Does education promote health? A case study of foodborne disease on Guam

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Abstract

In 1975, Guam stopped testing food workers for foodborne disease. Instead, it taught them how to avoid spreading disease to restaurant patrons. But this new policy did not much cut the rate of foodborne disease among patrons, suggests a statistical study. A major typhoon may have cut the disease rate more, perhaps by closing restaurants. [JEL I18, J28]

Introduction

More education may improve the health of many. Across countries, a high level of education may correlate with a low rate of infant death (Barro and Lee, 1993). But does specific training of workers in a key industry, such as food service, improve consumer health? A sharp transition in policy from traditional regulation of food workers and toward education of them could provide a useful case study.

From 1950 to 1975, the U.S. territorial government of Guam required all food handlers -- people who worked in places that prepared food for eating there or elsewhere -- to obtain medical clearance each year. The test most relevant to food safety was the examination of the worker's stool specimen for parasites and parasite ova. Such testing ended in 1975, when refugees from the Vietnam War almost doubled the population of the island. So pressured, the Guam Department of Public Health & Social Services cut back its routine workload by no longer requiring medical clearance each year for food handlers. Instead, they were to attend one lecture

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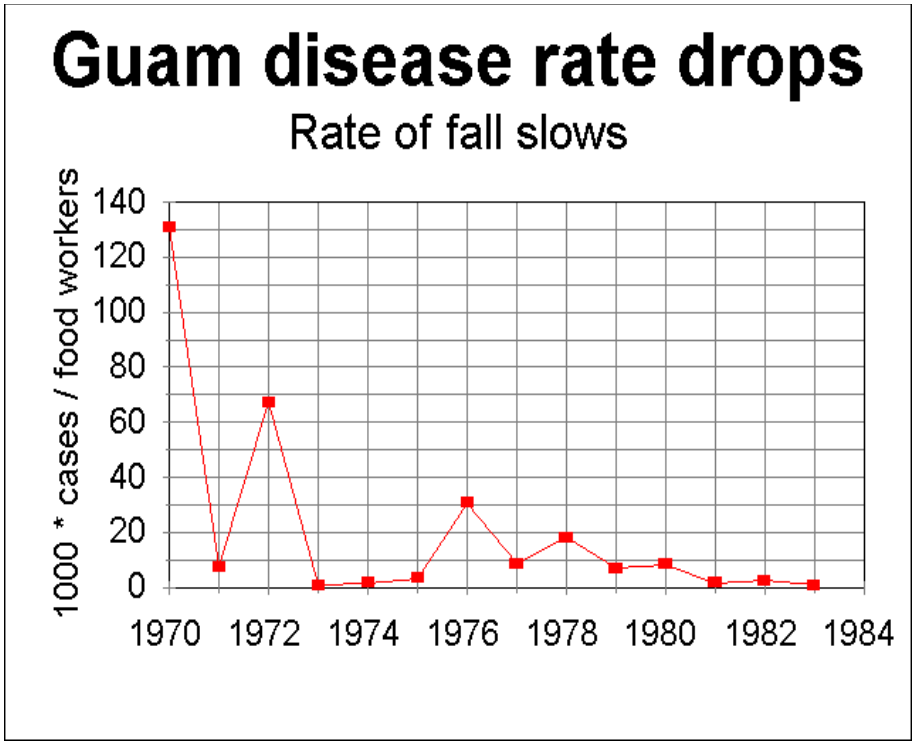
on food hygiene and to take a written test on food hygiene each year thereafter.

A 1986 study concluded that this new policy cut the rate of foodborne disease in places that sold food and drink (Haddock and Kampelmacher, page 143). Examining annual statistics from 1970 through 1983, the study calculated the number of cases of associated foodborne disease per 1000 employees. This rate seemed to fall fairly steadily from 1975 to 1983.

But Figure 1 suggests that the disease rate also fell before 1975, perhaps more steeply than after. Did the policy change truly cut this rate? This note re-examines the statistics.



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Methods: Naive models

Multiple regression may pinpoint how the policy change affected the rate of illness in Guam restaurants, holding other factors constant. The regression analysis uses the data presented by Haddock and Kampelmacher, with minor changes. Their study based the population estimates for noncensus years on the mean arithmetic change from

Statistics for foodborne diseases on Guam, 1970-1983

Year	Population	Food handlers	Foodborne disease cases	Cases per 100,000 residents	Eating, drinking establishment associated cases	Cases per 1000 workers
1970	84996	915			120	131.15
1971	86892	934	26	29.92	7	7.49
1972	88831	1011	119	133.96	68	67.26
1973	90812	1301	44	48.45	1	0.77
1974	92838	1236	54	58.17	2	1.62
1975	94909	1155	55	57.95	4	3.46
1976	97027	1267	165	170.06	39	30.78
1977	99191	1379	106	106.86	12	8.7
1978	101404	1262	51	50.29	23	18.23
1979	103666	1285	44	42.44	9	7
1980	105979	1307	51	48.12	11	8.42
1981	108343	1097	27	24.92	2	1.82
1982	110760	1142	29	26.18	3	2.63
1983	113226	1160	21	18.55	1	0.86

the 1970 census to the 1980 census. The present study bases the population estimates instead on an exponential model of growth, at 2.21% a year; the rate is extrapolated from the census figures for 1970 and 1980. Figure 2 presents the data used in this note.

The study uses two measures for the incidence of foodborne disease on Guam. One,

Eatrate, relates the number of illnesses among restaurant patrons to the number of food workers (Figure 2, last column). *Eatrate* fell from 131 in 1970 to 1 in 1983.

Eatrate may have defects. Its numerator is the number of cases of foodborne disease that the patient or a health investigator attributed to eating in a food establishment. Its denominator is the number of workers reported voluntarily by food establishments in a survey by the Guam Department of Commerce. (The two numbers appear in columns 6 and 3 respectively of Figure 2.) If patients do not report foodborne diseases, then *Eatrate* will underestimate the incidence.[2] If some establishments do not respond to the survey of workers, then *Eatrate* will overestimate incidence. It is not evident, however, that these deviations will vary in a systematic way over time. The analysis will treat them as errors over time that are independent of one another and yet are identically distributed.

The study also uses a more general measure of the incidence of foodborne disease on Guam as an independent variable. This is *Illrate*. It relates the number of cases of foodborne disease on the island to the population of the island, in terms of cases per 100,000 people (Figure 2, column 5). It rises to 170 in 1976 and then falls to 19 in 1983. The broad trend toward decline is like that of *Eatrate,* so the two measures may correlate. Which way the effect runs is not clear *a priori*. Communicable illness in the population may affect food workers and thus patrons. Alternatively, sick patrons may spread illness throughout the population. To produce results that compare with the earlier study, the models here use *Eatrate* as the dependent variable and *Illrate* as the independent variable. The models thus assume that illness may begin in the

[2] Health authorities may also fail to report some complaints of foodborne disease. Haddock, who collected morbidity statistics for Guam as its territorial epidemiologist, said the one civilian hospital on the island reported morbidity with diligence (page 146).

population and then spread to food workers and restaurant patrons. The models do not assume that disease may begin with the food workers and then spread to the general population.3

Illrate may correlate positively with the incidence of disease related to restaurants. *Eatrate* may also respond to changes in policy toward food workers. The statistical analysis measures these changes with a dummy variable, *Policy*. Its values are 0 for 1970 through 1974, when the health department enforced its old policy of testing food workers for TB and other diseases; ½ for 1975, when the department changed in mid-year toward a policy of educating workers; and 1 for 1976 through 1983, when the new policy remained in effect.

The policy reform is not the only onetime change that may have affected the incidence of disease. In May 1976, a typhoon destroyed almost one of every six homes on Guam and damaged most buildings. It also stripped the island of electricity for at least several weeks -- and, consequently, deprived it of drinking water pumped electrically out of deep wells. To study the effects of the storm on health, the analysis uses a dummy variable, *Typhoon*, which equals 1 for 1976 and 0 for all other years in the study. *Typhoon* may correlate positively with *Illrate*. On the other hand, *Typhoon*'s direction of correlation with *Eatrate* may depend on the severity of the storm. Minor damage to restaurant buildings and power could endanger the wholesomeness of food supplies, raising the incidence of disease in restaurants. But major damage could also shut down restaurants, lowering the incidence of disease. Since the typhoon was severe, *Typhoon* may correlate negatively with *Eatrate*.

A rise in the population of Guam (*Populate*) may boost the number of foodborne illnesses related to restaurants -- and thus boost *Eatrate*.

Finally, the passage of time (*Year*) may proxy for improvements in the technology of

3 Future research may address that possibility.

Figure 3
Descriptive statistics

Var	*Mean*	*Std. Dev.*	*CofV*	*Min*	*Max*	*Description*
Eatrate	20.73	36.44	1.76	.77	131.15	Restaurant rate
Handlers	1175.07	143.35	0.12	915	1379	Food workers
IllEat	21.57	33.96	1.57	1	120	Restaurant cases
Illness	60.92	42.89	0.70	21	165	Island cases
IllRate	62.76	45.97	0.73	18.55	170.06	Island rate
Policy	.61	.49	0.80	0	1	Reform dummy
Populate	98491.00	9082.53	0.09	84996	113226	Guam population
Typhoon	.07	0.27	3.86	0	1	Storm dummy
Year	1976.50	4.18	0.00	1970	1983	Time index

restaurants that stifle the spreading of disease. *Year* may thus correlate negatively with *Eatrate*.

Figure 3 sums up the variables in the study. Although only 13 or 14 observations are available for each variable, they range widely enough to permit a study of variance. A measure of dispersion -- the ratio of the standard deviation to the mean, or the coefficient of variation -- exceeds 12% for all variables but *Year*, for which variance is not an issue.

Results from naive models

Figure 4 presents results of the estimations, run mainly on Minitab. Durbin-Watson statistics do not indicate autocorrelation of errors in tests at the 1 percent level of significance (Kelejian and Oates, 1981). Estimates of the Variance Inflation Factor (not shown) do not suggest serious multicollinearity in the models.

Figure 4

Dependent variable: EATRATE					
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Adjusted R Square	0.56196	0.494	0.501	0.104	0.508
Standard Error	12.28706	13.208	13.12	34.499	13.027
F	4.07893	12.708	5.012	2.507	5.123
Signif F	0.049	0.004	0.026	0.139	0.024
D-W Test	2.45289	1.752	1.98	1.833	2.011
Independent variables					
ILLRATE	0.486121	0.296	0.416		0.401
Beta	1.203807	0.732	1.03		0.993
Elasticity	2.49	1.517	2.13		2.057
T	3.575	3.565	3.094		3.316
Sig T	0.009	0.004	0.0129		0.009
POLICY	7.233908			-31.081	-3.043
Beta	0.184567			-0.416	-0.078
T	0.311			-1.583	-0.355
Sig T	0.7647			0.139	0.731
POPULATE	0.025462		1.18E-05		
Beta	11.72032		0.005		
Elasticity	207.14		0.096		
T	1.625		0.023		
Sig T	0.1483		0.982		
TYPHOON	-31.0944		-28.24		-25.376
Beta	-0.46454		-0.422		-0.379
T	-1.575		-1.394		-1.238
Sig T	0.1592		0.197		0.247
YEAR	-56.2924				
Beta	-11.8088				
T	-1.573				
Sig T	0.1597				
Constant	108735.1	-6.321	-12.875	39.598	-8.989
T	1.572	-0.993	-0.231	2.628	-0.868
Sig T	0.16	0.342	0.823	0.022	0.408

The reform of policy toward food workers does not seem to have strongly affected the rate of foodborne disease in restaurants. In Model 4 of Figure 4, *Policy* accounts for only a tenth of the variation in *Eatrate.* The *Policy* coefficient is half again as great as the standard error in the estimate of the coefficient (T = -1.581), so the estimate of a negative coefficient seems somewhat precise. One's confidence is undermined, however, by examining the most complete of the five models, Model 1. Here, the *Policy* coefficient is positive. But the standard error of the estimate of the coefficient is more than three times larger than the coefficient (T = .311), so the estimate may not be precise enough to sustain a conclusion that its sign is positive.

The 1976 typhoon might have reduced the incidence of foodborne disease, presumably by shutting down restaurants across the island. Judging from beta coefficients, the typhoon may have had a more powerful effect on the incidence of disease than the policy reform. In Model 1, an increase of one standard deviation in *Typhoon* relates to a reduction of almost one-half of a standard deviation in *Eatrate*. An increase of one standard deviation in *Policy* relates to a smaller increase in the incidence of disease, of less than a fifth of a standard deviation. Even in the trimmer Model 5, where the *Policy* coefficient is negative, its effect remains small and imprecise. Estimates in Model 5 of the coefficients on both *Typhoon* and *Policy* are imprecise and merit cautious interpretation.

Similarly, the negative coefficient on *Year* -- and the relatively large beta coefficient -- suggest that improvements in technology over time may have done more to reduce the incidence of foodborne disease than did the policy reform, but the estimate of the coefficient is imprecise.

The most precise estimates available are for the relationship between *Eatrate* and *Illrate*.

An episode that raises the number of foodborne illnesses per capita by 1 percent will raise the number of illnesses per food worker by more than 2 percent. The incidence of food disease in restaurants may thus be sensitive to island-wide episodes of illness.

Methods: Probabilistic model

A probabilistic model will enable preliminary estimates of the chance that a food worker will pass on an illness to a customer. Suppose that external stochastic events drive foodborne illnesses in restaurants. Then the probability that a consumer will receive a foodborne illness through a food worker may be modeled as the product of several independent probabilities: the probability of an outbreak in the population, times the probability that the outbreak will touch a food worker, times the probability that the worker will pass on the illness to a customer, times the number of customers per worker. The model is

$$Eatrate = Illrate * \frac{Handlers}{Population} * \Pr[X] * \frac{g * Population}{Handlers}$$

Equation 1

where $X=1$ if the worker passes on the illness to a customer and $X=0$ otherwise; and g is a parameter that expresses the share of the population that dines in restaurants at a given time. Simplifying,

$$Eatrate = Illrate * g * \Pr[X].$$

Equation 2

Model *Pr[X=1] = 1 – Pr[X=0]* as a function of factors that affect whether the worker passes on the illness:

$$\Pr[X = 1] = \exp[-(a_1 Typhoon + a_2 Policy + a_3 YearCount)].$$

Equation 3

Here, *YearCount* tallies the number of years to pass since 1970 and thus reflects recent improvements in technology.

Pr[X=1] expresses the probability that a worker will pass on a foodborne illness to a customer, relative to the probability in 1970. When *Pr[X=1]* = 1, then it indicates no improvement in the safety of food service for the immediate contact between the worker and the customer, despite the new policy. The measure may thus provide a crude way to evaluate the safety of food service at the point of customer contact, as distinct from the safety of earlier links in the system that delivers food.

Inserting (3) into (2) and taking natural logs yields the equation to be estimated:

$$\ln Eatrate = \ln g + \ln Illrate - a_1 Typhoon - a_2 Policy - a_3 Year.$$

Equation 4

Figure 5 presents the results. The probabilistic model seems to explain less than do the naive models. No independent variable is statistically significant at the 10 percent level, though each carries the same sign as in the naïve models. The probabilistic results suggest that, although *Illrate* correlates with *Eatrate*, the incidence of foodborne illness in restaurants is not driven simply by external outbreaks (proxied by *Typhoon*, *Policy* and *YearCount*).

Figure 5

	Probabilistic model
Dependent variable: LnEatRate	
Adjusted R-square	0.293
Standard error	1.138
F	2.24
Sig F	0.154
D-W Test	1.53

Independent variables

Variable	Coefficient	T	Sig T
Constant	-3.699	-0.67	0.287
LnIllRate	1.3551	1.72	0.876
Typhoon	-0.24	-0.16	0.124
Policy	0.866	0.63	0.453
YearCount	-0.0766	-0.39	0.295

Typhoon	Policy	YearCount	Pr[X=1]	Year
0	0	1	0.926	1971
0	0	2	0.858	1972
0	0	3	0.795	1973
0	0	4	0.736	1974
0	1	5	1.621	1975
1	1	6	1.181	1976
0	1	7	1.391	1977
0	1	8	1.288	1978
0	1	9	1.193	1979
0	1	10	1.105	1980
0	1	11	1.024	1981
0	1	12	0.948	1982
0	1	13	0.878	1983

Turn now to estimates of the probability that a worker in contact with a foodborne illness will pass it on to a customer (*Pr[X=1]*). Calculations at the means of the independent variables yields *Pr[X=1] = .98*. An ill restaurant worker may be almost certain to pass on the contagion to a customer. The implied share of the population that dines in restaurants at a given time is $g = .025$.

The relatively poor fit of the model to the small dataset suggests a cautious view of these tentative estimates. They are presented mainly to illustrate uses of the model. Nevertheless, the estimates do not suggest that the new policy did much to improve food safety at the point of customer contact.

Conclusions

In a case study of food safety on an island, large external shocks to the food delivery system, such as storms and technological improvements, may have affected the incidence of foodborne disease more powerfully than policy reforms. The relatively weak effects of educating food service workers suggests that moral suasion may not provide workers with enough incentive to put their lessons into action. The imprecision of coefficient estimates, however, indicates a need for additional research on larger datasets.

References

Barro, Robert J. and Jong Wha Lee. Losers and winners in economic growth. April 1993. National Bureau of Economic Research Working Paper 4341.

Haddock, R.L. and E.H. Kampelmacher. 1986. The control of foodborne diseases on the island of Guam. *International Journal of Food Microbiology*. 3, 143-147.

Kelejian, Harry H. and Wallace E. Oates. 1981. *Introduction to econometrics: Principles and applications*. New York: Harper & Row.

Minitab® for Windows. 1995 and 1998. Releases 9 and 12. State College, Pa.