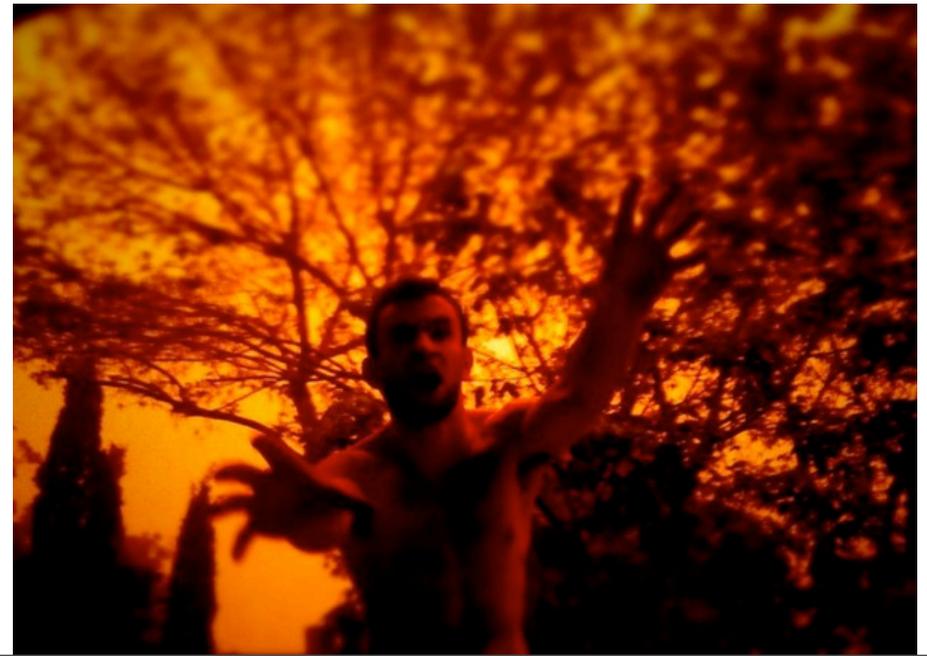
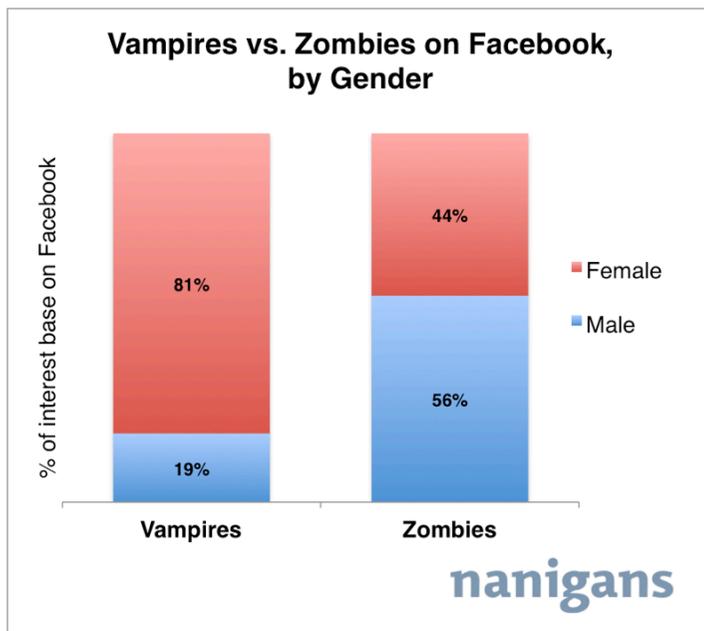


# Zombie demographics

## *Demographics of zombies in the United States*



# Demographics

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- Zombies are an infrequently studied demographic group
- For example, they remain unrecognised by the US Census
- A search for “zombies” at [www.census.gov](http://www.census.gov) does not return a single entry
- Conversely, the living population is a well-studied demographic metric
- Highly reliable Census data is available for the living.

# State demographics

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- Some states have greater numbers of zombies
- However, this may simply reflect larger populations
- Thus, we will adopt a zombie count relative to the living population
- A more useful denominator may be the number of deceased residents who died in each state
- Unfortunately, deceased residents are also unavailable from the US Census.

# State variations in zombie references

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- We will identify and characterise the distribution of zombies across
  - the fifty US states
  - plus the District of Columbia
  - but not including any incorporated or unincorporated territories
- The aim is to explain the wide variety of zombie references across the US states
- Beneficiaries of this research include those who are prone to zombie-avoidance behaviours.

# Data sources

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- The primary source of zombie distribution across each of the 50 US states was obtained using a Google search
- Performed in May 2010
- For each state, the word “zombie” followed by the state’s name was entered
- The number of hits was then reported
- Along with additional demographic data
- The spreadsheet is available by email request from [Daniel.Zelterman@yale.edu](mailto:Daniel.Zelterman@yale.edu).

# An unforeseen difficulty

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- Many Google searches returned counts of websites that were not relevant
  - eg singer/actress Hannah Montana
  - football great Joe Montana
- These names were often included in internet searches, even though they had little or no connection to the state of Montana
- We refer to this as the *Hannah Montana effect*
- Consequently, we were forced to omit the state of Montana from the analysis.

# Additional demographic variables

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- Google zombie references per 100,000
- Per-person zombie references
- Age-adjusted death rate per 100,000
- Percentage of the state population voting for George Bush in 2004
- Cremation rates as percentages of deaths
- Fraction of population who are binge drinkers
- Firearm deaths per 100,000
- Federal taxes paid per capita
- Number of Miss America winners.

# Univariate characteristics

Variable	Mean	Std Dev	Minimum	Maximum
Google zombie references per $10^5$	916	106	189	6900
State population (in millions)	6.14	6.81	0.55	37.0
Zombie refs per person	21.4	13.6	5.4	65.7
Age-adjusted death rate	826	94	624	1022
% votes for GWBush in 2004	52%	10%	9%	72%
% of binge drinkers	15%	3%	8%	22%
Gun death rate	11.4	5.2	2.8	31.2
Per-capita Fed tax in US\$1,000	7.4	4.3	3.0	30.9
# of Miss America winners	1.66	1.85	0	6
Per-capita shopping malls	0.162	0.037	0.076	0.238
% Cremation rate	30.7	16.3	3.2	63.3

- States include DC, but exclude Montana due to the Hannah Montana effect.

# Google references per 100,000

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- This is our primary outcome variable
- It measures zombie distribution
- However, it is not clear if we can precisely attribute zombies to a single state
- Zombies may migrate with seasons
  - perhaps maintaining summer and winter homes
- Younger zombies may return to the location of their former living relatives
  - live-at-home adult zombies
- Older zombies may buy smaller homes
  - downsizing, empty-nester zombies.

# Per-person zombie references

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- More populous states are likely to have more zombies
- Thus, we adjusted these rates on a per-person basis
- Populations are based on the 2009 Census
- This is our primary outcome variable
- It is used as a dependent variable in all linear regression models.

# Values

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- Excluding Montana, the highest value was 65.7 per-person zombie references
  - this occurred in Alaska
  - Montana was 125, but this is likely due to the Hannah Montana effect
- The mean per-person zombie reference rate is 21.4
  - standard deviation of 13.6
- The lowest was 5.4 per-person zombie references
  - this occurred in Pennsylvania.

# Age-adjusted death rate per 100,000

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- A higher death rate per unit population means more potential per-person zombies
- Duh
- Even so, a higher relative death rate may also indicate the presence of zombies who are angrier or more vindictive than usual
  - due to increased and competitive zombie populations
- Unemployment among zombies may also be a contributing factor
  - however, that is beyond the scope of our analysis.

# % voting for George Bush in 2004

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- It is unclear whether the presence of zombies is related to conservative political thinking or a reaction to it
- This measure is related to general attitudes against taxes and the power of a centralised, federal government
- Witness the rise in the US Tea Party, many of whom are zombies
- Zombies do not have the right to vote in the US
- Except in Chicago, where many long-dead have this privilege.

# Per-capita shopping malls

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- When times get tough, zombies go shopping
- This may be a measure of income and suburban sprawl
- Malls are built where there is ample real estate to do so
- Also where there is a sufficiently large population close enough to drive there in large numbers
- Shopping malls play an important role in zombie culture.

# Cremation rates as a % of deaths

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- If the cadaver is reduced to ashes, then it is less likely to reappear later as a zombie
- Intuitively, a high cremation rate would likely result in a lower per-person zombie rate
- Conversely, dissatisfied zombies may migrate to high-cremation states in the hope of being cremated
- This would result in a higher zombie prevalence.

# Fraction who are binge drinkers

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- Zombies may be more likely to attack individuals with impaired judgement
- Perhaps it is only through weak judgement, further reduced by alcohol, that the true nature of zombies can be appreciated and understood
- Alcohol and zombies just don't mix
- An alternative theory is that zombies can be seen more easily through the haze of an alcoholic stupor.

# Firearm deaths per 100,000

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- More gun deaths may not necessarily correlate with greater gun ownership
- US gun ownership is positively correlated with attitudes towards conservative politics
- A gun in the home may be a defence against a perceived high zombie prevalence
- Or the presence of guns may be effective in reducing the zombie population
- Legislation in several states allows patrons to carry loaded firearms into bars
  - this is enough reason to give up drinking entirely.

# Federal taxes paid per capita

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- This is an indication of income levels in each state
- The relationship between income and taxes is not linear because of progressive taxation
- States with higher per-capita taxes tend to have more shopping malls  
(see per-capita shopping malls, above)
- They also tend to be more interesting places to live and work
- And safer  
(see firearm deaths, above).

# Number of Miss America winners

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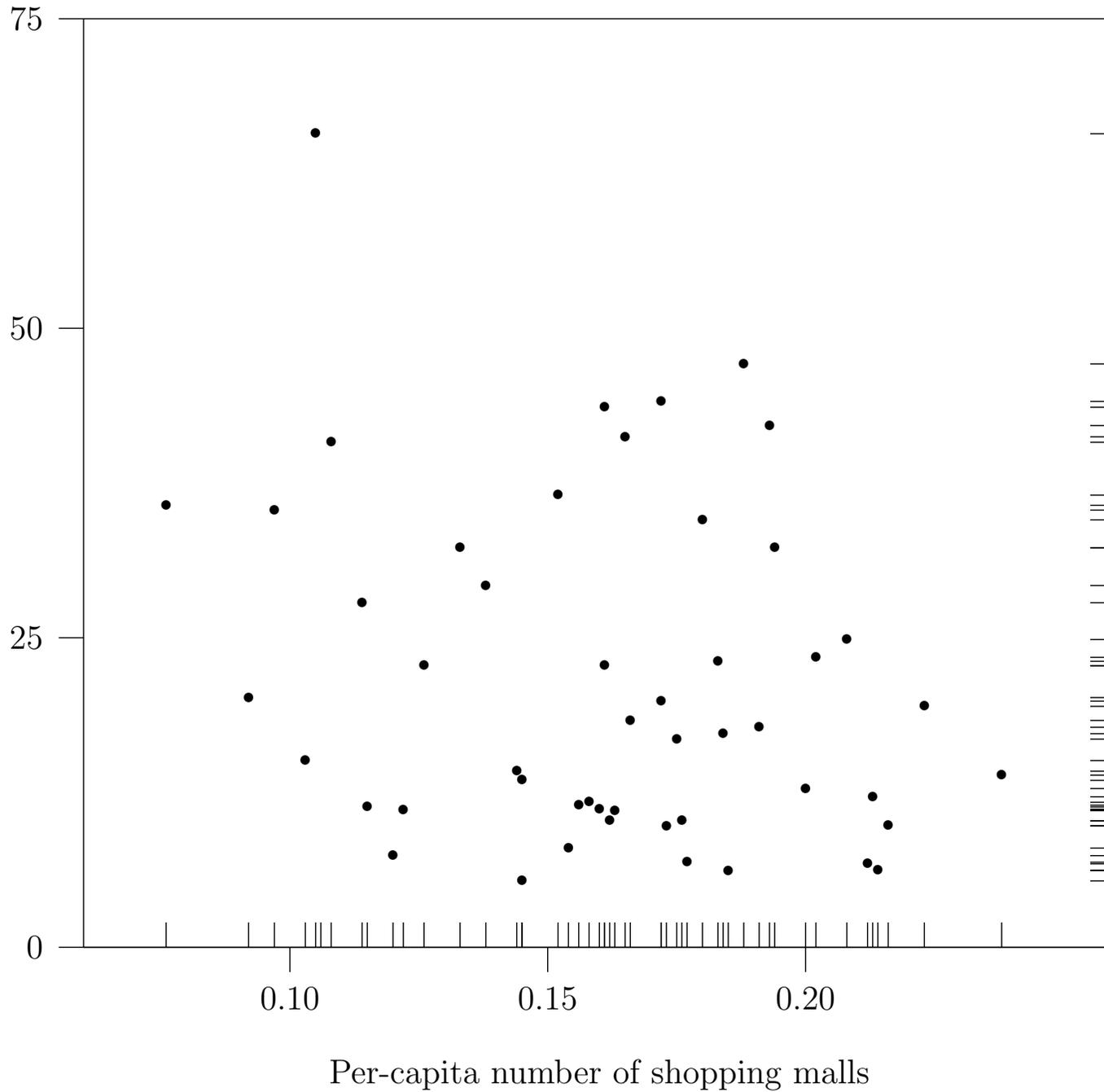
- Beauty contests are as old as humanity
- Homer described one in the *Iliad*
- We all know how that turned out
- We include this as a measure of the overall attractiveness of the residents of each state
- Zombies are viscerally challenged
- Thus, it stands to reason that states with more Miss America winners are likely to have more attractive residents overall
- And hence fewer zombies.

# Univariate analysis

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- We examined the univariate relationships between demographic measures
- The dependent variable is per-person zombie references
- Least-squares regression was used
  - this assumes the errors from the fitted linear models are normally distributed
- The two most highly correlated with per-person zombie references are
  - per-person number of shopping malls
  - the number of Miss America winners.

Per-person  
zombie references



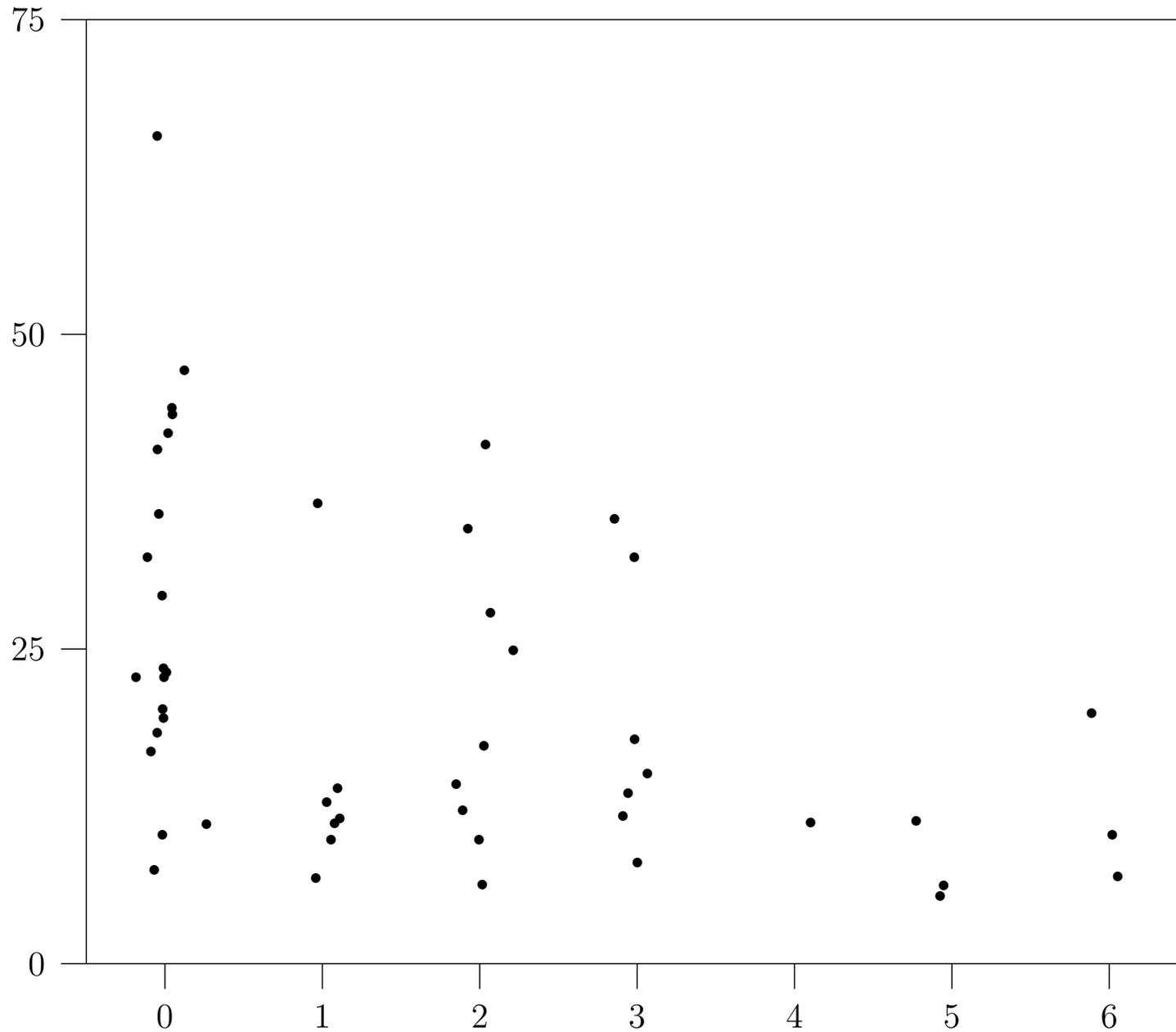
● The correlation is **-0.25**.

# Malls and Miss America winners

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- A level of statistical significance was achieved that causes us to reject the null hypothesis
- Namely, that such a high correlation could not have happened by chance alone
- The number of Miss America winners is a discrete count
- Thus, we *jittered* the data
  - ie added a small amount of random noise
- This spreads the values out just enough to aid in our visualisation of the relationship.

Per-person  
zombie references



Jittered Miss America winners

● The correlation is **-0.42**.

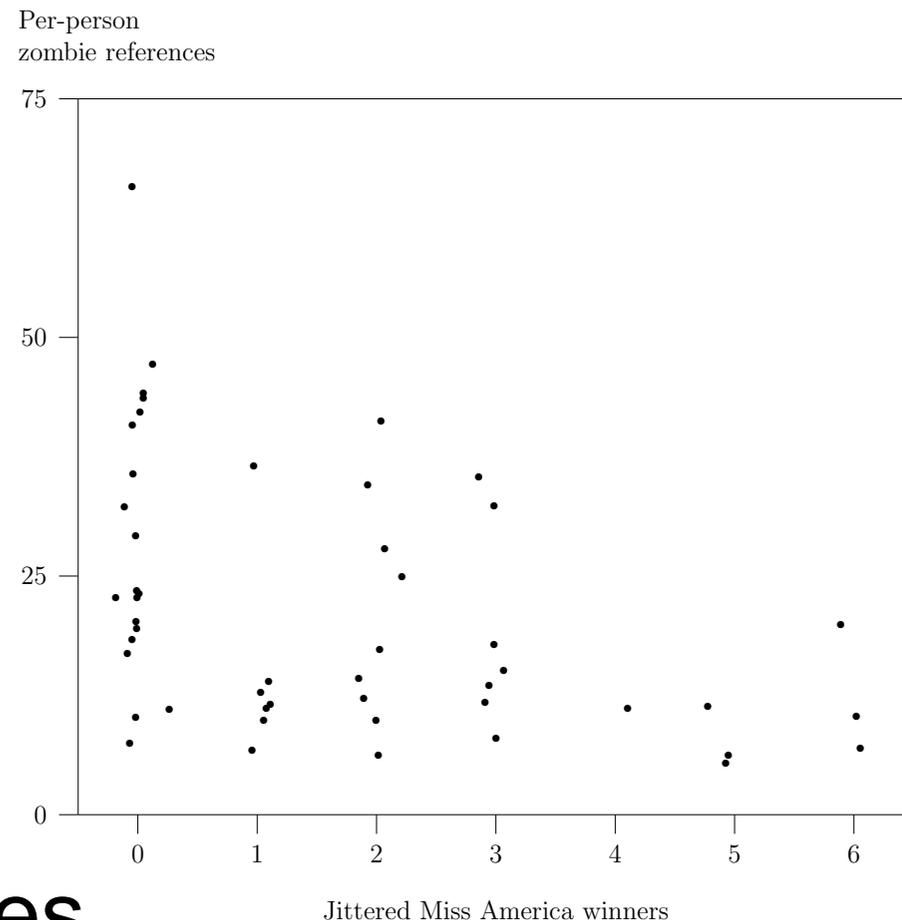
# Jittering

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- Too much jittering would only cause confusion as to the correct column
- Over-jittering Miss America is to be avoided
- The jittered Miss America values were only used in the figure
- The raw,unjittered Miss America counts were used in all statistical calculations.

# Extreme values

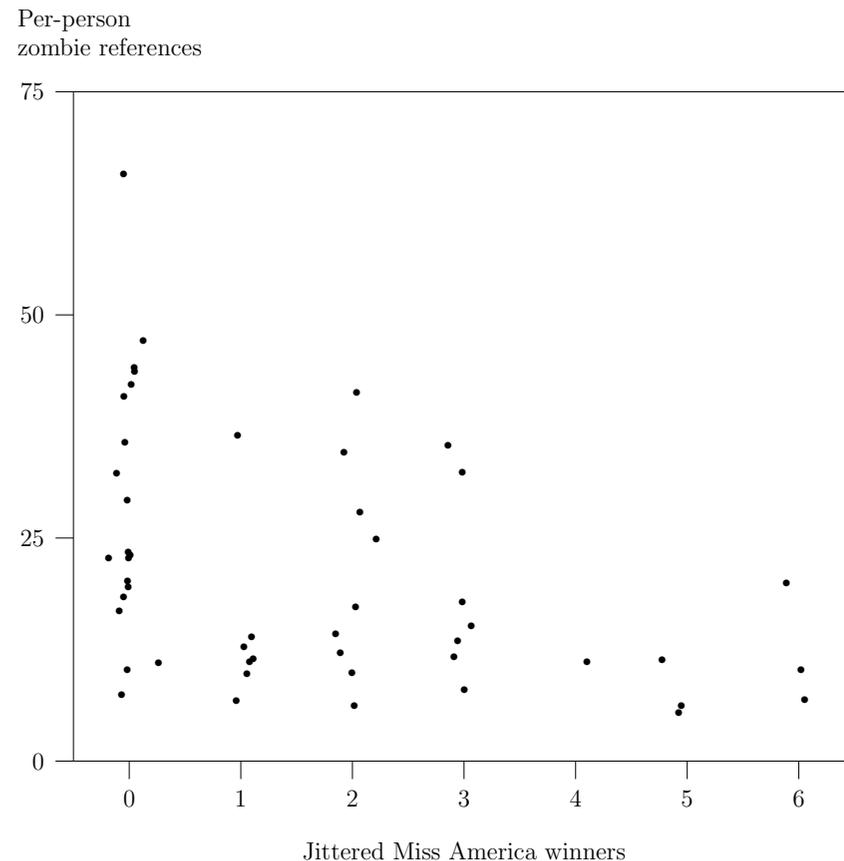
- The standout value in the extreme upper left corner corresponds to the state of Alaska, with 65.7 per-person zombies and no Miss America winners
  - (Sarah Palin didn't win)
- California, Ohio and Oklahoma had six Miss America winners
- Each had relatively low rates of zombie references.



# Miss America reduces zombies?

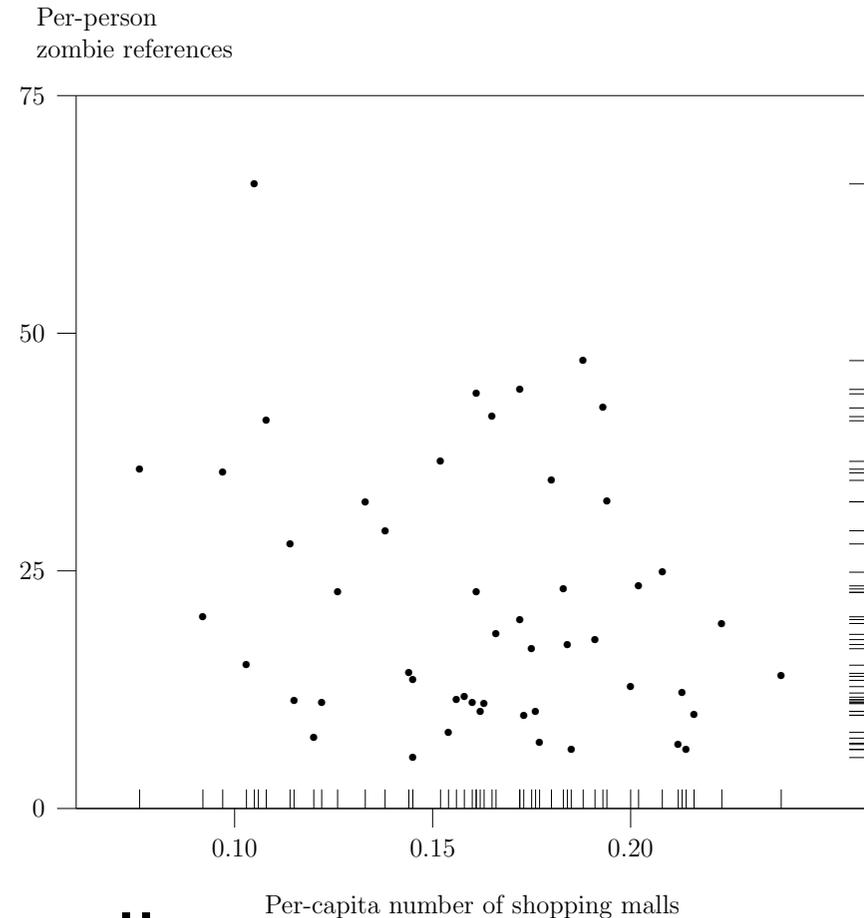
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- This supports our hypothesis that states with the most Miss America winners also tend to have the fewest zombies
- The direct cause and effect cannot be inferred though
- These variables may be closely tied to an unmeasured third variable
  - eg the overall level of attractiveness of the state's population.



# Shop til you drop

- The relationship with shopping malls isn't as strong as for Miss America winners
- However, there is still a negative correlation
- This is largely due to the standout value for Alaska
- An explanation may be that zombies don't drive or have credit cards
- Or perhaps they prefer dark cemeteries to bright malls.



# In defence of the mall

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- Shopping malls also provide an important defence against zombie attacks
- Survivors of zombie attacks barricaded in a mall are less likely to become zombies themselves
- This critical link serves to break the exponential feedback mechanism in which zombies beget ever more zombies
- The disperse population of Alaska and low per-person availability of malls suggests that this may be the case.

# Multivariate analysis

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- The aim of this analysis was to see if a linear combination of the explanatory variables provided additional information
- The multivariate linear regression  
Mean zombie rate =  $\alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_p x_p + \text{error}$   
was fit using standard statistical software
- The errors were assumed to be independent and normally distributed
- The regression coefficients  $(\alpha, \beta_1, \beta_2, \dots, \beta_p)$  were estimated using least squares.

# Estimated regression coefficients

Variable	Parameter estimate	Standard error	<i>t</i> Value	Pr >   <i>t</i>
Intercept	70.48	35.56	1.98	0.054
Age-adjusted death rate	-0.0385	0.0354	-1.09	0.282
% votes for Bush in 2004	-6.48	23.45	-0.28	0.784
% of binge drinkers	-89.4	54.5	-1.64	0.109
Gun death rate	0.891	0.541	1.65	0.107
Per-capita Federal tax in \$1K	0.00367	0.570	0.01	0.995
# of Miss America winners	-2.790	0.885	-3.15	0.003
Per-capita shopping malls	-89.7	43.7	-2.05	0.047
% Cremation rate	27.0	15.3	1.76	0.086

- Only malls and Miss America have  $p < 0.05$
- However, a the cremation rate is close.

# Multivariate synergism

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- The multivariate analysis did not reveal much more than the univariate analysis
- The relation between zombie references and Miss America winners was most significant
- Per-capita shopping malls were also significant
- There was no synergism or interaction between these two variables and the outcome
  - ie, the effect of malls and Miss America winners on zombie rates are the sum of their parts.

# A surprising result

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- The cremation rate had a positive correlation with per-person zombie references
- $p=0.86$   
(only slightly larger than the sacred  $p=0.05$  level cherished by scientific journals)
- Our assumption was that a higher cremation rate would reduce zombies to dust
- Perhaps cremation makes zombies vengeful
- Or perhaps the cremation rate is a reaction to a high zombie population by a fearful, living population.

# Binger drinkers

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- The percentage of binge drinkers nearly achieved significance at the  $p=0.1$  level
- The estimated regression on binge drinkers is negative
- Intuitively, after seeing a zombie, many of us would start drinking heavily
- However, the data discounts this simple explanation
- Perhaps people who have seen zombies give up drinking
- Or zombies avoid alcohol and singles bars.

# Gun-death rates

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- A higher gun-death rate is positively correlated with zombie references (at the  $p=0.1$  level)
- Perhaps upon seeing zombies, citizens rush out to purchase guns
- These are then left carelessly lying around the home
- Or, upon seeing a zombie, the gun owner reached for her piece...  
...only to accidentally shoot herself or someone else present at the time.

# Conclusion

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- We explored the demographic diversity of zombies across the US states and DC
- Zombie populations were estimated by the number of Google hits associated with each state
  - normalised to per-person rates via the 2009 Census
- The number of Miss America winners and per-capita shopping malls were significantly negatively associated with zombie rates
- Our best hope to survive?
- Pretty girls at the mall
- God help us all.

# Author

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- Daniel Zelterman (Yale University)

D. Zelterman, Demographics of Zombies in the United States.  
(In: R. Smith? (ed) Mathematical Modelling of Zombies,  
University of Ottawa Press, *in press*.)