NOISE AND VOCAL DOSES ACQUIRED BY AN ELEMENTARY SCHOOL MUSIC TEACHER ACROSS NINE DAYS: A DESCRIPTIVE CASE STUDY

By

Jennifer L Berroth

Submitted to the graduate degree program in Music Education and Music Therapy

and the Graduate Faculty of the University of Kansas

in partial fulfillment of the requirements for the degree of

Master of Music Education

____
Dr. James F. Daugherty, Chairperson

____
Dr. Julia Broxholm

____
Dr. Christopher Johnson

Date Defended: May 13, 2016

The Thesis Committee for Jennifer L. Berroth

certifies that this is the approved version of the following thesis:

NOISE AND VOCAL DOSES ACQUIRED BY AN ELEMENTARY SCHOOL MUSIC

TEACHER ACROSS NINE DAYS: A DESCRIPTIVE CASE STUDY

____

Chairperson Dr. James F. Daugherty

Date approved: May 13, 2016

Abstract

The purpose of this descriptive case study was to assess the status of vocal (KayPentax APM) and noise (Etymotic ER200D dosimeter) dosages acquired by an elementary school music teacher (*N*=1) during waking hours across (a) a full teaching week (5 days) and (b) 2 weekends (4 days), one prior to and one and after the teaching week. Various studies to date have examined vocal dosages acquired by music teachers. Other studies have analyzed noise dosages acquired by music teachers. No study, however, has yet examined vocal and noise dosages acquired simultaneously by the same music teacher. Primary findings indicated: (a) mean vocal distance doses and noise doses acquired during teaching hours exceeded doses acquired during non-teaching hours; (b) the most elevated D_d and noise dosage levels occurred during choir rehearsals and sixth grade general music classes; (c) the participant exceeded recommended NIOSH noise doses on 4 of the 5 teaching days. (d) comparison of noise dose percentage and vocal dose percentage during teaching hours indicated, overall, that voice dose percentage appeared to align directionally with noise dose percentage; (e) however, there were some class periods where vocal dose percentage exceeded noise dose percentage. These results were discussed in terms of proactive voice and hearing care for elementary school music teachers, possible relationships between acquired vocal and noise doses, limitations of the study, and suggestions for future research.

ACKNOWLEDGMENTS

This thesis would not have been possible without tremendous support and encouragement from several very important people. First, and foremost, I would like to thank my advisor, Dr. James F. Daugherty for his continuous mentorship, counsel, encouragement, and wisdom throughout this entire project. In the past two years while attending his classes, I have grown so much as an educator and choral director. Words cannot express my gratitude to him for all he has done to help me make the most of my journey in earning my Masters degree.

Dr. Julia Broxholm was my voice teacher and committee member. I am very grateful for all of her time and energy that she has spent helping me to develop my singing technique and performance chops. Our summer sessions always left me feeling inspired.

Dr. Christopher Johnson was my professor and committee member. He has helped me to remember to laugh, remain positive, and persevere even through difficult times. I will always remember his infectious smile.

I must extend my deepest thanks to Steve Scott, Alan Martin, and Evan Edwards, fellow graduate students and friends in the School of Music at the University of Kansas. This project would not have been possible without their help and I am so thankful for their freely given time.

Finally, I thank my parents, extended family, and friends who were my constant cheerleaders. They were all unwavering in their support of me pursuing my dreams and none of this would have been possible without their love and encouragement.

Table of Contents

List of Figures

List of Tables

CHAPTER 1

Introduction

Voice and hearing are intimately related. Sufficient auditory feedback from one's own voice plays an important role in pitch control and the physiological efficiency of vocal production (Howell, 1985). The relationship between phonation and hearing may be especially germane for classroom music teachers. Like other schoolteachers, music instructors typically employ their voices throughout the school day with few opportunities for vocal rest. Classroom music teachers, however, also promote student music-making, sometimes in less than ideal room acoustical environments. Thus, these teachers may be susceptible to excessive noise exposures as well as vocal stress.

Occupations at Risk

People in various occupations rely on their voices to do their jobs. The National Center for Voice and Speech (1993) estimates that 25% of the American working population considers voice use a critical aspect of their jobs. Williams (2003) reviews literature regarding groups at increased risk of developing occupational voice disorders. Teachers, singers, and aerobics instructors are among the more prevalent in experiencing voice problems.

According to The National Center for Voice and Speech (2013), teachers make up about 16 percent of the 37 million persons in the United States who are considered “occupational voice users.” For many teachers, regularly losing their voices may be viewed as just part of their job.

Smith, Kirchner, Hoffman, and Lemke (1998) report that out of 554 teachers surveyed, 38% think that teaching negatively affects their voices. Thirty-nine percent of the teachers mention having difficulty with teaching lessons because of voice problems. Some of the responding teachers report having surgery to remove vocal nodules and polyps.

Preciado J.A., Garcia Tapia R., and Infante J.C. (1998) try to identify the risk factors for voice disorders in teachers using a case-control study, including interviews, ENT examination, videostrobolaryngoscopy, perceptual evaluation of hoarseness, basic aerodynamic tests, the physical range of phonation, and a physical analysis of the acoustic signals. The results show that teachers in lower grade levels have a higher risk. Other factors associated with an increased frequency of vocal disorders are the physical size of the classroom, larger student numbers, longer classroom hours, and higher noise levels.

Niebudek-Bogusz and Sliwinska-Kowalska (2014) compile an overview of occupational voice disorders in Poland. In 2000, the newly registered voice disorders make up about 34% of all certified occupational disorders with teachers being the main voice disorder occupation. The total number of occupational voice disorders drop dramatically from 2000 to 2011. The authors attribute the declining trend in voice disorders to socio-economic changes in the teaching profession, improvement in the methods of voice assessment, and implementation of numerous preventative programs.

Male and Female Voices: Sex Distinctions

Research suggests that women have more voice disorders than men (Roy, Merrill, Thibeault, Parsa, Gray, & Smith, 2004, 2005). The difference in quantity voice disorders between sexes extends to occupational voice users such as teachers, singers, and customer service workers (Sliwinska-Kowalska, M., Niebudek-Bogusz, E., Fiszer M., Los-Spychalska T., Kotylo P., Sznurowska-Przygocka B., 2006; Smith, Kirchner, Taylor, Hoffman, & Lemke, 1998).

According to Hunter, Tanner, and Smith (2009), potential causes of this difference between sexes may include laryngeal physiology, hormone differences, other non-laryngeal physiology, and non-physiological or behavioral characteristics. Female vocal folds are, on average, 60% shorter than male vocal folds in the anterior-posterior dimension, which is one of the primary reasons for women's higher average fundamental frequency (F_0) (female MF_0 is 190 Hz while male MF_0 is 120 Hz). This difference in F_0 may increase women's risk for voice disorders because a higher F_0 results in more vocal fold oscillations and collisions for an equal amount of voicing. Other studies (Amir, Kishon-Rabin, & Muchnik, 2002; Amir & Kishon-Rabin, 2004; Amir, Biron-Shental, & Shabtai, 2006) suggest that hormonal fluctuations can also contribute to an increase in vocal fatigue, decreased range, and loss of vocal power and high harmonics.

Male lungs have higher static recoil during exhalation than do female lungs. Data also suggest that women require a higher percentage of lung volume used to create an equivalent lung pressure, a necessary driving force of vocal fold vibration (Stathopoulos & Sapienza, 1993).

Hunter and Titze (2010) report vocalization trends in male and female teachers using a voice dosimeter. First, female teachers phonate 10% more than males at work. Further, female teachers' non-occupational phonation is 7% more than male teachers, reinforcing the need to quantify women's additional non-occupational vocal load. In a study on teacher voice problems (Van Houtte, Claeys, Wuyts, & Lierde, 2011), female teachers report seeking medical help for their voice more than male teachers.

Factors in the Classroom

There are many factors that can contribute to teachers wreaking havoc on their voices. One of those factors is the number of students in classroom. Larger classroom populations may result in increased noise, which, in turn, may require more frequent or more intense teacher voicing. There are numerous studies regarding the noise level environment of the classroom (e.g. Bernstof &Burk, 1996; Cezar-Vaz, de Oliveira Severo, Borges, Bonow, Rocha, & de Almeida, 2013; Grebennikov, 2006; Yiu, & Yip, 2015) regarding classroom environmental noise levels. Research on background noise levels and their effect on the speaking voice dates back to 1949 when Hanley and Steer found that in the presence of masking noise, speakers reduce their rate of speaking and increase the duration and intensity of their utterances. As a 23 year veteran teacher puts it, “Probably by the middle of the week, by the end of the week, I would lose my voice, just from usage. The acoustics in the classrooms are not that good and when you’ve got a class of 30 kids, you’ve got to reach the ones in the back.”(nbcnews.com, 2013)

Vilkman (2000) suggests that one hazard associated with vocal health in teachers is “bad classroom acoustics (p.123).” McKay (1964) discusses factors to consider during the planning stage of school room construction. Good rehearsal rooms for large musical groups, for instance, must have at minimum 15 ft high ceilings. McKay points out that carpeting may make other acoustic treatment unnecessary because it cuts down on footfall and chair scraping. Controlling air flow and other masking noises can be useful in offices, classrooms, and small spaces. McKay states that thicker, absorptive materials may be needed to control excessive reverberations in music rooms.

Noise Induced Hearing Loss among Musicians

Experts argue that sustained exposure to noises exceeding 85dB will damage hearing for good (Texas Department of Insurance, 2015d). A typical conversation occurs at 60dB, which is not loud enough to cause damage. Kansas City Chiefs fans hold the Guinness Book of World Records for the loudest crowd roar of 142.2 dB (Guinness World Records, 2014). Noise Induced Hearing Loss (NIHL) is caused by a prolonged exposure to loud noise (American Hearing Research Foundation, 2012). Loud sounds can damage microscopic hair cells that line the ear.

These hair cells do not grow back and therefore there is no cure for NIHL. One early sign of hearing loss is tinnitus. (National Institute on Deafness and Other Communication Disorders, 2015). Tinnitus is the perception of sound when no sound is present. This condition is also referred to as “ringing in the ears.”

The ears are considered a primary tool for any musician so it is very ironic that numerous studies show that professional musicians are more likely to experience NIHL than the non-musician. Studies show that rock and classical musicians are at a higher risk for music related hearing loss than other types of musicians. One study (Pawlaczyk-Luszczynska, Dudarewicz, & Zamojska, 2010) shows that orchestra members are exposed to 81-90 dB for 21-48 hours a week, despite an established safe threshold of loudness at 85dB for 30 minutes a day. Another study (Jacob, 2014) states that professional musicians are 3.6 times more likely to suffer noise induced deafness. Professional musicians are also 57% more likely to suffer tinnitus. Legendary musicians such as Ozzy Osbourne, Neil Young, and Phil Collins quit music due to medical issues including hearing loss.

Noise Induced Hearing Loss among Music Teachers

Some of the largest classrooms with larger student numbers and higher noise levels can be the music room because students are exposed to many musical elements. Students explore playing instruments, singing, and dancing. Elementary music teachers often utilize audio tracks, pianos, and hand instruments as a part of their daily instruction. Choir, general music, and band classrooms can exceed safe listening levels leaving music teachers vulnerable to NIHL (Science Daily, 2004).

Numerous studies show that music room noise levels may reach or exceed the National Institute for Occupational Safety and Health (NIOSH) occupational exposure limits. In a health hazard evaluation report, NIOSH (2012) looked at elementary and high school music noise levels. In one band rehearsal the decibel levels reached as high as 110 decibels. The band director's full-shift noise exposure reached and exceeded occupational exposure limits. In another study (Zivkovic & Pityn, 2004) researchers suggest that practice spaces be acoustically designed for musical purposes as well as be sized appropriately for the number of students.

Standards of Noise Exposure

The American Speech-Language-Hearing Association's (ASHA's) Working Group on Classroom Acoustics (2004) recommends that an appropriate acoustical environment be established in all classrooms and learning spaces. ASHA endorses the American National Standards Institute (ANSI) standards and recommends the following criteria for classroom acoustics:

1. Unoccupied classroom sound levels must not exceed 35 dBA
2. The signal-to-noise ratio (the difference between the teacher's voice and the background noise) should be at least +15 dB at the child's ears.
3. Unoccupied classroom reverberation must not surpass 0.6 seconds in smaller classrooms or 0.7 seconds in larger rooms.

OSHA vs. NIOSH Noise Exposure

The Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) have different recommended limits on noise exposure in the workplace. With noise, OSHA's permissible exposure limit (PEL) is 90 dBA for all workers for an 8 hour day (United States Department of Labor, 1981). The OSHA standard uses a 5 dBA exchange rate. This means that when the noise level is increased by 5 dBA, the amount of time a person can be exposed to a certain noise level to receive the same dose is cut in half. NIOSH (1998) recommends that all worker exposures to noise should be controlled below a level equivalent to 85 dBA for eight hours to minimize occupational noise induced hearing loss. NIOSH states that significant noise-induced hearing loss occurs at the exposure levels equivalent to the OSHA PEL based on updated information obtained from literature reviews. NIOSH also recommends a 3 dBA exchange rate so that every increase by 3 dBA doubles the amount of the noise and halves the recommended amount of exposure time.

Daugherty, Nelson, Rollings, Grady, and Scott (2015) state that any degree of hearing loss should be a matter of grave concern. Small university practice rooms, where many graduate teaching assistants teach voice lessons, may expose students to exceedingly high amounts of noise exposure within a few hours of teaching lessons. Their recommendations for reducing the level of noise exposure are larger spaces for teaching lessons, receiving hearing tests, arrange voice lesson schedules in order for days when teachers do not engage in other rehearsals, and consider wearing protective hearing protection whenever the daily noise dose from all sound sources exceeds 50% of the permissible dose.

Further Education

Educators are starting to become more proactive in learning how to prevent vocal fatigue. Bistrizki and Frank (1981) compare two groups, one group having no voice education while the other received one hour per week of education for a year. An increase of incidence in vocal fatigue is present with the group that did not receive any education.

Schloneger (2011) documents graduate student voice use before, during, and after an intense week of opera rehearsals. The graduate students are teaching assistants and also teaching lessons through-out the week. The graduate students have higher vocal doses during their teaching times than at any other time during the recorded waking hours. Schloneger points out that the students do not show any effects from the teaching time periods partly because they were very aware of their vocal activities and adjusted their phonation activity based on their vocal health and demands. The discussion focuses on vocal health education and whether training might prevent teachers from developing voice problems. Only a few studies have tried to gain knowledge on long term preventative vocal education programs.

Need for the Present Study

A growing body of research to date employs ambulatory phonation dosimetry to objectively measure teacher voicing behaviors in various settings. Similarly, a growing body of research documents noise exposures acquired by teachers in various environments.

To date, however, no study documents simultaneously in the same elementary school music teacher acquired vocal and noise dosages across nine days (a full, five day teaching week plus weekends before and after the teaching week). Data from such a study could interest music educators, especially elementary school music teachers who typically instruct a variety of musical activities, including singing, playing instruments, and musical movement. Data from such a study may also be of interest to laryngologists, speech-language pathologists, and audiologists who may treat teachers experiencing vocal fatigue and hearing loss.

Purpose Statement

The purpose of this descriptive case study was to assess the status of vocal (KayPentax APM) and noise (Etymotic ER200D dosimeter) dosages acquired by an elementary school music teacher (N=1) during waking hours across (*a*) a full teaching week (five days) and (*b*) two weekends (four days), one prior to and one after the teaching week.

Research Questions

To that end, the following research questions directed guided this case study:

1. What do APM data indicate about the participant's phonation behaviors (F_0, time dose, distance dose) across nine days of varying activity, including disaggregations according to teaching versus other time periods?

2. What does a noise dosimeter indicate about the participant's noise levels acquired by the participant across nine days of varying activity, including disaggregations according to teaching versus other time periods?

3. Do acquired APM and noise dosimeter data suggest any relationship trends between participant voicing behaviors and noise exposures that might merit further research?

4. What do results of a Multi-Dimensional Voice Profile (MDVP) analysis administered prior to and after the study period indicate about the acoustical parameters of the participant's voice?

Definitions

Ambulatory phonation monitor (APM). A portable device that allows objective documentation of voicing during a specified period of time. Specifically, the APM measures the amount of time a participant has phonated, when the phonation occurred, and provides the participant's vocal intensity (dB SPL) and fundamental frequency (F_0) during all phonation activity.

Cycle Dose (D_c). The measurement of the number of oscillations of the vocal folds. The D_c depends both on F_0 and the total phonation time.

Distance Dose (D_d). The distance that tissue particles of the vocal folds travel in an oscillatory trajectory.

Fundamental Frequency (F_0). The lowest harmonic of sound, more or less the equivalent to the perceived pitch.

Lombard effect. The involuntary tendency of speakers to increase their vocal effort when speaking in loud noise to enhance the audibility of their voice. This change includes not only loudness but also other acoustic features such as pitch, rate, and duration of syllables. This compensation effect results in an increase in the auditory signal-to-noise ratio of the speaker's spoken words.

Perturbation. The irregularity of vibration of the vocal folds, often referred to as vocal jitter or vocal shimmer. If the irregularity is in the frequency of vibration, it is called jitter. If the irregularity is in the amplitude of vibration, it is called shimmer.

Sound Pressure Level (SPL). The average overall SPL in decibels provides an indication of the strength of the vocal fold vibration.

Time dose (D_t). This is the same as voicing time and measures the total time the vocal folds have spent vibrating.

Vocal Loading. A combination of prolonged voice use and additional loading factors (background noise, acoustics, air quality) affecting the fundamental frequency, the type and loudness of phonation, and the vibratory characteristics of the vocal folds.

CHAPTER 2

Review of Literature

This chapter reviews verifiable research literature related to vocal health among music educators and noise levels in a classroom environment. This chapter begins by examining occupation risks between teachers and the general population, male teachers versus female teachers, and voice disorders relating to music teachers. Thereafter, this review examines studies relating to specific factors relating to voice disorders and studies regarding education and awareness of vocal health among teachers.

Teachers vs. the General Population

Smith, Gray, Dove, Kirchner, and Heras (1997) surveyed primary, secondary teachers (n=240), and non-teacher (n=178) groups to compare voice symptoms in their occupation. The researchers found that 15 % of the teachers were more likely to report having a voice problem compared to 6% of those in other occupations. Researchers identified ten specific voice symptoms such as hoarseness, difficult high notes, tired voice, and a low speaking voice. Five physical discomforts were also identified from the survey: tiring, effortful, scratchy, ache, and an uncomfortable voice. This study determined that more than 20% of teacher participants reported missing work due to their voice symptoms versus non-teacher participants, who never missed a workday. The survey also indicated that for 4.2% of teacher respondents, their voice problems had prompted them to consider a job change.

McAleavy, Adamson, Hazlett, Donegan, and Livesey, (2008) used structural equation modeling to quantify the relative contributions of behavioral, environmental, and psychological factors to the self-reported vocal health of teachers, with a view to identifying preventative actions. The researchers did a cross-sectional survey of teachers (N=217) across 69 primary and secondary schools. They collected participant self-reports of voice quality, the frequency with which they perform a series of voice related behaviors, the quality of the environment in which they worked, their feelings about their vocal behavior, and their anxiety rating as measured by the State-Trait Anxiety Inventory (STAI) questionnaire. Data indicated that voice-related behaviors, teachers' work environment, and the presence of trait anxiety had a significant influence on the participants' vocal health. The model also indicated that the quality of the voice was related strongly to how the respondents felt about the condition of their voice, which, in turn, had an indirect reciprocal effect on the quality of teachers' perceived vocal health. The researchers suggested that the results should be considered in relation to rethinking policy and practice with the intention of identifying preventative actions to improve the vocal health of professional educators.

Van Houtte, Claeys, Wuyts, and Lierde, (2011) surveyed teachers (N=994) about vocal complaints, and knowledge of vocal care, treatment seeking behavior, and voice related absenteeism. In addition, 290 non-teacher participants served as control subjects because their jobs did not involve vocal effort. Comparisons were made between teachers with and without vocal complaints and with the control group. Teachers reported significantly more voice problems (51.2%) versus the control group (27.4%). Female teachers had significantly higher levels of voice disorder (38%) compared to the male teachers (13.2%). Approximately one fourth (25.4%) of participants sought medical care, and eventually 20.6% had missed at least one day of work due to their voice problems. Finally, only 13.5% of all the teachers had received voice care information during their education.

Spielman, Hunter, Halpern, and Titze (2012) assessed self-ratings of the Inability to Produce Soft Voice (IPSV) for tracking vocal improvement in teachers (N=11) with general voice complaints, during and after voice therapy. One group of the teachers received vocal training designed to strengthen the voice and improve vocal fold closure. The second group received voice amplification systems. The IPSV rating was used as a means to discern vocal swelling. The participants were asked to rate their ability to perform four simple vocal tasks as quietly as possible at a high pitch. The results from the IPSV ratings indicated that the participants who received direct voice treatment improved their ability to produce soft voice over time.

Remacle, Morsomme, and Finck (2013) compared the vocal loadings of 12 kindergarten teachers to 20 elementary teachers with voice problems. The researchers monitored the teachers for one week using an APM that measured fundamental frequency, sound pressure levels, time dose, distance dose, and cycle dose. Data showed that both the kindergarten and elementary teachers spoke with higher fundamental frequency and louder sound pressure levels in their professional environments than in their non-teaching environments. Kindergarten teachers spoke with an average fundamental frequency of 268 Hz while elementary teachers had an average fundamental frequency of 253 Hz. Sound pressure levels were higher for kindergarten teachers at an average 81.7 dB, and elementary teachers showed an average SPL of 79.9 dB. The study also looked at both groups non professional vocal loading. The teacher's vocal folds vibrated more than 1 million times during a work day plus an additional half a million times after work. The researchers thought it was important to take the non-professional data into account when considering the amount of vocal loading with teachers who already presented voice problems.

Male Teachers and Female Teachers

Two studies (Roy, Merrill, Thibeault, Parsa, Gray, & Smith, 2004; Smith, Kirchner, Hoffman, & Lemke, 1998). found that female teachers seem to show a higher prevalence of voice disorders over male teachers Roy, et al interviewed teachers (n=1,243) and non-teachers (n=1,288) by telephone using a voice disorder questionnaire. The researchers discovered the prevalence of reporting a current voice problem was significantly greater in teachers (11%) compared with non-teachers (6.2%). Women, compared with men, not only had a higher lifetime prevalence of reported voice disorders but also had a higher prevalence of chronic voice disorders (>four weeks in duration).

Smith, Kirchner, Hoffman, and Lemke (1998), compared a large sample of male (*n*= 274) and female teachers (*n*= 280) for differences associated with frequency of voice symptoms and the association between symptomatology and teaching-related activities, coursework taught, work impairment, and absenteeism. The same symptoms seen in other studies were identified by teachers in this study as well: hoarseness, tired voice, and a lower speaking voice. Many results of the study did not vary between participating male and female teachers; however, females reported a higher average number of voice symptoms and physical discomforts compared to males.

Voice Disorders in Music Teachers

Miller and Verdolini (1995) used a questionnaire format to ask singing teachers (*N*=125) as well as control subjects (*N*= 49) to assess the frequency of past and current voice problems. The results revealed that 21% of singing teachers perceived they had a voice problem. Teachers of singing were more likely to report having a voice problem than the participants who served as controls (64% to 33%). Having a past voice problem also increased the likelihood of reporting a current voice problem.

Morrow (2009) investigated the differences in voice-use profiles between elementary music teachers and elementary classroom teachers relative to phonation time, fundamental frequency, and vocal intensity. The study also investigated how music teachers perceived issues surrounding job-related voice use. Seven elementary music teacher and five elementary classroom teachers wore APMs for five full teaching days. Data collected showed that the music teachers averaged greater than 54 % more collisions (cycle dose) than classroom teachers. The music teachers also averaged 90% larger distance doses compared with classroom teachers. The distance dose for the music teachers was an average of 4.35 miles while the classroom teachers averaged 2.29 miles.

Hackworth (2010) used email and the social media page, Facebook, to gather demographic information, vocal health ratings for selected behaviors related to vocal health, and ratings of perceived vocal stress in selected teaching activities of music teachers (*N*=379). Hackworth used multivariate analysis of variance (MANOVA) procedures to determine whether the joint effect of years of teaching experience (pre-service or experienced) and specialty (vocal or instrumental) influenced ratings in each behavior and teaching activity category. Experienced music teachers (n=208) had a higher rating of speaking in noisy environments over pre-service teachers (*n*=171). Vocalist (*n*=198) also demonstrated a higher rating of speaking in noisy environments compared to instrumentalists (*n*=181). Vocalists tended to use more verbal instruction over noisy environments such as lunch duty and speaking while students were singing.

Voice Amplification

Voice amplification is one tool that music teachers have begun to use as a means of reducing their vocal load while teaching. Morrow and Connor (2009) compared voice-use profiles of elementary classroom teachers (*n*=5) and elementary music teachers (*n*=7). Music teachers were monitored for one week using an ambulatory phonation monitor and then monitored a second week while they used a vocal amplification unit. Results indicated music teachers had larger averages in variables of total phonation time, fundamental frequency, and vocal intensity (48% more phonation time and 62% more cycle dose than classroom teachers). Without amplification, music teachers were raising their fundamental frequency so they could sing with students or be heard over noisy environments. When the music teachers used the voice amplification unit, there was a significant decrease in mean vocal intensity, cycle dose, distance dose, and mean phonation time.

Gaskill, O'Brien, and Tinter (2012) looked at two elementary classroom teachers, one with a history of vocal complaints and one without such complaints. Both teachers wore a vocal dosimeter at school for a period of three weeks. Week two also included wearing a portable voice amplifier. In that week, both teachers showed a reduction in vocal load. There was a larger reduction in vocal load for the teacher who had a history of vocal difficulties. The same teacher also showed a decrease in hourly vocal fold distance dose that was measured by the dosimeter, even though the teacher still demonstrated longer phonation times.

Noise Dose and Vocal Dose

Cezar-Vaz, de Oliveira Severo, Borges, Bonow, Rocha, and de Almeida (2013) identified occupational characteristics and their potential implications for the occurrence of voice disorders among teachers in early childhood and primary education. The participants were 37 teachers in Brazil, all female. Data were collected using a closed, self-applied multiple choice questionnaire. The questionnaire addressed variables related to vocal health, including environmental characteristics of the school, voice disorders, and vocal health care measures. The teachers did not indicate certain environmental factors such as dust, humidity, ventilation, and temperature as risk factors of their vocal health, but 48.6% of them did identify noise as a possible trigger of voice disorders.

Summers, Pisoni, Bernacki, Pedlow, and Stokes (1988) studied the effects of noise on speech production; acoustical and perceptual. Their two speakers were found to increase word amplitude, fundamental frequency, and word duration when background noise was increased. Saniga and Carlin (1991) found that in the presence of noise, individuals with voice disorders may increase their vocal intensity significantly more than those who don't have voice disorders.

Bernstof and Burk (1996) studied the vocal integrity of elementary vocal music teachers (N=45): personal and environmental. Their purpose was to examine the predictive ability of three factors associated with professional voice use in elementary music teaching to predict scores on a self-rated index of vocal integrity (Voice Conservation Index). Factors were: (a) percentage of life span teaching, (b) teaching schedule, and (c) specific dosimetric measures of classroom noise. A significant relationship was found between max classroom noise levels and VCI pathology scores. Maximum noise levels were as high as 98.6dB- 117.4dB with these elementary music teachers spending approximately seven hours a day in these conditions. Bernstof and Burk point out that these factors require further investigation to determine the number of times of day and types of teaching activities during which teachers are exposed to these types of noise levels. The researchers argued the results suggested the need for in-service training regarding vocal use habits and teaching strategies for noisy environments.

Grebennikov (2006) investigated 25 full time preschool teachers in Australia while they were exposed to preschool classroom noise settings. The ambient noise level was monitored using high-quality personal 'Casella'sound exposure meter, model CEL-310/K1, which is designed to meet the standards of the National Code of Practice (2000). The participants were monitored for one day or 5-5.5 contact hours. Data collected showed the highest individual noise exposure levels were at 85.0, 85.1, 85.8, and 86.1 dB(A). Nine of the staff recorded peak noise rates that exceeded the maximum permissible level of 140 dB(C) for peak noise. Ten staff members were subjected to noise beyond the maximum acceptable levels under Australian standards. The highest levels of noise were recorded when a large number of students were located in a confined space, e.g. during music time and when students were playing with instruments.

Pelegrin-Garcia, Smits, Brunskog, and Jeong (2011) studied the vocal effort by changing talker-to-listener distance in acoustic environments. The researchers looked at four acoustically different rooms with thirteen male speakers addressing a listener at four distances. Volume, reverberation time, room gain, speech transmitted index between talker's mouth and ears, and background noise levels were measured in the rooms. Results showed that speakers raised their vocal intensity between 1.3dB-2.2dB per double distance to the listener. There was a variation in mean fundamental frequency, both across distances and among environments. However, speakers felt they had to raise their vocal intensity in the anechoic room. The researchers suggested the study showed a room that provides vocal comfort requires a compromise between room gain and speech transmitted index, supporting the voice from the talker but not degrading the perceived speech quality.

Nehring, Bauer, and Teixeira (2014) verified the sound intensity of music used by dance teachers (N=35) in dance classes. The researchers collected data through participant questionnaires and measuring sound intensity levels in the beginning, middle, and end of dance classes. Average sound pressure levels showed the beginning of dance classes to be around 80.91 dB(A), middle of dance class was 83.22 dB(A), and the end of classes at 85.19 dB(A). The researchers summarized that professionals exposed to high intensity music at the work place should be informed about the importance of using music at appropriate SPLs.

In 2014, Matthew Schloneger assessed 19 college students on their voice use, voice quality, and perceived singing voice function. The participants were enrolled in voice lessons and choir. Data was collected over three full days using an ambulatory monitor, acoustic and accelerometer transducers, and multiple Evaluation of the Ability to Sing Easily (EASE) questionnaires. Schloneger found major findings in the participants. Students had higher vocal doses correlate significantly with greater voice amplitude, more vocal clarity, and less perturbation. There were significant differences in vocal dose and voice quality among non-singing, solo singing, and choral singing periods. Schloneger also analyzed repeated vocal tasks with the acoustic transducer and found increases in fundamental frequency, perceived pitch, speaking phonation level, and resonance measures from morning to afternoon to evening. From the EASE questionnaire, the results displayed a less perceived ability to sing easily correlated positively with higher frequency and lower amplitude when analyzing repeated vocal tasks with the acoustic transducer. In the conclusion of the study, Schloneger pointed out that students were surprised to learn that their greatest amount of voice use came during their non-singing periods. He urged pedagogues and voice teachers to pay attention to students overall schedules and avoid too much potential vocal activity in one full day.

Yiu and Yip (2015) investigated the effects of environmental noise on the production of vocal intensity and fundamental frequency. Their study involved 24 adults recording a monologue passage in three natural environments: 1) quiet room of 35.5 dBA, 2) moderate level room of 54.5 dBA, and 3) high noise room of 67.5 dBA. Results from the study showed significantly higher vocal intensity, fundamental frequency, and vocal effort when the mean background noise increased from 35.5 dBA to 67.5 dBA. Researchers noticed Lombard effects were demonstrated under situations with high- background noise levels.

Classroom Acoustics

Kob, Behler, Kamprolf, Godschmidt, and Neuschaefer-Rube (2008) investigated the influence of room acoustics on the teacher's voice. Teachers (*N*=50) were asked to speak in classrooms with different acoustic qualities. Some rooms received treatment to become optimized classrooms while other rooms remained untreated. The optimized rooms seemed to exhibit a quieter atmosphere and subjectively assessed less background noise levels. Teachers' fundamental frequency decreased by 4 Hz after teaching under what the researchers determined as "good" room acoustical conditions and slightly increased by .4Hz after teaching under "poor" room acoustical conditions.

Brunskog, Gade, Bellester, and Calbo (2009) investigated six rooms of differing sizes and the voice sound power by speakers and the speakers' subjective judgments about the rooms. Four parameters were picked to characterize each room: room gain, reverberation time, room volume, background noise level. The authors found the average vocal intensity used by teachers in different classrooms is closely related to amplification of the room on the talker's perceived own voice (room gain). Reverberation time and background noise levels were not found to be significant in this case.

Ryan and Mendel (2010) measured the acoustic environments of unoccupied indoor and outdoor physical education settings (*N*=22) in order to compare the ambient noise levels to standards established by the American National Standards Institute (ANSI) and American Speech-Hearing Association (ASHA). ASHA and ANSI set their decibel standards at 30 dBA and 40 dBA, respectively. The mean unoccupied level ambient noise level for all 22 settings was 52.0 dBA with a range of 38.1-61.3 dBA. Outdoor settings produced a mean score of 50.5 dBA, the gymnasium setting produced a mean score of 50.6, and covered area settings produced a mean score of 56.1 dBA. Only one setting had background noise levels at or below 40 dBA. This room had been built within the past ten years, had carpet, and was the only room in the study to possess any type of acoustic treatment.

Bottalico and Astolfi (2012) investigated the vocal doses and parameters of six different schools and 40 primary classroom teachers. The schools were divided into two groups of three schools based on the type of building and their mid-frequency reverberation time in the classrooms. Both groups had a higher mean of background noise level (53.2dB and 50.4dB) than the threshold value of 35dB recommended by the World Health Organization. A Lombard effect was found to occur during traditional lessons with an increase of .72dB increase in speech per 1dB increase in noise level. Both classrooms showed no difference in vocal doses and parameters but Group A showed higher subjective scores regarding noise intensity and disturbance, reverberation and teacher vocal effort. Teachers also showed a significant increase in the mean value of sound pressure level of about 5dB between the morning and afternoon teaching periods. The researchers hypothesized from their results that reverberation time played an important part in a teacher's vocal effort. They suggested that a reverberation time of .75 to .85s could be considered as an optimal range to support a talker in a classroom. Since Group A schools had a reverberation time of 1.13, this could explain why Group A teachers had higher subjective scores in noise intensity and disturbance, reverberation and teacher vocal effort.

Cutiva and Burdorf (2015) conducted a cross-sectional study within 682 school workers at 377 workplaces in 12 schools to assess the agreement between objective measurements and self-reports of physical conditions at the workplace, and to evaluate their associations with the presence of voice symptoms among teachers. The researchers used a questionnaire and obtained measurements of sound levels, reverberation time, temperature, and humidity at the workplaces and outside schools. On average, results indicated background sound levels to be around 72dB(A) and reverberation to be 1.78 s exceeding national recommendation levels of 65dB(A) in daytime school zones and 55 dB(A) in classrooms. High noise outside the schools, poor acoustics inside the classroom, and high noise in workplaces showed the strongest odds ratio in the occurrence of voice symptoms.

Environmental factors

Masuda, Ikeda, Manako, and Komiyama (1993) measured a voicing percentage of 21% for teachers in an eight hour workday, compared to 7% for office workers. Earlier it was discussed that Bernstof and Burk (1996) attributed three factors to vocal stress: percentage of life span in teaching, teaching schedule, and specific dosimetric measures of noise (the last one having been previously discussed in the review). The Masuda et al. study also showed a positive intercorrelation between the participants teaching schedule and maximum noise levels suggesting additional studies are needed to determine activities that occur throughout a teaching schedule.

In an earlier mentioned study, Morrow (2009), music teachers were part of an investigation to assess voice-use of music teachers (N=7) compared to classroom teachers (N=5). Along with collecting quantitative data, Morrow also interviewed all seven music teachers and categorized all the interviews into three thematic groups: functional, emotional, and socio-functional effects from voice problems. Interviews showed that working conditions were identified as having a large impact on the music teachers' vocal health. The study participants identified factors such as the increased number of classes, little or no time for transitions between classes, larger class size, and the unspoken expectation of additional work outside already packed schedule. Scheduling for most of the music teachers involved one class leaving the music room as another class was entering with no break between groups. This back-to-back scheduling did not allow music teachers time to rearrange their classrooms for different grade levels. One teacher participant was quoted saying, “I’m competing with the noise outside in the hallway and I’m competing with kids getting excited about transition time inside the classroom.” Participants also attributed their increase in class size to increased student noise resulting in the participants feeling they needed to use a louder voice to establish discipline and teach.

Finally Morrow analyzed the participants’ desire for knowledge of vocal care. A few participants had a vague notion that they did not have sufficient knowledge about vocal care to protect their voice and might be doing things that could harmful. Three of the participants felt the school district should provide information on vocal hygiene.

Case Studies of Voicing and Silence Periods

Titze, Hunter, and Svec (2006) studied 31 teachers who used voice dosimeters to measure voicing and silence periods over the duration of two weeks. Data showed that the teachers had 1800 occurrences of voicing onset followed by voicing offset per hour at work and 1200 occurrences per hour while not at work. Voicing occurred 23% of the total time at work, 13% during off-work hours, and 12% on weekends. The total accumulation of voicing time was found to be about two hours in an eight hour workday. Titze, Hunter, and Svec pointed out that the voice turns on and off about 20,000 times a day for teachers and this could be a factor in teacher vocal fatigue since the adductor/abductor muscles must execute the switching on and off of the voice. This study helped to provide understanding of vocal fatigue in terms of repetitive motion and collision of tissue, as wells as recovery time from such vocal stress.

Hunter and Titze (2010) delved deeper into this theme by examining variations in teachers’ voicing percentages, estimated dB SPL, and fundamental frequency in occupational versus non-occupational settings. Fifty-seven teachers varying in grade level and subject wore a voice dosimeter for a two week period. Data gathered showed that occupational voicing percentage per hour is more than twice that of non-occupational voicing (29.9% to 14%). Even though the study showed a significant change in occupational verse non-occupational voicing, the researchers pointed out that 14% was still a higher percentage than previous studies had found in other occupational voicing besides teaching (Watanabe, Shin, Oda, Fukaura, & Komiyama (1987); Ohlsson, Brink, & Lofqvist, (1989). This percentage might not leave much time for vocal rest and add to an already overloaded voice.

Occupational voicing also showed a raised fundamental frequency over non-occupational voicing by about 10 Hz or 1-1.5 semitones and values appeared to move upward through-out the day. The average female teachers raised their mode intensity more than the male teachers. Hunter and Titze thought this to be more likely because younger grades have more female teachers than male and the teachers were required to speak louder in those class environments.

Schloneger (2011) examined the vocal use and vocal efficiency of two graduate students before, during, and after an intense week of opera rehearsals. Both students were female and were graduate teaching assistants on top of being cast in an opera production. Schloneger examined their amount of voice use by having the students wear an APM during their waking hours and he broke down their week in four categories of voice activities: Opera, other singing, teaching, and non-rehearsal time. The results indicated that the opera rehearsal times were not a significant part of the total vocal load time in both students. Higher distance time and distance dose were found during personal singing time and teaching. Both students had high vocal doses of 25.60% and 28.41% in about nine and eight hours of monitored teaching, respectively. Even though both students did not show or perceive any harmful effects from this, Schloneger points out the students were operating under student schedules with available vocal rest time. If the students were to start a full-time teaching schedule and continue the same phonation patterns, they could be putting their voices at risk for future problems.

Education and Awareness

Chan (1994) took 12 kindergarten teachers and had them participate in a 90 minute workshop exploring the concepts of vocal abuse. The teachers then practiced vocal hygiene for two months. Objective and subjective assessments suggested a significant improvement in participants when compared to a control group of 13 teachers.

Duffy and Hazlett (2004) used three groups of teachers (*N*=55) in training to determine the long term impact of preventative voice care programs. The indirect group was provided with information on the mechanics of normal voice production, the amount and type of voice use, vocal behaviors thought to be phonotraumatic, hydration issues, and lifestyle and diet factors that can support or interfere with a healthy voice. The direct group was given training to encourage healthy vocal behavior: posture, respiration, release of tension in the vocal apparatus, resonance, and voice projection. The final group served as the control group of the study. The direct group showed an improvement according to the acoustic measurements and limited change according to self-perceptual scales; the indirect group showed no change at all, and the control group showed a voice deterioration demonstrated either by acoustic measurements or in self-rated scales.

Bovo, Galceran, Petruccelli, and Hatzopoulos (2007) compared 21 female primary school teachers to a control group of 20 teachers matched for age, working years, hoarseness grade, and vocal demands. The 21 female teachers had to participate in a course on voice care, including a theoretical seminar, short voice group therapy, and three months of either attending a vocal ergonomics norms or follow exercises given for more efficient vocal technique. Data was collected after three months and then also twelve months after the course. Results showed that after three months, participants showed improvements in global dysphonia rates, jitter, shimmer, and VHI. Twelve month results showed the positive effects remained with a slight reduction. From this study and analyses of similar studies, the researchers concluded that primary prevention of vocal disorders in teachers should be based on three aspects: improvement of classroom acoustics, classroom or portable amplification systems, and voice care programs for future teachers and for those already practicing.

Niebudek-Bogusz, Kotylo, Politanski, and Sliwinska-Kowalska (2008) examined 51 teachers using the Voice Handicap Index, laryngovideostroboscopy and acoustic analysis to evaluate the treatment outcomes in occupational voice disorders. Before and after treatments were taken for two groups. One group received vocal training while the second group received vocal hygiene instruction. The results of the subjective assessment (VHI score) and objective evaluation (acoustic analysis) improved more significantly in group one who had received vocal training. Post treatment examination revealed a decreased percentage of subjects with deteriorated jitter parameters after vocal loading, especially in group one. The researchers concluded that acoustic analysis with vocal loading tests might be a helpful tool in the diagnosis and evaluation of treatment efficacy in occupational dysphonia.

Silverio, Goncalves, Penteado, Vieira, Libardi, and Rossi (2008) analyzed the vocal complaints, laryngeal symptoms, vocal habits and vocal profile of teachers of a public school before (*N*= 42) and after (*N*=13) their participation in voice workshops. The study was divided into three steps: 1) closed interview, larynx and perceptive auditory assessment, 2) voice workshops, and 3) perceptive auditory reassessment. Initially, 73% of the subjects presented vocal complaints; 57.14% presented mild to moderate hoarseness, 78.57% presented breathiness, and 52.38% presented vocal tension. After the workshops there was a significant difference in the level of vocal tension, both in the /e/ vowel and the analysis of Spontaneous Speech. Improvement was observed in vocal care and the understanding of intervening and determinant factors for vocal alterations, which the researchers pointed out, are present in the teaching environment.

Ricter, Nusseck, Spahn, and Echternach (2015) investigated the effectiveness of a preventative training program on vocal health for German student teachers. The study involved 204 student teachers, 123 which were involved in a vocal training program while the other 81 student teachers remained as the control group. Voice quality was measured at the beginning and end of their student teacher training period which lasted for a year and a half. Once ending measurements were collected, the training group showed improved voice quality over the control group. The trained group was also able to sustain their voice quality across the vocal loading test more than the control group. The researchers concluded the study showed the potential of a prevention program for student teachers on their vocal health.

Summary

A considerable number of studies have analyzed the phonation levels acquired by various populations. Other studies have analyzed the noise levels acquired in various teaching environments. Still, no study exists of both phonation and noise levels being collected together in one environment. Current technology presents the opportunity for these two variables to be studied simultaneously in a real-life teaching environment.

CHAPTER 3

Methods

The purpose of this descriptive case study was to assess the status of vocal (KayPentax APM) and noise (Etymotic ER200D dosimeter) dosages acquired by an elementary school music teacher (*N*=1) during waking hours, across (*a*) a full teaching week (five days) and (*b*) two weekends (four days), one prior to and one after the teaching week. This chapter details the context, procedures, and equipment employed to implement this purpose.

Participant and Participant Schedule

The researcher, a 27 year old female elementary school music teacher, served as the participant for this study. At the time of data collection, I was in my fourth year of teaching K-6 general music and 7th -8th grade choir at a parochial school with an enrollment of 561 students. I taught 481 students (*n* =428 general music students and *n* =53 7^{th}-8^{th} grade choir students) throughout the week. On a typical day of teaching I would teach an average of 206 students.

My typical school teaching day began at 8:15 a.m. and concluded around 3:30 p.m. During those 7 hours, I typically taught 9 class periods of 30 -45 minutes with either no time between classes or occasionally a 30 minute plan time depending on the day of the week. I had a daily planning period of 2 hours and 25 minutes. Table 1 presents my teaching day schedule during the five day week I acquired data for the study.

Table 1

Weekly Teaching Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00-8:15					
8:15-8:30	3rd grade	2nd grade	6th grade	4th grade	MASS
8:30-8:45					
8:45-9:00	3rd grade	2nd grade	6th grade	4th grade	
9:00-9:15					Plan
9:15-9:30	Plan	4th grade	Plan	2nd grade	Plan
9:30-9:45	Plan		Plan		Plan
9:45-10:00	2nd grade	4th grade	2nd grade	2nd grade	4th grade
10:00-10:15					
10:15-10:30	6th grade	4th grade	6th grade	3rd grade	6th grade
10:30-10:45					
10:45-11:00	Plan	5th grade	Plan	3rd grade	6th grade
11:00-11:15	Plan		Plan		
11:15-11:30	Choir 7/8	Choir 7/8	Choir 7/8	Choir 7/8	Choir 7/8
11:30-11:45	Men	7th grade	8th grade	Men	7th grade
11:45-12:00		Women	Women		Women
12:00-12:15	Lunch	Lunch	Lunch	Lunch	Lunch
12:15-12:30	Lunch	Lunch	Lunch	Lunch	Lunch
12:30-12:45	Plan	Plan	Plan	Plan	Plan
12:45-1:00	Plan	Plan	Plan	Plan	Plan
1:00-1:15	Plan	Plan	Plan	Plan	Plan
1:15-1:30	1st grade	Kindergarten	1st grade	Kindergarten	Kindergarten
1:30-1:45	(2 classes)	&	(2 classes)	(2 classes)	&
1:45-2:00		1st grade			1st grade
2:00-2:15	5th grade	Kindergarten	5th grade	Plan	5th grade
2:15-2:30		(2 classes)		Plan	
2:30-2:45	5th grade		5th grade	Plan	Stations of
2:45-3:00				Plan	The Cross
3:00-3:15	SHOP	SHOP	SHOP	SHOP	SHOP
3:15-3:30					

SHOP lasted from 3:00-3:30pm every day. This time allows students to travel to other teachers for help on school work. I used this time to practice Mass music with students who were song leaders for the week.

Prior to beginning this teaching position I obtained a Bachelors degree in music education with a vocal emphasis. I also received my teaching license certifying me to teach Pre-K through 12th grade music; general, voice, and instrumental. Once a week I would also sing in a semi-professional adult choir.

At the time of the study, I was in good health with no known major health issues. I had not perceived or experienced any hearing problems. However, I did experience periods of perceived "tired voice," especially during the work week. Prior to acquiring the phonation and noise data for this study, I underwent a video stroboscopic examination. Results of that examination (see Figure 1) revealed that I was in good vocal health with a known history of benign lesions of trauma. There was no significant dampening of vocal fold waves or amplitude.

Figure 1. Pre-video stroboscopic examination.

Prior to, as well as after, acquiring the phonation and noise data for this study I also participated in a Multidimensional voice program analysis (MDVP). The MDVP analyzed 33 quantitative voice parameters, among them fundamental frequency, amplitude, perturbations of frequency (jitter), perturbations of amplitude (shimmer), and harmonics to noise ratio. In addition, the MDVP program displayed results as a radial graph that plotted graphic contours of my voice compared with a standardized population (e.g., normal female voice).

Dependent Measures

Two dosimeters, a Kay Pentax Ambulatory Phonation Monitor (APM) and an Etymotic Personal Noise Dosimeter (Model ER-200D), acquired much of the data analyzed for this investigation. The APM unit featured a small accelerometer transducer attached to the anterior base of my neck at the sternal notch (i.e., below the larynx and above the sternum). This accelerometer captured phonation sensations at a rate of 20 samples per second. These data were then sent via a cable to a microprocessor unit worn in a waist pack. The microprocessor stored and calculated dose time (Dt), distance dose (Dd), total number of vibratory cycles, fundamental frequency (F_0), and voice amplitude levels (dB SPL).

I wore the APM unit during waking hours each day of the data collection period. Shortly after awaking each morning, I downloaded the previous day's data. I then calibrated the unit according to manufacturer's protocols.

Prior to each time I started the APM, I performed a sound level calibration by attaching the APM microprocessor to a computer with KayPentax software and phonating per manufacturer's directions into a microphone positioned 15 cm from my mouth. Figure 1 shows the APM unit used for this study.

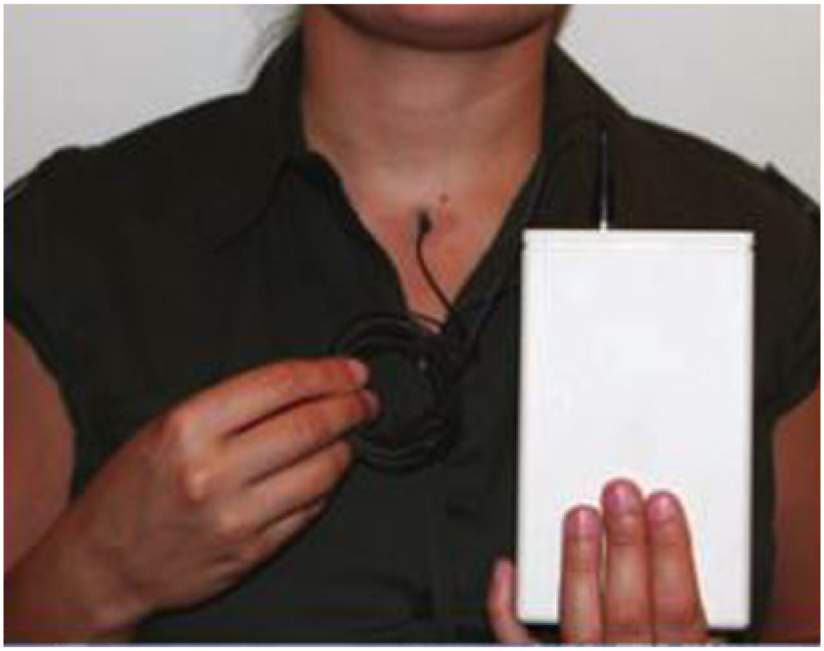

Figure 2. Ambulatory Phonation Monitor

I also wore the Etymotic Personal Noise Dosimeter during waking hours each day. Shortly after wakening each morning, I downloaded the previous day's data, then positioned the unit on my shoulder per American National Standards Institute (AINSI, 1996) specifications, such that the dosimeter microphone was situated at the midtop of my more noise-exposed shoulder and oriented approximately parallel to the plane of this shoulder. The factory calibrated noise dosimeter calculated dose values every 220 milliseconds and averaged these values over 3.75 minute intervals using the slow response setting with an A frequency weighting in accordance with National Institute of Occupational Health and Safety (NIOSH) recommendations.

The noise dosimeter measured sound levels continuously over waking hours each day. It integrated these obtained levels into a single value, the cumulative noise dose. The National Institute of Occupational Safety and Health (NIOSH) designated exposure level for occupational noise exposure is 85 dB(A) as an 8-hour time-weighted average (TWA), using a 3dB exchange rate for calculation of TWA exposures to noise (NIOSH, 1998). Thus, when daily exposure consisted of periods with different noise levels, the NIOSH recommended daily dose should not equal or exceed 100%. NIOSH described exposures at or above this permissible exposure limit as "hazardous." When set according to NIOSH standards, the Etymotic dosimeter did not record sound levels below a threshold of 75 dB.

Although the affordable Etymotic dosimeter met some of the criteria (linearity, microphone response, and frequency response) specified by AINSI for research grade, Type 2 instrumentation, it was not designed to be a Type 2 device. However, Cook-Cunningham (2014) compared the accuracy and reliability of the Etymotic dosimeter with two, Type 2-rated noise dosimeters (the Cirrus CR 110 A dose badge and the Quest Edge 5 personal noise dosimeter) in both repeated pink noise and natural environments. Results indicated (a) all three dosimeters, including the Etymotic unit, exhibited very strong, positive correlations for pink noise measurements; (b) each of the dosimeters was within the recommended AINSI SI-25 1991 standard of ± 2 dB(A) of a reference measurement; and (c) each dosimeter was within the recommended AINSI SI-25 1991 of ± 2 dB(A) when compared to each other. Thus, I felt confident in using the Etymotic dosimeter (see Figure 3) for this study.

Figure 3. Etymotic dosimeter.

Activity Logs

In order later to disaggregate the acquired data from both dosimeters according to such time periods as teaching hours and non-teaching hours and weekday hours and weekend hours, I completed daily activity logs, documenting each significant activity throughout the day and the time each activity commenced and ended. These disaggregations, accomplished with reference to the activity logs, permitted examination of potential trends according to type of activity and activity environment.

Teaching Venue

The classroom in which I taught measured approximately 30 ft by 30 ft. The height from the floor to the ceiling was nine ft feet. The walls were constructed of sheet rock. One side of the room had windows along the entire side, which looked out into the hallway of the school. The opposite side was lined with shelves, made of particle board, for classroom material and instrument storage. A tack board lined one side of the wall and measured four ft in height. The floor was a quarter inch of carpet, and the ceiling had sound deflecting panels that came down one ft . I could not typically hear noise from other rooms, but there was a ventilation system above the room that added extra noise when running during the day. Figure 4 shows the classroom setting for this study.

Figure 4 Classroom setting used for this study.

Proposed Statistical Analyses

The purpose of this case study was to describe the status of the participant's voicing and noise doses acquired in various settings. Therefore, this investigation will employ basic descriptive statistics such as frequency, percentage, and mean to present and analyze its data.

CHAPTER 4

Results

This chapter presents results according to the research questions posed for this investigation.

Research Question One: Ambulatory Phonation Monitor Data across Nine Days

The first research question asked about APM data indications concerning my phonation behaviors (F_0, time dose, distance dose) across nine days of varying activity, including disaggregations according to teaching versus other time periods. I wore the APM for an average of 14.18 hours each day over the course of nine monitoring days. There was one occurrence over the course of monitoring when the APM shut off before I finished that day of data collection. Table 2 shows data of phonation duration, phonation percentage, fundamental frequency mode and mean, amplitude mean, cycle dose, and phonation distance acquired across the nine days of study.

Table 2

APM Data across Nine Days

	APM	Time Dose		F_0 Data		Amplitude	Cycle Dose	Distance Dose	
	Duration Worn (hh:mm)	Phonation Time (hh:mm)	Phonation Percentage	Mode F_0 (Hz)	M F_0 (Hz)	M (dB)	Vibratory Cycles (in thousands)	Meters	m/s
Saturday	14:38	0:49	5.65	164	178.48	86.18	530,564	2492.85	0.05
Sunday	14:38	0:42	4.85	164	199.22	89.47	507,492	2659.89	0.05
Monday	14:41	2:31	17.17	176	229.43	89.14	2,070,114	9347.88	0.18
Tuesday	15:03	3:32	23.51	176	255.84	94.14	3,232,030	16,865.52	0.31
Wednesday	14:30	2:12	15.25	188	236.68	94.58	1,879,086	11,131.64	0.21
Thursday	11:48	2:14	18.94	176	230.76	93.98	1,846,656	10,812.56	0.25
Friday	14:31	2:19	16.00	176	239.98	91.99	1,986,349	10,465.74	0.20
Saturday	15:03	1:46	11.75	176	214.84	91.27	1,363,753	7760.26	0.14
Sunday	14:34	1:06	7.65	164	223.11	93.49	891,010	5522.81	0.11

As indicated by Table 2, Tuesday phonation time, phonation percentage, cycle dose, and distance dose exceeded the like data acquired on the other eight days. On Tuesday, I taught during the school day and also attended an adult choir rehearsal from 7:00 p.m.-9:30 p.m. that evening.

Disaggregated Workweek by Teaching Hours and Non-Teaching Hours. Table 3 disaggregates APM data by workweek teaching hours and non-teaching hours. The gray cells indicate non-teaching times.

Table 3

APM Data during Workweek Teaching and Non-Teaching Hours

	Monday		Tuesday		Wednesday		Thursday		Friday	
	D_d meters	D_t %	D_d meters	D_t %	D_d meters	D_t %	D_d meters	D_t %	D_d meters	D_t %
7:00-8:15	131.51	3.86	477.80	11.11	149.73	3.76	152.93	3.29	391.91	10.03
8:15-8:45	674.82	33.60	873.96	33.81	1264.95	46.55	455.11	17.05	469.97	14.22
8:45-9:15	775.24	39.11	946.76	37.02	1170.28	44.63	431.62	18.19	568.38	25.06
9:15-9:45	324.42	17.22	838.73	31.92	65.43	3.34	865.72	31.94	512.19	27.45
9:45-10:15	582.43	28.74	848.10	34.56	877.03	30.16	853.17	30.75	989.19	40.10
10:15-10:45	606.03	30.36	912.35	38.69	1029.45	37.41	926.73	35.48	1170.26	43.28
10:45-11:15	160.69	7.52	985.95	41.12	85.94	5.76	1092.24	40.30	1050.15	42.59
11:15-12:00	1066.82	38.46	1695.17	43.98	1913.17	43.86	1706.13	43.78	1745.15	45.19
12:00-12:30	296.38	14.63	513.67	25.96	268.08	13.47	428.89	21.29	427.90	23.99
12:30-1:15	120.29	5.62	40.65	1.70	166.33	5.65	121.87	4.39	278.01	11.89
1:15-2:00	972.18	31.59	1410.78	36.63	1162.15	32.69	1855.67	44.89	697.48	20.90
2:00-2:30	683.38	33.16	826.86	34.02	1214.32	43.69	199.94	15.53	997.35	43.04
2:30-3:00	598.88	30.06	660.85	28.4	1091.31	39.64	75.90	5.06	629.93	22.97
3:00-3:30	382.94	22.01	241.61	12.03	578.59	28.16	658.87	31.21	408.50	22.18
3:30-4:30	540.51	18.13	228.55	6.73	12.08	0.68	644.47	13.36	187.26	6.88
4:30-5:30	5.29	0.39	457.78	12.11	8.84	0.45	4.70	0.23	2.52	0.33
5:30-6:30	1167.63	35.08	323.09	7.11	11.56	0.70	3.66	0.29	5.14	0.61
6:30-7:30	3.15	9.55	758.67	16.01	8.52	0.43	454.01	16.13	3.55	0.37
7:30-9:30	9.53	0.53	3046.78	59.08	124.08	4.84	n/a	n/a	10.80	0.99
Sum of Non-Teaching Hours	2759.40	112.53	5846.99	139.81	900.59	39.08	2086.37	79.57	3487.56	144.79
Sum of Teaching Hours	6342.72	287.09	10,241.12	372.18	10,301.25	346.79	8845.26	293.59	7058.08	257.28

Note: n/a=APM shut off unbeknownst to the participant.

Results from Table 3 indicated that I acquired the highest D_d and D_t every day from 11:15 a.m.-12:00 p.m. I acquired a MD_d of 1,154.89 meters and MD_t of 42.86% on Wednesday from 8:15 a.m.-9:15 a.m. and 10:15 a.m.-10:45 a.m. On Friday I acquired a MD_d of 1,110.21 meters and MD_t of 42.94% from 10:15 a.m.-11:15 a.m. Tuesday, Wednesday, and Thursday showed MD_d of 1,476.20 meters and MD_t of 38.07% from 1:15 p.m.-2:00 p.m. Thursday's data from 1:15pm-2:00pm showed an especially high D_d of 1,855.67 meters and a D_t of 44.89%.

Monday's non-teaching hour from 5:30 p.m.-6:30 p.m. showed a D_d of 1,167.63 meters and D_t of 35.08%. I went to dinner at a restaurant during this time, which would explain the increased vocal doses during my non-teaching time. On Tuesday, between 7:30 p.m.-9:30 p.m., I acquired a D_d of 3,046.78 meters and D_t of 59.08%. During that time period I was at choir rehearsal, which would account for the elevated D_d and D_t outside of my teaching time.

On Wednesday (11:15 a.m.-12:00 p.m.), I acquired a D_d of 1913.17 meters and D_t of 43.86%. On this day I had eighth grade women's choir, which had 25 students in the class. I aided the students by leading vocal warm-ups, managing classroom behavior, and sometimes singing along with their parts during rehearsal. These factors would account for the acquired D_d and D_t.

Trends between Grand Mean D_d, D_t and Grade Level D_d and D_t. I wanted to find the mean D_d and D_t for each grade level (Tables 4-5) because my teaching schedule was not the same every day. Tables 6-12 show disaggregated D_d and D_t for each grade level by teaching day.

Table 4

Grade Level D_d and D_t Grand Means: 45 Minute Classes

	Mean		
	D_d meters	D_t %	Time (h:mm)
Choir	1625.29	43.05	0:45
Kindergarten/First grade	1083.71	32.73	0:45

Table 5

Grade Level D_d and D_t Grand Means: 30 Minute Classes

	Mean		
	D_d meters	D_t %	Time (h:mm)
Sixth grade	1048.52	40.80	0:30
Fifth grade	928.53	38.45	0:30
Third grade	867.26	37.12	0:30
Second grade	833.18	32.38	0:30
Fourth grade	745.85	30.09	0:30

Table 6

Disaggregated Choir D_d and D_t by Teaching Day: 45 Minute Classes

	Choir	
	D_d meters	D_t %
Monday	1066.82	38.46
Tuesday	1695.17	43.98
Wednesday	1913.17	43.86
Thursday	1706.13	43.78
Friday	1745.15	45.19

Table 7

Disaggregated Kindergarten/First Grade D_d and D_t by Teaching Days: 45 Minute Classes

	Kindergarten/First	
	D_d meters	D_t %
Monday	972.18	31.59
Tuesday A	1410.78	36.63
Tuesday B	1487.71	62.42
Wednesday	1162.15	32.69
Thursday	1855.67	44.89
Friday	697.48	20.90

Table 8

Disaggregated Sixth Grade D_d and D_t by Teaching Days: 30 Minute Classes

	Sixth Grade	
	D_d meters	D_t %
Monday	606.03	30.36
Wednesday A	1264.95	46.55
Wednesday B	1170.28	44.63
Wednesday C	1029.45	37.41
Friday A	1170.26	43.28
Friday B	1050.15	42.59

Table 9

Disaggregated Fifth Grade D_d and D_t by Teaching Days: 30 Minute Classes

	Fifth Grade	
	D_d meters	D_t %
Monday A	683.38	33.16
Monday B	598.88	30.06
Tuesday	985.95	41.12
Wednesday A	1214.32	43.69
Wednesday B	1091.31	39.64
Friday	997.35	43.04

Table 10

Disaggregated Third Grade D_d and D_t by Teaching Days: 30 Minute Classes

	Third Grade	
	D_d meters	D_t %
Monday A	674.82	33.60
Monday B	775.24	39.11
Thursday A	926.73	35.48
Thursday B	1092.24	40.30

Table 11

Disaggregated Second Grade D_d and D_t by Teaching Days: 30 Minute Classes

	Second Grade	
	D_d meters	D_t %
Monday	582.43	28.74
Tuesday A	873.96	33.81
Tuesday B	946.76	37.02
Wednesday	877.03	30.16
Thursday A	865.72	31.94
Thursday B	853.17	30.75

Table 12

Disaggregated Fourth Grade D_d and D_t by Teaching Days: 30 Minute Classes

	Fourth Grade	
	D_d meters	D_t %
Tuesday A	838.73	31.92
Tuesday B	848.10	34.56
Tuesday C	912.35	38.69
Thursday A	455.11	17.05
Thursday B	431.62	18.19
Friday	989.19	40.10

In order to compare the uneven class periods, I calculated the acquired MD_d in meters as a percentage of class time. Results indicated that choir (36.12%) and sixth grade general music (34.95%) displayed the highest acquired mean distance doses as a percentage of class time across the teaching week. By contrast, fourth grade (24.86%) displayed the lowest acquired mean distance dose as a percentage of class time across the teaching week.

Research Question Two: Etymotic Noise Dosage Data Across Nine Days

The second research question asked about noise doses acquired across the nine days, including disaggregations according to teaching versus other time periods. I wore the Etymotic noise dosimeter for an average of 14 hours and 33 minutes each day during a nine day monitoring period. One occurrence required the dosimeter to be turned off and restarted during the monitoring period. The error required me to redo that day the following week in order to acquire a 14-hour period of noise dosage. Table 13 shows duration, daily dosage levels expressed as a percentage of NIOSH recommended safe daily noise exposure, and equivalent sound level (*LEQ*) data acquired from the participant across nine days.

Table 13

Etymotic Noise Dosage Data across Nine Days

	Etymotic Duration Worn (hh:mm)	Noise Dosage Percentage	Overall *LEQ* Decibels
Saturday	14:28	38%	78.22
Sunday	14:33	29%	77.02
Monday	14:27	280%	86.86
Tuesday	14:53	180%	84.82
Wednesday	14:24	150%	84.16
Thursday	14:21	96%	82.28
Friday	14:24	200%	85.39
Saturday	14:52	100%	82.50
Sunday	14:38	53%	79.62

Note: Monday's data is the redo data due to equipment errors the first Monday of data collection.

NIOSH (1998) guidelines have recommended that all work noise exposure should be controlled below a level equivalent to 85 dBA for eight hours to minimize occupational noise induced hearing loss. Almost every weekday exceeded 100% noise dosage, excluding Thursday. I acquired the highest noise dosage of 280% on Monday as well as the highest average *LEQ* of 86.86 dB. The music content of sixth grade (10:15 a.m.-10:45 a.m.) as well as eighth grade women's choir (11:15 a.m.-12:00 p.m.) required me to use the piano for much of those class times.

Thursday was the only weekday in which I did not attain 100% noise dosage in the 14 hours of collection. Men's choir (11:15 a.m.-12:00 p.m.) only has eight boys in the group. I did not use the stereo or piano for the entire afternoon while teaching kindergarten (1:15 p.m.-2:00 p.m.). On Thursday, I had an hour of plan time after 2:00 p.m. during which I worked alone in my classroom.

There was one Saturday, post-teaching week, in which I acquired 100% noise dosage. On that Saturday I drove for two hours with the radio on. I also attended a child's birthday party. Both of those circumstances may have contributed to the elevated noise dosage on the weekend during that particular weekend.

Disaggregated Noise Dosage by Workweek and Weekend. Table 14 shows average noise dosage percentages and average *LEQ* decibels by workweek and weekends.

Table 14

Noise Dosage between Workweek and Weekend

	Workweek 5 days	Weekend 4 days
Average Noise Dosage (%)	181.20%	55.00%
Average *LEQ* (dB)	84.70	79.34

As indicated by Table 14, mean work week noise dosage and *LEQ* exceed mean weekend noise dosage and *LEQ*.

Disaggregated Noise Dosage by Teaching Day Hours and Non-teaching Day Hours. Table 15 shows the teaching time, noise dosage, and *LEQ* dB acquired during my teaching day hours as well as my non-teaching day hours across the five day work week.

Table 15

Noise Dosage between Teaching Day Hours and Non-Teaching Day Hours During the Work Week

	Teaching Day Hours			Non-Teaching Day Hours		
	Teaching Day (h:mm)	Noise Dosage Percentage	Overall *LEQ* Decibels	Non-Teaching Day (h:mm)	Noise Dosage Percentage	Overall *LEQ* Decibels
Monday	7:25	234.81%	65.90	7:20	42.71%	63.14
Tuesday	7:25	134.87%	76.35	7:65	43.86%	68.16
Wednesday	7:25	143.45%	73.64	7:17	4.92%	49.60
Thursday	7:25	85.83%	74.02	7:11	10.02%	45.25
Friday	7:25	190.25%	77.02	7:16	6.89%	48.61

I acquired noise dosage during an average of 7:25 teaching day hours per day across the work week. I acquired noise dosage during an average of 7:26 non-teaching day hours. Monday's teaching day hours' noise dosage was the highest at 234.81%, but the overall *LEQ* for Monday was the lowest *LEQ* for the teaching day hours at 65.90 dB. During Friday's teaching day hours, I acquired the second highest average noise dosage of 190.25% with the highest *LEQ* of 77.02 dB.

As indicated by Table 15, noise doses acquired during non-teaching day hours on Monday and Tuesday exceeded noise doses acquired during non-teaching day hours on Wednesday, Thursday, and Friday. I was in the car with the stereo playing for an hour after school on Monday and then with friends at dinner. On Tuesday evening, I participated in a church choir rehearsal from 7:00 p.m.-9:30 p.m. These particular after school activities may have contributed to the noise doses acquired during non-teaching hours on Monday and Tuesday.

Disaggregated Noise Dosage by Grade Level During Teaching Days. Tables 16-22 shows disaggregated noise dosage by grade level during teaching days. Choir, kindergarten, first grade were 45 minute classes. Second grade, third grade, fourth grade, fifth grade, and sixth grade were 30 minute classes.

Table 16

Disaggregated Choir Noise Dosage by Teaching Days: 45 minute classes

	Choir Noise Dosage %
Monday	79.65
Tuesday	35.48
Wednesday	36.84
Thursday	17.17
Friday	59.53

Table 17

Disaggregated Kindergarten/First Grade Noise Dosage by Teaching Days: 45 minute classes

	Kindergarten/First Noise Dosage %
Monday	14.73
Tuesday A	13.95
Tuesday B	15.19
Wednesday	11.12
Thursday	15.30
Friday	8.49

Table 18

Disaggregated Sixth Grade Noise Dosage by Teaching Days: 30 minute classes

	Sixth Grade Noise Dosage %
Monday	37.62
Wednesday A	17.41
Wednesday B	14.39
Wednesday C	16.12
Friday A	40.41
Friday B	31.15

Table 19

Disaggregated Fifth Grade Noise Dosage by Teaching Days: 30 minute classes

	Fifth Grade Noise Dosage %
Monday A	24.87
Monday B	35.99
Tuesday	14.31
Wednesday A	14.61
Wednesday B	11.18
Friday	14.53

Table 20

Disaggregated Third Grade Noise Dosage by Teaching Days: 30 minute classes

	Third Grade Noise Dosage %
Monday A	17.09
Monday B	9.67
Thursday A	3.73
Thursday B	6.02

Table 21

Disaggregated Second Grade Noise Dosage by Teaching Days: 30 minute classes

	Second Grade Noise Dosage %
Monday	8.15
Tuesday A	7.61
Tuesday B	8.49
Wednesday	14.42
Thursday A	6.61
Thursday B	10.99

Table 22

Disaggregated Fourth Grade Noise Dosage by Teaching Days:30 minute classes

	Fourth Grade Noise Dosage %
Tuesday A	11.30
Tuesday B	10.62
Tuesday C	11.93
Thursday A	6.61
Thursday B	10.99
Friday	13.50

Tables 16-22 indicated that among all classes taught, choir and sixth grade acquired the higher noise dosages in varied degrees during teaching days. Each grade level indicated some increased noise dosage but this varied between specific grades, class times, and what was being done in class that day.

Research Question Three: Acquired APM and Noise Dosimeter Trends

No study to date has looked at possible relationship trends between vocal and noise doses acquired by the same instructor across a teaching week. Such data might provide ideas for future research.

Table 23 presents my acquired distance dose (D_d), distance time (D_t), and noise dosage percentage during a five day work week, disaggregated by time of day.

Table 23

Participant's Acquired D_d, D_t, and Noise Dosage Across the Five Day Workweek Disaggregated by Time of Day

	Monday			Tuesday			Wednesday			Thursday			Friday		
	D(d) meters	*D*(t) %	Noise Dosage %	*D*(d) meters	*D*(t) %	Noise Dosage %	*D*(d) meters	*D*(t) %	Noise Dosage %	*D*(d) meters	*D*(t) %	Noise Dosage %	*D*(d) meters	*D*(t) %	Noise Dosage %
7:00-8:15	131.51	3.86	18.53	477.80	11.11	2.69	149.73	3.76	3.22	152.93	3.29	1.03	391.91	10.03	3.87
8:15-8:45	674.82	33.60	17.09	873.96	33.81	7.61	1264.95	46.55	17.41	455.11	17.05	6.61	469.97	14.22	6.09
8:45-9:15	775.24	39.11	9.67	946.76	37.02	8.49	1170.28	44.63	14.39	431.62	18.19	10.99	568.38	25.06	4.89
9:15-9:45	324.42	17.22	0.17	838.73	31.92	11.30	65.43	3.34	0.87	865.72	31.94	10.94	512.19	27.45	4.16
9:45-10:15	582.43	28.74	8.15	848.10	34.56	10.62	877.03	30.16	14.42	853.17	30.75	8.32	989.19	40.10	13.50
10:15-10:45	606.03	30.36	37.62	912.35	38.69	11.93	1029.45	37.41	16.12	926.73	35.48	3.73	1170.26	43.28	40.41
10:45-11:15	160.69	7.52	0.15	985.95	41.12	14.31	85.94	5.76	0.30	1092.24	40.30	6.02	1050.15	42.59	31.15
11:15-12:00	1066.82	38.46	79.65	1695.17	43.98	35.48	1913.17	43.86	36.84	1706.13	43.78	17.17	1745.15	45.19	59.53
12:00-12:30	296.38	14.63	0.00	513.67	25.96	4.46	268.08	13.47	1.28	428.89	21.29	1.82	427.90	23.99	0.82
12:30-1:15	120.29	5.62	2.64	40.65	1.70	0.18	166.33	5.65	1.59	121.87	4.39	1.10	278.01	11.89	0.99
1:15-2:00	972.18	31.59	14.73	1410.78	36.63	13.96	1162.15	32.69	11.13	1855.67	44.89	15.31	697.48	20.90	8.50
2:00-2:30	683.38	33.16	24.87	826.86	34.02	9.20	1214.32	43.69	14.61	199.94	15.53	0.06	997.35	43.04	14.53
2:30-3:00	598.88	30.06	35.99	660.85	28.40	5.99	1091.31	39.64	11.18	75.90	5.06	0.25	629.93	22.97	3.61
3:00-3:30	382.94	22.01	4.08	241.61	12.03	1.37	578.59	28.16	3.31	658.87	31.21	2.71	408.50	22.18	2.08
3:30-4:30	540.51	18.13	3.83	228.55	6.73	1.37	12.08	0.68	0.07	644.47	13.36	2.96	187.26	6.88	1.23
4:30-5:30	5.29	0.39	11.49	457.78	12.11	4.57	8.84	0.45	0.13	4.70	0.23	0.02	2.52	0.33	0.04
5:30-6:30	1167.63	35.08	3.73	323.09	7.11	2.75	11.56	0.70	0.38	3.66	0.29	0.46	5.14	0.61	1.61
6:30-7:30	3.15	9.55	1.04	758.67	16.01	5.91	8.52	0.43	0.04	454.01	16.13	6.31	3.55	0.37	0.00
7:30-8:30	4.84	0.27	3.66	1582.25	27.22	11.78	3.05	0.17	0.04	n/a	n/a	0.03	5.93	0.63	0.12
8:30-9:30	4.69	0.26	0.43	1464.53	31.86	4.52	121.03	4.67	1.03	n/a	n/a	0.02	4.87	0.36	0.02

Note: Due to equipment malfunction, Table 23 noise dose percentage reported for Monday reflects data acquired a week later than the reported D_d and D_t for Monday.

Because of noise dosimeter malfunction on Monday of the data acquisition week, noise doses reported in Table 23 were acquired one week later than the reported vocal dose data for Monday. I included that data in Table 23 for information purposes. However, direct comparison of vocal and noise doses will not be made in the figures that follow, which compare noise dose percentages and voice dose percentages first by teaching day and then by classes taught, because my teaching schedule on the subsequent Monday was not precisely the same as on the previous Monday.

Relationships Between D_d and Noise Dose by Teaching Day. Figures 5 - 8 show relationships between distance dose percentages and noise dose percentages acquired during teaching hours on Tuesday, Wednesday, Thursday, and Friday. In order to compare D_d in meters to noise dose percentages in a particular time frame, I first calculated D_d as a percentage of the given time period, that is, the meters traveled in a given time period divided by the number of minutes in the given time frame.

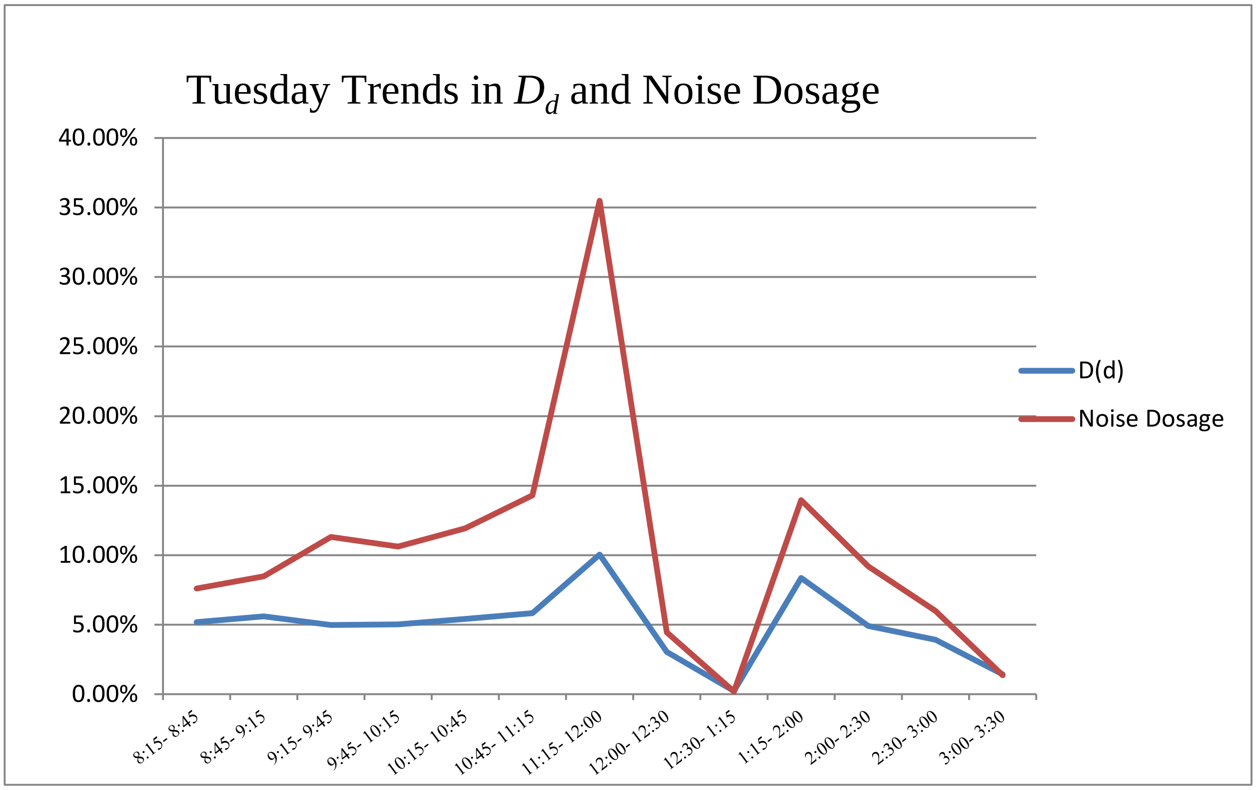

Figure 5. Tuesday trends in D_d and Noise Dosage

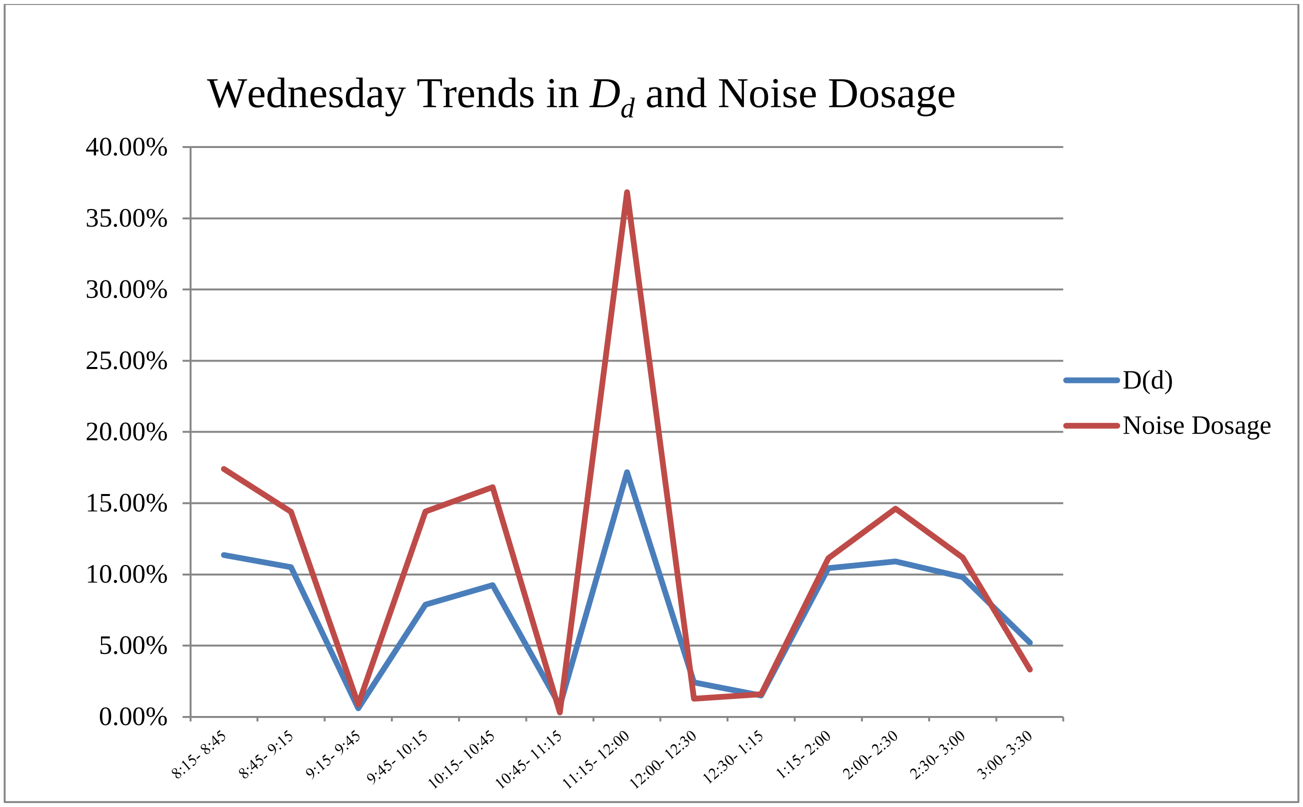

Figure 6. Wednesday Trends in D_d and Noise Dosage

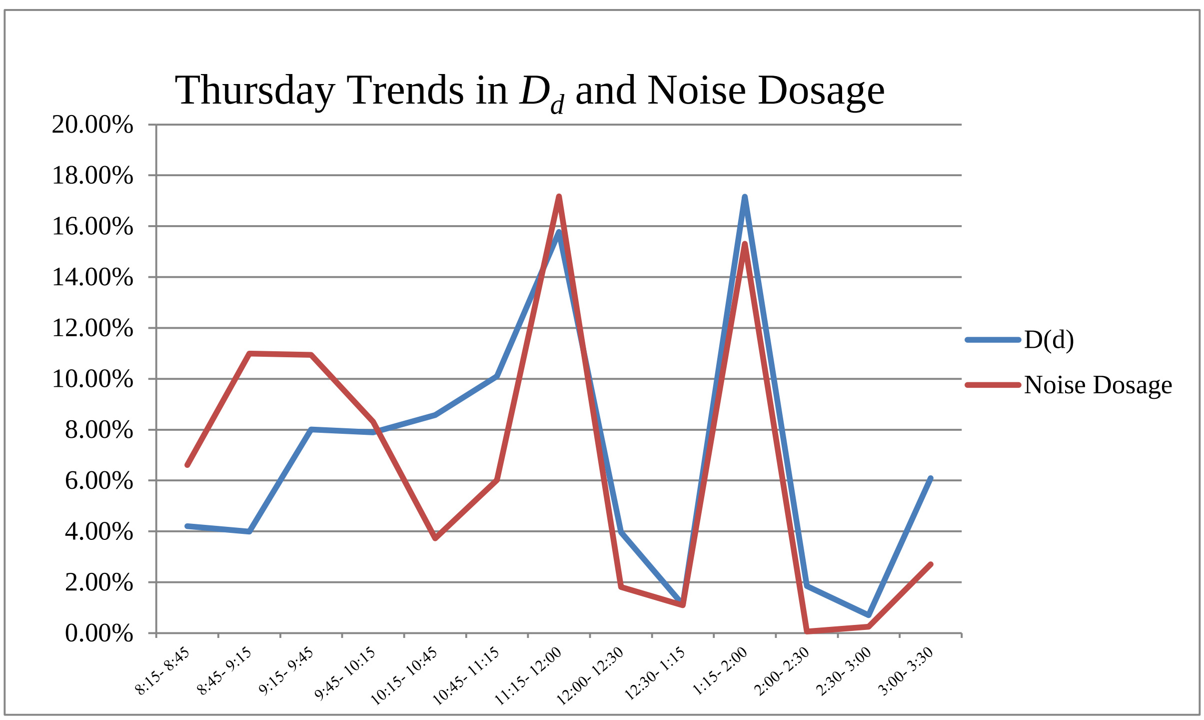

Figure 7. Thursday Trends in D_d and Noise Dosage

Figure 7 indicates similar trends in which I had an increased D_d and noise dosage during the day, excluding one class period. My D_d increased from 10:15 a.m.-11:15 a.m. but my noise dosage decreased during that same time. During that time I was teaching third grade and the students were beginning recorders. They only played for 10-15 minutes of the class period. Men's choir (11:15 a.m.-12:00 p.m.) showed an increase in both D_d and noise dosage just like the other choir days. Kindergarten (1:15 p.m.-2:00 p.m.) indicated that I had an increase in noise dosage and D_d but on this day my D_d percentage was higher than the noise dosage percentage.

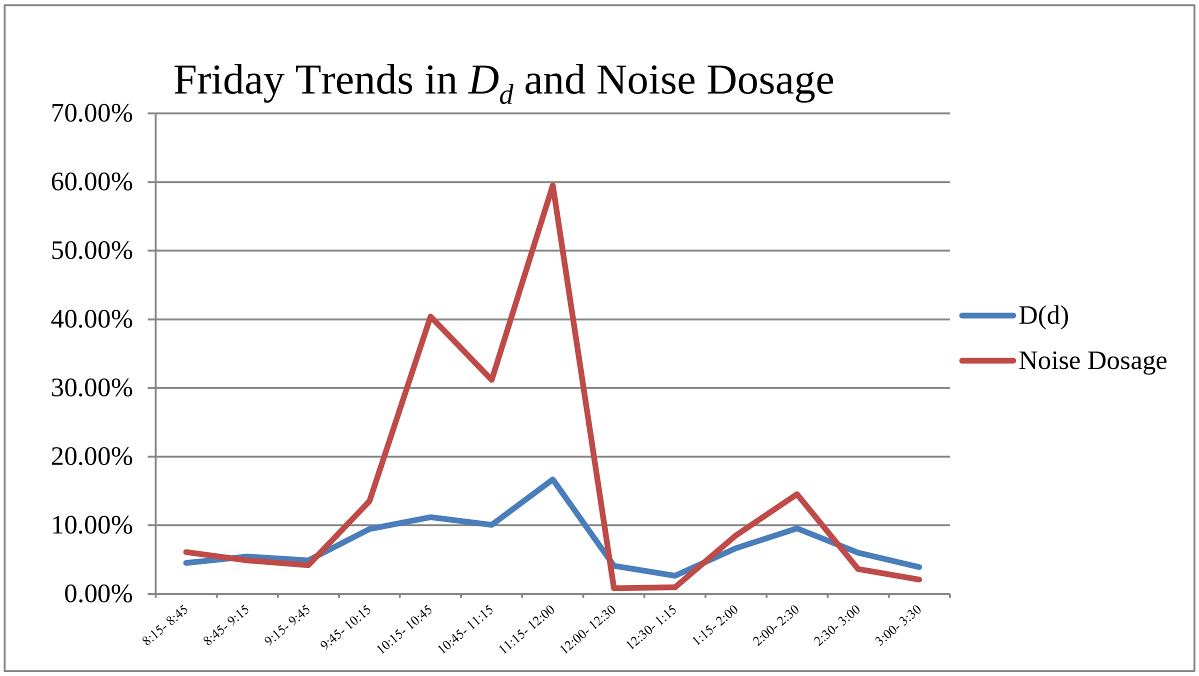

Figure 8. Friday Trends in D_d and Noise Dosage

As indicated by Figures 5-8, noise dose percentage and voice dose percentages by teaching day tended, for the most part, to track directionally. That is when noise dose increased, vocal dose percentage tended to increase, and vice versa, although the two dose percentages did not necessarily increase or decrease by similar amounts. However, there were exceptions within a particular day, e.g., Thursday from 10:15 to 11:15 a.m., when voice dose percentage increased and noise dose percentage decreased.

While these day by day comparisons afford interesting data, it must be remembered that a teaching day includes some non-teaching activities, such as bus or hall duty, lunch time, and planning time. Moreover, my particular teaching schedule dictates that, with the exception of the daily seventh and eighth grade choir class, I teach different classes on different days, sometimes at different times of day. Therefore, disaggregation of mean noise dose percentages and mean voice dose percentages by grade level classes taught during the data acquisition week, regardless of time of day taught, might provide still more interesting information.

Mean Weekly Noise Dose Percentage and Voice Dose Percentage by Classes Taught. Figures 9-15 show comparisons between weekly mean voice dose percentages and weekly mean noise dose percentages according to grade level of classes taught. Kindergarten and first grade were omitted from this comparison because I taught both classes for unequal lengths of time within the same 45 minute period at various times throughout the week; therefore, there was no way to compare just kindergarten or first grade D_d and noise dosage by individual grades with accuracy.

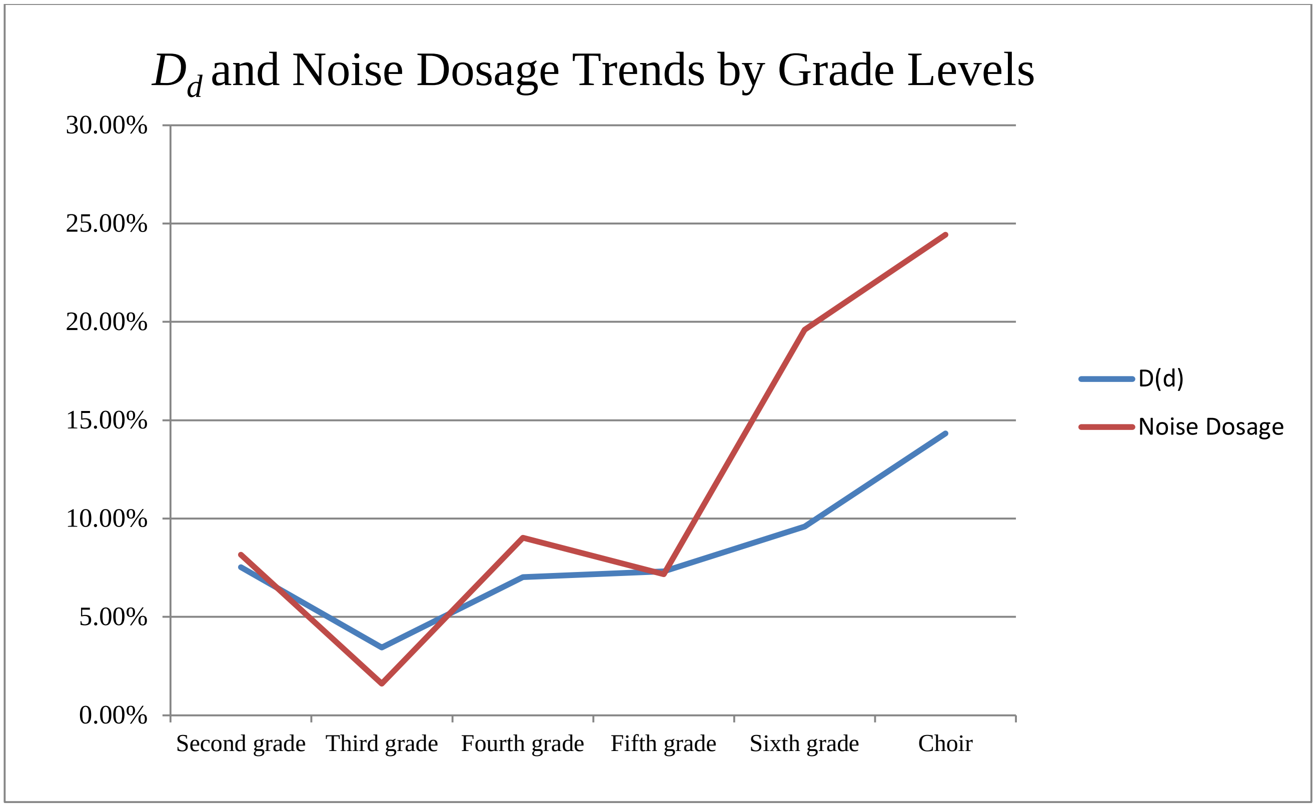

Figure 9. Teaching Week (Tuesday – Friday) Mean D_d and Noise Dosage Trends by Grade Level

As indicated by Figure 9, weekly mean vocal dose percentages and noise dose percentages disaggregated by grade level classes appeared overall to align directionally. That is, when noise dose percentage increased, vocal dose percentage increased, and vice versa. Moreover, with two exceptions, mean noise dose percentages exceeded mean vocal dose percentages, sometimes to a lesser extent (e.g., second grade noise = 8.16%, vocal dose = 7.59%), more often to a greater extent (e.g., sixth grade noise = 19.59%, vocal dose = 9.59%). Mean fifth grade percentages were nearly the same (vocal dose = 7.17%, noise dose = 7.32%), but third grade mean vocal dose percentage (3.44%) exceeded mean noise dose percentage (1.60%) by about a 2:1 ratio. With the exception of fifth grade, mean weekly noise dose percentages appeared to exceed mean weekly vocal dose percentages to a greater extent in the upper grades (fourth grade, sixth grade, seventh-eighth grade choir classes) compared to second grade and to third grade, where mean vocal dose percentage exceeded mean noise dose percentage.

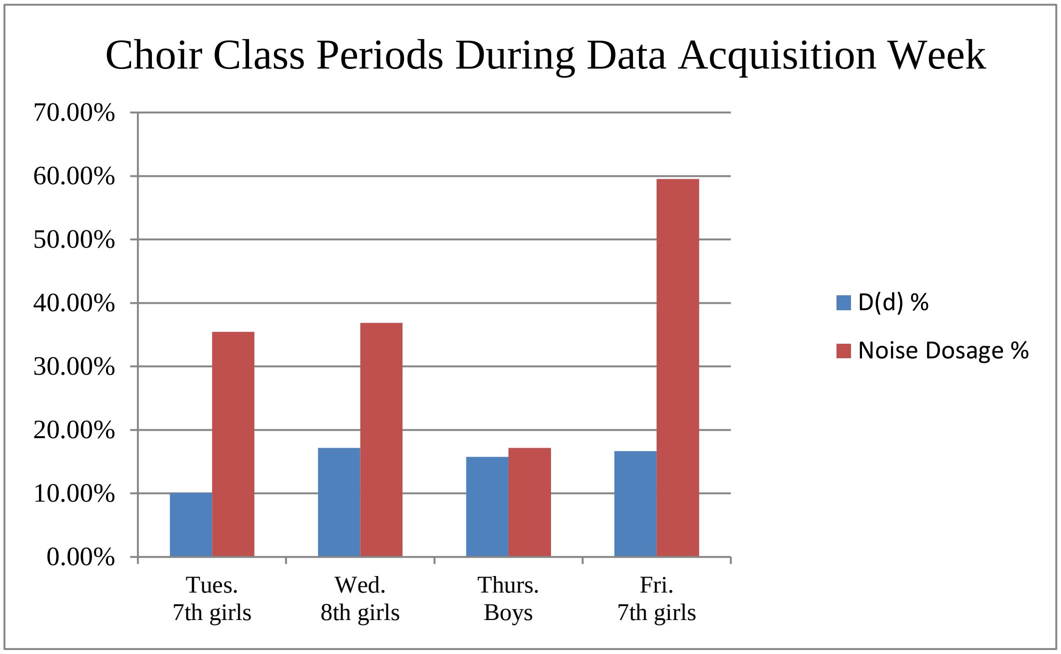

Figure 10. Choir Class Periods During Data Acquisition Week

Choir class met every day during the week from 11:15 a.m.-12 p.m. The composition of the choir, however, rotated on a three day schedule of seventh grade girls, eighth grade girls and boys choir. As indicated by Figure 10, noise dose and vocal dose percentages nearly aligned during the Thursday class. Moreover, this Thursday class showed the lowest percentage of noise dose acquired in choir class during the week of data acquisition. On Thursday I taught boys choir, which had eight students in the class. The smaller class size may have contributed to this circumstance. Yet, chorister sex may also have been a factor; lower frequency singing might be expected to yield less volume than higher frequency singing, due to the pitch-amplitude factor. As shown in Figure 10, I acquired higher noise dose percentages during Tuesday, Wednesday, and Friday choir classes, which were comprised of seventh or eighth grade girls than during the

Thursday class with seventh and eighth grade boys. My highest acquired noise dose percentage in choir occurred during Friday's choir class with seventh grade girls. Seventh grade girl's choir included me playing the piano, voice modeling, and managing talkative students. For all choir classes I led vocal warm-ups and sang along with students during parts of the rehearsal. This could be one reason that my D_d percentage in Figure 10 did not change day to day as much as my noise dosage.

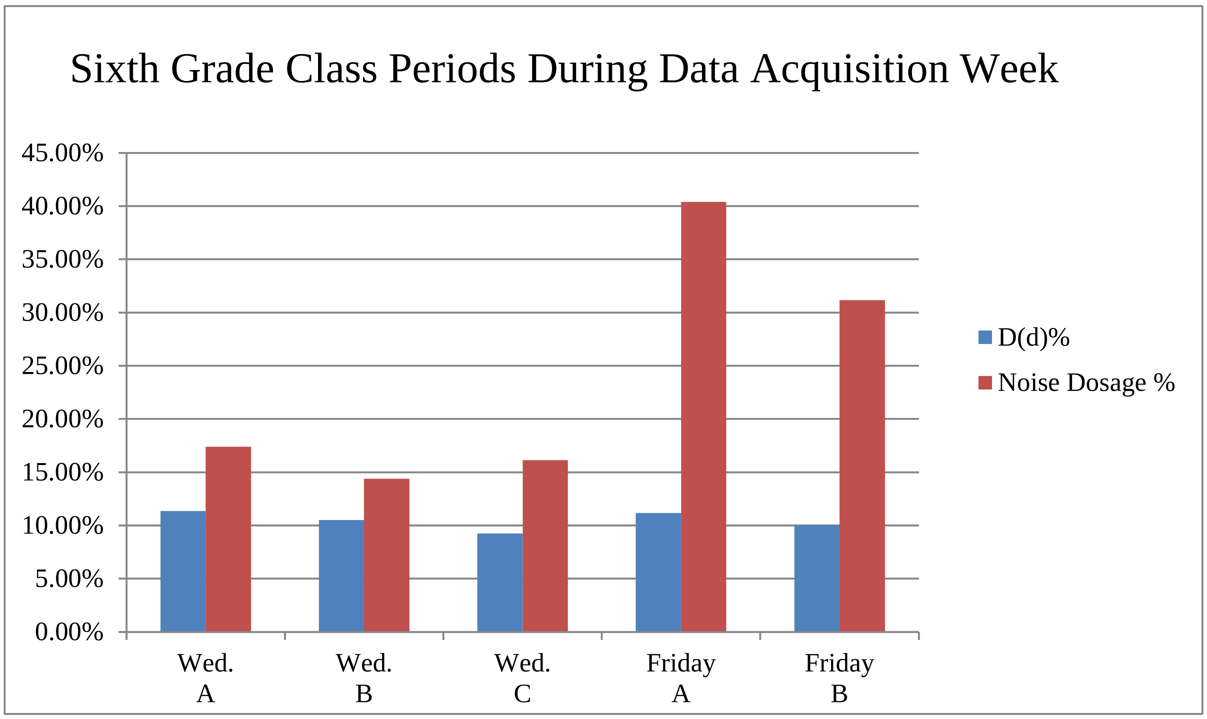

Figure 11. Sixth Grade Class Periods During Data Acquisition Week

Sixth grade classes met three times on Wednesday and twice on Friday the week of the study. On Wednesday I taught two sixth grade classes (Wednesday A and Wednesday B) back to back from 8:15 a.m.-9:15 a.m. and the other sixth grade class (Wednesday C) from 10:15 a.m.-10:45 a.m. Wednesday A to Wednesday B showed a slight decrease in both D_d percentage and noise dosage percentage. Wednesday B to Wednesday C showed a slightly lower D_d percentage but an increased noise dosage percentage. Friday I taught two sixth grade classes

(Friday A and Friday B) back to back from 10:15 a.m.-11:15 a.m. Although vocal dose percentages remained generally consistent between Friday A and Friday B, Friday noise dose percentages exceeded those acquired during the Wednesday sixth grade classes. During Friday A and B classes I was using the piano much of the class to teach students.

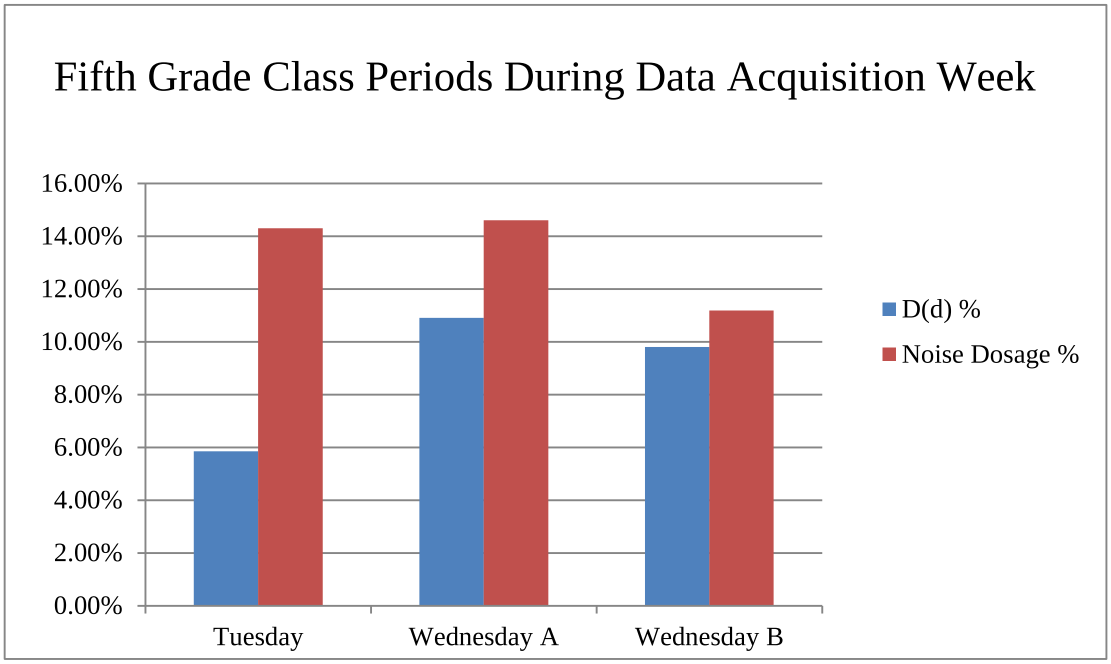

Figure 12. Fifth Grade Class Periods During Data Acquisition Week

Fifth grade classes met once on Tuesday, twice on Wednesday, and once on Friday. Friday data was excluded from Figure 12 because the class ended six minutes early in order to travel to another room for a Stations of the Cross service. Although the dosimeters were on, I decided for purposes of this disaggregation not to count traveling time as music teaching time. Given the complexity of data retrieval, it would have been difficult to omit those six minutes of dosimetry and also to compare unequal class time periods for the one grade. As indicated by Figure 12, comparison of the two Wednesday class periods appear to suggest that as noise dose percentage decreased so did voice dose percentage. However, during the Tuesday class period noise dose percentage exceeded voice dose percentage by a wider margin than was the case during the Wednesday sixth grade class periods.

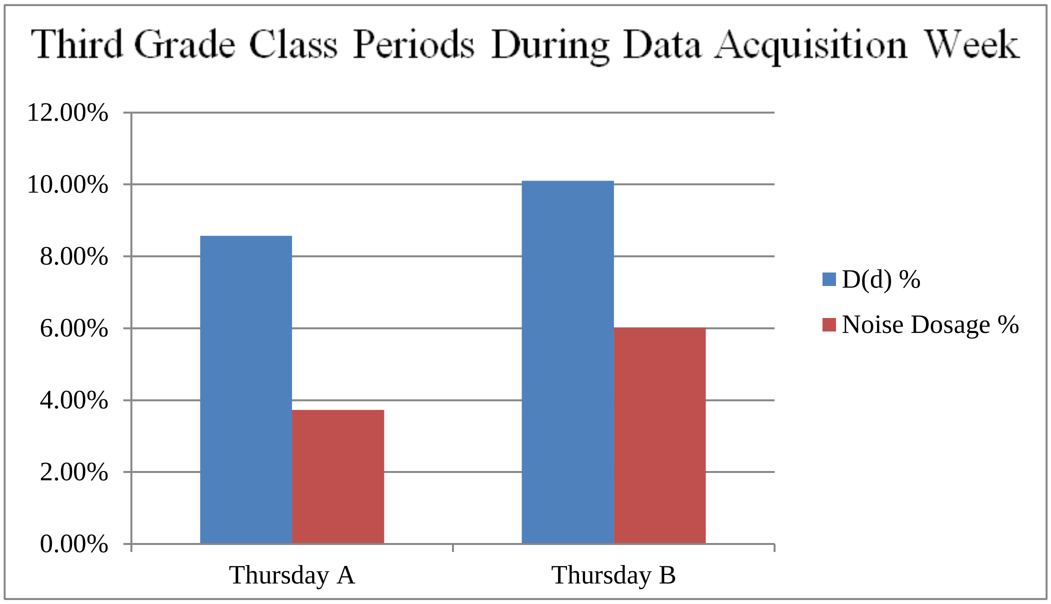

Figure 13. Third Grade Class Periods During Data Acquisition Week

The two third grade classes met on Monday and Thursday the week of the study. As indicated by Figure 13 vocal dose percentages exceeded noise dose percentages for both of the class periods. These two third grade classes constituted the only class periods during the week of the study where that was the case. I taught the students recorder during these particular class periods. The majority of the lesson included students clapping, singing, and speaking rhythms and notes names. It also may have been that I increased my vocal effort in order to make myself heard above the students' playing of recorders, even though noise dose data (Table 20) suggested they may not have played the recorders for very long at any one time after the first day. However, voice dose percentage and noise dose percentage aligned directionally; as noise dose percentage increased, vocal dose percentage increased.

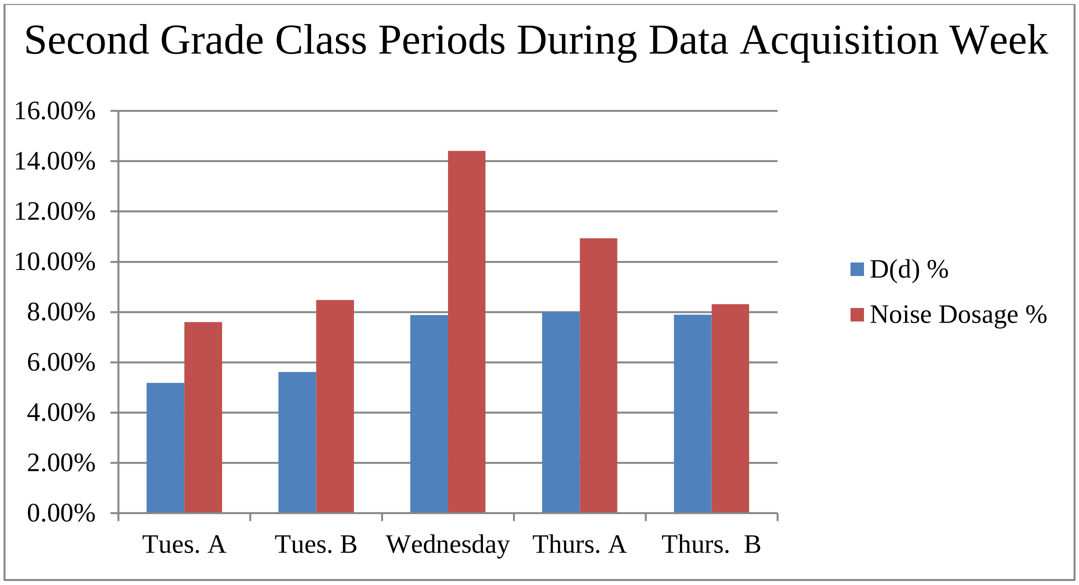

Figure 14. Second Grade Class Periods During Data Acquisition Week

Second grade met on Monday, Tuesday, Wednesday, and Thursday the week of the study. On Tuesday I taught two second grade classes (Tuesday A and Tuesday B) from 8:15 a.m.-9:15 a.m. As shown in Figure 14, Tuesday A, Tuesday B, and Wednesday classes indicated that as noise dose percentage increased so did voice dose percentage. However, from Wednesday to Thursday A classes, noise dose percentage decreased slightly while voice dose percentage remained about the same. During the Thursday B class, noise dose and vocal dose percentages were nearly the same.

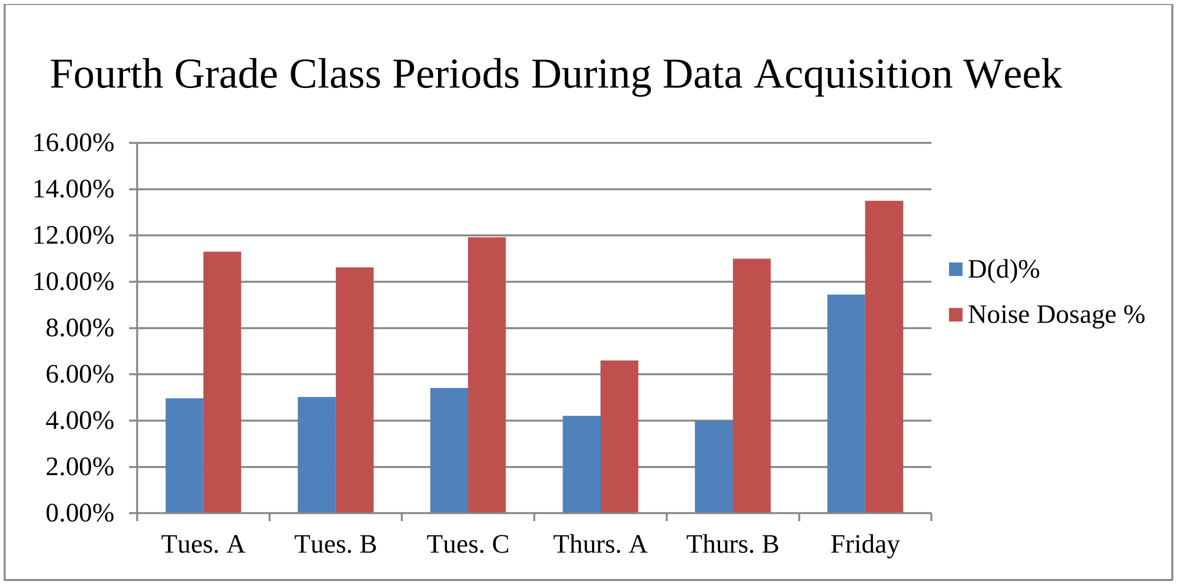

Figure 15. Fourth Grade Class Periods During Data Acquisition Week

Fourth grade classes met on Tuesday, Thursday, and Friday the week of the study. On Tuesday I taught all three classes (Tuesday A, Tuesday B, and Tuesday C) from 9:15 a.m.-10:45 a.m. Between Tuesday's A, B, and C classes there was not much of a change between D_d and noise dosage percentage. As indicated by Figure 15, from Tuesday A through Thursday A classes and again during the Friday class, noise dose percentage and vocal dose percentage overall appeared, again, to follow each other directionally. During the Thursday B class, however, noise dose percentage increased compared to the Thursday A class, while voice dose percentage remained largely consistent between those two class periods.

Summary: Research Question 3. Overall comparison of mean weekly noise dose percentages and mean weekly vocal dose percentages according to classes taught indicated that voice dose percentage appeared to align directionally with noise dose percentage. That is, when noise dose increased, vocal dose percentage increased, and when noise dose decreased vocal dose percentage decreased. Moreover, with two exceptions (third grade and fifth grade), noise dose percentages exceeded vocal dose percentages, particularly in the fourth, sixth, and seventh-eighth grade choir classes.

Disaggregation of these comparisons by individual classes taught indicated that while, for the most part, noise dose percentage and voice dose percentage aligned directionally, there were individual class periods within grade levels with marked exceptions to this overall pattern. Log data, moreover, suggested that such activities as playing the piano may offer at least partial explanation for markedly increased noise doses during particular class periods, regardless of grade level.

The comparisons above seemed to show that my overall noise and vocal doses tend to travel in the same direction, although to varying degrees. More importantly, these comparisons between noise dose and vocal dose seem to be more apparent when looking at the data by classes taught rather than the overall teaching day. Some classes like choir, sixth grade, second, and fourth showed that only some D_d and noise dosage percentages moved in the same direction. Certain classes and grade levels were more varied depending on what happened specifically in that class that particular day.

Research Question Four: MDVP Analysis Pre and Post

The final research question asked what results of a Multi-Dimensional Voice Profile (MDVP) analysis administered prior to and after the study period indicate about the acoustical parameters of the participant's voice. I was administered an MDVP analysis prior to and after the study period. Table 24 shows the results of the pre- and post- MDVP analysis along with the threshold and normal units of a MDVP analysis.

Table 24

Pre- and Post- MDVP Analysis

	Norm(f)	Pre		Post		Threshold
Average Fundamental Frequency	243.973	216.008	Hz	256.569	Hz	n/a
Mean Fundamental Frequency	241.080	216.001	Hz	265.558	Hz	n/a
Average Pitch Period	4.148	4.630	ms	3.766	ms	n/a
Highest Fundamental Frequency	252.724	219.908	Hz	270.775	Hz	n/a
Lowest Fundamental Frequency	234.861	211.372	Hz	260.255	Hz	n/a
Standard Deviation of F_0	2.722	1.219	Hz	1.650	Hz	n/a
Phonatory F_0-Range in semi-tones	2.250	1.000		2.000		n/a
Amplitude Tremor Frequency	2.375	2.548	Hz	4.301	Hz	n/a
Length of Analyzed Sample	3.000	3.287	s	3.750	s	n/a
Absolute Jitter	26.927	21.519		19.097		83.200
Jitter Percent	0.633	0.005		0.005		1.040
Relative Average Perturbation	0.378	0.003		0.003		0.680
Pitch Perturbation Quotient	0.366	0.002		0.003		0.840
Smoothed Pitch Perturbation Quotient	0.532	0.004		0.004		1.020
Fundamental Frequency Variation	1.149	0.006		0.006		1.100
Shimmer in dB	0.176	0.277	dB	0.288	dB	0.350
Shimmer Percent	1.997	0.032		0.026		3.810
Amplitude Perturbation Quotient	1.397	0.022		0.018		3.070
Smoothed Amplitude Perturbation Quotient	2.371	0.032		0.025		4.230
Peak-to-Peak Amplitude Variation	10.743	0.070		0.070		8.200
Noise to Harmonic Ratio	0.112	0.123		0.100		0.190
Voice Turbulence Index	0.046	0.041		0.044		0.061
Soft Phonation Index	7.534	14.045		10.315		14.120
F0-Tremor Intensity Index	0.304	0.001		0.003		0.950
Degree of Voice Breaks	0.200	0.000		0.000		1.000
Degree of Sub-harmonics	0.200	0.000		0.000		1.000
Degree of Voiceless	0.200	0.000		0.000		1.000
Number of Voice Breaks	0.200	0.000		0.000		0.900
Number of Sub-harmonic Segments	0.200	0.000		0.000		0.900
Number of Unvoiced Segments	0.200	0.000		0.000		0.900
Number of Segments Computed	92.594	109.000		124.000		n/a
Total Number Detected Pitch Periods	713.188	708.000		993.000		n/a

Table 24 indicated prior to the nine days of data collection I was phonating within normal limits of all the parameters other than the Soft Phonation Index (SPI). The normal limit for SPI was 7.534 units and the participant's SPI value was 14.045 units. The threshold unit for SPI was 14.120 units. I was administered an MDVP analysis again after ending the study period. Results of the post analysis showed that I was phonating within all normal limits including the Soft Phonation Index which was 10.315 units.

CHAPTER 5

Discussion

The primary findings of this investigation, the first to document acquired noise and voice doses simultaneously with the same elementary school music teacher, are: (a) mean vocal distance doses and noise doses acquired during teaching hours exceed doses acquired during non-teaching hours; (b) the most elevated D_d and noise dosage levels occur during choir rehearsals and sixth grade general music classes; (c) the participant exceeds recommended NIOSH noise doses on 4 of the 5 teaching days; (d) comparison of noise dose percentage and vocal dose percentage during teacher hours indicate, overall, that voice dose percentage appeared to align directionally with noise dose percentage; and (e) however, there were some class periods where vocal dose percentage exceeded noise dose percentage. Although these findings are limited to this particular case study, they do raise some matters that merit professional discussion and future research.

Acquired Vocal Doses

As an elementary school music teacher, my acquired vocal doses during this study appear to exceed somewhat the voice doses reported in previous literature for teachers overall. For example, Astolfi and Bottalicao (2012) report an average phonation time of 25.90% for female teachers during the teaching day. By contrast, my mean phonation time across the five day work week examined in this study is 35.99% MD_t range = 32.80% - 39.18%).

Similarly, Hunter and Titze (2010) indicate that voicing percentages in teachers may be as high as 33% per hour (60 min.). However, data from the present study indicate I acquired a mean D_t dose of 30% or higher during 30 - 45 min. class periods. According toTitze, Svec, and Popolo (2003), 520 meters constitutes a safe vocal distance dose and it can be reached in about 17 min. of continuous vocalization comprised of exaggerated speech, as opposed to normal speech or monotone speech. Data from the current study indicate my mean distance dose is 1625.29 meters during choir 45 min. classes across the teaching week, 1083.71 meters during 45 min. kindergarten-first grade classes, and 1048.52 meters during 30 min. sixth grade classes measured. Although one may not compare precisely distance dose meters from continuous phonation to distance dose meters acquired where there may have been brief intervals of non-phonation or vocal rest, my acquired mean distance doses in these particular classes of 45 min. and 30 min. may exceed that of the recommended safe distance dose of 500 meters in 17 min.

Subsequent research may well wish to investigate the vocal doses acquired by music teachers opposed to classroom teachers of other subjects. Future studies might also examine vocal doses acquired by elementary school music teachers, who often teach choirs, lead group singing, and incorporate recorders or Orff instruments, in comparison to secondary school vocal and instrumental music teachers.

Teachers, of course, continue to phonate beyond the hours they spend at school. For music teachers, this after work hours phonation may include extra evening rehearsals or participation in some forms of vocal music-making. According to Morrow and Connor (2009), vocal doses of elementary school music teachers indicate they exhibit an average work day cycle dose of 1.63 million vibratory cycles. Data from the current study indicate I exceeded 3 million cycles on Tuesday, which included an evening semi-professional choir rehearsal of 2.5 hours. Future studies might focus particularly on vocal loads acquired by music teachers on days where they phonate athletically during after school or evening activities, and the potential contributions of such vocally heavy days to perceptions of vocal fatigue.

According to previous studies (Morrow & Connor, 2009; O'Brien & Tinter, 2012) teachers who wear voice amplifiers while teaching show a reduction in vocal load including decreased distance dose. Although I did not wear any sort of voice amplifier during this study, future research could compare vocal and noise dose trends of music teachers who do not wear voice amplifiers while teaching to music teachers who do wear voice amplifiers. In regards to my own teaching situation, it would seem beneficial for me to utilize a voice amplifier in the future to reduce my vocal doses during the teaching day.

Acquired Noise Doses

I exceeded NIOSH recommended noise dosage during school hours alone on four of the five days of the teaching week examined. One might argue that NIOSH guidelines are more conservative than OSHA noise dose guidelines, and that schools currently must adhere to OSHA guidelines. On the other hand, one could argue that (a) it is better to err on the side of caution, because noise induced hearing loss is cumulative and irreparable, and (b) the U.S. military, European Union nations, and British Commonwealth nations have seen fit to adopt the more conservative NIOSH guidelines. Certainly, hearing is a necessary diagnostic tool in music teaching. Moreover, for music teachers who are singers, good hearing is essential for efficient voicing.

Several previous studies (Daugherty et al. 2015; Grebennikov, 2006; Roebuck, 2009) show high noise doses for other educational contexts. Grebennikov's study (2006) indicates preschool teachers acquire a daily mean noise dose percentage of 53.2% during a six-hour workday. In contrast, my noise dosage exceeded 100% four of the five teaching days (234.81%, 134.87%, 143.45%, and 190.25%) with a mean noise dose percentage of 157.84%. According to Roebuck (2009), seven band directors accumulate a total noise percentage dose of 152.1% of the maximum allowable daily noise dose under the NIOSH standard. In the current study, my Monday (234.81%) and Friday (190.25%) noise dose percentage exceed that of the band directors.

In one particular study, (Daugherty et al. 2015) a voice teacher who teaches two contiguous hour long lessons with piano accompaniment in an intimate studio setting acquires a 150% noise doses. By comparison, my 45 minute choir rehearsal on Monday, which included piano accompaniment, indicates a 79.65% dosage. In fact, that one 45 minute choir rehearsal brings me within 20% of acquiring my NIOSH permissible daily noise dose. Several studies (e.g., Daugherty, et al., 2015) indicate that female singers may acquire higher noise doses than males when singing, and female voice teachers who instruct and sometimes sing along with female voice students may acquire higher noise doses than male teachers in similar situations. In my own case, my choir rehearsals with seven and eighth grade girls register higher noise doses (79.65%, 35.48%, 36.84%, and 59.53%) compared to my choir rehearsal with boys alone (17.17 %). One reason for this finding could be that female singers phonate higher frequencies than male singers, thus yielding a pitch-amplitude effect. Another reason may be that there are more female than male singers in my seventh-eighth grade choir.

Results from Bernstof and Burk (1996) indicate a significant relationship between maximum classroom noise levels and teachers' self-rated indices of vocal integrity. Other previous studies (Kob et al., 2008 and Yiu &Yip, 2015) attribute increased noise levels to classroom construction and acoustics. For example, Yiu and Yip's 2015 study investigates effects of noise on vocal loudness. They indicate that background noise of 67.5 dBA constitutes a "high" noise room. Depending on the position of the teacher or the students relative to the background noise source, it is possible that teachers and students may experience a Lombard effect in such conditions, whereby, without them being aware of it, their phonation amplitude increases in order to hear themselves speak or sing. That sort of situation could set up a "perfect storm" type of situation, in that room background noise would prompt increased vocal effort and louder voicing, which in turn increases the noise (or sound) in the room, which then could lead to still more effortful voicing. For the present study, I did not measure the background noise in my music classroom. However, the automated ventilation system in my room turns on and off through-out the day. One could speculate that noise from the ventilation system might add to the noise levels in the room at those times. Kob et. al (2008) indicate that optimal rooms for teachers exhibit a quieter atmosphere and hence subjectively assessed less background noise levels. In my own case and the case of fellow music teachers, rooms with less environmental background noise would be preferable considering the varying instructional activities that take place, including group singing and the play of instruments, in music classrooms.

Another factor that might contribute to my high noise dosage is the large class numbers of certain grade levels. Sixth grade, and seventh-eighth choir classes show larger noise doses than those acquired in other grade level classes. Of course, there is no way to know from the present data whether class size or the nature of the instructional activities in the higher grade levels contributed more to the acquired noise doses in these contexts. Future studies might investigate the effects of various class sizes on noise doses acquired in a music classroom.

It is important for music teachers to understand just how quickly they can exceed their daily noise dosage and also the potential hearing loss that could stem from continuous noise exposure. Subsequent research will wish to continue to investigate the noise doses acquired by music teachers compared to classroom teachers of other subjects. For the present study, I did not undergo audiometric testing; however, future studies of this type may well include such testing. Future investigations might also include music teachers of all areas of emphasis (band, choir, orchestra, general music, etc.) to compare both acquired noise doses and hearing test results.

Future studies might also investigate specific protective hearing devices and their potential effects on music teachers' perceived hearing ability while teaching. Furthermore, researchers could investigate what effects the wearing of hearing protection earplugs might have on a music teacher's vocal dose.

Music educators could look into wearing protective hearing devices during the times they know they will be exposed to excessive noise doses. Even during my non-teaching hours, data from this study show I was exposed to some noise levels. This added exposure becomes very important when one realizes that noise dose and irreversible noise induced hearing loss are cumulative phenomena. My non-teaching routines include me playing music while getting ready in the morning, listening to the car radio to and from my way to work, and having music or the television on in the evening.

Weekend noise dosages, excluding the post Saturday, are much lower than the weekday noise doses I acquired during this study. Results from my post teaching week Saturday, however, showed I acquired 100% of permissible NIOSH noise exposure with an overall *LEQ* of 82.50 Various dBA. Various activities on that Saturday, including driving the car with the radio on, eating at a busy restaurant with my family, and attending a child's birthday party, likely contributed to that exposure.

Because music teachers may already approach or exceed the NIOSH recommended level of noise exposure by virtue of their occupations, they need to be aware that they may need to monitor closely noise exposure acquired after normal school hours. This awareness may not be as important for an office worker in a relatively quiet office environment, who does not phonate loudly or lead others in somewhat athletic phonation or in playing instruments throughout the day. However, for music teachers, such awareness may be recommended in order to proactively care for hearing health.

In my own situation, data from this study lead to the realization that Tuesdays may be particularly at risk days for me in terms of acquired noise dose. On Tuesdays, I teach non-stop from 8:15 a.m. – 12 p.m. Although I have some breaks during the afternoon on Tuesdays, I sing with a semi-professional choir for two hours on Tuesday evenings. Because acquired noise dosage is cumulative, unlike acquired vocal dose where periods of vocal rest can "reset" the vocal folds to some extent, it would be to my benefit to try to lessen my Tuesday noise exposures, whether by consciously avoiding or lessening high noise activities, particularly during the back-to-back classes taught, or by approaching my school administrator to see if my Tuesday schedule might be altered somewhat.

Possible Relationships Between Acquired Voice and Noise Doses

In order to compare acquired D_d in meters to acquired noise dose percentages within a particular time frame, e.g., a particular class period, I first calculated D_d as a percentage of the given time period, that is, the meters traveled in a given time period divided by the number of minutes in the given time frame. To the best of my knowledge, no previous study has employed this type of calculation, perhaps because no other studies to date have examined vocal and noise dosimetry data acquired simultaneously from the same music teacher.

It must be cautioned, however, that this comparison of vocal and noise dose percentages is a very rough way to get at possible relationships between acquired vocal and noise doses in a given time frame. Future researchers may well wish to devise more stringent means to compare simultaneously acquired vocal and noise doses.

Nonetheless, these comparisons of dose percentages afford at least a preliminary way to look at possible relationships between voicing and environmental noise, one of my interests in undertaking this study. Overall, there appears to be a general trend where vocal dose percentage aligns directionally with noise dose percentage. That is, when noise dose percentage increases vocal dose percentage increases, and when noise dose percentage decreases vocal dose percentage decreases. Future studies might examine simultaneous voice and noise dosimetry from more than one teacher to determine whether this apparent directional alignment between vocal dose percentage and noise dose percentage is simply a product of my particular teaching situation and teaching behaviors or if it might be a more widespread phenomenon.

One potentially confounding factor in the present study is the inconsistency of my teaching schedule. With the exception of seventh and eighth grade choir, I teach different grade levels at different times of day each day. That is, I may meet one grade in the morning on one day, during the afternoon on the next day, and not at all the following day. Although I suspect to some degree this type of schedule might be the case with many elementary school music teachers in contexts where music may be viewed as a "special" class scheduled around the needs of other, "regular" classes, this variance may have played a role in this study, particularly with respect to acquired vocal doses. For example, it could be that as the teaching day proceeds I become more vocally fatigued, which may impact my vocal effort when I teach a particular class later in the day as opposed to teaching it earlier in the day.

At the same time, however, perhaps one advantage of my teaching schedule for this particular study is that mean vocal dose and mean noise dose data by grade level may give a more complete idea of the potential contribution of grade specific music curricula, and perhaps even class size and age of students, to teacher voicing. That is, because different grade level music classes meet at different times of day each day, time of day may be ruled out to some degree as a possible confounding variable when looking at voicing in relation to class content and membership. Subsequent studies of acquired vocal and noise doses may wish to compare elementary school music teaching contexts where the teaching schedule is relatively consistent from day to day and where the schedule is highly variable day to day.

Association, of course, is not causation. But if one assumes that during this study, especially during teaching hours, I could exercise little control over the environmental noise reaching my ears, then this sort of directionality, in concert with the fact that noise dose percentage most often exceeded voice dose percentage, makes sense. As noise increased, the amplitude of my voice increased somewhat in a compensatory effort to receive sufficient airborne feedback from my voicing, i.e., in order to hear myself speak or sing. In other words, I likely experience a Lombard effect.

Comparison data, however, also show some occasions where vocal dose percentage exceeds noise dose percentage. In the third grade general music classes, for instance, where students played recorders, I may have employed particularly effortful voicing so that students could hear me above the noise of the recorders. Were that the case, however, noise doses acquired during those class periods (range: 3.73% - 17.09%) may suggest that students did not play the recorders for an extended period at any one time, which may suggest, in turn, that even relatively short bursts of hyper vocal effort, e.g., talking above the noise of the recorders, contributed to an increased vocal distance dose acquired during these class times overall.

Comparison of vocal dose percentage and noise dose percentage in the seventh and eighth grade choir classes to vocal and noise dose percentage in general music classes at lower grade levels suggest that teaching choral singing at the middle school age level may be a particularly robust arena for increased teacher voicing as well as increased environmental sound. There may be several reasons such could be the case. The students are older than students in the kindergarten through sixth grade general music classes; hence, they sing with somewhat greater vocal amplitude than the younger students. These students sing for most of the class period every day, as opposed to general music group singing that may occur some days, but not other days, or for part of the class period as opposed to the entire class period. Piano accompaniment is more frequent in choir and sixth grade general music classes than in the other general music classes. Moreover, because I play the piano as well as direct the students my acquired noise dose increases because I am the person in the class closest to the piano.

One contribution of this case study investigation may be its comparison of acquired voice and noise doses in elementary school general music classes and in seventh and eighth grade choir classes, because the data for this study come from the same teacher who teaches both general music and choir in the same room. However, more research is needed in order to examine more fully whether teachers may acquire elevated vocal and noise doses when teaching choir than when teaching general music classes. Such research would benefit from being more longitudinal in nature. For example, some weeks in general music students may be playing Orff instruments as well as singing, or moving to recorded music played through speakers.

Future research might also compare in various environments, including different rooms with different acoustical properties and different teaching schedules and class sizes, the vocal and noise doses acquired by elementary school general music teachers, middle school choir and band teachers, and high school choir and band teachers. Various studies to date have looked at one or more of these contexts in terms of either noise dose or vocal dose, but it may be of interest to examine and compare an array of music teachers at each of these levels in terms of simultaneously acquired noise and vocal doses.

Particular Instructional Activities That Might Contribute to Elevated Doses

Dosimeter data from this study in conjunction with daily log data may suggest, although they do not prove, that certain types of teaching and learning activities may result in elevated teacher vocal and noise doses. For example, keyboard accompaniment appears to occur in many of the class periods that evidence more elevated noise and vocal dosage compared to class periods where piano accompaniment did not occur. Subsequent studies might explore this possibility by keeping a record in minutes and seconds of how often the keyboard is played, something that this study did not do. Future investigations might also attempt to disaggregate teacher vocal and noise doses acquired during times of keyboard accompaniment with doses acquired during class activities without piano accompaniment.

The type of keyboard employed in the music classroom also merits investigation. I have an electronic keyboard in my room, which has a volume adjustor so that I can turn the volume up or down while playing. Future studies could investigate the sound levels acquired using various types of keyboards (e.g., electronic vs. acoustic piano) in various types of music rooms. Other studies could also look at what happens when the volume level on electronic keyboards is adjusted upward or downward.

The singing power and confidence of particular configurations of students may also contribute to greater or lesser teacher noise doses. Interestingly, on Thursday when the seventh and eighth grade choir boys met alone for rehearsal, my noise dose was less elevated than when the girl choirs, met on other days. Yet my D_d readings tend to show a similar amount of teacher voicing on all choir days. This finding suggests that although I still sing with my boys' choir during rehearsal, the boys, in effect, make less noise. By contrast, my choir girls are more confident, even spirited, singers phonating at higher frequencies, and they are more talkative than the boys as well. It would make sense that I acquire a more elevated noise dose when they are present. Future studies might well examine whether or not teachers acquire less noise dose with less confident middle school male students who sing a lower frequencies than more confident middle school female students who sing at higher frequencies. A possibly confounding factor in the present study, of course, is that I also have more girls in choir than boys. Future research might control for this variable by employing roughly equal numbers of male and female students.

Class size may also be a contributing factor to the noise and vocal doses teachers acquire. In the present study, there appears to be an association, with two exceptions, between grade level taught and increased noise and vocal doses. However, I also have more students in these upper grade level classes than in the lower grade level classes. A future investigation might compare noise and vocal doses acquired by the teacher when teaching the same curriculum in the same room to students of the same grade level with a smaller number of students and a greater number of students in the room.

Another possibly contributing factor that merits investigation is room size. Because I have greater numbers of students in seventh-eighth grade choir and sixth grade general music, the students in these classes sit and stand closer to one another than students in lower grade level classes where the class size is smaller, due to the constraints of room dimensions. My music classroom also lacks risers. Future studies might investigate what happens when the same class is taught in rooms of varying dimensions. Other studies might also examine whether the use of risers in rooms of varying sizes would lessen or increase the noise dose acquired by the teacher.

Limitations of the Study

This case study is the only known study investigation to date that compares vocal and noise doses acquired simultaneously by an elementary school music teacher during both teaching and non-teaching hours. Although its data present an interesting snapshot that may inform directions for future research, its findings cannot be generalized to other music teachers in other contexts.

Because I am both the researcher and the sole participant for this study, one could argue that I may have, intentionally or not, subtly altered my vocal behaviors and noise exposures given my awareness of the specific research questions guiding this investigation. One cannot rule out such possibility entirely. However, the tasks of doing one's job and going about one's life do not leave much time or opportunity to think consciously about what the dosimetry might be capturing at particular moments in time across nine days. Moreover, by the nature and placement of the dosimetry used and the necessity of obtaining informed consent, it could be argued that any participant would be cognizant of the purpose of the study and, if desired, potentially alter his or her typical behaviors in some ways. Yet, again, the ability to do so appreciably across nine days would be doubtful.

It should be noted as well that the data presented here represent simply a snapshot of one teaching week, along with its preceding and subsequent weekends. It may well be that another teaching week or other weekends could yield different results. For example, during this particular week of data collection, I had neither school day nor evening school concerts or rehearsals, which in my context would occur in the school gymnasium. During this particular week, I did not have cafeteria duty or before or after school, outside student morning drop-off or afternoon dismissal duty. With the exception of the Tuesday evening choir rehearsal, I did not participate in evening music making activities during this particular week. Changes in any of these factors could reasonably be expected to impact acquired vocal and noise doses.

Concluding Thoughts

By documenting vocal and noise doses acquired by an elementary school music teacher across nine days, including a teaching week and two weekends, this case study provides data that suggest numerous avenues for future research. The data of this study also afford music teachers an opportunity to reflect upon their own teaching situations and behaviors in terms of becoming proactive about protecting their voices and their ears.

Voicing and hearing are two tools that music teachers use regularly in the course of going about their jobs. Without increased awareness of the factors that may contribute to the degradation of these tools across time, such as the amount of vocal and noise dosage incurred during teaching in particular environments and contexts, the very thing that music teachers love to do, i.e., teach music, may potentially jeopardize their abilities to function most efficiently across time in the jobs they love. Without the ability to hear acutely and without the ability to offer vocally appropriate models for students, the music teacher's job becomes more complicated, if not compromised.

References

Aleccia, J. (2013) Hoarse teachers find talking is an occupational hazard. *Health-Healthcare*, Retrieved February 19, 2016 from http://www.nbcnews.com/id/44618330/ns/health-health_care/t/hoarse-teachers-find-talking-occupational-hazard/#.VtUMQPkrLIV

American Hearing Research Foundation. (October, 2012). *What is Noise Induced Hearing Loss?* Retrieved March 2, 2016, from http://american-hearing.org/disorders/noise-induced-hearing-loss/#whatis

Amir O., Kishon-Rabin L., & Muchnik C. (2002) The effect of oral contraceptives on voice: preliminary observations. *Journal of Voice*, *16*, 267 – 73.

Amir O., & Kishon-Rabin L. (2004) Association between birth control pills and voice quality. *Laryngoscope*, *114*, 1021 – 6.

Amir O., Biron-Shental T., & Shabtai E. (2006) Birth control pills and nonprofessional voice: acoustic analyses. *Journal of Speech Language and Hearing Research*, *49,* 1114 – 26.

Bernstorf, E.D., & Burk, K.W. (1996) Vocal integrity of elementary vocal music teachers: Personal and environmental factors. *Journal of Research in Music Education, 44,* 369-383.

Bistrizki, Y., & Frank, Y. (1981) Efficiency of voice and speech training of prospective elementary school teachers. *Israeli Journal of Speech and Hearing, 10,* 16-32.

Bottalico, P., & Astolfi, A. (2012) Investigations into vocal doses and parameters pertaining to primary school teachers in classrooms. *Acoustical Society of America, 131,* 2817-2827.

Bovo, R., Galceran, M., Petruccelli, J., & Hatzopoulos, S. (2007) Vocal problems among teachers: Evaluation of a preventative voice program. *Journal of Voice, 12*, 705-722.

Brunskog, J., Gade, A.C., Bellester, G.P., & Calbo, L.R. (2009) Increase in voice level and speaker comfort in lecture rooms. *Journal of the Acoustical Society of America, 125,* 2072-2082.

Cantarella G., Iofrida E., Boria P., Giordano S., Binatti O., Pignataro L., Manfredi C., Forti S., & Dejonckere P. (2014) Ambulatory phonation monitoring in a sample of 92 call center operators. *Journal of Voice, 28,* 393.

Cezar-Vaz, M.R., de Oliveira Severo, L., Borges, A.M., Bonow, C.A., Rocha, L.P., & de Almeida, M.C.V. (2013) Voice disorders in teachers. Implications for occupational health nursing care. *Occupational Health Program of the School of Nursing, 13,* 252-260.

Chan, R.W., (1994) Does the voice improve with vocal hygiene education? A study of some instrumental voice measures in a group of kindergarten teachers. *Journal of Voice, 8,* 279-291.

Cook-Cunningham, S.L. (2014) Personal noise dosimeters: Accuracy and reliability in varied settings. *Noise and Health, 16*, 143-148.

Cutiva C.C. & Burdorf A. (2015) Effects of noise and acoustics in schools on vocal health in teachers. *Noise and Health, 17,* 17-22.

Daugherty, J.D. (2003) Choir Spacing and Formation: Choral Sound Preferences in Random, Synergistic, and Gender-Specific Chamber Choir Placements. *International Research in Choral Singing, 1,* 48-59.

Daugherty, J.D., Nelson, H., Rollings, A.A., Grady, M.L., & Scott, S.T. (2015, May) Noise doses acquired by university singing voice instructors during voice lessons taught across one week in intimate studio venues. Oral Presentation. *44th Annual Voice Foundation*, Philadelphia, PA.

Duffy, O.M., & Hazlett, D.E. (2004) The impact of preventative voice care programs for training teachers: A longitudinal study. *Journal of Voice, 18,* 63-70.

Gaskill, C.S., O'Brien, S.G., & Tinter, S.R. (2012) The effect of voice amplification on occupational vocal dose in elementary school teachers. *Journal of Voice, 26,* 667e19-667e27.

Grebennikov, L. (2006) Preschool teachers' exposure to classroom noise. *International Journal of Early Years Education, 14,* 35-44.

Hackworth, R.S. (2010) The effect of teaching experience and specialty (vocal or instrumental on vocal health ratings of music teachers. *The National Association for Music Education, 28*, 13-19.

Hanley, T.D. (1949) Effect of level of distracting noise upon speaking rate, duration, and intensity. *The Journal of Speech and Hearing Disorders, 14,* 363-368.

Howell, P. (1985). Auditory feedback of the voice in singing. In Howell, P., Cross, I. & West, R. (Eds), *Musical structure and cognition*. London: Academic Press, 259-286.

Hunter, E.J., & Titze, I.R. (2010) Variations in intensity, fundamental frequency, and voicing for teachers in occupational versus nonoccupational settings. *Journal of Speech, Language, and Hearing Research, 53,* 862-875.

Hunter, E.J., Tanner, K., & Smith, M.E. (2011) Gender differences affecting vocal health of women in vocally demanding careers. *Logopedics Phoniatrics Vocology*, *36,* 128-136.

Janela, M. (2014) Kansas City Chiefs fans reclaim record for loudest crowd roar at sports stadium. *Officially Amazing.* Retrieved March 2, 2016, from http://www.guinnessworldrecords.com/news/2014/10/kansas-city-chiefs-fans-reclaim-record-for-loudest-crowd-roar-at-sports-stadium-60872/

Kob, M., Behler, G., Kamprolf, A., Goldschmidt, O., & Neuschaefer-Rube, C. (2008) Experimental investigations of the influence of room acoustics on the teacher's voice. *The Acoustical Society of Japan, 29,* 86-94.

Masuda, T., Ikeda, Y., Manako, H., & Komiyama S. (1993) Analysis of vocal abuse: fluctuations in phonation time and intensity in 4 groups of speakers. *Acta Oto-Laryngol*, *113,* 547-552.

McAleavy, G.J., Adamson, G., Hazlett, D.E., Donegan, H.A., & Livesey, G.E. (2008) Modeling determinants of the vocal health of teachers in Northern Ireland: implications for education policy and practice. *Public Health, 122,* 691-699.

McKay, R.L. (1964) How to keep school noise at the right level. *The Nation's Schools*, *74,* 1

Miller, M.K., & Verdolini, K., (1995) Frequency and risk factors for voice problems in teachers of singing and control subjects. *Journal of Voice*, *9,* 348-362.

Morrow, S.L. (2009) *Voices not heard: Voice-use profiles of elementary music teachers, the effect of voice amplification on vocal load and perceptions of issues surrounding voice use.* Retrieved from ProQuest Digital Dissertations. (UMI 3399929).

Morrow , S.L., & Connor, N.P. (2009) Comparison of voice-use profiles between elementary classroom and music teachers. *Journal of Voice*, *25*, 367-372.

Morrow, S.L., & Connor, N.P. (2011) Voice amplification as a means of reducing vocal load for elementary music teachers. *Journal of Voice*, *25,* 441-446.

Nacci, A., Fattori, B., Mancini, V., Panicucci, E., Ursino, F., Cartaino, F.M., & Berrettini, S. (2013) The use and role of the ambulatory phonation monitor (APM) in voice assessment. *Acta Otorhinolaryngologica Italica, 33,* 49-55.

National Center for Voice and Speech. 1993. *Occupational and Voice Data*. Iowa City, IA: National Centre for Voice and Speech.

National Institute for Occupational Safety and Health. (2012). *Noise Evaluation of Elementary and High School Music Classes and Indoor Marching Band Rehearsals* (Health Hazard Evaluation Report HETA 2011-0129-3160). Atlanta, GA: Brueck, S.E., Chen, L.

National Institute on Deafness and Other Communication Disorders. (n.d.) Noise-Induced Hearing Loss. Retrieved March 2, 2016, from http://www.nidcd.nih.gov/health/hearing/pages/noise.aspx

Nehring, C., Bauer, M.A., & Teixeira, A.R. (2012) Exposure to classroom sound pressure level among dance teachers in Porto Alegre. *International Archives of Otorhinolaryngology,17,* 20-25.

Niebudek-Bogusz E., Kotylo P., Politanski P., & Sliwinska-Kowalska M. (2008) Acoustic analysis with vocal loading test in occupational voice disorders: Outcomes before and after voice therapy. *International Journal of Occupational Medicine and Environmental Health, 21,* 301-308.

Niebudek-Bogusz E. & Sliwinska-Kowalska M. (2013) An overview of occupational voice disorders in Poland. *International Journal of Occupational Medicine and Environmental Health, 26,* 659-669.

Ohlsson, A.C., Brink, O., & Lofqvist, A. (1989) A voice accumulator-validation and application. *Journal of Speech, Language, and Hearing Research, 32,* 451-457.

Pawlaczyk-Luszczynska M, Dudarewicz A, & Zamojska M, (2010) Risk assessment of hearing loss in orchestral musicians. *Medycyna Pracy, 61*:493–511.

Pelegrin-Garcia, D., Smits, B., Brunskog, J., & Jeong, C.H. (2011) Vocal effort with changing talker-to-listener distance in different acoustic environments. *Journal of Acoustical Society of America, 129,* 1981-1990.

Preciado JA, Garcia Tapia R, & Infante JC. (1998) Prevalence of voice disorders among educational professionals. Factors contributing to their appearance or their persistence. *Acta Otorrinolaringol Esp, 49,* 137–142.

Remacle A, Morsomme D, & Finck C (2013) Comparison of vocal loading parameters in kindergarten and elementary school teachers. *Journal of Speech, Language, and Hearing Research., 57,* 406-415.

Richter B., Nusseck M., Spahn C., & Echternach M. (2015) Effectiveness of a voice training program for student teachers on vocal health. *Journal of Voice, 0,* 1-8.

Roebuck, N. M. (2009). *An analysis of collegiate band directors' exposure to sound pressure levels* (Order No. 3400185). Available from ProQuest Dissertations & Theses Global. (304929499). Retrieved from http://search.proquest.com.www2.lib.ku.edu/docview/304929499?accountid=14556.

Roy, N., Merrill, R.M., Thibeault, S., Parsa, R.A., Gray, S.D., & Smith, E.M. (2004) Prevalence of voice disorder in teachers and the general population. *Journal of Speech, Language, and Hearing Reasearch, 47,* 281-293.

Roy N., Merrill, R.M., Gray, S.D., & Smith, E.M. (2005) Voice disorders in the general population: prevalence, risk factors, and occupational impact. *Laryngoscope, 15,* 1988 – 1995.

Ryan S. & Mendel L.L. (2010) Acoustics in physical education settings: The learning roadblock. *Physical Education and Sport Pedagogy, 15,* 71-83

Saniga, R., & Carlin, M. (1991) Auditory dysfunction in voice disorder patients. *American Auditory Society Bulletin, 16,* 9-26.

Schloneger, M.J. (2011) Graduate student voice use and vocal efficiency in an opera rehearsal week: A case study. *Journal of Voice, 25,* e265-e273.

Schloneger M. J. (2014) Assessments of voice use, voice quality, and perceived singing voice function among college/university singing students ages 18-24 through simultaneous ambulatory monitoring with accelerometer and acoustic transducers. Retrieved from ProQuest Digital Dissertations. UMI 3681384.

Schink T, Kruetz G, Busch V, Pigeot I, Ahrens W. (2014) Incidence and relative risk of hearing disorders in professional musicians. *Occup Environ Med,0,*1-5.

Schwartz, S.M. (2009) Voice range profiles of middle school and high school choral directors. *Journal of Research in Music Education, 56,* 293-309.

Siverio K.C., Goncalves C.G., Penteado R.Z., Vieira T.P., Libardi A., & Rossi D. (2008) Actions in vocal health: A proposal for improving the vocal profile of teachers. *Pró-Fono Revista de Atualização Científica, 20,* 177-182.

Sliwinska-Kowalska, M., Niebudek-Bogusz, E., Fiszer M., Los-Spychalska T., Kotylo P., & Sznurowska-Przygocka B. (2006) The prevalence and risk factors for occupational voice disorders in teachers. *Folia Phoniatr Logop,58,* 85-101.

Smith, E., Gray, S.D., Dove, H., Kirchner, L., & Heras, H. (1997) Frequency and effect of teacher voice problems. *Journal of Voice, 11,* 81-87.

Smith, E., Kirchner, H.L., Taylor, M., Hoffman, H., & Lemke, J.H. (1998) Voice problems among teachers: Differences by gender and teaching characteristics. *Journal of Voice, 12,* 328-334.

Spielman, J.L, Hunter, E.J., Halpern, A.E., & Titze, I.R. (2012) Measuring improvement in teachers with voice complaints using the inability to produce soft voice (IPSV): Preliminary data. *The National Center for Voice and Speech Online Technical Memo, 13,* 1-19.

Summers, W.V., Pisoni, R.H., Bernacki, R. I., Pedlow, & Stokes, M.A. (1988) Effects of noise on speech production: Acoustic and perceptual analyses. *Journal of the Acoustical Society of America, 84,* 917-928.

Stathopoulos, E.T., Sapienza, C. (1993) Respiratory and laryngeal function of women and men during vocal intensity variation. *Journal of Speech and Hearing Research, 36,* 64-75.

The Texas Department of Insurance, Division of Workers' Compensation. (2015). *Noise and Hearing Protection Factsheet.* Austin, TX.

Titze, I.R., Svec, J.G., & Popolo, P.S. (2003) Vocal doses measures: Quantifying accumulated vibration exposure in vocal fold tissues. *Journal of Speech, Language, and Hearing Research, 46,* 919-932.

Titze, I.R., Hunter, E.J., & Svec, J.G. (2007) Voicing and silence periods in daily and weekly vocalizations of teachers. *Acoustical Society of America, 121,* 469-478.

United States Department of Labor. *Occupational Noise Exposure.* Retrieved March 2, 2016, from https://www.osha.gov/SLTC/noisehearingconservation/

University Of Toronto. (2004, May 19). Study Finds Music Teachers At Risk Of Hearing Loss. *ScienceDaily*. Retrieved February 19, 2016 from www.sciencedaily.com/releases/2004/05/040519071721.htm

U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. (2012). *Health hazard evaluation report: noise evaluation of elementary and high school music classes and indoor marching band rehearsals*. (NIOSH HETA No. 2011-0129-3160). Cincinnati, OH: Chen L., Brueck, S.E.

Van Houtte, E., Claeys, S., Wuyts, F., & Lierde, K.V. (2011) The impact of voice disorders among teachers: vocal complaints, treatment-seeking behavior, knowledge of vocal care, and voice-related absenteeism. *Journal of Voice, 25,* 570-575.

Vilkman, E. (2000) Voice problems at work: A challenge for occupational safety and health arrangement. *Folia phoniatrica et logopaedica, 52,* 120-125.

Watanabe, H., Shin, T., Oda, M., Fukaura, J., & Komiyama, S. (1987) Measurement of total actual speaking time in a patient with spastic dysphonia. *Folia Phoniatrica (Basel), 39,* 65-70.

Williams, N.R. (2003) Occupational groups at risk of voice disorders: a review of the literature. *Occupational Medicine, 53,* 456-460.

Yiu E.M. & Yip P.P. (2015) Effect of noise on vocal loudness and pitch in natural environments: An accelerometer (ambulatory phonation monitor) study. *Journal of Voice, 0,* 1-5.

Zivkovic, D. & Pityn, P. (2004) Music teachers' noise exposure. *Canadian acoustics, 32,* 84-85.

APPENDIX A

THE UNIVERSITY OF KANSAS
Research

NOT HUMAN RESEARCH

March 23, 2016

Jennifer Berroth
j291b882@ku.edu

Dear Jennifer Berroth:

On 3/23/2016, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Noise and Vocal Doses Acquired by an Elementary Music Teacher across Nine Days: A Descriptive Case Study
Investigator:	Jennifer Berroth
IRB ID:	STUDY00003769
Funding:	None
Grant ID:	None
Documents Reviewed:	• HSCL-NewSubmission-Form-V3.pdf

The IRB determined that the proposed activity is not research involving human subjects. IRB review and approval is not required.

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are being considered and there are questions about whether IRB review is needed, please submit a study modification to the IRB for a determination. You can create a modification by clicking **Create Modification / CR** within the study.

Sincerely,

Stephanie Dyson Elms, MPA
IRB Administrator, KU Lawrence Campus