

# Census Tract-Level Disparities: Examining Food Swamps and Food Deserts

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## ABSTRACT

Examining disparities in resources on the census tract-level is currently a public health priority. The Modified Retail Food Environment Index (mRFEI), provided by the CDC, incorporates two food environment metrics, "food deserts", areas with no access to healthy foods, and "food swamps", areas in which the quantity of unhealthy food options overwhelm healthy ones. We assess the association between the census tract racial make-up and food environment.

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## METHODS

In order to test the association between food deserts and food swamps and census tract-level racial make-up, we fit two regression models, adjusting for state and census tract level covariates (percent that did not graduate high school, percent in poverty, and percent rural population).

Food desert and food swamp are defined using the Modified Retail Food Environment Index (mRFEI):

$$mRFEI = 100 \times \frac{\# \text{ Healthy food retailers}}{\# \text{ Healthy food retailers} + \# \text{ Less healthy food retailers}}$$

### Food Desert:

Modified Retail Food Environment Index of 0, indicating that there are 0 healthy food sources in a given census tract.

### Food Swamp:

Modified Retail Food Environment Index greater than 0 and less than or equal to 10 for a given census tract.

### Data Analysis:

All analysis were completed using R version 3.1.1

We performed two logistic regression analyses.

To continue reading, click the green circle labeled "Methods".

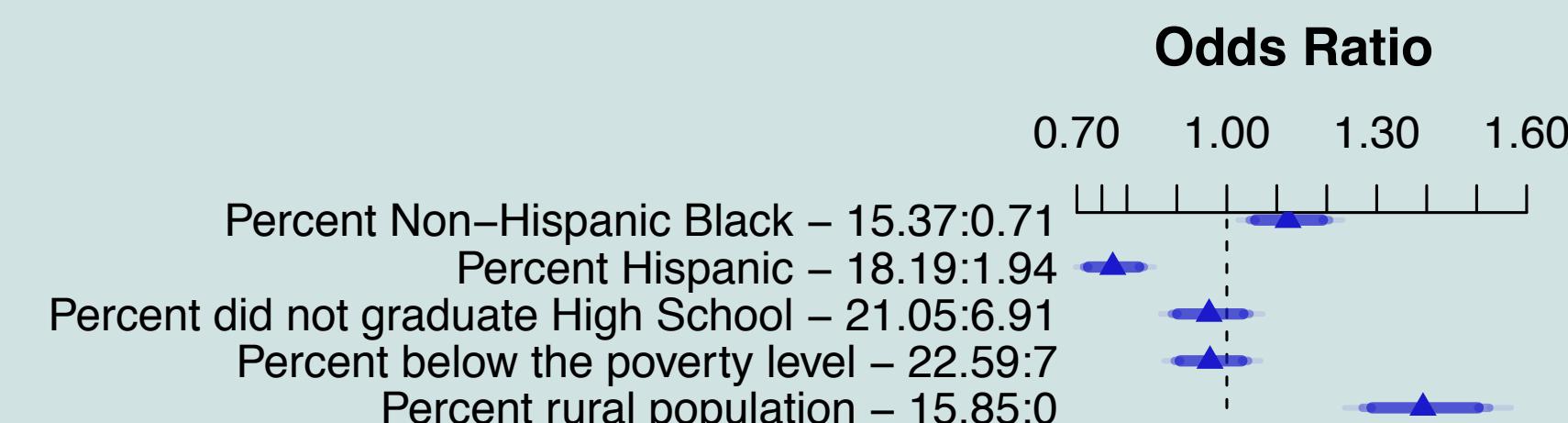
## RESULTS

### Food Deserts

Table 1. Mean percent difference between food desert census tracts and non-food desert census tracts.

	Overall N=50587	Food Desert N=12416	Non-food Desert N=38171	Difference
Percent Non-Hispanic Black	14.44	14.31	14.48	-0.17
Percent Hispanic	15.0	9.82	16.68	-6.86
Percent Non-Hispanic White	63.31	70.31	61.03	9.28
Percent without High School Graduation	15.44	14.59	15.71	-1.12
Percent in Poverty	16.38	15.76	16.59	-0.83
Percent Rural	19.11	38.05	12.95	25.1

Figure 1. The figure below represents the results from the logistic regression model predicting whether a census tract is a food desert. Interquartile-range odds ratios. Numbers on the left are the upper quartile: lower quartile. The bars represent 90%, 95%, and 99% confidence limits.

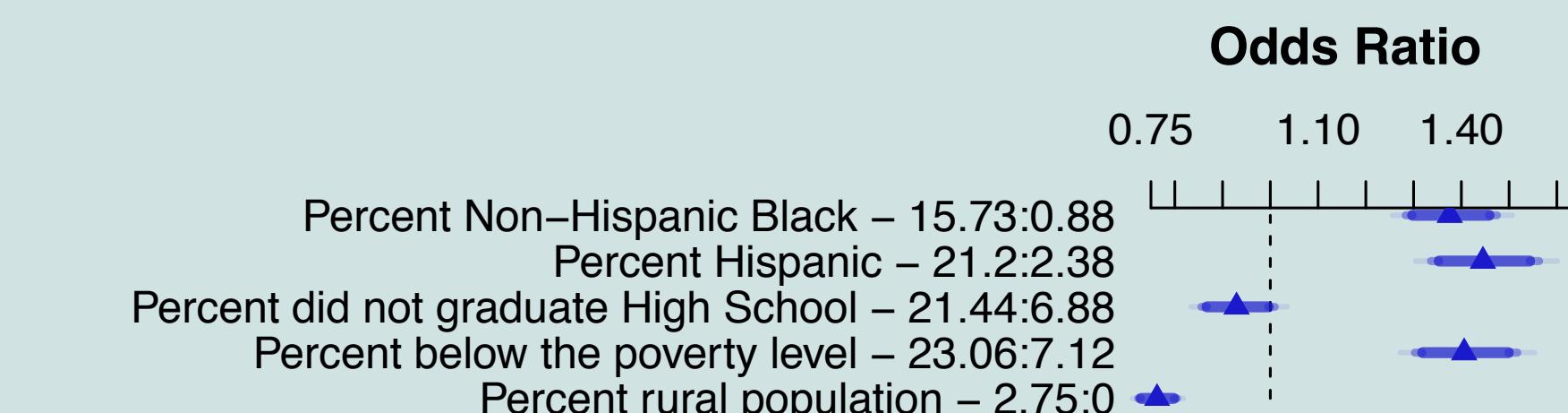


### Food Swamps

Table 2. Mean percent difference between food swamp census tracts and non-food swamp census tracts among non-food deserts.

	Overall N=38171	Food Swamp N=15495	Non-food Swamp N=22676	Difference
Percent Non-Hispanic Black	14.48	19.53	11.03	8.5
Percent Hispanic	16.68	20.12	14.33	5.79
Percent Non-Hispanic White	61.03	51.97	67.22	-15.25
Percent without High School Graduation	15.71	17.51	14.49	3.02
Percent in Poverty	16.59	19.19	14.81	4.38
Percent Rural	12.95	3.96	19.10	-15.14

Figure 2. The figure below represents the results from the logistic regression model predicting whether a census tract is a food swamp. Interquartile-range odds ratios. Numbers on the left are the upper quartile: lower quartile. The bars represent 90%, 95%, and 99% confidence limits.



## CONCLUSIONS

We found that the racial make-up of the census tracts is **significantly associated with food swamps and food deserts**.

### Food Deserts:

- The half sample odds ratio for percent non-Hispanic Black is **1.22 (95% CI: 1.05,1.20)**, indicating that food deserts are more likely to have a higher non-Hispanic Black percentage.
- The half sample odds ratio for percent Hispanic is **0.77 (95% CI: 0.71,0.83)**, indicating that food deserts are less likely to have a higher percentage of Hispanics.

### Food Swamps:

- The half sample odds ratio for percent non-Hispanic Black **1.38 (95% CI: 1.28,1.47)**, indicating that food swamps are more likely to have a higher non-Hispanic Black percentage.
- The half sample odds ratio for percent Hispanic is **1.46 (95% CI: 1.34, 1.56)**, indicating that food swamps are more likely to have a higher percentage of Hispanics.

To continue reading, click the green circle labeled "Conclusions".

## THANK YOU

### References:

- Census Tract Level State Maps of the Modified Retail Food Environment Index. CDC. Available at: [ftp://ftp.cdc.gov/pub/Publications/dnpao/census-tract-level-state-maps-mrfei\\_TAG508.pdf](ftp://ftp.cdc.gov/pub/Publications/dnpao/census-tract-level-state-maps-mrfei_TAG508.pdf)
  - United States Census Bureau."Summary File." 2008 – 2012 American Community Survey. U.S. Census Bureau's American Community Survey Office, 2014. Web. 1 December 2014. Available at: [http://www.census.gov/research/data/planning\\_database/2014/](http://www.census.gov/research/data/planning_database/2014/)
  - Harrell, F. E. (2013). *Regression modeling strategies: with applications to linear models, logistic regression, and survival analysis*. Springer Science & Business Media.
- We would like to thank Dr. Melody Goodman and the Goodman Lab who first introduced Lucy to the systemic issues surrounding racial health disparities.

# Abstract

Examining disparities in resources on the census tract-level is currently a public health priority. The Modified Retail Food Environment Index (mRFEI), provided by the CDC, incorporates two food environment metrics, "food deserts", areas with no access to healthy foods, and "**food swamps**", areas in which the quantity of unhealthy food options overwhelm healthy ones. We assess the association between the census tract racial make-up and food environment. Logistic regression models are fit, controlling for census-tract level covariates from 2008-2012 American Community Survey (ACS) estimates, as well as state. **Percent non-Hispanic Black is significantly associated with food swamps**, with an absolute increase of 8.5 percent black living in food swamps ( $p < 0.01$ ). **Percent Hispanic is significantly associated with food swamps**, with an absolute increase of 5.8 percent Hispanic living in food swamps ( $p < 0.01$ ), but **inversely related to food deserts** (absolute difference -6.9,  $p < 0.01$ ). After adjustment, all associations remain significant, and percent non-Hispanic Black is show to be significantly associated with food deserts as well. The strong association between the census tract-level racial make-up and food swamps shown here will allow for targeted interventions to census tracts where these disparities exist.

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# Methods

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In order to test the association between food deserts and food swamps and census tract-level racial make-up, we fit two logistic regression models, adjusting for state and census tract level covariates (percent that did not graduate high school, percent in poverty, and percent rural population).

Food desert and food swamp are defined using the Modified Retail Food Environment Index (mRFEI):

$$mRFEI = 100 \times \frac{\# \text{ Healthy food retailers}}{\# \text{ Healthy food retailers} + \# \text{ Less healthy food retailers}}$$

## **Food Desert:**

Modified Retail Food Environment Index of 0, indicating that there are 0 healthy food sources in a given census tract.

## **Food Swamp:**

Modified Retail Food Environment Index greater than 0 and less than or equal to 10 for a given census tract.

# Methods

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Healthy food retailer:

- Supermarkets
- Larger grocery stores
- Supercenters
- Produce stores

Less healthy food retailers:

- Convenience stores
- Fast food restaurants
- Small grocery stores with three or fewer employees

# Methods

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## Data Sources:

- Census tract covariates were obtained from the 2008-2012 ACS estimates.
- Food deserts and food swamps were determined using the Modified Retail Food Environment Index provided by the CDC.



# Methods

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## Data Analysis:

- All analysis were completed using R version 3.1.1
- We performed two logistic regression analyses:
  1. We predicted whether or not a census tract was a “food desert” with the following covariates:
    - Percent Non-Hispanic Black
    - Percent Hispanic
    - Percent without high school graduation
    - Percent in poverty
    - Percent rural
    - StateAll continuous covariates were fit using restricted cubic splines with 4 knots, chosen as Harrell suggests<sup>3</sup>. Adjusted odds ratios are report.
  2. We predicted whether or not a non-food desert census tract was a “food swamp” with the same covariates as above. For this analysis, we excluded those that were a food desert from the analysis.
- We then performed sensitivity analyses to see if including food deserts in our food swamp analysis changed the results.

# Results

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## Food Deserts

- Table 1 shows the differences in mean percent between census tracts that are food deserts and those that are not.
- We fit a logistic regression predicting whether a census tract was a food desert (yes/no). Table 3 shows the output.

# Results – Table 1

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**Table 1. Mean percent difference between food desert census tracts and non-food desert census tracts.**

	Overall N=50587	Food Desert N=12416	Non-food Desert N=38171	Difference
Percent Non-Hispanic Black	14.44	14.31	14.48	-0.17
Percent Hispanic	15.0	9.82	16.68	-6.86
Percent Non-Hispanic White	63.3	70.31	61.03	9.28
Percent without High School Graduation	15.44	14.59	15.71	-1.12
Percent in Poverty	16.38	15.76	16.59	-0.83
Percent Rural	19.11	38.05	12.95	25.1

# Results – Table 3

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**Table 3. Food Desert Model Wald Statistics**

Factor	Chi-Square	d.f.	P
Percent Hispanic	103.64	4	<.0001
Nonlinear	37.28	3	<.0001
Percent Non-Hispanic Black	94.42	4	<.0001
Nonlinear	8.67	3	0.0341
Percent did not graduate High School	2.22	4	0.6962
Nonlinear	2.14	3	0.5432
Percent below the poverty level	109.58	4	<.0001
Nonlinear	108.11	3	<.0001
Percent rural population	2349.21	4	<.0001
Nonlinear	17.97	3	0.0004
State	702.27	50	<.0001
TOTAL NONLINEAR	228.19	15	<.0001
TOTAL	5184.78	70	<.0001

# Results – Food Desert Model

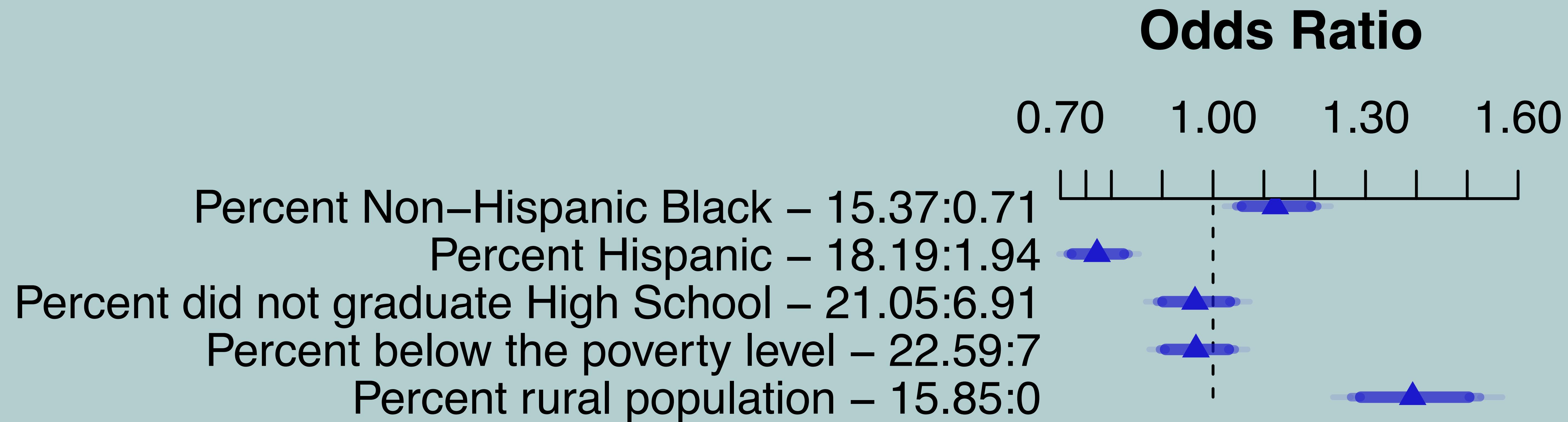
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$$\Pr(desert = 1) = \frac{1}{1 + \exp(-X\beta)}$$

		Model Likelihood Ratio Test		Discrimination Indexes		Rank Discrimination Indexes	
<b>Obs</b>	50587	LR $\chi^2$	5682.82	R2	0.158	C	0.712
0	38171	d.f.	70	g	0.847	Dxy	0.423
1	12416	Pr(> $\chi^2$ )	<0.0001	gr	2.333	gamma	0.425
<b>max  deriv </b>	2.00E-08			gp	0.154	tau-a	0.157
				Brier	0.163		

# Results – Figure 1



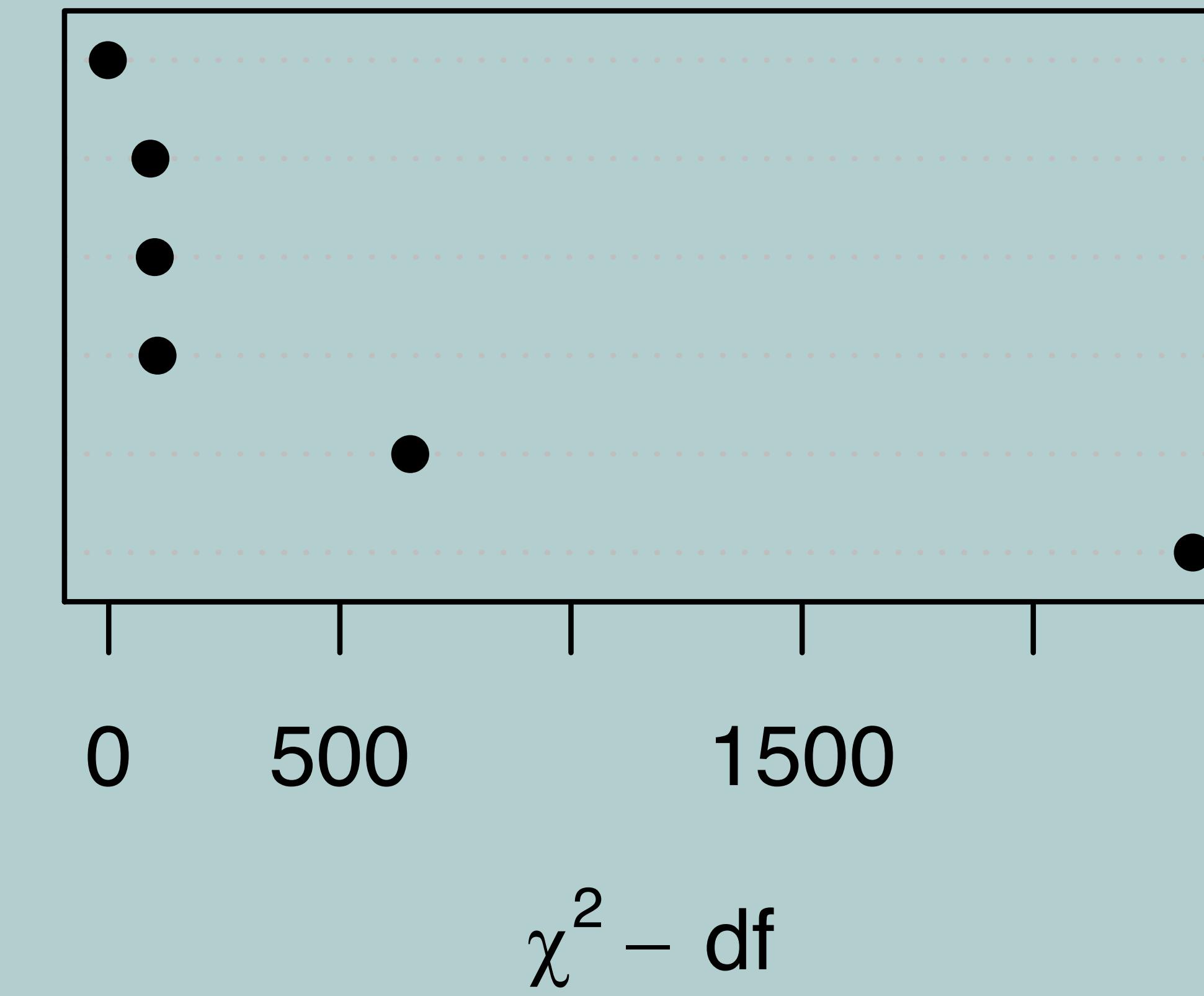
**Figure 1.** The figure above represents the results from the logistic regression model predicting whether a census tract is a food desert. Interquartile-range odds ratios. Numbers on the left are the upper quartile: lower quartile. The bars represent 90%, 95%, and 99% confidence limits.

# Results – Figure 3

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Percent did not graduate High School  
Percent Non-Hispanic Black  
Percent Hispanic  
Percent below the poverty level  
State  
Percent rural population



**Figure 3.** The figure above ranks the covariates by their  $\chi^2$  values. Here, we see that percent rural is highly predictive of food deserts.

# Results

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## Food Swamps

- [Table 2](#) shows the differences in mean percent between census tracts that are food swamps and those that are not.
- We fit a logistic regression predicting whether a census tract was a food swamp (yes/no). [Table 4](#) shows the output.

# Results – Table 2

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**Table 2. Mean percent difference between food swamp census tracts and non-food swamp census tracts among non-food deserts.\***

	Overall N=38171	Food Swamp N=15495	Non-food Swamp N=22676	Difference
Percent Non-Hispanic Black	14.48	19.53	11.03	8.5
Percent Hispanic	16.68	20.12	14.33	5.79
Percent Non-Hispanic White	61.03	51.97	67.22	-15.25
Percent without High School Graduation	15.71	17.51	14.49	3.02
Percent in Poverty	16.59	19.19	14.81	4.38
Percent Rural	12.95	3.96	19.10	-15.14

\*Interested in the mean percent difference without eliminating food deserts? Click [here](#).

# Results – Table 4

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**Table 4. Food Swamp Model Wald Statistics**

Factor	Chi-Square	d.f.	P
Percent Hispanic	122.54	4	<.0001
Nonlinear	53.78	3	<.0001
Percent Non-Hispanic Black	258.46	4	<.0001
Nonlinear	88.74	3	<.0001
Percent did not graduate High School	20.36	4	0.0004
Nonlinear	9.7	3	0.0213
Percent below the poverty level	186.92	4	<.0001
Nonlinear	15.85	3	0.0012
Percent rural population	1148.58	4	<.0001
Nonlinear	158.35	3	<.0001
State	1023.51	50	<.0001
TOTAL NONLINEAR	488.17	15	<.0001
TOTAL	4327.41	70	<.0001

# Results – Food Swamp Model

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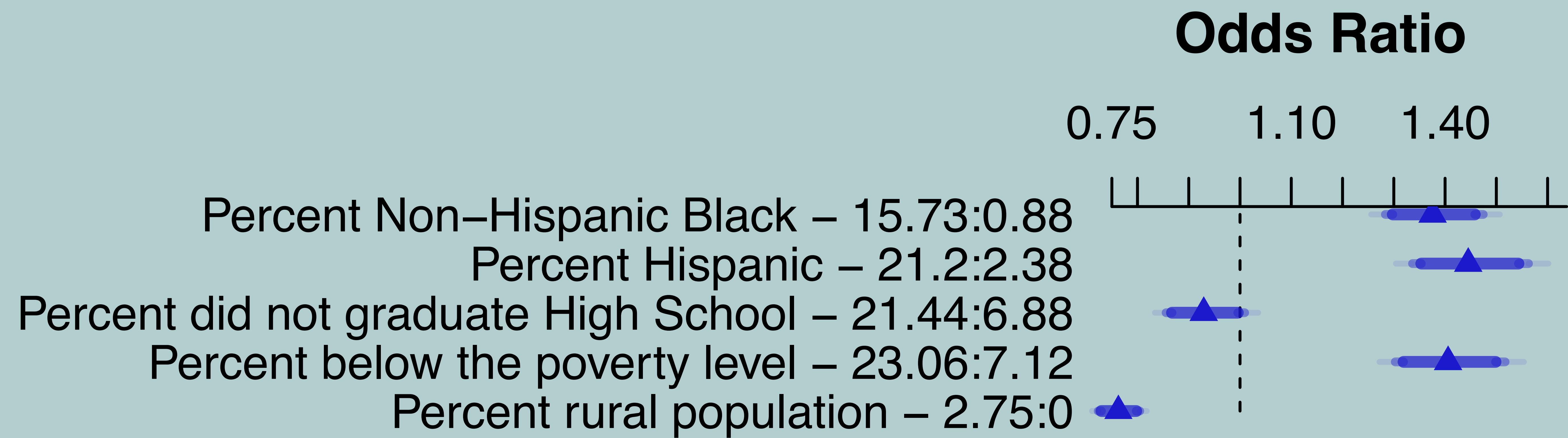
$$\Pr(swamp = 1) = \frac{1}{1 + \exp(-X\beta)}$$

		Model Likelihood Ratio Test		Discrimination Indexes		Rank Discrimination Indexes	
<b>Obs</b>	38171	<b>LR chi2</b>	5914.77	<b>R2</b>	0.194	<b>C</b>	0.717
0	22676	d.f.	70	g	1.067	Dxy	0.435
1	15495	Pr(> chi2)	<0.0001	gr	2.906	gamma	0.436
<b>max  deriv </b>	6.00E-08			gp	0.211	tau-a	0.21
				<b>Brier</b>	0.207		

# Results – Figure 2

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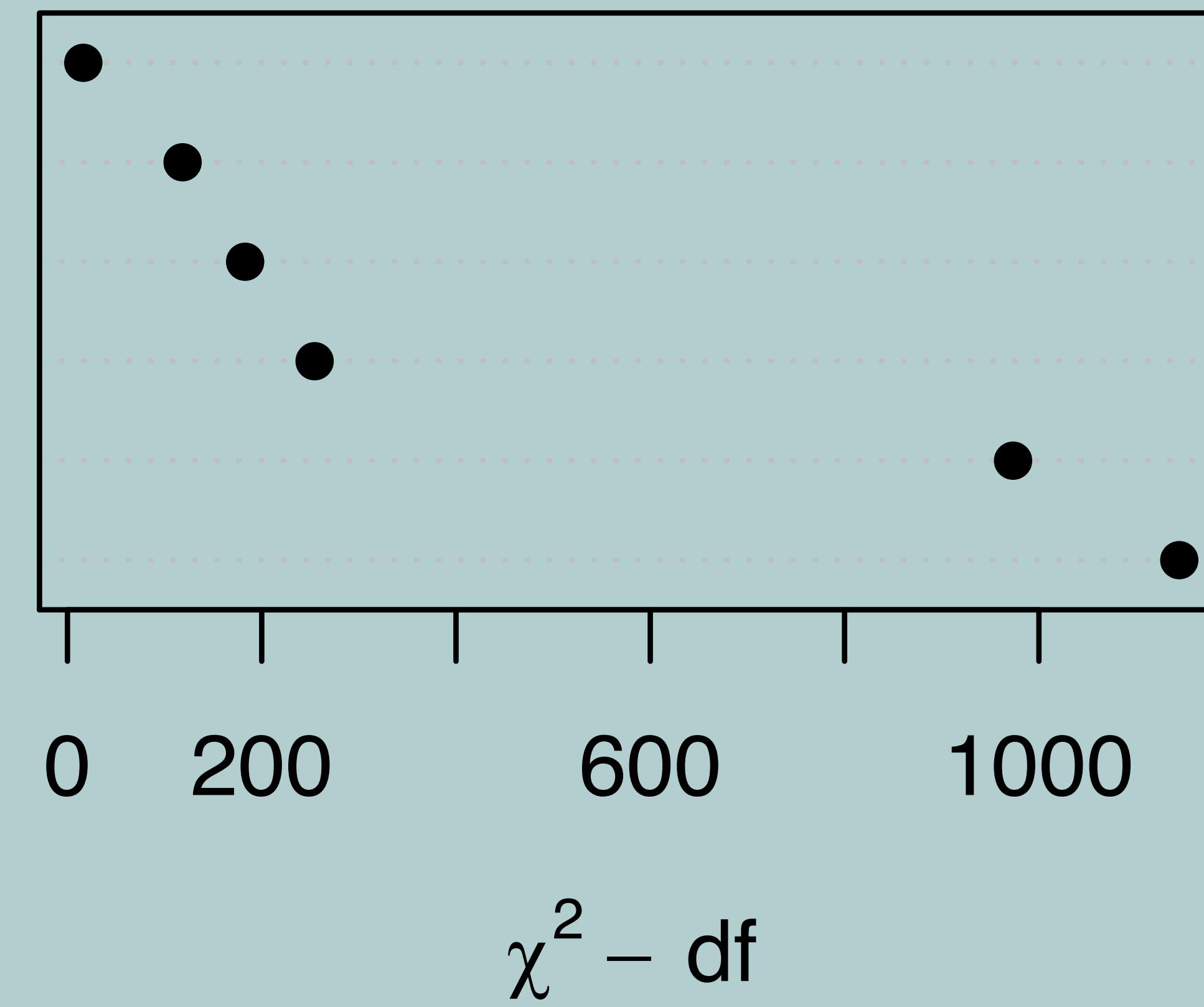
**Figure 2.** The figure above represents the results from the logistic regression model predicting whether a census tract is a food swamp. Interquartile-range odds ratios. Numbers on the left are the upper quartile: lower quartile. The bars represent 90%, 95%, and 99% confidence limits.

# Results – Figure 4

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Percent did not graduate High School  
Percent Hispanic  
Percent below the poverty level  
Percent Non-Hispanic Black  
State  
Percent rural population



**Figure 4.** The figure above ranks the covariates by their  $\chi^2$  values. Here, we see that state and percent rural is highly predictive of food swamps.

# Conclusions



- We found that the racial make-up of the census tracts is **significantly associated with food swamps and food deserts.**
- Examining food deserts:
  - The outer quartiles for census tract-level percent non-Hispanic Black are 0.71% and 15.37%
  - The “half sample” odds ratio for **non-Hispanic Black** is **1.22 (95% CI: 1.05,1.20)**
  - The outer quartiles for census tract-level percent Hispanic are 1.94% and 18.19%
  - The “half sample” odds ratio for **Hispanic** is **0.77 (95% CI: 0.71,0.83).**
- Examining food swamps:
  - The outer quartiles for census tract-level percent non-Hispanic Black are 0.88% and 15.73%
  - The “half sample” odds ratio for census tract-level percent **non-Hispanic black** is **1.38 (95% CI: 1.28,1.47)**
  - The outer quartiles for census tract-level percent Hispanic are 2.38% and 21.20%
  - The “half sample” odds ratio for percent **Hispanic** is **1.46 (95% CI: 1.34, 1.56).**

# Conclusions

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- We noticed areas with higher percentage **Hispanic populations are less likely to be food deserts** (OR: 0.77, 95% CI: 0.71, 0.83), but **more likely to be food swamps** (OR: 1.46, 95%CI: 1.34, 1.56).
- Areas with higher percentage **non-Hispanic Black populations are slightly more likely to be food deserts** (OR: 1.22, 95% CI: 1.05, 1.20), as well as **more likely to be food swamps** (OR: 1.38, 95% CI: 1.28, 1.47).



# Limitations

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- We chose to model our outcomes as binary, rather than using the full mRFEI scale, which led to some loss of information, however the index was difficult to model, since those with 0 healthy food options (food deserts) seemed so different than food swamps, and therefore the proportional odds assumption was violated.
- When modeling food swamps, we excluded food deserts, in order to only compare food swamps to census tracts with “better” healthy food availability. In order to check if this dramatically changed our analysis, we performed a sensitivity analysis, but our results did not dramatically change.

# Further Research

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- Next steps include:
  - fitting a proportional odds model
    - This was explored for this analysis, but the proportional odds assumption was violated, so we will have to look into more complex methods.
  - Delving deeper into these state-level disparities.

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# Appendix: Table 1

**Table A1. Mean percent difference between food swamp census tracts and non-food swamp census tracts.**

	Overall N=50587	Food Desert N=12416	Non-food Desert N=38171	Difference
Percent Non-Hispanic Black	14.44	14.31	14.48	-0.17
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# Appendix: Sensitivity Analysis

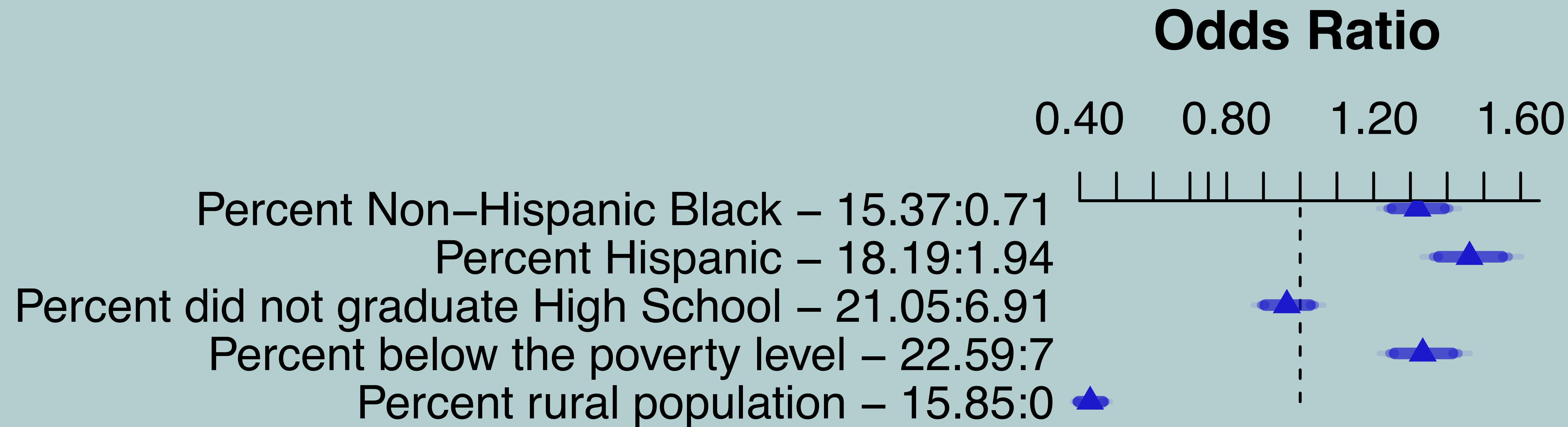


Figure A1. The figure above represents the results from the logistic regression model predicting whether a census tract is a food swamp. Interquartile-range odds ratios. Numbers on the left are the upper quartile: lower quartile. The bars represent 90%, 95%, and 99% confidence limits.