Welcome to the Valley

By John Benson

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1. Introduction

Having lived in the Livermore Valley for most of my adult life (since 1977), I heard about Valley fever early on. This disease is mostly prevalent in California huge Central Valley (and hence its name), but Livermore Valley is only separated from the Central Valley by the 35-mile Altamont Pass, so Valley fever occasionally creeps over the pass to infect someone in Livermore Valley, or more-likely someone commutes one way or the other through the Altamont, and thus spends much time in the Central Valley.

But guess what, Valley fever has been expanding its range for many years, and this is continuing, and accelerating – fueled by climate change.

In the spring of 2021, shortly after moving from Seattle to Arizona, Marc Evans, a retired broadcast industry lawyer, began tending the vegetable garden in his niece's backyard. Evans and his wife were staying in a guest house on the property, in the Phoenix suburb of Paradise Valley, while they house hunted. As Evans, then 71, turned soil to plant tomatoes, a backhoe was cratering the neighbor's yard next door to put in a swimming pool.[1]

A few weeks later, Evans began waking up at night short of breath. As his symptoms got worse, he started creeping out to the couch to sleep sitting up, so as not to disturb his wife, Arlene Evans. She already worried about his health: He is diabetic and had weathered two heart attacks decades earlier.

"I tend to just sort of ride [illnesses] out until they go away," Marc says. "Well, this one didn't go away. This one got worse, and I didn't want her to worry about it, so I let it go on longer than I should."

At night, he started seeing floating black-and-white checkerboards and stripes that he knew weren't there. "That was some scary shit," he recalls. He broke down and told Arlene, who took him to the emergency room (ER) in the middle of the night.

At the nearby Mayo Clinic Hospital, he was soon diagnosed with Valley fever, or coccidioidomycosis—a respiratory disease contracted by inhaling microscopic spores from the soil-dwelling fungus Coccidioides. Marc had never heard of the fungus, endemic in Arizona and California, whose San Joaquin Valley[2] *gives the disease its name. "You are a resident for a long time here, you know it's out there," he says. "But people who move from other places? They don't have a clue."*

[1] Meredith Wadman, Science Magazine, Jan 17 issue, "Dust devil," https://www.science.org/content/article/climate-change-may-be-driving-spread-deadly-fungus-u-s-southwest

[2] The San Joaquin Valley forms the southern 1/3rd of California's Central Valley that I mention above. The northern 2/3rdsof the Central Valley is the Sacramento Valley, named after the river that runs through it.

2. Coccidioides (Cocci)

"Cocci" (pronounced "coxey") – a nickname used, imprecisely, for both the fungus and the disease it causes – had taken up residence in Marc's left lung. There, an opaque, baseball-size blot was visible on his imaging results. Doctors stuck a needle in it and withdrew cells and fluid laced with the fungus.

Evans also had hints of meningitis, an inflammation of the membranes that envelop the brain and spinal cord. Beyond the floating checkerboards, he was complaining of headaches. But tests of his spinal fluid came back frustratingly ambiguous. He was started on high-dose antifungal medication and went home after 7 days.

Weeks later, Arlene rushed him back to the ER. His skin was gray and his shortness of breath had returned with a vengeance. Minutes after Marc was whisked away, three masked doctors emerged to ask Arlene whether he had a do not resuscitate order.

"I'm like, 'What are you talking about here?'" she remembers. "They told me all of his organs had failed."

In fact, Marc's Valley fever was improving. But, likely weakened by the stress of his bout with cocci pneumonia, his left ventricle, the workhorse of the heart, was failing to pump remotely enough blood to supply his vital organs. When Arlene was allowed into her husband's room in the intensive care unit, it was a "chaos" of nurses, she says. "All he kept telling them was, 'I don't want a catheter.' I'm like, 'You got bigger things to worry about than a catheter.'"

2.1. Cocci's History

The threat of Coccidioides isn't new. The disease it causes was first described by Argentinian medical student Alejandro Posadas in 1892. Valley fever is familiar in the Southwest, where it has infected wildland firefighters; carrot, beet, and radish pickers; solar power farm builders; and cast and crew members on a Ventura County film set.

Most don't get as sick as Marc did. In the roughly 40% who get symptoms at all, the fungal spores, nourished in the warm, wet confines of the lung, morph into structures called spherules that burst to release boatloads of tiny endospores that become new spherules, continuing the cycle. Most of these people have a flulike illness lasting weeks or months. But 5% to 10% of cases result in lifelong lung infections, sometimes forcing people to be on powerful antifungal medications permanently. In about 1.5% of illnesses, the fungus disseminates, attacking bones, joints, or skin, or causing meningitis. Invasive disease is more common in men, a skew not entirely explained by higher occupational exposures. Black people, like Marc, are at strikingly higher risk, for unknown reasons.

And cases are escalating fast. Diagnoses reported to the U.S. Centers for Disease Control and Prevention (CDC) have ballooned from about 2800 annually at the turn of the century to about 20,000 in 2023, with at least 200 people dying each year. Arizona and California, where roughly 97% of U.S. cases are reported, have seen dramatic increases recently: Incidence in Arizona has grown by 73% in the past 10 years—to 146 cases per 100,000 people. In California, incidence quadrupled between 2014 and 2023 to 23.2 cases per 100,000 people…

Author's comment: The above "…23.2 cases per 100,000 people…" for California are misleading. The population of California is almost 40 million, but most of these live in the three large coastal metro areas: The San Francisco Bay Area (7.7 million), Los Angeles Area (12.6 million) and San Diego Area (3.3 million). These total 23.6 million, and most of these people rarely go into the Central Valley where they could contract Cocci.

Coccidioides is spreading geographically. In several counties of both Arizona and California where cases had been relatively rare, disease incidence has increased dramatically during the past 5 to 10 years.

One likely contributor is a warming climate. The fungus thrives in hot, dry soil where it can get the best of competitors by going dormant during drought, then rebounding after rain returns. Valley fever cases tend to spike after wet winters that follow droughts, says Tom Chiller, chief of the mycotic diseases branch at CDC. And the U.S. West is becoming demonstrably hotter, drier, and more prone to weather extremes.

2.2. Chasing Cocci

It's a mid-October morning, and Jennifer Head, an infectious disease modeler at the University of Michigan, stands near the dry bed of the Kern River in Bakersfield. Clutching a sun hat, she surveys an expansive, uneven landscape of sand, dirt, and burnt yellow grass. "We just need a place where the drones can launch off, that's flat and clear," she says. "I feel like this will work."

It's 24°C (75°F) and will reach 33°C (91°F) by afternoon. It hasn't rained in 5 months. Kern County, home to Bakersfield, has the highest incidence of Valley fever in the country. Head has come to test the air and soil for signs of the fungus—and seek clues to why it is spreading.

Livermore, where your author lives, Bakersfield, where the current dialog takes place, California and surrounding States. The Central Valley is the light-colored area in the Center of my state.

Cocci's fleeting spores, which can appear in a location one day and be gone a few days later, are devilishly difficult to find. That has made defining the exact range of the fungus a challenge, and scientists have mostly used Valley fever case counts to infer its presence. They now suspect it occupies a laundry list of western and southwestern states outside its classic home states of Arizona and California.

It extends as far north as Washington state and across the Southwest to Texas, and it's present in scattered, semiarid parts of Mexico and Central and South America. Unfortunately, some endemic states—Texas is exhibit A —don't require physicians to report cases to CDC, which makes it impossible for the agency to keep an accurate tally.

Occasionally, serendipity helps reveal the fungus. In 2010, a boy with no recent travel history was diagnosed with Valley fever after crashing his all-terrain vehicle and wounding his knee at a public park in eastern Washington state, far from its known habitat. Enterprising local public health workers and Chiller's CDC lab identified a strain of cocci in the local soil identical to the one that infected the boy…

Dog infections, which veterinarians are alert for, also suggest the fungus is extending its range. (The animals are likely sickened at higher rates, and more severely, than humans.) An analysis of 835,000 canine blood tests in the United States from 2012–22 found 37.6% were positive, and the geographic spread was unmistakable: 2.4% of U.S. counties had positive canine tests in 2012; by 2022, 12.4% of counties reported positive tests.

Modeling studies that incorporate climate change suggest the spread will continue. A 2019 analysis led by climate scientist Morgan Gorris at Los Alamos National Laboratory found that southwestern counties with high Valley fever caseloads had higher average temperatures and lower average precipitation than other counties—conditions climate change will exacerbate. The study predicted that in a high-warming scenario, the fungus would colonize almost the entire western U.S. by 2100 and cases would grow by 50%. "The habitat suitable for Coccidioides is going to spread," Head predicts. "But we don't really know how the spores will get there."

One idea is that they hitch a ride on wildfire smoke. "When wildfires burn, they mobilize massive quantities of dirt," Head says—along with a plethora of diverse, living bacteria and fungi. No studies to date have found cocci in smoke, but a 2023 analysis of data from 22 California hospitals, 18 of them in or around major coastal cities, found a 20% increase in admissions for Valley fever following wildfire smoke exposure.

At their first study site of the day in Bakersfield, Head and her colleagues are refining their drone sampling techniques before they take on the harsh environment of controlled burns. In a proof of principle, they have already gathered two positive samples during 41 drone flights above the cocci-laden grasslands of the Carrizo Plain west of Bakersfield — the first cocci spores a drone has ever captured.

Now, they are on the hunt for more clues. The first of two drones lifts off over the brown scrubland. It will pull air onto two filters at a human breathing rate of 7.5 liters per minute, for 20 minutes. In the lab, the team will analyze the filters' catch for cocci DNA. The drones also gather data on temperature, humidity, and particulate matter every 8 seconds—shedding light, the scientists hope, on which combination of conditions are friendliest to airborne cocci spores. Because so little is known about cocci's airborne spread, "Anything we find is useful," says Environmental Protection Agency microbiologist James Markwiese, who leads the drone project.

The sampling in Bakersfield could also help researchers tackle another mystery. "We don't even know the dose of spores it takes for somebody to get ill," Head says. "We don't really know if these spores are somewhat ubiquitous and you just need a higher dose for infection to happen … or if it takes only a few spores."

To find out how prevalent the spores are, the team will compare the probability of finding them at altitudes of 12 and 20 meters, on stationary air filters set on tripods, and in soil.

Such sampling can also probe the source of the spores people inhale. Recent work led by computational biologist Robert Wagner, a former postdoc in the lab of mycologist John Taylor at UC Berkeley, found that in the San Joaquin Valley, the spores in the air are genetically quite different from those in the soil. The difference suggests the spores captured at altitude may have blown in from afar instead of being kicked up from nearby.

Rodent burrows are a good bet. It's been known for decades that diverse rodent species harbor cocci, mostly without showing symptoms, and the soil in rodent burrows is much more likely to test positive than random soil samples, where spores are vanishingly rare. The wind can sweep up spores in the loose dirt rodents leave near the mouths of burrows and carry them to nearby humans.

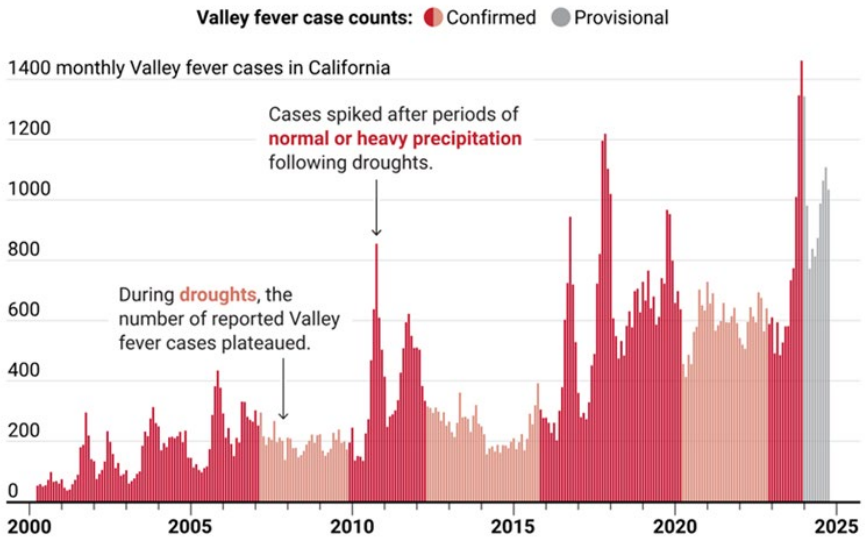
The rodents could also be spreading the spores from place to place. A recent study by ecologist Rebecca Rowe's group at the University of New Hampshire found that in general, spores of soil-dwelling fungi were more likely to catch a ride on small mammals than on the breeze.

A rodent connection could explain why Valley fever cases tend to surge after droughts end, when rodent numbers also multiply. Head and her group have helped nail down the drought link, crunching data on cases in California from 2000 to 2020 to show that droughts temporarily suppressed case numbers, though they more than bounced back immediately after droughts ended. The study, published in 2022, made Valley fever the first infectious disease causally linked to drought.

The standard explanation for that pattern is the long-held "grow and blow" hypothesis: Cocci mycelia, networks of spore-shedding filaments called hyphae that inhabit soil, go dormant during drought. But when a wet winter follows, they proliferate. After such a winter, dry and hot weather (think Central Valley summers) creates dusty conditions that trigger the hyphae to form spores that can be kicked or blown up from the soil. Recent California case trends – huge numbers of cases after the last two wet winters broke a years-long drought – have offered dramatic support for this hypothesis (see graphic, on the next page below).

Days when the rains came

In California, hot, dry summers following wet winters—especially after multiyear droughts—have sent Valley fever cases soaring, amplifying typical fall peaks. The “grow and blow” hypothesis holds that rains cause the fungus to proliferate underground. Then the heat and dryness that follow enhance the release of spores into soil and their airborne dispersal.



(DATA) J. HEAD ET AL., *THE LANCET PLANETARY HEALTH*, 6:10, (2022); CALIFORNIA DEPARTMENTOF PUBLIC HEALTH VALLEY FEVER PROVISIONAL DATA DASHBOARD; (GRAPHIC) V. PENNEY/*SCIENCE*

But rodent populations may be as important as weather. The “rodent hypothesis,” first published in 1942, holds that, rather than being accidental hosts of Coccidioides, burrowing rodents are primary hosts, harboring the fungus, alive but inactive, in their lungs. When the rodent dies, the theory goes, the fungus morphs into the mycelial form and feeds on the carcass to grow and produce spores.

Taylor[3] and soil microbiologist Bridget Barker at Northern Arizona University (NAU) found support for that scenario in cocci’s own DNA. With fellow microbiologist Thomas Sharpton at Oregon State University and colleagues, they showed Coccidioides has over time shed genes useful for digesting plants and multiplied genes for digesting animal protein.

“We know that rodent populations can bottom out during drought and then skyrocket afterwards,” Head notes. If dead infected rodents really introduce spores into soil, drought related die-offs could increase that spore supply. And during a population rebound, nutrients from the shedding of skin, hair, and excreta into soil could nourish fungal growth.

If the rodent hypothesis is right, masking or avoidance of burrow-laden areas could help lower the risk for people living in Coccidioides hot spots. (Taylor was employed as an expert witness in a trial on behalf of California Department of Transportation construction workers who sued the agency after they were infected with cocci in an area covered with rodent burrows. He found that burrows and surface soil where they had excavated were positive for cocci, and the workers won a $12 million award from the transit agency.)

[3] Mycologist John Taylor at UC Berkeley. Mycology is the scientific study of fungi. Taylor was first referenced near the top of page 5.

Final author's comment: Electrical workers that build and maintain electric power infrastructure in the Central Valley, Arizona and other locations are exposed to Cocci, and likely contract this disease at a high rate. Thus, I researched this, and found two reasonable references below that explored this potential risk.

Coccidioidomycosis among Workers Constructing Solar Power Farms, California, USA, 2011–2014,

https://wwwnc.cdc.gov/eid/article/21/11/15-0129_article

Authors: Jason A. Wilken, Gail Sondermeyer, Dennis Shusterman, Jennifer McNary, Duc Vugia, Ann McDowell, Penny Borenstein, Debra Gilliss, Benedict Ancock, Janice Prudhomme, Deborah Gold, Gayle C. Windham, Lauren Lee, and Barbara L. Materna

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Update on the Epidemiology of coccidioidomycosis in the United States, 2019.

https://pmc.ncbi.nlm.nih.gov/articles/PMC6823633/

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