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Evaluation of the Effectiveness of a Newly Implemented, Proactive Approach to Legionellosis Investigations Conducted by the Southern Nevada Health District

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EVALUATION OF THE EFFECTIVENESS OF A NEWLY IMPLEMENTED, PROACTIVE
APPROACH TO LEGIONELLOSIS INVESTIGATIONS CONDUCTED BY THE SOUTHERN
NEVADA HEALTH DISTRICT

By

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Bachelor's of Science in Public Health Education
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A thesis submitted in partial fulfillment
of the requirements for the

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ABSTRACT

This project is an evaluation of a new, more proactive approach to legionellosis investigations conducted by the Southern Nevada Health District. The new protocol was conceived, written and adopted in April of 2012 with the goal of preventing outbreaks of Legionnaires' disease that can have a significant impact on public health and the resort industry of Las Vegas. The objectives of this project were to determine if the remediation methods were successful at eliminating the target organism from water systems and maintaining a negative status throughout the monitoring period, to conduct a cost/benefit analysis, and to compare this protocol with other proactive health department protocols.

Ninety percent of facilities found to be sources were able to obtain and maintain a negative target organism status throughout the monitoring period, indicating that the remediation methods are effective. There was no significant difference between the remediation methods (hot water flush, chlorine flush or both) in obtaining and maintaining negative results for *Legionella*. This evaluation also found that average yearly costs for SNHD increased from about \$5,611 a year on legionellosis investigations to about \$82,675. An estimate of the cost to all facilities investigated since implementation is \$1,466,000 with an approximate total cost to SNHD and facilities of \$1,590,013. This is a minor investment when compared with the significant healthcare costs of legionellosis illness and outbreaks in the U.S., which total \$101-321 million per year. In addition, litigation awards can cost facilities hundreds of millions of dollars. No

other health departments were identified that conduct this type of proactive investigation, and often only initiate an environmental investigation after a second case is found with an association to the same facility as a previous case. Often, by then it is too late to prevent outbreaks and additional illnesses associated with that facility. This evaluation shows that the new protocol is potentially a strong public health prevention tool for legionellosis outbreaks, that it is cost effective, and would be an excellent template for other local health agencies to adopt in order to better protect the health of the public.

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CHAPTER 1

INTRODUCTION

Legionella pneumophila serogroup 1 is a bacterium that causes serious illness in thousands of people every year across the country, and in some cases it can be fatal. Illness caused by *Legionella spp.* is known as legionellosis and there are two distinct types of syndromes associated with this bacterium. The less severe form of the illness is known as Pontiac fever and the more severe form that causes pneumonia is known as Legionnaires' disease. The CDC estimates that between 8,000 and 18,000 people are hospitalized with Legionnaires' disease each year in the U.S. (CDC, 2013). In Clark County, it has been associated with seven outbreaks at major hotels on the Las Vegas strip between 2000 and 2012. Over the last four years, the Southern Nevada Health District (SNHD) has averaged 20.5 case investigations per year, with the 2013 case investigation count at 25 through October.

In an effort to provide a more proactive, preventative approach to *Legionella* investigations, SNHD completely revamped the Epidemiology and Environmental Health investigation protocols in April of 2012. Previously, standard procedure only dictated an environmental investigation after a second case was identified as being associated with the same facility. SNHD determined this was an inadequate response, as it allowed outbreaks to occur that could have been prevented had an environmental investigation been done after the first case association was found. The objective of this study is to

evaluate the effectiveness of a more proactive approach to legionellosis investigations by SNHD. Not only do improved investigation and remediation efforts protect the public's health, but they also protect the image and tourist perception of the Las Vegas strip as a fun and safe destination for visitors.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Discovery

Legionella bacteria were first discovered during an outbreak of severe pneumonia after an American Legion conference in Philadelphia in 1976 (Fraser, 1977). There were a total of 221 cases with 34 deaths, and two-thirds of the ill were hospitalized (Altman, 2006). A new bacterium was identified as the cause, and named *Legionella pneumophila*. The investigation led to discoveries regarding this bacterium. For example, it did not seem to spread from person to person, and people who had long-term exposures (hotel staff), seemed to be immune to it (Fraser, 1977). The CDC scientist who first identified the organism, Dr. Joseph McDade, went on to discover that this was not the first time this bacterium had caused illness or outbreaks (Altman, 2006). He found that the earliest verified case was from 1947 and the earliest verified outbreak was in 1957. Tissue samples from those two incidents had been saved by researchers, allowing *L. pneumophila* bacterium to be positively identified as the cause (Altman, 2006).

Today, the bacterial genus *Legionella* has at least 48 different species that have been identified, with 70 distinct serogroups (Heymann, 2008). Only a few of these species have been associated with illness; the rest are either environmental microorganisms or their capability to cause illness is unknown (Kwait, 1998). The

species primarily responsible for illness is *Legionella pneumophila*, which causes 90% of Legionnaires' disease cases (Newton, 2010). Within the species *L. pneumophila*, there are 18 different serogroups, with serogroup 1 being responsible for 95% of illness (Heymann, 2008; Kwait, 1998). The environmental distribution for *L. pneumophila* serogroup 1 shows a different pattern than the prevalence in clinical samples.

According to a large study done in France, *L. pneumophila* serogroup 1 comprises 95% of all clinical isolates but only 28% of environmental isolates (Doleans, 2004). One of the most common diagnostic tests performed on suspected patients is a urine antigen test that is specific for *L. pneumophila* serogroup 1, so the true clinical impact of other *L. pneumophila* serogroups is unknown.

Reservoir

Legionella bacteria are ubiquitous in the environment worldwide and are mostly found in water sources, such as lakes, rivers, and reservoirs. From these natural environments, the bacteria can migrate into a man-made environment, such as a building or a city water system (Hornei, 2007). The bacteria grow best in a warm environment with temperature ranges between 77 and 108 degrees Fahrenheit. *Legionella* will not survive in temperatures above 140°F and will fall into a dormant state and not multiply in temperatures below 68°F (ECDC, 2012). However, once the temperature rises into its ideal zone, it can return from dormancy to an active, multiplying state. An interesting aspect to *Legionella* bacteria is that they are parasitic and, in order to complete their life cycle, invade free-living soil and freshwater amoebas

(Newton, 2010). This relationship allows the bacteria to replicate and provides protection from harsh environments. Other favorable conditions for *Legionella* growth are the presence of sludge, sediment, rust, and biofilms, which are conducive to a healthy protozoa population (Murga, 2001). These conditions are commonly found in building water systems, particularly older buildings. Common areas in buildings that can harbor the bacteria are cooling towers, spas, whirlpools, misting systems, fountains, and showers. Each of these environments provides a mechanism for a susceptible person to inhale mist or water vapor containing the bacteria. Inhalation of this vapor or mist could deposit bacteria into the lungs and lead to illness.

Route of transmission

The route of transmission for *Legionella* bacteria is inhalation of aerosolized water droplets. Water is aerosolized by spraying or splashing, or by bubbling air into it. The smaller the bacteria containing droplet, the more likely it is to cause infection (ECDC, 2012). Drinking or swallowing the water will not cause illness; the bacteria must be introduced into the lungs for illness to occur. Legionellosis has never been documented with human-to-human transmission (Newton, 2010).

The illness

Legionnaires' disease is an illness that causes pneumonia and can be fatal for 10-15% of cases (ECDC, 2012). The disease usually begins with symptoms similar to influenza, which then progress to cough, difficulty breathing, and pneumonia. Other

common symptoms include diarrhea and altered mental status (Hornei, 2007). If appropriate antibiotics aren't administered quickly enough, the illness can rapidly progress to respiratory failure, multi-organ system failure, shock, and death. The incubation period is usually between 2 and 14 days, with an average of 7-10 days. The bacteria can also cause a form of the disease that does not involve pneumonia, called Pontiac fever. The incubation period for Pontiac fever is much shorter, 12 to 48 hours, and the illness is very similar to influenza. Treatment is rarely necessary and many cases go undiagnosed because the ill person either doesn't see a physician, or if they do seek care, the physician rarely orders *Legionella* testing for a mild illness. Pontiac fever cases are usually only detected in outbreak situations when there is one common source exposure identified. Many more people get Pontiac fever than Legionnaires' disease, but Legionnaires' is confirmed more often simply because the illness is so severe they are more likely to seek treatment and be tested. Those who get the severe form of illness usually have other co-morbidities that weaken their immune systems or are over 50 and are less able to resist infection (CDC, 2013).

The only way to diagnose pneumonia caused by *Legionella* is to order testing specific for *Legionella*. There are no clinical features that clearly distinguish Legionnaires' disease from other pneumonia illnesses and *Legionella* will not grow on a typical, nonspecific bacterial culture. Since the late 1990's, the use of the urine antigen test for confirming Legionnaires' disease has led to rapid diagnosis and increased reporting due to the speed and inexpensive nature of the test (ECDC, 2012). As

mentioned, the drawbacks are that this test only detects the most common serogroup, and if there is no culture analysis performed, then no environmental isolates can be obtained for comparison to determine the exact source of exposure.

Legionellosis trends

Over the last 10 years, there has been a threefold increase in legionellosis cases reported throughout the United States (Berkelman, 2008). In 2002, there were 1,310 cases reported and in 2009 there were 3,522 cases. This increase can be seen across all age groups and geographic regions (CDC, 2011). The increase can be attributed to several factors, including population changes, improved diagnostic testing, and enhanced national surveillance (CDC, 2013). Some of the population factors are the increase of the “built environment”, increase in travel and increase in aging and immune compromised people (Berkelman, 2008). In our man-made environment, we are constructing more buildings and they are becoming taller, which necessitates a more extensive water supply system that increases the chances of colonization by *Legionella*. People travel more and many cases of Legionnaires’ disease are associated with stays in hotels, because these are often large, tall buildings that the bacteria can readily colonize (CDC, 2013). A susceptible host is required for successful transmission from the environment to a human. A person who’s immune system is weakened either by age or a health condition is much more likely to become seriously ill than a younger, healthy adult.

The advent and use of the urine antigen test has improved diagnostic capability and become widely available, assisting health care providers in rapid, cost-effective, appropriate diagnoses. In Nevada, and every other state in the U.S., when a health care provider diagnoses Legionnaires' disease, the provider is required by law to report the case to the local health department (State of Nevada, 2012). The local health department then has to investigate the case, identify any potential risk factors, and report the details to their state health department. The state then reports the case to the Centers for Disease Control and Prevention (CDC). If it is discovered that the case had traveled during the two weeks prior to onset of symptoms, the CDC reports the case to the state health department(s) of the state(s) that the case visited. The national surveillance system relies on all states reporting cases of legionellosis to the CDC and the CDC providing information back to states about cases that had traveled to other states during the weeks before they became ill.

Legionellosis in Clark County

The Southern Nevada Health District (SNHD) is the local health authority for Clark County. SNHD is responsible for a variety of public health programs related to the safety and health of the community, including the investigation of all cases of legionellosis. Between 2000 and 2012, SNHD investigated seven major outbreaks related to large hotels on the Las Vegas strip. Two of the outbreaks occurred within a year of each other, between 2011 and 2012. After the second major outbreak in less than 12 months, legionellosis outbreak data were compiled and analyzed and it was

found that SNHD was deficient in preventing outbreaks and protecting the public when it came to *Legionella*. Prior to April of 2012, the *Legionella* investigation protocol dictated environmental investigation and intervention only after a second case was identified with an association to the same facility as a case in the previous year. After analyzing the outbreak data, it was found that, in every outbreak scenario, there was one seemingly sporadic case, shortly followed by several other cases (SNHD Figure 1, 2, 3 and 4). SNHD theorized that if an environmental investigation was initiated after the first case, then future cases and outbreaks could be avoided in association with that facility. A new standard operating procedure was developed between the offices of Epidemiology and Environmental Health with a new protocol for investigation of legionellosis cases. The purpose of this new protocol was to emphasize the prevention of future cases and outbreaks (See Appendix 1 for the new Epidemiology protocol and Appendix 2 for the new Environmental Health protocol). Where the old protocol only dictated an environmental investigation after a second case was found to be associated with a facility, the new protocol dictates an environmental investigation with any exposure to a public location. The new protocol also requires facilities that are found to be positive for the target organism (the organism that caused illness in the case, usually *L. pneumophila* serogroup 1) to undergo remediation until they are negative for the target organism and then complete a 14-month monitoring period. If at any point during the monitoring period, the facility becomes re-colonized and tests positive, they must go through another remediation process and start the monitoring period over.

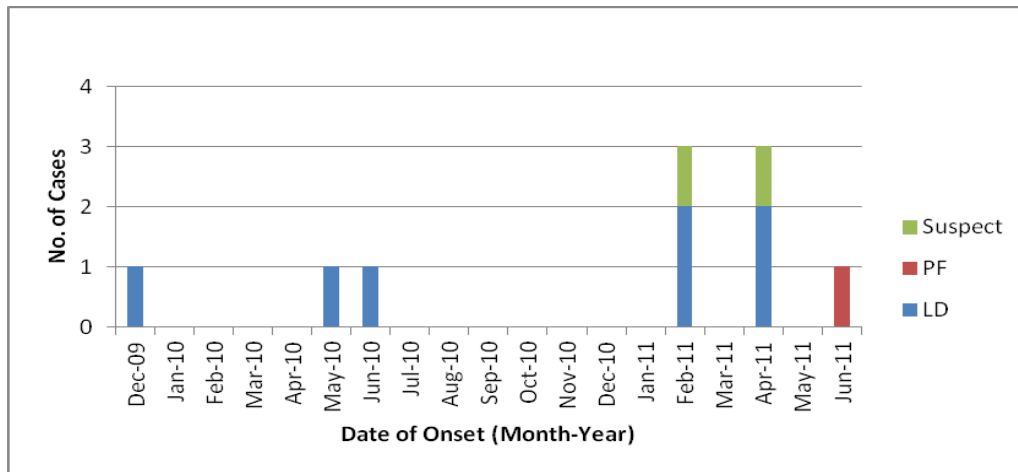


Figure 1. Epidemiologic curve, facility 1 legionellosis cases 2009-2011

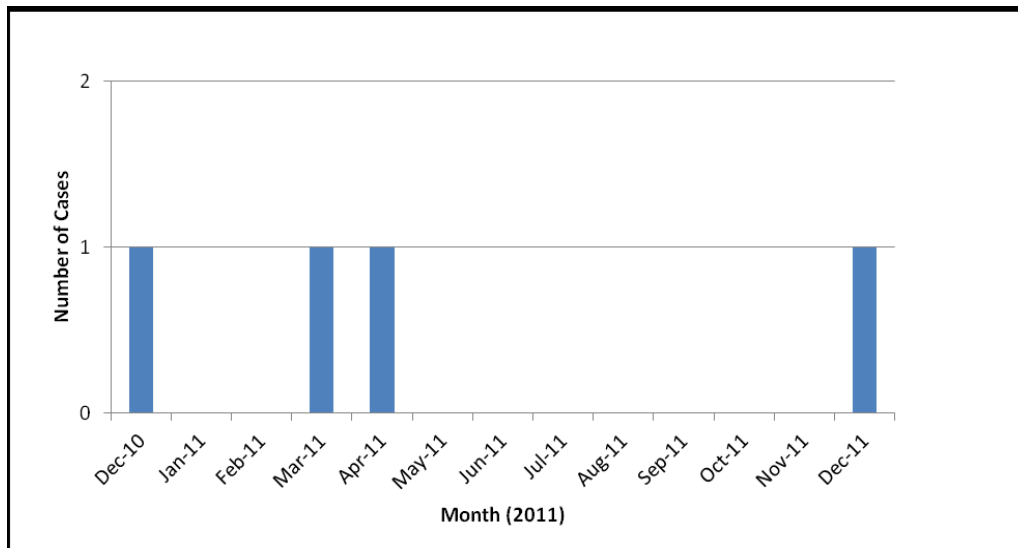


Figure 2. Epidemiologic curve, facility 2 legionellosis cases 2011

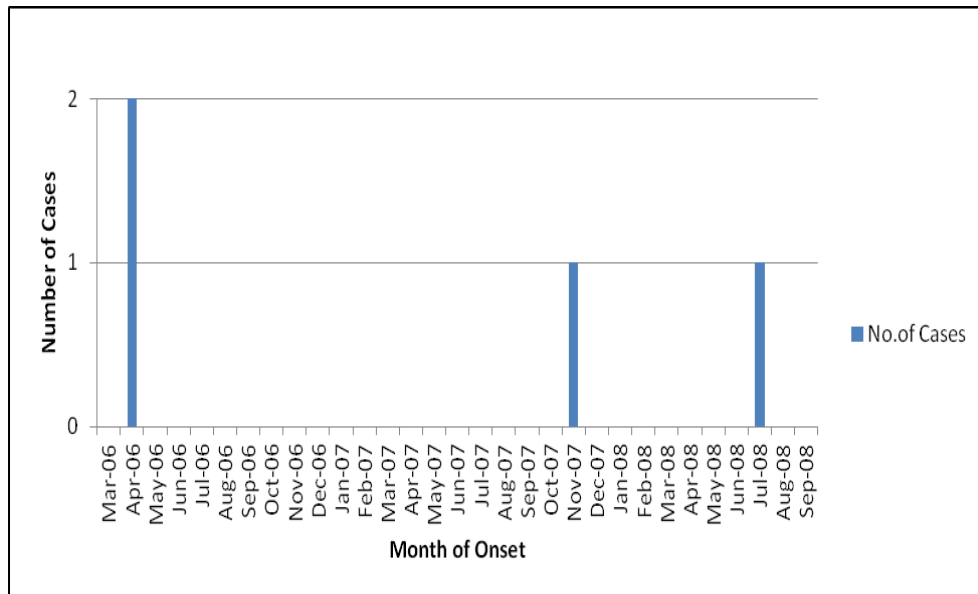


Figure 3. Epidemiologic curve, facility 3 legionellosis cases, 2006-2008

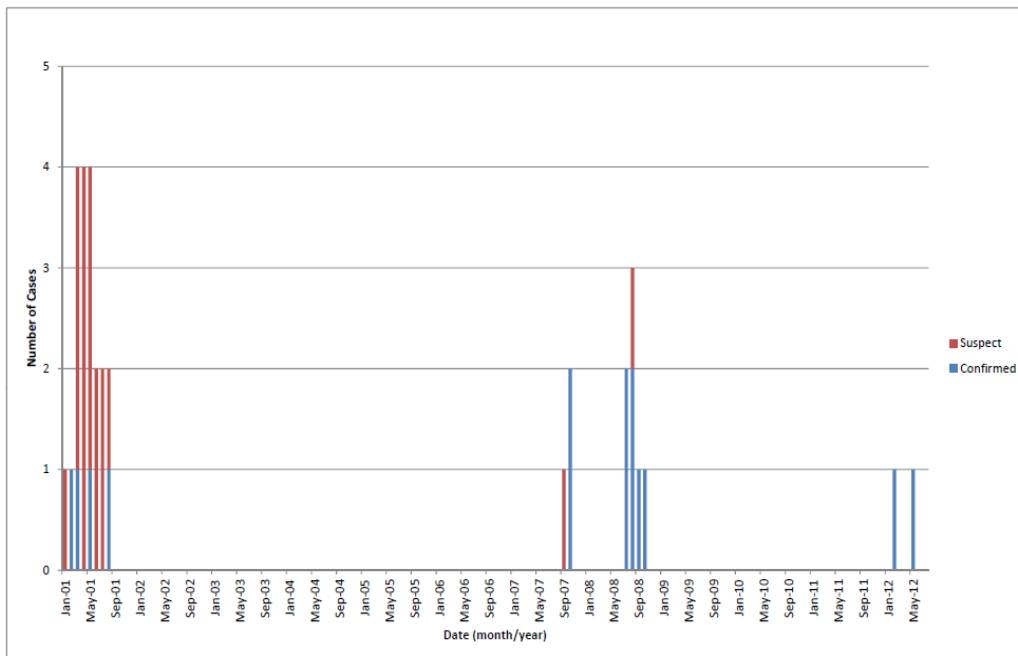


Figure 4. Epidemiologic curve, facility 4 legionellosis cases, 2001-2012

Clark County has also demonstrated the trend of increasing legionellosis cases. The table below illustrates the rates of legionellosis infections in Clark County from 2000-2009 (Figure 5). It is important to keep in mind that these rates are strictly for Clark County residents, yet often, half of the investigations SNHD conducts are in people who reside outside of Clark County who visited a hotel in Las Vegas during their incubation period (Figure 6).

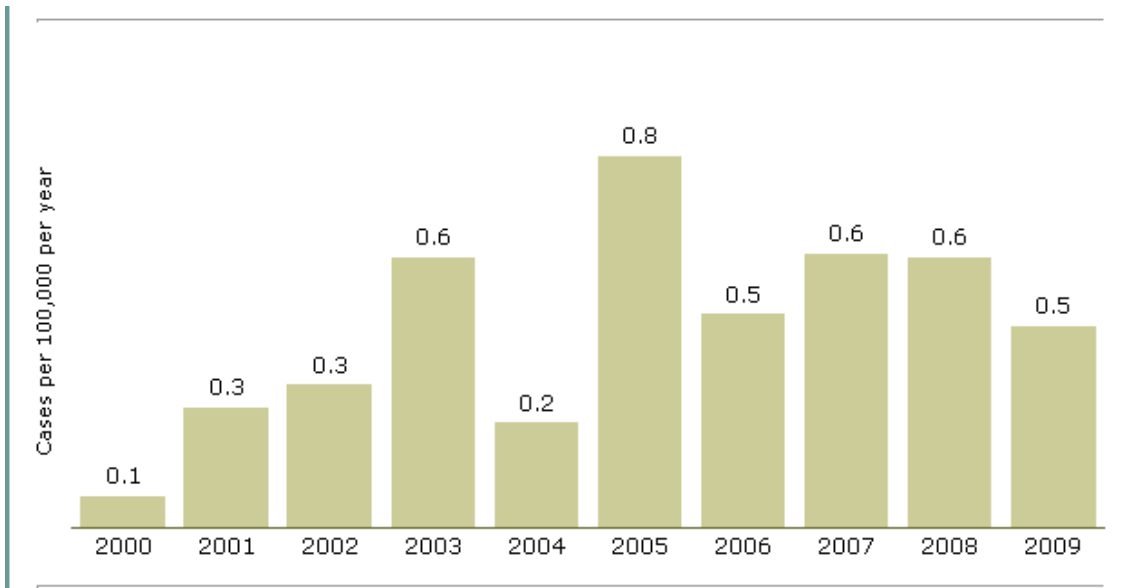


Figure 5. Legionellosis, annual rates in Clark County, 2000-2009

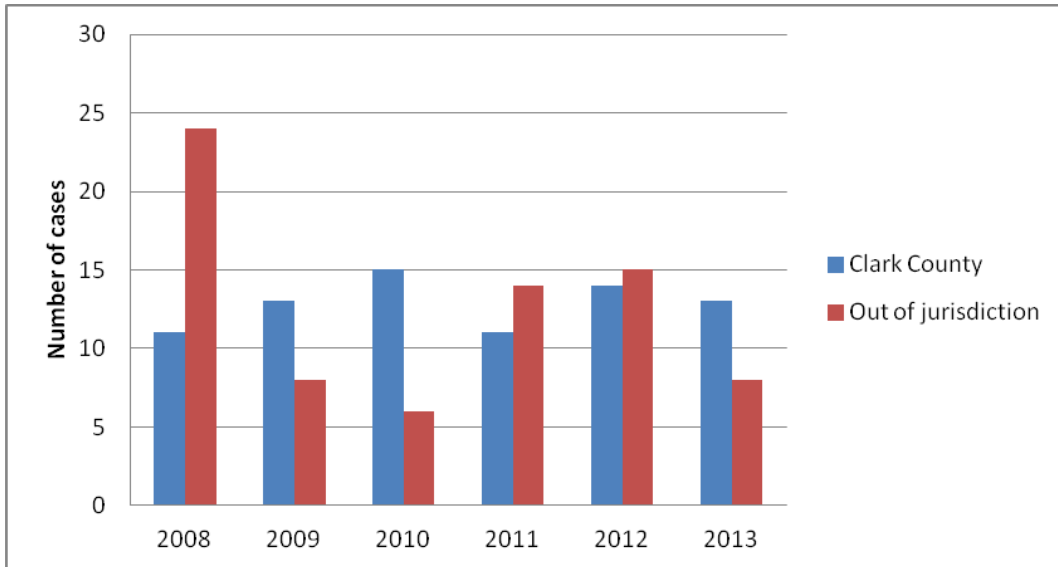


Figure 6. Legionellosis case investigations 2008-2013

Legionellosis case investigations

The starting point of any investigation is the report of disease, either by a laboratory or the diagnosing physician. When the Office of Epidemiology receives a report of legionellosis, the case is assigned to an investigator and that investigator attempts to interview the person. During the interview, the case is asked about potential risk factors, such as travel, staying overnight anywhere other than their usual residence, pool/Jacuzzi exposure, water fountain exposure, etc. If there are any local exposures identified that could expose other members of the public, an environmental investigation is initiated. If a risk factor is identified outside of Clark County, Nevada State Health Division is notified, they pass the information to the CDC and the CDC informs the state where the exposure may have occurred.

Environmental investigation

If a local public location is identified as a risk factor, then an environmental investigation is conducted. Most of the time the location is a hotel, but any location that could be considered a hazard to the public would be investigated. Examples of past investigations include public pools/jacuzzis, apartment complexes, and the misting system of a horse ranch. During the initial phase of the environmental investigation, a team from SNHD meets with management, risk management, and maintenance staff of the affected property. Water system protocols are reviewed, recent test results are reviewed if the property conducts any routine testing, and building schematics are assessed. A tour of the property commences to identify locations onsite that could expose a person to *Legionella* bacteria. Water samples are collected from all fixtures in the room where the case stayed as well as the distal room (the farthest room from the water heater on the same hot water pipe as the case's room). All other bodies of water from the property are sampled as well. In addition to the water collection for *Legionella* testing, temperature and chlorine measurements are taken with each sample. Samples are sent to a private laboratory to test for *Legionella*. The results are usually received back at SNHD within 10-14 days. SNHD informs the facility of the results, and if the target organism is identified (the organism that caused the illness in the case, usually *L. pneumophila* serogroup 1), then remediation is required.

Remediation

Remediation is based on standards set by the 2012 ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) guidelines (ASHRAE, 2011). They recommend two methods for eliminating *Legionella* from a water system – hot water flush and/or chlorine flush. SNHD offers facilities three options for remediation – hot water flush, chlorine flush or both. To accomplish the hot water flush, the temperature at every fixture in the affected area must reach between 160-170 degrees Fahrenheit. For a successful chlorination, the facility must maintain a chlorine level of at least 2 ppm for a minimum contact time of 2 hours. Every fixture on the line is checked to make sure that level is maintained throughout the entire system. Remediation can cause significant logistical difficulties for a facility because entire building areas must be unoccupied in order to safely and efficiently conduct the remediation procedures and testing. Once remediation is complete, the sites are sampled again for the target organism. If the target organism is detected, the facility must complete another round of remediation until the target organism is no longer detected.

Monitoring

Once a facility has been deemed successfully remediated, the facility moves into the monitoring phase of the protocol. Monitoring lasts a total of 14 months, consists of 9 rounds of water sampling and is divided into three phases. If the target organism is identified during monitoring, the facility must start over with remediation and monitoring from the first phase. The first phase of monitoring is the collection of bi-

weekly samples. The facility must have 3 consecutive bi-weekly negative samples to move on to the second phase. To pass the second phase, they must show 3 consecutive monthly negative samples before moving on to the final phase of monitoring, which are quarterly samples. Once the facility has provided 3 consecutive quarterly samples, negative for the target organism, they are deemed non-hazardous and are no longer monitored by SNHD. The facility is encouraged to maintain a water-monitoring plan to prevent any future problems because re-colonization can occur at any time.

CHAPTER 3

PROJECT PROPOSAL

Objective

This study evaluated the effectiveness of a more proactive approach to legionellosis investigations conducted by SNHD to determine if this approach is conducive to detecting and eliminating ongoing sources of *Legionella* before an outbreak occurs. It also determined whether the extensive resources necessary to implement the more proactive investigation and intervention are justified. One of the primary differences between the old protocol and the new one, that makes the approach more proactive, is the fact that the new protocol dictates an environmental investigation after only one case association is found with a public location. Another difference between the protocols is the fact that the new protocol provides strict guidelines and timelines for facilities to follow through a remediation and monitoring process if they are found to be sources of the target organism.

The objectives of this study were to:

- (1) Compare remediation methods to determine which, if any, are more effective at eliminating the target organism and maintaining baseline negative status.
- (2) Conduct a cost benefit analysis to determine if the public health benefits of the new protocol (conducting environmental investigations after one case

association vs. waiting until a second case is identified) justify the cost of the intervention on SNHD's part and the part of the affected facility.

- (3) Compare SNHD's data with those obtained by other health department protocols to determine if the more proactive approach is effective at reducing or eliminating clusters and outbreaks.

Research Questions

- (1) Are the remediation procedures (hot water flush, chlorine flush or both) implemented at facilities found to be contaminated with *L. pneumophila* serogroup 1 effective at preventing future contamination associated with that facility?
- (2) Are the costs associated with implementation of the new protocol justified by the health benefits achieved?
- (3) Is the new protocol comparable in cost and effectiveness to those used by other health departments?

Hypothesis

The goal of this study was to determine which of the remediation methods is most effective at eliminating the target organism and maintaining a negative baseline status throughout the 14-month monitoring period.

H₀: There is no difference between the remediation options - hot water flush only, chlorine flush only and both methods in obtaining and maintaining negative results for *L. pneumophila* contamination.

H_A: There is a difference between the remediation options - hot water flush only, chlorine flush only and both methods in obtaining and maintaining negative results for *L. pneumophila* contamination.

CHAPTER 4

PROJECT APPROACH

Methods

Objective 1: Comparison of remediation processes

All facilities that underwent an environmental investigation were reviewed for initial sampling results. Those facilities that were found to be positive with the target organism were identified as participants for the study. A facility can choose one of three options to complete the remediation process – hot water flush, chlorine flush or both. Ten facilities that were found to be sources began the remediation and monitoring process. Of the 10, 6 (60%) chose to utilize both methods of remediation, 1 (10%) chose the hot water flush and 3 (30%) chose the chlorine flush.

All results of post remediation and monitoring samples of these facilities were reviewed and a data table was compiled (Table 1). There were two possible results identified: negative – target organism not detected or positive – target organism detected. The only results that required action were the detection of the target organism at concentrations $\geq 10\text{cfu/ml}$ or if the target organism was present in more than one fixture at any concentration.

The repeated survival method was used to compare the water sampling results obtained with the three different remediation methods. The repeated survival method is useful for analyzing the time to the occurrence of an event (Cleves, 2008). In this case, the “event” would be a positive target organism result and the “time” is the

number of weeks from the remediation date to the date of a positive result. This will help identify any differences between remediation methods for each test event and which methods yielded the best outcomes. The data should have 10 test events per facility, the initial post remediation results, plus the nine monitoring samples. Not all facilities have completed the monitoring period so the data set is incomplete, but all completed sampling results were used for analysis.

Objective 2: Cost benefit analyses

The new protocol was designed to be a more proactive approach to legionellosis investigations. Based on the new protocol, more environmental investigations are conducted and they are much more intensive than previous investigations. One of the objectives of this study was to determine if the additional cost to SNHD and the affected facilities is cost effective.

To evaluate the cost effectiveness for of the new protocol for SNHD, several key sets of data were compiled including staff time and laboratory costs for the initial sample analysis results. This information was averaged based on facility size (small vs. large) and combined for each environmental investigation to determine a total cost for the new protocol to SNHD. For the cost to facilities, a range of prices for laboratory testing, remediation methods, and other additional measures that facilities chose to utilize were compiled with smaller facilities assigned the low end of the cost range and larger facilities the higher end. The estimated total costs for SNHD and affected

facilities were added for comparison to the estimated healthcare costs for patients diagnosed with Legionnaires' disease. Potential litigation costs were researched and noted as well. Sources were found that estimated the cost of Legionnaires' disease including hospitalizations, outbreaks, and the cost annually in the U.S. Past Clark County outbreak information was reviewed to determine the potential cost savings had those outbreaks been prevented.

Objective 3: Comparison with other health departments

Consultation was conducted with the CDC's Legionellosis Surveillance & Outbreak Response Coordinator, the Regional Manager for Phigenics, a national water management company that services all southwestern U.S. states and other large local health departments from New York, New Jersey, and Florida.

Participants

The target populations of this study were facilities that were found to be sources of the target organism, *Legionella pneumophila* serogroup 1. If a facility was found to be a source of the target organism during the environmental investigation, they were part of the sample group and the results from their remediation and monitoring process were compared with all other facilities that were found to be sources as well.

Measurement

SNHD follows OSHA guidelines for *Legionella* control to determine which facilities would be considered sources and deemed a public health hazard. This gives SNHD the authority to require remediation and monitoring. CFU, or colony forming units, is a common measurement for bacterial enumeration and provides a range for the acceptable number of bacteria in water supplies. OSHA requires that the bacteria be measured at ≤ 10 cfu/ml in domestic water supplies, ≤ 1 cfu/ml for misting systems, and ≤ 100 cfu/ml for cooling towers (OSHA, 1999).

Variables

In this study there are three independent variables related to the remediation methods chosen by facilities – hot water flush, chlorine flush, and both methods combined. The dependent variables are the sampling results when testing the water. Depending on the laboratory, results were either reported as non-detected or negative, detected but not the target organism, target organism detected but at non-hazardous levels, or target organism detected. Only detection of the target organism, *L. pneumophila* serogroup 1, at levels above the OSHA guidelines will result in a positive sample and a restart of the remediation and monitoring process. There are also some confounding variables that could have an effect on the dependent variable, for example, age of the facility, size of the facility, occupation rates of the facility and the monetary resources of the facility owners. Each of these could have an impact on a facility's

ability to obtain and maintain a negative baseline status, independent of which remediation method a facility chose.

Results

Objective 1: Comparison of remediation methods

Due to the various limitations mentioned, the results from the statistical analysis were not statistically significant. Using the repeated survival analysis, the P values were large (>0.05), indicating that we are unable to reject the null hypothesis - there is no difference between remediation methods. The comparison between the hot water flush and both methods together yielded a p -value of 0.378 and between the chlorine flush and both methods together had a p -value of 0.235. The one facility (Facility B) that was unable to maintain a negative status used the chlorine only method and completed four different remediation procedures. After four remediation procedures, the water system remained colonized, so the facility closed the entire building indefinitely and is currently working with consultants to develop a new remediation strategy.

Table 1. Comparison of remediation methods

Remediation Method	Facility	Remediation Date	Monitoring Results									
			IPRR	1 st BW	2 nd BW	3 rd BW	1 st M	2 nd M	3 rd M	1 st Q	2 nd Q	3 rd Q
HW	A	7/17/2012	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	MNC	
CL	B	8/30/12	NEG	NEG	POS							
		11/27/12		NEG	POS							
		2/20/13		NEG	POS							
		5/6/13		NEG	NEG	NEG	POS	CLSD				
	C	6/10/2013	NEG	NEG	NEG	NEG	NEG	PEND				
	D	9/11/2013	NEG	NEG	PEND							
BOTH	E	5/9/13	NEG	NEG	POS							
		6/28/13		NEG	NEG	PEND						
	F	6/14/2013	NEG	MNC								
	G	5/22/2013	NEG	NEG	NEG	MNC						
	H	9/9/2013	NEG	PEND								
	I	7/11/2013	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG
	J	1/27/2014	NEG	NEG	NEG	NEG	MNC					

Key – HW = Hot water flush
 CL = Chlorine flush
 BOTH = Hot water & chlorine flush
 IPRR = Initial post remediation results
 BW = Bi-weekly
 M = Monthly
 Q = Quarterly
 POS = Positive for target organism
 NEG = Target organism not detected
 PEND = Sample results pending
 MNC = Monitoring not completed
 CLSD = Investigation closed

Objective 2: Cost Benefit Analysis

For SNHD, the two biggest costs are staff time and laboratory fees. The initial environmental assessment and sampling is paid for by SNHD. All additional laboratory costs are the responsibility of the facility. The amount of staff time required varies widely based on the size of the facility (Table 2). According to SNHD's Environmental Health Division Permit and Plan Review Fee Schedule, the "Per Man Hour" cost of an Environmental Health Specialist is \$118 (SNHD, 2012). For smaller facilities, it takes an average of 13 staff hours per facility, so the average cost to SNHD is \$1,534 per small facility. For large facilities, it takes an average of 57.8 staff hours per facility and costs on average \$6,819 per facility.

Table 2. SNHD staff time summary (facility investigations July 2011 - October 2013)

	Facility	Facility Size S-small L-large	SNHD Staff Time hours	Investigation Status C-Complete O-Ongoing
	A	S	9.3	C
	B	L	23.3	O
	C	L	45.25	O
	D	L	78.75	O
	E	L	22	C
	F	L	19.5	C
	G	S	37.8	O
	H	L	68.6	C
	I	L	24.2	O
	J	L	15.75	C
	K	L	226.25	C
	L	L	10.5	C
	M	L	52.75	C
	N	L	150.1	C
	O	S	2	C
	P	S	23.8	O
	Q	L	14.25	C
	R	S	3	C
	S	S	2	C
Totals	19	S=6, L=13	874.35	C=13,O=6

The laboratory cost to SNHD ranges from \$1,500 to \$2,800 depending on how many samples are being tested. Therefore, SNHD’s approximate total costs (staff time + laboratory fees) associated with legionellosis investigations ranges from about \$3,034 for a small facility to \$9,619 for larger facilities.

Prior to implementation of the new protocol, only outbreaks were environmentally investigated, of which there were 7 over a 12 year period. Since the new protocol was established, 17 environmental investigations were conducted in a year and a half. Of the 17 facilities, 6 could be classified as small investigations. Based on these estimates, the cost for SNHD to initiate the new protocol has been approximately \$124,013 (total cost of 6 small facilities + total cost of 11 large facilities) since April 2012, or about \$82,675 per year. Based on these same numbers, over the previous 12 years, it can be estimated that SNHD spent approximately \$5,611 (7 large facilities/12 years) per year on legionellosis investigations.

Estimating the cost to facilities is much more challenging. Initially, the cost to the facility is minimal and it is basically comprised of the staff time to accompany SNHD staff on the environmental assessment, assist with sampling, and provide building schematics. If the sample results are negative, then that is the end of the cost to the facility, but, if the target organism is detected, there is a wide range of costs between facilities, with many factors coming into play. Some factors that can influence the cost to a facility are the age of facility, the type and age of the water distribution system, whether the facility wants side-by-side sampling (the facility hires an independent consultant to take samples at the same time and sites as SNHD) or independent oversight, how many sample sites are found to be colonized, and the type of remediation chosen. The sampling costs to the facility can range from \$1500 - \$5,000 depending on the analysis method and which laboratory is chosen. The remediation

costs can vary based on how many sample sites were contaminated and which method is utilized. For one zone, the remediation can cost approximately \$1,000 to \$12,000. The least expensive remediation method is hyper chlorination, which is accomplished by adding enough chlorine to maintain at least 2ppm for the required 2 hour contact time, then flushing the system. Super heating generally costs more because of the increase in power usage to heat the system (Marchesi, 2011). Some facilities choose to go beyond SNHD recommendations, such as draining hot water systems, cleaning tanks and then flushing with heat, chlorine or both. These additional precautions substantially increase remediation costs. Some facilities also opt for side-by-side testing. When SNHD takes a sample, the facility hires their own consultants to take a sample at the same time and location. Other facilities opt for independent oversight with water management companies, which charge up to \$5,000 for a consultant to be onsite without any testing. Generally, only the larger corporations will choose this option. When a hotel or apartment building has to close rooms it can quickly increase the cost due to lost revenue. One facility chose to keep an entire block of rooms closed while test results were pending. This facility had the highest cost of all facilities that required remediation, totaling an estimated \$1 -2 million. They chose to go beyond the recommendations of SNHD, but they are also part of a multi-national conglomerate with financial means that most other facilities do not have.

To estimate the general cost to facilities found to be sources, at the low end of the range it could be approximately \$1000 for initial remediation and about \$15,000 for

the post-remediation sampling with 9 monitoring phase samples tested. So, a small facility doing the minimum requirements would have a minimum cost of about \$16,000 (this estimate does not include any staff time). For a larger facility, the costs would be much higher and include approximately \$12,000 for remediation and about \$50,000 for the post-remediation sampling with 9 monitoring phase samples tested. For a large facility doing the minimum requirements from SNHD, the cost would be approximately \$62,000. Larger facilities generally choose the most cautious approach, which can quickly increase their costs.

Of the facilities found to have been a source for the target organism, only two would be considered small facilities and eight would be considered large facilities. A rough estimate of the total cost to all “source” facilities since the implementation of the new protocol is approximately \$1,466,000. That number includes \$16,000 times two for the small facilities, \$62,000 for each of the seven larger facilities, and an estimate of \$1 million for the large facility that chose to take many extra precautions. This number is an approximation and in all likelihood an underestimate of the total cost to facilities that were found to be sources, especially since no facility staff time is included. The approximate total cost to SNHD and the ten facilities since the implementation of the new protocol is about \$1,590,013.

Objective 3: Comparison with other health departments

After reaching out to multiple contacts at various levels of the national surveillance system, from the federal level (CDC) down to individual local health

departments, no data were found that any other agencies conduct such proactive legionellosis investigations. All local agencies that were consulted have similar protocols to SNHD's previous protocol, where an environmental investigation is only conducted after a second case association is found.

Discussion

Objective 1: Comparison of remediation methods

Out of 45 legionellosis case investigations (since April 2012), there were 17 environmental investigations conducted with 8 sources of the target organism found. In the data set, 2 additional facilities were included that were investigated as outbreaks just prior to April of 2012, but both went through the same environmental investigation, remediation and monitoring schedule as stated in the new protocol. So, with only 10 facilities to compare remediation methods, it is difficult to determine the significance of the results, especially the hot water flush, because only one facility chose that method.

Upon reviewing the post remediation results for the 10 facilities found to be sources, it was found that SNHD failed to follow up and complete the monitoring phase for four facilities. One facility went through the remediation process and initial post remediation results, but was never entered into the monitoring phase so no additional sampling results were completed. Two facilities did not complete all 9 required post remediation monitoring samples, one completed 7 post remediation monitoring samples and the other facility only completed 3. There are no plans to follow up and

require these facilities to complete the monitoring phase. Four facilities are currently in the monitoring phase and have results pending.

When comparing the effectiveness of the remediation methods, a review of other studies indicate that each of the methods can be effective in the short term, but re-colonization occurs relatively quickly. That is one of the reasons SNHD monitors for a 14-month period, to ensure that the target organism does not re-colonize the facility. In one study of apartment buildings, it was found that after utilizing the heat flushing method, the concentration of *Legionella* spp. was below the detection limit, but re-colonization occurred within a few months (Zacheus, 1996). Because we only had one facility choose the hot water flush only method, it is difficult to make any conclusive statements, but that facility did maintain a negative baseline status throughout the 14 month long monitoring process. Another study done at an Italian hospital demonstrated that negative results after the hot water flush and hyper chlorination methods were only temporary and *Legionella* spp. was detected shortly after remediation procedures were deemed effective (Marchesi, 2011). Another study done on the effectiveness of hot water flushing in hotels, hospitals and athletic venues also demonstrated that it was not effective unless repeatedly done in combination with chlorine disinfection of faucets (Mouchtouri, 2007). Another study done in hospitals found that heat flushing in combination with continuous supplemental chlorination of the hot water system was effective long term in the elimination of *Legionella* (Snyder, 1990). One of the factors that may be contributing to the re-colonization is the types of

microbes, amoeba and/or biofilms that may be in the water systems. These organisms can have a profound effect on the efficacy of a hot water or chlorine flush. *Legionella* that are associated with biofilms and amoeba are far more resistant to chlorine and heat and both need to be applied in higher doses and/or for longer exposure times in order to be effective (Green, 1993; Muraca, 1987, Kilvington, 1990). This could partially explain the differences between effective results over 14 months locally versus other studies that show re-colonization after only a few months.

The lack of continuity on SNHD's part to ensure that all facilities found to be sources were followed through the monitoring phase is a problem that was identified in this study. The facilities that SNHD failed to follow were some of the first to be investigated under the new protocol, so the practice had yet to be established and there was no established procedure on how best to follow up with the facilities. Since the beginning of 2013, and particularly since this evaluation discovered the gaps on the part of SNHD, a concerted effort has been made to ensure stringent follow up with all facilities is conducted and the monitoring schedule is completed.

Objective 1: Limitations

Some validity issues that could have affected the outcome were differences in laboratories performing the testing and different test methods utilized to detect the target organism. The initial sampling is done by SNHD through EMSL Analytical using the culture method for *Legionella* spp. All post remediation testing is done by a third party laboratory, chosen by the facility. The facility can also choose which type of

testing is ordered, i.e. PCR, culture, etc. The only requirement from SNHD is that the laboratory is ELITE certified, meaning the CDC has certified them as proficient in their ability to isolate *Legionella* from water samples.

Another limitation for this study is the small sample size. The sample size is dependent on how many legionellosis case investigations were conducted since the implementation of the new protocol. Of those investigations, how many resulted in environmental investigations, and out of the environmental investigations, how many sources were found.

Objective 2: Cost benefit analysis

One important component of the cost to facilities is their staff time to complete remediation and conduct all the follow up sampling. The results of the cost benefit analysis for facilities described above, do not include any facility staff time. I was unable to obtain any estimate related to local facilities, but a study done that monitored heat flushing of hospitals found the cost to be \$31,000 in staff time over a period of one month (Marchesi, 2011).

Some of the costs to facilities that are difficult to quantify are litigation and negative publicity associated with outbreaks. Settlement reports are rare because most stipulate a non-disclosure agreement, but reportedly awards range from \$255,000 to hundreds of millions (Smith, 2013). In 2006, a jury awarded a cruise line \$193 million dollars against the manufacturer of equipment because the equipment was found to be implicated in several Legionnaires' disease cases. The largest portion of this award was

due to interruption of services and lost bookings (Smith, 2013). In January of 2012, an article published by the Las Vegas Review Journal stated that, in 2011, eight guests sued MGM Resorts seeking \$337.5 million dollars in damages because they were allegedly part of well publicized Legionnaires' disease outbreaks associated with Aria and Luxor earlier that year (Harasim, 2012). At printing time of the article, the lawsuit was still pending and the final outcome is unknown at this time.

A study conducted in London on the public health and economic costs of Legionnaires' disease found that the overall cost of one outbreak investigation was \$729,096 (Lock, 2008). They also found that only 14% of that total was spent on investigation and control of the outbreak vs. 86% on hospital treatment of the cases. This study indicates that the time and money spent on public health prevention are a good value considering the potential cost of an outbreak (Lock, 2008).

According to the CDC, the cost of healthcare for Legionnaires' disease is approximately \$101-321 million dollars a year in the U.S. (Collier, 2012). On average, individual hospitalized cases cost more than \$34,000 each (Collier, 2012). According to a study presented at the CSTE (Council for State and Territorial Epidemiologists) conference in 2013, the average length of stay for a person hospitalized with Legionnaires' disease is 7.5 days to 25.1 days when analyzed from the category of lowest to highest severity, with cost per stay ranging from \$13,053 – \$71,318, respectively (Giambrone, 2013). The conclusion of the CSTE study was that Legionnaires' disease carries a significant economic cost, and with incidence increasing

yearly, that number is only expected to rise. The group who presented the study recommended more focus on preventing the illness in vulnerable populations as a cost saving measure (Giambrone, 2013). Also, according to the CDC, modest investments in disease prevention can yield significant healthcare cost savings (Collier, 2012). When comparing the approximate cost to SNHD and the local resort industry (\$1.6 million over a year and a half) vs. the potential costs of another outbreak (approximately \$700k, plus the potential of hundreds of millions in litigation costs); the information shows that the new proactive approach to investigations is worth the extra investment (Lock, 2008).

A consultant for a multi-national water management company who has worked all over the U.S. for the last 20 years and who works closely with several large resort properties in Las Vegas was interviewed for his knowledge and experience regarding SNHD's approach to legionellosis investigations (B. Winters, personal communication, October 15, 2013). According to him, SNHD's approach is very reasonable when it comes to the monetary burden that is put on the resort industry to protect the public. He also believes that the benefit vs. cost for this protocol is very favorable; by conducting thorough assessments after every case, the cost is minimal compared with the benefit of avoiding an outbreak.

CHAPTER 5

SIGNIFICANCE AND CONCLUSION

Significance

We have seen promising indications that the new protocol is preventing outbreaks because there have been no additional cases associated with a facility that has undergone an environmental investigation. Looking at facilities associated with outbreaks in the past, if we would have conducted an environmental investigation after the first case was found, we could have potentially prevented at least 24 cases of Legionnaires' disease if all the remediation and monitoring phases were successful. Applying the average hospitalization cost per case of Legionnaires' disease of \$34,000, those 24 cases cost approximately \$816,000 in healthcare alone. That number does not include the additional costs of death and litigation associated with outbreaks. This information suggests that the new protocol is cost effective and should be considered a successful public health prevention tool.

Another significant aspect to this protocol is the number of sources of *L. pneumophila* that have been identified that would have been ongoing sources of exposure to the public had SNHD continued operating under the former protocol. This evaluation found that approximately 38% of all legionellosis case investigations result in an environmental investigation and 59% of those environmental investigations found sources of the target organism. Based on those numbers, about 22% of all cases have

been linked to sources of the target organism (Table 3). If that percentage is applied to past investigations, an estimate can be made regarding how many sources were missed that could have been the cause of undiagnosed illnesses (Table 4). For example, between January 2008 and March 2012 there were a total of 70 Legionnaires' disease case investigations. By applying the estimated percentage of sources identified (22%), potentially there were 15 sources that were never identified and that could have caused many cases of undiagnosed illness in the public.

Table 3. Investigation summary, April 2012 – October 2013

Summary information	Percentage from total
Total legionellosis investigations	45
Environmental investigations initiated from cases	17/45 (38%)
Required remedial action	10/45 (22%)

Table 4. Investigation summary, January 2008 - March 2012

Summary information	Percentage from total
Total legionellosis investigations	70
Environmental investigations that would have been initiated from cases	25/70 (36%)
Percentage of potential sources	15/70 (22%)

Because no other health departments that were contacted are conducting this type of proactive approach to legionellosis investigations, SNHD has the opportunity to share this innovative protocol with other health departments who are interested in improving their own protocols. Already, several agencies have reached out for SNHD's assistance in adapting and implementing the protocol to their jurisdictions. SNHD has also been asked to present the new protocol at several environmental health conferences to share the experience of adopting the new practice, obtaining buy-in from the resort industry, and the results that have been obtained. This evaluation is an important component of sharing the protocol with others because SNHD can show what has worked well and what mistakes to avoid when adopting it.

Conclusion

By reviewing investigations done according to the new protocol, the effectiveness of the more proactive approach was assessed and evaluated. While the sample size is limited, the data does support that the remediation methods utilized by facilities are effective at protecting the health of the public by eliminating ongoing sources of *L. pneumophila* serogroup 1. Despite not all facilities completing the monitoring phase, each one was found to be negative for the target organism during post remediation testing. Even the facility that was unable to eradicate the organism from the water system closed the affected building, so while remediation efforts were unsuccessful, the protocol itself was successful in that it identified an ongoing threat to the public and allowed SNHD to take action to eliminate it.

Since implementation of the new protocol there have been no secondary cases or outbreaks associated with a facility that has undergone an environmental investigation. This was the primary goal of the new protocol and it seems to be successful so far. One recommendation for SNHD is to continue to monitor all legionellosis cases and remediated facilities for additional cases and/or outbreaks to more conclusively determine that the new protocol is effective at protecting the health of the public. Another recommendation for SNHD is to develop a mechanism for monitoring facilities that have been identified as sources to ensure that the remediation and monitoring schedules are followed and completed. Facilities themselves can also be more proactive in avoiding colonization with *Legionella spp.* by following guidelines as

reported in the proposed ASHRAE New Standard 188 (ASHRAE, 2011). These recommendations provide best practice standards for the prevention of legionellosis associated with building water systems. Because *Legionella* bacteria are so abundant and ubiquitous in the environment, proactive measures are essential to preventing the colonization and transmission of illness within the community. To reduce the incidence of illness, it is important for both SNHD and local facilities to engage in a proactive partnership and this new protocol has initiated an important first step in that ongoing process.

Appendix 1

Southern Nevada Health District (SNHD) Office of Epidemiology (OOE) Protocol for Joint OOE/Environmental Health (EH) Legionella investigations

SNHD OOE will investigate every report of Legionellosis.

Upon notification of a case, the OOE Disease Investigation and Intervention Specialist (DIIS) will investigate to confirm the case status and determine if there was an exposure to any public facility that falls within SNHD's jurisdiction. These include public accommodations or public bathing places regulated by SNHD Environmental Health (EH).

If a case had one or more potential *Legionella* exposures in the two to fifteen days before symptom onset, the DIIS will inform the Special Program EH Supervisor of the exposure(s) providing specific details to clearly identify a location:

- For each public accommodation exposure:
 - Name and address of the facility
 - Room number and/or floor number
 - Dates of exposure
 - Specific amenities used in a public accommodation that may be considered an exposure (i.e. – wet bar, in-room whirlpool bath, shower, spa, pool, hot tub, misters, etc.)
- For each public pool, spa or water feature exposure:
 - Name and address of the facility
 - Specific details to identify which pool spa or water feature the case-patient was exposed to if a facility has more than one
 - The condition of the pool, spa or water feature (cloudy, green, etc)
 - Anything abnormal about the pool, spa or water feature (strong smell of chlorine, temperature, slimy steps, etc.)

Once one or more exposures have been established, the DIIS will enter the information into the electronic surveillance system and review it for any other cases with the same exposure(s) in the past two years. If a cluster* or outbreak* is identified, an Epi-X posting will be drafted and submitted by the OOE.

Upon notification of exposure details, EH will conduct an investigation into the potential exposure at the permitted facility using its protocols for investigating Legionellosis. A DIIS will accompany EH staff to the facility to verify the case's dates of stay and room number

within the facility's registration system. If the EH investigation provides evidence of Legionella contamination an outbreak may be declared and public notifications may be deemed necessary by SNHD.

Case classification:

Single case: Case associated with a permitted facility that has not been linked with any other cases of Legionnaires' disease for at least the previous two years.

Cluster: Two or more cases associated with the same permitted facility where the patients' symptom onset occurred within the same two-year period.

Outbreak: Two or more cases associated with the same permitted facility where the patients' symptom onset occurred within the same two-year period and where environmental investigations provide additional evidence suggesting a common source of infection.

Appendix 2



Environmental Health Division Policy

1. PURPOSE

Southern Nevada Health District (SNHD) Environmental Health (EH) Division (EHD) staff may be called upon to conduct an environmental investigation of a facility that has been associated with a confirmed or suspected case or cases of legionellosis. The purpose of this policy is to provide guidance regarding the EHD's environmental investigation of systems or locations where *Legionella spp.* bacteria may be present.

2. POLICY

2.1 Initiate environmental investigation response protocol

- 2.1.1 SNHD EHD shall respond to every reported case of legionellosis, including sporadic cases.
- 2.1.2 Upon receipt of notification from the OOE regarding an alleged or confirmed case of legionellosis at a southern Nevada location, the Special Programs EH Supervisor will advise the public accommodation facility EH Supervisor and *Legionella* Response Team members that an upcoming response, including an environmental assessment and sampling, is being planned.
- 2.1.3 EH will schedule the site visit with the facility as soon as practical from the OOE-to-EH notification. The facility environmental assessment and sampling will not be scheduled for or occur on a Friday.
- 2.1.4 When necessary and sufficient information has been made available to clearly identify the area of concern, the Special Programs EH Supervisor will advise the affected facility to schedule the environmental assessment and sampling to occur on its property. The appointment shall be made so that there is at least 24 hours, but no more than 48 hours, between the contact time for the official notification and the scheduled site visit.

The site visit on the day selected for the appointment should preferably be held first thing in the morning.

- 2.1.5 The CDC form, “Environmental Assessment of Water Systems,” will be sent to the facility representative via e-mail after the meeting date and time is scheduled so that the facility may gather the pertinent information and complete the form prior to the meeting.

2.2 **Respirator-related requirements during the environmental assessment**

- 2.2.1 During an environmental investigation of a facility associated with a confirmed or suspected case or cases of legionellosis, there is a possibility that those SNHD *Legionella* Investigation Team members who conduct the environmental assessment and collect samples during the investigation may be exposed to *Legionella pneumophila (Lp)*, the pathogen that causes Legionnaires’ disease and Pontiac fever, or other pathogenic forms of *Legionella spp.*
- 2.2.2 SNHD EH staff must comply with all of the requirements of the most current SNHD RPP and the EH Policy #EH-14 prior to utilizing any type of respirator as part of their assigned *Legionella* Response Team duties.
- 2.2.3 EH staff must don respirators in all areas associated with increased risk of *Legionella exposure*. The facility may choose instead to reduce or eliminate the risk by turning off aerosol generating water features (i.e. water fountains, spas), if donning an appropriate respirator is not an option.

2.3 **Environmental investigation-facility preparatory meeting**

The SNHD *Legionella* Investigation Team, including possible OOE representatives, will meet with facility representatives at the scheduled site visit to:

- 2.3.1 Deliver official notification from OOE validating guest stay with a letter of initial report of case of Legionellosis, including formal request to access affected room(s).
- 2.3.2 Discuss *Legionella* ecology, sources, and pathogenicity.
- 2.3.3 Report cases, including how the case was identified to the SNHD.

- 2.3.4 Obtain room number from the facility by an OOE representative, if necessary.

- 2.3.5 Request following records from the first of the month that is at least **60 days prior** to case stay to present (date of site visit):
 - 2.3.5.1 Water management plan.
 - 2.3.5.2 Recent *Legionella* sampling results.
 - 2.3.5.3 Schematic of the plumbing system of the facility.
 - 2.3.5.4 Pool/Spa records.
 - 2.3.5.5 Cooling tower maintenance logs.
 - 2.3.5.6 Hot water maintenance logs.
 - 2.3.5.7 Water mister maintenance logs.

- 2.3.6 Require the facility to provide reasonable access to affected room(s), as per *SNHD Regulations Governing the Sanitation and Safety of Public Accommodation Facilities, Section 11*, and any associated areas impacting the affected room(s) and their water systems.

- 2.3.7 Schedule the investigation and associated sampling events, including:
 - 2.3.7.1 A comprehensive environmental assessment.
 - 2.3.7.2 Sampling events, as many as are necessary to determine source of *Legionella* and document remediation activities.
 - 2.3.7.3 A walk of the affected property to identify potential sources of exposure to *Legionella*.

2.4 **Environmental assessment-general instructions**

The SNHD *Legionella* Investigation Team shall:

- 2.4.1 Use CDC form, “Environmental Assessment of Water Systems,” to complete an environmental assessment at the affected facility. The form is available electronically to EH staff.
 - 2.4.1.1 As per instructions printed on the form, to not leave any sections of the form blank.
 - 2.4.1.2 If the section does not apply, mark it as “non applicable.”

- 2.4.2 Interview any facility staff who may have knowledge of the case(s) or water systems within the facility.

- 2.4.3 Collect as much information as possible. Utilize the CDC form as a guideline to ascertain all relevant information. Any blank information not readily available during the initial investigation can be filled out by facility staff and submitted to SNHD within a timeframe determined by SNHD.

2.5 **Environmental assessment-walk-through of property looking at specific areas**

The SNHD *Legionella* Investigation Team shall look at specific areas and document the conditions found within the facility which are the most likely to be the sources of *Legionella* within the facility, such as:

- 2.5.1 Cooling towers.
- 2.5.2 Public bathing places (SNHD-permitted bodies of water), spas, and swimming pools.
 - 2.5.2.1 Check sanitizer levels, pH, TA and cyanuric acid levels.
 - 2.5.2.2 Check temperature.
 - 2.5.2.3 Complete pages 7 and 8 of 13 on the Environmental Assessment Form.
 - 2.5.2.4 If any condition is noted that necessitates closure of the body of water, the body of water will be closed. If any body of water is closed, then the routine assigned EHS shall be notified.
- 2.5.3 Fountains
 - 2.5.3.1 Check sanitizer levels.
- 2.5.4 Water misters.
- 2.5.5 Hot water heaters.

2.6 Environmental assessment-water sampling

The SNHD *Legionella* Investigation Team shall select and complete water sampling within identified areas, as follows:

- 2.6.1 Room selection will be based on where guest stayed.
- 2.6.2 Samples will be taken from all sinks, bathtubs, showers, or similar fixtures in the room.
 - 2.6.2.1 Any easily accessible thermostatic cold mixing valve on hot water systems that can be accessed without the use of tools will be turned off.
- 2.6.3 Samples shall be taken from the room where the guest stayed.
- 2.6.4 Samples shall be taken from the distal room on the riser where the case stayed.
- 2.6.5 If possible, a sample shall be taken from the return of the hot water loop of the riser where the case stayed.
- 2.6.6 Samples from locations specified in **Section 5.6.2**, in guest rooms will include:
 - 2.6.6.1 A sample of cold water will be taken on first draw.
 - 2.6.6.2 A sample of cold water will be taken after a 1 minute flush.
 - 2.6.6.3 A sample of hot water will be taken on first draw.
 - 2.6.6.4 A sample of hot water will be taken after a 1 minute flush.
 - 2.6.6.5 An environmental swab of each fixture and the corresponding aerator will be taken.

- 2.6.7 Complete data on page 7 of 13 on the Environmental Assessment Form. Log times samples were collected.
- 2.6.8 Bulk water samples taken shall be one (1) liter.
- 2.6.9 If the facility requests split sampling, then the facility will bear the SNHD handling costs that include:
 - 2.6.9.1 Purchase of supplies including, but not limited to, the two (2)-liter sample bottles,
 - 2.6.9.2 Sample processing expenses, and
 - 2.6.9.3 The manpower to assist in conducting such sampling.
- 2.6.10 SNHD will collect a two (2) liter sample in a sterile bottle, then decant one (1) liter of aliquot into the SNHD one (1) liter sample container. SNHD will then decant the remaining aliquot into the third-party sample container.
- 2.6.11 Samples will be packed in insulated containers with frozen cold packs.
- 2.6.12 Samples will be shipped to a CDC ELITE certified laboratory.

2.7 Results of water samples and environmental specimens

The SNHD *Legionella* Investigation Team shall direct the following actions to occur, based on the laboratory results:

- 2.7.1 If a bulk water sample from any guest room fixture has a result of greater than 10 cfu/ml of the target organism in any location, then the riser will be remediated.
- 2.7.2 If samples from two or more different fixtures have a result of less than 10cfu/ml, but do not report as a non-detect of the target organism, then remediation will be required for that riser in the facility.
- 2.7.3 If environmental swabs indicate the presence of the target organism in more than one fixture, then the riser will be remediated.
- 2.7.4 If any water sample or environmental swab returns with results less than 10 cfu/ml, but is the target organism for the specimen used to diagnose the case individual, then the SNHD shall determine what type of remediation is required.
- 2.7.5 Environmental samples collected from areas that are not guest room fixtures must meet the OSHA standards. If the samples do not meet OSHA standards, then remediation of the system will be required.
- 2.7.6 SNHD will review recent facility history to determine if the actions indicated above are appropriate for the facility or if other actions are needed.

2.7.7 If a whole riser remediation is not required by the results of **Sections 5.7.1 to 5.7.5**, then SNHD will instruct the facility to remediate the system in a manner specified by their consultant. SNHD will not supervise this remediation, but will require follow-up sampling of the fixture in the same manner as the initial positive sample.

2.7.8 The following requirements are from the OSHA standard for *Legionella* control:

2.7.8.1 Domestic water=10 cfu/ml or less,

2.7.8.2 Misting water systems=1 cfu/ml or less,

2.7.8.3 Cooling tower water=100 cfu/ml or less.

2.8 Remediation

2.8.1 The sampling results and environmental findings must be reported to the facility in the form of a formal letter. At this time, the facility management shall be notified of additional required sampling within the facility.

2.8.2 Remaining risers/buildings in the facility shall be tested using one (1) percent of all rooms served by that riser/hot water tank.

2.8.3 The facility shall submit plans of remediation to SNHD for review and approval.

2.8.4 After review, SNHD will approve or deny the remediation plans and will communicate its decision to the facility operator. All remediation work will be completed by facility staff and/or consultants and will be supervised by SNHD.

2.8.5 SNHD shall directly supervise all on-site remediation activities.

2.8.6 SNHD shall determine the timeframe in which remediation activities will be conducted.

2.8.7 The facility shall coordinate remediation with SNHD.

2.8.8 Remediation shall be conducted according to best industry practices outlined in ASHRAE Guideline 12-2000.

2.8.9 All fixtures, including service and janitorial sinks, are to be checked by facility staff to ensure proper chlorine and temperature levels are met, as determined by the facility's consultant.

2.8.10 SNHD shall verify that all facility staff members are conducting remediation activities as specified.

2.8.11 The facility is responsible for all costs, including SNHD staff time, for resulting remediation activities.

2.9 Post-Remediation Follow-up Sampling

- 2.9.1** After conclusion of remediation, follow-up sampling will occur using the facility's selected CDC ELITE certified laboratory.
- 2.9.2** One (1) percent of all rooms, along with the distal room, served by the riser that was remediated shall be randomly selected and tested.
- 2.9.3** All fixtures on the remediated water system line(s), post-flush, within the randomly-selected room shall be sampled.
- 2.9.4** All sample results shall be submitted to SNHD.
- 2.9.5** Any additional remediation shall be determined by SNHD using the protocols outlined above in this document.

2.10 Post Investigation Monitoring Schedule

- 2.10.1** One (1) percent of randomly-sampled and distal rooms in the remediated riser of the facility shall be tested on the following schedule:
 - 2.10.1.1** Bi-weekly for three sampling periods (6 weeks).
 - 2.10.1.2** Monthly for three months.
 - 2.10.1.3** Quarterly for three quarters.
- 2.10.2** Room numbers and sample locations shall be provided to SNHD 48 hours (2 business days) prior to sampling.
- 2.10.3** Sample results shall be provided to SNHD and analyzed by SNHD using the protocols outlined above in this document.
- 2.10.4** Any additional remediation required will reset the monitoring schedule back to day one.

*Final version 8/30/12

REFERENCES

- Altman, Lawrence. *In Philadelphia 30 years ago, an eruption of illness and fear*. The New York Times, Aug 1, 2006. Retrieved from http://www.nytimes.com/2006/08/01/health/01docs.html?pagewanted=all&_r=0
- ASHRAE, America Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. ASHRAE Standard. Proposed New Standard 188, Prevention of Legionellosis Associated with Building Water Systems. June 2011
- Berkelman, N. K. *Increasing incidence of legionellosis in the United States, 1990-2005: changing epidemiologic trends*. Clinical Infectious Disease, 2008 Sep 1. 47(5):591-9. doi: 10.1086/590557
- CDC. Legionella (Legionnaire's Disease and Pontiac Fever). Centers for Disease Control and Prevention. Last updated 2/5/13. Retrieved from <http://www.cdc.gov/legionella/fastfacts.html>
- CDC, Centers for Disease Control and Prevention. *Legionellosis - United States, 2000 – 2009*. Morbidity and Mortality Weekly Report (MMWR), 2011 Aug 19. 60(32);1083-1086
- Cleves, M., Guierrez, R., Gould, W., Marchenko, Y. *An Introduction to Survival Analysis Using Stata*. Second edition. Texas: Stata Press, 2008.
- Collier, SA., Stockman, LJ., Hicks, LA., Garrison, LE., Zhou, FJ., Beach, MJ. *Direct*

healthcare costs of selected diseases primarily or partially transmitted by water.

Epidemiology and Infection. 2012 Nov; 140(11):2003-13

Doleans, A., et al. *Clinical and environmental distributions of Legionella strains in France are different.* Journal of Clinical Microbiology, 2004. 42:458-460

ECDC, European Centre for Disease Prevention and Control. European Legionnaires' Disease Surveillance Network (ELDSNet): Operating procedures. Stockholm: ECDC; 2012

Fraser.David, et. al., *Legionnaires' Disease: Description of an Epidemic of Pneumonia.*

The New England Journal of Medicine, December 1977, vol. 297, no. 22

Giambone, G., Giambone, A., Zansky, S. National Cost of Hospitalization for Legionnaires' Disease, 2001-2009. 2013 Annual CSTE Conference. Retrieved from <https://cste.confex.com/cste/2013/webprogram/Paper1490.html>

Green, P. *Efficacy of biocides on laboratory generated Legionella biofilms.* Lett Appl Microbiol 1993; 17:158-61

Harasim,P. *Former Luxor guest dies of Legionnaires' disease.* Las Vegas Review Journal. 1/30/12.

Retrieved from <http://www.reviewjournal.com/life/health/former-luxor-guest-dies-legionnaires-disease>

Heymann, D.L., ed. *Control of Communicable Diseases Manual.* 19th ed. Washington DC: American Public Health Association, 2008

Hornei B, Ewig S, Exner M, Tartakovsky I, Lajoie L, Dangendorf F, et al. Bartrum

- J, Chartier Y, Lee JV, Pond K, Surman-Lee S, editors. *Legionella and the Prevention of Legionellosis*. Geneva: World Health Organization; 2007. pp. 1–27
- Kwait, Yousef, et. al., *Invasion of Protozoa by Legionella pneumophila and Its Role in Bacterial Ecology and Pathogenesis*. Applied and Environmental Microbiology, Sept. 1998, vol. 64 no. 9, 3127-3133
- Lock, K., Millett, C., et. al. *Public health and economic costs of investigating a suspected outbreak of Legionnaires' disease*. Epidemiology and Infection. 2008 Oct; 136(10): 1306-1314
- Kilvington, S., Price, J. *Survival of Legionella pneumophila within cysts of Acanthamoeba polyphaga following chlorine exposure*. J Appl Bacteriol. 1990;68:519
- Marchesi, I., Marchegiano, P., Bargellini, A., Cencetti, S., Frezza, G., Miselli, M., Borella, P. *Effectiveness of different methods to control Legionella in the water supply: ten-year experience in an Italian university hospital*. Journal of Hospital Infection. 77 (2011) 47-51
- Mouchtouri, V., Velonakis, E., Hadjichristodoulou, C. *Thermal disinfection of hotels, hospitals, and athletic venues hot water distribution systems contaminated by Legionella species*. American Journal of Infection Control. 2007 Nov; 35(9):623-7
- Muraca, P., Stout, J., Yu, V. *Comparative assessment of chlorine, heat, ozone, and UV light for killing Legionella pneumophila within a model plumbing system*. Appl Environ Microbiol. 1987;53:447-53
- Murga, R., T. S. Forster, E. Brown, J. M. Pruckler, B. S. Fields, and R. M. Donlan. *Role of*

biofilms in the survival of Legionella pneumophila in a model potable-water system. Microbiology, 2001. 147:3121-3126

Newton, Hayley, et al. *Molecular Pathogenesis of Infections Caused by Legionella pneumophila.* Clinical Microbiology Reviews, April, 2010, vol. 23, no. 2, 274-298

Smith, S., Bernier, T. Legionnaires' disease and Premises Liability. Claims Management.

6/21/13. Retrieved from <http://claims->

management.theclm.org/home/article/Legionnaires-Disease-and-Premises-Liability

SNHD, Southern Nevada Health District, Environmental Health Division Permit and Plan Review Fee Schedule. Approved by the Board of Health on 6/24/2012. Retrieved from <http://www.southernnevadahealthdistrict.org/download/eh/eh-fee-schedule.pdf#search=%22eh>

Snyder, M., Siwicki, M., et. Al. *Reduction in Legionella pneumophila through heat flushing followed by continuous supplemental chlorination of hospital hot water.*

The Journal of Infectious Diseases, July 1990. Vol. 162, No. 1, 127-132

State of Nevada. Legislative Counsel. Nevada Administrative Code. State of Nevada,

2011. 28 January 2012. Retrieved from <http://www.leg.state.nv.us/NAC/NAC-41A.html#NAC441ASec580>

OSHA. OSHA Technical Manual, Section III: Chapter 7; Legionnaires' Disease. 1/20/1999.

Directive Number: TED 01-00-015. Retrieved from

https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_7.html#app_iii:7_3

Steinart, M. *Legionella pneumophila: an aquatic microbe goes astray.* FEMS:

Microbiology Reviews, 2002 June. 26(2): 149-162

Yu, Victor, et al. *Distribution of Legionella Species and Serogroups Isolated by Culture in Patients with Sporadic Community-Acquired Legionellosis: An International Collaborative Survey*. The Journal of Infectious Disease, 2002, 186 (1):127-128

Zacheus, O., Martikainen, P. *Effect of heat flushing on the concentrations of Legionella pneumophila and other heterotrophic microbes in hot water systems of apartment buildings*. Canadian Journal of Microbiology. 1996. 42: 811-818

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Education

Master's of Public Health, 2014

- University of Nevada, Las Vegas, 2011 – present
- Successfully defended thesis project – November 2013
- Completed 33 credit hours in the Graduate program with an emphasis on Environmental Health

Bachelor's of Science in Public Health Education, 2003

- University of Arizona, 1999-2003
- B.S., Public Health Education
- Dean's List
- First place at the 2001 Arizona Public Speaking Conference
- Academic Excellence Award, 2002

Employment

Senior Disease Investigation and Intervention Specialist, 2005-present

Southern Nevada Health District, Las Vegas, NV

- I conduct disease investigations on all reportable illnesses and am familiar with incubation periods, routes of transmission and what steps must be taken to prevent the spread of illness to others as well as what exposures could be the source of infection to each case.
- I am in charge of investigating all human West Nile Virus cases and I work closely with the Vector Control program to trap mosquitoes at case's homes to determine sources of positive mosquitoes.
- I investigate outbreaks, write reports and read through patient charts searching for additional information and cases during investigations.
- I was a team lead for the TriSano project which was a new data collection and disease surveillance system for The Office of Epidemiology (OOE). My responsibilities included working extensively with informatics and IT to analyze the business needs of OOE, develop and design questionnaire forms for all diseases reportable to OOE and included the

creation of approximately 100-150 forms. I also created power point presentations and trained all OOE staff on using the new system and presented the new system to the HIV, STD and TB programs for use in their surveillance. I created wiki pages on sharepoint to provide users instructions and guidance on using the new system.

- I was the primary disease investigator for the 2008 hepatitis C outbreak at a local endoscopy center. I uncovered the association between cases through my investigation and assisted the CDC in compiling information from patients and clinic charts.
- I identify and exclude persons with food borne illnesses from sensitive occupations until they are no longer considered infectious.
- Completed The National Environmental Health Association's Epi Ready Workshop 2007
- I was the principle disease investigator for the 2005 Global Gaming Expo hepatitis A exposure. 26,000 attendees, 1,000 samples given out from the ill vendor, 400 Clark County residents were vaccinated or given IG. All these notifications and logistics were done in a 5 day window of opportunity.
- Servsafe Certified 2005

Program Manager, Public Health Preparedness 2003-2005
Southern Nevada Area Health Education Center, Las Vegas, NV

- Attended grant planning meetings
- Managed the program budget
- Smallpox Vaccinator Training Program development
- Coordinated the training of over 5,500 health care professionals since September 2003
- Collected and evaluated statistical data regarding participant numbers, profession numbers and evaluations
- Coordinated satellite teleconferences
- Created and edited PowerPoint presentations
- Designed program manuals
- Reviewed and completed continuing education applications
- Collaborated with experts to ensure that the programs have the most updated information

Intern, Disease Control Department and the Bioterrorism Program
2002-2003

Pima County Health Department, Tucson, AZ

- Created and presented comprehensive PowerPoint presentations
- Assisted with disease investigations
- Provided new data in the form of graphs, tables and charts to the Surveillance System which monitored disease outbreaks in Pima County
- Field work in lab surveillance and in hepatitis patient homes
- Assisted in the planning and execution of a city-wide bioterrorism disaster drill