TEACHERS' TOPICS

A Case-Based Toxicology Module on Agricultural- and Mining-Related Occupational Exposures

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Objective. To develop and assess a toxicology module to teach pharmacy students about farming- and mining-related occupational exposures in the context of an existing toxicology elective course.

Design. A teaching unit that included lectures and case studies was developed to address the unique occupational exposures of patients working in agricultural and mining environments. Upon completion of this 4-hour (2 class periods) module, students were expected to recognize the clinical signs and symptoms associated with these occupational exposures and propose acceptable therapeutic plans.

Assessment. After completing the module, students scored significantly higher on a patient case involving suicide resulting from pesticide consumption. Seventy-three percent of the students scored higher than 90% on a 33-item multiple-choice examination. Eighty-two percent of students were able to correctly read a product label to determine the type of pesticide involved in an occupational exposure.

Conclusion. Pharmacy students who completed a module on occupation exposure demonstrated competence in distinguishing occupational exposures from each other and from exposure to prescription and nonprescription drugs. This module can be used to educate future pharmacists about occupational health issues, some of which may be more prevalent in a rural setting.

Keywords: case-based teaching, toxicology, occupational exposure, agriculture, pesticides, mining

INTRODUCTION

Case-based teaching fits well with the increased emphasis on evidence-based classroom management encouraged by the Accreditation Council for Pharmacy Education (ACPE) and other accrediting boards. The emphasis that the ACPE has placed on active learning and critical thinking in pharmacy curricula increased with the release of Guidelines 2.0.¹ Thus, pharmacy educators are obliged to investigate active-learning techniques for the classroom, not only in response to the accreditation guidelines, but also because they help students with process skills such as communication, team-building, and problem solving.^{2,3} Case studies are a natural way for pharmacy educators to incorporate active learning into a course curriculum as there are myriad patient cases to draw from in the literature. Additionally, case-based teaching effectively increases student engagement, particularly in the health sciences.⁴⁻⁶ This is advantageous as there are multiple studies linking student engagement to

learning, as the students feel more personally invested in learning outcomes if they are effectively engaged.⁷⁻⁹ Case-based teaching has found much success in the fields of pharmacy, including in pharmacokinetics,¹⁰ pharmaceuticals,¹¹ medicinal chemistry,^{12,13} pharmacology,¹⁴ and toxicology.¹⁵ Outside of pharmacy, faculty members have successfully used case-based teaching in nursing and professional ethics.^{16,17} Overall, case-based teaching is prevalent in medical education because it increases professional and clinical competence and fosters critical thinking.^{3,16,18}

Hiott and colleagues note the lack of appreciation within medication education for occupational exposures to chemicals and dust as such incidents relate to the diagnosis of illnesses.¹⁹ These authors emphasize that healthcare professionals often fail to recognize the symptoms of pesticide poisonings and that knowledge regarding such exposures is especially important for clinicians serving rural and migrant populations.¹⁹ Hiott and colleagues identify resources that clinicians can use, the most relevant of which is the Environmental Protection Agency's (EPA's) manual.²⁰ Unfortunately, the extent to which chemicals are encountered in various US occupations has outpaced their inclusion in medical curricula.¹⁹

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Colleges and schools of pharmacy are equally if not more deficient than medical schools in teaching students about occupational exposures; in fact, findings from an earlier study of the curricula of US colleges and schools suggested that approximately 30% offer a formal toxicology course in which occupational exposures are most likely to be covered.¹⁵ The module described here emphasizes exposures associated with the occupations of farming and mining. Epidemiologists have linked these exposures to increased risk of cardiovascular disease,²¹ respiratory illnesses,²² and cancers.²³ Because of these additional risks, the implications for pharmacists' intervention in occupational exposure go far beyond the job itself.

A unique aspect of the Bill Gatton College of Pharmacy at East Tennessee State University is a component of its mission statement that emphasizes rural health care. This paper describes a case-based module created for second- (P2) and third-year (P3) doctor of pharmacy (PharmD) students at the college to help prepare them to assess patients who have suffered occupational exposure related to mining and agricultural jobs, with specific emphasis on the farming community's exposure to pesticides. Through a pre- and post-module case study and 5 additional case studies, as well as summative-evaluation examination questions, the effectiveness of the module for addressing these ends was assessed. The summative evaluation questions were constructed to correspond to the first 2 levels of Bloom's Taxonomy: Level 1, which includes knowledge, comprehension, and application, and Level 2, which includes application, analysis, synthesis, and evaluation.²⁴ Upon completion of this module, students were expected to recognize the clinical signs and symptoms associated with agricultural and mining occupational exposures and propose therapeutic options for the affected patients.

DESIGN

The Principles of Toxicology elective course is offered to P2 and P3 students in the spring semester. During spring 2012, a new content module was introduced to address a deficiency regarding assessment of pesticide exposures by healthcare professionals. The content of the module included agricultural exposures, mainly focused on pesticides such as organochlorines, organophosphates, carbamates, and pyrethroids. Additionally, mining occupations, with exposures to silica dust, carbon monoxide, coal dust, and radon were discussed. To broaden the scope, mining occupational exposures were included in the module as both are somewhat unique to rural patient populations. The case studies used in this module as well as the summative assessment questions were geared toward the following 2 learning objectives: (1) recognize

clinical signs and symptoms associated with agricultural and mining-related occupational exposures, both chronic and acute, (2) propose emergency management plans for acute exposure patients and treatment plans for chronic exposure patients, including relevant diagnostic tests.

The class consisted of 13 P2 students and 20 P3 students, who divided into self-selected teams of 2-3 students each (13 groups) on the first day of class. Following an introductory toxicology lecture, the students were given a patient case with questions to work on as a group (Appendix 1^{25,26}). Students were instructed to use only their knowledge to work through the case, and were told not to use Google, Wikipedia, etc, to postulate answers. Upon completing the case, each group turned in a paper to the instructor, and the cases were checked for correctness but not marked. Over the next 2 class periods, the occupational exposure module, which consisted of lecture slides, audience-response questions, and additional group-solved cases, was delivered. These additional exposure cases related to organophosphate poisoning,²⁷ organochlorine poisoning,²⁸ and pyrethroid poisoning.²⁹ Additionally, they looked at cases involving coal dust toxicity³⁰ and carbon monoxide poisoning. A detailed outline of the content covered, as well as summaries of the relevant cases used, is shown in Appendix 2. At the end of the second day of the occupational exposure module, the "starter" case from day 1 was revisited by the groups, and each group was encouraged to change or add to their answers based on what they learned in class from the module content.

EVALUATION AND ASSESSMENT

The instructor examined the starter case submitted by each group before and after the delivery of the occupational exposure module. During the pre-module iteration, 92% (12 of 13) identified the patient's breath having a garlic odor as a significant clinical symptom of chemical or drug exposure and 38% (5 of 13) articulated the presence of a complement of cholinergic symptoms given the patient's clinical presentation. Thirty-one percent (4) of the groups hypothesized that pesticides could have been involved in the poisoning, yet none were able to expound on this hypothesis. Likewise, the same percentage proposed that questions regarding the individual's occupation may have been relevant to solving the case. Other explanations for the toxicity given by the groups included bite/sting (1), Lupron toxicity (1), aspiration of activated charcoal (2), and arsenic poisoning (6). After reexamining the case in class, all of the groups agreed that the garlic odor was a significant aspect to the clinical presentation, and were able to clarify the presence of cholinergic symptoms.

In the papers submitted after completion of the module, all 13 groups hypothesized that pesticides were involved in the poisoning, and of these, 12 of 13 further specified carbamate or organophosphate poisoning by correlating the expected with the actual clinical presentation (Figure 1). No pre-data were collected for the 5 additional group case study assignments. For all 5 cases, over 90% of the groups or individual students correctly identified the offending agent in the patient cases, and in most cases, an equally high percentage recommended an appropriate treatment plan (Figure 2). The exception was the carbon monoxide case, for which approximately half of the students (48%) failed to recommend the use of hyperbaric oxygen due to the patient's age. Students' ability to read and interpret pesticide labels using the appropriate EPA database³¹ was specifically emphasized by Hiott and colleagues in referencing those skills needed by healthcare professionals who expect to be in contact with patients who experience exposure.¹⁹ Students demonstrated this skill on the case study exercises involving pesticide exposures by determining the type of chemical (organophosphate, carbamate, organochlorine, or pyrethroid) based on the label. All 13 groups correctly identified the organophosphate and organochlorine pesticides and 12 of 13 groups correctly identified the pyrethroid. The pyrethroid case also involved translation from Spanish to English to discover the offending agent.

Immediately after completion of the occupational exposure module in class, a 33-item multiple-choice examination was administered to students as a summative evaluation. Of the summative evaluation questions, 18 were categorized as Level 1 of Bloom's Taxonomy and

15 were categorized as Level 2. Students worked individually rather than in groups to answer these questions. Seventy-three percent of the students scored higher than 90% on the examination (average $\pm$ standard deviation: $93.1\% \pm 6.7$). On the Level 1 questions (those assessing knowledge, comprehension, and application), $93.4\% \pm 6.9\%$ were answered correctly. On the Level 2 questions (those assessing application, analysis, synthesis, and evaluation), $92.3\% \pm 8.3\%$ were answered correctly. On the examination item assessing students' ability to read and interpret pesticide labels using the appropriate Environmental Protection Agency (EPA) database, 82% were able to correctly determine the type of pesticide involved in the exposure by reading the labels.

DISCUSSION

The Toxicology elective included P2 and P3 students, very few of whom had previous experience with the course content. Students voluntarily chose to take this elective course for a variety of reasons, including instructor preference, the case-based format of the class, and the course content; however, some may have been convinced to take the elective because of the potential benefit the knowledge gained in this course could give them in other classes, namely pharmacotherapy.¹⁵

During examination of the pre-module starter case results, the instructor was pleasantly surprised at the number of students who, before seeing any of the pesticide-related content, hypothesized the involvement of such chemicals. Also impressive was the fact that the side-effects of the medications, namely Lupron and Lortab, did not distract most students from considering other

Figure 1. Results from student outcomes on a pesticide poisoning case before and after delivery of occupational exposure module.

Figure 2. Results from student outcomes on clinical cases involving farming and mining occupational exposures.

non-medication related causes for the patient's demise. Following the module, the students showed a clear understanding of the complement of symptoms involved in pesticide poisoning and mining occupational exposures, as demonstrated by their outcomes on the additional case studies. Obviously, the timing of the lecture content primed the students to consider certain occupational exposures. Yet, the module proved to accomplish its short-term goals with regards to raising awareness of these exposures, and the students demonstrated that they could articulate the symptoms associated with pesticide and mining-related exposures as well as differentiate them from side effects of concomitant medications.

The impact of this awareness is not limited to students who will eventually serve rural populations. According to the Centers for Disease Control and Prevention, carbon monoxide, a gas associated with mining exposure, accounts for an average of 15,000 emergency department and 500 deaths per year in the general population.³² Additionally, our country's heavy dependence on pesticide use, both in large-scale farming and small-scale residential sites, leads to an estimated 10,000 to 20,000 pesticide poisonings each year.³³ Many of these are documented in the Sentinel Event Notification System for Occupational Risks (SENSOR) pesticides program, managed by the National Institute for Occupational Safety and Health, and represent all regions of the United States.³⁴

The students demonstrated a high level of engagement during the content delivery, as it used a rich and versatile active-learning component, the case study. Based on their revision of the starter case answers, students

demonstrated that they could better address the clinical needs of the patient following completion of the module. The students also performed well on summative assessment questions that evaluated their understanding of farming- and mining-related occupational exposures, the health effects and treatments associated with these exposures, and the relevant diagnostic tests used.

CONCLUSIONS

A multi-day module on occupational exposure provided a unique opportunity for students to learn about non-drug exposures that are likely to affect a significant number of the rural patients they may see in practice. This content is equally valid in non-rural settings as pharmacists may also encounter these chemicals in cases of attempted suicide and home-based poisoning. After completing the module, the students demonstrated their ability to address patient needs following these exposures through both formative and summative assessments. The content of the occupational exposure module addressed a well-documented knowledge deficiency among health professionals and increased students' awareness of non-drug related poisonings.

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Appendix 1. Introductory Patient Case^{25,26}

A 62 year old man was brought by paramedics to an emergency department at 2AM in a semi-conscious state and experiencing seizures. His wife stated that after dinner that night, the patient had excused himself to the family's barn with a cup in his hand. The wife thought he was drinking alcohol, but she has also brought all of his current medications thinking that he may have overdosed on something else. She also reveals that a week earlier he started radiation treatment for a prostate tumor. Soon after the ingestion, he returned to the house, collapsed, and had a seizure. She reported that for the past few hours, he had been in out of consciousness, was sweating, drooling, and had wet his pants. The patient also smelled of a garlic-odor. Heart rate (94 bpm) and blood pressure (138/90) were moderately elevated. The patient was coughing up mucous and complaining of headache. Additionally, his pupils were pinpoint but reactive to light. Arterial blood gases showed the following:

pH	7.53
pCO₂	19 mm
pO₂	149 mm
HCO₃⁻	16 meq/L

List of current medications:

Lortab 7.5/500mg, prn

Lotensin, 20 mg, daily

Ambien CR, 10 mg, daily or prn

Lupron, 1 mg, daily

1. What are the relevant symptoms that you need to consider to develop a theory about that may have intoxicated this man?
2. What is the indication for each of the medications this patient is taking? Of the medications listed, which of these could be correlated to the symptoms seen above?
3. Do you believe these symptoms could be caused by ethanol, as his wife originally assumed? Explain.
4. Do you believe his recent radiation treatment could have caused these symptoms?

Once the patient was stabilized, activated charcoal was administered using an NG tube. He then received 2 mg of IV atropine every 30 minutes for the next 2 hours, during which time his symptoms dramatically improved. However, over the next 12 hours he showed significant signs of pulmonary edema, and despite ventilator support died on the 3rd day of hospitalization.

5. Why was this patient given activated charcoal? Was this use of AC within the guidelines recommended for emergency medical personnel?
6. Why do you think the ER administered atropine to this patient?
7. Given the above information, what are the possible causes for this man's severe respiratory distress and untimely death? Explain your theory/theories.
8. What additional information would you like to have from/about this patient in order to make a more educated decision about #7?

Appendix 2. Summary of Rural Occupational Exposure Content with Corresponding Case Study Summaries

Content Summary	Corresponding Case Summary ²⁷⁻³⁰
<p>Introduction to Occupational Exposures</p> <ul style="list-style-type: none"> - Lung diseases affecting farmers <ul style="list-style-type: none"> • Organic Toxic Dust Syndrome • Farmer's Lung Disease <ul style="list-style-type: none"> ○ Risk factors for each, clinical presentations, appropriate treatments of each - Agrochemical Exposure <ul style="list-style-type: none"> • Risk factors for exposure, mechanism of exposure • Cultural competency considerations • EPA Toxicity Classifications • Components of Pesticide Formulations • General diagnosis & treatment of pesticide illness <ul style="list-style-type: none"> ○ Importance of decontamination ○ Pesticide Illness mimics common medical conditions / importance of occupational history in diagnosis <p>Agrochemical Exposure</p> <ul style="list-style-type: none"> - Carbamates & Organophosphates (Cholinesterase Inhibitors) <ul style="list-style-type: none"> • Structures / mechanism of toxicity / resulting clinical symptoms <ul style="list-style-type: none"> ○ Chronic versus acute toxicity ○ Organophosphate-induced delayed polyneuropathy (OPIDP) • Diagnostic tools <ul style="list-style-type: none"> ○ Red blood cell cholinesterase vs. plasma cholinesterase • Management of cholinesterase inhibitor poisoning <ul style="list-style-type: none"> ○ Use of atropine and/or pralidoxime (2-PAM) 	<p>None used</p> <p>You are the overnight pharmacist at a small hospital in Eastern, NC, and you are called down to OB to consult on a 34YO woman who has just experienced a spontaneous abortion at 17 weeks gestation. She reports that she experienced a similar pregnancy outcome 18 months earlier (15 weeks gestation), but prior to that she gave birth to 2 healthy children, ages 9 and 7. Fetal pathology reports indicate one underdeveloped limb and a shortened umbilical cord. The woman admits to smoking ½ pack per day for the last 19 years and takes an occasional Percocet (prescribed) for back pain from a previous injury. She currently is not working, and considers herself a stay-at-home mom. Thirty minutes into the visit, the woman's husband arrives, wearing coveralls bearing the logo for "Adams Christmas Tree Farms." You ask him about his job, and he indicates that he has worked there for 4 years, and had previously worked in the poultry industry in another part of the state. You ask him about pesticide use at his job, and he indicates that he does apply chemicals to the trees, but "it is only a few different things." He calls his supervisor, and within minutes, produces a list of the compounds the company uses: Baygon®, DDDVP, and Dursban®. You decide to order an examination for the husband, which reveals a history of GI problems, including persistent diarrhea and stomach cramps, a chronic cough with copious respiratory secretions, and general malaise that has lasted more than 6 months. You also note that his pupils are contracted, but this BP and heart rate are normal. <i>Students are expected to look up the pesticides used by the husband, propose a well justified theory about what is affecting the health of the couple, and propose treatment plans.</i></p>

(Continued)

Appendix 2. (Continued)

Content Summary	Corresponding Case Summary ²⁷⁻³⁰
<p>Agrochemical Exposure</p> <p>- Organochlorines</p> <ul style="list-style-type: none"> ● Structures / possible mechanisms of toxicity / resulting clinical symptoms <ul style="list-style-type: none"> ○ Chronic versus acute toxicity ○ Chloracne ● Management of organochlorine exposure ● Treatment of chloracne 	<p>Two men, ages 49 and 27, report to the Family Medicine practice where you work, complaining of persistent headaches and stomach cramps. The older man discloses that he is diabetic, but a blood glucose test indicates blood sugar at 98 mg/dL. However, after the physical examinations and x-ray revealed nothing extraordinary, both were sent home with recommendations of nonprescription acetaminophen or ibuprofen for controlling pain. Unfortunately, after 2 weeks of treating the stomach pain and headache, neither has achieved any relief and they return to the clinic. Both are complaining of back pain and facial blisters. During this second visit, you learn that they both work for a temporary contractor who hires them out to area farms for pesticide applications. They tell you they mostly work with a product called Endrin® that they mix with water prior to application. Both men also admit to occasionally smoking marijuana and using alcohol daily. You look back over the chart from the previous visit & see a notation of low blood pH for each man, 7.30 and 7.32 respectively.</p>
<p>Agrochemical Exposure</p> <p>Pyrethrins / Pyrethroids</p> <ul style="list-style-type: none"> ● Structures / possible mechanisms of action / resulting clinical symptoms <ul style="list-style-type: none"> ○ Type I and Type II compounds <ul style="list-style-type: none"> ■ Difference in duration of action ○ Chronic versus acute toxicity ● Management of pyrethroid poisoning 	<p><i>Students are expected to look up the nature of the pesticide given, propose a well justified theory that explains the patients' symptoms, propose a treatment plan to their physician, and explain the possible timing of the resolution of the skin lesions.</i></p> <p>You are the pharmacist-on-duty at a local community pharmacy when a family comes in seeking some nonprescription products to treat their daughter's cold/flu symptoms and skin rash that have materialized over the last 1 -2 days. They tell you that they have applied zinc oxide and hydrocortisone cream to the rash with no response. The daughter is also complaining of headaches, but has no fever. Upon speaking to them for a few minutes, you learn that they have just returned from a cruise to Mexico, and the daughter developed these symptoms shortly after the return. You ask about any odd foods or products she may have been exposed to during the trip, and they mention a gift basket from the cruise ship that had several candies and toys. The daughter's only known food allergy is strawberries, and none of the products appeared to contain this ingredient. The father remembers that part of the basket may be in the car, although he knows their daughter has eaten almost all the treats. He returns with a paper that shows the gift basket contents. It reads as follows:</p>

(Continued)

Appendix 2. (Continued)

Content Summary	Corresponding Case Summary ²⁷⁻³⁰
<p>Mining Exposures</p> <ul style="list-style-type: none"> - Coal dust and silica ● Associated diseases (Silicosis and Coal Workers' Pneumoconiosis, "Black Lung Disease") <ul style="list-style-type: none"> ○ Latency period ● Diagnostic tools <ul style="list-style-type: none"> ○ Role of x-ray & other imaging, pulmonary function tests ● Therapeutic recommendations <ul style="list-style-type: none"> ○ Role of smoking cessation, pharmacotherapy, immunization, and oxygen ● Misdiagnosis issues <ul style="list-style-type: none"> ○ Importance of occupational history 	<p><i>Bienvenidos a la Riviera Mexicana Cruceros!</i></p> <p><i>Los Contenidos:</i></p> <p><i>Xochitl rodajas</i></p> <p><i>Ibarra chocolate</i></p> <p><i>Pulparindo</i></p> <p><i>Tiza chino</i></p> <p><i>Mazapan de la Rosa</i></p> <p><i>Pico Diana</i></p> <p><i>Vero pica gomas</i></p> <p><i>Students are expected to translate the ingredients to see if the basket's contents could be the culprit of the toxicity, and ultimately settle on "Tiza chino", which translates into "Chinese chalk", an insecticide chalk containing deltamethrin. The students must discuss the girl's symptoms within the context of pyrethroid exposure and propose a treatment plan.</i></p> <p>A 58YO man presents to the emergency department where you work. This individual is complaining of headache, chest pain, lower back pain, shortness of breath, and persistent, painful coughing. The man's daughter joins him shortly thereafter and shares with you that her father is diabetic, uses tobacco, and has worked in the coal mining industry for his entire adult life. The company he works for switched their operations from underground mining to surface mining about 10 years ago, which her father has boasted is safer for the employees and does not require they wear as much uncomfortable gear while on the job. The resident on duty orders a chest x-ray, and notes the appearance of multiple fibrotic nodules, approximately 1cm in size.</p> <p><i>Students are expected to propose a well justified theory about the patient's clinical presentation, discuss the role that smoking likely played in the progression of his disease, and make short and long term treatment recommendations.</i></p>

(Continued)

Appendix 2. (Continued)

Content Summary		Corresponding Case Summary ²⁷⁻³⁰	
Mining Exposures		As the pharmacist on duty at a local Walgreen's, you are filling two new prescriptions for a 61YO man. These include Pentazine®, 12.5 mg (every 4-6 hrs as needed) and Ventolin® Inhaler (as needed). In talking with your patient, you learn that he has recently taken a job with a local underground coal mining operation. You also learn that he does occasionally use alcohol and smokes about ½ pack of cigarettes per day. He says that he is only taking one other prescription medication (Lipitor®). He admits to taking Advil® more often these days for frequent headaches. He visited his physician today to discuss his overall “flu” feeling that has lasted several weeks as well as describe additional recent symptoms, including nausea and shortness of breath. The physician did an EKG and chest x-ray, both of which were normal. He pulls a sheet of paper from his pocket that shows the following lab values:	
<ul style="list-style-type: none">- Carbon Monoxide• Mechanism of toxicity• Lifetime of carboxyhemoglobin under different conditions<ul style="list-style-type: none">◦ Role of cigarette smoking in carboxyhemoglobin levels• Common symptoms and diagnostic tools<ul style="list-style-type: none">◦ Use of COHb levels and unreliability of pulse oximetry◦ Risk factors for delayed neuropsychiatric syndrome• Treatment of acute CO exposure<ul style="list-style-type: none">◦ Guidelines for use of hyperbaric oxygen therapy		ALT	29 U/L
		AST	32 U/L
		Glucose	72 mg/dL
		pCO ₂	45 mmHg
		pO ₂	65 mmHg
		pH (arterial)	7.28
Mining Exposures		Students are initially asked if the patient's prescriptions are appropriate given the information about his clinical presentation, and following this, they are expected to articulate an alternative diagnosis to the “flu.” Additionally, the students are expected to discuss the role the patient's smoking plays in the exacerbation of his symptoms and propose a therapeutic plan.	
- Radon		None used	
• Mechanism of toxicity			
• Symptoms of poisoning (chronic)			