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Healthy Lungs: Cancer Education for Middle School Teachers Using a "Train and Equip" Method

E. Robert Burns

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Abstract Prevention of the initiation of tobacco use, which is associated with increased risk of developing cancer of the lung, the oral cavity, larynx, and emphysema, should target middle school-age children because that is where experimentation with tobacco use usually begins. Millions of children attending school do not receive proper education regarding the biological science of the human respiratory system coupled with the impact that tobacco use has at the cell, tissue, and organ levels of biological organization because their teachers are ill-prepared and ill-equipped to teach this normal and cancer-related content. The University of Arkansas for Medical Sciences has a statewide outreach program that provides middle school teachers training in a "Healthy Lungs" curriculum that covers the normal functional anatomy of the respiratory system as a basis for adding the effect of tobacco use and its associated cancers and emphysema. This training also provides each participant a resource kit of supplies, materials, and items of equipment. A long-term implementation survey identified a high degree of transference of content and use of the resource kit items into new classroom learning activities for the trainee's students for both the normal functional anatomy of the human respiratory system and associated general and cell/tissue/organ-specific cancer biology.

Keywords K-12 · Respiratory system · Tobacco use · Lung cancer · Professional development

E. R. Burns (✉)
Department of Neurobiology & Developmental Sciences,
College of Medicine–Slot 510,
University of Arkansas for Medical Sciences,
Little Rock, AR 72205, USA
e-mail: burnsbob@uams.edu

Introduction

Tobacco use and its associated development of cancers of the respiratory system and emphysema remains the single most preventable cause of cancer-related mortality and morbidity in the USA [1]. Hopkins et al. [2] concluded "despite 36 years of policies, regulations, education efforts, the increasing information on the negative health effects of tobacco use, and the positive health benefits of cessation or never starting smoking, tobacco use remains unacceptably high." Smoking rates have declined among adults, but the rate of smoking initiation among early adolescents remains high [3]. It is known that early experimentation with tobacco use increases the likelihood of eventual habitual smoking [4, 5]. Smoking rates during middle school double from less than 10% of sixth graders to nearly 20% of eighth graders [6].

In Arkansas [7], the smoking rate (2010 survey results) for high school students was down significantly from 2000 levels for the number of students smoking at 35.1% with boys at 37.5% and girls at 33.8% vs. 2010 levels of 23.5%, 27.8%, and 18.7%, respectively. However, the 2010 levels have increased from 2007 levels of 20.4%, 23.0%, and 17.8%, respectively, although these increases were not statistically significant. The Arkansas Youth Tobacco Survey [7] stated: "It is important to note that these behaviors start in middle school where 6.9% of public middle school students are current cigarette smokers and 5.1% are current users of smokeless tobacco."

Many researchers advocate for early intervention to prevent the onset of smoking [8–11]. In a Canadian study [12] of children in the fourth and fifth grades: (1) the prevalence of ever-smoking was 21.1% at baseline but 30.2% at 1-year follow-up, 2) almost 17% of the children classified as never-smokers at baseline initiated smoking within a year, and (3) 33% of ever-smokers continued smoking. Research findings regarding age of smoking initiation [6, 12, 13] strongly suggested that if smoking prevention is to succeed, the target group should be middle school-age children. Objective #27-3 of Healthy People 2010 [14] regarding "tobacco use in population groups" states, "reduce initiation use among young children and adolescents (developmental)." Healthy People 2020 [15] lists the first objective as: (1) "Tobacco Use Prevalence: Implementing policies to reduce tobacco use and initiation among youth and adults." Prevention programs have generally targeted adolescents rather than younger children and are usually focused on behavioral changes, not cell, tissue, and organ biology and the documented effects on these of tobacco use.

There are approximately "50 million students attending more than 98,000 schools nationwide-schools therefore provide the most far-reaching access to young people" [16]. In addition, young, school-age children are very interested in learning about their bodies. A study [17] to determine school-age childrens' interest or lack of interest in science topics reached the following conclusions: "compared to other subjects, biology enjoys the most popularity" and "the topics of student interest ranked in descending order were: 1st-anatomy and physiology, 2nd-science and medicine, 3rd-genetics and reproduction, 4th-behavior, neurobiology and the mind, 5th-man and animal relationships and lastly 6th-biotechnology." Young children, therefore, are very interested in learning specific facts and concepts about their own bodies, i.e., human organ biology both normal and diseased, but their teachers are not trained in this content and, therefore, do not teach it. For example, "a lot of my [middle school student] teachers tell me that smoking causes lung cancer, but none of them can tell me exactly how this happens."

This lack of teacher preparation in science has been studied by a variety of experts in science education, educational psychology, etc. An exhaustive study of this problem has been carried out at the national level. Duschl et al. [18] record the findings of "The Committee on Science Learning, Kindergarten Through Eighth Grade," established by the National Research Council. What follows are quotations of some of this committee's published statements, conclusions, and recommendations:

> P 296… Student learning of science depends on teachers having adequate knowledge of science. Currently K-8 teachers have limited knowledge of science and limited opportunities to learn science. In order for K-8 teachers to teach science as practice, they will need sustained science-specific professional development in preparation and while in service. Achieving science proficiency for all students will require…. teacher preparation and professional development for teachers across the K-8 years; P 297… It is a truism that teachers must know the content that they are to teach… no teacher could adequately support student learning without first mastering the content of the curriculum herself. In a Meta analysis of 65 studies, Druva and Anderson (1983) found that student science achievement was positively related to both the number of biology courses and the overall number of science courses their biology teachers had taken; P 299… Observed limitations in K-8 teachers' knowledge of science are not surprising given the mixed and generally low expectations laid out in teacher certification policy at the state level. Delaware, Maryland and Maine register on the high end of requirements requiring 12 semester hours in science. In contrast, Hawaii and Kansas are states that do not require credit hours in science or other subject areas; P 300… Only about 15% of states require a major in the subject area taught as part of the requirement to obtain a middle school certificate. Clearly the scientific knowledge of K-8 teachers is often quite thin. If they are to help students reach national and state standards science teachers will need substantial support in the form of better preservice training as well as inservice professional development that will bolster their knowledge of the science they teach; P 310… Professional development programs support teacher learning and instructional improvement. However, the faculties of many K-8 schools lack the science-specific expertise necessary for instructional improvement – deep knowledge of science – they will require substantial guidance and input from external support providers; P 318… Analysis of science textbooks suggests that by and large, those used in the American classrooms are of low quality; P 341… Comparisons of science standards and curricula in the United States with that of countries that perform well on international science tests reveal overly broad and superficial coverage of science topics in US classrooms, with little attention to building links across concepts or developing a specific concept over successive grades. Professional development is key to supporting effective science instruction.

The preparation of middle school teachers in science in Arkansas is no exception to the national problem presented above: "General Education Core Requirements for Baccalaureate Degree Program" in Arkansas (personal communication from C. Mackey, AR Department of Education) requires only eight semester credit hours in science and that may not include any biology especially human organ biology. And yet, K-8 teachers, according to the Arkansas Science Standards, are expected to help their students gain an "understanding of the anatomy and physiology of the respiratory system and the effects of tobacco use."

Because of these long-standing problems in teacher preparation in the sciences in the nation and in Arkansas, in 1991, the University of Arkansas for Medical Sciences (UAMS) established an outreach program to provide, on a statewide scale, PreK–12 teachers with professional development training in the health sciences accompanied by the gift of a resource kit (supplies, materials, and items of equipment)—the Partners in Health Science (PIHS) program. This concept has two major, interrelated components: (1) provide professional development to in-service and preservice teachers in the normal organ biology they are expected to teach and (2) integrate into that health science content a focus on diseases that have their beginning in early childhood such as those related to tobacco use.

Through August of 2011, 20,989 participants have consumed 75,793 h of training in 119 different health science topics taught by 202 different UAMS faculty members. This experience has resulted in four publications [19–22]. The "equip" component of the program is crucial because the newly trained teachers exit the training with the physical resources for immediate transference of the educational experience into new learning opportunities for their students that can be replicated annually for the duration of the teacher's career with no additional costs. This method is different from the "mobile laboratory" approach [23] wherein the equipment used in the training remains on the bus when it leaves the training site. This paper presents the details of a PIHS professional development activity focused on the human respiratory system—"Healthy Lungs" (HL).

Methods

The HL trainer (ERB) travels to the local communities to offer the training. The resource kit items include: a profusely illustrated syllabus written by the trainer specifically for the target audience (teachers and their students), a CD of all images used, a large plastic model of a human lung, a Plexiglas/rubber diaphragm/two balloon "thorax," a sponge lung smoking device, a set of laminated 8×10 color photographs showing normal and abnormal cell, tissue, and organ biology including images of emphysema, squamous cell and adenocarcinoma of the lung, and a list of links to selected websites. The 3-h workshop starts with a general overview of basic "Cancer Biology" (induction, invasion, lymphatic spread, metastases, and the basic concepts of surgical and radiation oncology and chemotherapy, etc.). This is followed by the normal functional anatomy of the human respiratory system at both the gross and microscopic levels of biological organization. Then, the pathological and epidemiological details of the effect of smoking and smokeless tobacco use are presented. A segment documenting the effects of smoking cessation is included. Throughout the workshop, there are many audience-participation activities specifically designed for student use: (1) students perform a blood walk carrying red or blue cards where appropriate from working cells in an organ where oxygen (red card) is exchanged for carbon dioxide (blue card) in a capillary bed, via systemic veins to the right heart, out the pulmonary artery to the lungs where carbon dioxide is exchanged for oxygen, via pulmonary veins to the left heart, and out the aorta for distribution to all body organs—repeat; (2) the ciliary wave (arm movements) moves the mucus film up from below the oropharynx and down from the nasal chambers to the oropharnyx where it is swallowed; (3) the effect of cigarette smoke on the normal ciliary wave, i.e., ciliotoxicity results in poor ciliary beat coupled with excess production of mucus resulting in the functional anatomical basis for the cigarette cough; (4) a holding hands lightly activity to show the ease of adding and removing oxygen to the hemoglobin molecule compared to binding some oxygen-carrying sites with carbon monoxide (hold hands tightly) resulting in hypoxia and a subsequent increase in the number of circulating red blood cells in the smoker; (5) alveolar macrophages ingest and digest bacteria vs. ingest complex carbon compounds found in cigarette smoke, but no digestion of these, therefore, they are carried in the macrophage cytoplasm as can be seen by both light and electron microscopic imaging; (6) destruction of normal recoil of pulmonary elastic fibers by cigarette smoke increasing elastase activity, but decreasing anti-elastase activity resulting in emphysema; and (7) basement membrane destruction by locally invading cancer cells is illustrated by wetting the center of a piece of poster board (basement membrane) with a lab alcohol spray (collagenase secretion) and passing a finger (cancer cell) through this weakened section of basement membrane to begin the process of local invasion into the underlying connective tissue area where small lymph and blood vessels are eventually encountered and can be entered.

Pre-/posttest data were collected before/after the session. There were 21 questions; 10 related to normal respiratory biology and 11 related to the effects of tobacco use on the respiratory system or general cancer biology content.

An evaluation tool (Table 1) was completed at the end of the training session. Once alumni of the workshop had a minimum of 6 months to return to their home classrooms and implement or not implement some new learning opportunities for their students, a long-term survey (Table 2) was conducted to determine the degree of use of the resource kit items and transference of the workshop content into new learning opportunities for the participant's students.

An example of how this "train and equip on wheels" approach works is illustrated in Fig. 1. The training site was the Educational Cooperative location in Melbourne, AR. Teachers drove to the training site from surrounding towns/counties. For example, of the 32 teachers attending, three came from their home community of Mountain Home, AR.

Table 1 Participant satisfaction with the healthy lungs workshop

Item	Mean				Standard deviation			
	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4
Overall, this was an excellent presentation.	4.65	4.87	4.82	4.77	.569	.335	.415	.464
The program was well organized.	4.77	4.81	4.87	4.80	.472	.426	.339	.431
I am satisfied with the level of health science content.	4.68	4.84	4.76	4.80	.543	.373	.428	.399
The program was well taught/presented.	4.71	4.82	4.79	4.80	.559	.416	.468	.442
I learned something new about the lung, lung cancer, and emphysema.	4.81	4.82	4.82	4.83	.408	.416	.385	.381
The program met my expectations.	4.56	4.81	4.74	4.71	.630	.426	.469	.570
I am satisfied with the level of interaction and instruction.	4.55	4.81	4.71	4.74	.711	.482	.528	.495
I plan to use program materials with my students.	4.64	4.70	4.60	4.81	.786	.648	.713	.439
The program increased my motivation to teach this information to my students.	4.53	4.68	4.69	4.71	.791	.589	.514	.492
I plan to use program information with my students.	4.35	4.48	4.45	4.60	.868	.749	.735	.613
Content is relevant to my professional development.	4.24	4.41	4.38	4.56	.866	.743	.835	.589

Results

From July 1, 2006 to June 30, 2010, a total of 645 middle school teachers attended the "Healthy Lungs" professional development workshop. Workshops were held in 17 communities in the state. Participants attended from those and nearby communities (150 towns/cities total). Of those in attendance, there were 561 (87%) females and 84 (13%) males; 85% were Caucasian, 13% were African Americans, and the remaining 2% self-identified as "other."

Pretest results were available from 575 (89.1%) of the trainees. Posttest results were available from 578 (89.6%) of the trainees. The data showed a pre–post gain of 29.4 percentage points in year 1, 28.1 in year 2, 30.9 in year 3, and 30.7 in year 4.

A total of 188 (grant year 1), 79 (grant year 2), 84 (grant year 3), and 223 (grant year 4) participants completed a satisfaction rating form at the end of the training session using a five-point Likert scale: 1=strongly disagree, 2= disagree, 3=sometimes agree/sometimes disagree, 4=agree, and 5=strongly agree. The data in Table 1 illustrate a consistent high level of satisfaction with the workshop over the 4-year time span.

A long-term implementation survey was mailed only to alumni of the workshop who had a minimum of 6 months after the training event to return to their classroom and implement or not implement some of the newly learned content and/or use of the resource kit items. This time lag of a minimum of 6 months from the training event allowed capture of data on the transference/use of the training into new classroom learning activities for the students of the trained teachers. This implementation survey was mailed to 54% (348/645) of the trainees (those completing the training event for 6 months or more) with a return rate of 26.1%. The data are presented in Table 2 and confirm earlier findings relative to implementation [19].

Table 2 Results of a long-term implementation survey

Items	% Strongly agreeing	% Agreeing	% Total agreeing
The materials ("resource kit") received were useful as teaching aids.	57.1	40.7	97.8
I plan to continue to use the materials with my class.	52.7	46.2	98.9
I plan to continue to use the information with my class.	49.5	47.3	96.8
This training provided me with skills to use the information with my class.	41.8	53.8	95.6
The information I gained was transferable to child learning activities.	38.5	49.5	88.0
These activities were able to hold the children's interest.	34.1	47.3	81.4
I was able to transform some of the training activities into classroom activities for my students.	33.0	54.9	87.9
The learning activities ("red + blue card blood walk," "using arms as cilia to move mucus," etc.) presented in the training were appropriate for use in my classroom.	33.0	50.5	83.5
The children in my class were able to gain knowledge from this unit.	30.8	58.2	89.0

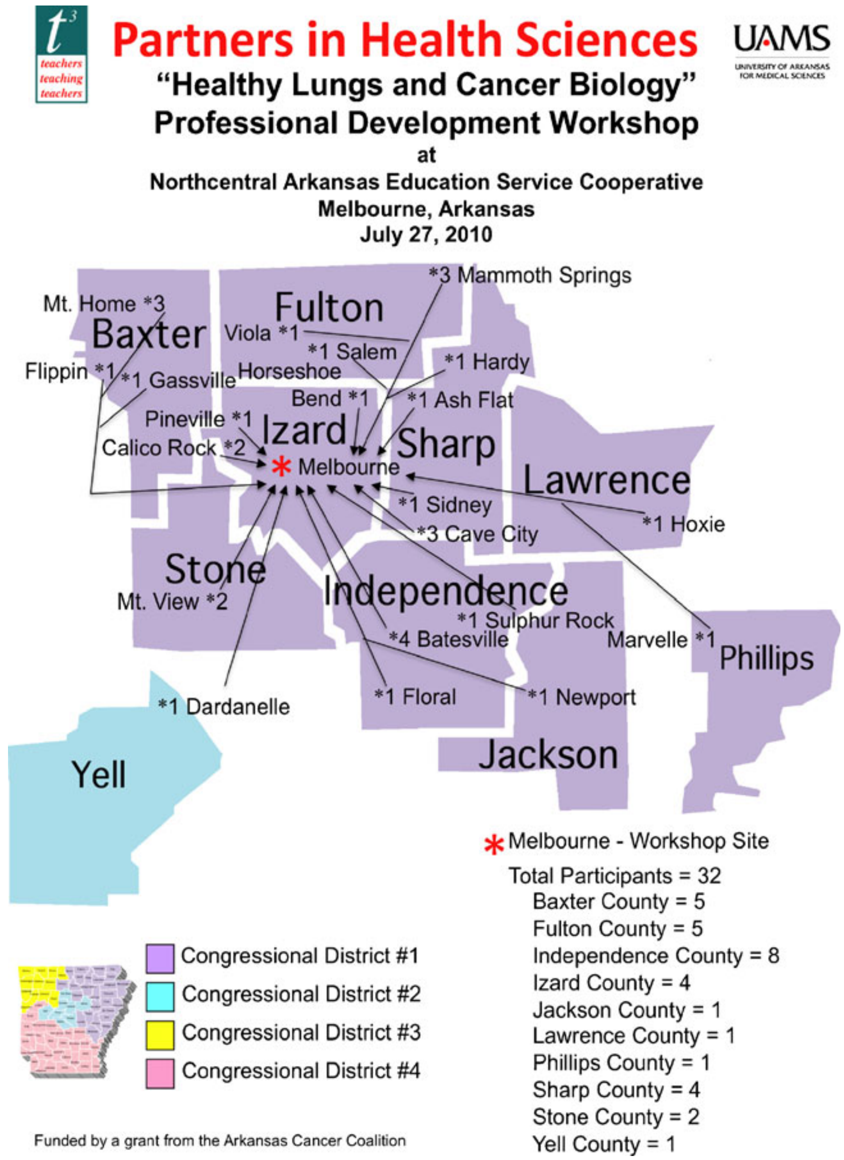

Fig. 1 An illustration showing an example of how the "train and equip on wheels" approach works

In addition to the questions on the implementation survey, participants were asked to describe any other activities they developed and conducted with their students as a result of the training plus their own initiative. Twenty-three (25%) of the 91 returning the implementation survey provided descriptions of their personally developed classroom activities. This finding attests to how innovative and motivated many teachers are or become relative to the "Health Lungs" training. Some examples were:

1. I used parts of the Healthy Lungs resource kit in a kit I developed for science/health teachers on secondhand smoke and its effects.
2. I had my pre-AP class develop a questionnaire about smoking/no smoking for other classes in our school. We compiled the data. It lets them see how many people they talk to smoke/why they started/times they tried to quit, etc.
3. The "Healthy Lungs" program has helped us with state standard implementation in PE, health, and science.
4. Created my "own" PowerPoint to share with my students—I used lots of the workshop images, but made it so it met the needs of my students.
5. I had students take a survey related to family members using tobacco products. They put the data in an Excel spreadsheet. From Excel, the students were able to turn their data into graphs. Using the graphs, we made posters showing both tobacco usage at different grades and the number of students whose family members use tobacco broken down by smokeless and smoking tobacco. By doing the project this way, we incorporated into the respiratory biology the use of math and

technology, and we could have gone further and written essays to incorporate English.

Overall, rating responses strongly indicated that the training activity, the materials, and the information participants received resulted in new curricular content and learning activities for the students of the trainees.

Discussion

The trainees used the resource kit items and their new knowledge/understanding of the respiratory system, its normal structure–function and the impact that smoking has on this system, to generate new classroom learning opportunities for/with their students. For example, 98.9% of the teacher-trainees stated that they agreed or strongly agreed with the statement "I plan to continue to use the materials with my class," and 96.8% agreed or strongly agreed with the statement "I plan to continue to use the information with my class."

The use of the resource kit items, new content, and hands-on activities presented in the "Healthy Lungs" workshop plus the generation of additional grade-appropriate activities by some of the trainees is not a single hit event, but can be replicated by these newly trained and equipped teachers annually for the duration of their teaching careers. This results in program dissemination and sustainability with no additional costs.

There is consensus that never starting to use tobacco is much better than trying to stop smoking because the long-term success rate for smoking cessation remains at about 5–10% [24, 25]. Thus, smoking onset among children and adolescents remains a major public health concern. The Department of Health and Human Services [26] recommended that public schools (PreK–12) incorporate health-related tasks, materials, and examples related to smoking in regular everyday instruction and develop "school-based strategies that lead to sustained reduction in smoking initiation." Although 90% of children visit a pediatrician, smoking prevention counseling is not routinely practiced with either the children or their parents [27]. Therefore, classroom teachers adequately trained and equipped to teach human organ biology content, that integrates the normal functional anatomy with appropriate cancer biology/cancer education, is a "marriage" that will provide an information base from which their students not only will gain an understanding of structure and function of human cells, tissues, and organs—addressing state and national science standards—but also they will be able to use this information base to make healthy lifestyle choices. This is a different approach than just telling students that "smoking causes lung cancer."

This brand of statewide professional development could serve as a model for other institutions to adopt. The "Healthy Lungs" program eventually will be placed on a website [k12education.uams.edu] as is the current situation for the syllabus dealing with the Lance Armstrong testicular cancer workshop [20].

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