HHE Health Hazard Evaluation Program

Evaluation of *Coccidioides* Exposure and Coccidioidomycosis Infections Among Warehouse and Distribution Employees

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Disclaimer

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Availability of Report

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Introduction

Request

Employer representatives of a warehouse and distribution facility requested a health hazard evaluation concerning coccidioidomycosis, also known as Valley fever or "cocci." Employees at the facility became concerned after several employees developed coccidioidomycosis in recent years.

Background

Coccidioidomycosis is an infection caused by the fungus *Coccidioides,* which lives in the soil in the area of the country where the facility is located. People get coccidioidomycosis by breathing in microscopic fungal spores. It is not spread from person to person. Workers who are exposed to dust from disturbed soil containing the fungus are at higher risk for coccidioidomycosis. Approximately 60% of people who become infected do not have symptoms. However, some people may develop flu-like symptoms that last weeks to months or severe disease in their lungs or other parts of the body.

Workplace

The warehouse and distribution facility consist of multiple buildings on several hundred acres mostly surrounded by farmland. Approximately 1,300 employees worked at the facility. The facility primarily received, stored, and distributed various types of goods. Typical job tasks were receiving and offloading trucks, storing goods in warehouses or outside, combining packages, picking goods from storage for shipment, repacking, and loading trucks.

To learn more about the workplace, go to Section A in the Supporting Technical Information

Our Approach

In May 2019, we visited the warehouse and distribution facility. For this evaluation, we completed the following activities:

- Interviewed some employees about work characteristics, time spent outdoors at and outside of work, residence in areas where *Coccidioides* has been found, and personal health.
- Observed work practices and conditions where the interviewed employees worked.
- Assessed the ventilation systems in areas where the interviewed employees worked.
- Reviewed policies and procedures, such as respiratory protection and excessive wind plans.
- Identified cases of coccidioidomycosis among employees (1) through interviews, medical records, and workers' compensation records and (2) by matching an employee roster to cases in the state health department's coccidioidomycosis surveillance database.

To learn more about our methods, go to Section B in the Supporting Technical Information

Our Key Findings

Employees could possibly breathe in dust during indoor and outdoor work

- Of 75 interviewed employees, 52 (69%) reported working outdoors for a median of 140 minutes per day (range: 2 minutes–9 hours).
- Of the 40 interviewed employees who reported operating any machinery outside, 35 (88%) reported that the machinery kicked up dust and 29 (73%) reported that the machinery had an open cabin. Of those who reported operating machinery, 7 (18%) employees reported wearing a respirator while operating machinery outside.
- Although employees did not necessarily do soil-disrupting work themselves, 38 (51%) of all interviewed employees reported their job involved being near activities that disrupted soil, such as construction, agriculture, and forklift use. Of those 38 employees, 6 (16%) reported wearing a respirator when working near soil-disrupting activities.
- Of all interviewed employees, 46 (61%) reported wearing a respirator when exposed to dust while working at this facility. We saw some employees wearing them incorrectly during the site visit.
- While the facility's respiratory protection plan outlined that an exposure assessment was to be performed to determine if respiratory protection should be required or voluntary, an exposure assessment for airborne dust was not documented in the respiratory protection plan we reviewed.
- Although management reported that respirator use for dust was voluntary, communications to employees were unclear on whether respirator use was voluntary or required during excessive wind conditions.
- Of the 68 interviewed employees who reported their primary work location was indoors, 60 (88%) reported that the windows or bays were "constantly" or "sometimes" open when working indoors. This was consistent with our observations during our site visit of open bays and doors in warehouses when no work activities were going on.
- Housekeeping practices varied in the buildings we visited. Some areas used dry sweeping, which can kick up dust.

At least 10 cases of coccidioidomycosis among employees occurred January 2014–April 2019; however, we cannot determine whether this number is higher than expected or whether the cases were work-related.

- Based on interviews, medical records, and workers' compensation records, we identified seven cases of coccidioidomycosis during January 2014–April 2019. Matching employee rosters with state health department records yielded eight cases during 2014–2018.
- Privacy considerations prevented the two lists from being compared at the individual level to find out which cases were in common. However, we can determine that there were at least 10 unique cases of coccidioidomycosis among employees based on the timeframe and group-level information available.
- In general, the incidence (number of new cases of a disease over a given timeframe) of coccidioidomycosis will vary by factors such as age, sex, race/ethnicity, and location. In our HHE, we did not calculate the incidence of coccidioidomycosis among facility employees. There was not enough information available about coccidioidomycosis incidence rates for the community or the characteristics of facility employees to adjust for these factors and make a meaningful comparison between the incidence of coccidioidomycosis among facility employees and the incidence in the community.
- Many employees reported spending time outdoors at work and outside of work and having lived for years in areas where *Coccidioides* is present. Therefore, determining if cases of coccidioidomycosis were related to exposures at work was not possible.
- Employees with coccidioidomycosis were severely affected. Among the seven cases identified based on interviews, medical records, and workers' compensation records, employees could not work for a median of 67 days (range: 30–270 days), and 5 (83%) employees were hospitalized.

To learn more about our results, go to Section B in the Supporting Technical Information

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Potential Benefits of Improving Workplace Health and Safety:

- ↑ Improved worker health and well-being
- ↑ Better workplace morale
- ↑ Easier employee recruiting and retention
- ↑ Enhanced image and reputation
- ↑ Superior products, processes, and services
- ↑ May increase overall cost savings

The recommendations below are based on the findings of our evaluation. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the

beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the "hierarchy of controls." The hierarchy of controls groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or practical, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls at https://www.cdc.gov/niosh/topics/hierarchy/.

We encourage the company to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in *Recommended Practices for Safety and Health Programs* at https://www.osha.gov/shpguidelines/index.html.

Recommendation 1: Reduce airborne dust exposure as much as practicable

Why? Reducing airborne dust exposure can help prevent inhalation of *Coccidioides* spores that leads to coccidioidomycosis infection, which can lead to severe illness or prolonged time away from work. While it is not possible to eliminate the risk of exposure to *Coccidioides* spores, taking steps to reduce dust exposures as much as practicable is a reasonable occupational health approach.

How? At your workplace, we recommend these specific actions:

Keep warehouse bays, doors, and windows closed as much as possible.

Do not dry sweep.

- Use a wet sweeping method or a filtered vacuum to capture dust. For example, you could use a commercially available, walk-behind wet/dry floor sweeper that uses water mist and a floor squeegee to suppress and capture dust.

When replacing equipment, choose machinery with closed cabs and increased filtration.

- Keep windows and air vents closed when possible, especially when driving or working on unpaved roads and work areas.
- Select equipment with high-efficiency particulate air filtration (HEPA) inside enclosed cabs.

- Retrofit existing equipment with HEPA filters inside enclosed cabs. Consult with equipment manufacturers to determine if increased filtration is appropriate and/or available.

Clean and maintain window air-conditioning units in warehouse breakrooms.

- Establish schedules and perform routine maintenance and filter cleaning on ventilation units in breakrooms.

Follow through with conducting exposure assessment(s) to determine whether respirator use to prevent dust exposure should be required or voluntary.

- Assess job tasks, engineering controls, and administrative controls. For example, assess and decide if respiratory protection is voluntary or required for outdoor job tasks like working in open-cab forklifts.
- Document the assessment findings in the written respiratory protection program.

Instruct employees voluntarily wearing N95 filtering facepiece respirators on how to wear them properly.

- Elements of a voluntary use respirator program include making sure that the respirator itself will not be a hazard for employees and providing employees with Appendix D of the Occupational Safety and Health Administration's Respiratory Protection Standard.
- The National Institute for Occupational Safety and Health (NIOSH) has a publication for employees on how to wear disposable respirators like N95 filtering facepiece respirators: NIOSH Publication 2010-131, How to Properly Put On and Take Off a Disposable Respirator.

Recommendation 2: Improve communication with employees about *Coccidioides* exposure and coccidioidomycosis

Why? Providing employees with more information about *Coccidioides* exposure and coccidioidomycosis can complement other efforts to reduce exposures to *Coccidioides*.

How? At your workplace, we recommend these specific actions:

Improve employee education and training about coccidioidomycosis.

- Provide training to employees when hired and at least annually thereafter.
- Include training topics such as these: symptoms of coccidioidomycosis, how the disease is spread, risk factors for severe disease, and ways to lessen exposures at work and outside of work.
- Tailor the training by job category and education level.
- The California Department of Public Health has created educational resources, available at https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/OHB/Pages/Cocci.aspx.

Explain to employees when respirator use for dust is required or voluntary based on the results of the exposure assessment.

- Update the site's wind advisory plan with clearer guidance on whether respiratory protection is required or voluntary during periods of high winds.

Encourage employees with suspected symptoms of coccidioidomycosis to seek evaluation from their health care providers.

- Symptoms of coccidioidomycosis include fatigue (tiredness), cough, fever, shortness of breath, headache, night sweats, muscles aches or joint pain, and rash on the upper body or legs.
- Contact a health care provider if symptoms last for more than a week.

Use workers' compensation reports and other available information sources to assess trends in coccidioidomycosis over time.

- Monitoring coccidioidomycosis trends will help address employee concerns and indicate if more steps to reduce exposure are needed.

Supporting Technical Information

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Section A: Workplace Information

Facility

The warehouse and distribution facility had over 20 buildings across the site (roughly 450 acres), ranging from large warehouses to smaller administrative and office buildings. Most of the warehouses were divided into several sections by separation walls. Most warehouses had large rack systems for goods storage. Large bay doors (roughly eight feet wide by nine feet high) were located on some of the perimeter walls for trucks to pull up for unloading. Warehouses had small office areas and breakrooms for employees to use during breaks. Other office buildings were located throughout the site. The site was surrounded by farmland except on the side facing the road where the main entrance was located.

Employee Information

Number of employees at time of the evaluation: approximately 1,300

Length of shift: varies, typically 8 hours/day

Number of shifts per day: varies by work group, from 1–3

Union: present

Median age (range) at the time of the evaluation: 49 years (19–74 years)

Mean job tenure (range) at the time of the evaluation: 10 years (5 weeks–49 years)

History of Issue at Workplace

In 2018, employees at the facility became concerned because several employees who spent substantial amounts of time working outside had reportedly developed coccidioidomycosis over the past 2 years. This occurred during an increase in the rate of coccidioidomycosis in the state and county where the facility was located. The NIOSH Health Hazard Evaluation program received a request from employer representatives to help determine how many employees developed coccidioidomycosis in recent years and assess ways to minimize exposures to the fungus *Coccidioides*. More information about coccidioidomycosis and *Coccidioides* can be found in Section D.

Process Description

The warehouse and distribution facility primarily received, stored, and distributed various types of goods. Commercial trucks containing goods were received at one location on-site where facility employees inspected and verified the contents. The trucks were then sent to any number of large warehouses for offloading, which depended on the type of goods the truck contained.

In general, employee job tasks included receiving and offloading trucks, storing goods in warehouses, combining goods or packages, picking goods from storage for reshipment, repackaging, and loading trucks. Some warehouses were more automated—in those, large conveyor systems moved goods around the warehouses. Other employees were required to transport goods around the site using

smaller trucks. Employees were also required to spend some time outdoors using forklifts to load trucks. Additionally, some goods were stored outside of the warehouses on either dirt areas or paved pads. Some storage locations were along property boundaries near farmland and required driving on unpaved roads.

Construction activities were ongoing during our assessment and included repairing underground pipes and road repair. Construction activities were contracted out; employees did not participate in these construction activities.

Section B: Methods, Results, and Discussion

The objectives of our evaluation were as follows:

- Evaluate the number and characteristics of employees diagnosed with coccidioidomycosis during January 2014–April 2019.
- Identify job tasks that might increase the risk of exposure to *Coccidioides*.
- Recommend ways to reduce exposure to *Coccidioides* at the facility.

Methods: Work Practices and Workplace Conditions

We gathered information about work practices and workplace conditions through (1) document review, (2) workplace observations, (3) ventilation assessment, and (4) confidential employee interviews.

Document Review

We reviewed relevant work and occupational health policies and practices obtained from the facility. These included the written respiratory protection plans and wind advisory plans. We also reviewed information about previous on-site construction projects during 2016–2017, which included information on environmental mitigation efforts to minimize employee exposures to dust.

Workplace Observations

We observed the following:

- Work processes, practices, and conditions in the warehouses and other buildings.
- Personal protective equipment (PPE) use, if any.

Ventilation Assessment

We met with facilities and management staff to discuss ventilation systems in the warehouses and office buildings. We visited warehouses and other buildings to observe the types of ventilation systems and air filters used in the systems. Because of the size of the complex, we assessed the warehouses and buildings where employees were also selected for medical interviews.

We also used ventilation smoke tubes to visually evaluate the direction of airflow between different warehouse areas, such as between breakrooms and work areas.

Confidential Interviews

Because of the size of the facility and workforce, we conducted interviews at eight locations during our site visit. We interviewed employees during both first and second shifts. We focused on six work areas and two employee groups (motor pool and police department) because employees in these work areas or employee groups were more likely to spend time working outdoors or had reported concerns about coccidioidomycosis. We allocated a set amount of time to each location and completed as many interviews in each location as time allowed.

For five of the work areas or employee groups, we were able to invite all employees who were working during the time we were conducting interviews in that location to participate. Because of time

constraints, for the other three work areas or employee groups, we invited as many employees who were working during the time that we were conducting interviews in that location to participate. In addition, four other employees requested and participated in interviews. Overall, our convenience sample consisted of 76 employees.

During the interviews, we discussed work characteristics, time spent outdoors at work, job tasks, training, and respirator use. We used the statistical software R, version 3.5.1, to summarize results using descriptive statistics.

Other interview topics and results are presented later in this report.

Results: Work Practices and Workplace Conditions

Document Review

Written Respiratory Protection Plan

At the time of the evaluation, the industrial hygiene office managed the respiratory protection program. The program contained the basic elements required by the Occupational Safety and Health Administration (OSHA) Respiratory Protection Standard [29 CFR 1910.134], including respirator selection, training, fit testing, and use; medical evaluation; and disposable respirator handling.

The respiratory protection program described that filtering facepiece respirators were available to employees for voluntary use in areas where respiratory protection had been determined by an exposure assessment to be "not required." According to management, some activities not evaluated by the NIOSH team and unrelated to *Coccidioides* exposure required the use of respiratory protection.

During our evaluation, management expressed that respiratory protection worn by employees for protection against exposure to *Coccidioides* was voluntary. However, at the time of our evaluation, an exposure assessment had not been performed as outlined in the facility's existing respiratory protection program to determine if dust was a hazard requiring respiratory protection or if voluntary protection could be worn.

Wind Advisory Plan

The wind advisory plan was a one-page information sheet sent by management to employees, as well as broadcasted on informational televisions in warehouses and breakrooms, for when excessive (high) winds were predicted for the San Joaquin county area. The plan did not specifically mention exposure to *Coccidioides*. The plan listed the following ways for employees to limit airborne dust exposure:

- Remaining indoors as much as possible.
- Keeping warehouse windows and doors closed when not in use.
- Keeping windows closed in vehicles with air conditioning units set to recirculate air.
- Considering the use of N95 filtering facepiece respirators.
- Contacting the on-site occupational health clinic if nonemergency care is needed.

The language in the current wind advisory plan about the use of N95 respirators is unclear. The term "considering" could imply that respiratory protection is an option to reduce exposures to airborne dust

during excessive wind conditions. This is contrary to voluntary use of respiratory protection during conditions where it has been determined that no exposures exist that would require the use of respiratory protection. Management informed us that respiratory protection for dust exposures was voluntary.

During our assessment, the excessive wind advisory was not in effect.

Past Construction Projects Review

We reviewed a list of construction projects that included information such as project locations, environmental reviewer comments, and occupational safety and health comments. We used the information to help select locations to focus our on-site assessment. The list included 23 construction projects with dates during September 2016–April 2017. During the review, it was noted that the San Joaquin Valley Air Pollution Control District (APCD) had a rule requiring dust control plans to be submitted and approved prior to construction activities of a specific acreage or greater. Rule 8021 included control measure options for construction, excavation, extraction, and other earth-moving activities. These control measure options included prewatering the site, applying water or chemical/organic stabilizers during operations, and using wind barriers [San Joaquin Valley APCD 2004]. Of the 23 projects on the list, 5 (22%) required a dust control plan based on Rule 8021.

Workplace Observations

Housekeeping practices varied across the buildings we visited and included dry sweeping. Some warehouse supervisors required employees to use push brooms to sweep areas at the end of work shifts. Other warehouses had push-behind dry sweepers for cleaning.

We observed that entry doors and cargo bay roll-up doors in the warehouses were left open in many warehouses when no work (such as loading or unloading trucks) was actively being performed. We also saw forklift trucks and other motor vehicles that were either not enclosed or operated with windows open while in use.

According to employer representatives, use of N95 filtering facepiece respirators for dust was voluntary for all employees. We observed some employees wearing them incorrectly. For instance, we saw employees who did not have both straps on their head or in the correct positions.

During our assessment, construction was actively occurring on-site. We saw nonfacility employees digging soil and repaving roads. We observed water being applied to the top layer of soil to suppress dust during these activities. Additionally, we saw facility employees working outdoors retrieving items stored on paved and unpaved ground and driving on unpaved roads.

Ventilation Assessment

Most warehouses we visited used evaporative cooling units to bring outdoor air inside, in addition to several large fans overhead to circulate air. The evaporative cooling units did not have filters but used cooling pads to help condition the incoming air. These cooling pads were changed seasonally. We did not visually inspect the pads or coolers up close, as they were inaccessible during the assessment because of their location inside the warehouses. Inside the warehouses we visited, most breakrooms had individual window air-conditioning units installed for comfort (heating and cooling). In general, most

window air units were visibly dirty (inside and outside of the breakroom), and management was unaware of any maintenance schedules or the last time that the filters were cleaned.

Breakrooms in the warehouses were either under negative pressure relative to the warehouses (meaning that air flowed into the breakroom from the warehouse) or neutral pressure relative to the warehouses (meaning air neither flowed into or out of the breakroom from the warehouse). It was difficult to determine room pressurizations inside the warehouses relative to the outdoors as warehouses had multiple bay doors open throughout the day.

For nonwarehouse buildings, outdoor air was brought into the buildings via constant-air volume heating, ventilation, and air conditioning (HVAC) units. These HVAC systems used air filters with a minimum efficiency reporting value (MERV) rating of 10. One nonwarehouse building was reported to use MERV 14 filters. The MERV rating system is used by ANSI/ASHRAE to compare the particulate collection efficiency of air filters. The ratings range from 1 to 16 with higher numbers representing more efficient filters. A MERV 8 filter is typically used in commercial buildings, while MERV 13 (or higher) filters are used in areas requiring a higher level of filtration, such as hospital surgery suites [ANSI/ASHRAE 2017]. Filters were reported to be changed out every 90 days.

Confidential Interviews

Work and Demographic Information

Of the 84 employees invited for interviews, 72 participated (86%). Participation rates varied, ranging from 60% at one location to 100% at five locations. Overall, including the 4 employees who requested an interview, we began interviews with 76 employees. One employee interview was stopped early because of a shift change, so we included only 75 interviewed employees in the analysis.

The median job tenure for the 75 interviewed employees was 10 years (range: 4 months–39 years). Employees worked a median of 40 hours a week, (range: 40–60 hours per week); 70 (93%) employees reported working 40 hours per week.

Job titles for the 75 interviewed employees are summarized in Table C1. Most interviewed employees (n = 51, 68%) were distribution process workers. Thirty-six (48%) employees reported that they worked in multiple locations in the facility, of whom 8 (11%) were motor vehicle operators in the motor pool or police officers who reported working throughout the entire facility.

Job Activities

Of the 75 interviewed employees, 52 (69%) reported working outdoors for a median of 140 minutes per day (range: 2 minutes–9 hours) (Table C2). This included 19 (25%) employees who reported working outdoors for 4 or more hours a day, corresponding to at least half of the typical 8-hour workday at the facility. The number of employees who reported other outdoor activities at the worksite and the duration of those activities are also shown in Table C2.

Table C3 shows the types of outdoor work activities reported by the 52 interviewed employees who reported working outdoors. The most common outdoor work activity reported was operating any machinery (n = 40; 77%), followed by loading and unloading materials onto trucks (n = 32; 62%) and assembling or dissembling pallets (n = 13; 25%). Among the 40 interviewed employees who reported operating any machinery outside, forklifts (n = 38, 95%) and motor vehicles (n = 12; 30%) were the

most common types of machinery operated. Most employees who reported operating any machinery outside reported that the machinery kicked up dust (n = 35; 88%) and had an open cabin (n = 29; 73%). Respiratory protection use while operating any machinery outside was reported by seven (18%) of these employees.

Of the 75 interviewed employees, 38 (51%) reported their job involved being near activities that disrupt soil. The most common types of soil-disrupting activity reported were construction (n = 19; 50%), followed by agriculture (n = 5; 13%) and forklift use (n = 3; 8%). Not all these activities were performed by facility employees. Among these 38 employees, 6 (16%) reported wearing a respirator when working near soil-disrupting activities. Of the six employees who reported wearing a respirator, five (83%) employees reported using a N95 filtering facepiece respirator. Information about respirator type was missing for the remaining employee. In addition, of the 75 interviewed employees, 58 (77%) reported working with materials that were dusty from being outside.

Of the 75 interviewed employees, 68 (91%) reported that their primary work location was indoors. Figure B1 shows how often employees reported the windows or bays were open to the outdoors when working indoors at their primary work location. Among the 60 (88%) employees who responded that the windows or bays were open "constantly" or "sometimes," 42 (70%) reported that the doors or bays were opened only because it was necessary for work activities.

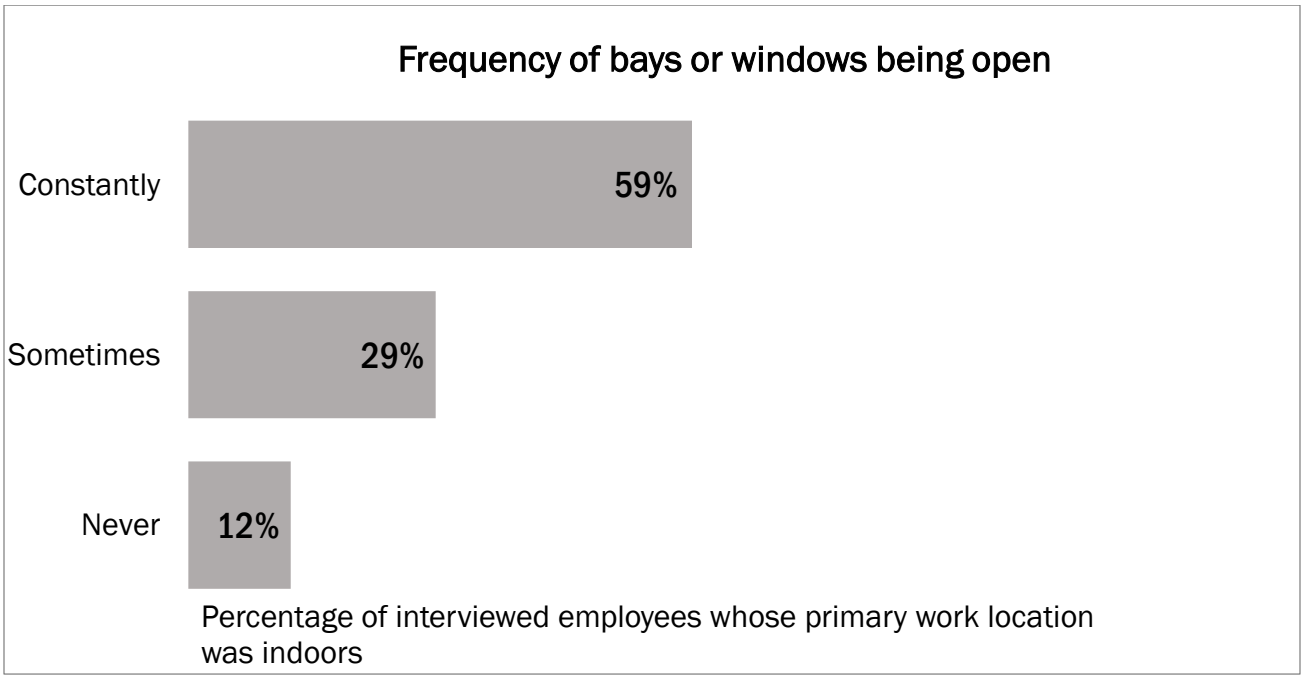


Figure B1. Percentage of interviewed employees whose primary work location was indoors reporting how often windows or bays were open to the outdoors in their work areas.

Training About Coccidioidomycosis

While 70 (93%) of the 75 interviewed employees reported having heard of "cocci or valley fever," 21 (28%) reported ever receiving training about how it might be related to their work at this facility. Of these 21 employees, interactions with supervisors or at meetings (n = 10, 48%) were the most common ways employees reported receiving training on how it might affect their work at this facility.

Interactions or meetings were followed by an information sheet (n = 6, 29%) and receiving information about coccidioidomycosis in the context of respiratory protection (n = 4, 19%). Only one (1%) employee mentioned receiving annual training about coccidioidomycosis.

Respiratory Protection

Regarding respiratory protection, 46 (61%) of the 75 interviewed employees reported ever wearing a respirator when exposed to dust while working at this facility. Among these 46 employees, 43 (94%) characterized this respirator use as voluntary, 2 (4%) as required, and 1 (2%) as either voluntary or required, depending on context. Of the 46 employees, 38 (83%) reported using N95 filtering facepiece respirators when exposed to dust. Other respirator types included a surgical or dust mask (n = 2; 4%), half-mask respirator (n = 1; 2%), and gas mask (n = 1; 2%). Table C4 shows the types of instances when respirators were worn. The most common responses were windy or dusty conditions (n = 28; 61%), wildfire or smoke (n = 11; 24%), and being near construction or renovation (n = 7; 15%). Among the six employees who reported respirator use during cleaning tasks, three employees specifically mentioned respirator use when using or emptying a sweeper. Of the 75 interviewed employees, 60 (80%) interviewed employees reported currently having access to a respirator.

Methods: Employee Health Assessment

We gathered information about employee health through (1) confidential medical interviews, (2) medical records, (3) workers' compensation records, and (4) a summary of state health department surveillance data.

Confidential Medical Interviews

During confidential interviews, we asked employees about the following possible risk factors for coccidioidomycosis:

- Demographic characteristics
- Pertinent medical history
- Time spent outdoors outside of work
- Residence in areas where *Coccidioides* has been found

We also asked employees whether they had been diagnosed with coccidioidomycosis. If an employee answered "yes," we asked for details about the illness and attempted to obtain relevant medical records.

We used information from interviews and medical records, when available, to determine if an interviewed employee had underlying medical conditions that might increase the risk of severe or disseminated coccidioidomycosis. These conditions included diabetes mellitus, lung disease, diseases that suppress the immune system or taking immunosuppressive medications, organ or bone marrow transplant, or cancer requiring chemotherapy or radiation therapy [Brown et al. 2013; CDC 2019b; Odio et al. 2017]. In addition, those who are pregnant, aged 65 years or older, smoke, or are of African American or Filipino descent face an increased risk of developing severe lung complications or disseminated disease [McCotter and Chiller 2017].

For residence history, we asked employees about their current town or city of residence and how long they have lived there. We also asked about past cities and states of residence and duration among places that *Coccidioides* has been found. We excluded information about residence duration from the analysis if the sum of durations for all reported residences was greater than the employee's age at the time of interview by more than 1 year to account for possible discrepancies due to rounding. Hyperendemic counties in California were defined as the six counties with annual case rates consistency higher than those for the state: Fresno, Kings, Kern, Madera, San Luis Obispo, and Tulare [CDPH 2019; Sondermeyer et al. 2013]. Similarly, Maricopa, Pima, and Pinal counties in Arizona were considered hyperendemic [Arizona Department of Health Services 2018].

Review of Coccidioidomycosis Among Employees

We compiled information on coccidioidomycosis cases from interviews, medical records, and workers' compensation records. We defined a case as a laboratory diagnosis of coccidioidomycosis, as documented by a laboratory report or physician documentation of laboratory findings, in a facility employee during January 2014–April 2019. This case definition is adopted from the California Department of Public Health (CDPH) case definition for coccidioidomycosis, which no longer required clinical confirmation of disease as of January 1, 2019 [CDPH 2018].

State Health Department Surveillance Data Summary

The facility provided a roster of employees who had worked at the facility at any time from January 2014 through April 2019. This roster consisted of employees who were currently working at the facility when the roster was provided (current employees) and employees who were no longer working at the facility (former employees). Employment start dates were not available for former employees, and end dates were available only for some former employees. CDPH's Infectious Diseases Branch matched the employees on the roster to cases in the CDPH coccidioidomycosis surveillance database during 2014–2018 based on name and date of birth. Because of regulations protecting privacy, CDPH provided a de-identified summary of matches. We did not share information about coccidioidomycosis cases from interviews, medical records, and workers' compensation records with CDPH. Therefore, it was not possible to align the coccidioidomycosis cases identified by CDPH and NIOSH.

Data Analysis

We summarized descriptive statistics for interview findings and coccidioidomycosis cases identified through interviews and workers' compensation records using R version 3.5.1.

To evaluate the possible degree of overlap between the cases identified by CDPH and NIOSH, we visually inspected the numbers of matched employees with various characteristics provided by CDPH and the number of employees with those characteristics identified through interviews, medical records, and workers' compensation records. We did not attempt to identify the matched employees.

Results: Employee Health Assessment

Confidential Medical Interviews

Demographic and Health Characteristics

Of the 75 interviewed employees, 54 (72%) were male. The median age was 48 years (range: 24–74 years); 2 (3%) employees were aged 65 years or older. Self-identified race and ethnicity among interviewed employees are shown in Table C5; 11 (15%) employees self-identified as black or African American. Among the 16 (21%) employees who self-identified as Asian, 11 (69%) reported being Filipino, corresponding to 15% of interviewed employees (Table C5).

Based on interview responses and available medical records, 28 (37%) interviewed employees had one or more medical conditions that might increase the risk of severe or disseminated coccidioidomycosis. No female employees reported being pregnant at the time of the interviews. Overall, five employees (7%) reported smoking tobacco at the time of the interviews.

Time Spent Outdoors Outside of Work

Interviewed employees reported spending a median of 2 hours per day outdoors outside of work (range: 0–6 hours). This included five (7%) employees who reported spending no time outdoors outside of work. Table C6 summarizes the types of outdoor activities that interviewed employees reported regularly doing outside of work. Gardening was the most reported outdoor activity outside of work (n = 46; 61%), followed by hiking, walking, or running (n = 42; 56%) and biking (n = 25; 33%).

Residence History

We excluded three interviewed employees from the analysis about residence history because of discrepancies between age and residence durations. At the time of the interviews, 58 of 72 (81%) interviewed employees lived in a city or town in San Joaquin county. Interviewed employees also lived in Stanislaus (n = 9; 13%), Alameda (n = 3; 4%), Sacramento (n = 1; 1%), and Contra Costa (n = 1; 1%) counties. San Joaquin and Stanislaus counties had a similar or higher of coccidioidomycosis as California overall but a lower rate than each of the six hyperendemic counties in California during 2011–2018. Alameda, Sacramento, and Contra Costa counties had a lower rate of coccidioidomycosis as California overall during 2011–2018 [CDPH 2019]. These 72 interviewed employees reported living in their current city or town for a median of 27 years (range: 1–64 years).

These 72 interviewed employees reported living in California and Arizona—the two states with > 95% of coccidioidomycosis cases [CDC 2019a]—for a median duration of 39 years (range: 4–64 years); 33 (46%) employees reported living in California and Arizona for their entire lives. Three employees reported having lived in one of the six hyperendemic counties in California and one employee reported having lived in a hyperendemic county in Arizona. Interviewed employees also reported prior residence in Texas (n = 4), Nevada (n = 3), Washington (n = 1), and Mexico (n = 2). None reported living in Utah or New Mexico.

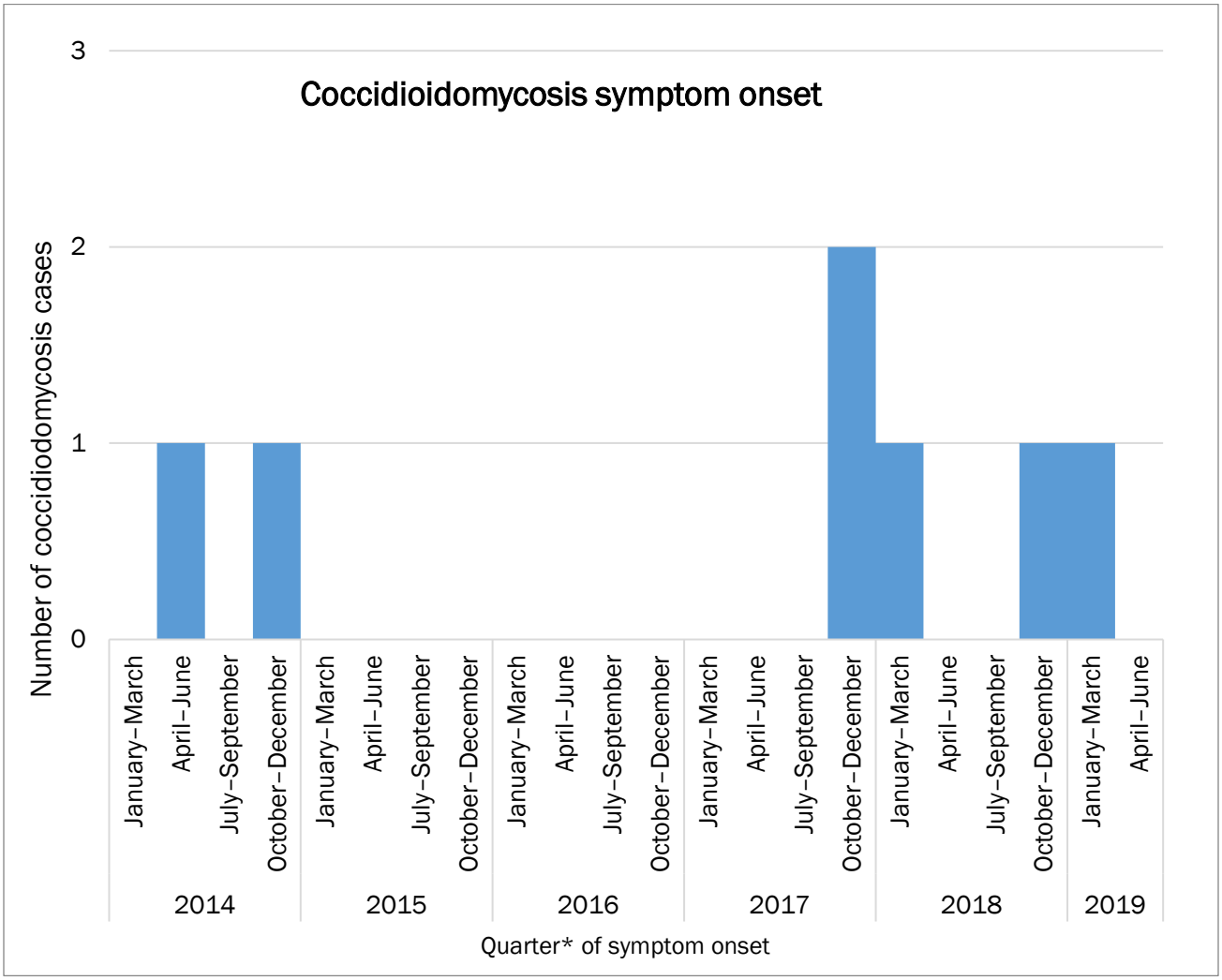
Review of Coccidioidomycosis Among Employees

In total, we identified seven cases of coccidioidomycosis among employees during January 2014–April 2019 through interviews, medical records, and workers' compensation records. Five case-employees participated in confidential medical interviews and had medical records or workers'

compensation records available for review. Two case-employees were identified only based on workers' compensation records. Workers' compensation records contained medical documentation.

Table C7 summarizes the characteristics of employees with coccidioidomycosis. Most were male (n = 6; 86%). The median age of case-employees at onset was 54 years (range: 35–61 years). Among the five interviewed case-employees, three (60%) self-identified as black or African American, one self-identified as being of Hispanic ethnicity, and none self-identified as Filipino. Most (n = 5; 71%) were distribution process workers. The median duration of living in California's Central Valley before illness onset was 17 years (range: 14–58 years) among the five case-employees interviewed.

In general, cases were spread out across January 2014–April 2019, with no cases in 2015 and 2016 (Figure B2). Four (57%) cases occurred during October through December, roughly corresponding to autumn. Studies have shown that coccidioidomycosis cases tend to peak in autumn in California [CDC 2019a; Gorris et al. 2018].



*Data only available through April 2019.

Figure B2. Epidemic curve of symptom onset among employees with coccidioidomycosis identified through interviews, medical records, and workers' compensation records, January 2014–April 2019 (n = 7).

All seven cases occurred during employment at the facility. The most common job title among case-employees was distribution process worker (n = 5; 71%). Among the six employees with available dates of employment, the median job tenure at the time of symptom onset was 10 years (range: 7–15 years). All seven illnesses were reported to the employer. The median duration of absence from work was 67 days (range: 30–270 days).

Of the seven case-employees, three (43%) had an underlying medical condition that might increase the risk of severe or disseminated coccidioidomycosis. Of six symptomatic case-employees, five (83%) were hospitalized. In the remaining asymptomatic case-patient, a periodic health examination led to the discovery of coccidioidomycosis. One patient (14%) had confirmed disseminated disease based on the records available for review.

State Health Department Surveillance Data Summary

Of the 1,887 current and former employees on the employee roster, CDPH initially identified 13 matches with their coccidioidomycosis surveillance records during 2014–2018 based on name and date of birth. Approximately 31% of employees on the roster were former employees for whom dates of employment were not available. Two employee matches were excluded because their estimated illness onset date was either before their employment start date or after their employment end date. Three employee matches were excluded because employment start dates were not available to determine whether their illness began while employed at the facility.

Table C8 summarizes the characteristics of the eight matched employees with estimated illness onset during employment. Most were male (n = 5; 63%). Six matched (75%) employees were aged 50 years or older at estimated illness onset, which was defined as the earliest reported date associated with the illness episode. Most (n = 5; 63%) were distribution process workers.

Estimated illness onset occurred in 2014 (n = 3), 2017 (n = 2), and 2018 (n = 3). The date of estimated illness onset usually corresponded to the collection date of the laboratory specimen that indicated coccidioidomycosis.

Information about medical history and course of illness were not available for most employee matches. Three (38%) matched employees had confirmed symptoms. One (13%) matched employee was known to be hospitalized.

There were at least two cases of coccidioidomycosis identified through interviews, medical records, and workers' compensation records that were not part of the CDPH summary data. One case occurred in 2019, which was outside the 2014–2018 timeframe available for matching. Differences in the number of employees with various characteristics identified using the two approaches indicated one other case identified through interviews, medical records, and workers' compensation records with onset within the 2014–2018 timeframe could not be part of the CDPH summary data.

Discussion

We used two different approaches to identify cases of coccidioidomycosis among facility employees. In one approach, seven cases were identified based on interviews, medical records, and workers' compensation records during January 2014–April 2019, the last full month before our site visit. One case occurred in February 2019. The other approach involved matching employee roster data with

CDPH coccidioidomycosis surveillance data from 2014–2018. This approach identified eight matches among employees with estimated illness onset during employment and three additional matches where it was unclear if estimated illness onset occurred during employment. Because of privacy considerations, it was not possible to determine which cases identified by each approach were in common.

In addition to the case outside of the timeframe we used for matching, it was possible to deduce that at least one other person we identified was not part of the CDPH matches. Thus, 10 is the lowest possible number of unique coccidioidomycosis cases identified among facility employees during January 2014–April 2019. The number of unique coccidioidomycosis cases among facility employees from this period can possibly be as high as 18 if the two approaches identified completely different individuals and the 3 individuals with unknown dates of employment were indeed employed at the facility during illness onset. However, it is unlikely that all the cases identified through interviews, medical records, and workers' compensation records were not in the CDPH coccidioidomycosis surveillance database because coccidioidomycosis is a reportable condition in California [CDPH 2018].

We did not have enough information to evaluate whether this range of 10–18 cases over approximately 5 years represents an excess risk of coccidioidomycosis among employees of this facility. One standard epidemiologic approach is to compare the observed number of coccidioidomycosis cases to the expected number of cases among facility employees. It was only possible to identify a range for unique observed cases among facility employees.

The expected number of cases among facility employees depends, among other factors, on the incidence (i.e., the number of new cases of a disease over a period of time) in the larger population being used as a reference. For a meaningful estimate of the expected number of cases among facility employees, it is important to consider any differences in characteristics such as age, sex, and race/ethnicity between facility employees as a whole and the reference population. If there is a higher proportion of persons in categories with higher risk of coccidioidomycosis among facility employees than among the reference population, the number of expected cases would need to be adjusted to account for differences in these background factors related to the health outcome. For coccidioidomycosis, incidence varies by factors such as location as well [CDC 2019b; CDPH 2019].

For example, according to 2018 data from CDPH, males in California have an incidence of coccidioidomycosis that was 1.6 higher than the incidence among females in California. Similarly, incidence by county of residence in 2018 ranged from 31.8 cases per 100,000 population for San Joaquin county to 13.8 cases per 100,000 population for Stanislaus county—the two counties where most case-employees lived. Overall incidence of coccidioidomycosis statewide has been increasing each year since 2015 [CDPH 2019]. We were not able to obtain county-level incidence calculations that adjusted for age, sex, and race/ethnicity or sufficiently detailed information about the number of facility employees broken down by these characteristics for each year; this information is needed to appropriately interpret incidences for facility employees. Thus, we did not calculate crude or adjusted incidence of coccidioidomycosis among facility employees.

In addition, it was not possible to determine whether each case of coccidioidomycosis among facility employees was due to exposures at work or outside of work. Our interview findings revealed that

employees are likely exposed to *Coccidioides,* which is presumed to be present in the area, both at work and outside of work.

Some interviewed employees reported working outdoors on job tasks that might generate dust, even though facility employees do not necessarily perform soil-disrupting activities themselves. Our workplace observations, discussions with employees and management during our walkthrough assessment, and interview findings indicate that exposure to dust and potentially *Coccidioides* can occur indoors as well. For example, we saw open bays and doors in the warehouse buildings even when no work activities were ongoing, which was consistent with reports from many employees who primarily work indoors that the windows and bays were "constantly" or "sometimes" open to the outdoors.

Some work practices could unnecessarily increase the risk of exposure to *Coccidioides*. For example, dry sweeping during housekeeping activities can resuspend dust inside the warehouse, and driving motor vehicles with windows open can result in dust exposure. In addition, we observed items stored outdoors brought inside with visible dust on their surfaces when they were being repackaged or shipped out. Employees could also carry dust indoors on clothing and shoes. Among interviewed employees, 77% reported working with materials that were dusty from being outside. Although it might not be often possible to determine the source of dust found indoors or how long dust from outdoors has been indoors, it is prudent to limit dust exposure. In one laboratory study, dry *Coccidioides* spores stored in temperature range –15°C–37°C and relative humidity 10%–95% remained viable after 6 months outside of soil [Berman et al. 1956].

Some case reports in the scientific literature illustrate that coccidioidomycosis could be spread through dusty materials. For example, a forklift operator at a waste cotton processing plant with no travel to areas where *Coccidioides* is normally found developed disseminated coccidioidomycosis. This worker's only exposure to items from areas where *Coccidioides* is found was unloading bales of cotton from California on three occasions in the weeks before illness onset [Albert and Sellers 1963]. More recently, a port worker in Hong Kong who unloaded and occasionally swept out shipping containers from the United States developed coccidioidomycosis; he had no history of travel to areas where the fungus is found [Tang and Tsang 2011].

In addition to potential exposures to *Coccidioides* at work, exposures could also have occurred outside of work. Interviewed employees also spent a median of 2 hours per day outdoors when not at work. Nearly half of interviewed employees reported living in California and Arizona, the two states with > 95% of coccidioidomycosis cases, for their entire lives. Gardening was also a commonly reported outdoor activity outside of work.

Coccidioidomycosis placed a severe burden on affected employees. Most symptomatic case-employees were hospitalized; two of seven (29%) had disease that had spread outside the lungs. Case-employees missed a median of 67 days from work. Symptoms of coccidioidomycosis, such as cough, fever, chills, and fatigue, are common and may last weeks to months in otherwise healthy people [Galgiani et al. 2005; Thompson 2011; Tsang et al. 2010; University of Arizona 2019]. In one study, 75% of patients said their illness prevented them from performing their usual daily activities at some point during their illness. Among the employed patients in that study, 74% missed work because of their illness [Tsang et al. 2010].

Although dust reduction measures, such as wetting soil during construction activities and paving work areas, can reduce the dust levels generated and may lower the risk for airborne dispersion of *Coccidioides*, they neither eradicate the organism from the soil nor prevent exposure to dust from areas outside of the site, such as the adjacent farmland. Nevertheless, reducing dust is a reasonable risk-based strategy to reduce occupational exposure to *Coccidioides* [NIOSH 2014].

As most of the breakrooms we visited in the warehouses had air flow from the warehouse into the breakroom, routine maintenance and filter cleaning is important for maintaining the efficiency of the unit filtration [Department of Energy 2020]. If possible, increasing the filtration of the unit with a more efficient filter would be beneficial and another reasonable risk-based strategy to help reduce occupational exposure to *Coccidioides*.

Whether the facility requires respiratory protection or if respiratory use was voluntary for employees, with respect to potential exposures to *Coccidioides*, was unclear from our assessment. The site's respiratory protection plan outlined that an exposure assessment was to be performed for potential hazards to determine if respiratory protection was required or voluntary; this had not been documented for *Coccidioides*. Additionally, language in the wind advisory plan, which was used to inform employees of excessive wind conditions, was subjective and did not clearly indicate if N95 filtering facepiece respirator use was required or not. If respiratory protection is required, employees must be included in the written respiratory protection program, medically evaluated, trained, and fit tested in conformance with the OSHA Respiratory Protection Standard. For respirators to be voluntarily worn by employees, employers need to document and determine through an exposure assessment that no airborne hazard exists that would require respirator use, as well as provide a copy of Appendix D of the OSHA Respiratory Protection Standard to employees.

Using high-wind advisories and conditions to make risk management decisions on when outdoor work is permitted is useful despite no specific guidance on acceptable or unacceptable wind speeds in relation to the risk of exposure to *Coccidioides* [NIOSH 2014]. However, language should be updated once a determination is made and documented in the facility's written respiratory protection program.

Soil and air sampling to determine if *Coccidioides* is present is currently not recommended as sampling and analytical methods have not been validated.

Limitations

Our evaluation had some additional limitations. First, information from interviews were based on self-report and may not be generalizable to all employees at the facility. We only interviewed a small subset of employees. Participation rates varied across work areas or employee groups and a few employees requested an interview. However, we focused on work areas or employee groups who were more likely to spend time working outdoors or had reported concerns about coccidioidomycosis. Second, workplace observations during the site visit may not reflect conditions over time.

Conclusions

We identified at least 10 cases of coccidioidomycosis among facilities during January 2014–April 2019. However, it was not possible to determine whether this represented an excess risk of

coccidioidomycosis at this workplace or whether exposure to *Coccidioides* occurred at work or outside of work. Most employees reported performing job activities outdoors or handling materials that were dusty from being outdoors. Minimizing exposure to dust as part of a risk-based strategy to help reduce occupational exposure to *Coccidioides* is recommended.

Section C: Tables

Table C1. Job titles among interviewed employees (n = 75)

Job title	Number (%)
Distribution process worker*	51 (68)
Motor vehicle operator*	8 (11)
Transportation assistant*	5 (7)
Police officer*	4 (5)
Materials examiner and identifier	3 (4)
Other	4 (5)

*Includes employees with "leader" in the job title.

Table C2. Time spent outdoors at work among interviewed employees, by activity

Activity	Median duration per day (range), minutes*
Working (n = 52)	140 (2–540)
Fitness time† (n = 36)	36 (5–60)
Eating (n = 24)	27 (5–60)
Walking from building to building (n = 27)	15 (1.5–120)
Walking to and from car or vanpool (n = 73)	5.5 (1–60)

*Calculated for employees who reported any time performing the activity.

†If an employee reported 3 hours per week, this was converted to 36 minutes per day.

Table C3. Outdoor work activities among interviewed employees who reported working outdoors (n = 52)

Outdoor work activity*	Number (%)
Operating any machinery*	40 (77)
Forklift	38 (95)
Motor vehicle	12 (30)
Scooter	3 (8)
Other	3 (8)
Loading or unloading material onto trucks	32 (62)
Assembling or dissembling pallets	13 (25)
Providing security	2 (4)
Material handling	10 (19)
Other truck-related activities	9 (17)
Walking	1 (2)

*Employees' responses were categorized into one or more categories.

Table C4. Respirator use during dust exposure at work among interviewed employees (n = 46)

Instance type*	Number (%)
Windy or dusty conditions	28 (61)
Wildfire or smoke	11 (24)
Construction or renovation	7 (15)
Cleaning	6 (13)
Personal health reason	3 (7)
Potential hazard not related to dust	3 (7)
Other	3 (7)

*Employees' responses were categorized into one or more categories.

Table C5. Self-identified race and ethnicity among interviewed employees (n = 75)

Characteristic	Number (%)
Race*	
White	23 (31)
Asian	16 (21)
Filipino	11 (15)
Black or African American	11 (15)
American Indian or Alaskan Native	6 (8)
Native Hawaiian or other Pacific Islander	4 (5)
Ethnicity	
Hispanic or Latino	31 (41)

*Employees could select one or more categories.

Table C6. Outdoor activities outside of work among interviewed employees (n = 75)

Outdoor activity outside of work*	Number (%)
Gardening	46 (61)
Hiking, walking, or running	42 (56)
Biking	25 (33)
Other sports or physical activity	21 (28)
Golfing	8 (11)
Hunting or fishing	6 (8)
Grilling	5 (7)
Errands or chores	5 (7)
Going to the park	4 (5)
Relaxing	2 (3)
Boating	1 (1)
Construction	1 (1)
None	7 (9)

*Employees' responses were categorized into one or more categories.

Table C7. Characteristics of employees with coccidioidomycosis identified through interviews, medical records, and workers' compensation records (n = 7)

Characteristic	No. (%) of employees
Male sex	6 (86)
Race (n = 5)	
African American / Black	3 (60)
Other	2 (40)
Hispanic ethnicity	1 (14)
California county of residence	
San Joaquin	5 (71)
Stanislaus	1 (14)
Other	1 (14)
Job title	
Distribution process worker	5 (71)
Other	2 (29)

Table C8. Characteristics of employee matches with CDPH coccidioidomycosis data during 2014–2018 (n = 8)

Characteristic	No. (%)* of matched employees
Male sex	5 (63)
Age group at estimated illness onset, years	
≤ 49	2 (25)
50–59	4 (50)
≥ 60	2 (25)
California county of residence	
San Joaquin	7 (88)
Stanislaus	1 (12)
Job title†	
Distribution process worker	5 (63)
Other	3 (14)

*Some percentages do not total 100 because of rounding.

†Based on the employee roster provided by the facility

Section D: Coccidioidomycosis and *Coccidioides*

Coccidioidomycosis

Coccidioidomycosis, also known as Valley fever or "cocci," is an infection caused by the fungus *Coccidioides*. The disease is also sometimes called San Joaquin fever or desert rheumatism. The fungus is known to live in the soil in the southwestern United States and parts of Mexico, Central America, and South America. Recently, *Coccidioides* was also found in South-Central Washington. Areas where the fungus is found are collectively known as endemic areas.

Infection usually occurs when a person inhales spores of the fungus that are in the air. Human disease caused by a single *Coccidioides* spore is hypothesized to be possible [Galgiani 1993]. In extremely rare cases, fungal spores can enter the body through a break in the skin (e.g., cut, wound, or splinter) and cause a skin infection [Chang et al. 2003].

Most people with coccidioidomycosis live in or visit places where the fungus is in the soil and engage in activities that exposure them to soil dust. Infection does not spread from person to person or from animals to people. Infection usually does not occur again if a person has a healthy immune system [McCotter and Chiller 2017].

During 2011–2017, a total of 95,371 cases of coccidioidomycosis in 26 states and the District of Columbia were reported to CDC. The annual number of cases decreased from 2011 through 2014, but then subsequently increased. Most cases were reported from Arizona (65%) and California (33%) [CDC 2019a]. In 2018, there were 7,515 cases of coccidioidomycosis in California, corresponding to an incidence of 18.8 per 100,000 population. Most cases within California were reported among residents of counties in the southern Central Valley and Central Coast. The incidence of coccidioidomycosis in California has been increasing since 2015 [CDPH 2019]. While reasons for this increase are unclear, environmental factors, including climate, and increased population density in areas where the fungus is, might play a role.

The true burden of coccidioidomycosis is likely underestimated. Approximately 150,000 infections are estimated to happen each year [Galgiani et al. 2005]. However, 60% of infections might result in no symptoms or symptoms so mild that medical attention is not sought. Some illnesses might not be correctly diagnosed as coccidioidomycosis because rates of testing for the disease are low [CDC 2019b].

There is a wide range in the severity of coccidioidomycosis. Many have no symptoms. When symptoms do occur, they usually start about 1–3 weeks after inhaling the spores. Among people who develop symptoms, a flu-like illness is common; symptoms include fever, fatigue, cough, chest pain, shortness of breath, night sweats, headache, skin rash, and joint aches [CDC 2019b; University of Arizona 2019]. Recovery can take weeks to months in otherwise healthy people [Galgiani et al. 2005; Thompson 2011; Tsang et al. 2010; University of Arizona 2019]. About 5%–10% of infected people develop serious or long-term lung disease [CDC 2019b; McCotter and Chiller 2017]. In 1% of infected persons, infection spreads from the lungs to other parts of the body, such as the brain and spinal cord (central nervous system), skin, or bones or joints [CDC 2019b; McCotter and Chiller 2017].

Anyone who lives in or travels to the areas where *Coccidioides* is found can develop coccidioidomycosis. Certain groups of people may be at higher risk for developing severe coccidioidomycosis. This includes people with underlying medical conditions, such as diabetes mellitus, lung disease, diseases that suppress the immune system or taking immunosuppressive medications, organ or bone marrow transplant, or cancer requiring chemotherapy or radiation therapy [Brown et al. 2013; CDC 2019b; Odio et al. 2017]. Others at an increased risk of developing severe lung complications or disseminated disease are pregnant women, people aged 65 years or older, people who smoke, and people of African American or Filipino descent [McCotter and Chiller 2017].

Coccidioidomycosis is diagnosed through laboratory testing. The most common way that healthcare providers test for coccidioidomycosis is by taking a blood sample and sending it to a laboratory to look for *Coccidioides* antibodies or antigens (serology). Coccidioidomycosis can also be diagnosed through histopathology (looking for evidence of *Coccidioides* in tissue samples examined under a microscope), culture (isolating and growing *Coccidioides* from a clinical sample), or molecular techniques that look for DNA specific for *Coccidioides*. Skin testing can determine if a person has been exposed to *Coccidioides* but does not indicate when exposure occurred. However, skin testing can provide information about risk of future illness because a reactive skin test generally indicates the person has an immune response that will protect from coccidioidomycosis in the future [CDC 2019b; Galgiani 1993; University of Arizona 2019].

Treatment for coccidioidomycosis varies by disease severity. Some patients do not require treatment for self-limited illness while others require antifungal medications. In one study based in Arizona, 61% of patients were prescribed antifungal medications and 41% were hospitalized [Tsang et al. 2010]. An academic medical center focusing on coccidioidomycosis has started referring patients with profound fatigue, often the last symptom to resolve, to a physical therapist to assist with reconditioning [University of Arizona 2019]. No vaccine against coccidioidomycosis is currently available.

Coccidioides

Coccidioides is the fungus that causes coccidioidomycosis. It lives in the upper part of arid or semiarid soil in endemic areas, about 2–12 inches from the surface [Fisher et al. 2000; Pappagianis 1988]. Within endemic areas, the distribution of the fungus in the soil is patchy and unpredictable [Fisher et al. 2000; Kollath et al. 2019; Nguyen et al. 2013]. Climate, seasonality, and environmental conditions can influence the life cycle of the fungus and the incidence of disease. *Coccidioides* is hypothesized to grow in the soil when there is abundant moisture. Spores are released into the air when the soil dries out. Studies have found that the incidence of coccidioidomycosis is higher when there is a heavy wet period followed by a prolonged dry period [Gorris et al. 2018; Kollath et al. 2019; Pappagianis 1988]. One study showed that the incidence of coccidioidomycosis in the San Joaquin Valley peaked in October, approximately 3 months after peak surface air temperature and 2 months after the summer minimum in precipitation and soil moisture [Gorris et al. 2018].

Coccidioides spores are approximately 2–5 micrometers, which means that they can become airborne, stay in the area for long periods of time, and go deep into the lungs [Schmelzer and Tabershaw 1968; University of Arizona 2019]. Spores can be carried in dust particles from soil. Dry spores stored in a

range of temperatures from –15°C–37°C and relative humidity between 10%–95% remained viable outside of the soil after 6 months [Berman et al. 1956].

There are no occupational exposure limits associated with exposure to *Coccidioides*.

Section E: References

Coccidioidomycosis and *Coccidioides*

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