Using Logistic Regression to Model New York City Restaurant Grades Over a Two-Year Period

David W. Nadler [1]

ABSTRACT

BACKGROUND: The New York City Department of Health and Mental Hygiene restaurants to verify how they comply with regulations which dictate how restaurants must handle and store food, control vectors, and employ personal hygiene among its employees. A grade is then provided which must be posted in the restaurant's front window to inform potential customers of their record. This study explored if there are significant differences between a restaurant earning the highest grade and the type of restaurant.

METHODS: A cross sectional study design has been used to conduct measurements on the restaurants' health department grades over a two-year period. The subjects have their restaurant grading data publicly available through the New York City Open Data repository.

The study population was composed of restaurants in the five boroughs of New York City that had at least one inspection in calendar year 2011 or 2012.

RESULTS: The eight restaurant types showed a significant Pearson's chi-square statistic with restaurant score (X^2 = 28,000, $p < 0.001$). A one-way ANOVA was used to test for differences between borough and restaurant score and the effect of borough on score was significant, $F(4, 138908) = 36.46$, $p < 0.001$.

Citywide, all of the restaurant types except Italian had significant crude odd ratios for the prediction of the highest grade. All of the restaurant types except American-style restaurants showed significant odds ratios. Logistic regression further showed that Caribbean, Chinese, Italian, Japanese, Latin, Mexican and Pizzerias had lower odds of receiving the highest grade when using American-style restaurants as the reference.

CONCLUSIONS: This study suggested that there are associations between receiving the highest inspection grade and restaurant type in New York City. Public and environmental health agencies and professionals can use this study as a roadmap for building upon their own restaurant inspection programs. Identifying who the lower performers are and the specific reasons as to why they are can be used to help protect the public, particularly in the lowering of foodborne illness cases in a community.

Key words: Restaurants, Public Health, Inspections, Regression

(1) New York Institute of Technology

CORRESPONDING AUTHOR: *David W. Nadler, New York Institute of Technology, Northern Boulevard, PO Box 8000, Old Westbury, NY 11568. Tel. 800-345-6948. Email: dwnadler@gmail.com*

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INTRODUCTION

The New York City Department of Health and Mental Hygiene (DOH) "conducts unannounced inspection of restaurants at least one time per year" [1]. Health inspectors look at how a restaurant complies with regulations which dictate how restaurants must handle food, store food, control vectors, and employ personal hygiene among its employees. Depending upon the number and severity of violations revealed during an inspection, the restaurant may receive a letter grade which must be posted in its front window. This transparency easily allows for potential customers to see how a restaurant fares before entering and consuming a meal.

DOH has three scales of violations: public health hazard, critical violation and general violation [2]. Public health hazards may include a restaurant not being able to keep food at a certain temperature and warrants at least seven points. Critical violations may include a restaurant not washing food that is served raw and would account for at least five points. The general violations, which are at least two points, include not washing utensils before use.

A restaurant receiving no more than thirteen points may receive a Grade A. Grade B may be issued if the inspection point total ranges from fourteen to twenty-seven points. Finally, a Grade C may be given to a restaurant if there are twenty-eight or more points scored.

Typical public health studies on restaurants have focused on the prediction of foodborne illnesses [3,4]. Data such as type of violation and number of employees have been used to predict foodborne illness in a community. This study explored if there are significant differences between a restaurant earning a Grade A from DOH and the type of restaurant.

METHODS

Study Design

A cross sectional study design has been used to conduct measurements on the restaurants' health department grades over a two-year period [5,6]. The subjects, made up of a representative sample of the population at large, have their restaurant grading data publicly available. A cross sectional design was most feasible for this study because it is appropriate for measuring the outcomes and the other variables of interest at any given point in time [7]. Organizing the data of those with and without the highest grade earned ("A"), grouped by cuisine type, has allowed for the prediction of the odds ratios of certain restaurants receiving a Grade A from DOH.

This study relied on 547107 database records made available by DOH. The main association that was studied was between the type of cuisine served at a restaurant (predictor) and a Grade A (outcome). Certain criteria were used to eliminate a number of records from this study, including the years of restaurant inspections, missing data, and types of restaurants based on cuisine that had less than 3% of the total number of recorded inspections.

Study Population

The study population was composed of restaurants in the five boroughs of New York City that had at least one inspection in calendar year 2011 or 2012. Restaurants identified as "American" represented the greatest frequency of those facilities that were inspected (23.7%). Of the remaining types of restaurants, those that accounted for at least 3% of the total inspections were used in the sample population. These restaurant types have been identified as "Caribbean," "Chinese," "Italian," "Japanese," "Latin," "Mexican," and "Pizzeria." Furthermore, grading data that was not scored as "A," "B," or "C" was not used in data analysis. Table 1 presents the study population by cuisine type and grade.

Sample Size and Data Collection

Raw data is available through the City of New York's "Open Data" program. Over 540 000 records were stored in the file for restaurant inspections and grades. Records meeting the following requirements were eligible for study inclusion: 1) inspection date in either calendar year 2011 or 2012, 2) restaurant type had at least 3% of the City's total inspections, 3) a grade of "A," B," or "C" was received, and 4) one of the five boroughs of New York City was recorded. Records that

did not meet all of these requirements were excluded from analysis. In total, 132 002 data records have been used in this study. The sample population is presented in Table 1.

RESULTS

Bivariate Analysis

The eight restaurants used as an independent variable showed a significant Pearson's chi-square statistic with restaurant score in the bivariate analysis (X^2 = 28,000, $p < 0.001$). A one-way ANOVA was used to test for differences between the types of restaurants their grade. The effect of restaurant type on score was significant, F (7, 84464) = 172.17, $p < 0.001$. Bonferroni analysis was significant between American restaurants and Caribbean, Chinese, Japanese, Latin and Mexican restaurants ($p < 0.001$); between Caribbean restaurants and Chinese, Italian, Latin restaurants and Pizzerias ($p < 0.001$); between Chinese restaurants and Italian, Japanese, Mexican restaurants and Pizzerias ($p < 0.001$); between Italian restaurants and Japanese, Latin and Mexican restaurants ($p < 0.001$); between Japanese restaurants and Latin restaurants and Pizzerias ($p < 0.001$); between Latin restaurants and Mexican restaurants and Pizzerias ($p < 0.001$); and between Mexican restaurants and Pizzerias ($p < 0.001$).

A one-way ANOVA was used to test for differences between borough and restaurant score. The effect of borough on score was significant, F (4, 138908) = 36.46, $p < 0.001$. Besides the insignificant difference in restaurant scores between those in Queens and Brooklyn, there was a significant difference between every other borough-borough comparison (i.e., Manhattan-Bronx, Queens-Staten Island, Brooklyn-Bronx, and so forth).

Logistic Regression

The results of listwise logistic regression are presented in Table 2. Grades of A were coded as a 1 and Grades B and C were coded as 0 to get a dichotomous outcome [8]. Records with missing data were not regressed by the software for the listwise method. The independent variable was regressed against the outcome variable one at a time, providing the crude odds ratios. The adjusted odds ratios were recorded after every independent variable was used in the same regression.

The grade outcome of a restaurant inspection, either as a "Grade A" or "not a Grade A", was logistically regressed against the eight restaurant types. The logistic regression models were done citywide and individually for each of the five boroughs of New York City. The 2x2 table for logistic regression in this study is represented in Figure 1. The odds ratio for a restaurant type receiving a Grade A is calculated as [9]:

$$OR = \frac{A \times D}{B \times C}.$$

TABLE 1

SAMPLE POPULATION FROM NYC OPEN DATA

	GRADE			
CUISINE TYPE	A	B	C	TOTAL
American	32 400	13 443	7 404	53 247
Caribbean	3 261	1 924	1 194	6 379
Chinese	10 948	8 887	4 961	24 796
Italian	6 005	3 023	1 605	10 633
Japanese	3 416	2 449	1 290	7 155
Latin	4 861	3 649	2 419	10 929
Mexican	3 507	2 238	1 386	7 131
Pizzeria	6 836	3 376	1 520	11 732
Total	71 234	38 989	21 779	132 002

TABLE 2

RESULTS OF INDIVIDUAL AND LISTWISE LOGISTIC REGRESSIONS, CITYWIDE

VARIABLE	CRUDE OR	95% CI	ADJUSTED OR	95% CI
American	1.23	1.20 – 1.26	0.99	0.95 – 1.01
Caribbean	0.80	0.75 – 0.85	0.67	0.63 – 0.72
Chinese	0.55	0.53 – 0.57	0.50	0.48 – 0.51
Italian	0.99	0.94 – 1.04	0.84	0.79 – 0.88
Japanese	0.70	0.66 – 0.74	0.59	0.56 – 0.63
Latin	0.62	0.59 – 0.65	0.54	0.51 – 0.56
Mexican	0.75	0.70 – 0.79	0.63	0.60 – 0.67
Pizzeria	1.08	1.03 – 1.14	0.91	0.86 – 0.95

FIGURE 1

2X2 MATRIX FOR ODDS RATIO DEVELOPMENT.

	GRADE A	NOT A GRADE A
Restaurant	A	B
Other Restaurants	C	D

Citywide, all of the restaurant types except Italian had significant crude odd ratios for the prediction of a Grade A. When adjusted, all but American restaurants showed significant odds ratios. Figures 2 and 3 present the citywide odds ratios by restaurant type and by borough.

In Manhattan, six of the restaurant types showed significant odds ratios for receiving a Grade A. The odds ratios are interpreted as the odds of a specific restaurant type receiving a Grade A compared to all other restaurant types receiving a Grade A divided by the restaurant type not receiving a Grade A compared to all other restaurant types not getting a Grade A. The logistic regression model was significant (X^2 = 1393, p < 0.001, n = 55770), Chinese (OR = 0.33, 95% CI = 0.30 – 0.35), Italian (OR = 0.78, 95% CI = 0.73 – 0.84), Japanese (OR = 0.51, 95% CI = 0.47 – 0.55), Latin (OR = 0.47, 95% CI = 0.43 – 0.52), Mexican (OR = 0.71, 95% CI = 0.64 – 0.79) and Pizzerias (OR = 0.77, 95% CI = 0.71 – 0.84).

In The Bronx, seven of the restaurant types showed significant odds ratios for receiving a Grade A. The logistic regression model was significant (X^2 = 438, p < 0.001, n = 13952), Caribbean (OR = 0.72, 95% CI = 0.61 – 0.84), Chinese (OR = 0.51, 95% CI = 0.46 – 0.57), Italian (OR = 0.54, 95% CI = 0.44 – 0.65), Japanese (OR = 0.27, 95% CI = 0.19 – 0.39), Latin (OR = 0.41, 95% CI = 0.37 – 0.46), Mexican (OR = 0.41, 95% CI = 0.34 – 0.48) and Pizzerias (OR = 0.70, 95% CI = 0.61 – 0.80).

In Brooklyn, seven of the restaurant types showed significant odds ratios for receiving a Grade A. The logistic regression model was significant (X^2 = 509, p < 0.001, n = 33879), American (OR = 0.91, 95% CI = 0.85 – 0.96), Caribbean (OR = 0.59, 95% CI = 0.54 – 0.65), Chinese (OR = 0.54, 95% CI = 0.51 – 0.58), Italian (OR = 0.80, 95% CI = 0.71 – 0.90), Japanese (OR = 0.71, 95% CI = 0.62 – 0.81), Latin (OR = 0.56, 95% CI = 0.50 – 0.62), and Mexican (OR = 0.57, 95% CI = 0.51 – 0.63).

In Queens, six of the restaurant types showed significant odds ratios for receiving a Grade A. The logistic regression model was significant (X^2 = 368, p < 0.001, n = 31385), American (OR = 1.09, 95% CI = 1.02 – 1.16), Caribbean (OR = 0.78, 95% CI = 0.70 – 0.88), Chinese (OR = 0.63, 95% CI = 0.58 – 0.67), Latin (OR = 0.65, 95% CI = 0.59 – 0.70), and Mexican (OR = 0.73, 95% CI = 0.65 – 0.83).

In Staten Island, three of the restaurant types showed significant odds ratios for receiving a Grade A. The logistic regression model was significant (X^2 = 92, p < 0.001, n = 4615), American (OR = 0.80, 95% CI = 0.68 – 0.93), Caribbean (OR = 0.41, 95% CI = 0.18 – 0.94),

FIGURE 2

ODDS RATIOS BY RESTAURANT TYPE

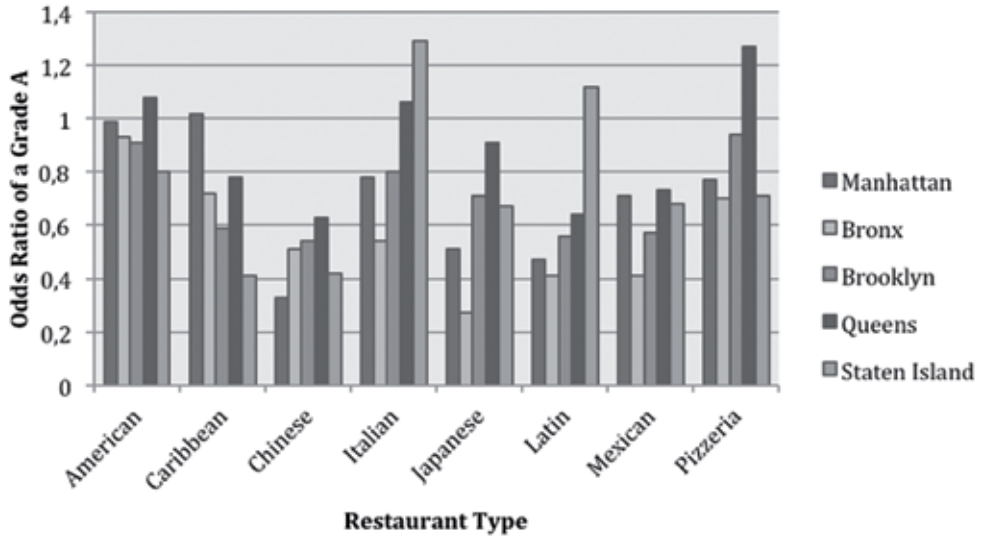
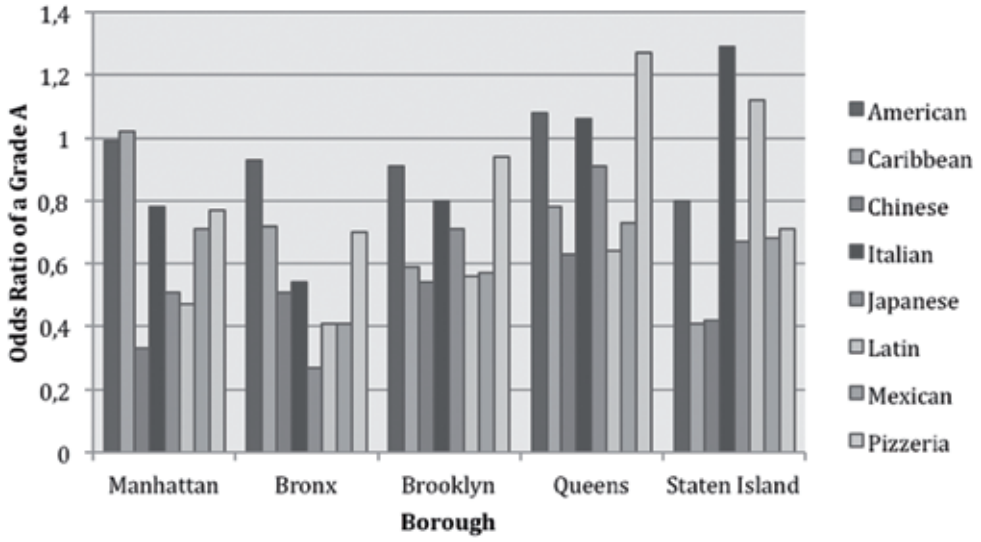


FIGURE 3

ODDS RATIOS BY BOROUGH



Chinese (OR = 0.42, 95% CI = 0.34 – 0.52), Japanese (OR = 0.67, 95% CI = 0.49 – 0.91), Mexican (OR = 0.68, 95% CI = 0.50 – 0.93), and Pizzerias (OR = 0.71, 95% CI = 0.55 – 0.92).

Using the coefficients from the logistic regression of the selected model using the logit command in Stata 12, the fitted equation for the citywide prediction of a Grade A in the eight studied restaurant types is:

logit(p) = 0.28 - 0,14X_1 - 0.39X_2 - 0.70X_3 - 0.18X_4 - 0.52X_5 - 0.62X_6 - 0.46X_7 - 0.10X_9, where

0.28 = constant,
X_1 = American,
X_2 = Caribbean,
X_3 = Chinese,
X_4 = Italian,
X_5 = Japanese,
X_6 = Latin,
X_7 = Mexican,
X_8 = Pizzerias.

DISCUSSION

Implications for Practice

There are some important outcomes in this study for the prediction of a Grade A rating for restaurants in New York City. One outcome of this study is the prediction of the odds for a particular style of restaurant receiving a Grade A inspection. An exhaustive literature review did not reveal similar outcomes or studies. Analogous studies typically analyzed associations between restaurant violations and the likelihood of foodborne illnesses. Future studies may refer to the database for the development of a model on restaurant grades, cuisines and the types of violations cited.

This study can be used by health departments across the United States to help them streamline restaurant inspections. It has been shown in this study that there are disparities between different restaurant types and the likelihood of the highest grade granted compared to other restaurant types in the region. Assuming that each health department inspects all restaurants in their jurisdiction with the same frequency, how can they use these presented results? One answer would be to develop a strategy that would focus on why certain restaurant types fare better than others. Italian restaurants in Staten Island have much higher odds of getting a Grade A than Japanese restaurants in The Bronx. This has been shown to be statistically significant. It would appear that a logical step would be for DOH to focus on how the Japanese restaurants in The Bronx could increase their odds of receiving the highest rating possible. Solutions should focus on discussions between the local inspection agencies and the statistically poorer performers to develop a roadmap to success. Specific violation types would need to be analyzed in a future study to help advance the underperformers. This was beyond the scope of this study.

This study also showed disparities between the five boroughs of New York City. Each borough is its own county, so health departments which may oversee more than one county can develop a protocol for 1) finding how restaurants fare from county-to-county and 2) where they would need to focus their resources to help restaurants get better grades. This may be more practical at the state level.

Limitations

Sample Size. The size of the sample population was large enough for the number of variables, power and effect size chosen for this study. Furthermore, the methodology chosen was the correct technique for this type of study. The restaurant type variable was not a diversely recorded one; the American style restaurant accounted for approximately 40 % of the data in the study.

Lack of Prior Research. Previous studies had more focus on the prediction of foodborne illnesses from restaurant data. Petran et al. [3] developed a predictive tool for the risk of norovirus, Salmonella and *Clostridium perfringens* outbreaks. Other studies have used restaurant grades are interpreted by the public and health inspectors [10]. Results of this study cannot be compared directly to similar studies.

Longitudinal Effects. This study did not account for the period before 2011 and after 2012 within the study population. Accounting for this type of effect would be better suited for a long-term study.

Missing Variables. A number of other variables could have been collected to help test the hypotheses that were posed in this study. Sato [11] used a number of additional variables were included such as type of ownership (corporation or franchise), number of years under current ownership, number of menu items, hours of operation, number of food handlers employed, and number of customers served daily.

CONCLUSIONS

This study suggested that there are associations between receiving a Grade A inspection and restaurant type. American-style restaurants, when compared to seven other ethnicity-specific restaurants, did not have significant odds of receiving a Grade A. Five restaurant types had significant odds ratio less than 0.85 of receiving a Grade A from inspections across New York City as a whole. Several other restaurant styles, such as “Indian,” “Coffee Shops,” and “Thai” were not included in this study due to lower inspection data in

comparison to the ones used. A future study should incorporate all types of restaurants and use "American" restaurants as the reference group. Odds ratios of the ones presented in this study would differ when all restaurant types are used in the prediction modeling.

Public and environmental health agencies and professionals can use this study as a roadmap for building upon their own restaurant inspection programs. Identifying who the lower performers are and the specific reasons as to why they are can be used to help protect the public, particularly in the lowering of foodborne illness cases in a community.

A novel equation was developed based upon those variables used in the statistical analyses. In its current state, this equation should be used as one to be built upon as a method for predicting a Grade A inspection.

This study was conducted because there is no other research that appears in peer-reviewed literature that poses the same questions. Several peer-reviewed journals were searched for restaurant grading and cuisine type, particularly from 2009 through present. Most models using restaurant data were for the prediction of foodborne illnesses, not grades given by public health inspectors. The results of this study should be used as a building block for the enhancement of this field of research.

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