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Association of Category of Cattle Exposure with Tuberculosis Knowledge among Dairy Workers in Bailey County, Texas

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ABSTRACT

Objective: To determine the knowledge of tuberculosis (TB) among dairy workers in Bailey County, Texas.

Methods: A cross-sectional study design was used to collect 225 survey responses concerning knowledge of TB among dairy workers on 10 dairy farms in Bailey County, Texas. Subjects used iPad tablets to log responses to 15 demographic questions and a 17-item TB knowledge quiz, measured by: (1) TB characteristics, (2) TB transmission, (3) TB symptoms, (4) TB diagnosis, (5) TB treatment, and (6) bovine TB. A proxy for exposure, dairy workers were classified into categories of cattle exposure – high, medium, and low.

Results: Relative to the medium/low group, workers in the high group tended to be younger (32.6 (SD 11.0)), Guatemalan (52.6%), K'iche' speaking (37.8%), males (89.1%) with less years living in the U.S. (10.8 [SD 12.5]) and lower levels of formal education completed (59.6% with no formal/elementary level). Overall, the average score was 7.1 (SD 4.9) out of 17 (41.8% out of 100.0%). Relative to one another, the medium/low group (8.0 (SD 4.6) out of 17) scored better than the high group (6.7 [SD 5.1] out of 17). No significant associations were found between the category of exposure and TB knowledge score.

Conclusion: Deficiencies in TB knowledge were identified in all categories of exposure. TB training on dairy farms should include all measured tested in this study and should be administered to all workers regardless of the category of exposure.

KEYWORDS
Dairy; workers; knowledge; tuberculosis; Texas

Background

A health hazard on a dairy farm is the potential exposure to *Mycobacterium tuberculosis* (TB).[1–6] In general, TB affects one out of four individuals globally.[7,8] Most recently, the United States reported a rate of 2.9 TB cases per 100,000 persons – a record low.[8] However, 67.9% of confirmed TB cases in 2018 originated from foreign-born individuals residing in the United States.[8] Besides the human version, there is also a *bovine* (cattle) version of the disease called *Mycobacterium bovis* (bTB) or bovine tuberculosis. Bovine TB is predominantly found among cattle and other grazing animals. However, bTB is also transmissible to humans due in part to its zoonotic characteristic.[2,3,9] Globally, estimated 147,000 bTB cases were confirmed and 12,500 deaths recorded in 2016.[10] The overall impact of TB/bTB among U.S. dairy workers remains unknown.[3]

Large animal veterinarians undergo extensive bTB training during professional schooling.[11] Through this training, veterinarians learn the characteristics, transmission, symptoms, diagnostic tests, treatment, and prevention of bTB among cattle. They are also trained on the inherent health hazards while working with bTB suspected cattle and the potential health consequences.[12] However, milkers and all other job positions on a dairy farm do not undergo this type of extensive professional training education.[13,14] There

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is a small body of literature addressing bTB and TB knowledge among dairy workers. In addition, there is a limited understanding of the level of knowledge dairy workers have concerning the characteristics, transmission, symptoms, diagnostic tests, treatment, and prevention of TB, as well as the potential exposure of bTB on a dairy farm. Currently, there are no standard TB knowledge questionnaires for dairy workers or other vulnerable high-risk occupations.[15] Knowing levels of TB knowledge and awareness among dairy workers can help guide the creation, delivery, and evaluation of a culturally, linguistically, and literacy conscious health and safety training focused on TB and bTB prevention.

Currently, the Department of Labor's Occupational Safety and Health Administration (DOL-OSHA) requires training on applicable hazards but does not specifically address a form of safety training on TB and bTB as potentially transmissible diseases on the farm.[3] The few studies which have investigated the prevalence of bTB among dairy workers have suggested worker personal protective equipment and bTB education programs as an addition to the existing governmental eradication programs.[2,4-6] However, before a TB and bTB educational course/program can be created, delivered, and evaluated on dairy farms, a need exists to assess what content needs to be included and deficiencies in the knowledge that need to be addressed.[13,16] The primary objective is to determine the awareness and knowledge of TB among dairy workers in Bailey County, Texas. This study was approved by the University of Texas Health Science Center at Houston Committee of the Protection of Human Subjects (CPHS) (HSC-SPH-18-0886).

Methods

Study design

A cross-sectional study design was used to collect survey responses concerning knowledge of TB among dairy workers in Bailey County, Texas. Bailey County has a total of 10 farms, employs approximately 225 workers, and milks estimated 22,537 cows.[17] All 10 dairy farm producers were called, personally visited, and invited to participate in this study. A total of 225 dairy workers were included in the study. Data collection took place between February and March 2019.

Eligibility criteria

A total of 225 consenting dairy workers were invited to participate and surveyed in Bailey County, Texas. Subject eligibility included being a male or female worker ≥18 years of age employed full-time/part-time/temporary on any of the 10 dairy farms visited.

Consent procedures

The research staff read and explained the consent form to participants before the survey was completed. Participants were asked to consent and sign an electronic informed consent on an iPad© tablet in order to participate. All participants were given a hard copy of their consent form in English or Spanish. Once consent was collected, the research staff proceeded to administer the survey. Surveys were administered in privacy in breakrooms, conference rooms, parlors, maintenance sheds, tractors, and other accessible dairy farm workspaces. Participants were compensated for their time with a 10 USD gift card.

Survey measures

The survey included 15 demographic questions and a 17-item TB knowledge quiz. Currently, there are no standard TB knowledge questionnaires for dairy workers or other vulnerable high-risk occupations.[15] Therefore, the help of a dairy extension specialist and previously published peer-reviewed literature were used to finalize the survey content. All TB knowledge questions were adopted from material publicly released by the CDC,[18] WHO,[19] University of Rochester Medical Center,[20] and a current study on workplace TB interventions by Eggerth *et al.*[15] All questions were placed on the survey platform Qualtrics Mobile Survey Software® with both English and Spanish options. Subsequently, surveys were uploaded to iPad© tablet devices for offline use. Trained bilingual (English and Spanish proficient) research staff used these iPad© tablet devices to read questions to participants and log, in real-time,

their responses (Figure 1). Completed surveys were uploaded to our private and encrypted Qualtrics online account once internet services were available.

Outcome variable

TB knowledge was measured via several questions on six different aspects: (1) TB characteristics, (2) TB transmission, (3) TB symptoms, (4) TB diagnosis, (5) TB treatment, and (6) bovine TB. Questions testing knowledge were asked in both "True-False" and multiple-choice format. In addition, administrators had the option of selecting "I don't know" if the participant expressed not knowing the answer to a question or also had the option of selecting "Did not answer" if the participant did not choose an answer or did not want to answer the question. Each participant had a maximum of 17 points: one point for a correct answer and zero points for an incorrect answer (*Knowledge questions in* Appendix A).

Exposure measure

Following previous research by Torres *et al.*,[6] job position on a dairy farm was used as a proxy for categories of cattle exposure: (1) high exposure among workers with direct contact with cattle in confined spaces (e.g., milkers, pusher, veterinarians, supervisor/manager, hospital workers, and slaughter); (2) medium exposure among workers with direct contact with cattle in non-confined spaces (e.g., feeders, tractor operators, breeders, calf caretaker, maternity, hoof trimmer, maintenance technicians); and, (3) low exposure among workers with no direct contact with cattle in any type of space (e.g., owners, office staff).

Data analyses

A preliminary dataset check was completed in order to assess the percentage of missing data. Subsequently, a complete case analyses (CCA) was performed because <10% of the data was missing. Basic descriptive statistics (e.g., frequencies, proportions, means, and standard deviations) of all sociodemographic characteristics by category of exposure were estimated and reported in Table 1. Both chi-square and the nonparametric Kruskal–Wallis tests were conducted to explore potential confounders between the category of exposure and sociodemographic variables. Corresponding p-values are also shown in Table 1. A type I error level of 0.05 was used to declare significance.

Table 2 shows individual TB knowledge questions by category of exposure (high, medium, low). The medium and low groups were collapsed due to limited sample size. After analyzing TB

Figure 1. Bilingual research staff member administering survey to dairy worker outside maintenance shed in Bailey County, Texas.

Table 1. Demographic characteristics of surveyed dairy workers by category of TB exposure.

		Category of TB exposure		
	All (n = 225)	High (n = 156)	Medium/Low (n = 69)	
Characteristics		Mean (SD) or n (%)		*p**
Age	34.4 (12.0)	32.6 (11.0)	38.3 (13.1)	0.0022
Male	201 (89.3)	139 (89.1)	62 (89.9)	0.8660
Nationality				
United States	26 (11.6)	11 (7.1)	15 (21.7)	<0.0001
Mexico	97 (43.1)	57 (36.5)	40 (58.0)	
Other Latin American Countries	102 (45.3)	88 (56.4)	14 (20.3)	
Years in the US	13.0 (14.0)	10.8 (12.5)	18.0 (16.0)	0.0002
Primary Language				<0.0001
English	22 (9.8)	11 (7.1)	11 (15.9)	
Spanish	134 (59.6)	83 (53.2)	51 (73.9)	
Other	69 (30.7)	62 (39.7)	7 (10.1)	
Secondary Language				0.0010
English	47 (20.9)	23 (14.7)	24 (34.8)	
Spanish	83 (36.9)	67 (43.0)	16 (23.2)	
Other	15 (6.7)	13 (8.3)	2 (2.9)	
None	80 (35.6)	53 (34.0)	27 (39.1)	
Education				0.0010
No Formal/Elementary school	116 (51.6)	93 (59.6)	23 (33.3)	
Middle school	41 (18.2)	24 (15.4)	17 (24.6)	
High school/College/Graduate	68 (30.2)	39 (25.0)	29 (42.0)	
Years of experience on dairy farms	7.4 (8.2)	7.0 (8.6)	8.3 (7.5)	0.0410
Years working with cattle in origin country	4.8 (8.8)	4.3 (8.6)	6.0 (9.3)	0.1482
Full-time employment	218 (96.9)	151 (96.8)	67 (97.1)	0.5800
Hours per day	10.6 (6.0)	10.7 (6.5)	10.4 (4.8)	0.0715
Days per week	6.0 (0.6)	6.0 (0.6)	6.0 (0.6)	0.8773

*p-value from X^2; p-value from Kruskal–Wallis

knowledge scores separated on the basis of "Correct," "Incorrect," and "Don't know," by high, medium, and low category of exposure, we noticed the sample size for the low group was much lower (n = 5) compared to high (n = 156) and medium (n = 64). The medium and low group frequencies for "Correct," "Incorrect," and "Don't know" were statistically similar; therefore, we decided to collapse these groups into one labeled medium/low. In this same preliminary analysis, we also collapsed the "Incorrect" and "Don't know" categories of TB knowledge due to sample size and conceptual methods. A separate analysis found that several "Incorrect" cells had counts <5. Conceptually, an incorrect answer indicates a gap in knowledge or a state of not knowing the answer to a question. Correspondingly, previous studies assessing content knowledge, using similar methodological techniques, collapsed "Incorrect" and "Don't know" categories.[4,21,22]

Frequencies are reported for correct and incorrect answer choices for each of the 17-questions by all, high, and medium/low groups (Table 2). In addition, multivariate models were fitted for individual knowledge questions utilizing Hosmer and Lemeshow's model building methods. Crude prevalence odds ratio (POR), adjusted prevalence odds rations (aPOR), and corresponding 95% confidence intervals (95%CI) were reported (Table 1). All statistical analyses were performed using Stata/SE v.14.0.[23]

Results

The mean age of workers was 34.4 (SD 12.0), with a range of 17–65 years-of-age; 89.3% of surveyed dairy workers were male. Almost all dairy workers (96.9%) were full-time employees, with 7.4 (SD 8.2) years of dairy farm work experience in the United States, and 4.8 (SD 8.8) years of experience working with cattle in their country of origin. The majority of dairy workers were Hispanic (88.0%), with 43.1% of participants reporting Mexico as their country of birth, 45.3% other Latin American countries, and 11.6% United States. On average, workers had 13.0 (SD 14.0) years residing

Table 2. TB knowledge scores by categories of TB exposure (n = 225).

	All (n = 225)		Category of TB exposure: High (n = 156)		Category of TB exposure: Medium/Low (n = 69)		Medium/Low (*High as reference*)	
	n(%)		n(%)		n(%)		POR (95%CI)[c]	
TB knowledge evaluation content	Correct [a]	Incorrect [b]	Correct [a]	Incorrect [b]	Correct [a]	Incorrect [b]	Crude	Adjusted
TB CHARACTERISTICS								
1. TB is caused by germs called bacteria. [d]	123 (54.7)	102 (45.3)	79 (50.6)	77 (49.4)	44 (63.8)	25 (36.2)	1.7 (1.0–3.1)	0.9 (0.4–1.8)
2. The flu vaccine protects me from TB infections. [d]	77 (34.2)	148 (65.8)	47 (30.1)	109 (69.9)	30 (43.5)	39 (56.5)	1.8 (1.0–3.2)	0.8 (0.4–1.6)
3. TB affects the lungs and other organs. [d]	117 (52.0)	108 (48.0)	75 (48.1)	81 (51.9)	42 (60.9)	27 (39.1)	1.7 (0.9–3.0)	0.9 (0.4–1.7)
TB TRANSMISSION								
4. How do you get TB? [d]	64 (28.4)	161 (71.6)	44 (28.21)	112 (71.8)	20 (29.0)	49 (71.0)	1.0 (0.6–1.9)	0.8 (0.4–1.6)
5. TB can be transmitted from person-to-person through touching or sharing plates and cups. [e]	22 (9.8)	203 (90.2)	14 (9.0)	142 (91.0)	8 (11.6)	61 (88.4)	1.3 (0.5–3.3)	0.9 (0.3–2.4)
6. Who is at risk of developing TB in this country? [d]	82 (36.4)	143 (63.6)	54 (34.6)	102 (65.4)	28 (40.6)	41 (59.4)	1.3 (0.7–2.3)	0.5 (0.3–1.1)
TB SYMPTOMS								
7. What are the main symptoms of TB disease? [d]	74 (32.9)	151 (67.1)	51 (32.7)	105 (67.3)	23 (33.3)	46 (66.7)	1.0 (0.6–1.9)	0.5 (0.3–1.1)
8. You could have TB and not have symptoms. This is called latent tuberculosis. [f]	76 (33.8)	149 (66.2)	57 (36.5)	99 (63.5)	19 (27.5)	50 (72.5)	0.7 (0.4–0.2)	0.3 (0.2–0.7)
TB DIAGNOSIS								
9. TB can be tested by your local clinic. [g]	105 (46.7)	120 (53.3)	69 (44.2)	87 (55.8)	36 (52.2)	33 (47.8)	1.4 (0.8–2.4)	0.7 (0.4–1.4)
10. How is TB diagnosed? [h]	47 (20.9)	178 (79.1)	29 (18.6)	127 (81.4)	18 (26.1)	51 (73.9)	1.5 (0.8–3.0)	0.9 (0.4–1.8)
TB TREATMENT								
11. How is TB treated? [g]	96 (42.7)	129 (57.3)	67 (43.0)	89 (57.1)	29 (42.0)	40 (58.0)	1.0 (0.5–1.7)	0.4 (0.2–0.7)
12. TB can be cured. [f]	106 (47.1)	119 (52.9)	69 (44.2)	87 (55.8)	37 (53.6)	32 (46.4)	1.5 (0.8–2.6)	1.0 (0.5–1.8)
13. Untreated TB can be fatal. [d]	142 (63.1)	83 (36.9)	86 (55.1)	70 (44.9)	56 (81.2)	13 (18.8)	3.5 (1.8–6.9)	1.9 (0.8–4.2)
14. TB can be cured drinking tea and making natural home remedies. [d]	103 (45.8)	122 (54.2)	59 (37.8)	97 (62.2)	44 (63.8)	25 (26.2)	2.9 (1.6–5.2)	1.2 (0.5–2.5)
BOVINE TB								
15. Cattle can also experience a TB infection called bovine tuberculosis. [i]	145 (64.4)	80 (35.6)	96 (61.5)	60 (38.5)	49 (71.0)	20 (29.0)	1.5 (0.8–2.8)	0.7 (0.3–1.5)
16. Transmission of bovine TB can happen between cattle and humans. [g]	139 (61.8)	86 (38.2)	95 (60.9)	61 (39.1)	44 (63.8)	25 (36.2)	1.1 (0.6–2.0)	0.6 (0.3–1.1)
17. How can bovine TB be transmitted? [d]	76 (33.8)	149 (66.2)	49 (31.4)	107 (68.6)	27 (39.1)	42 (60.9)	1.4 (0.8–2.5)	0.9 (0.5–1.8)
Mean (SD) TB Knowledge Score (max. 17)	7.1 (4.9)		6.7 (5.1)		8.0 (4.6)			

[a] *Frequency and percentage of correct answers chosen;* [b] *Incorrect is the sum of wrong and "don't know" answers;* [c] *Prevalence odds ratio (POR) and corresponding 95% confidence interval;* [d] *Adjusted for age primary language, education, and years of dairy work experience;* [e] *Adjusted for education;* [f] *Adjusted for primary language;* [g] *Adjusted for primary language and education;* [h] *Adjusted for age and education;* [i] *Adjusted for primary language, education, and years of dairy work experience.*

in the United States, with a range of 3 months to 64 years. Almost 60.0% of workers reported Spanish as their primary language, 9.8% English, and 30.7% spoke another language. In contrast, 36.9% reported Spanish as their secondary language, 20.9% as English, 6.7% spoke another language, and 35.6% claimed they had no proficient secondary language. The majority of workers reported no formal education/elementary (51.6%) as the highest level of education achieved, followed by high school/college/graduate (30.2%) levels, and middle school (18.2%).

The sociodemographic characteristics of surveyed dairy workers by category of exposure: high and medium/low groups are found in Table 1. Workers in the high category of exposure group tended to be younger, Guatemalan, K'iche' speaking males with less years living in the United States and lower levels of formal education completed. Relative to the medium/low group, high group had less dairy farm work experience in the United States and less work experience with cattle in their country of origin but worked similar days per week and hours per day.

In this study, general awareness refers to consciousness that a condition (e.g., TB) exists, and knowledge refers to understanding facts/information about a subject (e.g., TB).[24] Overall, 37.3% of surveyed workers had a general awareness of TB – the high group was less aware of TB (34.0%) compared to the medium/low group (44.9%). The individual TB knowledge questions by category of TB exposure including high and medium/low groups are found in Table 2. Overall, the average score was 7.1 (SD 4.9) out of 17 (41.8% out of 100.0%). Relative to one another, the medium/low group (8.0 [SD 4.6] out of 17) scored better than the high group (6.7 [SD 5.1] out of 17). Besides correct answers, most notable were the frequencies for incorrect answer choices. In general, dairy workers reported higher frequencies of incorrect answers than selecting the correct answers for 12 out of the 17 questions administered. In general, higher frequencies of incorrect answers than correct were found for all aspects of TB knowledge: (1) TB characteristics, (2) TB transmission, (3) TB symptoms, (4) TB diagnosis, (5) TB treatment, and (6) bovine TB.

Crude and adjusted POR and corresponding 95% CIs for the medium/low group with the high as the reference group can be found in Table 2. For crude POR, statistical TB knowledge score differences between the medium/low group relative to high occurred for three items (questions 2, 13, and 14) pertaining to TB characteristics and TB treatment. After adjustments, statistical TB knowledge score differences between the medium/low group relative to high occurred for two different items (questions 8 and 11).

Discussion

The authors observed TB knowledge deficiencies at all quizzed measures: (1) TB characteristics, (2) TB transmission, (3) TB symptoms, (4) TB diagnosis, (5) TB treatment, and (6) bovine TB. In addition, these deficiencies in TB knowledge were also found in both the high and medium/low exposure groups. Overall, the average score was 7.1 (SD 4.9) out of 17 (41.8% out of 100.0%). Relative to one another, the medium/low group (8.0 [SD 4.6] out of 17) scored better than the high group (6.7 [SD 5.1] out of 17). This study also found that 37.3% of surveyed workers had a general awareness of TB – the high group was less aware of TB (34.0%) compared to the medium/low group (44.9%).

Similarly, bTB knowledge assessments were conducted among 510 Nigerian dairy workers. Results indicated that 58.6% of herdsmen and 46.9% of abattoir workers were knowledgeable of bTB prevention.[25] Another study performed in Cameroon found that 73.9% out of 164 dairy farmers were aware of bTB. Despite this high bTB awareness, 55.9% were not able to correctly identify clinical signs and symptoms among themselves, coworkers, or cattle on the farm.[4] A similar study from Malawi found that 74.3% out of 140 dairy farm workers were aware that bTB was a zoonotic disease; yet, only 15.7% were able to identify preventative measures (e.g., medical check-up), and only 7.9% identified contact with infected animals as a mode of transmission.[26] However, bTB is endemic in Nigeria, Cameroon, and Malawi, whereas quality control standards have helped Texas manage sporadic bTB outbreaks among cattle.[27] This may be the reason for the

difference in awareness levels between dairy workers in these countries and dairy workers in Texas.

Torres-Gonzalez *et al.*[6] created three categories of cattle exposure groups based on activity, duration, and conditions of exposure to cattle – high, medium, low. These categories were used in this study to help categorize workers into proxy exposure groups.[6] Results indicated that there were no significant associations between the category of exposure and TB knowledge score by question. An alternative to categories of cattle exposure could have been a level of education. The no formal education/elementary group scored a 27.5% (out of 100%), compared to the middle school group at 48.4%, and the high school/college/graduate with the highest percentage at 61.8%. The study previously described assessing knowledge of dairy workers in Nigeria found that dairy workers with post-primary education were 2.70 (95%CI: 1.68-4.33) more knowledgeable of bTB prevention compared to individuals with no formal education.[25]

Study limitations

Study limitations included potential recall bias of information collected on the survey. A total of 15 demographic questions and 17 TB-knowledge quiz questions were administered. Asking workers to recall the exact number of years in the United States, years of experience working on dairy farms, years of experience working with cattle in their country of origin, hours a day and days per week (which can vary in agriculture), along with recalling TB knowledge information (if learned in the past education) could have led to an underestimation or overestimation of these variables and/or the overall individual TB knowledge score. However, demographic characteristics obtained in this study resulted similarly to previous studies indicating dairy workers are predominantly an immigrant,[28] Hispanic male,[29] of approximately 30 years of age,[16] with limited English proficiency and formal education.[14] Another source of error could have come from respondent bias. There could have been a difference in reluctance to answer between individuals who had a personal experience or knew someone with TB or had an encounter/familiarity with bovine TB on the farm. In addition, participants could have felt the urgency to answer a question even if the attempt was wrong instead of electing to select "I don't know."

According to the USDA National Agricultural Statistics Service (NASS), as of July 1, 2018, Bailey County had a total of 10 licensed farms and milked estimated 22,537 cows.[17] All 10 dairy farm producers listed were called, personally visited, and invited to participate in this study. A total of 225 dairy workers were included in the study. When dairies were visited, producers were asked to provide the number of workers currently employed in order to best prepare for the day of survey administration and gift card compensations. As of March 23, 2019, a total of 293 dairy workers were totaled on 10 dairy farms in Bailey County, Texas. This means that 77.0% (225/293) of available workers participated in this study. This information created a more accurate census of dairy workers in Bailey County, Texas. Unfortunately, this census will never be accurate because of high worker turnover rates.[30,31] This participation rate came about because eight workers chose not to participate. Despite the possibility of non-response bias and these eight workers being different compared to those who chose to participate in this study, the number is small enough to not affect overall results obtained. In addition, the remaining 60 workers not included were out on vacation, resting the days we visited the farms, or their work day was too busy for non-work-related interruptions. Lastly, the methods of this study ensured interviewer bias remained low. A detailed script was created to guide research staff through survey administration and ensured quality assurance. A total of two researchers administered all 225 surveys. Both researchers were fluent and literate in English and Spanish. Several team meetings were held before and after data collection trips to train and guarantee the consistency of survey administrations.

Future plans and conclusions

This study found TB knowledge deficiencies at all assessment measures among all categories of TB exposure groups. The results found in this study have allowed us to conclude that a TB educational training could be beneficial for dairy workers at all job positions in Bailey County, Texas. Due to gaps identified in knowledge, the training should include content pertaining to: (1) TB characteristics, (2) TB

transmission, (3) TB symptoms, (4) TB diagnosis, (5) TB treatment, and (6) bovine TB. Effective occupational health and safety training is a method that can be used to reduce fatal and nonfatal incidents on dairy farms.[32] Health and safety training can be delivered as class lecture, computer training, and hands-on demonstration.[16,33] Mobile learning (m-learning) uses mobile devices for learning experiences.[34] M-learning has been used in occupational settings to provide learning experiences to individual workers or a group of workers.[13,34] Most recently, safety awareness training was delivered to 1,436 dairy workers in Texas, New Mexico, Colorado, Kansas, and New York using iPad© tablets. This safety training proved effective, with a score change from 74.2% in the pre-test (baseline) to a 92.5% average in the post-test.[13] Similar methods can be used to create, deliver, and evaluate a TB educational course in Bailey County, Texas. Pre- and post-tests would be used to assess the change in knowledge gained from training. The majority of workers surveyed identified Spanish as their primary language (60.0%), and 51.6% stated they had no formal education/elementary level education; therefore, this training must be culturally, linguistically, and literacy conscious.[31] Despite the medium/low group scoring slightly higher than the high group, both groups showed low levels of TB knowledge and awareness. This training should be made available and required for all new employees and currently employed workers regardless of their years of experience on dairy farms.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix A.

TB characteristics

(1) Tuberculosis is caused by germs called bacteria. [CDC]
   a. True
   b. False
   c. I don't know
   d. Did not answer

(2) The flu vaccine protects me from tuberculosis infections. [Eggerth *et al*., 2018]
   a. True
   b. False
   c. I don't know

d. Did not answer

(3) Tuberculosis affects the lungs and other organs. [WHO]
   a. True
   b. False
   c. I don't know
   d. Did not answer

TB transmission

(4) How do you get tuberculosis? [URMC]
   a. Through the air
   b. Through sexual partners
   c. Through blood
   d. Through contaminated food
   e. I don't know
   f. Did not answer

(5) Tuberculosis can be transmitted from person-to-person through touching or sharing plates and cups? [WHO]
   a. True
   b. False
   c. I don't know
   d. Did not answer

(6) Who is at risk of developing tuberculosis in this country? [URMC]
   a. Health care workers
   b. Migrant farm workers
   c. People with HIV
   d. All of the above
   e. I don't know
   f. Did not answer

TB symptoms

(7) What are the main symptoms of tuberculosis disease? [WHO]
   a. Persistent cough for >2-3 weeks
   b. Weight loss
   c. Fever
   d. Night sweats
   e. Coughing up blood
   f. All of the above
   g. I don't know
   h. Did not answer

(8) You could have tuberculosis and not have symptoms. This is called latent tuberculosis.[CDC]
   a. True
   b. False
   c. I don't know
   d. Did not answer

TB diagnosis

(9) Tuberculosis can be tested by your local clinic. [CDC]
   a. True
   b. False
   c. I don't know
   d. Did not answer

(10) How is tuberculosis diagnosed? [URMC]
   a. Chest x-ray
   b. Sample of sputum
   c. Blood sample
   d. All of the above
   e. I don't know
   f. Did not answer

TB treatment

(11) How is tuberculosis treated? [WHO]
   a. Antiviral medication
   b. Antibiotics
   c. Surgery
   d. Chemotherapy
   e. I don't know
   f. Did not answer

(12) Tuberculosis can be cured. [CDC]
   a. True
   b. False
   c. I don't know
   d. Did not answer

(13) Untreated tuberculosis can be fatal.[CDC]
   a. True
   b. False
   c. I don't know
   d. Did not answer

(14) Tuberculosis can be cured drinking tea and making natural home remedies. [Eggerth *et al.*, 2018]
   a. True
   b. False
   c. I don't know
   d. Did not answer

Bovine TB

(15) Cattle can also experience a tuberculosis infection called bovine tuberculosis. [CDC]
   a. True
   b. False
   c. I don't know
   d. Did not answer

(16) Transmission of bovine tuberculosis can happen between cattle and humans. [CDC]
   a. True
   b. False
   c. I don't know
   d. Did not answer

(17) How can bovine tuberculosis be transmitted? [CDC]
   a. Breathing air contaminated by infected people
   b. Breathing air contaminated by infected cattle
   c. Consuming unpasteurized dairy products
   d. Contact with an infected wound of cattle
   e. All of the above
   f. I don't know
   g. Did not answer