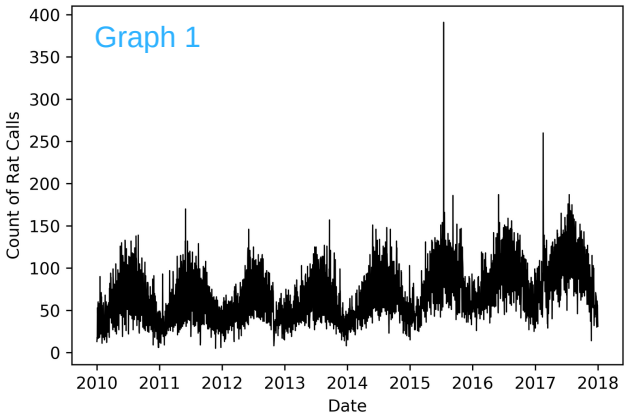
Predicting NYC Rodent Complaints

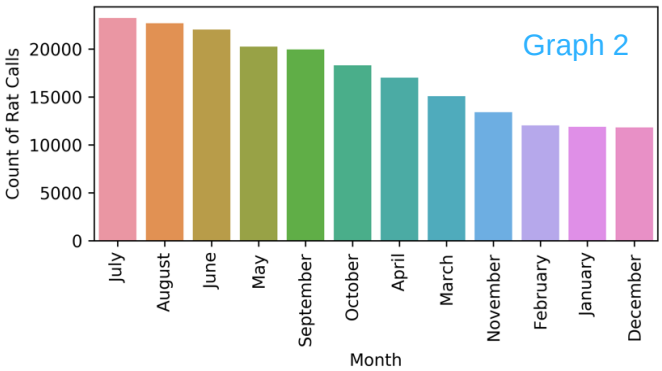
Summary

The NYC 311 calls dataset consists of over 20 million complaints on civic issues made to the city government since 2010. Rodent is the number one complaint made to the Department of Mental Health and Hygiene, with >600,000 instances of the complaint. This report analyses trends in rodent complaints across zip codes and builds a model (Vector Auto-Regression) to predict future rodent complaints in each zip code using previous rodent complaints and related health and sanitation complaints. Rodent complaints are more likely to be made in the summer, show an upward trend, and display sharp peaks or outbreaks. Rodent complaints for the next month in each zipcode can be predicted effectively using rodent complaints and related sanitation calls in previous months. A csv file of average predicted complaints for the next five months with 95% confidence intervals is available online.

Time trends

The data shows a strong seasonal trend over time as evident from the time series plot (Graph 1). The waves in the time series occur yearly and show an upward trend. Rat complaints are lodged more in the summer months than in the winter months (Graph 2). Table 1 shows the dates on which the number of calls were abnormally high (>185).





	Date	Count of Rat Calls
0	16/07/15	391
1	15/02/17	260
2	17/07/17	187
3	31/05/16	187
4	08/09/15	186

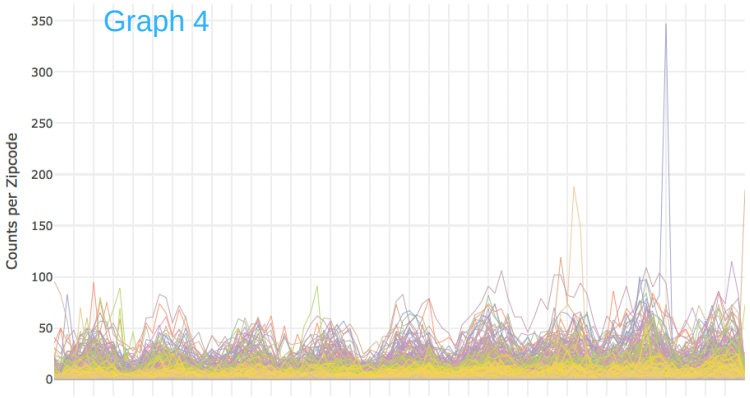
Table 1

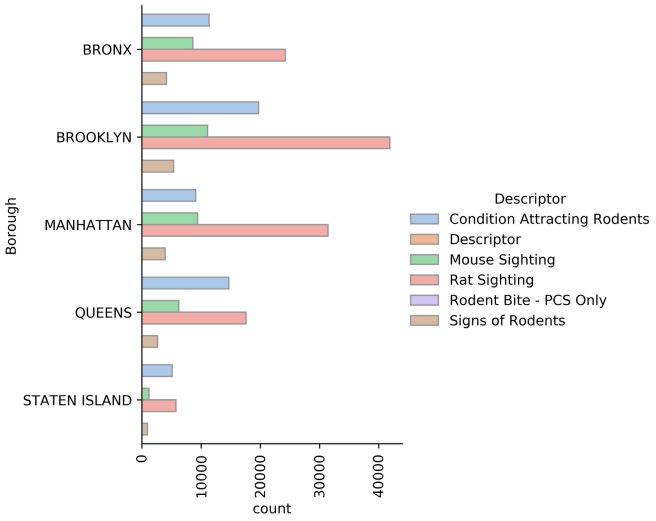
Why zip codes?
1) Small enough to be meaningful, large enough to have a sufficient number of complaints per month
2) Can be easily looked up by residents making housing decisions

Variation across zip codes: Zip-codes show large amounts of variance in number of rodent complaints per month. Graph 3 shows that Brooklyn, Manhattan and Bronx have the most rodent complaints in that order. The per-zipcode monthly trends are also strongly cyclical, as seen in Graph 4.

Auto-correlation Function (ACF): The autocorrelation function shows how counts for the current month are related to previous months. 'lag' on the x axis denotes the number of months before the current month. The plot shows that the time series is largely cyclical (every 6 months) and that predictions for rodent complaints can be made from previous month's complaints. (Graph 5 - next page)

Partial Autocorrelation Function (PACF): This shows how counts for the current month are related to previous months, but the effect for the previous months are removed. For example, the second lag does not include the effect of the first lag. This shows a more complex cyclical relationship that is not as clear as the autocorrelation function, showing that the effect of the previous month is very high. (Graph 6 - next page)

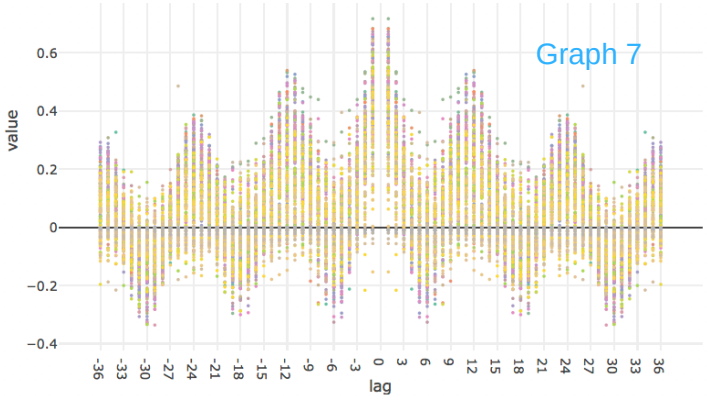




Graph 3 (Total borough-wise counts since 2010)

Model

We saw that rodent complaints for the next month are strongly related to number of complaints made in the previous month, and that the correlations follow a cyclical pattern that fades in importance after ~ 12 months. Rodent complaints are also related to other sanitation complaints. Graph 7 shows a Cross-Correlation Function plot for rodent complaints against the complaint category 'Dirty Conditions' (DC). There is a strong correlation between the two time series when the DC time series lagged. This is useful for building the prediction model. The other complaint categories that show a similar trend are: Sanitary Conditions (SC) and Litter baskets overflowing (LB).



Graph 7

The CCF shows that both time-series are related to each other across time periods, whether moving backward (-36 to -1) or forward (1 to 36). This shows that both time series can be used for predicting each other in the future. The time series do not display a clear cause-effect relationship from past to future.

Hence, I decided to fit a Vector Auto-Regression (VAR) model to the problem. A VAR model does not assume any cause-effect relationships between the variables, and fits lagged regressions on each of the time series, treating them as both predictors and dependent variables. I fitted the VAR model on one to 12 month lags for all four time series - Rodent Complaints (RC), DC, SC and LB. The VAR model was fitted after first differencing the model to remove the dependence on the first lag (and ensure stationarity). Hence, the predicted values show the changes from the previous month.

Pros of VAR model:
1) No cause-effect relationship assumed
2) Allows for exogenous time series and lags at the same time

The only disadvantage of the model is that it is fairly complicated.

Appendix A has a sample VAR model for the Columbia university zip-code: 10027.
(The predictions fit reasonably well for time series RC and SC and not that well for the LB and DC series. It is notable that this model performs better on other zipcodes.)

The model was fitted for the 175 zipcodes to generate average predictions for the next five months and 95% confidence intervals. These are available as a csv file at: https://github.com/kalyani-subbiah/nyc-311-public-health/blob/master/var-zip-predictions.csv

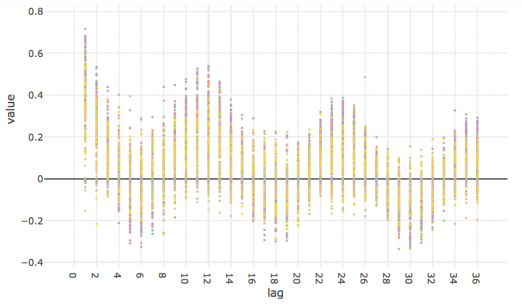
Conclusion

The top 311 complaint categories on public health and sanitation exhibit strong time/cyclical trends which can be used for prediction. After exploratory analysis, a VAR model was fitted on four time series: Rodent Complaints (RC), Litter Baskets Overflowing (LB), Dirty Conditions (DC) and Sanitary Conditions (SC). These time series are from 2010 to present and were fitted on monthly data. One model was fitted for each zip-code in order to enable actionable predictions for government, and for home-owners to be aware of sanitation issues in their area.

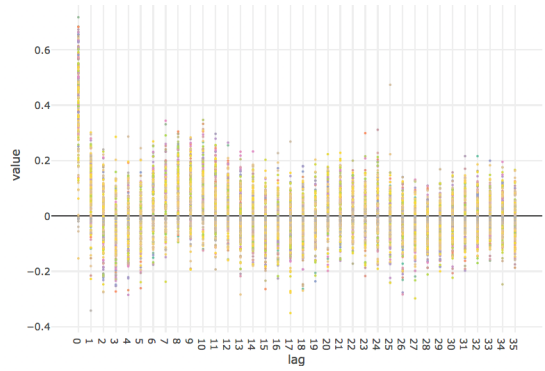
The VAR model can also be used for predicting RC, DC and SC complaints, and to a lesser extent, the LB category. A sample model for zip-code 10027 is presented in Appendix A. The predictions can be downloaded as a csv file from: https://github.com/kalyani-subbiah/nyc-311-public-health/blob/master/var-zip-predictions.csv

Data

https://data.cityofnewyork.us/Social-Services/311-Service-Requests/fvrb-kbbt



Graph 5



Graph 6

Appendix A

VAR Estimation Results:
==========
Endogenous variables: rats, litter, dirty, sanitary
Deterministic variables: const
Sample size: 94
Log Likelihood: -932.531
Roots of the characteristic polynomial:
1.012 1.012 0.9986 0.9921 0.9921 0.9858 0.9858 0.985 0.985 0.9763 0.9763 0.9639 0.9639 0.9622 0.9622 0.951 0.951 0.9445 0.9445 0.9414 0.9414 0.936 0.936 0.9289 0.9289 0.915 0.915 0.91 0.91 0.8982 0.8982 0.8974 0.8974 0.8885 0.8885 0.8845 0.8845 0.8786 0.8786 0.851 0.851 0.8244 0.8244 0.5941 0.5941 0.455 0.3785 0.3785
Call:
VAR(y = mat1, p = 12)

Estimation results for equation Rodent Complaints:
==========
rats = rats.l1 + litter.l1 + dirty.l1 + sanitary.l1 + rats.l2 + litter.l2 + dirty.l2 + sanitary.l2 + rats.l3 + litter.l3 + dirty.l3 + sanitary.l3 + rats.l4 + litter.l4 + dirty.l4 + sanitary.l4 + rats.l5 + litter.l5 + dirty.l5 + sanitary.l5 + rats.l6 + litter.l6 + dirty.l6 + sanitary.l6 + rats.l7 + litter.l7 + dirty.l7 + sanitary.l7 + rats.l8 + litter.l8 + dirty.l8 + sanitary.l8 + rats.l9 + litter.l9 + dirty.l9 + sanitary.l9 + rats.l10 + litter.l10 + dirty.l10 + sanitary.l10 + rats.l11 + litter.l11 + dirty.l11 + sanitary.l11 + rats.l12 + litter.l12 + dirty.l12 + sanitary.l12 + const

	Estimate	Std. Error	t value	Pr(>|t|)	
rats.l1	0.37044	0.15252	2.429	0.0192	*
litter.l1	-0.89747	1.59443	-0.563	0.5763	
dirty.l1	-0.04122	0.12876	-0.320	0.7504	
sanitary.l1	-0.28966	0.31687	-0.914	0.3655	
rats.l2	0.13362	0.16427	0.813	0.4203	
litter.l2	-0.08336	1.49678	-0.056	0.9558	
dirty.l2	-0.28297	0.12151	-2.329	0.0244	*
sanitary.l2	-0.08400	0.33778	-0.249	0.8047	
rats.l3	0.02790	0.16957	0.165	0.8700	
litter.l3	0.11843	1.59685	0.074	0.9412	
dirty.l3	0.23230	0.13570	1.712	0.0938	.
sanitary.l3	0.35225	0.34407	1.024	0.3114	
rats.l4	0.07127	0.18435	0.387	0.7009	
litter.l4	-0.11186	1.54594	-0.072	0.9426	
dirty.l4	-0.10308	0.13711	-0.752	0.4561	
sanitary.l4	0.04307	0.33624	0.128	0.8987	
rats.l5	0.20157	0.18027	1.118	0.2694	
litter.l5	0.70932	1.58998	0.446	0.6577	
dirty.l5	-0.18970	0.14657	-1.294	0.2022	
sanitary.l5	0.08452	0.37197	0.227	0.8213	
rats.l6	-0.38844	0.17029	-2.281	0.0273	*
litter.l6	2.55553	1.51167	1.691	0.0978	.
dirty.l6	0.10361	0.14746	0.703	0.4859	
sanitary.l6	0.09833	0.35898	0.274	0.7854	
rats.l7	-0.03079	0.17887	-0.172	0.8641	
litter.l7	-2.77876	1.40789	-1.974	0.0546	.
dirty.l7	-0.08217	0.15484	-0.531	0.5983	
sanitary.l7	-0.59213	0.38417	-1.541	0.1302	
rats.l8	0.32195	0.17818	1.807	0.0775	.
litter.l8	-0.72686	1.55871	-0.466	0.6432	
dirty.l8	-0.03638	0.14953	-0.243	0.8089	
sanitary.l8	0.62886	0.36114	1.741	0.0885	.
rats.l9	-0.11128	0.18215	-0.611	0.5443	
litter.l9	0.01030	1.50986	0.007	0.9946	
dirty.l9	0.07146	0.14081	0.507	0.6143	
sanitary.l9	0.11125	0.38832	0.286	0.7758	
rats.l10	0.28426	0.19253	1.476	0.1468	
litter.l10	-0.86795	1.43075	-0.607	0.5471	
dirty.l10	0.07249	0.14341	0.505	0.6157	
sanitary.l10	-0.12856	0.35380	-0.363	0.7180	
rats.l11	-0.01600	0.19397	-0.082	0.9346	
litter.l11	-1.50024	1.45769	-1.029	0.3089	
dirty.l11	-0.05819	0.13892	-0.419	0.6773	
sanitary.l11	0.25253	0.33430	0.755	0.4540	
rats.l12	-0.07477	0.17155	-0.436	0.6650	
litter.l12	0.82989	1.34725	0.616	0.5410	
dirty.l12	0.09256	0.15434	0.600	0.5517	
sanitary.l12	0.51862	0.35821	1.448	0.1546	
const	2.66336	8.42898	0.316	0.7535	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8.924 on 45 degrees of freedom
Multiple R-Squared: 0.7671, Adjusted R-squared: 0.5186
F-statistic: 3.088 on 48 and 45 DF, p-value: 0.0001064

Estimation results for equation Litter Baskets:
==========
litter = rats.l1 + litter.l1 + dirty.l1 + sanitary.l1 + rats.l2 + litter.l2 + dirty.l2 + sanitary.l2 + rats.l3 + litter.l3 + dirty.l3 + sanitary.l3 + rats.l4 + litter.l4 + dirty.l4 + sanitary.l4 + rats.l5 + litter.l5 + dirty.l5 + sanitary.l5 + rats.l6 + litter.l6 + dirty.l6 + sanitary.l6 + rats.l7 + litter.l7 + dirty.l7 + sanitary.l7 + rats.l8 + litter.l8 + dirty.l8 + sanitary.l8 + rats.l9 + litter.l9 + dirty.l9 + sanitary.l9 + rats.l10 + litter.l10 + dirty.l10 + sanitary.l10 + rats.l11 + litter.l11 + dirty.l11 + sanitary.l11 + rats.l12 + litter.l12 + dirty.l12 + sanitary.l12 + const

	Estimate	Std. Error	t value	Pr(>|t|)	
rats.l1	-0.010144	0.014581	-0.696	0.49018	
litter.l1	-0.048488	0.152422	-0.318	0.75187	
dirty.l1	-0.015324	0.012309	-1.245	0.21959	
sanitary.l1	0.089234	0.030292	2.946	0.00509	**
rats.l2	-0.003779	0.015703	-0.241	0.81090	
litter.l2	0.112687	0.143087	0.788	0.43509	
dirty.l2	-0.002699	0.011616	-0.232	0.81728	
sanitary.l2	-0.049273	0.032290	-1.526	0.13403	
rats.l3	0.030065	0.016210	1.855	0.07020	.
litter.l3	-0.112972	0.152654	-0.740	0.46311	
dirty.l3	-0.001228	0.012972	-0.095	0.92498	
sanitary.l3	-0.021362	0.032892	-0.649	0.51934	
rats.l4	-0.011213	0.017623	-0.636	0.52781	
litter.l4	-0.234314	0.147787	-1.585	0.11986	
dirty.l4	0.015265	0.013107	1.165	0.25031	
sanitary.l4	0.064118	0.032143	1.995	0.05215	.
rats.l5	-0.035747	0.017233	-2.074	0.04380	*
litter.l5	0.180947	0.151997	1.190	0.24011	
dirty.l5	-0.011051	0.014011	-0.789	0.43440	
sanitary.l5	0.024557	0.035559	0.691	0.49337	
rats.l6	0.020455	0.016279	1.257	0.21542	
litter.l6	0.114197	0.144511	0.790	0.43354	
dirty.l6	-0.011558	0.014097	-0.820	0.41658	
sanitary.l6	-0.092364	0.034317	-2.691	0.00995	**
rats.l7	-0.030846	0.017100	-1.804	0.07794	.
litter.l7	-0.174660	0.134589	-1.298	0.20099	
dirty.l7	-0.003587	0.014802	-0.242	0.80964	
sanitary.l7	-0.044634	0.036726	-1.215	0.23057	
rats.l8	0.003670	0.017033	0.215	0.83040	
litter.l8	-0.187605	0.149008	-1.259	0.21451	
dirty.l8	-0.005397	0.014295	-0.378	0.70756	
sanitary.l8	0.039952	0.034524	1.157	0.25328	
rats.l9	0.018491	0.017413	1.062	0.29393	
litter.l9	-0.023083	0.144338	-0.160	0.87365	
dirty.l9	-0.024548	0.013461	-1.824	0.07486	.
sanitary.l9	0.070410	0.037122	1.897	0.06430	.
rats.l10	0.019084	0.018405	1.037	0.30534	
litter.l10	-0.048975	0.136775	-0.358	0.72196	
dirty.l10	-0.002749	0.013709	-0.200	0.84200	
sanitary.l10	0.029741	0.033822	0.879	0.38390	
rats.l11	-0.021858	0.018543	-1.179	0.24467	
litter.l11	-0.106759	0.139350	-0.766	0.44761	
dirty.l11	-0.017220	0.013281	-1.297	0.20138	
sanitary.l11	-0.024687	0.031958	-0.772	0.44388	
rats.l12	-0.006522	0.016400	-0.398	0.69274	
litter.l12	-0.111282	0.128793	-0.864	0.39215	
dirty.l12	-0.009948	0.014754	-0.674	0.50359	
sanitary.l12	0.024671	0.034243	0.720	0.47496	
const	2.408549	0.805783	2.989	0.00452	**

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8531 on 45 degrees of freedom
Multiple R-Squared: 0.5824, Adjusted R-squared: 0.137
F-statistic: 1.308 on 48 and 45 DF, p-value: 0.1832

Estimation results for equation Dirty Conditions:
==========
dirty = rats.l1 + litter.l1 + dirty.l1 + sanitary.l1 + rats.l2 + litter.l2 + dirty.l2 + sanitary.l2 + rats.l3 + litter.l3 + dirty.l3 + sanitary.l3 + rats.l4 + litter.l4 + dirty.l4 + sanitary.l4 + rats.l5 + litter.l5 + dirty.l5 + sanitary.l5 + rats.l6 + litter.l6 + dirty.l6 + sanitary.l6 + rats.l7 + litter.l7 + dirty.l7 + sanitary.l7 + rats.l8 + litter.l8 + dirty.l8 + sanitary.l8 + rats.l9 + litter.l9 + dirty.l9 + sanitary.l9 + rats.l10 + litter.l10 + dirty.l10 + sanitary.l10 + rats.l11 + litter.l11 + dirty.l11 + sanitary.l11 + rats.l12 + litter.l12 + dirty.l12 + sanitary.l12 + const

	Estimate	Std. Error	t value	Pr(>|t|)	
rats.l1	-0.116893	0.181062	-0.646	0.52182	
litter.l1	-2.651311	1.892761	-1.401	0.16814	
dirty.l1	0.277034	0.152855	1.812	0.07660	.
sanitary.l1	0.464954	0.376166	1.236	0.22286	
rats.l2	-0.319600	0.195004	-1.639	0.10820	
litter.l2	-2.537602	1.776844	-1.428	0.16015	
dirty.l2	-0.042731	0.144244	-0.296	0.76841	
sanitary.l2	0.755398	0.400979	1.884	0.06605	.
rats.l3	0.356270	0.201296	1.770	0.08352	.
litter.l3	-0.001567	1.895642	-0.001	0.99934	
dirty.l3	-0.044612	0.161088	-0.277	0.78309	
sanitary.l3	-0.253030	0.408447	-0.619	0.53872	
rats.l4	-0.335568	0.218845	-1.533	0.13219	
litter.l4	2.801183	1.835205	1.526	0.13392	
dirty.l4	0.017603	0.162767	0.108	0.91436	
sanitary.l4	-0.059180	0.399151	-0.148	0.88280	
rats.l5	0.046662	0.214000	0.218	0.82838	
litter.l5	-0.864532	1.887489	-0.458	0.64913	
dirty.l5	0.110900	0.173992	0.637	0.52710	
sanitary.l5	-0.377261	0.441571	-0.854	0.39743	
rats.l6	-0.199697	0.202153	-0.988	0.32851	
litter.l6	1.153795	1.794523	0.643	0.52352	
dirty.l6	0.156278	0.175052	0.893	0.37674	
sanitary.l6	-0.125469	0.426148	-0.294	0.76979	
rats.l7	0.195952	0.212340	0.923	0.36102	
litter.l7	-0.190988	1.671317	-0.114	0.90953	
dirty.l7	-0.301048	0.183816	-1.638	0.10844	
sanitary.l7	-0.362640	0.456056	-0.795	0.43069	
rats.l8	-0.039221	0.211520	-0.185	0.85373	
litter.l8	1.275540	1.850368	0.689	0.49415	
dirty.l8	-0.062723	0.177510	-0.353	0.72547	
sanitary.l8	-0.378111	0.428712	-0.882	0.38248	
rats.l9	0.101853	0.216231	0.471	0.63989	
litter.l9	0.212263	1.792377	0.118	0.90626	
dirty.l9	-0.096395	0.167160	-0.577	0.56704	
sanitary.l9	0.428896	0.460980	0.930	0.35713	
rats.l10	0.267916	0.228553	1.172	0.24728	
litter.l10	-1.843223	1.698455	-1.085	0.28360	
dirty.l10	0.149354	0.170239	0.877	0.38497	
sanitary.l10	0.168599	0.420004	0.401	0.69001	
rats.l11	-0.058933	0.230261	-0.256	0.79916	
litter.l11	-0.903892	1.730436	-0.522	0.60399	
dirty.l11	-0.382537	0.164917	-2.320	0.02496	*
sanitary.l11	1.240162	0.396856	3.125	0.00311	**
rats.l12	-0.158735	0.203651	-0.779	0.43980	
litter.l12	-1.303774	1.599337	-0.815	0.41925	
dirty.l12	-0.053458	0.183216	-0.292	0.77180	
sanitary.l12	-0.177394	0.425232	-0.417	0.67854	
const	21.998270	10.006135	2.198	0.03310	*

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 10.59 on 45 degrees of freedom
Multiple R-Squared: 0.6435, Adjusted R-squared: 0.2632
F-statistic: 1.692 on 48 and 45 DF, p-value: 0.0388

Estimation results for equation Sanitary Conditions:
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sanitary = rats.l1 + litter.l1 + dirty.l1 + sanitary.l1 + rats.l2 + litter.l2 + dirty.l2 + sanitary.l2 + rats.l3 + litter.l3 + dirty.l3 + sanitary.l3 + rats.l4 + litter.l4 + dirty.l4 + sanitary.l4 + rats.l5 + litter.l5 + dirty.l5 + sanitary.l5 + rats.l6 + litter.l6 + dirty.l6 + sanitary.l6 + rats.l7 + litter.l7 + dirty.l7 + sanitary.l7 + rats.l8 + litter.l8 + dirty.l8 + sanitary.l8 + rats.l9 + litter.l9 + dirty.l9 + sanitary.l9 + rats.l10 + litter.l10 + dirty.l10 + sanitary.l10 + rats.l11 + litter.l11 + dirty.l11 + sanitary.l11 + rats.l12 + litter.l12 + dirty.l12 + sanitary.l12 + const

	Estimate	Std. Error	t value	Pr(>|t|)	
rats.l1	0.142555	0.072080	1.978	0.0541	.
litter.l1	0.183366	0.753503	0.243	0.8088	
dirty.l1	0.037510	0.060851	0.616	0.5407	
sanitary.l1	0.336393	0.149751	2.246	0.0296	*
rats.l2	-0.105957	0.077630	-1.365	0.1791	
litter.l2	-1.535659	0.707357	-2.171	0.0352	*
dirty.l2	-0.034130	0.057423	-0.594	0.5552	
sanitary.l2	0.313960	0.159629	1.967	0.0554	.
rats.l3	-0.013696	0.080136	-0.171	0.8651	
litter.l3	0.535240	0.754651	0.709	0.4818	
dirty.l3	0.011517	0.064129	0.180	0.8583	
sanitary.l3	0.268891	0.162602	1.654	0.1052	
rats.l4	0.013805	0.087122	0.158	0.8748	
litter.l4	-0.069466	0.730591	-0.095	0.9247	
dirty.l4	-0.067802	0.064797	-1.046	0.3010	
sanitary.l4	-0.240549	0.158901	-1.514	0.1371	
rats.l5	-0.059521	0.085193	-0.699	0.4884	
litter.l5	0.105778	0.751405	0.141	0.8887	
dirty.l5	0.001641	0.069266	0.024	0.9812	
sanitary.l5	-0.177056	0.175788	-1.007	0.3192	

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rats.l6     -0.086052   0.080476  -1.069   0.2906
litter.l6   -0.486865   0.714395  -0.682   0.4990
dirty.l6     0.083794   0.069688   1.202   0.2355
sanitary.l6  0.089123   0.169649   0.525   0.6019
rats.l7      0.036866   0.084532   0.436   0.6648
litter.l7    0.831366   0.665347   1.250   0.2179
dirty.l7    -0.085853   0.073177  -1.173   0.2469
sanitary.l7 -0.057856   0.181555  -0.319   0.7515
rats.l8      0.070345   0.084205   0.835   0.4079
litter.l8    1.573738   0.736627   2.136   0.0381 *
dirty.l8     0.150901   0.070666   2.135   0.0382 *
sanitary.l8 -0.365561   0.170669  -2.142   0.0376 *
rats.l9     -0.183120   0.086081  -2.127   0.0389 *
litter.l9   -0.289041   0.713541  -0.405   0.6873
dirty.l9    -0.056871   0.066546  -0.855   0.3973
sanitary.l9 -0.155681   0.183515  -0.848   0.4007
rats.l10     0.148255   0.090986   1.629   0.1102
litter.l10  -0.238594   0.676151  -0.353   0.7258
dirty.l10    0.080850   0.067772   1.193   0.2391
sanitary.l10 0.228912   0.167203   1.369   0.1778
rats.l11     0.024505   0.091666   0.267   0.7904
litter.l11   0.633414   0.688882   0.919   0.3627
dirty.l11   -0.153582   0.065653  -2.339   0.0238 *
sanitary.l11 0.336738   0.157987   2.131   0.0386 *
rats.l12     0.113786   0.081073   1.403   0.1673
litter.l12  -0.921663   0.636692  -1.448   0.1547
dirty.l12   -0.063362   0.072938  -0.869   0.3896
sanitary.l12 -0.095376  0.169284  -0.563   0.5760
const        4.425820   3.983418   1.111   0.2724
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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.218 on 45 degrees of freedom
Multiple R-Squared: 0.7526, Adjusted R-squared: 0.4888
F-statistic: 2.852 on 48 and 45 DF,  p-value: 0.0002749


Covariance matrix of residuals:
          rats  litter   dirty sanitary
rats     79.6458  0.8206 -14.075  11.6873
litter    0.8206  0.7279  -1.375   0.8463
dirty   -14.0754 -1.3750 112.240   2.6238
sanitary  11.6873  0.8463   2.624  17.7879

Correlation matrix of residuals:
          rats  litter   dirty sanitary
rats     1.0000  0.1078 -0.14887  0.31051
litter   0.1078  1.0000 -0.15212  0.23521
dirty   -0.1489 -0.1521  1.00000  0.05872
sanitary  0.3105  0.2352  0.05872  1.00000
```