HHS Public Access

Author manuscript

Workplace Health Saf. Author manuscript; available in PMC 2022 July 01.

Published in final edited form as:

Workplace Health Saf. 2021 July ; 69(7): 306–314. doi:10.1177/2165079920976521.

Association of exposure to cattle with self-reported history of TB among dairy workers

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Abstract

Background: *Mycobacterium bovis* (bTB) is a potential health hazard to dairy workers. This study uses the One Health wholistic framework for examining bovine TB and its relationship to human health. This approach can help bridge surveillance data gaps and contribute to disease control and prevention programs for dairy farm workers, cattle, and the environment. The primary objective of this study was to compare the self-reported history of TB among dairy workers in Bailey County, Texas with occupational categories of risk and exposure to TB.

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Methods: A cross-sectional study was conducted among dairy workers. Job positions were used as a proxy for exposure to cattle—high and medium/low. We employed bivariate analyses to examine differences between groups using both the chi-square test and the nonparametric Kruskal-Wallis test.

Results: Of the 293 dairy workers invited, 77.0% (n=225) participated. No statistically significant associations were found between job categories and reported history of TB exposure. Workers in the high group were younger, Guatemalan males with lower levels of formal education, more likely to be single with no children and cohabitating with co-workers compared to the medium/low group.

Conclusion/Application to Practice: Self-reported TB history among dairy workers is an imprecise measure of being previously diagnosed with TB. Dairy workers at risk for occupationally acquired TB could be tested for TB before employment and tested periodically thereafter, and more expeditiously treated if a positive test is obtained. Future studies should focus on the feasibility of offering on-farm health services, such as TB screening.

Keywords

dairy; workers; prevalence; tuberculosis; Texas

Background

Zoonotic diseases account for approximately 60.3% of emergent diseases among the world population (Palmer, Thacker, Waters, Gortazar, & Corner, 2012; Thoen, Steele, & Kaneene, 2014). *Mycobacterium bovis* or bovine tuberculosis (bTB) is a zoonotic disease predominantly found among cattle and other grazing animals, but can be transmitted and cause pulmonary and extra-pulmonary disease among humans (HK Adesokan, Akinseye, & Sulaimon, 2018; WHO, 2018). Globally, an estimated 147,000 bTB human cases were confirmed and 12,500 deaths recorded in 2016 (WHO, 2018). In the United States (U.S.), an estimated 2–4% of clinical tuberculosis disease cases are caused by *M. bovis* (CDC, 2011; Hlavsa et al., 2008). *Mycobacterium tuberculosis* (TB) and *M. bovis* are both mistakenly grouped as clinical TB disease due to their similar clinical manifestations, similar health consequences, and indistinguishable confirmative clinical tests (BLS, 2017; CDC, 2016; WHO, 2018). There is a limited number of tools that are able to differentiate *M. bovis* from *M. tuberculosis* in humans and, thus, the true burden of the zoonotic TB disease in humans is mostly unknown and largely underestimated (WHO, 2018). Dairy farm workers are potentially exposed to both TB and bTB (HK Adesokan, Jenkins, van Soolingen, & Cadmus, 2012; Bekele et al., 2016;RF et al., 2016; Torres-Gonzalez et al., 2013)

The U.S. dairy industry is a vital economic contribution and source of food security to this nation (Adock, Anderson, & Rosson, 2015). In Texas, the total economic impact of dairy products produced and sold is $39.5 billion in addition to the 70,000 direct jobs and 133,000 indirect jobs provided (IDFA, 2018)—making it the 3rd largest job-generating state, after California and Wisconsin (O'Keefe, 2018). Dairy cattle in the U.S. undergo bTB surveillance as part of a United States Department of Agriculture (USDA) quality control standard—TB-free accredited herd status requirement (USDA, 2014). Whole herd bTB

infections have adverse economic, public health, and governmental implications (McCluskey et al., 2014). Yet, the overall impact of TB and bTB among U.S. dairy workers remains unknown due to insufficient surveillance practices of dairy farm workers (Hlavsa et al., 2008; Olea-Popelka et al., 2016).

The etiology of bTB infections on dairy farms can be difficult to establish. The exact mechanism of cross-infection between cattle-to-cattle, cattle-to-person, person-to-cattle, and person-to-person is challenging (HK Adesokan et al., 2012). One Health is a model used to describe disease "shared risk" between humans, animals, and the environment. One Health interdisciplinary research can help bridge human TB and bTB surveillance data gaps with the purpose of creating, delivering, and evaluating disease control and prevention programs that promote health for dairy farm workers, cattle, and environment (Olea-Popelka et al., 2016; Thoen et al., 2014). Rather than solely focusing on the human aspect or the cattle or the environment, there is an added economic and public health significance when implementing a One Health collaborative approach (Thoen et al., 2014).

Currently, the Department of Labor's Occupational Safety and Health Administration (DOL-OSHA) does not require dairy producers to test dairy workers for bTB/TB infections before their employment start date or during their employment—as required and completed for other high risk occupational groups like healthcare workers (Bekele et al., 2016; CDC, 2018b; Hlavsa et al., 2008). High exposure job positions, such as milking, animal maternity, hospital work, and veterinarian services are at higher risk of communicable transmission of bovine TB (Bekele et al., 2016; RF et al., 2016; Torres-Gonzalez et al., 2013). These job positions involve direct contact with cattle in closed or confined spaces of the farm. In particular, milkers work in crowded parlors with direct interaction with hundreds to thousands of cows during their 8 to 12-hour work shifts (RF et al., 2016). As a proxy for occupational exposures, job position has been proposed for epidemiological investigations concerning bTB exposure on dairy farms (HK Adesokan et al., 2012; Cosivi et al., 1998). For example, Torres-Gonzalez *et al.* (2013) created three groups of cattle exposure—high, medium, low—to categorize dairy farm job positions. Exposure levels were based on type of activity (e.g., veterinary, milking, feeding, heavy machinery tasks, etc.), duration of exposure, and conditions of exposure to cattle (direct or indirect cattle contact and contact in closed or open spaces).

In 2016, the Texas Department of State Health Services (DSHS) Public Health Region 1 (PHR 1) in Lubbock, Texas responded to two requests from the United States Food and Drug Administration (FDA) to test 140 dairy farm workers potentially exposed to cattle infected with bTB who were employed at two different dairy farm facilities in Bailey County, Texas. A secondary analysis of these data found a 10.0% latent tuberculosis infection (LTBI) among dairy workers at these two facilities (Rodriguez, Prot, et al., 2020). The second study determined that 37.3% of surveyed workers had a general awareness of TB—the high exposure group was less aware of TB (34.0%) compared to the medium/low exposure group (44.9%) (Rodriguez, Hagevoort, et al., 2020). The current study is the third study of this population. The primary objective of this study was to compare the self-reported history of TB among dairy workers in Bailey County, Texas with occupational categories of risk and exposure to TB.

Methods

This cross-sectional study collected self-reported history of TB among dairy workers in Bailey County, Texas. Bailey County has a total of 10 dairy farms, employing approximately 225 workers, and milking an estimated 22,537 cows (Dairyman, 2020). We requested a publicly-available census and contact information of dairy farms licensed by the Texas Department of State Health Services (DSHS) Milk and Dairy Unit. We worked with state dairy extension personnel to make an initial contact with dairy farm owners via phone. We made contact with the owners of all 10 dairy farms. Upon verbal approval from owners to participate in the study, arrangements were made for a subsequent on-farm visit and data collection. Bilingual (English and Spanish) research staff individually met with each dairy farm worker to explain the purpose of the study and invite them to participate.

A total of 225 dairy workers consented to participate in the study between February and March 2019. Subject eligibility included being a worker who was at least 18 years of age employed on any of the ten dairy farms. 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, which was provided in English or Spanish. Surveys were administered in privacy in breakrooms, conference rooms, parlors, maintenance sheds, tractors, and other accessible dairy farm work spaces. The questions were placed on the survey platform Qualtrics Mobile Survey Software® in both English and Spanish with offline compatibility. Trained bilingual research personnel used iPad© tablets to read questions and log responses. Participants were compensated for their time with a $10 gift card. This study was approved by the University of Texas Health Science Center at Houston Committee of the Protection of Human Subjects.

The survey included 15 sociodemographic items and 13 TB history questions which were adapted from standard TB contact investigation forms from the Texas DSHS Health Service Region 1 dairy TB evaluation form (Services, 2018). History of TB, the primary dependent variable, was measured by past TB exposure including: (1) current occupational status (years, work hours, job position), (2) bacille Calmette-Guérin (BCG) vaccination history, (3) self-reported TB diagnosis and treatment history, (4) TB contact history, (5) consumption of unpasteurized dairy products, and (6) prior bovine TB exposure. Answer choices for questions were in fill-in-the-blank and Yes/No format. Research personnel had the option of selecting “I don’t know” if the participant expressed not knowing the answer to a question or selecting “Did not answer” if the participant chose not to answer the question.

We used Torres-Gonzalez *et al.* (2013) job position on a dairy farm as a proxy for categories of cattle exposure. Dairy farm job positions were categorized into three categories of cattle exposure: high (direct contact with cattle in confined spaces), medium (direct contact with cattle in non-confined spaces), and low (no direct contact with cattle in any type of space). Job positions defined as *high* exposure included milker pusher, veterinarians, supervisors, managers, hospital workers, slaughter, those with *medium* exposure included feeders, tractor operators, breeders, calf caretakers, maternity, hoof trimmers, and maintenance, and *low* exposure included owners and office personnel.

Data Analysis

Descriptive statistics (e.g., frequencies, proportions, means, and standard deviations) of all sociodemographic characteristics by category of job-related exposure were estimated. In addition, we examined other measures of possible TB exposure by category of job-related TB exposure. We conducted bivariate analyses to examine differences between groups using both the chi-square test and the nonparametric Kruskal-Wallis test. All statistical analyses were performed using Stata/SE v. 14.0 (StataCorp, 2015).

Results

Table 1 reports the sociodemographic characteristics of surveyed dairy workers by category of job-related TB exposure: high and medium/low groups. The medium and low groups were collapsed due to limited sample size. After analyzing history of TB frequencies by high, medium, and low category of TB 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 were statistically similar; therefore, we elected to collapse these groups into a low/medium category.

Workers in the high exposure job position group were younger, Guatemalan males with lower levels of formal education completed relative to the medium/low exposure group. Workers in the high exposure group were also more likely to be single with no children renting a home/apartment with co-workers relative to the medium/low exposure group. The majority of dairy workers were < 30 years of age (39.5%) and between 30–39 years old (32.9%). Most dairy workers were Hispanic (88.4%) with 43.1% from Mexico, 41.8% from Guatemala, and 11.6% from United States. Only 30.0% reported traveling outside the U.S. in the past 12-months (with 90.0% visiting Mexico for an average of two-weeks). Most dairy workers reported elementary (34.7%) as the highest level of education achieved, followed by middle school (18.2%) and no formal education (16.9%). The sociodemographic portion of the survey also asked several lifestyle and living arrangement questions. Close to 67.0% of workers reported being married and about three-fourths of workers claimed to have an average of 2.3 (SD 1.9) children. As far as living accommodations, most dairy workers rented a house/apartment (58.2%). The average number of household residents, including self, reported was 3.7 (SD 1.8). The majority of workers reported living with their spouse and children (37.3%), while 20.0% reported living with an average of 3.4 (SD 1.8) co-workers, 12.4% with only with their spouse, and 11.1% reported living alone. Only 16.0% disclosed being current smokers and having an average of 1.8 (SD 6.0) alcoholic drinks per week.

Table 2 presents the history of other TB-related items by category of TB exposure. The high exposure group worked 9.1 (SD 2.9) hours per day in close-proximity to cattle compared to the medium/low exposure group working 5.0 (SD 4.4) hours per day in close-proximity to cattle. A large majority of workers (78.2%) reported having been vaccinated with the BCG vaccine as an infant. A total of 4 (1.8%) individuals identified having been diagnosed with active TB in the past. However, only 2 of these 4 reported seeking TB treatment which was successfully completed. A small fraction of workers (2.2%) reported having lived or worked closely with someone who had been diagnosed with TB. About a third (n=70) of workers

reported consuming raw dairy products, with 81.4% of those had consumed these raw dairy products in their non-U.S. home country and 18.6% while working on a U.S. dairy farm. Almost 6.0% of workers had worked with bTB infected cattle on U.S. dairy farms while 33.3% had heard of bTB outbreaks on other farms in Bailey County, Texas. Relative to the medium/low exposure group, the high exposure group had a higher frequency of BCG vaccination. The high exposure group had 3 of the 4 workers previously diagnosed with TB with only one seeking and finishing treatment compared to the one TB diagnosed case in the medium/low exposure group which sought and finished treatment. The high exposure group had 4 of 5 workers who lived or worked closely with someone who had been diagnosed with TB—all which did not wear respirators. The high exposure group had more workers who consumed raw milk on U.S. dairy farms, but were not as aware of bTB outbreaks on other farms in Bailey County, Texas compared to the medium/low exposure group.

Discussion

No statistically significant differences were found between history of TB and assigned categories of TB exposure. In contrast, Torres-Gonzalez *et al.* (2013) found statistically significant differences in positive tuberculin skin test (TST) between the high exposure group and medium and low groups. Torres-Gonzalez *et al.* (2013) clinically tested dairy workers using two confirmative tests: (1) TST and (2) interferon-gamma release assay (IGRA). Due to financial and time constraints, our study used survey methodology to simultaneously collect previous diagnosis of TB and other characteristics. In addition, no power analysis for an appropriate sample size was warranted because this pilot study was hypotheses generating. Potentially, this approach could have led to the difference and subsequent underestimation of TB life prevalence among dairy workers surveyed in Bailey County, Texas.

History of BCG vaccination had a 10.0% difference between the high and medium/low exposure groups. Crude and adjusted POR were not statistically different. Due to a consistent low TB frequency, the U.S. does not vaccinate its population (CDC, 2011). On the other hand, Mexico has had a 99.0% vaccination coverage since 1996 (Orduna, Castillo-Rodal, & Lopez-Vidal, 2013) compared to Guatemala with an 81.0% BCG vaccination coverage in 2017 (WHO & UNICEF, 2018). These self-reported differences in BCG vaccination are consistent with the distribution of U.S. born dairy workers (21.7%) in the medium/low exposure group compared to 36.5% Mexican and 52.6% Guatemalan in the high exposure group.

The groups we created were consistent with the groups recommended by Torres-Gonzalez *et al.* (2013) with the high exposure group working 9.1 (SD 2.9) hours in close-proximity to cattle compared to the medium/low exposure group working 5.0 (SD 4.4) hours in close-proximity to cattle. Results indicated that there were no significant associations between category of exposure and history of TB. An alternative to categories of cattle exposure could have been nationality. Overall, crude differences were observed between nationalities. All previous TB diagnoses were reported by Central American workers, more Mexican workers (42.3%) reported consuming raw dairy products compared to U.S. (26.9%) and Guatemalan (17.0%) dairy workers. Also, U.S. workers were more likely to report working with bTB

infected cattle, >44.0% of U.S. and Mexican workers were aware of previous bTB outbreaks among cattle in Bailey County, Texas compared to Guatemalan (17.0%) dairy workers. Lastly, Guatemalan workers spent 9.4 (SD 2.9) hours working in close-proximity to cattle compared to Mexican workers with 7.0 (SD 3.9) and U.S. workers with 5.2 (SD 4.6) hours.

Study Limitations and Strengths

The limitations of this study included recall bias of information, respondent bias, and temporal ambiguity. The survey included 15 sociodemographic items and 13 history of TB questions. Our survey asked workers to recall the exact number of years in the U.S., experience working on dairy farms, experience working with cattle, work shift hours (vary on dairy farms), among self-reporting TB exposure history could have led to an overestimation or underestimation of these variables. In addition, respondent bias could have led to a difference in willingness to answer between individuals who had a personal experience or exposed to someone with active TB or had experience with bovine TB on the dairy farm. Last, our cross-sectional survey captured both exposure and outcome simultaneously and; therefore, lacks the ability establishing temporality between previous self-reported TB exposure and dairy farm job position. We also did not have the ability to determine active immunity among participants who reported BCG vaccination history.

Ideally, a dose-response measure for each specific worker would be the best measure of exposure. In practice, there is a limitation in collection feasibility and measurement data; therefore, inferring indirectly from previous studies is often common practice (Checkoway, Pearce, & Kriebel, 2004). Risk can be assessed by occupation and taking into consideration a worker's job position and job duties. Another way can be by self-reported perceived risk (Checkoway et al., 2004). Demographic characteristics obtained from our study population were similar to previous studies indicating dairy workers are predominantly an immigrant (Passel, Cohn, & Rohal, 2014), Hispanic male (Adock et al., 2015), of approximately 30 years of age (Roman-Muniz et al., 2006), with limited English proficiency and formal education (Jenkins, Stack, May, & Earle-Richardson, 2009). In addition, the groups we created for this study were consistent with the groups tested and validated by Torres-Gonzalez *et al.* (2013). Last, 77.0% (225/293) of available workers participated in this study. This information helped our team to create a more accurate census of dairy workers in Bailey County, Texas. Unfortunately, this census will never be accurate because of high worker turnover rates. (Arcury, Estrada, & Quandt, 2010).

Application to Occupational Health Practice

Efforts to eradicate TB such as surveillance, routine occupational testing, direct-observational treatments (DOT) by health departments, and TB information sheets online and at clinics (BLS, 2017; CDC, 2016) have not been expanded to bovine TB and dairy workers in the U.S. Dairy workers are not tested before starting their jobs at a dairy farm (Bekele et al., 2016). In order to determine the prevalence of TB among dairy workers, employers and occupational health professionals should endorse more wide-spread TB testing. As an at-risk occupational group, dairy workers could be tested before their start date, tested if suspected of infection (while working in close-proximity with bTB positive cattle), and treated if positive for latent or active TB disease.

Most foreign-born individuals from TB endemic countries are vaccinated as newborn infants with the BCG live-vaccine to prevent tuberculous meningitis and miliary disease; consequently, circulating antibodies can cross-react with the tuberculin purified protein derivative (PPD) injected for a Mantoux tuberculin skin test (TST) resulting in a false-positive (CDC, 2018a). While the BCG vaccine does not confer lifetime immunity (only 15–20 years), knowing the BCG vaccination history of a dairy worker is important when determining the appropriate TB diagnostic tool as a frontline occupational health practitioner (CDC, 2018a). The T-SPOT.*TB* test is the preferred clinical diagnostic tool of choice for foreign-born and previously BCG-vaccinated individuals, including predominately foreign-born dairy workers. While the TST has a sensitivity of 70%, the T-SPOT.*TB* test has a much higher sensitivity of 95.6% (CDC, 2018b; Laboratories, 2017). This means that 95.6% of the time, the T-SPOT.*TB* test will correctly identify a TB infection—even if previous BCG vaccinated.

Furthermore, hosting on-farm health services would overcome traditional barriers to health care such as cost, transportation, communication difficulties, absence of health insurance, cultural differences, limited knowledge locations, transient lifestyle, and fear of law and immigration enforcement (Arcury & Quandt, 2007). On-farm health services could be offered on dairy farms once a year offering services such as TB tests and other preventative exams, programs, or vaccinations for workers and their families. Future studies and outreach should focus on the need and feasibility of offering on-farm health services to dairy farm workers and their families.

Funding

Funding for this research was supported by Grant No. T42OH008421 09 from the National Institute for Occupational Safety and Health (NIOSH)/Centers for Disease Control and Prevention (CDC) to the Southwest Center for Occupational and Environmental Health (SWCOEH), a NIOSH Education and Research Center.

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Application to Professional Practice

Mycobacterium bovis (bTB) is a potential health hazard to dairy farm workers. This study aligns with the One Health wholistic framework for examining bovine TB and its relationship to human health. Understanding zoonotic diseases at multiple medical levels is critically important and can help bridge surveillance data gaps and contribute to disease control and prevention programs for dairy farm workers, cattle, and the environment. Currently, dairy workers are not tested for TB before start of employment. As a frontline occupational health practitioner, there is power is knowing TB exposure and BCG vaccination history of dairy workers because it is central when determining the appropriate TB diagnostic tool. Occupational health practitioners have the opportunity to help include dairy workers in state and local TB eradication and control programs.

Table 1.

Sociodemographic characteristics of dairy workers in Bailey County, Texas (n=225)

		Category of TB exposure**		
	All (n=225)	High (n=156)	Medium/Low (n=69)	
Characteristics	Mean (SD) or n (%)			*p**
Age				
<30 years	89 (39.5)	68 (43.6)	21 (30.4)	0.0410
30–39 years	74 (32.9)	52 (33.3)	22 (31.9)	
40–49 years	33 (14.7)	22 (14.1)	11 (15.9)	
≥50 years	29 (12.9)	14 (9.0)	15 (21.8)	
Gender				
Male	201 (89.3)	139 (89.1)	62 (89.9)	0.8660
Female	24 (10.7)	17 (10.9)	7 (10.1)	
Nationality				
United States	26 (11.6)	11 (7.1)	15 (21.7)	<0.0001
Mexico	97 (43.1)	57 (36.5)	40 (58.0)	
Guatemala	94 (41.8)	82 (52.6)	12 (17.4)	
Other	8 (3.5)	6 (3.8)	2 (2.9)	
Traveled outside of US in past 12-months				0.9320
Yes	30 (13.3)	21 (13.5)	9 (13.0)	
No	195 (86.7)	135 (86.5)	60 (87.0)	
Education				<0.0001
No formal	38 (16.9)	32 (20.5)	6 (8.7)	
Elementary	78 (34.7)	61 (39.1)	17 (24.6)	
Middle school	41 (18.2)	24 (15.4)	17 (24.6)	
High school	34 (15.1)	14 (9.0)	20 (29.0)	
College/Graduate/Professional	34 (15.1)	25 (16.0)	9 (13.0)	
Marital status				0.1720
Single	64 (28.4)	50 (32.1)	14 (20.3)	
Married	150 (66.7)	98 (62.8)	52 (75.4)	
Divorced/Separated/Widowed	11 (4.9)	8 (5.1)	3 (4.4)	
Children				0.0040
Yes	167 (74.2)	107 (68.6)	60 (87.0)	
No	58 (25.8)	49 (31.4)	9 (13.0)	
Number of children	2.3 (1.9)	2.2 (2.0)	2.6 (1.6)	0.0600
Living accommodations				0.0820
Own home	69 (30.7)	41 (26.3)	28 (40.6)	
Rent home/apartment	131 (58.2)	96 (61.5)	35 (50.7)	
Employer provided housing	24 (10.7)	19 (12.2)	5 (7.3)	
Living company				<0.0001
Alone	25 (11.1)	21 (13.5)	4 (5.8)	
Parents	6 (2.7)	4 (2.6)	2 (2.9)	

Characteristics	All (n=225)	Category of TB exposure** High (n=156)	Medium/Low (n=69)	p*
	Mean (SD) or n (%)			
Spouse	28 (12.4)	14 (9.0)	14 (20.3)	
Spouse and children	84 (37.3)	50 (32.1)	34 (49.3)	
Children only	5 (2.2)	3 (1.9)	2 (2.9)	
no. children living at home	2.9 (1.7)	3.1 (2.0)	2 (1.2)	
Co-workers	45 (20.0)	43 (27.6)	2 (2.9)	
Number of co-workers	3.4 (1.8)	3.5 (1.8)	3 (0.0)	
Other	34 (15.1)	22 (14.1)	12 (17.4)	
Number of household residents	3.7 (1.8)	3.7 (1.9)	3.6 (1.4)	0.8366
Current smoker				0.2310
Yes	36 (16.0)	28 (18.0)	8 (11.6)	
No	189 (84.0)	128 (82.0)	61 (88.4)	
Number of alcoholic drinks per week	1.8 (6.0)	1.4 (4.3)	2.7 (8.5)	0.1482

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

** Job position on a dairy farm as a proxy for categories of cattle exposure: high (direct contact with cattle in confined spaces), medium (direct contact with cattle in non-confined spaces)/low (no direct contact with cattle in any type of space).

Table 2.

History of other TB-related items by category of TB exposure (n=225)

		Category of TB exposure**		
	All (n=225)	High (n=156)	Medium/Low (n=69)	
History of Other TB-Related Items	Mean (SD) or n (%)			*p**
History of TB diagnosis				0.6250
Yes	4 (1.8)	3 (1.9)	1 (1.5)	
No	221 (98.2)	153 (98.1)	68 (98.5)	
History of BCG vaccine				0.1510
Yes	176 (78.2)	127 (81.4)	49 (71.0)	
No	49 (21.8)	29 (18.6)	20 (29.0)	
History of raw dairy consumption				0.8910
Yes	70 (31.1)	47 (30.1)	23 (33.3)	
No	155 (68.9)	109 (69.9)	46 (66.7)	
Consumption setting				0.4050
Non-U.S. country	57 (81.4)	37 (78.7)	20 (87.0)	
Working on farm in U.S.	13 (18.6)	10 (21.3)	3 (13.0)	
History of working with bTB infected cattle				0.9970
Yes	13 (5.8)	9 (5.8)	4 (5.8)	
No	212 (94.2)	147 (94.2)	65 (94.2)	
Hours working in close-proximity to cattle	7.9 (3.9)	9.1 (2.9)	5.0 (4.4)	<0.0001
Heard of bTB outbreaks on other farms				0.7390
Yes	75 (33.3)	50 (32.1)	25 (36.2)	
No	150 (66.7)	106 (67.9)	44 (63.8)	

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

** Category of TB Exposure defined as job position on a dairy farm as a proxy for categories of cattle exposure: high (direct contact with cattle in confined spaces), medium (direct contact with cattle in non-confined spaces)/low (no direct contact with cattle in any type of space).