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Awareness and Environmental Exposures Related to Coccidioidomycosis Among Inmates at Two California Prisons, 2013

Kaitlin Benedict, MPH[1], **Anne E. Purfield, PhD**[1], **Janet Mohle-Boetani, MD, MPH**[2], **Charlotte Wheeler, MD, MPH**[2], and **Benjamin J. Park, MD**[2]

[1]Centers for Disease Control and Prevention, Atlanta, GA, USA

[2]California Correctional Health Care Services, Public Health Branch, Elk Grove, CA, USA

Abstract

Coccidioidomycosis (Valley fever) is a major cause of illness in inmates in some California prisons. This article discusses an investigation conducted at two prisons to describe potential environmental exposures. The study did not identify modifiable risk factors; limiting the type or duration of outdoor activity in these prisons may not decrease coccidioidomycosis morbidity.

Keywords

coccidioidomycosis; Valley fever; *Coccidioides*; prisons; California

Introduction

Coccidioidomycosis (Valley fever) is a fungal infection caused by inhalation of *Coccidioides* spp. arthroconidia. Symptomatic infection occurs in approximately 40% of cases and typically presents as a self-limited influenza-like illness, but a small proportion of patients experience severe or chronic pulmonary disease or life-threatening disseminated disease (Galgiani et al., 2005). Coccidioidomycosis is endemic to the southwestern United States, with hyperendemic foci in Arizona's Sonoran Desert and California's southern Central Valley.

Coccidioidomycosis is a substantial public health problem in prison inmates in some areas of California (Burwell et al., 2009; Pappagianis, 2007). During 2011, the incidence per 100,000 persons at prisons A and B was 5,189, which is 110 times higher than the combined

Corresponding Author: Kaitlin Benedict, MPH, Mycotic Diseases Branch, Centers for Disease Control and Prevention, 1600 Clifton Road NE, Mailstop C09, Atlanta, GA 30033, USA. jsy8@cdc.gov.
All the authors contributed equally to this work.

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rates of the nonprison populations in the counties where the prisons are located (Wheeler, Lucas, & Mohle-Boetani, 2015). Previous strategies to reduce coccidioidomycosis in this population involved exclusion of immunosuppressed inmates from eight prisons located in highly endemic areas beginning in August 2006 (California Correctional Health Care, 2012), cancelling planned construction at Prison B, implementation of educational and awareness efforts, and a cohort study to determine demographic and medical risk factors for infection among inmates who spent at least one night at Prison A or B in 2011. Prisons A and B house adult men, are structured similarly, and are located < 15 miles apart in California's Central Valley, with arid surrounding areas and minimal vegetation on the prison grounds. No construction occurred at either prison during 2011.

It is not known if certain activities in these prisons are associated with higher risk of disease. As part of an epidemiologic investigation requested by corrections agency management, we evaluated potential exposures to understand if limitations on these exposures could contribute to reducing the likelihood of coccidioidomycosis.

Methods

Participant Selection

We conducted a nested case–control study using data from the subset of participants from the 2011 cohort study. Because the amount of allowable outdoor recreation time can vary by housing facility, case–control study participants were limited to those who had lived continuously at a single housing facility from January 1, 2011, to June 1, 2013. Cases were inmates who had documented coccidioidomycosis diagnosed in 2011 according to prison medical records, and controls were randomly selected inmates without coccidioidomycosis diagnosis. Three to five controls were matched to each case-inmate by prison (A or B), age group (18 to 35, 36 to 55, and ≥ 56 years), and race/ethnicity category.

Data Collection

Data on age, race/ethnicity, housing facility, and underlying medical conditions were from the cohort study. Additional data were collected on time spent outdoors, outdoor activities, occupation, exposure to dirt or dust, residence history, and knowledge of coccidioidomycosis during confidential in-person interviews using a standardized questionnaire. To minimize recall bias, participants were asked about the amount of time they currently spend outdoors as a proxy for the amount of time spent outdoors before they developed coccidioidomycosis (case-inmates) or before their matched case-inmate developed coccidioidomycosis (controls). The analysis of time spent outdoors was limited to participants who said that the amount of time they spend outdoors had not changed since 2011. Controls' current outdoor recreational activities and current occupations were compared to those of their matched case-inmate before he developed coccidioidomycosis. Study participants were asked to provide a detailed lifetime residence history, including incarceration at other institutions. Two investigators independently categorized each location as "nonendemic," "moderately endemic," or "highly endemic" for coccidioidomycosis based on the categories of coccidioidin skin-test reactivity described in the 1957 report by Edwards

and Palmer (1957). The highest level of coccidioidomycosis endemicity among prior residences was then recorded for each participant.

Statistical Analysis

Survey responses were entered into a Microsoft Access database and analyzed using Statistical Analysis Software (SAS, Version 9.3). Categorical variables were compared using χ^2 or Fisher's exact tests, and continuous variables were compared using Student's *t*-test or Wilcoxon rank-sum tests, as appropriate. Logistic regression was used to calculate odds ratios (*OR*s) and 95% confidence intervals (CIs) for the matched case–control analysis. Two-sided *p* values of ≤ .05 were considered statistically significant.

Ethics Approval and Informed Consent

Due to the nature of the public health investigation, formal institutional review board approval was not necessary; however, we consulted human subjects' research experts regarding the questionnaire design since prison inmates are considered a vulnerable population. Case-inmates and controls provided verbal consent to participate in the interviews, and no personally identifying information was collected.

Results

We identified 40 case-inmates and 174 controls: 17 and 23 case-inmates and 71 and 103 controls from prisons A and B, respectively. Case-inmates at prisons A and B were demographically similar (Table 1). Thirty-eight (95.0%) case-inmates were aware of their coccidioidomycosis diagnosis. Of those, 36 (94.7%) experienced symptoms, for a median of 14 days (range = 0 to 210) before diagnosis and 21 days (range = 0 to 570) after diagnosis. Thirty-eight (95.0%) reported receiving antifungal treatment (median = 24 weeks; range = 1 to 104). Median treatment duration was significantly longer at Prison A (46 weeks; range = 8 to 104) than at Prison B (24 weeks; range = 1 to 76; $p = .037$).

Case-inmates and controls had similar proportions of underlying medical conditions such as hepatitis C, cardiac disease, diabetes, and asthma (Table 2). Approximately half of case-inmates ($n = 20$, 50.0%) and controls ($n = 92$, 52.9%) said that the amount of time they spend outdoors had not changed since their coccidioidomycosis diagnosis (case-inmates) or since January 1, 2011 (controls); median time spent outdoors was 19.9 hours per week (range = 3.5 to 45.5) for case-inmates and 17.3 (range = 0.0 to 77.0) for controls. The frequencies of various recreational activities were not significantly associated with case status. Both groups were also equally likely to have a job or be enrolled in an educational program (87.5% vs. 87.4%, *OR* = 0.96; 95% CI: [0.29, 3.72], $p = 1.000$). Similar proportions of case-inmates and controls reported breathing in dirt or dust outdoors (85.0% vs. 84.5%, *OR* = 1.19; CI: [0.35, 3.52], $p = .917$) and indoors (54.6% vs. 67.2%, *OR* = 0.50; CI: [0.19, 1.28], $p = .164$). Nearly all participants ($n = 191$, 90.1%) had previously lived in areas with high or moderate coccidioidomycosis endemicity, with no significant difference between case-inmates and controls.

Sixteen of 174 matched controls self-reported that a physician had diagnosed them with coccidioidomycosis (either prior to or during incarceration); however, the results of the case–control study did not change when these persons were excluded from the analysis.

Case-inmates and controls were both knowledgeable about coccidioidomycosis; 195 (91.1%) were able to correctly describe how it is acquired. Only 58 (27.2%) participants had heard of coccidioidomycosis prior to their current incarceration; participants most commonly indicated that they learned about it from other inmates (n = 85, 39.7%) or posters displayed in the prison (n = 60, 28.0%). Case-inmates were more likely than controls to have learned about coccidioidomycosis from their family (20.0% vs. 3.5%, OR = 8.48; CI: [2.22, 39.09], p = .001).

Discussion

We did not find specific outdoor recreational activities, occupations, or time spent outdoors to be associated with coccidioidomycosis in Prison A or B inmates. Therefore, attempting to modify these potential exposures by limiting activity type or duration is probably unlikely to be highly effective in reducing coccidioidomycosis rates.

Although several outbreak investigations have shown associations between dust or dirt exposure and coccidioidomycosis, no data exist that clearly demonstrate risk reduction by limiting outdoor activities (Cummings et al., 2010; Werner, Pappagianis, Heindl, & Mickel, 1972). Similar to our results, one study in a nonprison setting did not find specific recreational activities or time spent outdoors to be associated with illness (Leake et al., 2000). These data suggest that in highly endemic areas where dust exposure is common, limiting outdoor activity alone may not be effective in reducing coccidioidomycosis risk.

It is also unknown if environmental modification can reduce risk. Previous efforts to prevent aerosolization of *Coccidioides* spores by binding or paving soil have been performed, but the effects on coccidioidomycosis incidence were unclear (California Correctional Health Care, 2012; Smith, Beard, Rosenberger, & Whiting, 1946). Although inmates reported exposures to dirt or dust both outdoors and indoors, our investigation was not designed to evaluate the possible effects of outdoor dust control methods or improved indoor air filtration on risk of disease. It is possible that environmental measures such as these might reduce the risk of *Coccidioides* spore inhalation, and reducing dust exposure can also result in general respiratory health benefits. Further study in this area is needed.

The primary limitation of our study was that we could not determine whether controls were truly *Coccidioides*-uninfected since testing was not conducted on controls. Prior *Coccidioides* infection is believed to confer immunity and is detectable with an antigenic skin test that was unavailable during this investigation (Johnson et al., 2012). Therefore, controls could have been infected either prior to or during incarceration, thus limiting our ability to detect significant differences between case-inmates and controls.

Participants had a good understanding of how coccidioidomycosis is acquired, suggesting the benefit of an active educational campaign. Continuation of ongoing educational efforts

may help to alleviate fears and resolve misperceptions about coccidioidomycosis and encourage inmates to promptly seek medical care for relevant symptoms.

Prison officials and public health practitioners face challenges when trying to prevent coccidioidomycosis. Although we did not identify any activities or occupations that could reduce coccidioidomycosis in these prisons, prison officials may consider other strategies: exclusion of persons at high risk, identified by demographic or clinical risk factors or by using an antigenic skin test, is a method to potentially reduce disease and is worthy of future study.

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Table 1

Description of Coccidioidomycosis Case-Inmates at Prisons A and B.

	Prison A (*n* = 17)	Prison B (*n* = 23)	
Characteristic	***n* (%)**	***n* (%)**	***p***
Age, years (median, range)	42.0 (26–64)	45.0 (24–62)	.272
Race/ethnicity			.678
African American	6 (35.3)	9 (39.1)	
Hispanic	5 (29.4)	8 (34.8)	
White	6 (35.3)	5 (21.7)	
Other	0 (0.0)	1 (4.4)	
Aware of coccidioidomycosis diagnosis	17 (100.0)	21 (91.3)	.499
Symptomatic	16 (94.1)	20 (95.2)	1.000
Symptom duration, days (median, range)	24 (1–180)	70 (8–630)	.132
Before diagnosis (median, range)	14 (0–180)	14 (3–210)	.716
After diagnosis (median, range)	14 (0–120)	30 (2–570)	.241
Received treatment for coccidioidomycosis	16 (94.1)	22 (95.6)	.436
Treatment duration, weeks (median, range)	46 (8–104)	24 (1–76)	.037

Table 2

Comparison of Coccidioidomycosis Case-Inmates and Controls at Prisons A and B Combined.

Characteristic	Case-Inmates *n* (%)	Controls *n* (%)	*OR* (95% CI)	*p*
Demographics				
Age, years (median, range)	43.5 (24–64)	45 (23–73)	n/a	.593
Race/ethnicity				.949
African American	15 (37.5)	59 (33.9)	n/a	
Hispanic	13 (32.5)	63 (36.2)	n/a	
White	11 (27.5)	49 (28.2)	n/a	
Other	1 (2.5)	3 (1.7)	n/a	
Underlying medical conditions				
Hepatitis C	3 (7.5)	16 (9.2)	0.72 [0.13, 2.69]	.874
Cardiac disease	1 (2.5)	7 (4.0)	0.51 [0.01, 4.12]	.904
Asthma	3 (7.5)	9 (5.2)	1.42 [0.25, 5.23]	.803
Diabetes	3 (7.5)	11 (6.3)	1.10 [0.19, 4.55]	1.000
Ever smoked	25 (62.5)	110 (63.2)	0.92 [0.41, 2.10]	.979
Time spent outdoors				
Amount of time outdoors has not changed since 2011[a]	20 (50.0)	92 (52.9)	0.87 [0.42, 1.81]	.823
Hours outdoors per week (median, range)[b]	19.9 (3.5–45.5)	17.3 (0.0–77.0)	n/a	.598
Recreational and occupational activities[c]				
Basketball	9 (22.5)	29 (11.5)	2.62 [0.91, 7.31]	.077
Handball	4 (10.0)	19 (10.9)	0.99 [0.22, 3.51]	1.000
Softball/baseball	5 (12.5)	13 (7.5)	1.90 [0.45, 7.32]	.451
Run/walk	19 (47.5)	104 (59.8)	0.61 [0.28, 1.31]	.228
Work out	20 (50.0)	83 (47.7)	1.11 [0.53, 2.31]	.904
Soccer	3 (7.5)	16 (9.2)	0.84 [0.14, 3.63]	1.000
Sedentary	7 (17.5)	41 (23.6)	0.66 [0.23, 1.67]	.485
Have a job or enrolled in an education program	35 (87.5)	152 (87.4)	0.96 [0.29, 3.72]	1.000
Administration	3 (8.6)	8 (5.3)	1.79 [0.29, 8.52]	.632
Carpentry/furniture fabrication	1 (2.9)	9 (5.9)	0.48 [0.01, 3.64]	.835
Education program	9 (25.7)	41 (27.0)	0.98 [0.37, 2.47]	1.000
Food service	5 (14.3)	20 (13.2)	1.08 [0.28, 3.49]	1.000
Janitorial	8 (22.9)	37 (24.3)	0.96 [0.35, 2.45]	1.000
Yard crew	4 (11.4)	15 (9.9)	1.27 [0.28, 4.52]	.899
Welding/metalwork	3 (8.6)	5 (3.3)	3.16 [0.33, 41.09]	.424
Other	3 (8.6)	20 (13.2)	0.51 [0.08, 2.12]	.513
Work mainly indoors	28 (87.5)	123 (86.0)	1.23 [0.35, 5.53]	.985
Windows or door usually left open	10 (40.0)	32 (31.7)	3.71 [0.72, 36.78]	.149
Breathe in dirt or dust	34 (85.0)	147 (84.5)	1.19 [0.35, 3.52]	.917
Breathe dirt or dust indoors	18 (54.6)	92 (67.2)	0.50 [0.19, 1.28]	.164
Residence history				

Characteristic	Case-Inmates *n* (%)	Controls *n* (%)	*OR* (95% CI)	*p*
Highly endemic area	15 (37.5)	58 (33.7)	Ref	Ref
Moderately endemic area	22 (55.0)	96 (55.8)	0.88 [0.40, 1.98]	.872
Nonendemic area	3 (7.5)	18 (10.5)	0.69 [0.11, 2.97]	.857
Knowledge of coccidioidomycosis				
Correctly described how a person gets coccidioidomycosis	39 (97.5)	156 (89.7)	4.31 [0.64, 186.1]	.213
Heard about coccidioidomycosis prior to current incarceration	10 (25.6)	48 (27.6)	0.91 [0.36, 2.13]	.987
Received information about coccidioidomycosis during current incarceration	35 (87.5)	149 (85.6)	1.22 [0.42, 4.39]	.930
From a prison official	7 (17.5)	15 (8.6)	2.26 [0.73, 6.38]	.164
From a health care provider	11 (27.5)	25 (14.4)	2.13 [0.87, 4.97]	.102
From a wall poster	7 (17.5)	53 (30.5)	0.46 [0.15, 1.19]	.125
From a family member	8 (20.0)	6 (3.5)	8.48 [2.22, 39.09]	.001
From TV/media	3 (7.5)	35 (20.1)	0.29 [0.05, 1.10]	.076
From another inmate	15 (37.5)	70 (40.2)	0.89 [0.41, 1.86]	.883

[a] For case-inmates, before coccidioidomycosis diagnosis; for controls, since January 1, 2011.

[b] Among participants whose time spent outdoors had not changed (for case-inmates, before coccidioidomycosis diagnosis; for controls, since January 1, 2011).

[c] For case-inmates, before coccidioidomycosis diagnosis; for controls, current activities.