THESIS

A CHARACTERIZATION OF FOODBORNE ILLNESS DATA, DENVER METROPOLITAN AREA, COLORADO, 1986-1989

Submitted By

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY CHARLES L. HIGGINS ENTITLED, A CHARACTERIZATION OF FOODBORNE ILLNESS DATA, DENVER METROPOLITAN AREA, COLORADO, 1986-1989 BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

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ABSTRACT OF THESIS

A CHARACTERIZATION OF FOODBORNE ILLNESS DATA, DENVER METROPOLITAN AREA, COLORADO, 1986-1989

A records search was conducted for foodborne illness complaints to local health departments in the Denver, Colorado Metropolitan Area, defined as Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson counties. Records for the four-year period beginning with 1986 through 1989 were searched for reports in which two or more persons were alleged to have become ill, experienced similar symptoms and had a common food exposure. Program administrators were interviewed about the procedures used to investigate these complaint reports.

Out of 410 reports located, 340 reports of illness were retained for the study. These complaints occurred at a rate of 4.48 per 100,000 population or 6.4 per 100 licensed establishments over the four-year period of the study. Restaurants were most often cited by the complainants as the source of the suspected meal. Over the period of the study, the highest number of complaints occurred in June and the lowest number of complaints were reported in February. Complaints increased steadily over this time period with 52 in 1986 and 112 in 1989.

Only 20 of the complaints resulted in laboratory confirmed agents,

with bacterial agents accounting for 19 of these confirmations. Salmonella species were the leading cause of the confirmed cases of illness, causing 9 of the outbreaks. Poultry was the leading vehicle of the confirmed outbreaks and time-temperature abuse of foods was the primary process failure leading to illness.

The documented cases of foodborne illness in the Denver Metropolitan Area are not sufficient to justify regulatory activities or to target prevention. The assistance of the public, academic and medical community appears to be needed in order to increase the percentage of complaints that can be properly investigated.

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I want to thank the local health departments in the Denver area for allowing me access to their files, and the staff sanitarians that struggle so hard, with so little to protect and promote the public health.

DEDICATION

I wish to dedicate this thesis to my wife, Alexis who has been my best friend and supporter and who made me do this.

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CHAPTER I

INTRODUCTION

In the United States, over 3,000 local health agencies have the responsibility for conducting most of the governmental inspections that are designed to protect the nation's food supply. In order to properly and efficiently target these programs, the collection and analysis of statistics on foodborne disease should be a vital component of these local agencies activities.

Each year in the Denver Metropolitan area, a large number of complaints of possible foodborne illness are received by several local health departments. These reports of injury or illness may originate in medical laboratories, hospitals, private physicians' offices or with a personal call to the local health department by an individual or individuals. Local and state health agencies field these inquiries, investigate the reports and funnel this information to the Centers for Disease Control and Prevention (CDC), of the United States Public Health Service, which is the central repository for disease statistics in the United States. It is at this national level where analysis of the patterns of foodborne disease have traditionally been conducted. Short- and long-range planning, at all levels of government, is dependent on the quality and quantity of this locally-collected, nationally-analyzed foodborne disease information. This tradition of national examination of disease statistics has had the net effect of decreasing the relevance and interest in the collection and analysis of data at the local level. Without local interest, efforts to collect epidemiological data often lag and methods are not corrected and improved.

The purpose of this study was to: 1. Describe the data collected by local health agencies in the Denver, Colorado Metropolitan area during the four-year period of 1984 through 1987; 2. To compare this data to national statistics maintained by the United States government; and 3. To make recommendations for further data collection and study.

Chapter II

BACKGROUND

To describe the scope of foodborne disease is to describe the ecology of mankind's interactions with our energy and nutrient sources, our foods. In the process of obtaining the necessary chemicals and stored energy for our own uses, we ingest agricultural and animal products. Along with these purposeful foods come unintentional contaminants. These contaminants include physical objects, chemicals, and living organisms that cause injury or illness. This web of interaction between us, our foods, and foodborne illness, can be mapped by describing the total impact on the host, the agents of disease and their routes of transmission.

Impact

In the United States from 1973 through 1987, there were 7,458 outbreaks of foodborne illness reported to the CDC (a mean of 532.7 outbreaks per year during this period).[1] These outbreaks involved a total of 237,545 cases of injury or illness (a mean of 16,967.5 cases per year for 1973 through 1987). It is known that the actual number of outbreaks and cases is much higher than these government-reported figures and some research suggests that the ratio of actual cases to reported cases is 25:1.[2] Other research indicates that CDC statistics account for only a small fraction (1 to 2 percent) of the cases that actually occur.[1,3] Foodborne illness researchers using varying methods of estimating the actual number cases of illness, have come up with case numbers that range from five million cases per year to almost twenty million cases per year.[4] Economic loss from these illnesses in the United States may be greater than eight billion dollars per year.[4] Direct and indirect costs from outbreaks originating in food processing plants is estimated at over two thousand dollars per case.[5] In outbreaks associated with foodservice establishments, the costs are estimated at 788 dollars per case.[6] The reasons for the large differences in numbers and the difficulty in estimation of the scope of foodborne disease can be found in the nature of the illnesses and the reporting systems.

Foodborne disease is actually a collection of many illnesses caused by a myriad of organisms and chemicals. Some of these illnesses are acute with severe symptomology that cause the seeking of medical attention and laboratory support. These severe illnesses are more likely to be entered into the official reporting systems.[1,3] Other illness likely to be reported are those occurring in groups of people dining together at a commercial foodservice establishment. These people are likely to know each other and know of each others' illnesses. People who have a mild illness, sporadic cases or people who contract a foodborne disease in the home setting are all less likely to report their problem to authorities.[1,3,7] Other factors that influence the official reporting of foodborne disease include the government jurisdiction in which the outbreak occurs; the resources, ability, and timeliness of the investigating agency; the detection methods available for the agent involved; and the recognition of the disease as food related.[1,7]

Over the last 20 to 30 years, the incidence of foodborne illness has remained relatively stable.[1,3] Fluctuations have, from time to time occurred, including an increase from 1973 to 1982. The number of outbreaks increased from around 300 in 1973 to over 600 in 1982. This trend reversed after 1982, decreasing to less than 400 in 1987, nearly matching the numbers reported in 1973. The outbreaks tended to be larger over time, involving a greater number of cases per outbreak. In relation to the population, the rate of reported foodborne outbreaks in 1973 was 0.14 per 100,000 population and the rate of outbreaks in 1987 was 0.16 per 100,000 population.[1,8] Rates for outbreaks and cases from 1983 through 1987 are listed in Table 1.[7,8]

Table 1. Rates of Foodborne Illness in the United States by Outbreaks and Cases Per 100,000 Population, for the Years 1983 Through 1987

YEAR	POPULATION	OUTBREAK RATE PER 100,000	CASE RATE PER 100,000
1983	234,799,000	0.22	6.35
1984	237,007,000	0.23	6.93
1985	239,279,000	0.21	12.99*
1986	241,625,000	0.19	5.29
1987	243,934,000	0.16	6.76

* A single outbreak in 1985 of *Salmonella typhimurium* in milk produced 16,000 culture positive cases.

In a summary of the outbreaks that occurred in New York State during 1990, 131 outbreaks were reported that were made up of 2,425 cases of food-related illness.[8] The population of New York State in 1990 is listed in the United States Census data as 17,990,455. This is a foodborne disease rate in New York State in 1990 of 0.73 outbreaks per 100,000 population, and 13.48 cases per 100,000 population.[8,9] New York State regularly accounts for a large percentage of the reported outbreaks in the United States. These larger numbers of outbreaks and cases may be due to a very active and thorough reporting and outbreak investigation system.[7,9]

Bean and Griffin, researchers working at CDC, have suggested that the decline in reported outbreaks from 1983 through 1987 may be partially the result of a decline in local and state health agency resources available to investigate foodborne disease outbreaks.[1] These researchers suggested that this time frame coincides with the onset of the AIDS epidemic. From 1973 to 1982, 20 percent of the total outbreaks in the United States were reported from New York City. From 1983 to 1987, New York reports made up only nine percent of the national totals.[1] Since this city has had a large number of AIDS cases, a shift of priorities may have occurred that masked the true incidence of foodborne illnesses. A diversion of attention from other public health concerns to the growing problem of HIV infection may be a factor in the reporting of foodborne illness since the early 1980s.

Foodborne illness ranges from very mild impact on the host to much more serious, life threatening or debilitating symptomology.[10] Some bacterial, viral, and chemical agents may cause, depending on dose, only mild nausea or discomfort over relatively short periods of time. Others can lead to acute symptoms that involve extensive, rapid host damage and death.[10,11] Foodborne diseases can generally be classified into two categories, infections or poisonings. Some organisms enter the body, grow, multiply, and even migrate, causing damage to tissues by their presence or from toxins which they synthesize in the host. Examples of this type of illness are the *Salmonella* species of bacterial foodborne infections, and viruses such as *Hepatitis A.* Parasites such as *Giardia lamblia* and *Trichinella spiralis* would also be listed in the category of foodborne infection. Poisonings occur from chemicals that are intentionally or unintentionally added to foods during growing, harvesting, processing, distribution and/or preparation. These poisons may include toxins that are produced by microorganisms before consumption of the food, such as *Staphylococcus* enterotoxin and botulinal toxin. Natural toxins may also be present in the tissues of some plants, certain species of mushrooms, and certain animals, such as the puffer fish.

The impact of foodborne illness extends beyond the morbidity described in the preceding paragraphs. The CDC reported 137 deaths attributed to foodborne disease between 1983 and 1987.[7] As with other aspects of foodborne illness, mortality may be greatly under-reported and some researchers have estimated that there are actually several thousand deaths each year that can be attributed to foodborne illness.[4]

Agents

The available evidence indicates that biologic agents are the leading cause of foodborne illness in the United States. Of the biologic agents, bacteria cause the greatest number of outbreaks and cases of food-related disease.[1,3,4,7] During the period of 1973 to 1987, bacteria were identified as the causative agent in 66 percent of the outbreaks in which the agent was known.[1] An agent was identified in 2,841 outbreaks and remained unknown in 4,617 outbreaks. In the CDC reporting period from 1982 through 1987, bacteria were confirmed as the agent in 66 percent of the outbreaks and 92 percent of the cases in which a causative agent was identified.[7] It has been estimated that greater than 5,500,000 cases of bacterial foodborne disease may occur each year in the United States (see Figure 1).[4]

This estimate must be interpreted in light of the large number of outbreaks in which a causative agent is never confirmed. From 1983 through 1987, 62 percent of the outbreaks were never attributed to any specific agent.[7]

Bacterial agents appear in the literature as leading causes of food-related diseases in other countries as well. In a 1980 summary of foodborne illness in the Netherlands, bacterial agents accounted for 83 percent of the outbreaks in which etiology was identified.[12] In Canada, a 1982 summary indicated that microbial agents caused 75.3 percent of the outbreaks with known causes (bacteria made up most of these totals).[13]

From 1983 through 1987, seven microorganisms made up 95.8 percent of the total bacterial agents identified as causes of

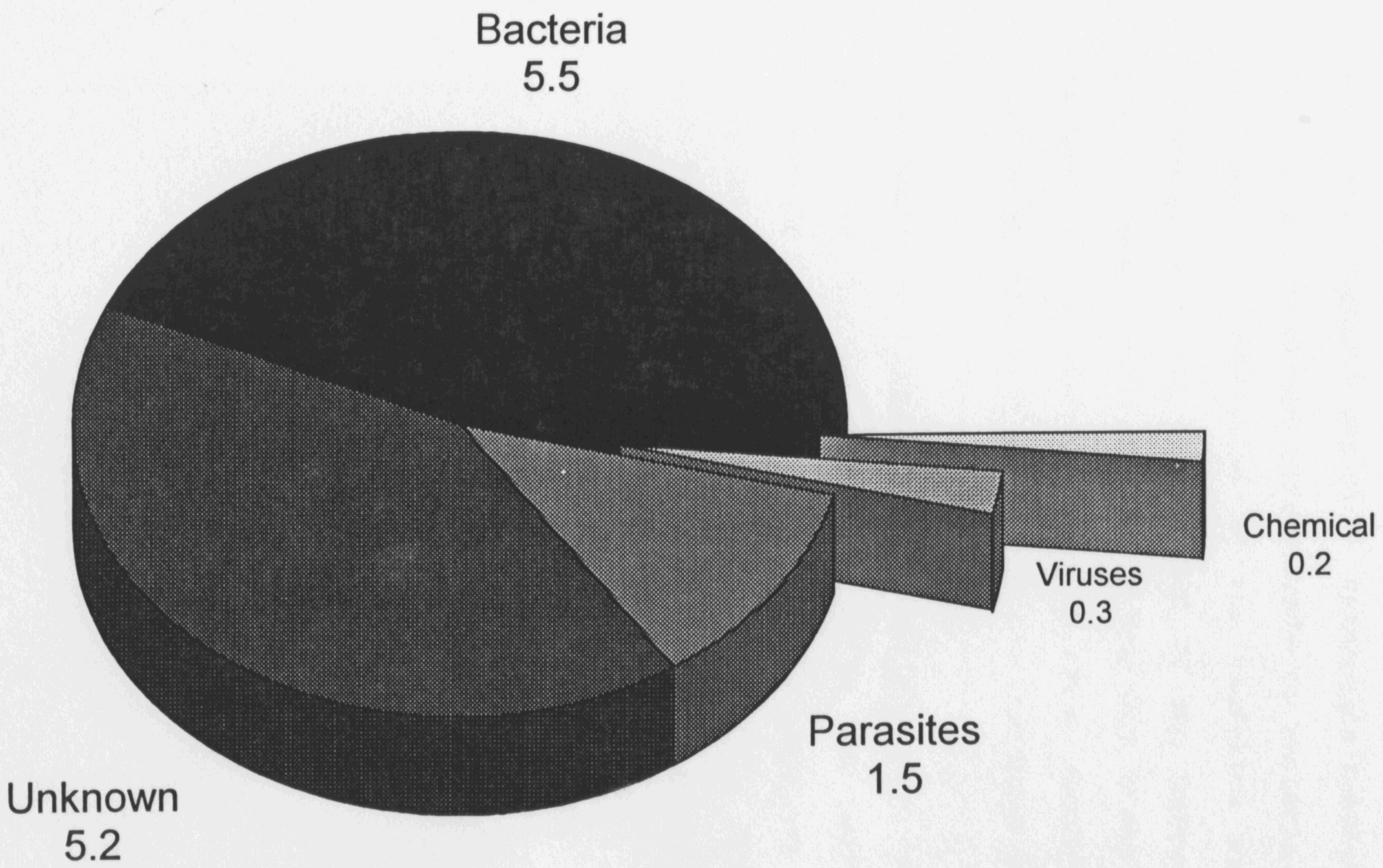

Figure 1. Estimated annual number of cases of foodborne disease in the United States, by agent in millions of cases.

outbreaks (Tables 2 and 3).[7] *Salmonella* species caused over half of all outbreaks attributable to bacteria. *Salmonella* organism was identified as the causative agent in more outbreaks than any other agent of any category (over 37 percent of all outbreaks). In New York State during 1990, *Salmonella* was the agent most often confirmed and was responsible for 58.3 percent of the confirmed outbreaks.[9]

When individual cases of foodborne illness are considered, the *Salmonella* species was found to be the leading cause of illness in the United States. Various serotypes of *Salmonella* comprise 62.1 percent of the cases in which bacterial agents were the cause of disease; and 57.3 percent of all causes of illness associated with foods.[7]

Table 2. Outbreaks of Foodborne Illness in the United States, by Agent and Year

AGENTS	OUTBREAKS AND YEAR OF REPORT					
	1983	1984	1985	1986	1987	TOTALS
BACTERIAL						
BACILLUS CEREUS	0	3	7	4	2	16
BRUCELLA	1	0	1	0	0	2
CAMPYLOBACTER	8	4	9	4	3	28
CLOSTRIDIUM BOTULINUM	13	11	17	22	11	74
CLOSTRIDIUM PERFRINGENS	5	8	6	3	2	24
ESCHERICHIA COLI	3	2	1	1	0	7
SALMONELLA	72	78	79	61	52	342
SHIGELLA	7	9	6	13	9	44
STAPHYLOCOCCUS AUREUS	14	11	14	7	1	47
STREPTOCOCCUS GROUP A	1	2	1	2	1	7
STREPTOCOCCUS OTHER	1	0	0	1	0	2
VIBRIO CHOLERA	0	0	1	0	0	1
VIBRIO PARAHEMALITICUS	0	0	0	1	2	3
OTHER BACTERIAL	2	0	1	0	0	3
TOTAL	127	128	143	119	83	600
CHEMICAL						
CIGUATOXIN	13	18	27	18	11	87
HEAVY METALS	4	3	3	1	2	13
MSG	0	2	0	0	0	2
MUSHROOMS	5	2	1	4	2	14
SCOMBROTOXIN	13	2	15	20	22	72
SHELLFISH	0	13	2	0	0	15
OTHER CHEMICAL	10	4	10	5	2	31
TOTAL	45	44	58	48	39	234
PARASITIC						
TRICHINELLA SPIRALIS	4	11	8	6	4	33
GIARDIA LAMBLIA	0	0	1	2	0	3
TOTAL	4	11	9	8	4	36
VIRAL						
HEPATITIS A	10	2	5	3	9	29
NORWALK VIRUS	1	1	4	3	1	10
OTHER VIRAL	0	1	1	0	0	2
TOTAL	11	4	10	6	10	41
TOTALS FOR ALL AGENTS	187	187	220	181	136	911

Table 3. Cases of Foodborne Illness in the United States, by Agent and Year

AGENTS	CASES OF FOODBORNE ILLNESS AND YEAR OF REPORT					
	1983	1984	1985	1986	1987	TOTALS
BACTERIAL						
BACILLUS CEREUS	0	23	42	187	9	261
BRUCELLA	29	0	9	0	0	38
CAMPYLOBACTER	162	125	174	227	39	727
CLOSTRIDIUM BOTULINUM	46	16	33	27	18	140
CLOSTRIDIUM PERFRINGENS	353	882	1,016	202	290	2,743
ESCHERICHIA COLI	157	76	370	37	0	640
SALMONELLA	2,427	4,479	19,660	2,833	1,846	31,245
SHIGELLA	1,993	470	241	773	6,494	9,971
STAPHYLOCOCCUS AUREUS	1,257	1,153	421	250	100	3,181
STREPTOCOCCUS GROUP A	535	83	12	248	123	1,001
STREPTOCOCCUS OTHER	16	0	0	69	0	85
VIBRIO CHOLERA	0	0	2	0	0	2
VIBRIO PARAHEMALITICUS	0	0	0	2	9	11
OTHER BACTERIAL	107	0	152	0	0	259
TOTAL	7,082	7,307	22,132	4,855	8,928	50,304
CHEMICAL						
CIGUATOXIN	43	78	106	70	35	332
HEAVY METALS	97	44	13	3	19	176
MSG	0	7	0	0	0	7
MUSHROOMS	23	4	4	16	2	49
SCOMBROTOXIN	27	67	57	60	95	306
SHELLFISH	0	0	3	0	0	3
OTHER CHEMICAL	74	16	209	66	6	371
TOTAL	264	216	392	215	157	1,244
PARASITIC						
TRICHINELLA SPIRALIS	8	60	39	40	15	162
GIARDIA LAMBLIA	0	0	13	28	0	41
TOTAL	8	60	52	68	15	203
VIRAL						
HEPATITIS A	530	29	118	203	187	1,067
NORWALK VIRUS	20	137	179	463	365	1,164
OTHER VIRAL	0	444	114	0	0	558
TOTAL	550	610	411	666	552	2,789
TOTALS FOR ALL AGENTS	7,904	8,193	22,987	5,804	9,652	54,540

Other bacteria that contributed to outbreak totals from 1983 through 1987 were; *Clostridium botulinum, Staphylococcus aureus, Shigella* species, *Campylobacter* species, *Clostridium perfringens*, and *Bacillus cereus*.[7] After *Salmonella*, the second highest number of **cases** can be attributed to the *Shigella* species, followed by *Staphylococcus aureus*, *Clostridium perfringens, Streptococcus group A, Campylobacter*, and *Escherichia coli*.[7]

From 1983 through 1987, the second largest cause of outbreaks were chemical agents, including natural marine toxins. Most of these outbreaks involved a small number of cases. Viral agents accounted for the second largest number of cases of foodborne illness during this time period. From 1973 to 1987, the number of outbreaks due to chemical and viral agents remained consistent.[1] Sampling and testing for viruses is not routinely done at local and state health departments which affects the reporting of these agents. Parasitic agents during the period of 1973 to 1987 declined. A large proportion of the decrease in the number of cases and outbreaks of parasitic agents was due to a decrease in *Trichinella spiralis* detection.[7]

TRANSMISSION

A survey of the literature shows that the transmission of foodborne disease can be classified into two broad categories. In the first type of transmission, which could be termed passive-indirect, the foods involved serve only as a simple vehicle of the agent involved in illness or injury. These agents are typically organisms or chemicals requiring small initial doses to cause damage to the host. Many of the biologic agents involved in this cycle employ several routes of transmission including person-to-person, water, and food. The critical factors involved in passive-indirect transmission are: contamination, survival (or non-elimination of the agent), and ingestion. The second type of transmission, which could be called active-indirect, requires the increase in numbers of a biologic agent, using the environment and nutrients in the food to multiply. In this case the critical factors are; contamination, opportunity for growth, survival, and ingestion. These categories are important because they suggest strategies for prevention.

Examples of the passive-indirect transmission include chemical, viral and some bacterial agents. An outbreak in September of 1983 in Vermont illustrates a case where a chemical was carried in a food to people who ingested it and became ill.[14] Niacin had been added to rice as an enrichment and mixing of this mixture was inadequate. This resulted in portions of the rice that contained 2,636 milligrams (mg) of niacin per pound of rice. The outbreak produced intense flushing and facial heat within ten minutes of eating a beet and rice soup made from the incorrectly mixed rice and niacin.

Other examples of possible chemical agents associated with foods are: pesticide residues in agricultural products or from use of pesticides inside food processing and preparation areas, antibiotic residues in food animals, or man-made environmental contaminants in aquatic and land food animals (such as polychlorinated biphenyls or dioxin). Naturally occurring toxins produced by mushrooms or plants such as the nightshade family are familiar examples of chemicals that "come with" the foods involved and require no additional change during processing or preparation to cause illness. Naturally occurring toxins that accumulate in shellfish and finfish are also examples of passive-indirect transmission.[15]

Many viral agents use foods to travel from one host to another by hitching a ride on the food involved. Since virus particles can only replicate inside of a living cell, the foods involved do not provide for viral multiplication, only a protected environment until entry into a new host is achieved. Viruses that are frequently involved in food-related outbreaks include: Norwalk and *Norwalk*-like viruses, *Hepatitis A, Calicivirus* and *Polio.*[11,16,17] These viral agents are also capable of being transmitted from person-to-person, usually in a fecal-oral route. Food is usually contaminated from an infected person who is shedding the virus particles in fecal material.

In 1982 an outbreak of *Norwalk* viral gastroenteritis occurred at a hotel restaurant. From November 10th until November 16th, 220 of 383 attendees at several banquets experienced diarrhea and vomiting within three days of eating at the banquet. Acute and convalescent serum samples from the patients indicated that the causative agent was *Norwalk* virus. During an investigation of the incident, it was learned that 54 percent of the employees at the hotel kitchen had experienced a similar illness prior to the outbreak. Illness was associated with several fruit and vegetable dishes which were not cooked and which were prepared by the ill employees.[18]

According to the CDC, *Hepatitis A* incidence increased from 1983 through 1989 by 58 percent.[19] These outbreaks included raw oysters contaminated with sewage discharged into a coastal area, and intravenous drug users that contracted the virus and prepared food during their illness. *Hepatitis A* continues to be a national problem. During the Christmas and New Year holiday season of 1992/1993, a large outbreak in the Denver, Colorado area occurred in which over 15,000 people were exposed to *Hepatitis A.*[20] Investigation of this outbreak revealed a symptomatic foodservice worker who prepared several food items used in many catered events over the holiday season. The food items involved were directly handled by the ill food worker and these items received no cooking or no further cooking after being handled by the worker. Transmission of the virus was most probably by feces to food to ingestion.

Some bacteria have developed the capability of producing disease in humans with the introduction of a very small number of cells into the host. Because large numbers of organisms are not needed to cause illness, these bacteria do not need to grow and multiply in foods. They complete their transmission simply by using food and the ingestion of food as a pathway to a host. One important, relatively new pathogen that fits into this category is the 0157:H7 serotype of *Escherichia coli.* This bacterium causes an intestinal ailment that can be quite severe and sometimes involves continued chronic disease. *E. coli* 0157:H7 was first recognized in the United States in 1982 when two outbreaks involving ground beef occurred.[21] The disease associated with this pathogen is characterized by diarrhea, cramps and in some cases, bloody diarrhea. About 4 percent of the cases develop an involvement of the kidneys known as hemolytic uremic syndrome (HUS). This syndrome is manifested in children and consists of anemia, low platelet counts and kidney failure. Death from this infection occurs in about 2 percent of patients.[22] Outbreaks have recently been seen in foods as diverse as apple cider, melons and ground beef.[23] Most frequently, *E. coli* 0157:H7 outbreaks are associated with ground beef and raw milk.

In 1986, an *E. coli* 0157:H7 outbreak occurred in Washington state and was associated with the state-wide distribution of contaminated beef.[24] This beef was ground and used in hamburger patties. The meat was traced to farms where 1 percent of the cattle tested positive for 0157:H7, but the plasmid and toxins differed somewhat from the human isolates. Under-cooking of the hamburger was thought to be a contributing factor.

A nursing home outbreak in 1984 was traced to *Escherichia coli* 0157:H7 that had contaminated ground beef and was served to the residents as hamburgers. Thirty-four of 101 residents became ill with diarrhea and bloody diarrhea. Fourteen were hospitalized and four people died.[21]

A one-year prospective study carried out at a health maintenance organization (HMO) in Washington State screened all stool specimens submitted for culture to the HMO for *E. coli* 0157:H7.[25] This study found that of all the stool specimens screened (6,485) 0.4 percent of them were positive for 0157:H7. Follow-up with food histories revealed associations with the consumption of rare ground beef and raw milk. Other food items were implicated and the researchers concluded that cross contamination may have occurred from raw beef to other food items. There was also evidence of person-to-person transmission.

Seventy percent of the 2,000 attendees at an agricultural show in North Dakota, in July of 1990 became ill with *E. coli* 0157:H7. Sixteen persons were hospitalized and two children were diagnosed with HUS. Roast beef served at the event was implicated in the investigation and the people who were ill were more likely to have eaten their roast beef rare.[26]

During January of 1993, the state of Washington reported that at least 230 culture confirmed cases of *E. coli* 0157:H7 had occurred.[27] Some estimates place the number of persons ill at over 500.(27A) Three deaths are attributed to this outbreak.(27A) Subsequent investigation revealed that the cases occurred at several outlets owned by a fast-food restaurant chain. Meat from the same lot of ground beef had been distributed to several other western states, in which there was an increase in the number of reports of bloody diarrhea.[27]

Because ground beef and raw milk have been implicated in several outbreaks of *E. coli* 0157:H7, it has been suggested that dairy cattle are an important reservoir of this organism.(27A) This microorganism has been isolated from the feces of a small percentage of dairy cattle.(27A)

Another bacterial pathogen that does not require time to grow to large numbers in a food vehicle is *Vibrio cholera* 01. This organism is usually associated with contaminated water but may also contaminate foods such as shellfish and foods washed or processed in contaminated water. *Vibrio cholera* 01 has been responsible for a pandemic covering the last several decades and most recently causing a large number of cases in South America. Since 1973, there have been less than 40 proven cases of cholera reported in the United States. No major outbreaks of this organism have occurred in the United States since 1911.[28]

Shigella flexneri, Shigella sonnei, Shigella disynteriae, and Shigella boydii do not appear to require large numbers of organisms to cause illness (perhaps 10 to 100 cells).[10,29] Although this organism will multiply in foods if conditions are correct, food can serve as a simple vehicle for these bacteria. *Shigella* outbreaks occur from person-to-person, waterborne and foodborne transmission.[10] The food-related outbreaks from these agents have most often been caused by the contamination of foods by infected food handlers.[30] Many different foods have been implicated and are typically contaminated after cooking or are foods that receive no cooking.

During August to October, 1986, a *Shigella* outbreak emerged involving 374 cases and several fast food establishments in Texas.[31] The subsequent investigation implicated lettuce that had been contaminated at a commercial processor by an infected worker.

Agents generally requiring the use of a food vehicle to increase the dose delivery to the host (active-indirect transmission) are all bacteria. Doses seem to vary for these organisms, and is dependent on the serotype involved and the immune status of the host. It is important to note that the age of the individual and general condition of the host's immune system is an important factor in the outcome of exposure to these bacterial pathogens. The very young, the very old and immune-compromised individuals (such as AIDS patients) succumb to much lower counts of pathogens. Pathogens such as *Salmonella* species, *Clostridium* species, *Bacillus cereus, Staphylococcus aureus,* and others require an opportunity for multiplication within the contaminated food product. Outbreaks of this type generally occur because foods have been held, over time, at temperatures that allow these organisms to enter the long phase of their growth. No further cooking of the foods or inadequate cooking temperatures are then needed to allow the large numbers of cells to be ingested by a host. (The emetic toxins produced by *Staphylococcus aureus* and *Bacillus cereus* are heat stable and will survive most common cooking temperatures.) Time/temperature abuse of foods (including improper cooling, improper hot holding, improper cold holding, improper thawing, preparing foods more than twelve hours ahead of service, and combined with improper cooking temperatures) is generally associated with this type of outbreak and causative agent. Time/temperature abuse of foods is the largest single contributing factor for the transmission of food-related illness (see Table 4).[32]

Table 4. Causes of Foodborne Disease Outbreaks in the United States From 1961 Through 1982, by Factors Identified and Percent

Factor Involved In Outbreak*	Percent Of Factors Identified
Time and Temperature abuse	62.3
Infected Food Handler	10.3
Contaminated Raw Ingredients	9.0
Foods From Unsafe Sources	5.7
Chemicals	4.9
Cross-Contamination	3.1
Improper Cleaning	3.1
Other	3.1

*3,376 factors were identified as being involved in causing 1,918 outbreaks (multiple factors were involved in each outbreak).

Different serotypes of *Salmonella* show variations in virulence, with some serotypes apparently capable of producing disease with the entry of only a few organisms.[29] An outbreak in 1979 appeared to involve the transmission of *Salmonella typhimurium* from an infected food handler.[33] The food involved (salad) did not seem to support the growth of the organism, and served only to transport it. Most outbreaks involving *Salmonella*, however, involve situations where the bacteria have had a chance to grow and multiply in foods. Many types of Salmonella are important pathogens for animals and man, causing a great deal of illness each year in the United States. In the CDC reporting period of 1983 through 1987, there were a total of 31,245 cases of Salmonellosis entered into the national statistical base.[7] This organism, like many others, appears to be under-reported. For every case of *Salmonella* that is laboratory confirmed, there may be more than 29 other cases that remain hidden from the official reporting system.[34] *Salmonella* cases and isolates have risen steadily since the inception of the national surveillance network.[34] Outbreaks from this organism were more likely to occur in the warmer summer months and have most often been associated with foods of animal origin. The most common vehicles were beef, turkey, homemade ice cream, and eggs. Studies have shown that *Salmonella* bacteria grow very rapidly, to large numbers, when potentially hazardous foods are improperly cooled.[35] This factor is the single largest cause of foodborne illness, and the factor most often associated with outbreaks involving *Salmonella*.

In recent years, outbreaks from *Salmonella enteritidis* have been concentrated in the Northeastern United States and eventually were reported all across the country. This organism was connected to outbreaks that involved the use of uncooked or minimally cooked eggs. Undercooked scrambled eggs caused an outbreak in Maryland in 1985 that resulted in the hospitalization of 16 persons.[36] In 1991, state health department officials reported to CDC an outbreak involving *Salmonella enteritidis* and a restaurant serving Caesar salad. The origin of this microorganism was traced back to a chicken flock by the USDA, and the flock was destroyed. It is believed that this organism is incorporated into the chicken egg as it is formed and that 0.01 percent of the shell eggs in the United States are contaminated in this manner.[37]

Salmonella outbreaks have frequently been associated with poultry, as was the case with an outbreak in 1991, in Norwalk, Connecticut.[38] *Salmonella heidelberg* was isolated from people complaining of a gastrointestinal illness that eventually tallied 650 cases. Partially cooked chicken was held in large containers under questionable temperature control and then "heated" briefly at an outdoor event and served as chicken fajitas. Improper cooking led to survival of the organism, improper cooling allowed growth and multiplication, and inadequate reheating allowed most of the bacteria to survive a last would-be hurdle.

Vehicles other than foods of animal origin have been shown to support the growth and multiplication of *Salmonella* bacteria.[39] On July 5, 1991, the FDA issued an advisory that melons, once cut, are capable of supporting the growth and multiplication of *Salmonella*. This advisory stemmed from five outbreaks that involved *Salmonella poona* in melons. One of these outbreaks involved 30 states and 25,000 persons. This outbreak occurred from December 1989 to March 1990 and caused at least two deaths. The foods involved were cantaloupes eaten mostly from various salad bars.[39]

Changes in the importance of various serotypes of *Salmonella* have occurred over time in the United States. *Salmonella typhi* was once of great importance in the United States, accounting for much of the morbidity and mortality from *Salmonella*. The incidence of typhoid fever has declined to about 400 cases per year in the United States. Outbreaks involving foods have been associated with shellfish, home prepared foods and some restaurants. As in the past, asymptomatic carriers were an important source of the organism.[40]

Clostridium perfringens is a common cause of foodborne illness when foods have been prepared more than twelve hours ahead of service.[41] An outbreak in November of 1985 illustrates this point. A factory in Connecticut that held an employee banquet ended up dealing with over 100 visits to their company infirmary. The outbreak eventually consisted of 305 cases of gastroenteritis caused by *Clostridium perfringens* that grew in a chicken gravy prepared over 24 hours before the meal. The gravy was held for more than five hours at room temperature and then placed in a walk-in refrigerator in a large container. Improper reheating seemed to contribute to this outbreak, as the people who ate gravy that had been reheated for a longer period of time were less likely to be ill.[41]

Other *Clostridium perfringens* outbreaks have involved preparation ahead of service and improper cooling after cooking. Of several hundred community members who attended a firehouse luncheon in 1984, 112 contracted gastroenteritis.[42] Roast beef that had been prepared up to 48 hours before service and improperly cooled was implicated in the outbreak.

Clostridium botulinum which forms a deadly, heat labile neurotoxin has had a steady decline over the last several decades. Still, this microorganism continues to cause disease in the United States and is always of great concern to public health officials because of its potential for high mortality rates. Botulism has traditionally been associated with home canned and commercially canned foods. Regulation of the canning industry and education of people conducting home canning have substantially reduced this problem.[43] Botulism has shown some surprising shifts to a few new food vehicles and has the potential to produce outbreaks in other emerging food practices. Both onions and garlic prepared with or covered with oil that excludes oxygen from their surfaces, have produced botulism outbreaks.[44] Alaskan natives have experience botulism by switching from traditional preparation of a buried, fermented food to placing these foods in sealed containers.[45]

Some new technologies such as the vacuum packaging of foods show great potential for creating a good environment for new outbreaks of *Clostridium botulinum*.[46] Many small commercial retailers now have access to technology that allows them to package foods in a vacuum or in a modified atmosphere. The economic advantage of reducing the growth of spoilage microorganisms and extending shelf-life of products is causing this trend. These procedures may create an environment devoid of competing spoilage organisms in which the surviving *C. botulinum* spores can germinate and grow inside a package that excludes oxygen.

A microorganism that produces a heat stable, although less destructive toxin than botulinal toxin, is *Staphylococcus aureus*. This emetic toxin causes illness when produced from a large number of vegetative cells. This trait means that the *Staphylococcus* must have the time and temperature conditions to allow for this massive growth. Outbreaks from this toxin usually occur when a proteinaceous food has been cooked and then contaminated by *Staphylococcus aureus*.[10,47] Cooked meats, dairy products, and cream-filled or based pastries have all been associated with outbreaks. A study published in 1993 showed that eleven to thirty percent of cream-filled pastries tested contained cells of enterotoxin producing *Staphylococcus aureus*.

Listeria monocytogenes is an organism that poses some difficult challenges to control because it grows fairly rapidly at traditional refrigeration temperatures (45 degrees fahrenheit).[48,49] This microorganism has forced a re-examination of the temperature range which is considered as temperature abuse of potentially hazardous foods. This organism has been involved in outbreaks associated with foods such as cooked-processed meats, dairy products, and vegetables.[50,51] People with compromised immune systems and pregnant women seem to be particularly vulnerable to this organism.[48,52]

SUMMARY

A review of the literature reveals that foodborne illness can be described as a collection of diseases. These diseases occur when chemicals, toxins or organisms contaminate foods destined for human consumption or when bacteria use these same foods to grow and multiply to large numbers or to produce toxins. Foodborne illness agents are major contributors to morbidity in the United States. Only a small fraction of foodborne illness is actually reported to officials but researchers have estimated that 6.5 million to 81 million cases occur annually.[1] Bacterial agents are the largest contributor to these numbers of illness, with the *Salmonella* species the leading cause of bacterial foodborne disease.[1] Food vehicles for these diseases are most often foods of animal origin, although when foods are a simple carrier of an agent, uncooked vegetables and fruits may be involved.[1,32] The practices or factors that lead to the outbreaks are, in order of importance: time/temperature abuse of potentially hazardous foods (including preparing foods a day or more ahead of service), infected food handlers, contaminated raw products, unsafe sources of foods, foods contaminated with harmful chemicals or natural toxins, and cross-contamination of organisms to cooked or ready to eat foods.[32,53]

Researchers have suggested that the understanding of the epidemiology of foodborne illness and the factors involved in the cycle of disease can lead to useful prevention strategies.[54,55]

Chapter III

METHODS

A search was conducted for foodborne illness complaints to local health departments in the Denver, Colorado metropolitan area, defined as Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson counties. Records for a four-year period from 1986 through 1989 were searched. Reports retained in the evaluation were those in which two or more people were alleged to have become ill, experienced similar symptoms and had a common food exposure. Single reports of botulism and other severe or rare diseases were also included in the evaluation.

Health departments with jurisdiction in the six counties included Tri-County Health Department, Denver Department of Health and Hospitals, Boulder County Health Department, and the Jefferson County Health Department.

Information gathered from each report was recorded on a standard form (Figure 2). Most of the health departments involved did not assign case or form numbers to reports of illness, and the data forms used in this study were numbered sequentially as found physically in the files. A description of program operations was obtained by asking the person responsible for direct oversight of the investigations to list procedures. The program administrators were asked to describe the procedures for: logging incoming complaints, conducting investigations, assignment of investigations, sampling, and follow-up.

THESIS DATA SUMMARY SHEET #____

DATE COLLECTED ________

DEPARTMENT: ____

COUNTY: ____________________ DATE OF INIT REPORT _________

INVESTIG Y N CONTROLS Y N

TYPE OF ESTAB. ____

NUMBER ILL _____ MALE ___ FEMALE ___ HOSPITALIZED _______

DEATHS _____ PHYSICIAN CONTACTED Y N

DATE OF SUSPECT MEAL(S) ______________________________

DATE OF ONSET FOR INITIAL CASE ________________ AVG OS ____

AVG DURATION ____

SYMPTOM 1 ____________________SYMPTOM 2 ____________________

SYMPTOM 3 ____________________SYMPTOM 4.____________________

SYMPTOM 5.____________________

AGENT ________________________ SAMPLES Y N CONF Y N

VEHICLE ______________________ CONF Y N METHOD _________

FACTOR 1 ____

FACTOR 2 ____

FACTOR 3 ____

FACTOR 4 ____

FACTOR 5 ____

Person descriptors, where available, were recorded. Number ill, gender, medical disposition, and physician contact were included. Occupation was almost always unobtainable, and this descriptor was not included on the data summary sheet. Population figures for the United States and for the counties involved in the study were obtained from the U.S. Bureau of the Census.

Time elements such as symptom onset, duration, date of suspect meal and date of report to the health department were taken from initial reports or subsequent investigation findings. The time of year in which the incident was considered to have occurred was the date on which the report was initially made to the health department. This date was usually within one week of the suspect meal, but was more universally available than the date of onset.

Symptoms were recorded as reported to the health department by the complainants. Symptoms were not placed on the data summary in any particular order of occurrence or predominance because this information was not available. All symptoms listed by the complainants are listed as an aggregate in the summary sheet.

Investigation conclusions were placed into the categories of agent, vehicle (food), and factors involved in the disease transmission. Factors were listed in order of importance (for example, primary, secondary, etc.) as reported by the health department investigator. Any information that was not provided on the health department forms, but was prompted for in the data summary sheets, was listed as unknown or left blank.

Data summary sheet information was entered into a personal computer using dBASE III software. Data transformations and analysis were conducted using this same software. Three-hundred forty data summary sheets were entered into the system and were compared to a data print out for data entry error correction.

Because the data obtained consisted largely of "reports" of suspected illness and very few cases were confirmed with laboratory verification, statistical analysis was limited to calculation of the mean, the use of percentages of totals, and some rates.

Chapter IV

RESULTS

There are two primary avenues of report collection for all of the health departments in the Denver metropolitan area. Many reports of possible foodborne illness came from the patients involved. These self-reports usually came to the health departments in the form of a phone call. In all jurisdictions, information from the caller was recorded on a foodborne illness or complaint form. The other route of reporting was through medical channels such as physicians, laboratories or hospitals. In some cases the handling of the medical reports was different from consumer complaints. These medical reporting systems were often set up to handle infectious diseases for which there was some statutory requirement for reporting. This meant that an official or office of the health department separate from the section handling food issues, may have dealt with medical reports. All health departments included in this study, had some split functions of this kind. Program managers had some doubts that all food-related reports of illness reaching the infectious disease office were always reported to the section handling food safety issues. This was thought to be particularly true if an organism isolate was reported to the health department. Because many organisms associated with foodborne disease may also have been transmitted person to person or by other intermediate media such as water, infectious disease offices did not always see the need to communicate these isolate reports to food sections. Most departments did not have any means of providing a central database accessible by all sections of the organization. Tri-County Health Department, however, was working on such a database.

Forms differed for each department with respect to the extent to which they prompt for epidemiologically relevant information from complainants. All health departments involved clerical staff to some extent in the initial collection of information from the complainant.

Initial screening of the report was conducted by supervisory or field personnel. Assignment for investigation of the alleged incident was almost exclusively based on geographic responsibility. The departments studied had a tendency to disregard district lines if the report was of a large number of people. In these cases, the assignment was based on perceived expertise or supervisory status.

Investigations varied widely between jurisdictions and within certain health departments. Tri-County Health Department was the only health department that followed what could be called an administrative policy regarding the nature of an investigation. Even within this organization, a variety of investigational styles and techniques were used. The scope of most investigations was dependent on the decisions of individual sanitarians. Some reports appeared in the records to not have been acted upon at all, and others were subjected to full investigation including: interviews, sampling, on-site inspection and follow-up. A report was considered to be investigated if any action, even if limited to telephone contact of the complainant or food establishment, was carried out.

Sampling of foods, collection of descriptors for person, place and time and other epidemiological data were often missing from the written investigations. Most investigations were hand written and reading some of them was difficult or, at times, not possible.

Reporting of information to the State Health Department, was informal. All health department personnel interviewed stated that complaints were forwarded to the State Health Department if the incidents involved large numbers of people or "looked real."

Out of 410 reports located, 340 reports of illness were retained for this study. Of the reports included in this study, a total of 121 were from the Tri-County Health Department files, 94 were from the Jefferson County Health

Department, 75 were from the Denver Department of Health and Hospitals, and 50 were found in the Boulder County Health Departments records. Investigations, which ranged from simple one-time telephone contacts to complete epidemiological investigations, occurred in 318 of the complaints.

The population at risk for foodborne disease from any source, was the entire population of each county. Table 5 shows the county, the 1988 estimated population, number of reports, the mean number of complaints over the four-year period, and the rate of reported incidents per 100,000 population. Due to the small numbers of reports for some counties during some years, the four-year mean of individual county reports was used in Table 5. The four-year report mean was compared to the county populations for 1988 which was the nearest census estimate to the mid-point of the study time frame. Dates and/or county of origin was not obtainable for 25 of the 340 records.

Table 5. Rates of Reports of Foodborne Illness Per 100,000 Population, by County, for the Denver Metropolitan Area, 1986-1989

COUNTY	1988 POPULATION	TOTAL REPORTS 1986 - 1989	AVERAGE YEARLY # OF REPORTS	RATE/ 100,000
ADAMS	281,000	32	8.0	2.85
ARAPAHOE	391,200	82	20.5	5.24
BOULDER	217,900	50	12.0	5.51
DENVER	492,200	76	19.0	3.86
DOUGLAS	45,400	0	0.0	0.00
JEFFERSON	430,200	77	19.3	4.48
UNKNOWN COUNTY		25		
TOTALS	1,857,900	340	85	4.58

People who eat foods prepared outside the home was another measure of the population at risk. A large number of reports (98.9 percent) were from meals eaten at locations other than the home. Since this population is unknown, the approximated risk, seen in Table 6, was calculated using the rate of reports per 100 licensed food establishments in each county. The only accurate licensing figures available for the metropolitan area were for 1990. The change in total number of establishments over the period of the study is unknown.

Table 6. Rates of Foodborne Illness **Reports** Per 100 Licensed Food Establishments in the Denver Metropolitan Area 1986-1989

HEALTH DEPARTMENT	COUNTY	NO. OF REPORTS	NO. OF LICENSES	PER 100 LICENSES
TRI-COUNTY	ADAMS	31	808	3.8
TRI-COUNTY	ARAPAHOE	82	1,203	6.8
TRI-COUNTY	DOUGLAS	0	160	0.0
DENVER	DENVER	76	1,186	6.4
BOULDER	BOULDER	50	863	5.8
JEFFERSON	JEFFERSON	94	1,136	8.3
	UNKNOWN	7		
TOTALS		340	5,356	6.4

From the 340 records it was determined that at least 1,648 people were involved in the alleged food-related illness incidents reported to Denver area health departments. Cases of illness by county and the rates per 100 food service licenses are shown in Table 7.

Table. 7 Rates Per 100 Licensed Food Establishments of Reported **Cases** of Foodborne Illness in the Denver Metropolitan Area 1986-1989

DEPARTMENT	COUNTY	CASES	LICENSES	CASES/100 LICENSES
TRI-COUNTY	ADAMS	104	808	12.9
TRI-COUNTY	ARAPAHOE	468	1,203	38.9
TRI-COUNTY	DOUGLAS	0	160	0.0
DENVER	DENVER	481	1,186	40.6
BOULDER	BOULDER	161	863	18.7
JEFFERSON	JEFFERSON	409	1,136	36.0
	UNKNOWN	25		
TOTALS		1,648	5,356	30.8

Some person-characteristics were obtained from the records. Of the records identified, 315 of those complaining of illness were males and 382 were females. Nine-hundred fifty-one of the total 1,648 possible cases of foodborne disease were not identified in the investigations with respect to gender. Hospitalizations did occur and 38 people were identified as hospitalized as a result of their illness. One death was recorded. Ninety-seven people contacted a physician or hospital emergency room.

The place of the suspect meal was reported in all but four incidents. Of the 336 incidents for which data were available, 296 were from people who ate the suspect meal at a restaurant. Table 8 shows the number and percent of reports by location of suspect meal.

Table 8. Number and Percent of Illness Reports by Alleged Location of Exposure

PLACE	REPORTS	PERCENT
RESTAURANT	296	87.1
HOME	17	5.0
PROCESSOR	13	3.8
INSTITUTION	6	1.8
OUTDOOR	4	1.2
UNKNOWN	4	1.2
TOTALS	340	

Illness reports to health departments were not evenly distributed throughout the year (Figure 3 and Table 9). Over the four-year period studied, the highest number of reports occurred in the months of June and July. The lowest number of reports came to health departments in February. The number of reports increased over the four-year period with 52 in 1986 and 112 in 1989, (Figure 4).

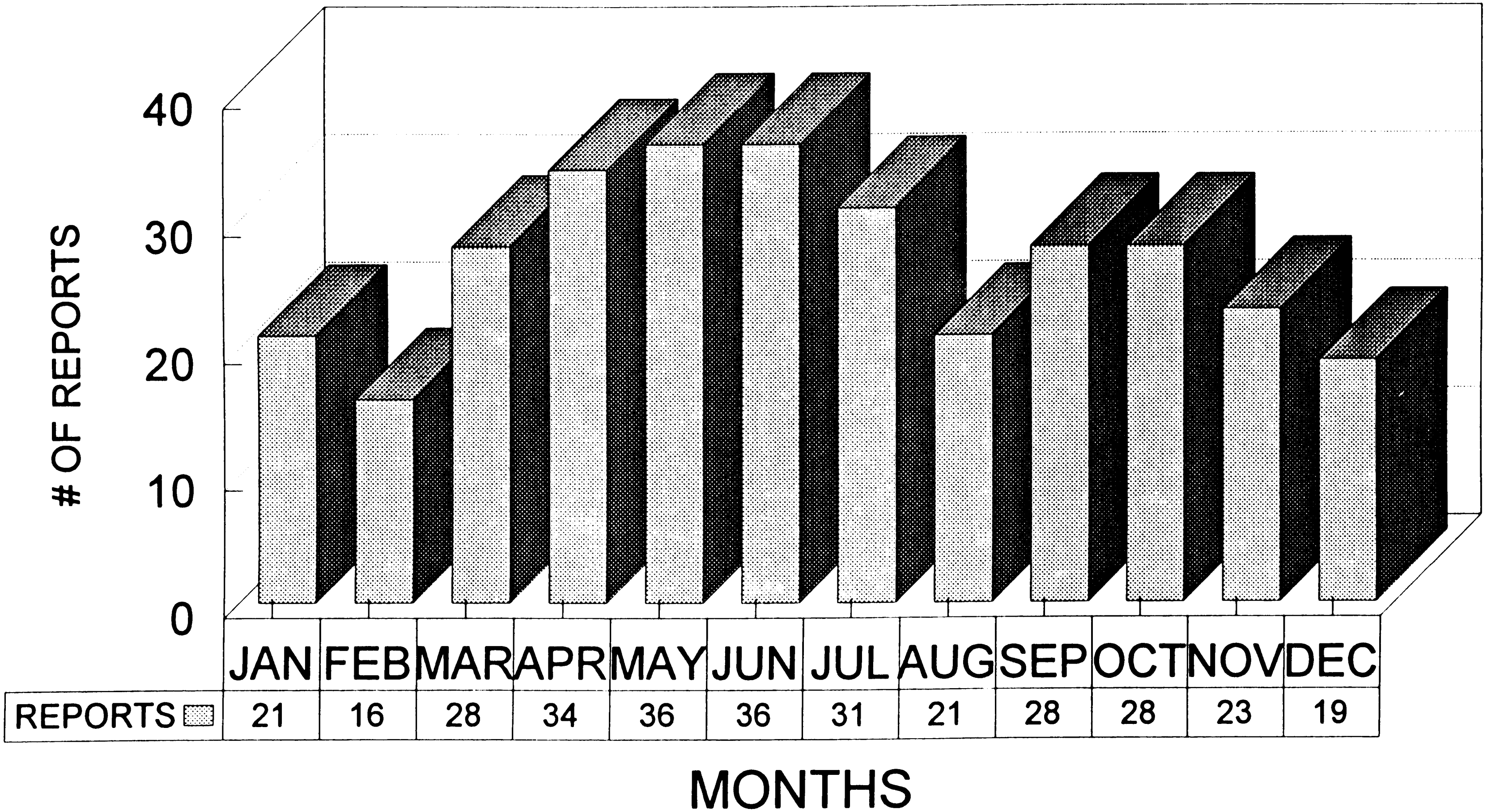

Figure 3 Reports of suspected foodborne illness to health departments in the Denver Metropolitan Area 1986 - 1989, by month.

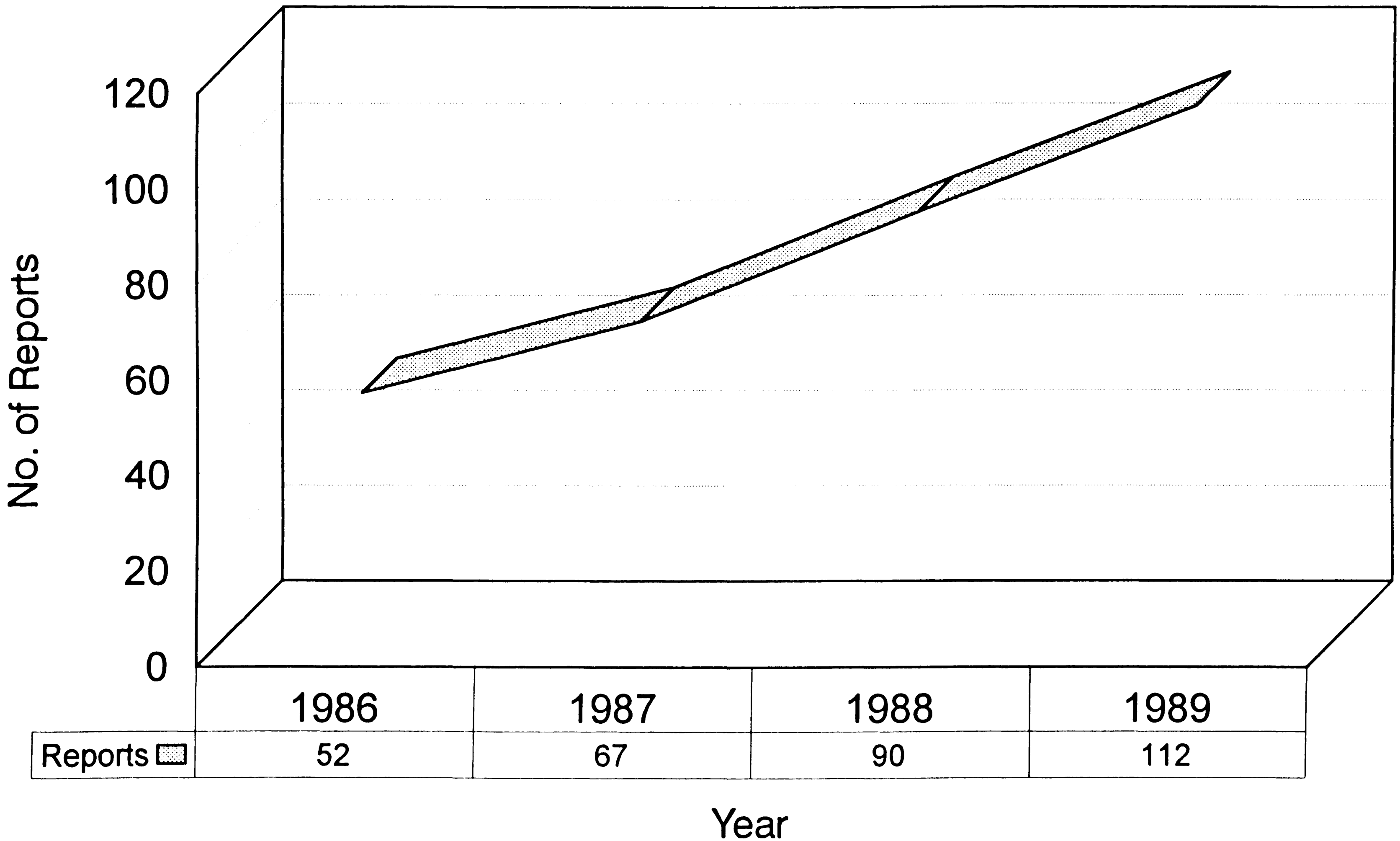

Figure 4. Reports of suspected foodborne illness to health departments in the Denver Metropolitan Area 1986 - 1989, by month.

Table 9. Number of Foodborne Illness Reports Meeting Study Criteria, Received by the Denver Metropolitan Area Health Departments 1986-1989

	1986	1987	1988	1989	TOTAL
JANUARY	3	6	4	8	21
FEBRUARY	3	1	9	3	16
MARCH	4	10	7	7	28
APRIL	6	8	9	11	34
MAY	9	9	9	9	36
JUNE	2	12	11	11	36
JULY	3	3	13	12	31
AUGUST	3	2	8	8	21
SEPTEMBER	4	6	8	10	28
OCTOBER	9	4	5	10	28
NOVEMBER	3	4	3	13	23
DECEMBER	3	2	4	10	19
UNKNOWN					19
TOTALS	52	67	90	112	340

The average onset for all illness was 8.2 hours, and the duration averaged 10.5 hours. The average time that elapsed between date of onset and the date on which the report was made to the health departments was 2.3 days.

Laboratory samples were collected from individuals in only 36 of the 318 investigations. Twenty of these samples were positive for agents associated with foodborne disease. In an additional 48 investigations, the investigator listed an agent as suspected, based on information collected about symptoms, vehicle, onset, duration, or other epidemiologic evidence. Bacterial agents were the most common causes cited for illness, accounting for 53 (73.6 percent) of the 72 suspected or confirmed agent identifications. Table 10 lists the 72 incidents by agent that were confirmed or suspected. In 268 of the 340 reports, (78.8 percent) the agent was not identified.

Table 10. Number Of Reports of Foodborne Illness in the Denver Metropolitan Area in the Years 1986-1989 for Which the Cause Was Suspected or Confirmed--Listed by Agent

AGENT	NUMBER OF REPORTS	
	SUSPECTED	CONFIRMED
BACTERIAL	34	19
VIRAL	9	1
CHEMICAL	8	0
FOREIGN OBJECT	1	0
UNKNOWN	268	
TOTAL	340	

Bacterial agents that were confirmed by laboratory evidence or that were suspected (epidemiologic evidence) of causing outbreaks were:

1. *Salmonella species* = 9 confirmed /8 suspected
2. *Staphylococcus aureus* = 1 confirmed /15 suspected
3. *Campylobacter jejuni* = 5 confirmed /2 suspected
4. *Clostridium perfringens* = 2 confirmed /2 suspected
5. *Bacillus cereus* & Scombroid = 0 confirmed /3 suspected
6. *Shigella sonei* = 1 confirmed /1 suspected
7. *E. coli* 0157:H7 = 1 confirmed /0 suspected

Viral agents included: hepatitis A (1 case); Norwalk-like agents (5 cases); unspecified viral (4 cases). Chemical agents were mostly unspecified, with only 6 reports. Additional chemical agents consisted of one case of heavy metal poisoning and one reported monosodium glutamate reaction.

Foods that may have been vehicles of illness are listed in Table 9. Controls (people not ill who ate the same meal) were obtained for only 27 of the incident reports. Food sampling was rare, reportedly because local health departments receive little assistance from the state health department laboratory. In interviews with the state health department, it was stated that funding for the laboratory is not adequate for the analysis of samples from all possible outbreaks. The laboratory tries to require that the available evidence include several people who are complaining of similar symptoms and food histories implicate a particular food. Four of the investigations produced a confirmation for the vehicle involved in disease transmission. In 188 of the 318 investigations (58.9 percent), the investigator was unable to suspect or confirm a specific food vehicle. A specific food or foods were implicated in 153 of the 318 investigations. Of the known or suspected foods, products of animal origin such as beef and poultry made up the largest percentage of the vehicles. Milk and bakery goods were not cited as suspected or confirmed vehicles during the four-year study period.

Table 11. Foods Suspected or Confirmed as the Vehicles of Foodborne Illness in the Denver Metropolitan Area From 1986-1989

FOOD	REPORTS		FOOD	REPORTS	
	S	C		S	C
POULTRY	30	9	PORK	5	1
BEEF	20	3	FISH	6	0
SOUPS & STEWS	19	2	EGGS	2	1
MIXED FOODS	12	2	SHELLFISH	2	0
OTHER DAIRY	13	0	OTHER	2	0
VEG. & FRUITS	9	0	MILK	0	0
RICE	7	0	BAKERY GOODS	0	0
MIXED SALADS	7	0	UNKNOWN	186	2

S = Suspected C = Confirmed

Factors that were identified during the investigation as suspected or confirmed as leading to the reported incidents are listed in Table 12.

Table 12 Factors Suspected or Confirmed as Contributory to Foodborne Illness in the Denver Metropolitan Area, 1986-1989. Reports Listed as Number and Percent by Factors Identified

FACTOR	REPORTS	PERCENT
TEMPERATURE ABUSE	51	70
HOLDING OUT OF RANGE	14	
UNSPECIFIED	14	
IMPROPER COOLING	12	
IMPROPER COOKING	6	
POOR RE-HEATING	2	
EQUIPMENT FAILURE	2	
IMPROPER THAWING	1	
PERSONAL HYGIENE	12	16
CROSS CONTAMINATION	9	12
INFECTED FOOD HANDLER	4	5
NO SANITIZING	2	3
EQUIPMENT CLEAN	2	3
RAW FOODS	1	1
PHYSICAL CONTAMINATION	1	1
COOKED AHEAD	1	1
OTHER	2	3
TOTALS	73	

Investigators found operating practices in 73 of the reported incidents that could be linked to the reported illness. Temperature abuse was by far the leading factor and was involved in 51 of the 73 incidents (69.9 percent). This was followed by breaks in personal hygiene and by cross contamination. Together, these three causes were involved in almost all, 72 out of 73, of the incidents. The items listed as factors in Table 8 account for greater than 100 percent of the identified causes due to the fact that some reports involved multiple factors identified by the investigator.

Chapter V

DISCUSSION

The health departments included in this study all maintained some system for investigating complaints of alleged foodborne illness. All procedures were highly informal and varied between jurisdictions, and none of the departments conducted active surveillance for possible food-related illness in their respective communities. These informal systems resulted in the collection of data which was severely limited in epidemiologic value. The records of illness were, for the most part, self-reported and poorly documented. It is clear from comments made by the complainants during investigations, that several factors influenced whether or not an illness was reported to the health department. The severity of illness and the decision to seek medical care seem to play a large role.

A lack of scientific method in the investigation of reported illnesses made the determination of etiology difficult and subjective. Verification of the agent, vehicles and factors involved (agent and route) was uncommon. Most investigations substituted investigator opinion for the laboratory evidence of a biological or physical agent in food and person samples. If a complainant had seen a physician there was a much greater chance of verifying the agent involved. In fact, in all but one of the outbreaks in which the agent was verified (95 percent), the complainant(s) had contacted a physician during their illness. Comments in the written records and from interviews with program directors indicated that there was virtually no laboratory support at the local or state level for the collection and analysis of samples. A lack of personnel trained in the collection of epidemiological data inhibited the much needed recording of descriptors for person, place and time. There was ample evidence in the investigative record of sanitarians phoning an establishment after a complaint to ask if there were any other complaints. All departments complained of staff shortages versus the number of licensed establishments that they are asked to regulate. Sanitarians frequently were required to maintain case loads of 250 or more establishments each. State regulations and departmental policies on the frequency of inspection and follow-up, it was said, keep the individual sanitarian from having the time to contact the complainant for additional information of others who might be ill, of food that might be left from the meal, or to collect any type of samples for analysis. Food histories were frequently not obtained. This lack of immediate follow-up contributed to the large number of unknowns in the database. Routine inspectional backlog seems to take priority from conducting full investigations of possible outbreaks.

Limitations on the way in which data was collected translated into a limited description of alleged foodborne illness in the Denver Metropolitan Area. Information available about agent, vehicle and practices was garnered from the few reports for which complete information was available. A wider, more complete database, might cause important shifts in trends and conclusions. For example, since most of the verified outbreaks involved patient contact with a physician, the outbreaks for which much is known may involve foodborne disease which was more severe, longer lasting or otherwise caused complainants to seek medical care. This would mean that milder, shorter duration diseases could be under-represented in the data. Some information can, however, be compared to national statistics and cautious conclusions may be drawn.

The CDC maintains a national database of foodborne illness. Summaries of this information are periodically released. The latest summary is for a period of time similar to the period of this study. In its five-year summary of foodborne disease outbreaks for the years 1983 through 1987, the CDC acknowledged the limitations of locally-derived surveillance data. The report cautioned that firm conclusions about foodborne disease could not be made because data varied in both quality and completeness. The authors described limitations of resources, training and consistency which was similar to those encountered in this collection of data in the Denver area.

The CDC report stated that in 1987 (the only year in the report that coincides with this study), there were 427 outbreaks. Table 13 shows one possible comparison of this national rate of reported foodborne illness to the rate of reports in the Denver area during the same time period.

Table 13. The Average Rates of Foodborne Illness Reports During 1986 and 1987 Per 100,000 Population for the United States and the Denver Metropolitan Area

AREA	POPULATION 1987	REPORTS AVG/YR	RATE /100,000
UNITED STATES	242,289,000	427	0.18
METROPOLITAN DENVER	1,856,300	67	3.61

While these rates seem to indicate a much larger number of illnesses associated with food in the Denver area, the large differences can be explained by the data collection system. The reports to the CDC are the result of local and then state self-selection of which records to report to CDC. Local health departments in the Denver area reported that they sent information to the state only when the report seemed significant. Which reports met the test of "significant" was a subjective judgement of the local jurisdiction. Thus not all of the reports were passed on to the state health department. The state health department performed its selection of reports to be passed on to the federal government in a similar fashion. This can be illustrated by looking at reports for specific years. In 1986, for example, the state of Colorado reported no cases of foodborne illness to the CDC. Colorado also reported that no cases occurred in 1987. By contrast to these reports, the records of local officials contained information on 52 possible outbreaks in 1986 and 67 reports in 1987. Some of these reports contained confirmatory information such as laboratory identification of specific organisms and fairly complete epidemiological data. *Salmonella enteritidis* and *Clostridium perfringens* are two examples of laboratory confirmed agents identified by local departments during 1987. These subjective decisions of what to report at each jurisdictional level to each level above, would appear to give an under-reported effect to the national rates of foodborne illness. In fact, the CDC report theorizes that these problems exist and that, the number of outbreaks of foodborne disease reported by this surveillance system clearly represents only a small fraction of the outbreaks that occur. The results of this investigation support that conclusion.

National statistics show a 23 percent decline in reported incidents of food-related illness between 1983 and 1987. Researchers with CDC believe that there is evidence that this drop is a reporting change rather than a true decline in incidence. The Denver data was from a different time period, but indicated a dramatic 115 percent increase from 1986 to 1989. These numbers were subject to variations in public awareness of what and where to report, as well as individual health department activity levels. Since information was not available on these variables, it was difficult to assess the true reasons for this increase.

Of the agents suspected or confirmed, 73.6 percent of the illness was caused by bacteria. This is similar to the proportion cited in national statistics (66 percent). In both databases the leading agents of illness were bacteria. Table 14 shows a comparison between the two data sets.

Table 14. Percent of Foodborne Illness Outbreaks by Agent for the United States and the Denver Metropolitan Area

AGENT	PERCENT OF OUTBREAKS NATIONAL	PERCENT OF OUTBREAKS DENVER AREA
BACTERIAL	66	73.6
CHEMICAL	26	11
VIRAL	5	13.8
PARASITIC	4	0

These figures are for the reports in which an investigation identified agents as suspected or confirmed in causing the outbreak.

The vast majority of reports were never identified as to agent. This inability to positively identify the agent is a problem nationally (60 percent of the reports) and in the Denver area (78.8 percent of the reports). The relatively high percentage of viral agent reports for the Denver area may be due to reporting practice. From the investigation records it was clear that, in the Denver area, a case was classified as viral if the symptoms matched a viral disease and no bacterial agent was cultured or no samples were obtained.

This informal, local classification scheme could easily lead to misclassification as a viral agent when other agents may have been responsible. It was not possible to tell from interviews or from the records why this classification practice has developed.

The large number of unknown etiologies created great difficulty when trying to draw conclusions or to direct intervention strategies. The CDC believes that this lack of identification may be due to inadequate training in investigational techniques which leads to poor discovery of agents. Local data sets indicated that this is most likely a contributory factor, but suggest other causes as well. Denver area records indicated that local jurisdictions did not have routine access to laboratory resources and that the state health department was relatively unable to assist in routine analysis of this kind. Statements or notes were made on investigation forms that the State Health Department had been contacted but was "uninterested" in or "unwilling" to analyze samples from a local investigation. This type of information suggests that increased training of local personnel may not in and of itself lead to better identification of the agents involved in foodborne outbreaks. Additional resource questions, such as sanitarian work loads and laboratory funding, may need to be addressed.

Of the bacterial agents identified, the national figures indicated that *Salmonella spp.* contribute to the most incidents of foodborne illness. Over the five-year period of the latest CDC report (1983-1987) *Salmonella spp.* accounted for 57 percent of the bacterial related outbreaks. In a study by Bean and Griffin covering 1973 through 1987, *Salmonella spp.* were identified as responsible for 42 percent of the outbreaks involving bacterial agents. In the Denver area between 1984 and 1989, *Salmonella spp.* were identified as the agent in 32 percent of the outbreaks. *Salmonella enteritidis* is a microorganism which has increased in incidence dramatically in the late 1980s. In recent years it has been hypothesized that this organism enters chicken eggs by transovarian transmission. This organism has had its highest number of outbreaks in the Northeastern United States and the United Kingdom. The Denver area records did not contain any cases reported to health departments from 1984 through 1989.

In this study, Salmonella species were closely followed by *Staphylococcus aureus* as main contributors to foodborne illness (30 percent of bacterial outbreaks). In fact, in the Denver area, *Salmonella spp.* and *Staphylococcus aureus* appeared to be of almost equal concern as agents of foodborne illness. This was in contrast to the most recent CDC information which showed *Staphylococcus aureus* occurring at under 5 percent of the bacterial outbreaks from 1983 through

1987. Statistics showed, however, that during the early to middle 1970s, *Staphylococcus aureus* was responsible for around 32 percent of the bacterial outbreaks.[3] This is a figure much like the Denver area information for 1984 through 1989. Bean and Griffin reported that of the outbreaks of unknown etiology, the highest proportion had short (one hour to seven hour) incubation periods.[3] This is consistent with the incubation periods of the toxins produced by *Staphylococcus aureus* and *Bacillus cereus*. In the Denver area, the average incubation period of the outbreaks of unknown etiology was 8.2 hours and the duration averaged 10.5 hours. Sixty percent of the outbreaks of unknown etiology had a reported incubation time of seven hours or less. This figure was consistent, with the national statistics. In both cases the high percentage of unknown agents with short incubation periods may have been due to the difficulty of investigating a disease which has a rapid onset followed by a rapid recovery. Outbreaks are often over long before the health department receives any reports of illness. Denver, may have a *Staphylococcus aureus* problem which approximates that of the country a decade ago. Other factors should be considered in drawing conclusions about the rate of *Staphylococcus aureus* intoxication in the Denver area. Denver health departments reported that only 11 percent of their foodborne illness was due to chemical agents, while the CDC states that, nationally, chemical contamination accounts for 22 to 28 percent of known outbreak agents. Denver health departments, with their lack of access to laboratory testing, may be misclassifying chemical agents as *Staphylococcus aureus* intoxications. Both agents usually exhibit rapid onset and rapid recovery.

Information across the country indicated that food prepared in a commercial or institutional setting accounted for 79 percent of outbreaks. In Denver, this same source was responsible for a larger percentage (89 percent) of the outbreaks. Information from health departments indicated that consumers in the Denver area may be less aware of where to report illness than people across the nation as a whole. When questioned about public awareness activities, no health departments in the Denver area had any substantive activity ongoing for informing the public about foodborne disease. It is unknown if other health departments across the country conduct public awareness activities.

In the CDC information for 1983 through 1987, fish was implicated as the vehicle of foodborne illness 21 percent of the time. This is in sharp contrast to the data collected for the Denver area where fish was implicated in only about four percent of the outbreaks in which a vehicle was identified. The difference in the amount and frequency of fish consumption in the Denver area versus the nation as a whole is unknown. Variations in eating habits may have something to do with this deviation from national statistics. Beef and poultry top the list as agents of illness in the Denver area and in Canadian statistics. United States foodborne illness information is driven to a large extent by what occurs on the East and West coasts. CDC states in its latest summary that a large proportion of the outbreaks were reported from New York, California, Hawaii, and Washington because of their active reporting systems. Eating habits in the Denver area could more closely resemble Canadian habits than the two coastal areas of the United States. The large number of outbreaks in which no specific food vehicle could be implicated (55 percent) made it difficult to draw conclusions about relative risk of certain types of foods. The scarcity of laboratory support and the slow response of the public to report illnesses (an average of 2.3 days after onset), contributed to the lack of identification of a specific food vehicle.

Of all of the data collected for the Denver area, the operational factors identified as leading to the reported incidents most closely parallel national findings. There were seven factors (improper cooling of foods, holding foods at improper temperatures, improper cooking temperatures, poor re-heating, equipment failure, and unspecified temperature abuse) cited by investigators that can be combined in a related grouping, having to do with temperature abuse of foods. This broad category of temperature abuse of potentially hazardous foods was suspected or confirmed as responsible for just over half of all of the reported outbreaks. Temperature abuse of foods has long been reported in the national literature as the number one factor in outbreaks.[3,4,26] The predominance of bacterial agents of foodborne illness would seem to be linked to temperature abuse of foods as a factor in outbreaks. Unlike the parasitic or viral agents, most bacterial agents must multiply to relatively large numbers in food before illness results. This time and temperature requirement has been recognized as a tool for the prevention of many foodborne diseases.[25] Because of the importance of this time-temperature relationship, the federal model food code and corresponding state and local versions, require that potentially hazardous foods be cooked and stored within certain, specified temperature parameters.

As a food is prepared, there are several steps that can allow for bacterial survival and multiplication if preparation is not carried out correctly: cooking, cooling, hot holding, re-heating, and others. These critical steps are reflected in the factors identified during investigations of illness in the Denver area.

Cooking, for example, must occur at temperatures which will destroy vegetative cells. Improper cooking was identified in six of the outbreaks as a contributing factor. These cases were frequently due to *Salmonella* species or other organisms normally found in the intestinal tracts of food animals. Cooking temperatures of 140^{0}F for even short periods of time will kill large numbers of vegetative cells. In pork products, an internal cooking temperature of 150^{0}F is required because of the problems traditionally associated with trichinosis. National statistics have shown a steady decline in trichinosis due to production techniques and the common acceptance of the need for the proper cooking temperature. No cases of trichinosis were reported to the Denver area health departments during this time period. Poultry products have been identified as frequently contaminated with *Salmonella, Campylobactor* and other pathogenic organisms which have been found inside of carcass tissues because of processing techniques. Therefore, in poultry, an internal cooking temperature of 160^{0}F is needed to destroy these organisms. Several outbreaks of Salmonellosis were identified in the Denver area. Some of these were due to the failure of the establishment to cook the poultry to a satisfactory kill temperature. One elderly woman died from Salmonellosis after eating improperly cooked chicken.

Although proper cooking kills the vegetative cells of both pathogens and spoilage microorganisms, if foods become re-contaminated with pathogens or spores are allowed to germinate, illness may result. Thus the rapid cooling of foods after cooking is an important way to prevent illness. In the Denver area, 12 outbreaks of foodborne illness were traced to improper cooling of foods. National figures have identified this factor as the number one preparation error leading to foodborne disease.

Holding foods at temperatures which allow bacterial multiplication was responsible for 14 of the outbreaks. It was reported in the investigations that holding foods at room temperature was a common finding. Even though the food was thought to have been held at room temperature for extended periods of time, operators stated to investigators that foods were in some stage of preparation, cooling or reheating. When questioned about times and temperatures, it was discovered that the food had been held for periods of several hours at room temperature awaiting further preparation.

A lack of personal hygiene precautions was the factor involved in 12 of the outbreaks in which a cause was determined. Employees were not practicing effective hand washing between working with raw meats and working with cooked foods. A lack of hand washing after using the rest room was another finding. Next to temperature abuse, this was the second most common factor in outbreaks. This finding was important in the possible transmission of viral agents such as Hepatitis A and Norwalk-like agents.

Chapter VI

CONCLUSIONS

These investigative findings indicated that, not unlike national trends, bacterial diseases lead the list as causes of foodborne outbreaks in the Denver area because of the procedures followed in food service establishments. Clearly, the leading cause of foodborne illness in the Denver area was the failure of food preparers to keep foods out of bacterial incubation temperatures. Findings also indicated that food-service employees may be conveyances for microorganisms from raw products or themselves to cooked foods. Ninety-eight percent of the outbreaks in which an operational factor was identified, were due to one of three practices: temperature abuse of foods, poor personal hygiene, and/or cross contamination. Concentrating surveillance and intervention on these three factors should prove quite effective at reducing the incidence of foodborne illness.

Health departments in the Denver Metropolitan area have a need to actively search for and analyze the trends in foodborne illness in order to target prevention strategies. From 1986 through 1989, the files of the local health departments in the Denver Metropolitan Area contain only 20 documented cases of the transmission of disease involving foods. This documentation is not sufficient to justify regulatory activities or to target prevention. In fact, the level of documentation found at the time of this study does not allow for the conclusion that foodborne illness is a demonstrable problem in the Denver area. The assistance of the public, academic, and medical community should be sought in an attempt to increase the percentage of complaints that can be properly investigated. The possible effectiveness of this kind of outreach is indicated by the large ratio of successfully identified agents when physicians were involved in the case. Rapid reporting by hospitals and physicians could serve to bring useful information to these health departments. The information obtained from this investigation leads to several suggestions for systematic changes and further study.

1. Establish a metropolitan foodborne illness surveillance team on a two-year project aimed at determining the true incidence of foodborne illness in the Denver area. This would allow for decisions about future surveillance and prevention activities to be based on solid information about the nature of the problem. Provide adequate staffing levels to allow for the complete investigation of outbreak complaints. Provide adequate epidemiologic investigative training to two people from each health department (one to serve on the team and one for back-up). Each team member would be responsible for investigating outbreaks in his or her jurisdiction and

for assisting with area-wide investigations. The state health department should assign an epidemiologist to be the coordinator for this team. This team could be funded by the Denver Regional Council of Governments and could be part of a larger study of the structure and function of the metropolitan area health departments. Students and professors in the area universities might be a source of possible support for the design and data collection during this project.

2. Provide for laboratory assistance in the analyzing of samples from foodborne illness investigations. The Food and Drug Administration district laboratory at the Denver Federal Center could be a possible partner in this endeavor. The Food and Drug Administration could be approached to provide some regional (393-research grant) money for this purpose. This testing may be too slow to provide for the intervention in outbreaks but could provide valuable information to target prevention strategies.

3. Provide for an area-wide database of outbreaks and investigation results. A computerized database will assist in the coordination of investigations and will provide local program managers with vital statistical data for program management.

4. Provide for an ongoing inventory of foodborne illness risk factors in the Denver area. This could be accomplished by setting up formal ties with the University of Colorado, Colorado State University and the University of Denver. The University of Denver, Colorado State University, and the Auraria Community College have Restaurant Management programs which could also provide valuable assistance. Ongoing research should be conducted with funds set aside from the combined efforts of the state health department and the counties of Boulder, Adams, Arapahoe, Denver, Douglas and Jefferson. A complete survey of the known risks using Hazard Analysis and Critical Control Point (HACCP) techniques could be a place to start. All establishments should be surveyed to identify the prevalence of temperature abuse, personal hygiene problems and cross contamination.

5. Initiate research in the following areas:
   A. Determine the prevalence of foodborne pathogens in stool samples analyzed at area hospital and private laboratories. This study could be done with the assistance of the University of Colorado Medical School and Hospital, located in Denver.

B. A retrospective study of local physicians and their records of diagnosis of suspected and confirmed food-related ailments.

C. A prospective study of food service employees to determine if they are a possible reservoir of such diseases as Hepatitis A, Norwalk virus and Shigella. The Education Foundation of the National Restaurant Association is a possible source for the funding of this type of research.

D. Testing of HACCP based inspectional techniques, with measurement of the behavioral changes that result in the decrease of behaviors that most often lead to outbreaks. Encourage the use of HACCP in internal HACCP systems by industry and the monitoring of these systems by regulators in the area. Regulators could use the hazard analysis and critical control point concepts to better identify hazards during routine inspections and thus better inventory risk practices for possible intervention.

E. Conduct a survey of area residents that inventories the prevalence of practices in the preparation of foods at home that are risk factors for foodborne illness. Work with organizations such as the USDA extension service and the United Neighborhood Citizen Groups to fund and conduct the survey. These organizations could also assist in the distribution of teaching materials or other public information, once prevention strategies (if any) are identified. Area grocery store chains and the Food Marketing Institute are also potential partners.

F. The state health department and area universities should meet to determine if sampling of various finished food products in grocery stores and restaurants would assist in determining the level of public risk.

Chapter VII

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