Dust and Valley Fever: Facts, Fiction, & Speculation

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• Fungus *Coccidioides* spp.
• Soil-borne, air-dispersed
• Regional disease
• Unique to the Americas
• Animals are incidental hosts?
• Reportable disease in AZ
• Former-select agent, BSL-3
• Unobserved sexual phase
• Infection ≈ lifelong immunity

(Rixford & Gilchrist, 1896)
desseminated infections

erythema nodosum

pneumonia-like infiltration
Life cycle of *Coccidioides* spp. (© H.B. Levine)
order Onygenales
*Coccidioides immitis* and *C. posadasi*
Dust
Valley Fever Epidemic

Everything tourists, residents and YOU need to know about this incurable, debilitating and deadly disease

“...The authors have filled the need for a detailed understanding of San Joaquin Valley Fever...This volume is complete, up to date, and accurate in describing this illness...”
- Hans Einstein, MD, FACP
  Legendary Valley Fever Pioneer & Expert

“...This is a disease that many would just as soon sweep under the rug—you’ve laid the dust out where all can see!”
- Sandra Larson, Executive Director,
  Valley Fever Vaccine Project of the Americas

“...If you breathe here, you can catch it.”
- Jose Miguel, KXXV-15 Phoenix, Arizona

David Filip and Sharon Filip
Reported valley fever cases in Arizona

Cases per 100,000 population

Year

Reported valley fever cases in Arizona

Cases per 100,000 population

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Year


Benjamin J. Park,1 Keith Sigel,1,** Victorio Vaz,2 Ken Komatsu,1 Cheryl McRill,3 Maureen Phelan,2,* Timothy Colman,2 Andrew C. Comrie,4 David W. Warnock,1 John N. Galgiani,3,6 and Rana A. Hajjeh1

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2% incident rate (0.4% to 24% per year)

0.02

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2% incident rate (0.4% to 24% per year)
40% symptomatic (misdiagnosis as pneumonia)

0.02 × 0.30

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2% incident rate (0.4% to 24% per year)
40% symptomatic (misdiagnosis as pneumonia)
40% immune (non-Hispanic)

0.02 X 0.30 X 0.5

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2% incident rate (0.4% to 24% per year)
40% symptomatic (misdiagnosis as pneumonia)
40% immune (non-Hispanic)

\[0.02 \times 0.30 \times 0.5 \times 100,000 = 300 \text{ per 100,000}\]
Reported valley fever cases in Arizona

Year


Cases per 100,000 population

0.0 50.0 100.0 150.0 200.0 250.0 300.0
Reported valley fever cases in Arizona

Cases per 100,000 population

Year

1990
1995
2000
2005
2010
2015
Reported valley fever cases in Arizona

Cases per 100,000 population

Year

Reported valley fever cases in Arizona

Year:
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

Cases per 100,000 population:
Reported valley fever cases in Arizona

Year

Cases per 100,000 population
Reported valley fever cases in Arizona

Cases per 100,000 population

Year

Age-specific monthly case frequency averaged from 1992 to 2003 notifiable coccidioidomycosis case data for Pima County, Arizona.
Fluctuation in reported cases are influenced by normal inter-annual changes in climate. Not “climate change”.

Fore-summer rainfall with a 1-1.5 year time lag
PM$_{10}$ not associated

“Exposures” based on reported cases and assumes an average 2 month lag until reported

Tamerius & Comrie, 2011
Ecology & Exposure
• 37M in endemic areas of US;
• 6.4M highly endemic areas of US, 4.7M in AZ
• 62% of 2006 US reported cases in Arizona (n=5,535)
• 5,624 reported Arizona cases in 2014 (3,937 in Maricopa Co.)
Proportion of residents born in Arizona by Census block groups.

Darker areas - more people immune
Lighter areas - more people susceptible
Proportion of population 50 or older by 2000 Census blocks

Darker areas - more older people at greater risk
Lighter areas - more younger people at less risk
Coccidioides spp.  
Soil type dependent?
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1992

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases=101
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1993

Cases=134

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1994

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases per 100,000 total population
- 0
- 1 - 50
- 51 - 100
- 101 - 200
- 201 - 300
- 301 - 338

Cases=125
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1995

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases per 100,000 total population
- 0
- 1 - 50
- 51 - 100
- 101 - 200
- 201 - 300
- 301 - 463

Cases=155
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1996

Cases per 100,000 total population

- 0
- 1 - 50
- 51 - 100
- 101 - 200
- 201 - 300
- 301 - 307

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases=108
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1997

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases=141
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1998

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases per 100,000 total population

Cases=214
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 1999

Cases per 100,000 total population

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases=284
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 2000

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases=274

Cases per 100,000 total population
- 0
- 1 - 50
- 51 - 100
- 101 - 200
- 201 - 300
- 301 - 427

Santa Catalina Mountains
Marana
Tucson Mountains
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 2001

Cases per 100,000 total population

- 0
- 1-50
- 51-100
- 101-200
- 201-300
- 301-1029

Cases=365

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 2002

Cases per 100,000 total population

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases=462
State Reported Frequency of Valley Fever in Greater Tucson, Arizona, by Census 2000 Block Group Populations 2003

Cases per 100,000 total population

Support from ADCRC, ATPM-CDC, Ken Komatsu & ADHS, and Dr. John Galgiani & the Valley Fever Center for Excellence.

Cases=336
Odds ratios of canine valley fever for 1 km² areas. Values are based on a 2 month prevalence of the total study population. Tucson, Arizona

Odds ratios for 1 km² areas with dog populations greater than 20:

- 0 - 0.3
- 0.3 - 0.7
- 0.7 - 1.5
- 1.5 - 3.0
- 3.0 - 26

Dog population density of areas with 20 dogs/km² or less:

- 1 - 10
- 10 - 20

Major Streets

Cases reported (n = 473) over 53 days, from 11/16 to 3/29/99, 12/27/99 to 1/31/00, and 3/21 to 29/00. Dogs licensed by Pima County Animal Control in 2002 (n = 84,967) serve as the population denominator.

Funding provided by ATPMCDC.

Glendale, shallow variant
Fine-silty, mixed, superactive, calcareous, thermic Typic Torrifluvents
Current Facts

- Disease frequency is spatially and temporally variable at coarse and fine scales
- Group-level exposures are important at neighborhood-scale
- Disease frequency associated with weather and climate
- Limited to warm, dry areas of the Americas
- Soil surface temperatures >50º C kills spores
- UV light kills spores
- Mice are the detection standard, PCR & direct plating
- Hyphae 2 to 4 µm in diameter
- Maintains presence at site location for decades
Current Assumptions

• More likely to occur in more alkaline soils, from the neutral to moderately alkaline range (pH 6.6 to 8.4)

• Less likely to occur in more clayey soils of the sand, loamy sand, and sandy loam soils

• More tolerant to salts than competing microorganisms

• Irrigation will kill-off *Coccidioides* spp.

• Spores remain viable up to 10 years (stored samples)

• Association with rodents

• Genetic variability of isolates suggest geographic dispersal is by mammals, not wind.
What are the processes/characteristics that limit *Coccidioides* occurrence?
Water activity \((w_a)\) = soil water potential \((\Psi)\)

\[
\frac{RT}{V_w} \ln(w_a) = \Psi_T = \Psi_\pi + \Psi_\rho + \Psi_z
\]

90\% \(w_a\) or -13.4 MPa soil water potential
Grow and blow: patterns and scales using a landscape ecology approach

• Phenomenon scale
• Sampling scale
• Analytical scale

• Static and dynamic data
• Information rich and information poor areas
Scale and Spatial Relationships and Patterns

Kilometers?
Meters?
Centimeters?
Coccidioides Ecology

Grow
- Soil surface growth & spore formation
- Soil sub-surface growth & spore formation

Weather
- Spore dispersion (natural & anthropogenic soil disturbance)

Blow
- Distant sources (fine particles)
- Local sources (coarse & fine particles)

Airborne Exposure Locations and Events
- Spatial risk factors (residence, work, play)

Spatial – Temporal Factors of Airborne Exposure
(individual & group factors)

Exposure Etiology for Coccidioides

Coccidioidomycosis Epidemiology

Cases & possible uninfected subjects (e.g., serologic false-positive)
- Non-qualifying cases and undiagnosed cases

Disease Frequency (e.g., incidence rate, prevalence)
- Non-qualifying controls and skin test false-positive subjects
- Controls & possible unexposed subjects and immune subjects (e.g., skin test false negative)

Individual Risk Factors
- Race-ethnicity
- Age
- Gender
- Health status
- Smoking history

Symptomatic (infected)

Exposed

Non-symptomatic (infected & uninfected)

Exposed

Unexposed

Severity Factors of Airborne Exposure (individual & group factors)

Spore dose & location of deposition in respiratory system due to particle size

Population consists of susceptible hosts & immune hosts that were previously infected