Uses of a Recordkeeping System to Evaluate RAT INFESTATION and to Develop Control Programs

ELDEN J. WALLER, R.S.

ADEQUATE BASELINE information is necessary to develop an effective program to control Norway and roof rats. In the Contra Costa County Health Department we decided to design a recordkeeping system which would clearly indicate activity or presence of Norway rats in sewers and creeks and on the waterfront. Our purpose was to obtain information that would be a sound basis for conducting control measures.

We wanted to know what kind of records aid in analyzing the effectiveness of and need for an existing program and in enlarging, if necessary, the program. Another goal was to find out if a system of records could be developed that would define actual rat infestation and be useful in evaluation. Devising a recordkeeping system was an experimental project; the recordkeeping methods and the analysis techniques we used were not the only ones available. Many other types of forms, graphs, and analyses could have been used.

Contra Costa County is a rapidly growing urban area adjacent to San Francisco and Oakland, Calif. It contains 13 cities, and in 1960 the county ranked 10th in population in the State.

In addition to heavy industry, the county has extensive port facilities. Two-thirds of the ships passing through the Golden Gate to and from foreign ports dock at the county's waterfront. Some ships come from ports that are in endemic plague areas, such as Vietnam.

Since 1907 Contra Costa County has had periodic episodes of plague in human beings and in wild rodents (*1*). Wild rodent populations, when encrouched upon by expanding subdivisions, can introduce plague among the commensal rodents in urban areas (*2*). In light of these factors, the county health department was particularly concerned about rat infestations and about a system for evaluating them.

Mr. Waller is vector control supervisor, division of environmental health, Contra Costa County Health Department, Martinez, Calif.

Methodology

To define the areas of rat infestation in Contra Costa County we developed forms to record and analyze the following items:

1. Areas of rat infestation, sources of rodent breeding, harborage, and paths of migration.
2. Public concern about community rat problems.
3. Effect of health department activity in rodent control.
4. Evaluation techniques available to determine the effectiveness of poisoning and trapping in sewer manholes, creeks, and in the waterfront area.
5. Infestation rates of rodents in creeks, sewer manholes, and waterfront areas and the correlation of infestation with the complaints of the citizens and with the results of surveys.

We used acceptance of poison bait placed in manholes, creeks, and waterfront sites as a criterion for developing basic records for evaluating purposes. Also rodents were suppressed.

An initial step in focusing on areas of possi-

ble rat infestation was to use the rates of complaints about rats per 100,000 population (fig. 1), both countywide and by individual census tracts, for a 3-month period in 1965. We recognized that basing a control program on the rate of complaints was not completely justified without considering the variables of publicity, surveys, and others, but this basis did give us some indication of the areas we should investigate (*3*).

Survey

In 1965 we started on a survey of urban areas of Contra Costa County using personnel who had several weeks training in rodent and pest control methods. (The health department was training welfare recipients in pest control operations in a program conducted under title V of the Economic Opportunity Act.) Ten trainees were used in the survey. Later they helped in limited recordkeeping procedures and in setting out poison bait. More than 5,000 residents were interviewed regarding presence of rats, use of poison and traps, and location of rodent harborages. Where complaint rates had been high, nearly 90 percent of the residents were interviewed. In areas with no history of rodent complaints, the interview sample was smaller. We used a modification of the Merced County Environmental Health Appraisal. (*4*)

Residents were asked these five questions.

1. Have you had any rat problems?
2. Have you used poison or traps?
3. Do you have garbage service?
4. Do you have a garbage can with a tight-fitting lid?
5. Do you have any penned animals or poultry?

Staff members made their own observations on these points.

6. Are there any accumulations of rubbish and debris?
7. Is there any garbage on the ground?
8. Are there any rat burrows or signs?

The answers and observations were recorded on a form containing checkoff boxes for "yes" and "no" replies. The date, city, street address, and census tract were also recorded on the form.

With an 80 percent sample of the homes in one area we found that 25 percent were infested with rats. The range of infestation among the

Figure 1. Rates of complaints about rats per 100,000 population, by census tract, August 1–November 1, 1965, Contra Costa County

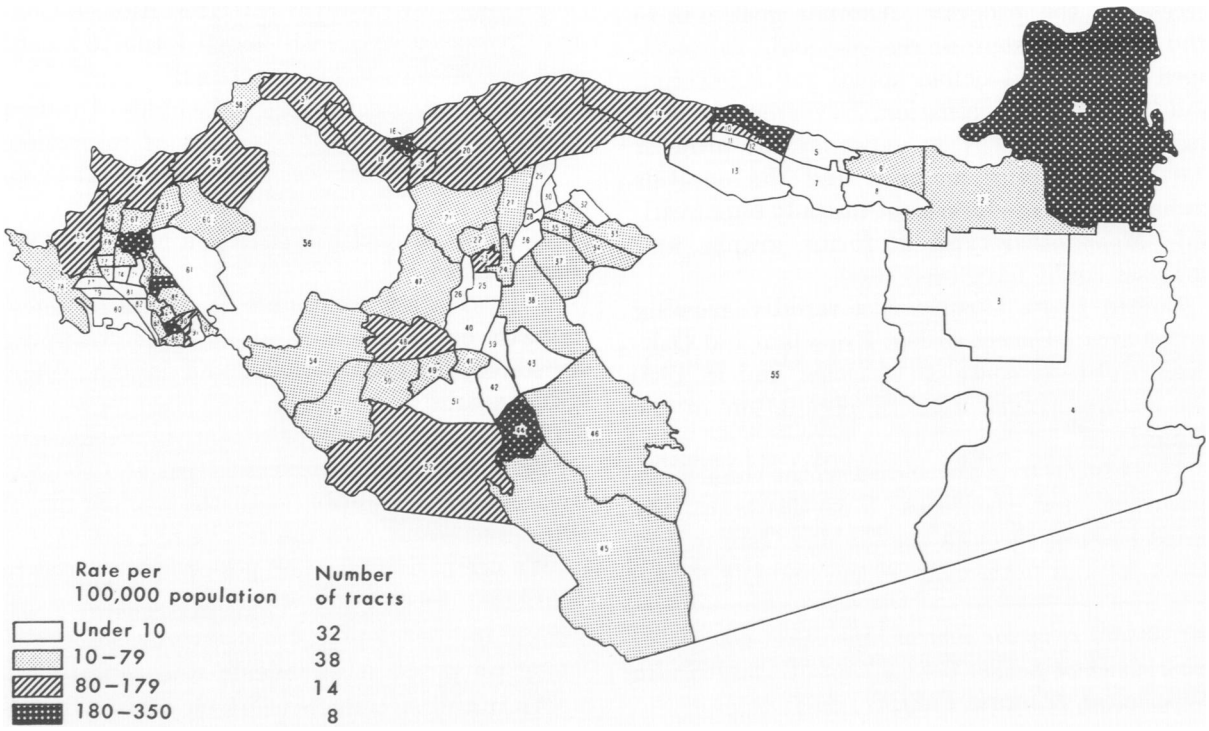
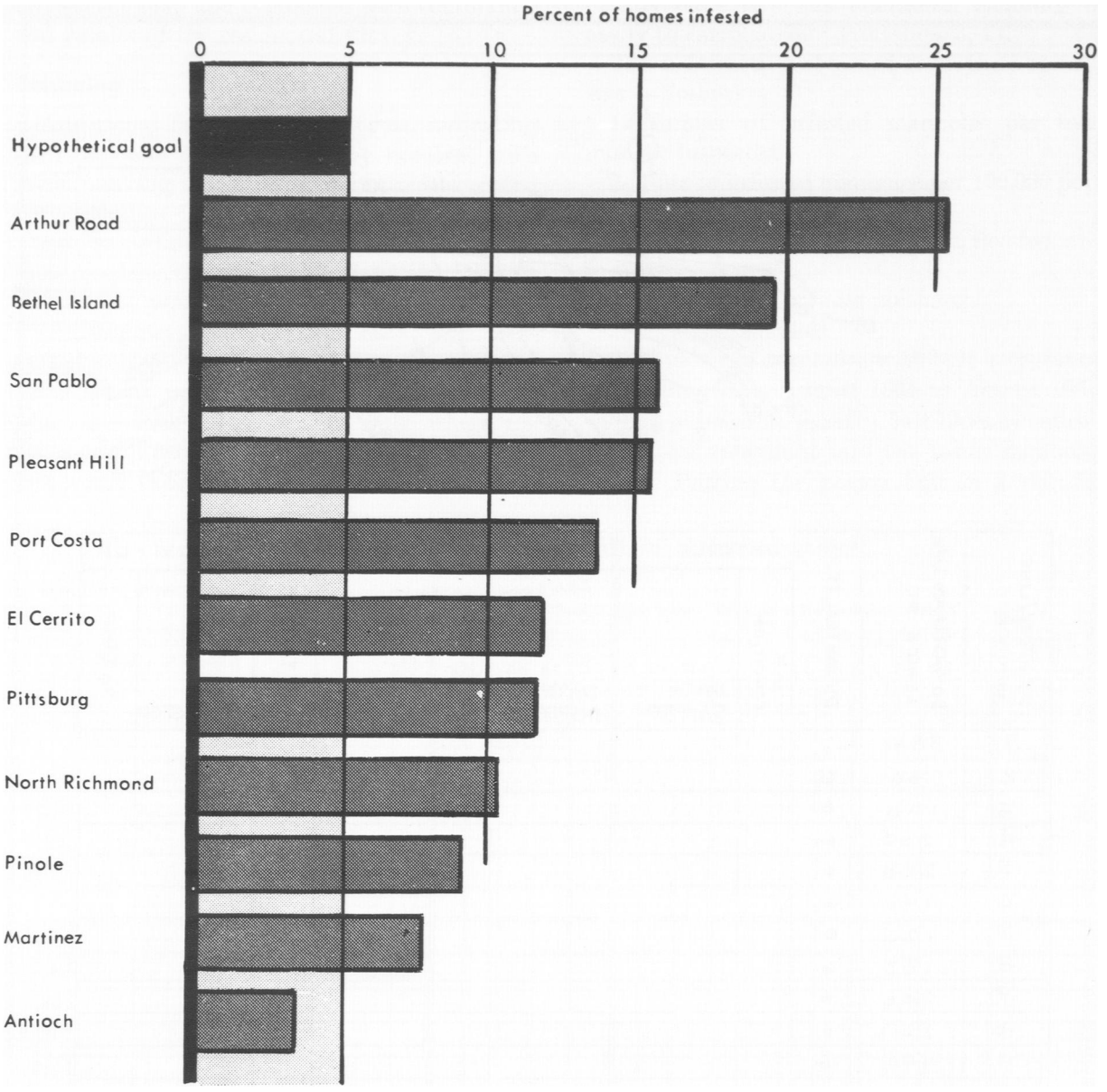


Figure 2. Percent of homes in areas of Contra Costa County infested with rats, 1965 survey



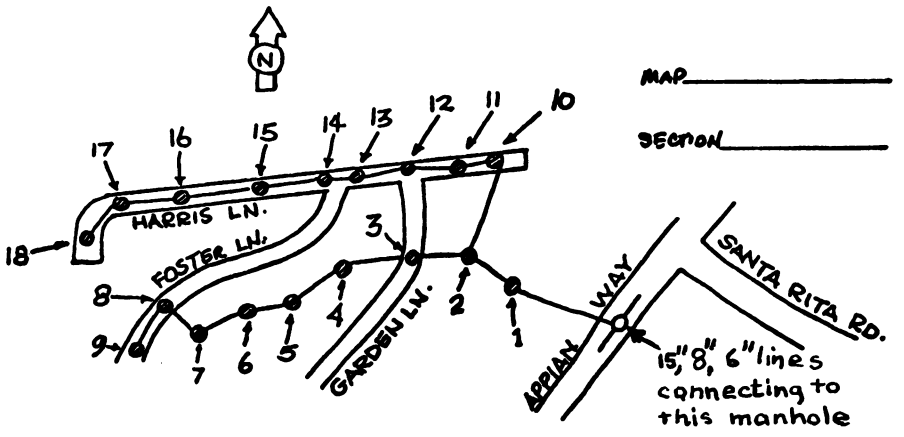
areas was 5 to 25 percent. A total of 5,000 homes in the county were surveyed. For the entire county we found an average of 17 percent of the homes were rat infested or had a history of infestation (fig. 2).

We used the survey data and past records to plot on maps of each city or sewering agency the blocks that had infested residences.

All figures and results of the survey, control measures, publicity, and complaints were also recorded by census tracts. The census tracts in Contra Costa County were chosen because these units reflect demographically equal as well as socioeconomically similar populations. The geographic divisions reflect the industrial, densely populated sections, sprawling residential sections, and agricultural-recreational sections.

Before proceeding with the poison bait operation we investigated the creeks that transversed the areas where residential surveys had been conducted. Indications of rat harborage

Figure 3. Map and data sheet for sewer inspections



STRUCTURE/LINE NUMBER	DOWNSTREAM LINE LENGTH, FT.	DIAMETER, FT.	INITIAL		FOLLOW-UP		FOLLOW-UP		FOLLOW-UP	
			MH CONDITION	DATE BAITED	DATE INSPECTED	% TAKE	DATE INSPECTED	% TAKE	DATE INSPECTED	% TAKE
1	300	6								
2	60	6								
3	100	6								
4	220	6								
5	220	6								
6	143	6								
7	120	6								
8	133	6								
9	200	6								
10	122	6								
11	149	6								
12	20	6								
13	259	6								
14	234	6								
15	220	6								
16	160	6								
17	240	6								
18	210	6								
TOTAL	3080									

Section Sewer Map

or rat infestations were noted on the residential survey map and correlated with complaints and results of the residential survey.

Poisoning

Additional field recording forms, indicating each manhole in the system by number, with accompanying index maps, were used to record our activities in sewering jurisdictions (*5a*). These recording forms were adopted from those used by the San Pablo Sanitary District for several years. The forms, designed to use with computers in analyzing data, also permitted analysis of variables in sewer line maintenance that might affect a sewer rat control program—such as broken laterals where rodents might burrow, nest, or tunnel to the surface and invade nearby residences. These forms were invaluable in reinspections; we could readily reidentify the manholes, enabling us easily to correlate our data (figs. 3, 4).

The information obtained from these records was as follows:

1. Number of infested manholes per total number inspected
2. Rats in infested manholes per 100,000 population, by census tracts
3. Manhole condition (dry, wet, flooded, and so forth)
4. Number of manholes poisoned
5. Type of bait used
6. Number of manholes with bait acceptance.

The first year, August 1965 to August 1966, we put permanent paraffin bait blocks containing an anticoagulant into the sewer manholes (*6*, *7*). Putting the poison bait in a paraffin

Figure 4. Rat poisoning record in sewer manholes

SEWER RAT POISONING RECORD

Rodent and Vector Control
Contra Costa County Health Department Division of Environmental Health

Area _____ Sheet # _____

#	Location of Manhole	Ct	Date IN	T/S	WE	BA	Date IN	T/S	WE	BA	Date IN	T/S	WE	BA	Date IN	T/S	WE	BA	TOTALS Insp.	Take
1.																				
2.																				
3.																				
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				
11.																				
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15.																				
16.																				
17.																				
18.																				
19.																				
20.																				
	INIT. INSP.																			
	RE-INSP.																			

Use these markings only: X = yes, 0 = no, L = light, M = medium, H = heavy

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NOTE: IN=inspected, T/S=Take/sign, WE=wet, BA=bait placed.

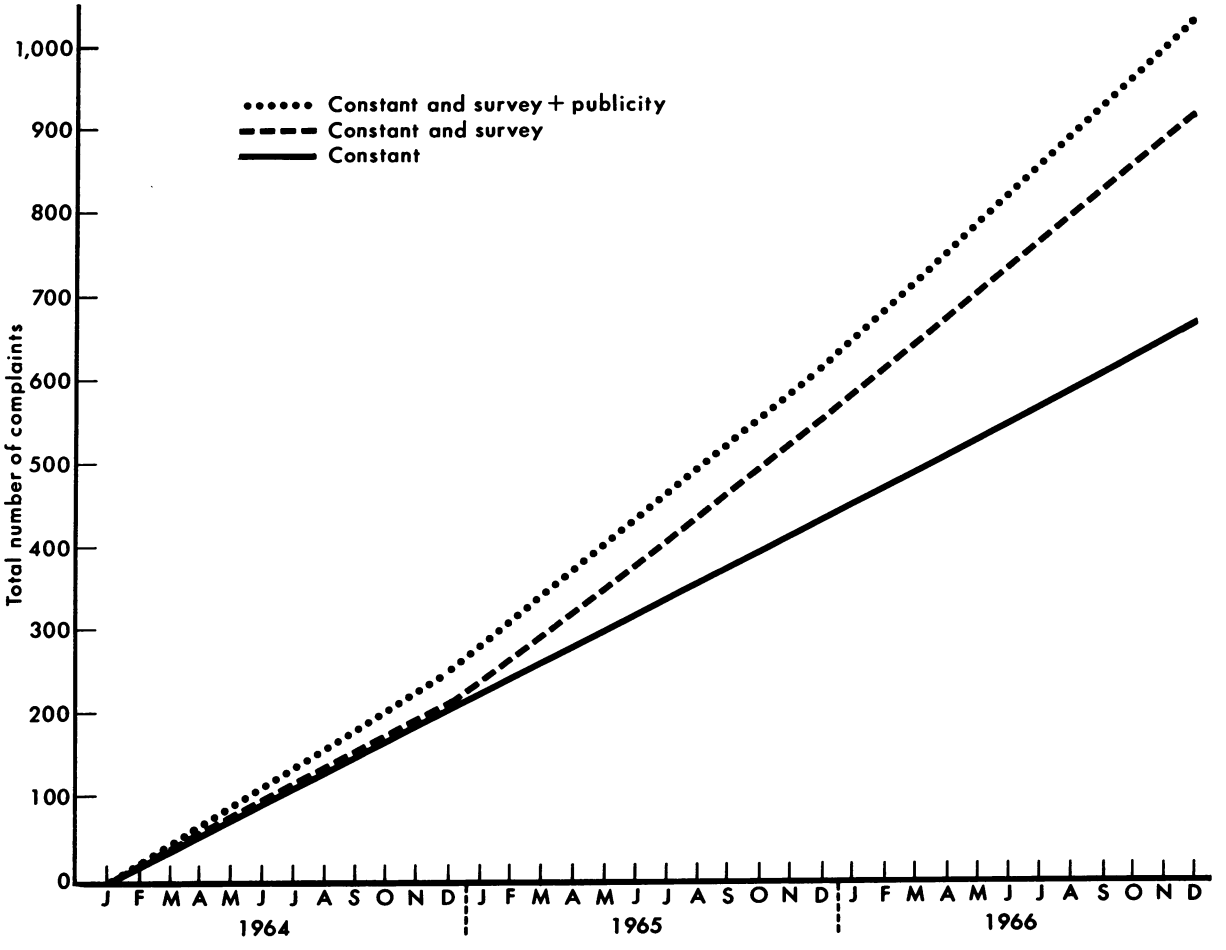
block permitted later evaluation of the block and bait acceptance in the sewer environment. Paraffin bait blocks are durable and hold up well in sewers. The degree of consumption of the bait block can easily be measured. Even if the bait blocks were entirely consumed, the wire attaching the block to the manhole wall would remain. Through the evaluation we were able to obtain baseline data on the rodent population in the sewers of the county (fig. 4).

Results

Several reinspections were made in the first 2 years of the poisoning program, and in some cities we have been able to determine the areas of heavy infestation. After reinspection, all bait stations that showed acceptance of baits were plotted on a sewering map of the sewering agency responsible for stations showing acceptance. Stations that had wet manholes or were inaccessible were also recorded. These were indicated on our report.

In plotting the acceptance of bait in sewer manholes, patterns emerged which showed that certain sections of the cities had greater infestations of rodents. Comparisons between old and new sewer systems seemed to indicate that old, unrepaired systems are more conducive to rats (*8*). Garbage grinders feeding into poorly maintained and deteriorating sewer mains offer the food necessary for rat survival. However, some new systems serving homes with garbage grinders did provide the proper ecology for rats (*8–10*). The advantage of plotting information on bait acceptance on sewer maps is that, if the plotting shows that a lateral or a trunk line is infested, increased control measures can be concentrated in the area (*5b*).

Figure 5. Effects of survey and publicity on complaint rates



Data Record Sheet for Multiple Regression Analysis

Date	Number of residences surveyed *S*	Inches of publicity per month *P*	Number of complaints *C*
1964			
January			8
February			9
March		15	6
April		10	7
May			13
June			13
July		15	14
August			18
September		20	10
October			10
November		15	8
December		24	7
1965			
January		16	9
February			8
March	20	20	10
April			8
May	1, 214	40	20
June	1, 214	13	24
July	1, 214	15	23
August	1, 214	25	69
September	1, 214	17	79
October	161	54	57
November	545	211	59
December		15	33
1966			
January	40	25	33
February	83	21	34
March	117	35	37
April		17	52
May	20	220	55
June	65	87	57
July			53
August		11	64
September		38	57
October		12	39
November	40	40	32
December		41	17

Evaluation

A primary consideration in any public rat control program is the volume of complaints of rat infestation. In many jurisdictions, evaluation of the effectiveness of the program is based on a lessening complaint rate or on finding a great number of dead rats in the grit chamber at the sewer plant. Since we used a slow-acting anticoagulant poison, the dead rats would not be flushed down the sewer to the plant but would probably die in their nesting area. In order to test the hypothesis that complaints indicate infestation, a series of statistical comparisons were made. These comparisons were based on the data in our records which had been gathered up to January 1967. All the data were organized in a similar fashion:

1. Monthly averages of the number of complaints
2. Inches of publicity in the newspapers
3. Number of residential and business locations surveyed

All data were listed by census tract. The various combinations of the three variables listed were compared by the chi-square test in which:

$$\chi^2=\frac{N[(AD-BC)-N/2]^2}{(A+C)(B+D)(A+B)(C+D)}$$

χ^2=distribution of observations arranged in the following manner:

N=total number of observations

$C+A$=number of observations $>\overline{M}$ complaint rate

$D+B$=number of observations $<\overline{M}$ complaint rate

$D+C$=number of observations $>\overline{M}$ publicity rate

$A+B$=number of observations $<\overline{M}$ publicity rate

Solving the equation for χ^2 shows whether the observed frequencies of publicity compared with complaints differ significantly from estimated frequencies.

All relationships that gave a chi-square value of 3.84 with 1 degree of freedom or more, which is equivalent to a 95 percent probability that the relationship was not due to chance, were treated by a more sophisticated method (*11*).

The next procedure was to develop a mathematical relationship between the number of complaints received and the number of locations surveyed by the least squares method. From this was developed the equation:

$$C=21.68+0.03798S$$

in which C represents complaints and S the number of surveys.

The regression line (fig. 5) indicates that in any one month, 22 complaints could be predicted, with no surveys done. The curve indicates that for each 30 residences surveyed per month, one additional complaint would be predicted. The next step was to combine in one calculation the independent variable, surveys

and the inches of newspaper publicity published, in a comparison with the number of complaints received as an independent variable. This method of multiple regression analysis is essentially the comparison of the deviation from the sums of the squares and cross products of the variables being studied. The relationship is shown by the equation:

$$C=18.17+0.35338S+0.1661P$$

in which C represents the number of complaints, S the number of residences surveyed, and P the inches of publicity (see data sheet for multiple regression analysis).

The results of this equation can be shown by a graph which represents the cumulative complaints, surveys, and inches of publicity for the 36-month period under study. This equation further illustrates the fact that there is a basic backlog of complaints, in this case 18 per month, which occur regardless of surveys or publicity (fig. 5). Because of the arrangement of the recording system, variables can be added or subtracted as needed.

The next step in analyzing the data is to plot the deviation from the equation and compare it with other variables by the chi-square test to see if it is advisable to include another variable in the multiple regression analysis. This stepwise calculation method limits the amount of data handled at any one time to the volume which can be handled on a desk calculator. Putting a huge mass of data through a computer to discover that the multiple tests are correlated and the probability levels are affected so that only

Figure 6. Sanitary conditions found in survey of one census tract compared with acceptable standards

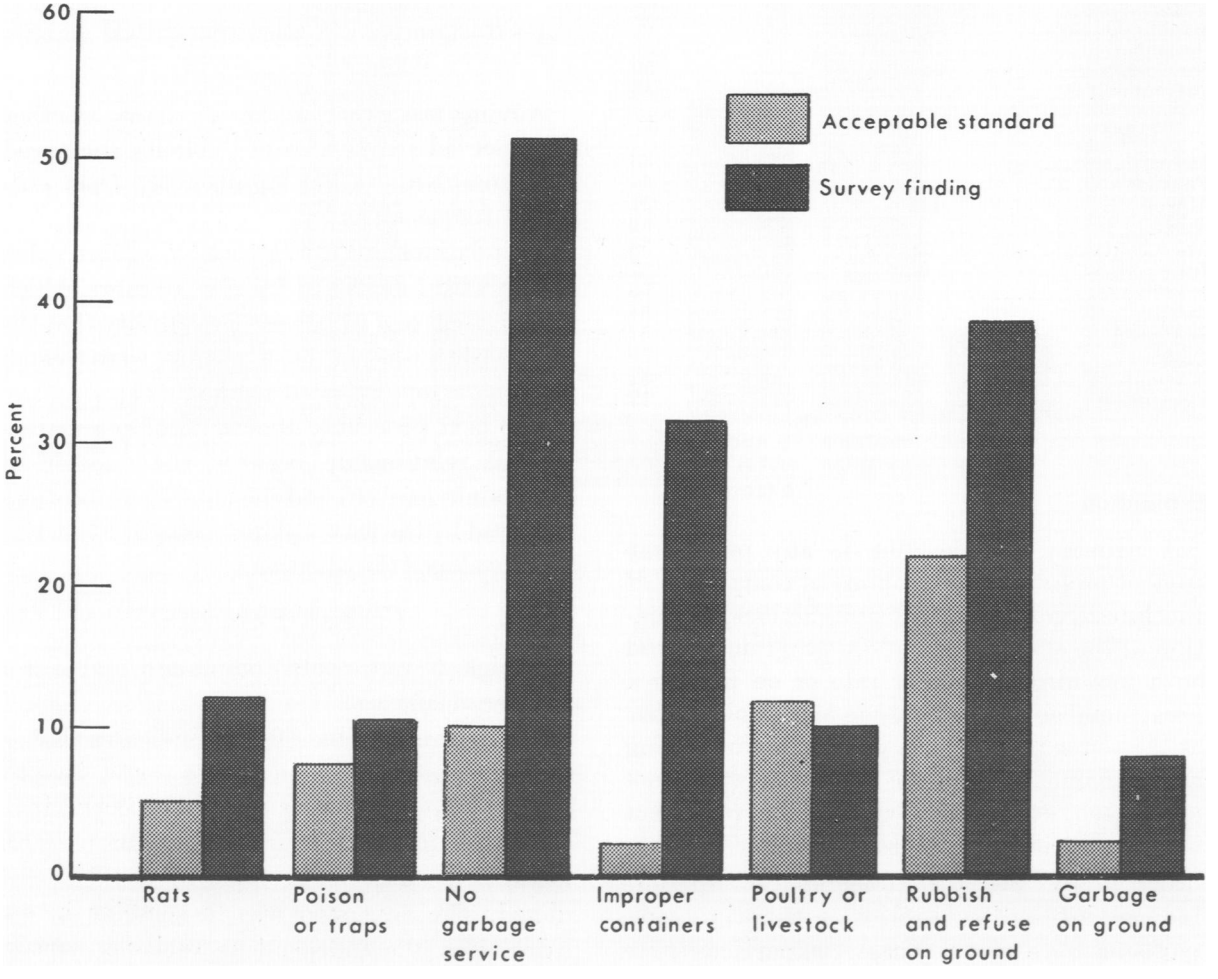
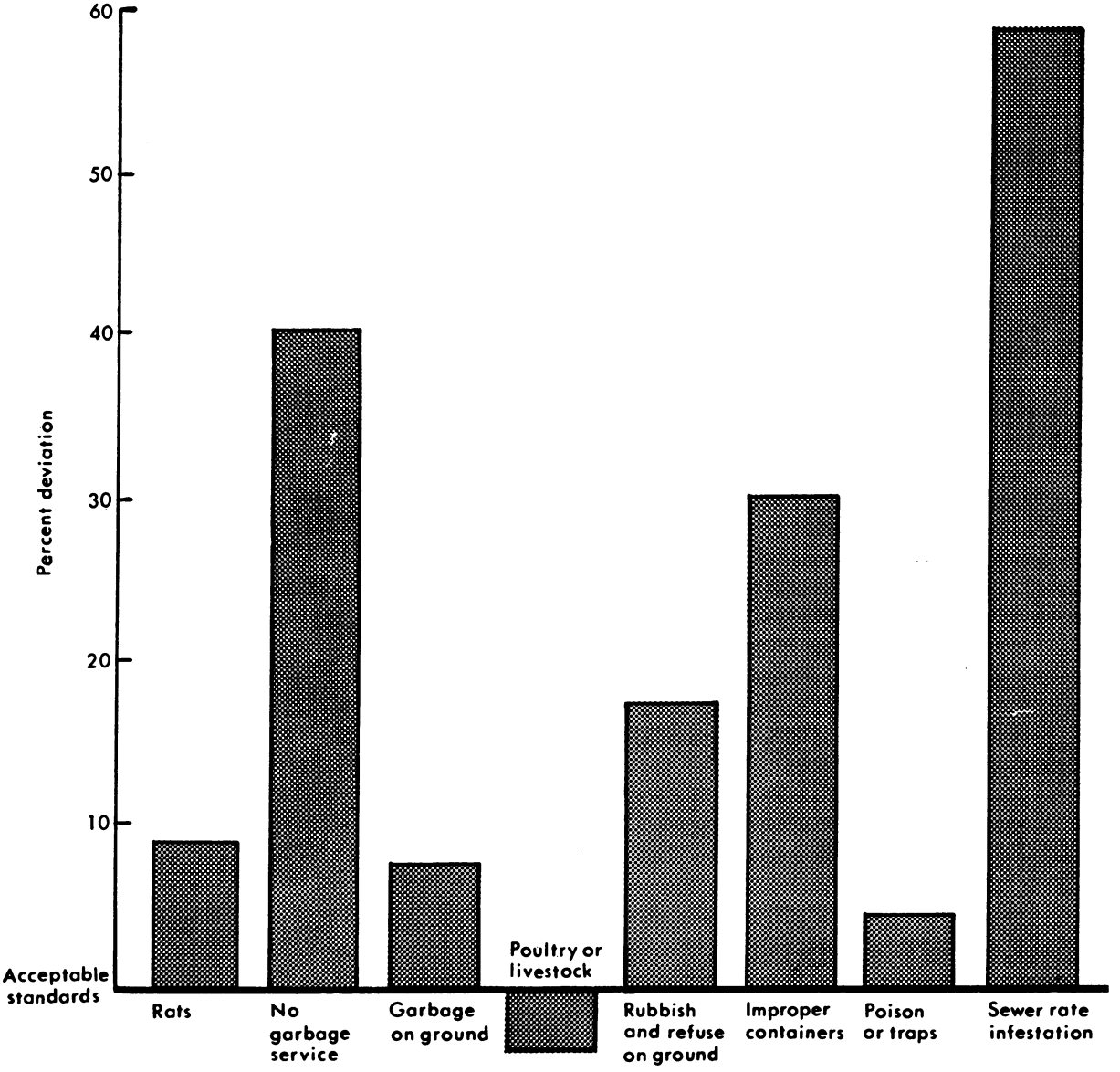


Figure 7. Deviations from acceptable standards found in survey of one census tract



two or three of the variables are significant seems considerably less efficient.

In one census tract, the variables that might affect the rate of rat infestation of sewer manholes were studied. Mean acceptable standards for several environmental health sanitary violations were based on standards in the Merced County Environmental Health Appraisal (*4*). Findings for sanitary violations or conditions are indicated in figure 6 as percentages compared with mean acceptable standards. The deviation from these mean acceptable standards indicates, in this particular census tract, the factors that might be important in the rodent infestation rate of manholes (fig. 7).

Conclusions and Summary

The use of sewering maps and records as a means of determining areas of heavy rat infestation is valid. These records permitted us to evaluate the effect of a poisoning program and to conduct an ongoing surveillance program. Statistical correlation and analysis of results

indicates the need for a solution that consists of several steps. The use of significant variables pinpoints more clearly approaches to rat control that are specific to an area.

Records were developed and kept of infestation rates of rats in sewer manholes, creek sites, waterfront areas, and residences. In addition, records of variables such as weather conditions, socioeconomic status of residents of an area, geographic data, and business activity are needed to analyze Norway rat infestations and to develop control measures adaptable to the variables.

A complete reappraisal of the signpost indicators of rat infestation is mandatory.

We used the facts accumulated from our records to compare and evaluate rat infestation and the reasons for infestation in sewer manholes throughout Contra Costa County as well as in individual census tracts. Analyzing this infestation we were able to relate, by order of importance, infestation rates with complaint rates and with other evaluation criteria in each census tract of the county. The causes of sewer infestation in one census tract are not necessarily the causes in another tract. Record analysis permitted delineation of the degree of Norway rat infestation in sewer manholes, the effect of the rats upon the residential population, and the population's response by complaints, action, or otherwise in different census tracts. This analysis was the basis for developing a countywide rodent control program which, of necessity, has different intermediate goals in various areas and census tracts.

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