdays from 8:30 am to 5pm and

Thursdays from 8:30am to 1:30pm. A similar process was followed for the 4 sample streets in the metro and rural areas. Example of screenshots of the MapQuest maps and times can be seen in Appendices B through E.

The second series of data we collected was to estimate the travel-time mean, standard error, and confidence interval of the mean in each of the three study areas (Chicago, Metro, and Rural). The samples' specifications remain the same as previously defined in sampling.
The data was collected from September through November 2016 and in February 2017 in an attempt to account for both good and bad weather. Some days were skipped. The periodicity of data collection was every 15 minutes from 6:30 am to 7:00 pm during weekdays.

Data Analysis. We analyzed the data using the IBM SPSS Statistics 20 software. In the first part of the data analysis, we tested two assumptions that allow us to increase our sample while avoiding unnecessary duplication of data and accounting for daily variation. The first assumption we tested was that travel distances per 10 miles do not vary significantly when traveling from point A to point B and traveling from point B to point A in our samples. We used two-independent sample t-tests to evaluate this assumption. This test assumes that the difference between the means of the two samples is not significant; therefore, we accept this hypothesis when the p-value is higher than 0.05.

The second assumption we tested was that there was no significant difference between weekday travel distances for the same time. We only tested the distributions for Monday and Tuesday, as knowing if the travel-time distribution is different at least for two different days of the week is sufficient. We used the t-test to assess this assumption. This test assumes that the difference in means between the two distributions is not significant. We accept this hypothesis when p-value is higher than 0.05.

In the second part of the data analysis, we verified the normality assumptions and provided the estimates of the means, standard errors, and confidence intervals of the means. As our samples were randomly selected, we expect a normal distribution of all the 51 samples and means for each study area. We use the Shapiro-Wilk test to verify the normal distribution assumption. The null hypothesis in this test is that the distribution of our dataset is not significantly different from a normal distribution. Therefore, normal distribution is assumed when the p-value is higher than 0.05. Once the normality requirement is met, the mean of the

sample means should be considered as the unbiased estimate of the true mean of travel time in each area.

We finally provide the estimated travel-time means, standard errors, and confidence intervals of the means in term of travel-distance for the need of CON rule making. 10-mile travel time data (T_0) converts to travel distance data (D_i) for chosen travel times (T_i), with the following formula: $D_i = \frac{10\ miles}{T_0} \times T_i$, where i varied from 1 to 2 with T_1 =30 min, T_2 = 45. The mean in term of travel distance is a factor of the harmonic mean of travel time. We use the transformed data to compute distance boundaries (95% confidence interval of the mean values) that CON application reviewers can use for each distinguished area of Illinois.

Results

Hypothesis Testing

Difference of Travel Time in Round Trip

The first assumption we tested was that travel distances per 10 miles do not vary significantly when traveling from a specific location to a health care facility and traveling from the health care facility back to the location. Table 1 summarizes the results of this test. The probability (p) of making the error of rejecting the hypothesis that the variation of the distances traveled from point A to point B and from point B to point A is not significant when this hypothesis is actually true is higher than 0.05 (the acceptable level of error) for each area. Table 1 show that the p-value was 0.227 for Chicago, 0.503 for the Metro, and 0.072 for the Rural. Therefore, we do not have enough evidence to reject the hypothesis that there is no significant difference between the travel times going from point A to point B and coming from point B to point A using the same route of 10 mile in each area. This result allows us to assume that travel direction does not matter in collecting data for our estimations.

Table 1: SPSS output for Independent Samples T-Test for Round Trip Travel Times

Group Statistics

Area		TravelType	N	Mean	Std. Deviation	Std. Error Mean
Chicago	Round Trip	Travel to a health care facility	35	30.63214	2.828255	.478062
		Travel from a health care facility	35	31.37857	2.265974	.383019
Metro	Round Trip	Travel to a health care facility	35	19.10000	.829599	.140228
		Travel from a health care facility	35	19.21786	.621566	.105064
Rural	Round Trip	Travel to a health care facility	35	15.23571	.477212	.080664
		Travel from a health care facility	35	15.01429	.535308	.090484

Independent Samples Test

			Levene's Test for Equality of Variances		t-test for Equality of Means						
										95% Confidence Interval of the Difference	
Area			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Chicago	Round Trip	Equal variances assumed	1.557	.216	-1.219	68	.227	-.746429	.612575	-1.968802	.475945
		Equal variances not assumed			-1.219	64.912	.227	-.746429	.612575	-1.969856	.476999
Metro	Round Trip	Equal variances assumed	2.539	.116	-.673	68	.503	-.117857	.175221	-.467505	.231790
		Equal variances not assumed			-.673	63.026	.504	-.117857	.175221	-.468005	.232291
Rural	Round Trip	Equal variances assumed	.175	.677	1.827	68	.072	.221429	.121218	-.020459	.463316
		Equal variances not assumed			1.827	67.122	.072	.221429	.121218	-.020516	.463373

Difference of Travel Time between Weekdays

The second assumption we tested was that there was no significant difference between weekday travel distances for the same time. This hypothesis was tested for the different areas using only Monday and Tuesday data. The t-test results are shown in Table 2. Travel time was significantly different between Monday and Tuesday for all three areas. The p-value was 0.019 for Chicago, 0.000 for Metro, and 0.000 for Rural. This result suggests we should collect our data to account for day-to-day variations in travel times.

Table 2: SPSS output for Independent Samples T-Test for Weekday Travel Times

Group Statistics

Areas		Day	N	Mean	Std. Deviation	Std. Error Mean
Chicago	Travel Time	Monday	41	31.692245	1.9472521	.3041097
		Tuesday	41	30.554962	2.3355175	.3647465
Metro	Travel Time	Monday	41	18.442954	1.2695447	.1982696
		Tuesday	41	19.310976	.8531934	.1332464
Rural	Travel Time	Monday	41	13.678281	1.0090114	.1575811
		Tuesday	41	15.271341	.5390258	.0841817

Independent Samples Test

			Levene's Test for Equality of Variances		t-test for Equality of Means						
										95% Confidence Interval of the Difference	
Areas			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Chicago	Travel Time	Equal variances assumed	6.379	.014	2.395	80	.019	1.1372822	.4748924	.1922163	2.0823481
		Equal variances not assumed			2.395	77.494	.019	1.1372822	.4748924	.1917469	2.0828176
Metro	Travel Time	Equal variances assumed	2.925	.091	-3.634	80	.000	-.8680217	.2388837	-1.3434155	-.3926279
		Equal variances not assumed			-3.634	70.010	.001	-.8680217	.2388837	-1.3444590	-.3915843
Rural	Travel Time	Equal variances assumed	17.106	.000	-8.917	80	.000	-1.5930604	.1786571	-1.9485994	-1.2375214
		Equal variances not assumed			-8.917	61.111	.000	-1.5930604	.1786571	-1.9502942	-1.2358266

Normality of Data

Distributions of the 15-minute Measurements. Most of the travel time distributions were normally distributed in Chicago and Metro, except the 4 pm distribution in Chicago (p=0.041), and the 8:30 am (p=0.023) and 2:45pm (p=0.048) distributions in the Metro area. The p-values are reported in the last column of Appendix G (Chicago) and H (Metro) tables. These isolated cases of non-normality distribution may relate to randomness. Most of the travel time distributions in rural area were not normally distributed. Appendix I shows the normality test results for the Rural area. The general normality of the individual samples gives credibility to the CLT assumptions, that the mean of sampling means from normally distributed samples should accurately approximate the population mean.

Distribution of the Means. The sampling means for the Chicago and Metro areas were also normally distributed (p= 0.785 for Chicago and p=0.323 for Metro). This result shows that the sample data for these areas meet the CLT assumptions for approximating a population mean. The Rural sampling means were not normally distributed (p=0.022). This result was not surprising, given the observed uniformity of the travel time data for Rural areas. For this reason (uniform distribution), the mean of the sampling means for the Rural area may also approximate the population mean, as well.

Table 3: Normality test results for the mean distributions

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Area	Statistic	df	Sig.	Statistic	df	Sig.
Mean	Chicago	.085	30	.200*	.979	30	.785
	Metro Area	.132	20	.200*	.947	20	.323
	Rural Area	.230	20	.007	.885	20	.022

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Estimate of Means, Standard Errors, and Confidence Intervals

Chicago

In Chicago, the mean travel time for 10-mile drive is 30.50 minutes (95%CI: 30.13 – 30.87) and the median value is 30.50 minutes. The mean travel distance for 30-minute drive is 10.48 miles (95% CI: 10.34 – 10.62) with a median value of 9.83 miles and, for 45-minute drive, 15.72 miles (CI: 15.51-15.93) with a median value of 14.75 miles (table 4). The travel distance distributions is moderately skewed (skw = 0.925 ± 0.063) toward higher values, as figures 2 and 3 show. Figure 1 shows a more acceptable normal distribution of the travel time sample means, which is confirmed by the approximately equal values of the mean (30.498 min) and the median (30.50 min). Figure 1 also shows that the travel time modal value for 10-mile drive is nearly 31 minutes, which is very close to the mean and the median values.

Table 4: Estimates of mean travel time and distance for Chicago

Descriptives[a]

	Area			Statistic	Std. Error
Travel Time (min) per 10 miles	Chicago	Mean		30.497680	.1897974
		95% Confidence Interval for Mean	Lower Bound	30.125389	
			Upper Bound	30.869970	
		5% Trimmed Mean		30.386311	
		Median		30.500000	
		Variance		55.115	
		Std. Deviation		7.4239653	
		Minimum		15.0000	
		Maximum		54.0000	
		Range		39.0000	
		Interquartile Range		11.0000	
		Skewness		.192	.063
		Kurtosis		-.532	.125
Travel Distance (miles) per 30 minutes	Chicago	Mean		10.4824	.07104
		95% Confidence Interval for Mean	Lower Bound	10.3430	
			Upper Bound	10.6217	
		5% Trimmed Mean		10.3069	
		Median		9.8361	
		Variance		7.721	
		Std. Deviation		2.77867	
		Minimum		5.56	
		Maximum		20.00	
		Range		14.44	
		Interquartile Range		3.67	
		Skewness		.925	.063
		Kurtosis		.669	.125
Travel Distance (miles) per 45 minutes	Chicago	Mean		15.7236	.10656
		95% Confidence Interval for Mean	Lower Bound	15.5146	
			Upper Bound	15.9326	
		5% Trimmed Mean		15.4603	
		Median		14.7541	
		Variance		17.372	
		Std. Deviation		4.16800	
		Minimum		8.33	
		Maximum		30.00	
		Range		21.67	
		Interquartile Range		5.50	
		Skewness		.925	.063
		Kurtosis		.669	.125

a. Area = Chicago

Figure 1: Distribution of sample travel time means for 10-mile drive in Chicago

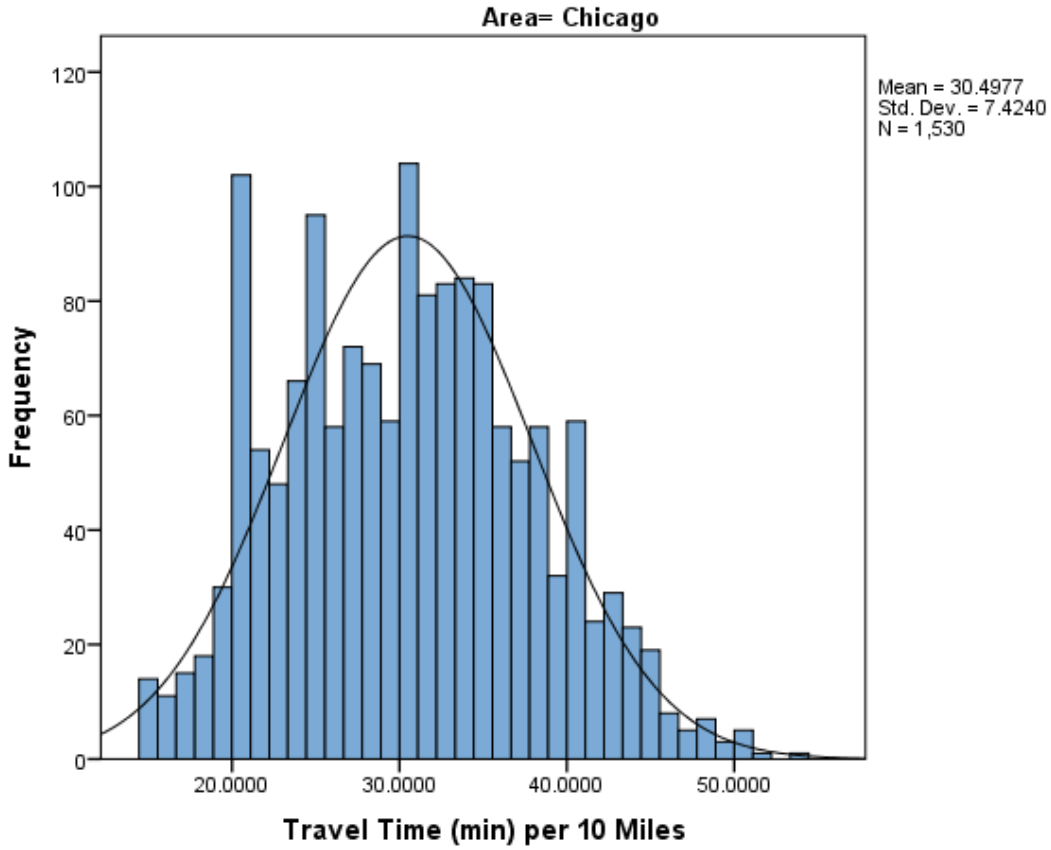


Figure 2: Distribution of sample travel distance means for 30-minute drive in Chicago

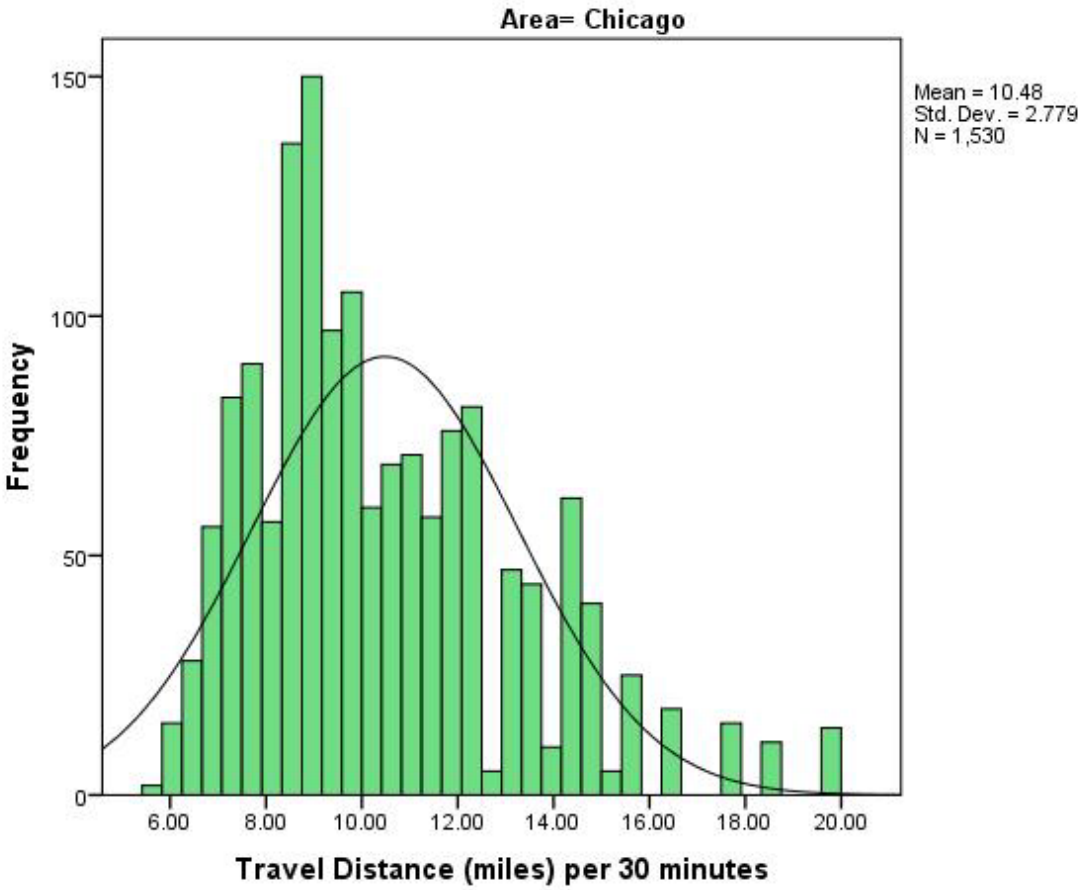
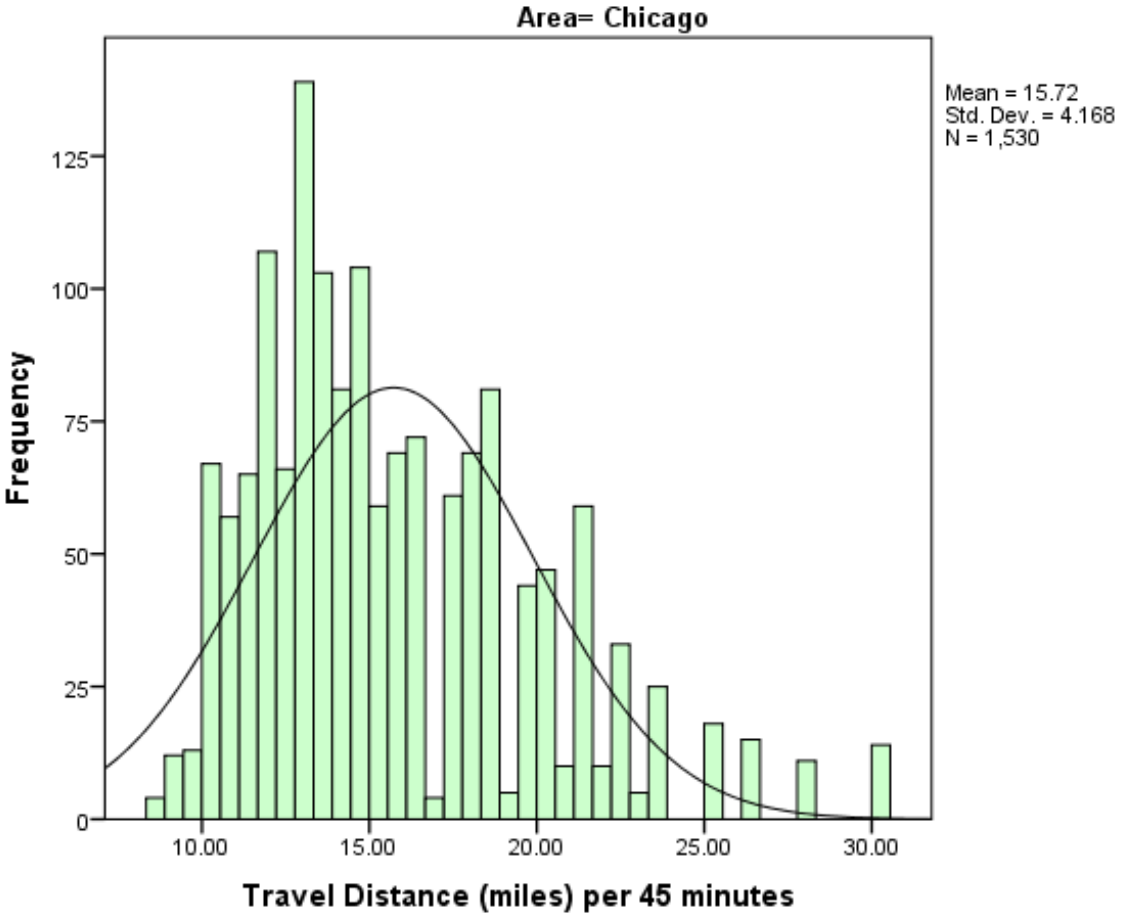


Figure 3: Distribution of sample travel distance means 45-minute drive in Chicago



Metro Area

In the Metro area, the mean travel time for 10-mile drive is 18.17 minutes (95%CI: 17.98– 18.35) and the median value is 18.00 minutes. The mean travel distance for 30-minute drive is 17.01 miles (95% CI: 16.83 – 17.20) with a median value of 16.67 miles, and for 45-minute drive, 25.52 miles (CI: 25.24-25.80) with a median value of 25.00 miles (table 5). The travel time distribution is very slightly skewed (skw=-0.002±0.077) toward lower values and the mean is very close to the median value. Figure 4 shows that the distribution compares acceptably to a normal distribution. The travel distance distributions is moderately skewed (skw = 0.593 ± 0.077) toward higher values (figures 5 and 6).

Table 5: Estimates of mean travel time and distance for Metro area

Descriptives[a]

	Area			Statistic	Std. Error
Travel Time (min) per 10 miles	Metro	Mean		18.166683	.0957242
		95% Confidence Interval for Mean	Lower Bound	17.978844	
			Upper Bound	18.354522	
		5% Trimmed Mean		18.127215	
		Median		18.000000	
		Variance		9.346	
		Std. Deviation		3.0571868	
		Minimum		12.0000	
		Maximum		27.0000	
		Range		15.0000	
		Interquartile Range		4.0000	
		Skewness		-.002	.077
		Kurtosis		-.714	.153
Travel Distance (miles) per 30 minutes	Metro	Mean		17.0126	.09449
		95% Confidence Interval for Mean	Lower Bound	16.8272	
			Upper Bound	17.1980	
		5% Trimmed Mean		16.9222	
		Median		16.6667	
		Variance		9.107	
		Std. Deviation		3.01781	
		Minimum		11.11	
		Maximum		25.00	
		Range		13.89	
		Interquartile Range		3.75	
		Skewness		.593	.077
		Kurtosis		-.606	.153
Travel Distance (miles) per 45 minutes	Metro	Mean		25.5189	.14174
		95% Confidence Interval for Mean	Lower Bound	25.2408	
			Upper Bound	25.7970	
		5% Trimmed Mean		25.3832	
		Median		25.0000	
		Variance		20.491	
		Std. Deviation		4.52671	
		Minimum		16.67	
		Maximum		37.50	
		Range		20.83	
		Interquartile Range		5.63	
		Skewness		.593	.077
		Kurtosis		-.606	.153

a. Area = Metro

Figure 4: Distribution of sample travel time means for 10-mile drive in Metro area

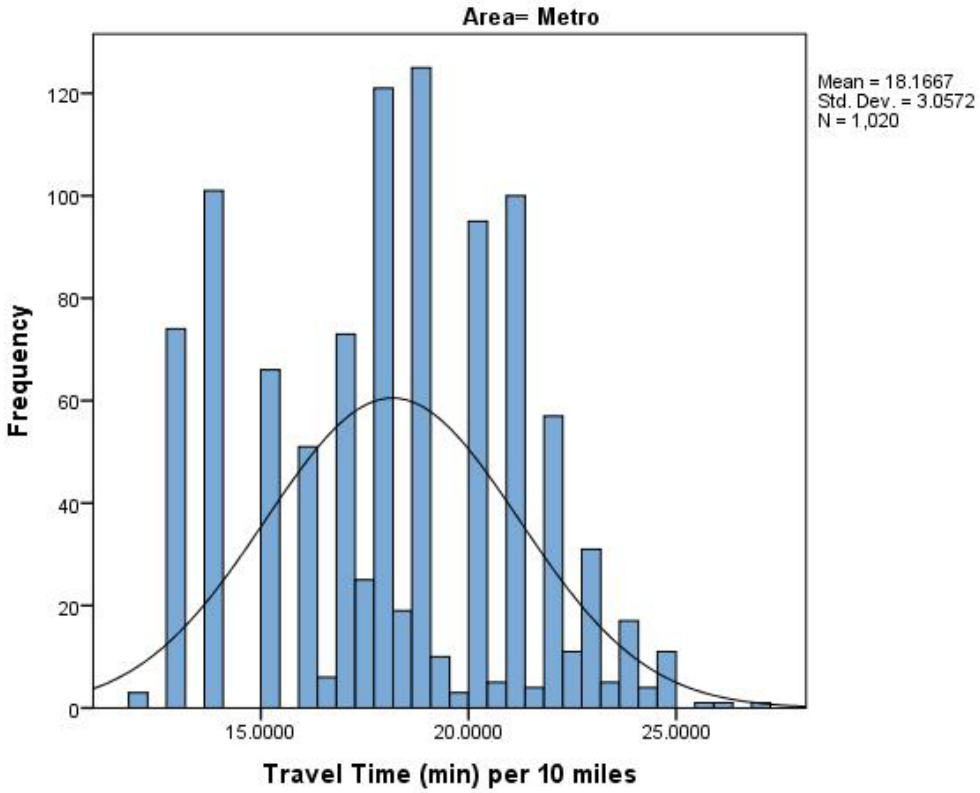


Figure 5: Distribution of sample travel distance means 30-minute drive in Metro area

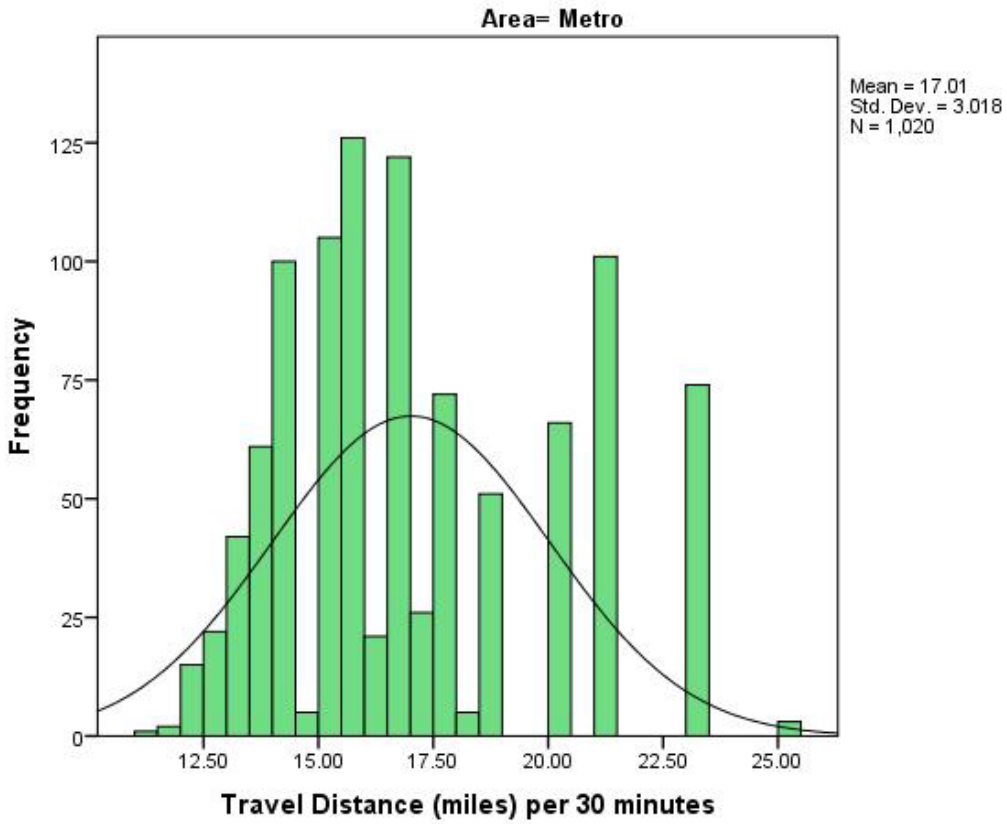
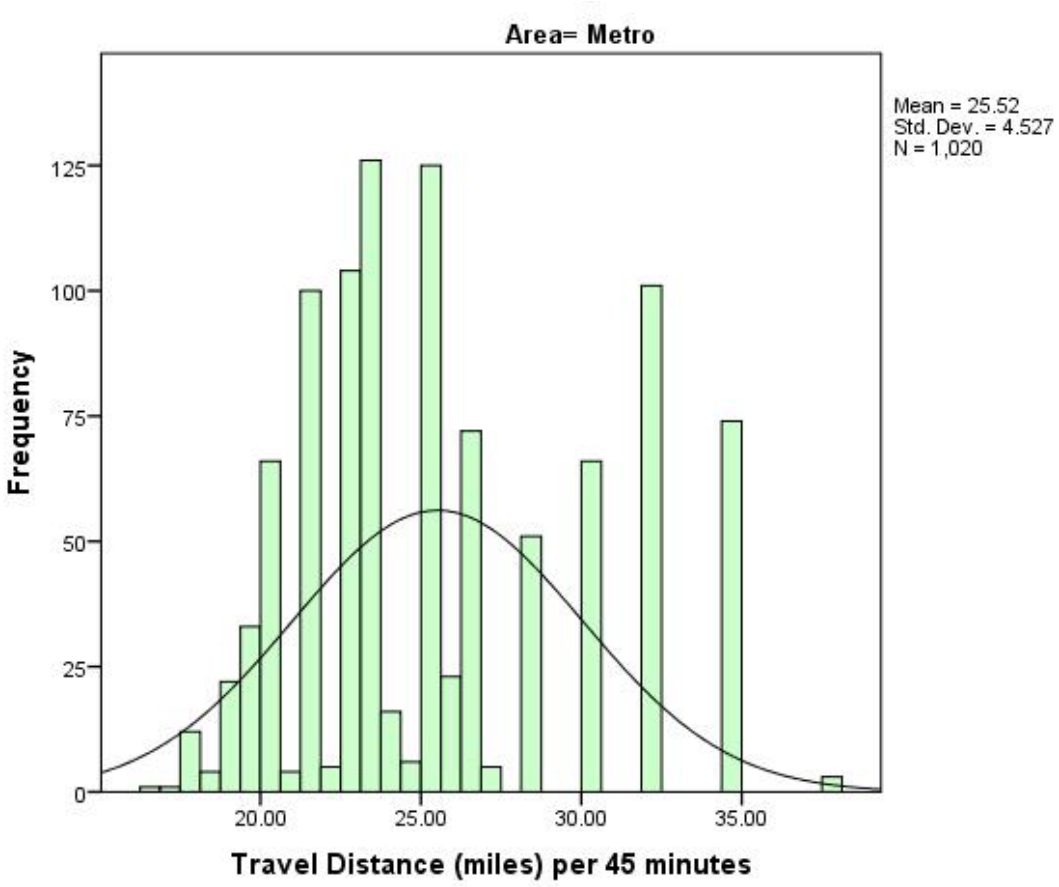


Figure 6: Distribution of sample travel distance means 45-minute drive in Metro area



Rural Area

In the Rural area, the mean travel time for 10-mile drive is 14.36 minutes (95%CI: 14.24–14.49) and the median value is 14.00 minutes. The mean travel distance for 30-minute drive is 21.24 miles (95% CI: 21.08 – 21.39) with a median value of 21.43 miles, and for 45-minute drive, 31.86 miles (CI: 31.62-32.09) with a median value of 32.14 miles (table 6). The travel time distribution is highly skewed (skw=1.505±0.077) toward higher values. Figure 7 shows differences between the distribution and a normal distribution. The travel distance distributions are skewed toward lower values (skw = -0.611 ± 0.077) (figures 7 and 8). These finding suggest the use of median values (instead of the mean values) for rule making.

Table 6: Estimates of mean travel time and distance for Rural Area

Descriptives[a]

	Area			Statistic	Std. Error
Travel Time (min) per 10 miles	Rural	Mean		14.358007	.0615555
		95% Confidence Interval for Mean	Lower Bound	14.237216	
			Upper Bound	14.478797	
		5% Trimmed Mean		14.178831	
		Median		14.000000	
		Variance		3.865	
		Std. Deviation		1.9659256	
		Minimum		11.0000	
		Maximum		25.0000	
		Range		14.0000	
		Interquartile Range		2.0000	
		Skewness		1.505	.077
		Kurtosis		3.172	.153
Travel Distance (miles) per 30 minutes	Rural	Mean		21.2368	.07989
		95% Confidence Interval for Mean	Lower Bound	21.0800	
			Upper Bound	21.3936	
		5% Trimmed Mean		21.3608	
		Median		21.4286	
		Variance		6.510	
		Std. Deviation		2.55148	
		Minimum		12.00	
		Maximum		27.27	
		Range		15.27	
		Interquartile Range		3.08	
		Skewness		-.611	.077
		Kurtosis		.388	.153
Travel Distance (miles) per 45 minutes	Rural	Mean		31.8552	.11983
		95% Confidence Interval for Mean	Lower Bound	31.6200	
			Upper Bound	32.0903	
		5% Trimmed Mean		32.0412	
		Median		32.1429	
		Variance		14.648	
		Std. Deviation		3.82722	
		Minimum		18.00	
		Maximum		40.91	
		Range		22.91	
		Interquartile Range		4.62	
		Skewness		-.611	.077
		Kurtosis		.388	.153

a. Area = Rural

Figure 7: Distribution of sample travel time means for 10-mile drive in Rural area

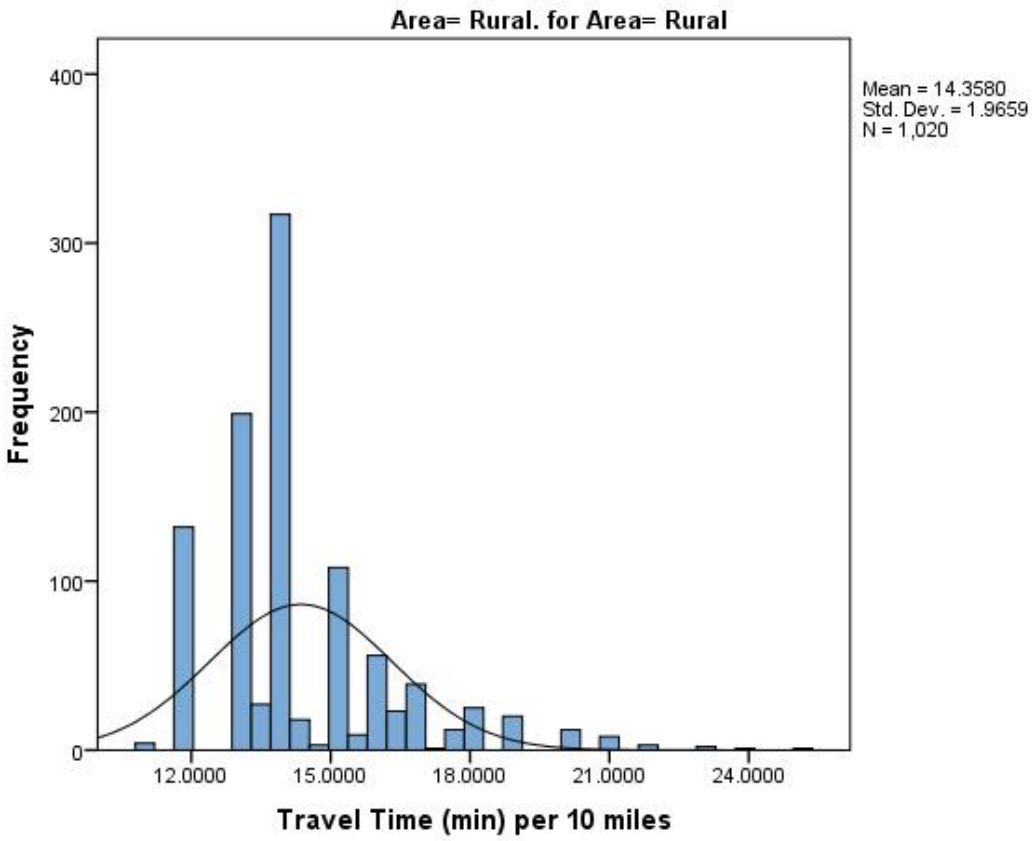


Figure 8: Distribution of sample travel distance means 30-minute drive in Rural area

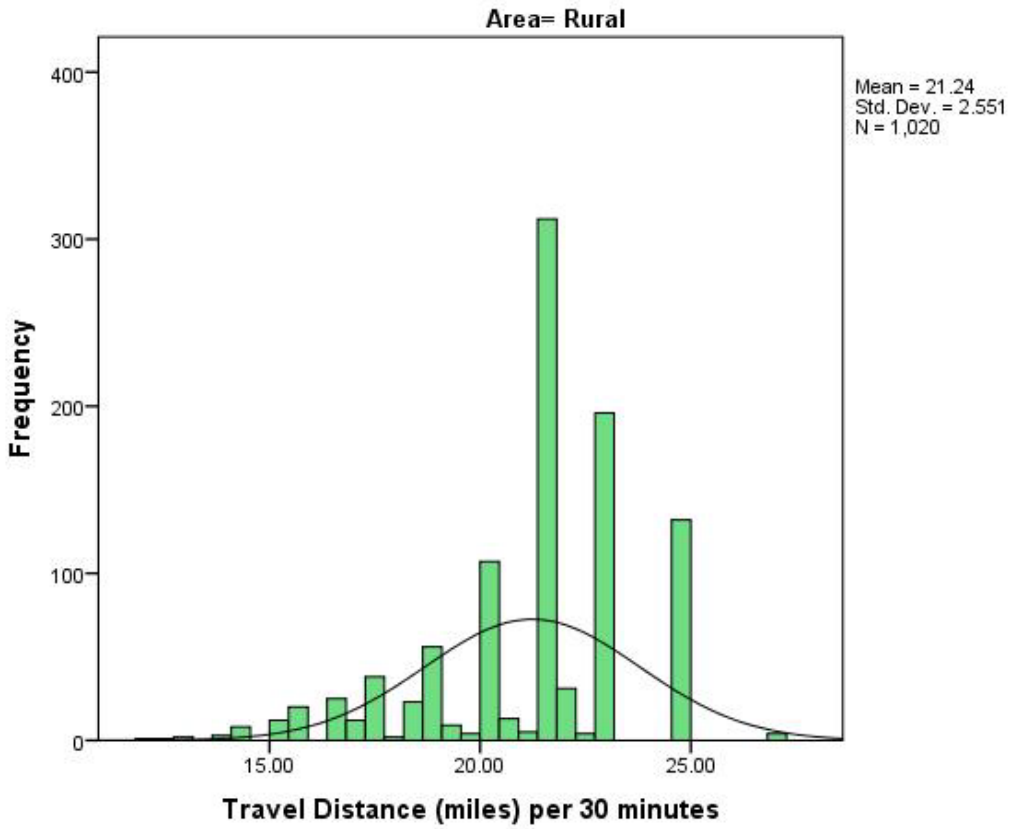
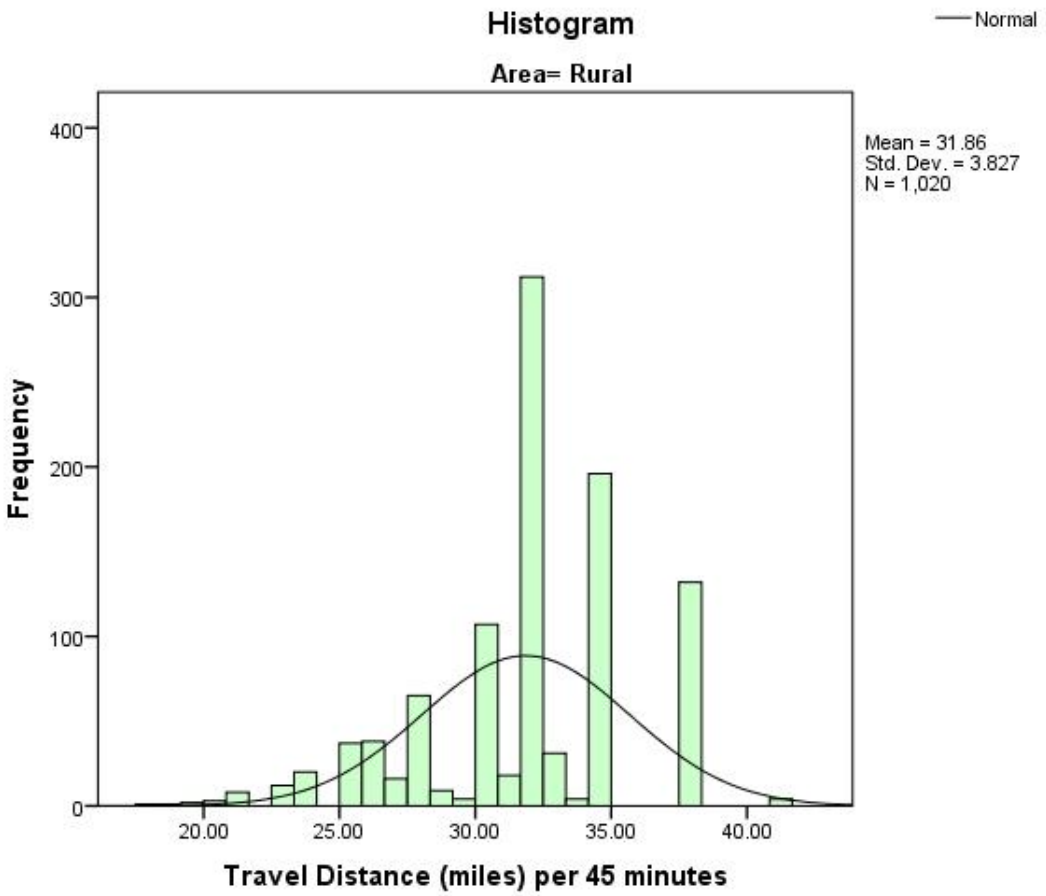


Figure 9: Distribution of sample travel distance means 45-minute drive in Rural area



Distance Multipliers

Distance multiplier is herein defined as the ratio of the travel distance of a given area to the travel distance of a reference area: *Area travel distance/reference area travel distance.*

Considering the Rural area as the reference with a median travel distance of 21.43 miles for 30-minute drive and 32.14 miles for a 45-mile drive, the estimates of the distance multipliers are:

- Chicago :
  - $\frac{10.34}{21.43}$; $\frac{10.48}{21.43}$; $\frac{10.62}{21.43}$ => 0.4825; 0.4890; 0.4956 for 30-minute drive
  - $\frac{15.52}{32.14}$; $\frac{15.72}{32.14}$; $\frac{15.93}{32.14}$ => 0.4829; 0.4891; 0.4956 for 45-minute drive
- Metro area:
  - $\frac{16.83}{21.43}$; $\frac{17.01}{21.43}$; $\frac{17.12}{21.43}$ => 0.7854; 0.7938; 0.7999 for 30-minute drive
  - $\frac{25.24}{32.14}$; $\frac{25.52}{32.14}$; $\frac{25.80}{32.14}$ => 0.7853; 0.7940; 0.8027 for 45-minute drive

These multipliers suggest that on average, travel distance is nearly twice shorter in Chicago and one-time-and-a-quarter shorter in Metro area for a fixed drive time (i.e. 30 min or 45 min), compared to the Rural area. Table 7 provides a summary of the estimates.

Table 7: Summary of estimated values

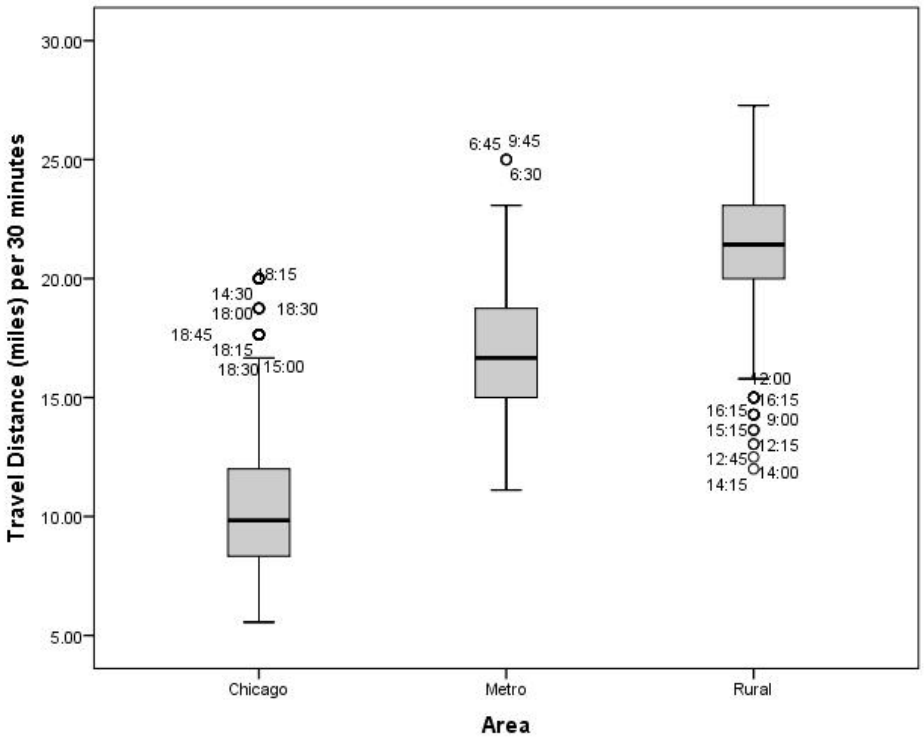
		Travel Distance (miles)			95% Confidence Interval of the mean		Distance Multiplier		
Travel Time Assumption	Area	Median	Mean	Standard Deviation	Lower Bound	Upper Bound	Lower Bound	Mid point	Upper Bound
30-minute travel time	Chicago	9.84	10.48	2.78	10.34	10.62	0.483	0.489	0.496
	Metro	16.67	17.01	3.02	16.83	17.12	0.785	0.794	0.799
	Rural	21.43	21.24	2.55	21.08	21.39	-	1.00	-
45-minute travel time	Chicago	14.75	15.72	4.17	15.52	15.93	0.483	0.489	0.496
	Metro	25.00	25.52	4.53	25.24	25.80	0.785	0.794	0.803
	Rural	32.14	31.86	3.83	31.62	32.09	-	1.00	-

Discussions

This study aims to estimate the mean travel time, mean distance, and distance multiplier in the three CON defined areas (Chicago, Chicago metro, and rural area) of Illinois. In reference to the Central Limit Theorem (CLT), the use of random sampling and repeated measures method to collect the data for this study increased the reliability and validity of the estimates. For each study area, we repeatedly measure travel time on the same sample 51 times per day many days from September 2016 to February 2017. This procedure helped account for most of road conditions that affect travel time in each area, making our estimates more realistic. Therefore, these estimates are best linear and unbiased estimates (BLUE) of the "true values". The Chicago and Metro area data met the normality requirement of the CLT. The Rural area data did not meet the normality assumption; however, the estimates may remain valid due to repeated measures. Also, the travel time sample means were very close, varying from 14.90 minutes to 13.78 minutes (Appendix F).

The 30-minute drive travel distance estimates show higher reliability than the 45-minute drive estimates, as the standard deviations—and the standard errors—in the first case are lower than the standard deviations in the second case (table 7). Choosing the 30-minute drive travel time estimates for rule making, we preferred the means values for Chicago and Metro areas and the median value for the Rural area. Indeed, the distributions of the travel time and distance were moderately skewed for Chicago and slightly skewed for Metro; whereas the distributions were highly skewed (skewness > 1) in Rural area due to presence of outliers. When the distribution is highly skewed, the median better represents the central tendency of the distribution than the mean, as outliers do not influence the median. On the other hand, with the mean, the outliers skew the mean toward the outliers. For example, for the 30-minute drive data, the interquartile range (IR) was 3.08 miles and the maximum value was 27.27 miles, which is higher than 3 times the IR (table 6). Figure 10 shows the outliers in terms of distance for 30-travel time for each area. The outliers were high values in Chicago and Metro whereas in Rural area they were lower values. For instance, highest travel distances were recorded at 2:30 pm, 3:30pm, and from 6:00pm to 6:45pm. In rural area, lowest values were recorded at 9:00am, from 12:00pm to 12:45pm, and from 2:00pm to 4:15pm. We recall that high travel distances correspond to low travel times due to data transformation formula (refer to page 10).

Figure 10: box plot showing travel distance outliers in Chicago, Metro, and Rural areas.



Considering Rural area as the reference, the point estimate of the distance multiplier is 0.49 for Chicago and 0.79 for Metro area, which means that on average, travel distance is nearly twice shorter in Chicago and one-time-and-a-quarter shorter in Metro area for a fixed-drive time, compared to the Rural area. The interval estimate for the distance multiplier, computed using the 95% confidence interval of the mean travel distances, is 0.483 to 0.496 for Chicago and 0.785 to 0.799 for Metro area. Current multipliers apply to travel time and are 1.25 for Chicago and 1.15 for Metro area (Section 1100.510 (d)). Compared to our estimates on time scale, the multiplier for Chicago increased from 1.25 to 2.00 and that of Metro area increased from 1.15 to 1.27. These increases are consistent with the factual increase in traffic density due to population and automotive growth. Indeed, this study achieves its objective of updating the current multiplier using real traffic data.

Further consideration was given to 77 Ill. Adm. Code 1100.510(d) as well in the process of creating this report. Data points were taken in accordance with the original rule, but in reality the data may be too general to apply to city limits. It may be more reasonable, then, to consider a change. The aim of this change would be to more accurately group larger counties adjacent to

Chicago with Chicago rather than counties with far less traffic. Because this was not the focus of this study, we are not making a recommendation at this time. However, we suggest that future studies examine adding the entire county of Cook, as well as DuPage, Will, Lake and Kane counties in part 1 of the rule as the new "Chicago" area. One factor to consider is the significant increase in population density to these top five counties from the next highest county by density (highest being Cook at 5495.1 people/sq mi, lowest being Will at 809.6 people/ sq mi): Winnebago (575.2 people/sq mi), as well as projected population increases in DuPage, Will, Lake, and Kane counties. Similarly, the study should explore adding excluded counties with larger population densities than Champaign County (201.8 people/ sq mi) to the Metro region up to Winnebago at 575.2 people/sq mi. This may add Tazewell, Rock Island, Madison, and St Clair county to part 2 of the rule as "Metro" areas. The other areas may include all other counties, from densities of 12.1 people/sq mi in Pope County to 193 people/sq mi in Boone County.

Some limitations of this study include representativeness of the selected traffic periods and roads for data collection. Traffic in the Chicago area drastically change throughout the days whereas in the Metro and rural areas, the traffic shows some stability. Our data collection only covers some days between September and November 2016 and during February 2017, from 6:30 am to 7:00 pm. Traffic during the missing periods of the year and between 7 pm to 6 am may be different from the considered periods and times in this study. We also control for distance by limiting traffic time data collection to 10 miles of travel distance for each selected streets. This procedure may not allow for measuring scarcity in flat travel time estimates. Places further away than the standardized distance in rural areas might affect the utilization of such facilities much more than closer facilities would in downtown Chicago, regardless of having a longer travel time.

Conclusion and Recommendations

In this study, we estimated the mean travel time, mean distance, and distance multiplier in the three CON defined areas of Illinois: Chicago, Chicago metro, and rural area. The mean travel time was 3.05 ±0.19 minutes per mile in Chicago area, 1.80 ± 0.096 minutes per mile in Metro area, and 1.40 ± 0.06 minutes per mile in the rest of the state (rural area). The corresponding average distances for 30-minute travel time, is 10.48 ± 0.071 miles for Chicago, 17.01 ± 0.095 miles for Metro area, and 21.24 ± 0.08 miles for Rural area. For 45-minute travel

time, the average distance was 15.72 ± 0.11 miles for Chicago, 25.52 ± 0.14 miles for Metro area, and 31.86 ± 0.12 miles for Rural area. The travel distance distribution show acceptable normal distribution for Chicago and metro areas but was highly skewed toward lower values in rural areas. Therefore, we suggest using the median values instead of the means values for the rural area and the means values for the Chicago and Metro areas. For 30-minute travel time, the mean travel distance was 10.48 miles in Chicago, 17.01 miles in Metro area; the median value was 21.43 miles in Rural area. The corresponding distance multiplier was 0.49 ±0.007 for Chicago, 0.79 ± 0.009 for Metro, and 1 for rural area (the reference). These values are the best estimates of the "true values," as the underlining data met the theoretical requirements for approximating the "population" parameters.

We recommend:

- Use of these estimated multipliers to update the CON normal travel distance rule. The distance multiplier for rule making should be approximately 0.49 for Chicago area, 0.79 for Metro area, and 1.00 for Rural area.
- Further studies may redefine the sample of roads (point A to B) and time period for data collection to improve representativeness. It should also consider differentiating travel distance estimates for hospital, long-term care and other CON regulated health care facilities (i.e., dialysis centers and ambulatory surgical centers).
- Further studies may examine changing the different regions in Part 1, 2 and 3 of 77 Ill. Adm. Code 1100.510(d). Part 1 might include the full counties of Cook, Lake, DuPage, Kane, and Will, – the top 5 Illinois counties by population density. Part 2 might include the remaining Chicago Metro area: Kankakee, Grundy, Kendall, DeKalb, McHenry, Lake, Winnebago, Champaign, Sangamon, Peoria, Tazewell, Rock Island, Madison, and St Clair counties. Part 3 might include all other areas of Illinois.

References

Frison, L. and Pocock, S. J. (1992), *Repeated measures in clinical trials: Analysis using mean summary statistics and its implications for design*. Statist. Med., 11: 1685–1704. doi:10.1002/sim.4780111304.

Henk, T. (2004). Understanding probability: Chance rules in everyday life. Cambridge: Cambridge University Press.

Hoeffding, W. and Robbins, H (1948). The central limit theorem for dependent random variables. Duke Math. J. (15) 3, 773-780. doi:10.1215/S0012-7094-48-01568-3.

Kellstedt, P. M., and Whitten, G. D. (2013). *The Fundamentals of Political Science Research*. Cambridge University Press. ISBN: 9781107621664.

Loubes, J., Maza, É, Lavielle, M., & Rodríguez, L. (2006). Road trafficking description and short term travel time forecasting, with a classification method. *The Canadian Journal of Statistics / La Revue Canadienne De Statistique, 34*(3), 475-491. Retrieved from http://www.jstor.org/stable/20445215

Mapquest. (2007). How can we help you?. Retrieved February 28, 2017 from https://help.mapquest.com/

Scheiner, S. M., and Gurevitch, J. (2001). *Design and analysis of ecological experiments.* Oxford University Press. ISBN 9780198030225.

Appendix A

Starting and Ending Points Delineating data collection streets

Area	n	Start	End	Route
Chicago	1	3858 s Racine ave	2259 n fremont st	I-94 W
	2	2124 w 47th st	1646 n halsted st	I-90 W
	3	2727 s poplar ave	3025 n kostner ave	I -90 W
	4	2526 w 18th dr	8880 s western ave	S California Ave
	5	521 N Kedzie Ave	7200 S Western Ave	S Western Ave
	6	3924 N Janssen Ave	4093 W 19th St	N Ashland Ave
	7	586 N Michigan ave	1150 W 59th st	I -90 E
	8	3025 S Harding ave	4845 N Drake ave	S Pulaski Rd
	9	5361 S Dorchester ave	2728 S Ridgeway ave	E Pershing Rd
	10	116 W Chicago ave	5138 S Hamlin ave	S Archer Ave
	11	1459 W Potomac ave	5785 S Rockwell st	I-90 E
	12	3021 N Gresham ave	317 E 25th pl	I-90 E
	13	2307 W 70th st	2961 W Walton st	S Western Blvd
	14	1312 S Plymouth ct	4396 W Wilson ave	I-90 W
	15	738 W 46th st	3814 N Fremont st	S Haslted St
	16	3501 W 55th st	300 N Green st	S Kedzie Ave
	17	5031 N Sheridan rd	2422 S State st	US-41 S
	18	4056 W 42nd pl	200 E Superior st	I-90 W
	19	332 E Illinois st	1673 N Nagle ave	IL-64
	20	6881 N Ravenswood ave	92 E Hubbard st	N Lake Shore Dr S
	21	681 W Division st	6145 N Milwaukee ave	I-90 W
	22	536 W Grenshaw st	5111 N Elston ave	I-90 W
	23	4665 S Western ave	1385 N State pkwy	I-55 N
	24	225 E 70th st	913 W Jackson blvd	I-90 (local) W
	25	9099 Shields ave, Brookfield	Mercy Medical, 4321 S Pulaski Rd, Chicago	
	26	1143 e 82nd, Chicago	Mercy Medical, 4321 S Pulaski Rd, Chicago	
	27	5111 w Bloomingdale, Chicago	Mercy Medical, 4321 S Pulaski Rd, Chicago	
	28	13509 s crawford, Robbins	Mercy Medical, 4321 S Pulaski Rd, Chicago	
	29	3961 S State St	504 W Wellington Ave	US-41 N
	30	1449 S Newberry Ave	4900 N Bernard St	I-90 W to N Pulaski Rd

Appendix A

Starting and Ending Points Delineating data collection streets (Continued)

Area	n	Start	End	Route
Metro	1	550 S Mulford rd, Rockford	3916 W Riverside blvd, Rockford	E Riverside Blvd
	2	50 Adloff ln, Springfield	4048 Hollyhock dr, Springfield	Wabash Ave to S Veterans Pkwy
	3	1689 S Faraday ave, Peoria	4636 W Andover dr, Peoria	US-150 W
	4	3099 N brickhouses rd, Urbana	1915 S Mattis ave, Champaign	I-74 W to N Mattis Ave
	5	49W927 Old State Rd, Maple Park	3298 Resource pkwy, DeKalb	Barber Greene Rd
	6	23657 Douglas Dr, Plainfield	2021 Randi Dr, Aurora	W 119th St to US-30 W
	7	535 E Haven Ave, New Lenox	2230 McDonough St, Joliet	I-80 W
	8	1043 S Trainer Rd, Rockford	2503 Canterbury Ln, Rockford	E Riverside Blvd
	9	4156 S High Cross Rd, Urbana	109 Kenwood Rd, Champaign	E Springfield ave
	10	1470 County Road 2200, Urbana	101 W Windsor Rd, Urbana	N Cunningham ave
	11	608 Ralston Rd, Machesney Park	346 Roxbury Rd, Rockford	N Mulford rd
	12	2805 Mansion Rd, Springfield	1025 S 6th St, Springfield	I-72 E
	13	7459 Buckhart Rd, Rochester	701 N Walnut St, Springfield	IL-29 to IL-97
	14	1919 Colt Dr, Washington	5409 N Knoxville Ave, Peoria	US-24 W
	15	1614 Meadow Ave, East Peoria	4909 N Glen Park Pl, Peoria	I-74 W to N Sterling Ave
	16	7516 N Cherry Vale Mall Dr	2400 N Rockton Ave, Rockford	
	17	10931 N Highcrest ln Dunlap, Il	500 W Romeo B Garrett Ave, Peoria	
	18	2775 Haydon dr Urbana, Il	1701 Curtis Rd, Champaign	
	19	3999 Spaulding Orchard rd	320 E Carpenter St, Springfield	
	20	4050 Sand Hill Rd, Springfield	4101 W Iles Ave, Springfield	IL-4

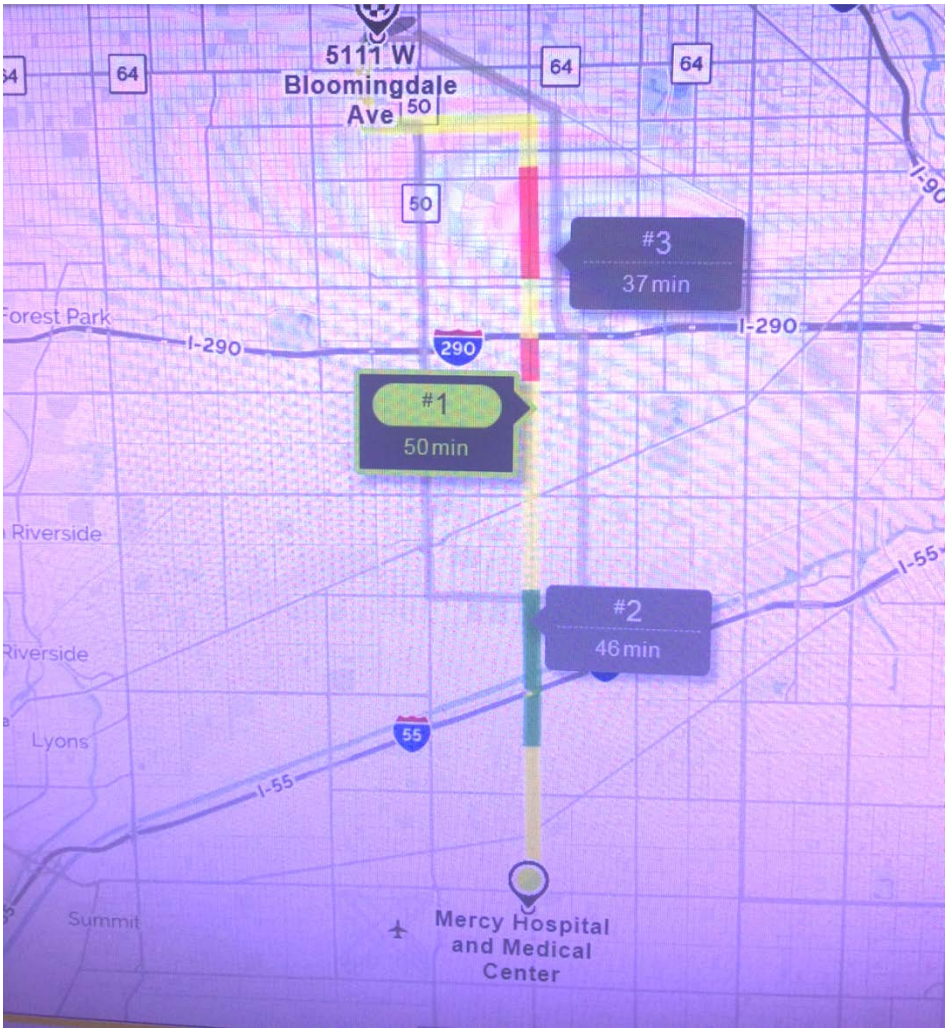
Appendix A

Starting and Ending Points Delineating data collection streets (Continued)

Area	n	Start	End	Route
Rural	1	17391 Shed Church	3333 W Deyoung St, Marion	
	2	189 Walnut, West Liberty	800 E Locust St, Olney	
	3	840 Constitution rd, Colchester	1600 E Jackson St, Macomb	
	4	2650 N 13th rd	111 Spring St, Streator	
	5	1712 18th Ave, Viola	409 NW 9th Ave, Aledo	IL-17
	6	50 Prairie Dr, Sterling	101 W 2nd St, Dixon	IL-2
	7	205 Paula Ln, Carterville	900 Skyline Dr, STE 200, Marion	IL-13
	8	203 S East St, Watson	904 W Temple Ave, Effingham	US-45 N
	9	19305 State Route 142, Opdyke	2900 Broadway St, SUITE B, Mount Vernon	IL-142
	10	1185 Cheryl Dr, Carterville	2601 W Main St, Carbondale	IL-13
	11	351 Hillside Dr, Franklin Grove	200 W Hawley St, Amboy	Franklin rd
	12	7310 E Railroad St, Jonesboro	315 Brady Mill Rd, Anna	IL-127
	13	9015 Midway Rd, Oreana	2650 N Monroe St, Decatur	IL-48
	14	174 E 700 North Rd, Cerro Gordo	601 N Morgan St, Bement	E 700 North Rd
	15	1760 14th Ave, Viola	304 SW 12th St, Aledo	IL-17
	16	2489 State Route 116, Benson	1102 W Randolph St, Roanoke	IL-117
	17	2121 County Road 850E, Lovington	423 S Eberhardt Dr, Arthur	State Highway 133
	18	1876 US Highway 30, Franklin Grove	307 Alan St, Ashton	Pine Hill rd
	19	456 N Main St, Summerfield	349 W 1st St, Aviston	US-50 E
	20	17071 IL Route 125, Virginia	310 E 8th St, Beardstown	State Route 125

Appendix B

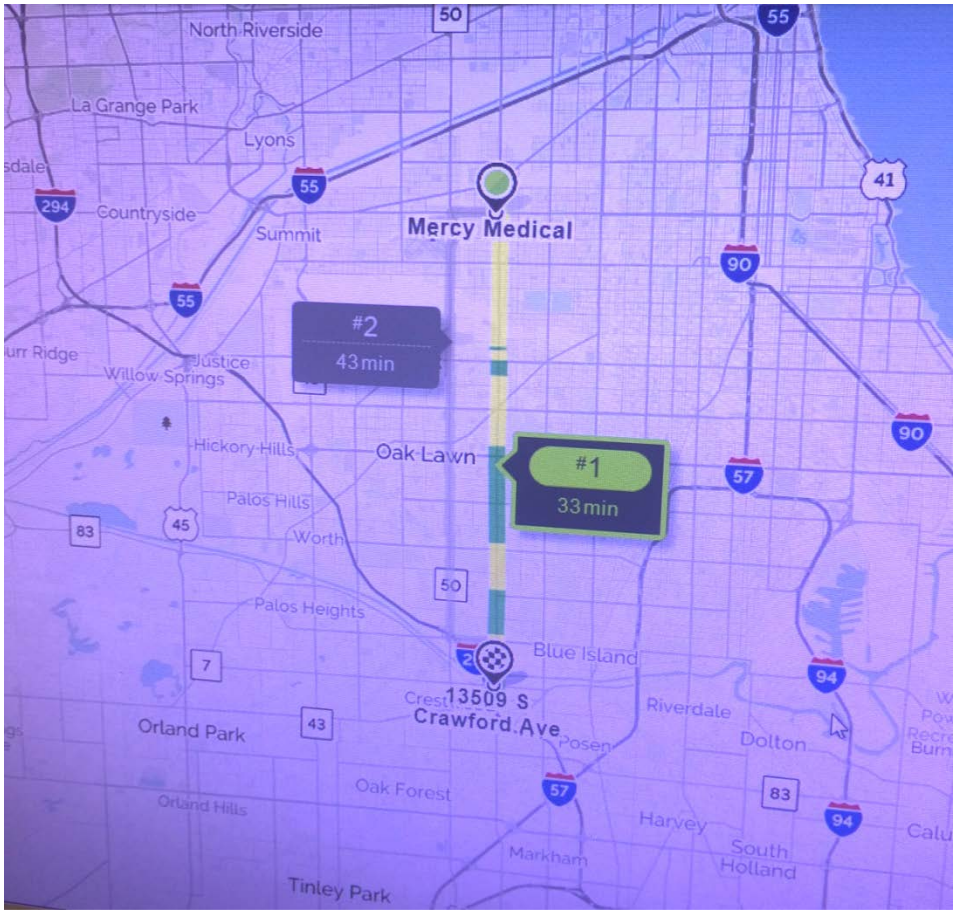
Screenshot of MapQuest map showing peak time in North Chicago area at 5:00pm



Source: MapQuest.com

Appendix C

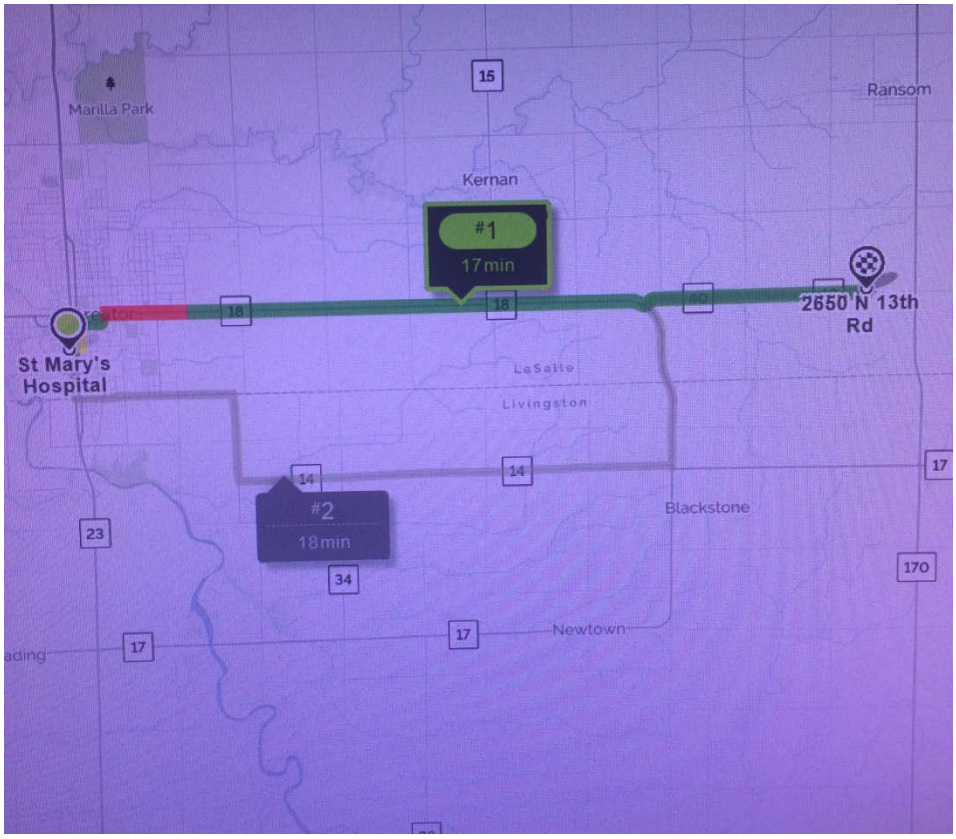
Screenshot of MapQuest map showing peak time in South Chicago area



Source: MapQuest.com

Appendix D

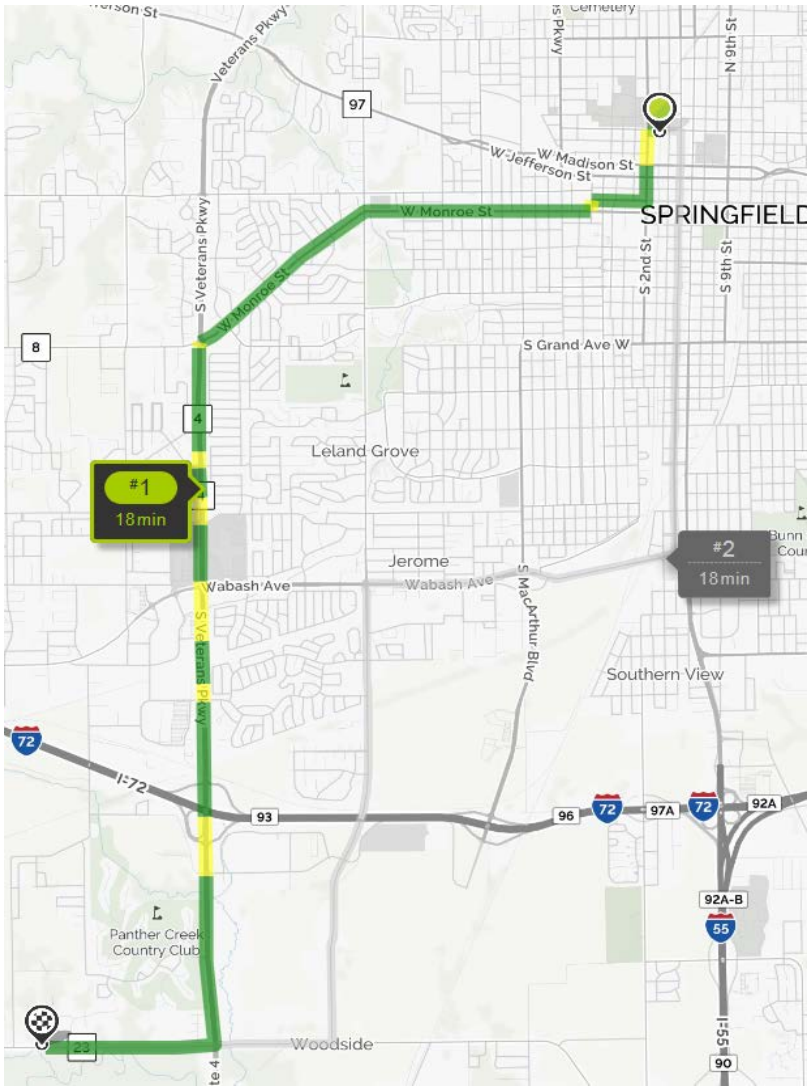
Screenshot of MapQuest map showing normal travel time in rural area



Source: MapQuest.com

Appendix E

Screenshot of MapQuest map showing normal travel time in Metro



Source: MapQuest.com

Appendix F

Average Travel Time (in minutes) for 10 miles

Recording Time	Chicago	Metro	Rural
6:30:00 AM	26.40	16.90	14.15
6:45:00 AM	27.17	16.70	14.10
7:00:00 AM	28.43	16.80	14.00
7:15:00 AM	29.10	17.05	14.05
7:30:00 AM	31.07	17.30	14.00
7:45:00 AM	32.72	18.10	14.25
8:00:00 AM	32.82	18.63	14.43
8:15:00 AM	32.97	18.45	14.18
8:30:00 AM	33.02	17.86	14.13
8:45:00 AM	32.93	17.86	13.78
9:00:00 AM	31.19	18.36	14.00
9:15:00 AM	31.09	18.15	13.79
9:30:00 AM	30.26	18.02	13.90
9:45:00 AM	29.81	17.88	13.93
10:00:00 AM	29.04	18.15	14.01
10:15:00 AM	29.35	18.43	13.98
10:30:00 AM	28.96	18.52	13.95
10:45:00 AM	29.08	18.20	14.03
11:00:00 AM	28.25	18.20	14.20
11:15:00 AM	28.50	18.77	14.30
11:30:00 AM	28.42	18.45	14.15
11:45:00 AM	28.45	18.12	14.50
12:00:00 PM	28.73	18.13	14.55
12:15:00 PM	29.13	18.18	14.40
12:30:00 PM	29.43	18.50	14.70
12:45:00 PM	29.69	18.25	14.60
1:15:00 PM	29.11	18.28	14.35
1:30:00 PM	28.95	17.93	14.59
1:45:00 PM	29.25	18.20	14.33
2:00:00 PM	28.87	18.20	14.53
2:15:00 PM	28.47	17.88	14.85
2:30:00 PM	29.73	17.88	14.48
2:45:00 PM	29.88	17.95	14.35
3:00:00 PM	30.28	18.20	14.30
3:15:00 PM	31.12	18.08	14.73
3:30:00 PM	31.77	18.30	14.68

Appendix F

Average Travel Time (in minutes) for 10 miles (continued)

Recording Time	Chicago	Metro	Rural
3:45:00 PM	33.28	18.80	14.58
4:00:00 PM	33.77	18.93	14.48
4:15:00 PM	33.87	18.93	14.90
4:30:00 PM	35.05	18.93	14.83
4:45:00 PM	35.43	18.40	14.78
5:00:00 PM	34.18	19.14	14.78
5:15:00 PM	32.55	18.90	14.53
5:30:00 PM	32.90	19.13	14.65
5:45:00 PM	33.55	19.10	14.65
6:00:00 PM	30.50	18.65	14.28
6:15:00 PM	30.07	18.20	14.58
6:30:00 PM	30.22	17.93	14.73
6:45:00 PM	29.43	17.40	14.25
7:00:00 PM	28.23	17.35	14.50

Appendix G: Normality test result for Chicago sample data

Tests of Normality[a]

		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	RecordTime	Statistic	df	Sig.	Statistic	df	Sig.
Minute-10Mile	6:30:00.00	.109	30	.200*	.973	30	.615
	6:45:00.00	.101	30	.200*	.960	30	.309
	7:00:00.00	.096	30	.200*	.962	30	.340
	7:15:00.00	.115	30	.200*	.954	30	.210
	7:30:00.00	.084	30	.200*	.960	30	.305
	7:45:00.00	.090	30	.200*	.983	30	.898
	8:00:00.00	.119	30	.200*	.964	30	.395
	8:15:00.00	.102	30	.200*	.975	30	.692
	8:30:00.00	.124	30	.200*	.969	30	.515
	8:45:00.00	.129	30	.200*	.977	30	.745
	9:00:00.00	.090	30	.200*	.987	30	.972
	9:15:00.00	.126	30	.200*	.968	30	.482
	9:30:00.00	.057	30	.200*	.992	30	.997
	9:45:00.00	.073	30	.200*	.994	30	.999
	10:00:00.00	.103	30	.200*	.980	30	.816
	10:15:00.00	.095	30	.200*	.983	30	.895
	10:30:00.00	.065	30	.200*	.990	30	.992
	10:45:00.00	.094	30	.200*	.982	30	.883
	11:00:00.00	.080	30	.200*	.986	30	.951
	11:15:00.00	.068	30	.200*	.982	30	.877
	11:30:00.00	.095	30	.200*	.975	30	.684
	11:45:00.00	.092	30	.200*	.979	30	.801
	12:00:00.00	.103	30	.200*	.972	30	.590
	12:15:00.00	.104	30	.200*	.965	30	.408
	12:30:00.00	.080	30	.200*	.972	30	.605
	12:45:00.00	.084	30	.200*	.981	30	.857
	13:15:00.00	.128	30	.200*	.960	30	.313
	13:30:00.00	.110	60	.068	.981	60	.477
	13:45:00.00	.101	30	.200*	.974	30	.639
	14:00:00.00	.109	30	.200*	.954	30	.220
	14:15:00.00	.121	30	.200*	.970	30	.541
	14:30:00.00	.143	30	.121	.962	30	.357
	14:45:00.00	.093	30	.200*	.968	30	.481
	15:00:00.00	.109	30	.200*	.966	30	.447
	15:15:00.00	.096	30	.200*	.958	30	.274
	15:30:00.00	.112	30	.200*	.961	30	.334
	15:45:00.00	.131	30	.199	.941	30	.099
	16:00:00.00	.138	30	.150	.927	30	.041
	16:15:00.00	.098	30	.200*	.957	30	.255
	16:30:00.00	.125	30	.200*	.946	30	.133
	16:45:00.00	.091	30	.200*	.976	30	.703
	17:00:00.00	.142	30	.128	.961	30	.330
	17:15:00.00	.187	30	.009	.934	30	.062
	17:30:00.00	.093	30	.200*	.957	30	.259
	17:45:00.00	.099	30	.200*	.964	30	.390
	18:00:00.00	.132	30	.190	.951	30	.181
	18:15:00.00	.121	30	.200*	.962	30	.349
	18:30:00.00	.128	30	.200*	.956	30	.241
	18:45:00.00	.137	30	.159	.953	30	.209
	19:00:00.00	.138	30	.152	.944	30	.113

*. This is a lower bound of the true significance.

a. Area = Chicago

Appendix H: Normality test result for Metro area sample data

Tests of Normality[a]

		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	RecordTime	Statistic	df	Sig.	Statistic	df	Sig.
Minute-10Mile	6:30:00.00	.167	20	.145	.951	20	.389
	6:45:00.00	.198	20	.038	.945	20	.300
	7:00:00.00	.183	20	.078	.931	20	.162
	7:15:00.00	.111	20	.200*	.962	20	.583
	7:30:00.00	.139	20	.200*	.953	20	.409
	7:45:00.00	.141	20	.200*	.965	20	.658
	8:00:00.00	.147	20	.200*	.956	20	.465
	8:15:00.00	.193	20	.050	.907	20	.056
	8:30:00.00	.172	20	.124	.886	20	.023
	8:45:00.00	.119	20	.200*	.968	20	.708
	9:00:00.00	.124	20	.200*	.948	20	.338
	9:15:00.00	.101	20	.200*	.957	20	.482
	9:30:00.00	.125	20	.200*	.963	20	.603
	9:45:00.00	.165	20	.155	.910	20	.064
	10:00:00.00	.160	20	.194	.921	20	.102
	10:15:00.00	.153	20	.200*	.925	20	.126
	10:30:00.00	.116	20	.200*	.957	20	.491
	10:45:00.00	.151	20	.200*	.942	20	.259
	11:00:00.00	.114	20	.200*	.960	20	.540
	11:15:00.00	.155	20	.200*	.956	20	.459
	11:30:00.00	.115	20	.200*	.943	20	.273
	11:45:00.00	.121	20	.200*	.936	20	.203
	12:00:00.00	.133	20	.200*	.947	20	.326
	12:15:00.00	.126	20	.200*	.936	20	.199
	12:30:00.00	.194	20	.047	.934	20	.182
	12:45:00.00	.108	20	.200*	.966	20	.675
	13:15:00.00	.115	20	.200*	.961	20	.556
	13:30:00.00	.161	40	.011	.949	40	.071
	13:45:00.00	.099	20	.200*	.963	20	.595
	14:00:00.00	.125	20	.200*	.949	20	.351
	14:15:00.00	.161	20	.184	.929	20	.149
	14:30:00.00	.134	20	.200*	.941	20	.250
	14:45:00.00	.183	20	.077	.904	20	.048
	15:00:00.00	.179	20	.092	.908	20	.057
	15:15:00.00	.148	20	.200*	.946	20	.308
	15:30:00.00	.116	20	.200*	.958	20	.503
	15:45:00.00	.141	20	.200*	.975	20	.853
	16:00:00.00	.197	20	.040	.933	20	.177
	16:15:00.00	.120	20	.200*	.961	20	.565
	16:30:00.00	.131	20	.200*	.980	20	.937
	16:45:00.00	.149	20	.200*	.960	20	.540
	17:00:00.00	.159	20	.200*	.957	20	.491
	17:15:00.00	.162	20	.177	.942	20	.256
	17:30:00.00	.164	20	.162	.936	20	.199
	17:45:00.00	.103	20	.200*	.951	20	.378
	18:00:00.00	.100	20	.200*	.969	20	.725
	18:15:00.00	.101	20	.200*	.942	20	.266
	18:30:00.00	.160	20	.191	.952	20	.400
	18:45:00.00	.120	20	.200*	.952	20	.392
	19:00:00.00	.160	20	.195	.912	20	.069

*. This is a lower bound of the true significance.

a. Area = Metro

b. Lilliefors Significance Correction

Appendix I: Normality test result for Rural area sample data

Tests of Normality[a]

		Kolmogorov-Smirnov[b]			Shapiro-Wilk		
	RecordTime	Statistic	df	Sig.	Statistic	df	Sig.
Minute-10Mile	6:30:00.00	.294	20	.000	.874	20	.014
	6:45:00.00	.231	20	.007	.931	20	.163
	7:00:00.00	.250	20	.002	.899	20	.040
	7:15:00.00	.214	20	.017	.899	20	.040
	7:30:00.00	.300	20	.000	.861	20	.008
	7:45:00.00	.293	20	.000	.781	20	.000
	8:00:00.00	.283	20	.000	.869	20	.011
	8:15:00.00	.204	20	.029	.869	20	.011
	8:30:00.00	.233	20	.006	.911	20	.066
	8:45:00.00	.239	20	.004	.868	20	.011
	9:00:00.00	.256	20	.001	.729	20	.000
	9:15:00.00	.180	20	.090	.891	20	.028
	9:30:00.00	.227	20	.008	.860	20	.008
	9:45:00.00	.182	20	.080	.894	20	.032
	10:00:00.00	.203	20	.031	.878	20	.016
	10:15:00.00	.196	20	.043	.886	20	.023
	10:30:00.00	.189	20	.059	.929	20	.147
	10:45:00.00	.207	20	.025	.855	20	.007
	11:00:00.00	.197	20	.040	.902	20	.046
	11:15:00.00	.309	20	.000	.844	20	.004
	11:30:00.00	.231	20	.006	.890	20	.027
	11:45:00.00	.329	20	.000	.784	20	.001
	12:00:00.00	.338	20	.000	.770	20	.000
	12:15:00.00	.218	20	.013	.817	20	.002
	12:30:00.00	.184	20	.075	.895	20	.033
	12:45:00.00	.242	20	.003	.810	20	.001
	13:15:00.00	.232	20	.006	.903	20	.047
	13:30:00.00	.265	40	.000	.887	40	.001
	13:45:00.00	.177	20	.099	.916	20	.083
	14:00:00.00	.281	20	.000	.696	20	.000
	14:15:00.00	.266	20	.001	.746	20	.000
	14:30:00.00	.210	20	.021	.904	20	.049
	14:45:00.00	.197	20	.040	.909	20	.060
	15:00:00.00	.268	20	.001	.895	20	.033
	15:15:00.00	.212	20	.018	.786	20	.001
	15:30:00.00	.186	20	.070	.910	20	.063
	15:45:00.00	.323	20	.000	.845	20	.004
	16:00:00.00	.252	20	.002	.866	20	.010
	16:15:00.00	.303	20	.000	.844	20	.004
	16:30:00.00	.230	20	.007	.908	20	.058
	16:45:00.00	.239	20	.004	.866	20	.010
	17:00:00.00	.197	20	.040	.886	20	.023
	17:15:00.00	.240	20	.004	.878	20	.016
	17:30:00.00	.233	20	.006	.835	20	.003
	17:45:00.00	.233	20	.006	.835	20	.003
	18:00:00.00	.163	20	.170	.917	20	.085
	18:15:00.00	.293	20	.000	.843	20	.004
	18:30:00.00	.269	20	.001	.866	20	.010
	18:45:00.00	.184	20	.076	.908	20	.058
	19:00:00.00	.282	20	.000	.884	20	.021

a. Area = Rural

b. Lilliefors Significance Correction