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Including a Service Learning Educational Research Project in a Biology Course-II: Assessing Community Awareness of Legionnaires' Disease?

Amal Abu-Shakra[1]

[1]*Department of Biology, North Carolina Central University, Durham NC 27707, USA*
E-mail: aabushak@nccu.edu>

For a university service learning educational research project addressing Legionnaires' disease (LD), a Yes/No questionnaire on community awareness of LD was developed and distributed in an urban community in North Carolina, USA. The 456 questionnaires completed by the participants were sorted into yes and no sets based on responses obtained to the first question on whether the participant has heard of LD, and 194 participants (~43%) answered in the affirmative. For the other nine questions the yes response percentages ranged from 16% - 68%. Using χ^2 analysis, the study showed that the age of the participant was a major factor in enhancing awareness of LD, whereas education was a minor factor at best. Differences in responses among the age groups were strongly significant ($\alpha<0.005$) for general LD awareness, knowledge of its causes and prevalence, as well as body systems affected, prevention and treatment. Significance at the lower level of $\alpha <0.05$ was observed among the different age groups on knowledge of exposure to LD through inhalation of contaminated air (Q5). In fact Q5 was the only question for which the responses of pre-university and university groups varied significantly ($\alpha <0.05$). Interest among the participants in learning more about LD (68%) was higher than in attending a university seminar on the topic (54%). This study provided many educational opportunities to the students to enhance and apply their data analysis skills and to intensify several aspects of their knowledge acquisition and communication skills. Fostering the active involvement of students in an educational activity that can set the stage for an innovative university-community partnership on enhancing awareness of the preventable environmental disease LD is of benefit to all stakeholders.

Keywords: Legionnaires' disease, community awareness, service learning

Introduction

A fatal outbreak of pneumonia associated with the 1976 American Legion convention held at the Bellevue Hotel in Philadelphia, Pennsylvania, USA, introduced the research and clinical communities to the new Legionella species of bacteria and Legionnaires' disease (LD), both named after that tragic moment in time. Fraser et al. (1977) provided an early and comprehensive description of the discovery and major environmental and epidemiological features of Legionella and LD, such as the airborne spread of the bacterium, impact on people present only within close proximity to the contaminated source, lack of person-to-person spread, and possible immunity among people previously exposed to low titers of the bacterium. Several subsequent LD outbreaks in the US and worldwide took place between 1977 and

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2005, when Fraser (2005), in a historical review, described the challenges that were associated with the breakthrough 28 years earlier that led to discovery of *Legionella pneumophila*, as the cause of the fatal LD outbreak of 1976 in Philadelphia, USA.

The Legionella species have been associated with the frequently linked LD, community-acquired pneumonia, hospital-acquired or nosocomial pneumonia, as well as the generally self-limited, influenza-like illness called Pontiac Fever. Furthermore, LD received additional attention recently for mimicking the swine influenza (H1N1) pneumonia (Cunha et al., 2010a; Cunha, Mickail, Syed, Strollo & Laguerre, 2010b). More patients' lives could now be saved thanks to rapid clinical diagnosis of LD, leading to the quick distinction between the two diseases, and resulting in more appropriate treatment.

The age-adjusted incidence rate for Legionellosis (the collective term for LD and Pontiac fever) in the US in 2002 was 0.45 cases per 100,000 residents. This rate, however, underwent an increase since 2003 to 0.75 cases per 100,000 (Neil & Berkelman, 2008), and this increase was observed particularly in the eastern US. The reported risk factors for LD (Den Boer, Nijhof & Friesema, 2006; Neil & Berkelman, 2008) have been categorized as: older age, smoking, male gender, diabetes, chronic lung disease, renal failure and a compromised immune system, among others. Den Boer, Nijhof & Friesema (2006) considered smoking the most consistent and strongest independent host-related risk factor for LD, especially by facilitating infection due to deep inhalation, and due to possible poor physical defense in the airways.

Regarding age, Neil & Berkelman (2008) reported that Legionellosis have become most commonly reported in persons aged 45-64 years, although, in the 1990's the most susceptible age group was older (65-74 years). On the other end of the age spectrum, it has been predicted that the widespread use of Legionella diagnostic tests, would likely lead to increased detection of LD and Legionellosis in children (Greenberg, Chiou, Famigilleti, Lee & Yu, 2006). In addition, in cases of acute pneumonia during pregnancy, albeit rare, an undiagnosed LD involvement was believed to pose serious risk to the safety of mother and fetus (Eisenberg, Eidelman, Arbe & Ezra, 1997; Evenson, 1998).

Several outbreaks of LD or sporadic community-acquired pneumonia worldwide have been attributed to occupational exposure to Legionella. According to Ricci et al. (2010), the telephone workers in Italy have been victims of occupational exposures to LD in the workplace (telephone manholes). Similar associations between occupations and LD were made by Simmons et al. (2008), regarding a water blaster at a marina in New Zealand, and Ishimatsu, Miyamoto, Hori, Tanaka & Yoshida (2001), regarding an industrial cooling tower in Japan. In fact, according to the US Department of Labor's Occupational Safety and Health Administration (OSHA), cooling towers, evaporative condensers, fluid coolers, and other aerosol generators found in industrial, recreational and/or residential settings have been known to create ideal conditions for the Legionella bacterium growth. Outbreaks have been reported in a country club in Atlanta, Georgia, USA, due to an evaporative condenser (Cordes et al., 1979); and in the vicinity of cooling towers in Greece (Mouchtouri, Goutziana, Kremastinou & Hadjichristodoulou, 2010), Turkey (Ozerol et la. 2006) and the United Kingdom counties of Hereford (Kirrage et al. 2007a; Kirrage, Reynolds, Smith & Olowokure, 2007b) and Shropshire (Carr et al., 2010). These aerosol generator-caused outbreaks are in addition to the examples of the industrial cooling tower in Japan (Ishimatsu et al., 2001) and a water feature at a fair in Belgium (De Schrijver et al., 2003).

More recently, travel has become more associated with LD outbreaks (Erdogan, Erdogan, Lakamdayali, Yilmaz & Arslan, 2010). There has been special media attention on cruise ship-associated LD (Centers for Disease Control and Prevention, 2007). LD among other bacterial diseases as well as some viral diseases have been reported to spread in such closed environments, and major efforts have been invested in addressing this serious health risk faced by an ever-increasing number of cruise ship passengers (Guyard & Low 2010; McCarter 2009). Furthermore, being confined to a hospital or health care facility has also been shown to be strongly connected to outbreaks of nosocomial LD (Goetz et al. 1998; Neil & Berkelman 2008; Ozerol et al., 2006; Phares et al 2007; Squier et al. 2005). Intensive and ongoing environmental research has focused on enhancing the laboratory detection of Legionella species in environmental samples (Diederen, 2008; Ishimatsu et al., 2001; Mietzner and Stout, 2002). Den Boer et al. (2007) focused on outbreak detection and secondary prevention of LD, whereas Kool, Carpenter &

Fields (1999) proposed alternative types of disinfection of municipal water sources that could be more effective than chlorination. Such studies underscore the importance of multidisciplinary approaches (Dunn et al., 2007) to this major environmental exposure – environmental health relationship.

Since the aim of the study presented here was to involve students in assessing community awareness of LD, and since the course project was included in a biology course titled “Environmental Problems”, the students went through a variety of pedagogical exercises in the classroom and were engaged in many experiential opportunities in the community, both of which were of major educational value. The students, who were also instructed and guided through the various steps of developing and administering a scientific survey to community participants, used their acquired course knowledge of the topic and their computer skills to become an essential part of a productive dialogue between the university campus and the community. This effort to enhance community awareness of LD represents a novel academic and experiential approach to confront an environmental disease that, despite being not too prevalent and preventable, may still be fatal if ignored.

Methods

In the questionnaire, shown in the Appendix, the questions (Q1-Q10) proceeded from asking whether the participant has heard of LD (Q1) to its causes (Q2), and prevalence (Q3). Assessing awareness of possible personal risk (Q4) perhaps due to inhalation of contaminated air (Q5) represents the introduction to the more intensive environmental health and toxicology questions (Q6-Q8). Knowledge of the body organs most affected by the infections (Q6), precaution and prevention (Q7), and possible treatment (Q8) followed. The final two questions were on the participants’ interest in acquiring additional information on LD (Q9) and whether this acquisition can be in the form of a university seminar (Q10).

The preparation, distribution and administration of the questionnaire, as well as the experimental procedure followed were as described in the preceding paper by the author in this journal on assessing community awareness to childhood lead poisoning (Abu-Shakra & Saliim, 2012). Briefly, the experimental approach involved an initial phase of compiling the collected questionnaires (a total of 456), and then dividing them into two categories based on the responses given to Q1. After this step, the questionnaires went into two groups: The “Y group” in which samples were given the Y prefix followed by the sample number (Y001 – Y194), and the “N group” in which samples were given the N prefix followed by the sample number (N001 – N262). The “Yes” answer to each question was given a value of 1, and the “No” answer was given a value of 0. On each questionnaire, in addition to answering the 10 Yes/No questions, the participant as also asked to circle his/her age range (18-20, 20-30, 30 to 40 or >40) and educational level (secondary, high school, or university). Not providing one or both of these demographic data did not preclude the questionnaire from the study as a whole but only from sections that analyzed the impact of age and/or education as described below.

As shown by Abu-Shakra and Saliim (2012), the prefix devised for the samples that lacked both age and educational level information was “na” followed by the sample number. For the samples that had the age but not the educational level the prefix was “nae” followed by the numeral corresponding to the age group and then the sample number, e.g. nae2N055. The samples that had the educational level, but not the age, had the prefix of the corresponding education level, as shown above, followed by “naa”, e.g. bnaaY136. Statistics on the data was conducted using the Chi square analysis.

Results

The Y group (194) samples were tallied for “Yes” responses to the rest of the nine questions, which were in decreasing order (after Q1=194): Q9 (141); Q5 (130); Q10 (115); Q2 (103); Q3 (96); Q6 (94); Q4 (93); Q7 (78); Q8 (70), as shown in Table 1. It was of interest that among the participants who have heard of LD the majority needed to know more based on the questions posed in this study (Q9). Among the science-based questions, Q5 received the highest number of yes responses (130 or 67%), although the knowledge of the link between the disease and the inhalation of contaminated air did not extend to knowledge of body organs affected, causes, prevention and treatment, which were at ~50% level. Interestingly, in the N group (n=262), Q5 was also the question that received the most Yes responses (74; Table 1) among the science-based questions. In fact when "Yes" responses for all 456 samples were compiled, Q5 had the highest number overall (204/456 which was ~45%; Table 2). Less than one quarter of the participant knew the body organs affected, or the prevention and treatment of this disease. The cumulative responses for Q9 (68%) and Q10 (54%) showed that the participants wished to receive more information and, to a slightly lower extent, to receive it as a university seminar (Table 2).

Table 1. Responses and percentages per question for the Y group and N group

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
In the Y group										
YES	194	103	96	93	130	94	78	70	141	115
% (n=194)	100%	53%	49%	48%	67%	48%	40%	36%	73%	59%
NO	0	91	98	101	60	99	116	124	53	79
Unanswered					4	1				
In the N group										
YES	0	4	7	62	74	15	12	5	170	129
% (n=262)	0%	<2%	3%	24%	28%	6%	5%	2%	65%	50%
NO	262	258	255	196	182	244	249	256	92	133
Unanswered				4	6	3	1	1		

Note: The Y group included all the samples that had "Yes" in response to question #1, and the N group included all the samples that had "No" in response to question #1

Table 2. Cumulative Yes and No responses per question for all 456 samples

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
194	107	103	155	204	109	90	75	311	244
43%	23%	23%	34%	45%	24%	20%	16%	68%	54%

Table 3 lists the samples where participants answered all the 10 questions but chose not to provide the education level (nae; 34 samples); the age (naa; 1 sample), or both (na: 24 samples). These samples were included in the cumulative Table 4 that showed in a grid format the Yes/No response breakdown for each of the education sub-total (n=398 samples), the age sub-total (n=431 samples) and the total number of samples (n=456).

Table 3. Samples that lacked one or both of the demographic information on age and education

naeY	naeN	naY	naN	naa
nae1Y119	nae1N144	naY055	naN068	bnaaY136
nae2Y061	nae1N150	naY056	naN069	
nae2Y062	nae1N179	naY057	naN133	
nae2Y063	nae1N252	naY058	naN141	
nae2Y078	nae2N080	naY135	naN191	
nae3Y014	nae2N083	naY137	naN192	
nae3Y084	nae2N221	naY138	naN193	
nae3Y101	nae2N222	naY171	naN194	
nae3Y181	nae2N233		naN195	
nae3Y185	nae2N250		naN196	
nae4Y016	nae2N253		naN197	
nae4Y094	nae3N012		naN198	
nae4Y124	nae3N014		naN199	
nae4Y125	nae3N070		naN200	
nae4Y179	nae3N071		naN201	
nae4Y182	nae3N132		naN260	
nae4Y184	nae3N244			

Note: The nae prefix was used for the samples that lacked the education information but included age (a total of 34 samples), the naa prefix was used for the samples that lacked age but included the education information (one sample), and the na prefix was used for the samples that lacked both age and education information (a total of 24 samples).

Most of the participants (176) came from the 20-30 years range. The distribution and percentages for all four age groups of the participants in the study are shown in Table 5. Among the education levels groups, most of the participants (255) came from the university-level group. The distribution and percentages for the three education groups are shown in Table 6.

Table 7 shows the impact of age on the responses given to the 10 questions. Using χ^2 statistical analysis, the yes responses to questions Q1, Q2, Q3, Q5 Q6, Q7 and Q8 were shown to be significantly different among the age ranges in the study. Table 8 shows the impact of education level on the yes responses given to the 10 questions. Because the number of participants was extremely low for secondary education, that group was combined with the high school group under the description of pre-university. The only significant difference in responses between the pre-university and university group was observed with question Q5.

Discussion

The service learning educational research project presented here aimed to shed light on the level of awareness in an urban community in North Carolina, USA of LD. Questions Q6 through Q8, which addressed clinically-significant specifics about LD awareness, such as the body systems impacted most by

Table 4. Impact of the demographic aspects of age and education of the cumulative questionnaire data

	1 (<20 yrs)	2 (20-30)	3 (30-40)	4 (>40 yrs)	naa#	Sub-totals for education
b *(university)*						
Y group	7	58	37	36	1	139
N group	27	111	20	7	0	165
g *(secondary)*						
Y group	2	0	0	1	0	3
N group	7	0	1	1	0	9
p *(high school)*						
Y group	8	8	4	7	0	27
N group	25	11	14	5	0	55
						398 (education sub-total)
nae@						
Y group	1	4	5	7	0	17 (not included in sub-total)
N group	4	7	6	0	0	17 (not included in sub-total)
Sub-totals for age	81	199	87	64	1 (not included in age total)	431 (age sub-total)
na$						
Y group			8			
N group			16			
Total Number of Samples =456						

Note: @ nae stands for educational level not available, # naa stands for age not available, and $ na stands for both educational level and age not available.

LD as well as its prevention and treatment, were positioned in the questionnaire just ahead of the education-related (Q9) and service-related (Q10) questions that aimed to gauge the community's readiness to learn more about this serious, albeit not too prevalent, environmental disease. The results obtained indicated that 68% of the participants wished to learn more about LD. Since the main focus of any service learning project is to address a community need, this study succeeded in identifying a community need that a possible university-community partnership can address. Based on the responses to Q10, the planning of any educational effort to enhance the community awareness of LD would include a university seminar on the topic (selected by 54% of the participants). In addition, future efforts in addressing the local community need can include an "environmental problem prevention day" during which information can be provided to the community on LD alongside major environmental health concerns such as childhood lead poisoning (Abu-Shakra & Saliim, 2012) and others. The students can contribute via short presentations, brochures, scientific demonstrations, as well as moderating informal discussions. The educational activities can take place in a community venue in order to provide an informal setting for the participants.

Table 5. Distribution with percentages of the 4 different age ranges of the participants between the Y group and the N group

	<20	20-30	30-40	>40	Total
Y group	18	70	46	51	185
	4%	16%	11%	12%	43%
N group	63	129	41	13	246
	15%	30%	19%	3.0%	57%
Total	81	199	87	64	431[@]
	19%	46%	20%	15%	100%

Note: @ the total number of samples that included the age range (431) was the 456 collected samples less the 24 na samples and one naa sample.

Table 6. Distribution with percentages of the 3 different education levels of the participants between the Y group and the N Group

	Secondary	High School	University	Total
Y group	3	27	139	169
	<1%	7%	35%	43%
N group	9	55	165	229
	2%	14%	41%	57%
Total	12	82	304	398[@]
	3%	21%	76%	100%

Note: @ the total number of samples that included the both the age range and educational level (398) was the 456 collected samples 24 na samples and the 34 nae samples.

The responses to Q4 on whether a participant believed he or she were at risk of LD were of major interest and concern. Among the participants who belonged to the Y group, and therefore were aware of LD, 93 out of 194 believed that they may be at risk of contracting LD, whereas 101 did not, which showed an even split among the participants. In contrast, among the N group, who stated that they have not heard of LD, 62 participants only believed they could be at risk, whereas 196 (more than 3-fold) believed they were not. It is this particular last group that needs most to receive education on LD. In addition, for Q4, the "Yes" responses across age groups and educational levels were in the 27%-40%, and did not show any significant statistical variation (Tables 7 & 8). Because the environmental problem of LD seems to attract the general population's attention only when an outbreak strikes or when a cluster is identified, it would be understandable that the majority of the participants in this study did not believe to be at risk themselves of LD.

Table 7. The Yes responses with percentages to the 10 questions based on age range

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
<20 (n=81)	18 22%	8 10%	7 9%	22 27%	24 30%	9 11%	8 9%	5 6%	51 63%	34 42%
20-30 (n=199)	70 35%	35 18%	37 19%	64 32%	90 45%	35 18%	27 14%	24 12%	137 69%	105 53%
30 -40 (n=87)	46 53%	24 28%	25 29%	35 40%	44 51%	27 31%	24 28%	19 22%	60 69%	50 57%
>40 (n=64)	51 80%	30 47%	26 41%	24 38%	37 58%	30 47%	24 38%	20 31%	53 83%	42 66%
χ^2 (df=3)	$39.9^{\$}$	$29.7^{\$}$	$23^{\$}$	3.1	9.26^{**}	$28.1^{\$}$	$23.6^{\$}$	$20.6^{\$}$	3.04	5.5

Note: Chi Square analysis (χ^2) at degrees of freedom of 3 showing the significance at α<0.005($) and at α <0.05(**)

As was observed by Abu-Shakra & Saliim (2012) in their study on childhood lead poisoning, the largest number of participants in the LD study also came from the university-level group. The main difference between the two studies, however, was the finding that the education level of the participant, which had a significant impact on lead poisoning awareness, had minimal to no impact on LD awareness. It was the age of the participant, especially being at or above 40 years of age, that seemed to furnish consistent and, to a certain extent, sophisticated level of knowledge of LD. It would be safe to conclude that individuals who were born in the 1960s or before may have learned about LD from the strong media coverage in 1976 of the then emerging fatal pneumonia outbreak at American Legion convention in Philadelphia, USA (Fraser et al., 1977). Another assumption could be based on the likelihood that among the middle aged population there may exist heightened awareness of a variety of diseases known to be more prevalent among the older population, of which LD is an example.

Abu-Shakra & Saliim (2012) discussed limitations to their study on lead poisoning awareness that could be extrapolated to other questionnaire-based studies such as the one presented here. Categorizing such limitations can be as follows: (a) questionnaire content-related, e.g. the type of questions asked or demographics targeted, (b) questionnaire administration-related, e.g. sites of distribution, and (c) questionnaire-format related, e.g. language or length. The third limitation, relating to the impact of the chosen language of the questionnaire applies more in this study than the former two on content and administration. In future studies, in order to ensure optimal community representation in the survey, community participants representing the ethnic spectrum will be able to choose between questionnaires prepared in English or Spanish.

Table 8. The Yes responses with percentages to the 10 questions based on education *level*

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Pre-University (n=94)	30 32%	14 15%	15 16%	28 30%	29 31%	17 18%	13 14%	13 14%	56 60%	42 47%
University (n=304)	139 48%	71 23%	70 23%	108 36%	152 50%	72 24%	62 20%	50 16%	219 72%	169 56%
χ^2 (df=1)	3.20	1.68	1.26	0.55	4.46**	0.86	1.06	0.13	1.09	0.79

Note: Chi Square analysis (χ^2) at degrees of freedom of 1 showing the significance at at α <0.05 (**)

The educational impact of this study was observed at many levels. The students learned the science behind LD through the traditional didactic avenues as well as through assignments, namely student-initiated computer-based research on the many health and environmental aspects of LD. Brochures on LD prepared by a previous class were shared with the students for evaluation and assessment. It was of major importance to have the students reach a high level of knowledge on LD before their visits to community venues to distribute the questionnaires. In classroom reflections, students reported situations in which they were asked several thorough questions on LD by the participants after completing the questionnaire. Heightened commitment to the project and the course was reported by the students, and observed by the professor, during enthusiastic class discussions as well as through effective team work.

On the experiential front, the students exhibited a respectful appreciation to being exposed first-hand to the "town-gown divide". Studies such as the one presented here as well as the study by Abu-Shakra & Saliim (2012) empowered the students to play a role in the university-community dialogue, and allowed them to contribute to the bridging that divide.

In conclusion, although LD is not a prevalent environmental disease, it remains a serious and possibly fatal disease if ignored. Therefore, enhancing awareness of LD can be extremely beneficial to those in the community who may one day get exposed to *Legionella pneumophila* occupationally or environmentally, on home ground or on a cruise ship, in a country club or on a farm. In other words, LD can impact any member of the community who happens to be in the vicinity of an outbreak. This feature of the disease underscores the need for education and enhanced awareness of its prevention, symptoms, and prompt treatment.

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Appendix. The Yes/No questionnaire was used to assess community awareness of Legionnaires' disease. The participants were also asked to circle their corresponding age and educational level ranges provided at the top of the questionnaire. The 10 questions addressed causes, prevalence, risks, symptoms, prevention, treatment, and interest in obtaining more information generally and from the university specifically.

Legionnaires' Disease Questionnaire

Please circle your answer:

Age Group: 18- 20 20-30 30-40 Older than 40

Education level: Secondary High School University

1.	Have you heard of Legionnaires' disease?	YES	NO
2.	Do you know the causes of Legionnaires' disease?	YES	NO
3.	Do you know how infectious Legionnaires' disease is?	YES	NO
4.	Do you believe that you are at risk of contracting Legionnaires' disease?	YES	NO
5.	Does Legionnaires' disease happen as a result of inhalation of contaminated air?	YES	NO
6.	Do you know what body organs suffer most from Legionnaires' disease infection?	YES	NO
7.	Are you aware of precautions to take to lessen the risk of Legionnaires' disease?	YES	NO
8.	Are you aware of treatments to cure Legionnaires' disease?	YES	NO
9.	Would you be interested in learning more about Legionnaires' disease?	YES	NO
10.	Would you be interested in attending a seminar on Legionnaires' disease?	YES	NO