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Body Mass Index, Neighborhood Fast Food and Restaurant Concentration, and Car Ownership

Sanae Inagami, Deborah A. Cohen, Arleen F. Brown, and Steven M. Asch

ABSTRACT *Eating away from home and particularly fast food consumption have been shown to contribute to weight gain. Increased geographic access to fast food outlets and other restaurants may contribute to higher levels of obesity, especially in individuals who rely largely on the local environment for their food purchases. We examined whether fast food and restaurant concentrations are associated with body mass index and whether car ownership might moderate this association. We linked the 2000 US Census data and information on locations of fast food and other restaurants with the Los Angeles Family and Neighborhood Study database, which consists of 2,156 adults sampled from 63 neighborhoods in Los Angeles County. Multilevel modeling was used to estimate associations between body mass index (BMI), fast food and restaurant concentration, and car ownership after adjustment for individual-level factors and socioeconomic characteristics of residential neighborhoods. A high concentration of local restaurants is associated with BMI. Car owners have higher BMIs than non-car owners; however, individuals who do not own cars and reside in areas with a high concentration of fast food outlets have higher BMIs than non-car owners who live in areas with no fast food outlets, approximately 12 lb more (p=0.02) for an individual with a height of 5 ft. 5 in. Higher restaurant density is associated with higher BMI among local residents. The local fast food environment has a stronger association with BMI for local residents who do not have access to cars.*

KEYWORDS *Multilevel, Fast food, BMI, Obesity, Mobility, Neighborhood, Restaurant*

INTRODUCTION

In 2003, 41% of family food budgets in the USA were spent eating out.[1] Fast food sales, which comprise more than 41% of restaurant sales, have increased from $16.1 billion in 1975 to $123.9 billion in 2003,[1] and because consumption of fast food is associated with higher body mass index (BMI) in adults and children,[2–4] there has been recent interest in understanding whether fast food consumption is causally related to the US obesity epidemic.[2–7]

Inagami is with the General Internal Medicine, Center for Health Equity Research and Promotion (CHERP) of the VA Pittsburgh Healthcare System and University of Pittsburgh in Pittsburgh, Pittsburgh, PA, USA; Cohen is with the Health, RAND Corporation, Santa Monica, CA, USA; Brown is with the General Internal Medicine, University of California, Los Angeles, Los Angeles, CA, USA; Asch is with the HSR&D, VA Greater Los Angeles Healthcare System and University of California, Los Angeles, CA, USA.

Correspondence: Sanae Inagami, MD, MPH, General Internal Medicine, Center for Health Equity Research and Promotion (CHERP) of the VA Pittsburgh Healthcare System and University of Pittsburgh in Pittsburgh, Pittsburgh, PA, USA. (E-mail: sanae.inagami@va.gov)

It is unclear whether proximity to fast food outlets can explain the higher prevalence of obesity in low-income minority populations. Studies examining the location of outlets in relation to at-risk populations in Europe and the USA have yielded mixed results[8–14,37,41–43]; furthermore, the association between access to fast food restaurants and obesity has also been mixed.[5,7,15–17,37–40] Mehta and Chang[5] found an association between higher US county concentration of fast food restaurants and increased BMI; they also found that higher county concentration of full-service restaurants and total restaurants (fast food+full service restaurants) were associated with lower BMI. In another US study, Chou et al.[7] found that higher concentration of total restaurants at the state level made the largest contribution to increasing weight. All the other cited studies showed no association between obesity and geographic access to fast food restaurants.

One reason for the mixed results in fast food studies may be due to how access and proximity are measured. Studies have used distance to the nearest fast food site[15] and number of fast food outlets per 1,000 people[16,17] to measure fast food exposure. Distance to the closest fast food site may be insensitive in measuring spatial accessibility in congested urban areas where one may find many fast food outlet options at similar distance from any reference point. Additionally, fast food per population measure is a supply ratio that grossly compares supply of fast food between different areas, which may misrepresent access because it does not incorporate any measure of distance or travel impedance.[18] Concentration of fast food outlets as measured by locations per roadway mile may be a more appropriate measure of fast food access in modern urban environments because it accounts for spatial dispersion,[19,20] which captures not only the fast food environment but its interaction with people.[21] This may be particularly relevant in cities where individuals traverse the city and access fast food outlets along major and minor arterial roadways. Studies of alcohol outlet density measures have used alcohol outlet stores per roadway miles to show an association with violent assaults and with alcohol-related motor vehicle accidents.[22,23]

Related to this issue, fast food associations with BMI may not have been seen if factors, such as car ownership, that reduce barriers to alternative healthier food choices were not taken into account. Early studies have shown that neighborhood associations with health outcomes are stronger in individuals who do not own cars.[27,44] No study has yet examined the role of car ownership in the association between access to fast food and obesity.

In this multilevel study, we examined whether fast food and general restaurant access, defined as the number of fast food outlets (or restaurants) per roadway miles per residential census tract, is associated with neighborhood socioeconomic levels and the BMI of its residents and whether this association is moderated by car ownership.

MATERIALS AND METHODS

Sample

The Los Angeles Family and Neighborhood Survey (L.A.FANS) is a longitudinal study that was undertaken to understand how neighborhoods affect a variety of outcomes, including health in adults. We used data from L.A.FANS 2000–2001, the first wave of the study, a stratified random sample of 65 neighborhoods (census tracts from the 1990 Census) in Los Angeles County designed to oversample poor neighborhoods or those census tracts with a high proportion of residents living below the poverty line. Twenty tracts were selected from the very poor group (the top 10% of the poverty distribution in Los Angeles County), 20 from the poor strata (tracts in the 60th–89th percentile) and the remaining 25 tracts comprise the non-poor (tracts in the bottom 60% of the distribution). The choice of three strata and the specific cutoffs were based on analysis that examined the trade-off under different schemes between likely yield of welfare recipients and the concentration of the sample in a small number of high poverty areas.[24] The household survey asked adults about household economic status, education, employment, income, marital history, and neighborhoods of residence. We eliminated respondents for whom either income (n=37) or BMI (n=273) was missing and for whom BMI was >47 (n=10) as well as those who listed their income as "0" but who were also employed (n=23). We also eliminated "other race/ethnicity" (n=74) because of small sample size. Our final sample size was 2,156 after eliminating two very large census tracts (n=88) that differed substantially from other tracts that were sampled, with areas larger than 126,000 acres and roadway miles greater than 350 miles. With these two tracts deleted, the largest census tract was 2,467 acres and contained 79 roadway miles.

Residential neighborhoods were identified at the census-tract level. The L.A. FANS sampling strategy was based on census tract boundaries identified from the 1990 Census (before data from the 2000 Census was available). When the survey was undertaken, in 2000–2001, data were extracted from the 2000 decennial census file. Because the 2000 census tract boundaries were somewhat different from the 1990 census tract boundaries, we computed census tract values for the old boundaries as a population-weighted average of all new census tracts falling within the old boundaries (only the population of the new census tract that falls within the old boundaries is used in constructing weights). For example, if a 1990 census tract was split into two 2000 census tracts, we computed a weighted average of the two census tracts where the weights are proportional to the 2000 tract population.

Measures

Dependent Variable Respondents were asked to provide their height and weight; from this information, each respondent's BMI was calculated in kilograms per square meter. BMI was analyzed as a continuous outcome.

Fast Food Restaurants We obtained a list of all restaurants in Los Angeles County from the L.A. County Department of Public Health, Environmental Health Division and used the 1997 North American Industry Classification system codes to identify fast food restaurants (limited-service restaurants considered chains or franchises). Data on the fast food outlets were merged with individual-level data using census tracts (see Appendix A for complete list of outlets included). The number of fast food outlets within a census tract was divided by census tract roadway miles to create a fast food density measure for each census tract. Roadway miles came from Department of Commerce-2000 Census boundary files.

The fast food density measure was divided into three groups. The reference group included all census tracts with no fast food outlets. The second and third groups were created by dividing the remaining census tracts at the midpoint, defined as "low fast food density" (range, 0.025–0.15 fast food outlets/roadway miles) and "high fast food density" (range, 0.16–0.43 fast food outlets/roadway miles).

Other Food Outlets Total food outlets per roadway miles within the census tract were also calculated using the list of all restaurants provided by the L.A. County Department of Public Health, Environmental Health Division. We specifically excluded restaurants that did not have public access, such as catering businesses, and those that were located within sports arenas, private clubs, cinemas, senior citizen centers, airports and hotels; we also excluded restaurants that were located in bars, pool halls, stores such as Kmart and Target, and restaurants within supermarkets (i.e., delis and bakeries).

The total restaurant measure was divided into three groups. The reference group included all census tracts with no restaurants. The second and third groups were created by dividing the remaining census tracts at the midpoint, defined as "total restaurants: low density" (range, 0.04–0.57 restaurants/roadway miles) and "total restaurants: high density" (range, 0.59–9.93 restaurants/roadway miles). The total restaurant measure included fast food outlets.

Residential Neighborhood Disadvantage Four summary statistics of census tracts in Los Angeles County were each standardized and combined to create a neighborhood "disadvantage score," a well-described and often-used measure of socioeconomic status (SES)[25]: (1) percent living below the poverty line, (2) percent of households that are headed by a woman, (3) percent male unemployment, and (4) percent of families receiving public assistance. The continuous disadvantage score of residential neighborhoods was used for regression analysis, lower scores referring to higher SES areas. The score was categorized into four quartiles based on the distribution of all census tracts in Los Angeles and referred to as Very Low (the most disadvantaged), Lower Middle, Upper Middle, and Very High SES areas for Tables 1 and 2.

Car Ownership Respondents were asked in the survey whether or not they or their spouse/partner had one or more working cars. Car ownership was separated into two categories, those who had access to a working car and those who did not; the reference category refers to those respondents who did not have access to a working car.

Sociodemographic Controls Models were controlled for (1) gender; (2) age (logged); (3) education; (4) race/ethnicity (Latino, African-American, Asian, white); (5) employment; (6) marital status; (7) annual household income (logged); (8) immigrant status; and (9) car ownership (respondent or spouse/partner owns one or more working cars).

Weights The study used a multistage stratified sample design in which tracts, blocks within tracts, and households within tracts were sampled. Tracts were stratified by the percentage of the population in the tract who were in high poverty and by whether household included children under age 18. Sampling weights provided by L.A.FANS reflect both unequal probabilities of sample selection and household nonresponse.[24] Weights were used as probability weights in HLM 6.02 (2004).[26]

Statistical Analyses

Multilevel weighted linear regression models using HLM 6.02 (2004)[26] were used to estimate simultaneously the association between BMI and the individual sociodemographic variables and residential neighborhood characteristics.

TABLE 1 Individual characteristics of respondents: L.A.FANS 2000–2001

Characteristics	Values
Total Sample	2,156
Family income ($)	
Median (range)	26,550 (0–1,303,000)
Mean (range)	52,338
Age	
Mean (range)	39.4 (18–91)
BMI	
Mean (range)	26.6 (14.2–46.6)
% Married	50
% Own car	76
% Female	57.6
% Employed	66
% College	20
% Immigrant	57
Race/ethnicity	
Latino	1,243 (58)[a]
African-American	198 (9)[a]
White	552 (26)[a]
Asian	158 (7)[a]
Residential area SES	
Very Low	824 (38)[a]
Lower Middle	651 (30)[a]
Upper Middle	346 (16)[a]
Very High	335 (16)[a]
Concentration fast food	
High	563 (26)[a]
Low	409 (19)[a]
Zero	1,184 (55)[a]
Concentration total restaurant	
High	868 (40)[a]
Low	874 (41)[a]
Zero	414 (19)[a]

[a] *N* (% total sample)

Cross level interactions between fast food/total restaurant concentration (level 2) and car ownership (level 1) were examined to determine whether car ownership moderated the effect of fast food concentration on BMI.

RESULTS

Descriptive Statistics

The 2,156 L.A.FANS respondents were predominantly young (mean age 39 years) and Latino (58%) as shown in the last column of Table 1. Thirty-eight percent of the adult sample resided in the lowest SES neighborhood quartile; nearly 70% of the total sample lived in the two lowest SES neighborhood quartiles.

Respondents missing BMI information had lower median income and were significantly ($p<0.05$) less likely to own a car, less likely to live in a Very High SES Area, and less likely to be white, employed, and college educated. Concentration of neighborhood fast food establishments did not differ between those missing and those not missing BMI information.

TABLE 2 Measures of the fast food environment in the 63 census tracts* included in the analyses L.A.FANS 2000–2001

	Very Low	Lower Middle	Upper Middle	Very High	Total
# Census tracts	25	19	10	9	63
# Total restaurants/tract					
Mean (SD)	9.1 (10.9)	15.7 (15.4)	15.3 (16.5)	5.7 (8.1)	11.6 (13.8)
Range	0–58	0–58	0–52	0–23	0–58
# Fast food/tract					
Mean (SD)	0.6 (1.2)	1.7 (1.9)	2.2 (2.4)	1.6 (1.9)	1.3 (1.9)
Range	0–4	0–6	0–8	0–5	0–8
# Fast food/roadway miles/tract					
Mean (SD)	0.05 (0.10)	0.12 (0.14)	0.10 (0.08)	0.09 (0.12)	1.3 (1.9)
Range	0–0.35	0–0.43	0–0.23	0–0.37	0–0.43
Roadway miles/tract					
Mean (SD)	15 (7.6)	17 (13)	20 (6.2)	24 (11)	17.8(10.4)
Range	6–37	9–79	13–35	9–46	6–79
Acres/tract					
Mean (SD)	389 (382)	425 (431)	559 (317)	866 (553)	498 (448)
Range	83–1,664	159–2,467	245–1,223	176–1,725	83–2,467

*Two census tracts were eliminated. These census tracts had disproportionately large acreages (126,000 and 129,714 acres) and roadway miles (726 and 355 miles) compared to other census tracts. The largest census tract in the sample used for analysis contains 2,467 acres and 79 roadway miles.

Fast Food and other Restaurant Locations

On average, Lower Middle SES census tracts had the highest total number of restaurants (15.7); Very High SES areas had the least, 5.7 (see Table 2). The number of restaurant establishments per roadway miles remained highest in the Lower Middle SES areas and lowest in the Very High SES areas.

On average, Upper Middle SES census tracts had the highest absolute number of fast food outlets, with 2.2 outlets; Very Low SES areas had the least, with 0.6 outlets (see Table 2). However, because census tract acreage and roadway miles increase as SES increases, the density of fast food outlets (per roadway mile) was highest in Lower Middle SES areas: 0.12 fast food outlets/roadway mile.

Multilevel Analyses

Individual and neighborhood factors associated with BMI are shown in Table 3. Model A examines the role of total restaurant density, and model B, fast food outlet density; model C examines the interaction between car ownership and fast food outlet density, and model D examines the interaction between car ownership and total restaurant density. All models in Table 3 show that BMI was positively associated with car ownership and being Latino, older, and female.

Model A shows that higher density of total restaurants was associated with about a 1.0 BMI unit increase in residents who lived in the same census tract. In contrast to total restaurants, neither high nor low concentration of fast food outlets was associated with BMI (see model B). However, when we included the interaction between fast food establishments and car ownership (model C), residents living within an area of high fast food concentration were found to weigh 2.03 BMI units more than residents living in areas with no fast food outlets; this effect was nearly erased in those residents who owned cars living in areas with high fast food concentration (-1.86 BMI units). In addition, model fit was significantly improved (a decrease in deviance of two/variable is considered a statistically significant

TABLE 3 Multilevel model: individual and neighborhood factors associated with BMI

	Model A		Model B		Model C		Model D	
BMI Units (n=2,156)	β	P	β	P	β	P	β	P
Residential SES[a]	0.20	0.00	0.23	0.00	0.24	0.00	0.22	0.00
Restaurant								
High concentration	0.92[b]	0.03[b]	0.46[c]	0.20[c]	2.03[c]	0.02[c]	1.95[b]	0.07[b]
Low concentration	0.15[b]	0.70[b]	0.12[c]	0.80[c]	0.64[c]	0.54[c]	0.02[b]	0.98[b]
Zero concentration	Reference							
Own car	0.82	0.04	0.82	0.04	1.41	0.00	1.40	0.14
Does not own car	Reference							
Interaction: High concentration fast food outlet × Own car					−1.86	0.05	−1.24	0.26
Interaction: Low concentration fast food outlet × Own Car					−0.64	0.45	0.17	0.87
Immigrant	−0.88	0.10	−0.85	0.11	−0.84	0.11	−0.91	0.08
Non-immigrant	Reference							
African-American	0.64	0.25	0.56	0.33	0.56	0.33	0.67	0.24
Latino	1.32	0.02	1.29	0.03	1.26	0.03	1.32	0.03
Asian	−0.66	0.45	−0.68	0.44	−0.66	0.46	−0.62	0.48
White	Reference							
Female	−0.95	0.01	−0.94	0.01	−0.94	0.01	−0.94	0.01
College educated	−0.02	0.97	−0.03	0.95	−0.05	0.92	−0.04	0.95
Married	0.60	0.09	0.58	0.10	0.56	0.11	0.57	0.11
Employed	0.71	0.10	0.72	0.09	0.71	0.10	0.68	0.12
Log age	1.54	0.00	1.54	0.00	1.55	0.00	1.56	0.00
Log income	−0.15	0.19	−0.15	0.19	−0.14	0.21	−0.14	0.20
Intercept	20.46	0.00	20.85	0.00	20.17	0.00	19.86	0.00
Deviance	12,681.92		12,688.41		12,678.43		12,673.70	
Var (U0j)	0.61(0.00)		0.75(0.00)		0.77(0.00)		0.61(0.00)	
Var (Rij)	20.56		20.56		20.50		20.52	
Intraclass correlation coefficient (ICC)	0.029		0.035		0.045		0.029	

[a]Residential SES: higher values imply lower SES areas
[b]Total restaurants
[c]Fast food outlets only

TABLE 4 Predicted change in weight for a person 5 ft 5 in. tall

Characteristic	Change in predicted weight (lb)[a]
Gender	−5.6
Race/ethnicity	
Latino (vs. white)	+7.6
African-American (vs. white)	NS
Asian (vs. white)	NS
Owns car	
High fast food concentration	+9.5
Zero fast food concentration	+8.5
Does not own car	
High fast food concentration	+12.2
Zero fast food concentration	0

[a]Average change in weight as derived from model C of Table 3 for a 5 ft 5 in. individual where 1 BMI unit is equivalent to approximately 6 lb

improvement in model fit). Though including the interaction between total restaurants and car ownership improved model fit, the interaction was not significant and did not change the association between BMI and total restaurant concentration. Eighty percent of respondents who lived in areas with high fast food concentration and 75% in areas with low fast food concentration owned cars; 73% of those who lived in areas with no fast food establishments owned cars.

Table 4 estimates the impact of fast food concentration (from model C) on weight for a reference individual who is 5 ft 5 in. tall, in whom 1 BMI unit would be equivalent to about 6 lb. Women who are 5 ft 5 in. would weigh 5.6 lb less than a 5 ft 5 in. man. Those of Latino ethnicity would be approximately 7.6 lb greater in weight compared to whites. Car owners on average weigh 8.5 lb more than non-car owners. Non-car owners who live in areas of high fast food concentration weigh 12 lb more than non-car owners who live in areas without fast food outlets and 2.7 lb (0.45 BMI units) more than car owners who live in areas of high fast food concentration. Those who do not own cars who live in areas without any fast food outlets (reference group) weigh the least (low concentration of census tract fast food alone was not associated with BMI). We found no significant interactions between race/ethnicity and immigration status. We also found no interactions between gender and car ownership, between gender and concentration of fast food, between gender and African-American race (β=0.88; p=0.49), nor between gender and Asian ethnicity (β=−1.93; p=0.10). We did note an interaction effect between Latino race and female gender (β=1.21; p=0.034), suggesting that increased weight in Latinos associated with proximity to restaurants is manifested by increased weight in women alone. Introducing the gender interaction with race/ethnicity did not alter the association between fast food and BMI nor the association among fast food, car ownership, and BMI. Though these interactions for the most part were not statistically significant, we suspect that, given greater power, there may be more gender, race/ethnicity, car ownership, and environmental interactions.

We also explored other measures to characterize the fast food environment. The number of fast food outlets/census tract area behaved similarly to fast food/roadway miles. In contrast, number of fast food outlets/population density was not associated with BMI. We did not measure distance to nearest fast food establishment for this analysis.

DISCUSSION

Our study supports the possibility that local food environments influence the risk of obesity, especially among adults without cars and living in proximity to a large number of fast food outlets.[27] Those able to travel farther may have wider access to healthier food products, while those limited to their neighborhoods may be more likely to purchase energy-dense foods that contribute to weight gain.[28–31] While all residents appear to be affected by the concentration of restaurants, the magnitude of the magnitude of effect of fast food outlets is much smaller for residents able to travel by car than for individuals without cars. Car ownership may reduce the local effect of fast food outlets in the neighborhood, while lack of car access appears to exacerbate it. Those who do not own cars may be more likely to visit fast food outlets than most costly full-service restaurants in their neighborhood.

Our use of roadway miles as a measure of fast food and restaurant density in Los Angeles suggests that measures of access by car or by foot for day-to-day activities may be a more relevant measure of exposure than the number of fast food establishments per population density or most proximate fast food location. The measure appears to be particularly germane in urban environments where fast food establishments may be located along roads in strip mall developments. However, these findings may not be applicable to data from Europe or in cities with high population density and with well-developed public transportation systems. Furthermore, our findings underscore the need to take local development and planning patterns into account when considering neighborhood effects on public health indicators.

Our study showed that total restaurant concentration was associated with higher BMI, whereas Mehta and Chang[5] found that it was associated with lower BMI. Two factors may explain the different outcomes in our study; they did not include car ownership in their models and also analyzed their data at the level of the county. While Mehta and Chang[5] focused on county differences in BMI of its residents, our study focused on the differences in the local environments within one county and sought to explain whether these local differences were associated with the differences in BMI amongst disparate populations. Our study suggests that it is the widespread easy access to prepared food locally, regardless of whether or not it is "fast food," that is associated with increased weight, but that "fast food" appears to be particularly associated to increased weight in residents not owning cars. Though populations within urban counties like Los Angeles are increasing in weight, urban residents have been shown to have lower BMI compared to their rural counterparts[32–34]; this may explain Mehta and Chang's findings that showed lower BMI in residents of counties with greater number of total restaurants.

Although some studies have found fast food access to be more concentrated in low-income and ethnic minority areas,[8–10] in our study the density of fast food outlets appears to be more concentrated in middle-income areas and least concentrated in the lowest income areas.[12,13] Therefore, fast food access alone cannot explain residential SES associations with BMI in Los Angeles. The food environment is complex, and exposure to different types of food outlets depends upon both urban design and access to transportation.

Limitations

The study is cross-sectional in nature and thus cannot prove causality. Our study cannot determine whether the effect we are seeing using the fast food measure is due to fast food access specifically or general access to restaurants or to other factors related to commercial development. In addition, detailed individual information regarding measures of the specific food eaten and physical activity was not available. Another concern is that self-reported height and weight are often underestimated and vary significantly among different race/ethnic groups[35] and gender.[36] However, underestimation would most likely underestimate the associations found in our study; on the other hand, variations in self-report among different race/ethnic groups would bias our study in directions unknown. While eliminating those missing BMI could have biased the results, they were equally distributed among the groups residing in high and low fast food concentration areas, so the likelihood of bias resulting from confounding is reduced. Bias may also result from the sampling strategy used, but weights were used to offset oversampling from poor areas in Los Angeles County. Lastly, boundaries that affect people's health are not necessarily fixed within census tracts.

CONCLUSIONS

Combating the obesity epidemic requires an understanding of the factors that contribute to it, both at the individual and neighborhood level. Those residents most vulnerable to barriers to healthy eating in their local food environment appear to be those who do not own cars. The relationship of access to fast food and BMI, illuminated by the interaction with car ownership, suggests that limiting fast food density, especially where a large proportion of the population do not have cars, may be an important measure to help curb the obesity epidemic. Facing higher levels of obesity and diabetes levels and the highest concentrations of fast food restaurants, the City Council currently is considering a proposal to ban new fast food restaurants in South Los Angeles.

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APPENDIX A

Fast food establishments: McDonald's, Starbucks, Baskin-Robbins, Carl's Jr., Burger King, Taco Bell, Jack in the Box, Arby's, 7-Eleven, Subway, In-N-Out Burger, Kentucky Fried Chicken, Domino's Pizza, El Pollo Loco, Panda Express, Pizza Hut, Quiznos, Little Caesar's Pizza, Der Wienerschnitzel, Winchell's Donuts, Popeye's Chicken, Papa John's Pizza, Wendy's, Baja Fresh Mexican Grill, Hong Kong Express, Yoshinoya, Del Taco, Pizza Man, China Express, Tacos Mexico, Togo's Eatery, Round Table Pizza, Fatburger, La Salsa.

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