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NAVAJO NATION HANTAVIRUS SURVEILLANCE REPORT

1992-2016

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INTRODUCTION

Acknowledgements

The Navajo Epidemiology Center (NEC) prepared this report with assistance by Alison Ryan, an epidemiology intern from UCLA Fielding School of Public Health. Data contributions from the Centers for Disease Control and Prevention Viral Special Pathogens Branch and from the Arizona Department of Health Services made this project possible. Insight and expertise from the team at the CDC, the Arizona Department of Health Services, the New Mexico Department of Health, the Utah Department of Health, the Colorado Department of Public Health & Environment, and the Navajo Area Indian Health Service were invaluable. Support and technical guidance from the entire team at the NEC were deeply appreciated and essential to the findings of this project.

Purpose

The purpose of the report was to assess the burden of hantavirus among Navajo residing in the Four Corners area (the region of the southwestern United States formed by the juncture of Arizona, New Mexico, Colorado, and Utah). Though hantavirus is a rare disease that occurs throughout the United States, the highest number of cases have occurred in New Mexico, Arizona, and Colorado (1). Hantavirus disproportionately affects Native American communities who make up 1.7 percent of the U.S. population but, as of January 2016, account for 18 percent of hantavirus cases (2, 3). The goal of the project was to quantify available data in order to serve as a platform for future surveillance efforts and to reveal patterns that may assist in targeting prevention.

Background

Hantavirus is a genus of viruses in the Bunyaviridae family (4). The primary species of hantavirus in the American Southwest is Sin Nombre Virus (SNV). Its main host, the deer mouse (Peromyscus maniculatus), can carry the virus in feces, urine, and saliva. The most common mode of transmission to humans is inhalation of aerosolized particles containing the virus (5). SNV is highly pathogenic, causing most people who are infected to develop hantavirus pulmonary syndrome (HPS). The syndrome consists of two phases – a prodromal phase characterized by fever, headache, and myalgia, sometimes accompanied by abdominal pain, vomiting, and/or diarrhea, and a second phase characterized by shock, hypotension, and pulmonary edema (6).

Data Included

The NEC received data from the CDC Viral Special Pathogens Branch for 139 HPS cases between November 1992 and May 2016 that were linked to a city of residence or city of exposure in one of 10 counties in and around Navajo Nation. These counties are Apache (AZ), Coconino (AZ), Navajo (AZ), McKinley (NM), Cibola (NM), Sandoval (NM), San Juan (NM), La Plata (NM), Montezuma (CO), and San Juan (UT). Four cases missing from CDC data were included from Arizona's state surveillance records. One additional case for which an environmental homesite assessment had been conducted, but was missing in other databases, was also included.

INTRODUCTION

Two methods were used to restrict analysis to Navajo cases. First, data were included for all individuals listed as American Indian with a community of residence on the Navajo Nation. Based on the Navajo Population Profile Report (2013), it can be assumed that approximately 90 percent of these individuals identify as Navajo (7). A review of narrative reports available for half of the cases suggests that the percentage may be higher in this situation. Cases with a community of residence outside Navajo Nation were evaluated individually. Three of these cases were not included for further use because they were residents of other tribal nations. The remaining seven had potential to be Navajo cases and were included in analysis. Data was managed in Microsoft Excel 2013 and analyzed using SAS 9.3.

REPORT HIGHLIGHTS

Report Highlights

One hundred and eight cases that were potentially Navajo occurred between November 1992 and May 2016. The highest numbers of cases occurred during the late spring and early summer months – April, May, June, and July – with a slight peak again in November. The overall case fatality rate was 44 percent. This is higher than the case fatality rate among the total U.S. population of 36 percent, though this could be a result of the relatively small sample size or the fact that this national estimate does not include 1992 or 2016 (8).

Cases were divided almost evenly between men and women, 48.2 percent and 51.9 percent respectively. Women appear to experience a higher rate of mortality (OR=1.87 95% CI 0.86, 4.03), though this could again be an artifact of the small sample size. Mortality among women in the 40-49, 50-59, and 60-69 age groups is especially high. Higher mortality among women has been observed before in studies of hantavirus strains in Argentina and China. In contrast to Navajo Nation and in spite of higher mortality seen in women, Argentina and China both experience a higher incidence among men (9, 10).

HPS affected a wide range of ages from 9 years old to 75. The average age at symptom onset was 35, and the highest number of cases occurred in the 10-19, 20-29, and 30-39 age groups.

Four households experienced more than 1 case. There were 3 parent-child pairs and 1 spousal pair.

Navajo Nation contains 5 geopolitical regions called agencies. Though every agency experienced hantavirus cases, almost half occurred in Eastern Agency. Given that Eastern Agency lies within New Mexico, this is consistent with the fact that New Mexico reported the highest number of cases compared to other states.

Of the 56 cases for whom detailed exposure information was available, 69.8 percent were recorded as having exposure to mice at home, 5.7 percent were recorded as having work-related mouse exposure, 15.1 percent were recorded as having both work-related and homesite exposure, and 9.4 percent were recorded as both homesite and recreational exposure. 53.1 percent of the 56 individuals resided in mobile homes. 35.7 percent of homesites had floors primarily covered with carpet. 47.9 percent lived in areas characterized by piñon/juniper woodland, and 65.9 percent lived between 6000 and 7000 feet of elevation.

Of the 55 cases for whom medical information was available, 70.9 percent were seen at a health care facility 2 to 3 times over the course of their illness. One case visited a health care facility 5 separate times. 14 cases were listed as having received extracorporeal membrane oxygenation (ECMO) treatment. Due to potentially serious side effects, ECMO treatment is usually reserved for patients who are not expected to survive. Survival for cases placed on ECMO was 50 percent. It is important to note that these are cases for whom ECMO treatment was recorded, and it is possible that others received ECMO but were not listed as such in the available records.

INCIDENCE

Figure 1. Incidence by Year
November 1992 - May 2016 (n=108)

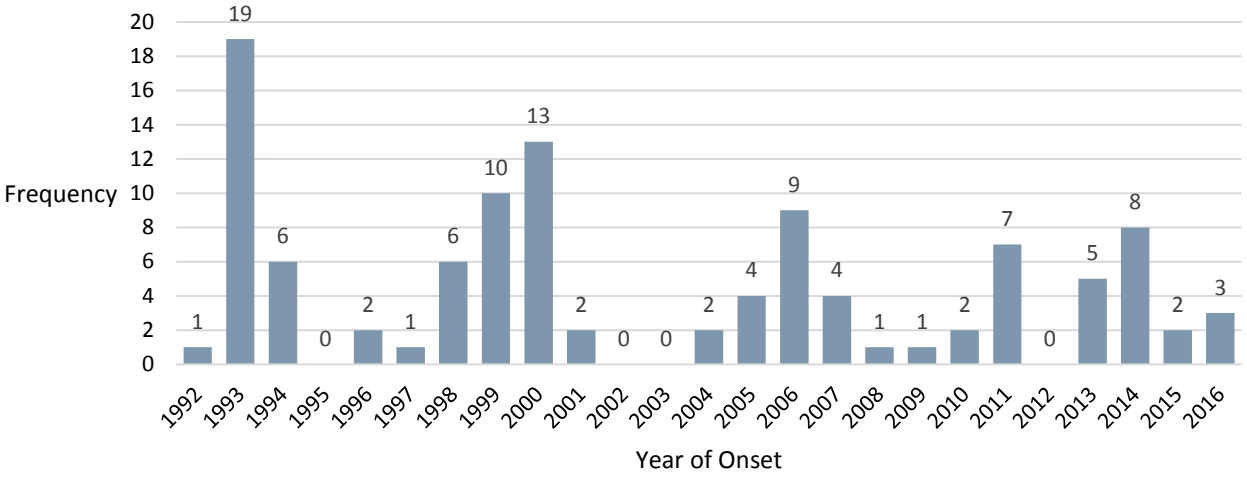
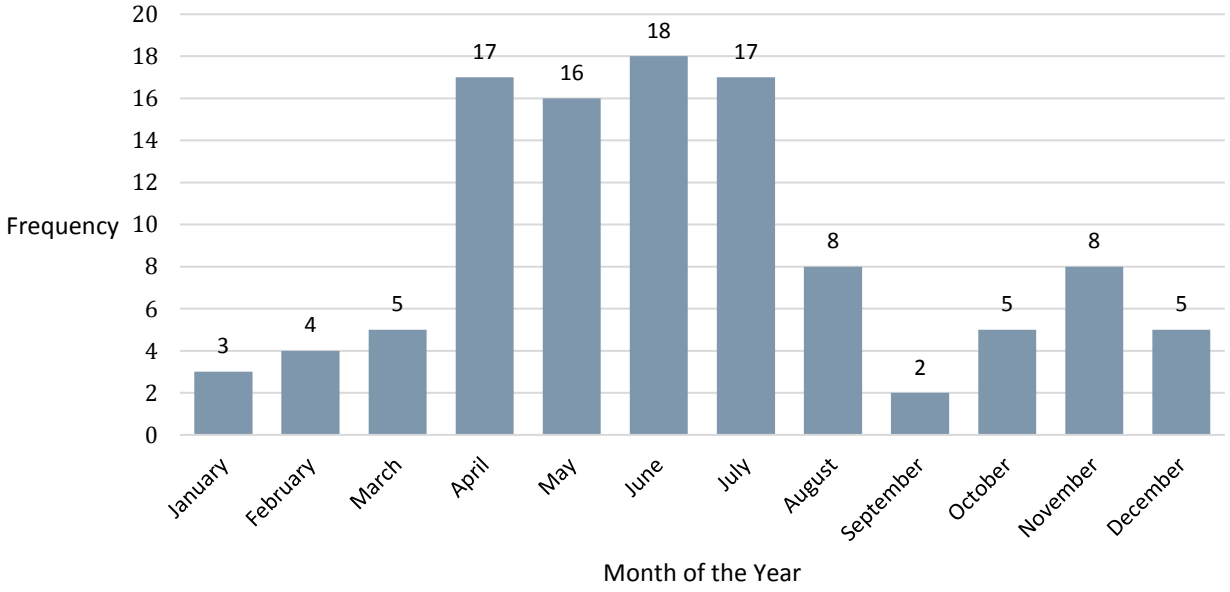


Figure 2. Incidence By Month of the Year,
November 1992 - May 2016 (n=108)



CASE FATALITY RATE

Table 1. Case Fatality Rate by Year (n=108)

Year	Total Cases	Non-Fatal Cases	Fatal Cases	Case Fatality Rate
1992	1	0	1	100%
1993	19	10	9	47%
1994	6	3	3	50%
1995	0			N/A
1996	2	2	0	0%
1997	1	1	0	0%
1998	6	2	4	67%
1999	10	5	5	50%
2000	13	9	4	31%
2001	2	1	1	50%
2002	0			N/A
2003	0			N/A
2004	2	1	1	50%
2005	4	2	2	50%
2006	9	7	2	22%
2007	4	2	2	50%
2008	1	1	0	0%
2009	1	1	0	0%
2010	2	1	1	50%
2011	7	4	3	43%
2012	0			N/A
2013	5	4	1	20%
2014	8	2	6	75%
2015	2	1	1	50%
2016	3	1	2	67%
Total	108	60	48	44%

DEMOGRAPHIC DISTRIBUTION

Table 2. Distribution by Sex (n=108)

Sex	Count	Percent
Female	56	51.9
Male	52	48.2
Total	108	100

*Numbers may not sum to 100% due to rounding

Table 3. Mortality by Sex, Female (n=56)

Outcome	Count	Percent
Lived	27	48.2
Died	29	51.8
Total	56	100

Table 4. Mortality by Sex, Male (n=52)

Outcome	Count	Percent
Lived	33	63.5
Died	19	36.5
Total	52	100

Note: The odds of death among women infected with hantavirus was 1.87 times the odds of death among men infected with hantavirus (95% CI 0.86, 4.03). The confidence interval suggests the data is more compatible with an odds ratio greater than 1. However, given the small sample size, it is difficult to make an inference about increased risk.

DEMOGRAPHIC DISTRIBUTION

Table 5. Descriptive Statistics by Age (n=107)

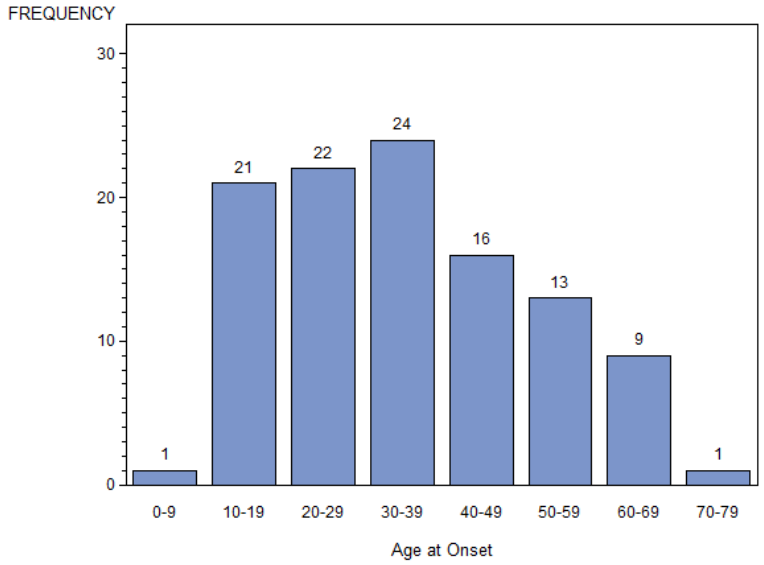
Mean	Standard Deviation	Median	Minimum	Maximum
34.9	16.15	32	9	75

Table 6. Distribution by Age (n=107)

Age*	Count	Percent	Cumulative Frequency	Cumulative Percent
0-9	1	0.9	1	0.9
10-19	21	19.6	22	20.6
20-29	22	20.6	44	41.1
30-39	24	22.4	68	63.6
40-49	16	15	84	78.5
50-59	13	12.2	97	90.7
60-69	9	8.4	106	99.1
70-79	1	0.9	107	100

*Age at onset

Figure 3. Age at Onset (n=107)



DEMOGRAPHIC DISTRIBUTION

Table 7. Case Fatality Rate by Age and Sex (n=107)

Age Group	Gender	Total Cases	Non-Fatal Cases	Fatal Cases	Case Fatality Rate
0-9	Female	1	1	0	0%
	Male	0	0	0	N/A
10-19	Female	12	7	5	42%
	Male	9	6	3	33%
20-29	Female	9	6	3	33%
	Male	13	8	5	38%
30-39	Female	12	6	6	50%
	Male	12	5	7	58%
40-49	Female	9	4	5	56%
	Male	7	6	1	14%
50-59	Female	5	1	4	80%
	Male	8	6	2	25%
60-69	Female	7	1	6	86%
	Male	2	1	1	50%
70-79	Female	0	0	0	N/A
	Male	1	1	0	0%
Total		107	60	47*	44%

*Number differs from Table 1 because age is missing for one female case

Note: The largest differences in mortality between men and women occurred in the 40-49, 50-59, and 60-69 age groups (n=38). The odds of death among women ages 40-69 infected with hantavirus was 8.13 times the odds of death among men ages 40-69 infected with hantavirus (95% CI 1.87, 35.23).

Table 8. Highest Level of Education Achieved (n=32)

Education	Count	Percent	Cumulative Frequency	Cumulative Percent
None	2	6.3	2	6.3
Grade School K-8	4	12.5	6	18.8
Some High School	10	31.3	16	50.1
High School Graduate / GED	6	18.8	22	68.9
Some College	5	15.6	27	84.5
College Graduate	1	3.1	28	87.6
Some Graduate Work	1	3.1	29	90.7
Postgraduate Degree	2	6.3	31	97
Trade School	1	3.1	32	100

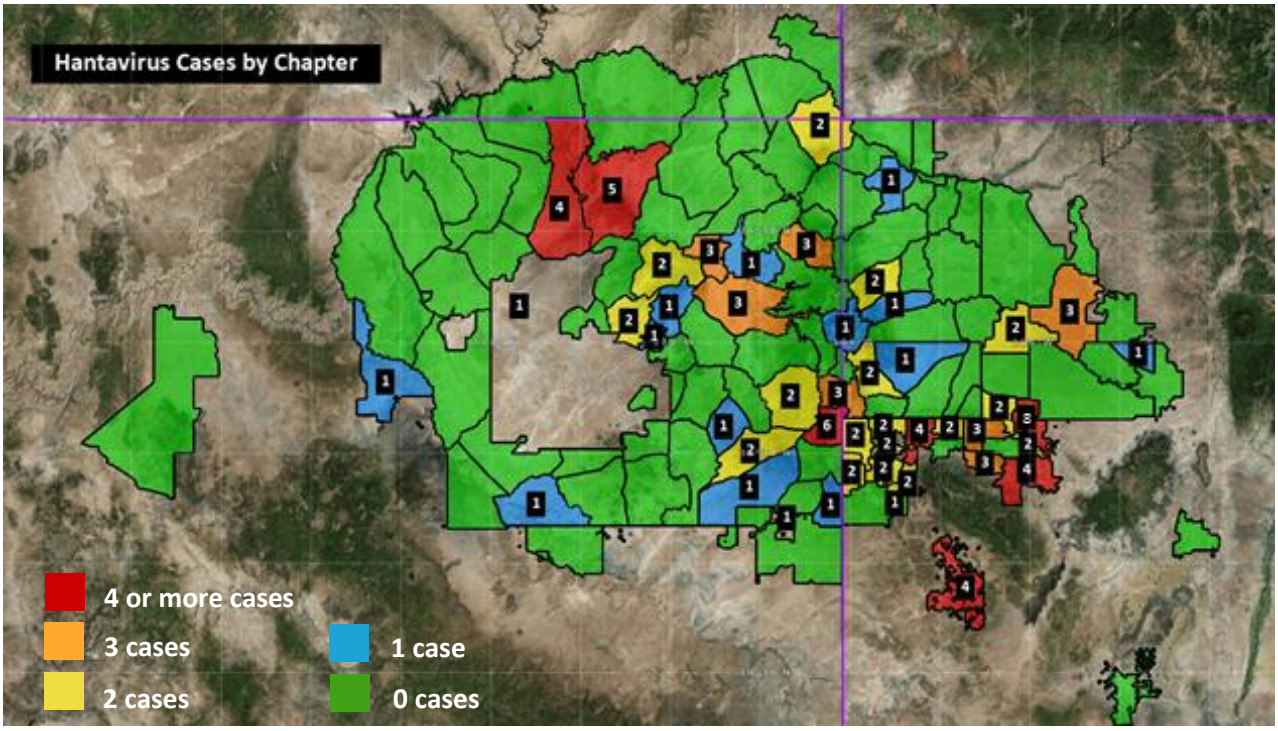
GEOGRAPHIC DISTRIBUTION

Table 9. Distribution by Reporting State (n=107)

Reporting State	Count	Percent
NM	60	56.1
AZ	46	43
CO	1	0.9
Total	107	100

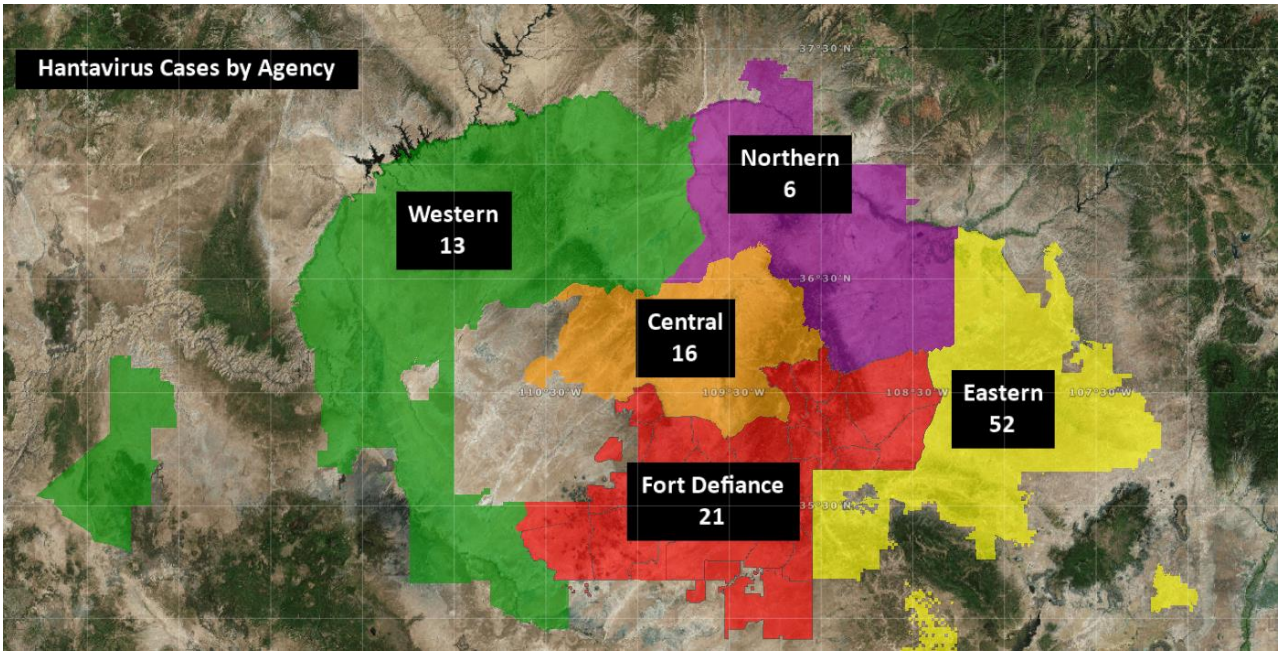
GEOGRAPHIC DISTRIBUTION

Figure 4. Distribution by Chapter (n=107)*



*This map does not include one case with probable exposure in Phoenix.

Figure 5. Distribution by Agency (n=108)*



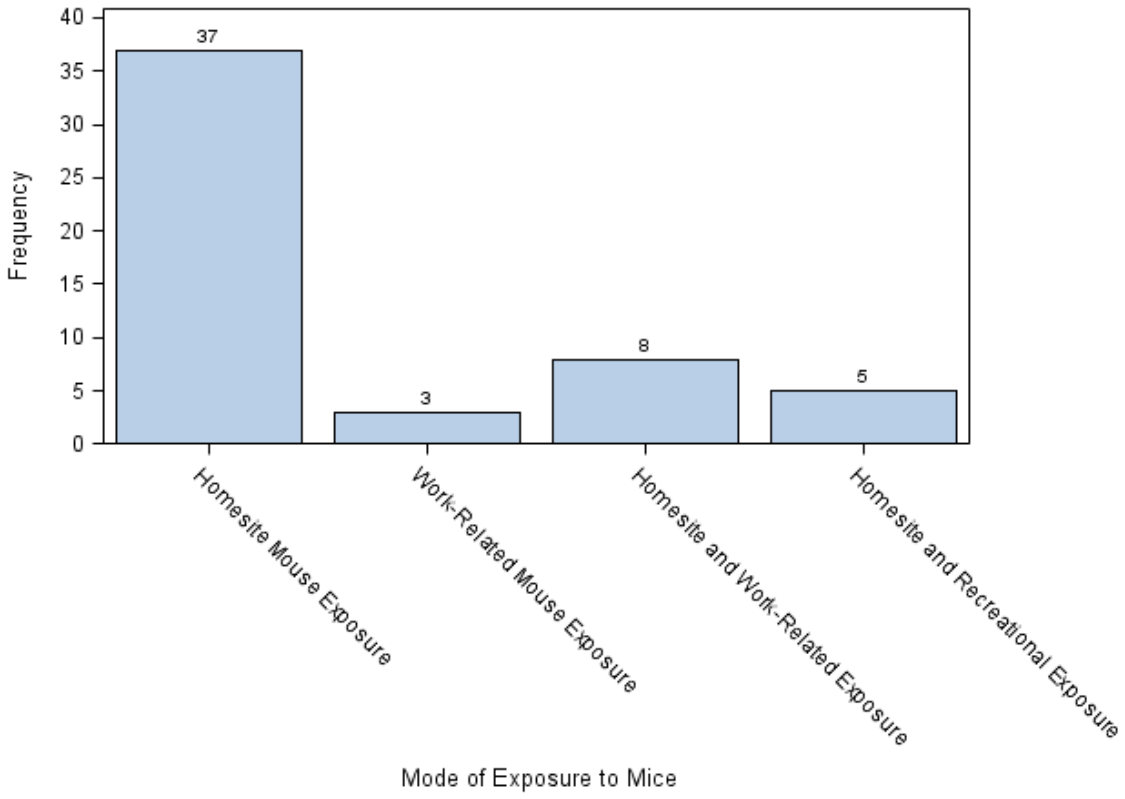
*Border town exposures were incorporated into nearest agency (n=4).

EXPOSURE INFORMATION

Table 10. Distribution by Mode of Exposure (n=53)

Type of Mouse Exposure	Count	Percent
Homesite	37	69.8
Work-Related	3	5.7
Recreational	0	0
Homesite and Work-Related	8	15.1
Work-Related and Recreational	0	0
Homesite and Recreational	5	9.4
Total	53	100

Figure 6. Distribution by Mode of Exposure (n=53)

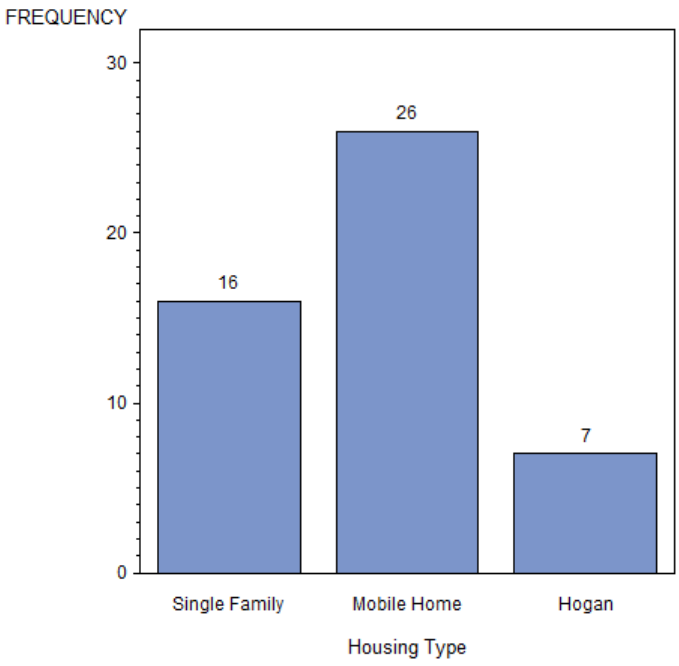


EXPOSURE INFORMATION

Table 11. Distribution by Housing Type (n=49)

Housing Type	Count	Percent
Single Family	16	32.7
Multiple Unit	0	0
Mobile Home	26	53.1
Hogan	7	14.3
Other	0	0
Total	49	100

Figure 7. Distribution by Housing Type (n=49)



EXPOSURE INFORMATION

Table 12. Distribution by Floor Material (n=42)

Material	Count	Percent
Carpet	15	35.7
Cement	1	2.4
Dirt	7	16.7
Tile	3	7.1
Tile, Carpet	1	2.4
Tile, Vinyl, Carpet	1	2.4
Vinyl	5	11.9
Wood	7	16.7
Wood, Tile	1	2.4
Wood, Vinyl, Carpet	1	2.4
Total	42	100

Table 13. Distribution by Ecology (n=48)

Ecological Type	Count	Percent
Desert Grassland	7	14.6
High Desert	8	16.7
High Desert with Pinon/Juniper Woodland	4	8.3
Piñon/Juniper Woodland	23	47.9
Plains Grassland	2	4.2
Scrub/Chaparral	4	8.3
Total	48	100

Table 14. Distribution by Elevation (n=41)

Elevation	Count	Percent	Cumulative Frequency	Cumulative Percent
2001-3000	1	2.4	1	2.4
3001-4000	1	2.4	2	4.9
4001-5000	2	4.9	4	9.8
5001-6000	3	7.3	7	17.1
6001-7000	27	65.9	34	82.9
7001-8000	7	17.1	41	100

Table 15. Number of Times Seen at Health Care Facility (n=55)

Number of Visits	Count	Percent	Cumulative Frequency	Cumulative Percent
1	6	10.9	6	10.9
2	23	41.8	29	52.7
3	16	29.1	45	81.8
4	9	16.4	54	98.2
5	1	1.8	55	100

Figure 8. Mortality by Number of Times Seen at Health Care Facility (n=55)

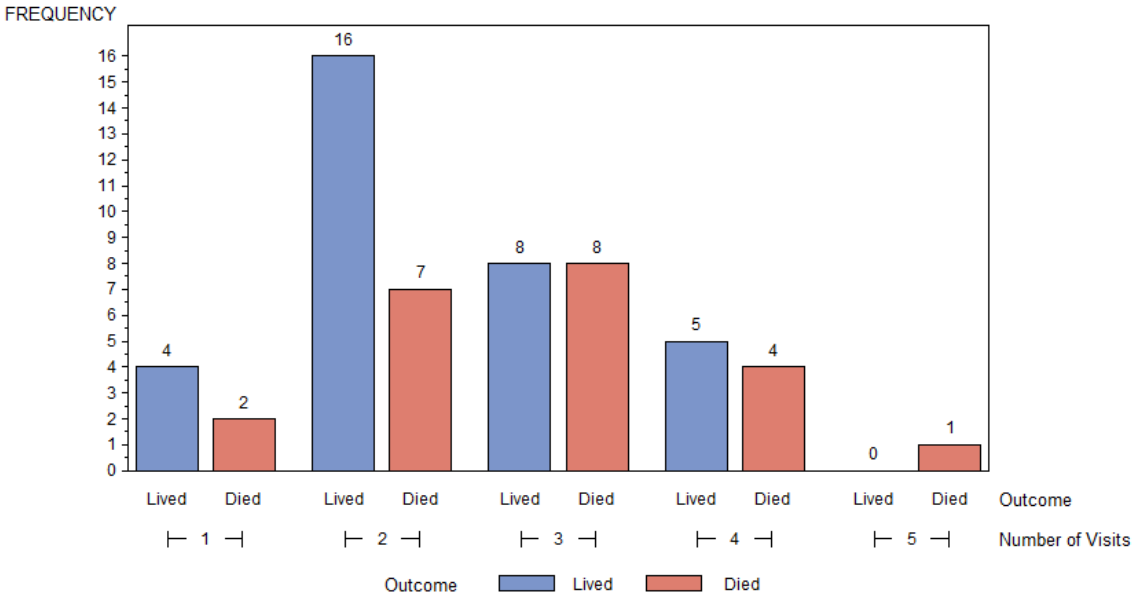


Table 16. Known ECMO Patient Outcomes (n=14)

Outcome	Count	Percent	Cumulative Frequency	Cumulative Percent
Lived	7	50	7	50
Died	7	50	14	100

LIMITATIONS

Limitations

This report faces some significant limitations due to the complicated nature of collecting and working with surveillance data.

1. There may be cases missing, either less severe cases that went unrecognized or cases that were diagnosed but did not make it into the National Notifiable Diseases Surveillance System. The cases contained in this report have been checked with Arizona's state surveillance data but not with New Mexico, Colorado, or Utah, and it is possible that there are cases missing.
2. Multiple data sources were used, and they often contained conflicting values for variables. It was unclear which to prioritize as correct. In these situations, information that was gathered directly from a case, a case's surrogate, or an assessment of a case's home was utilized first. When that information was not available, an effort was made to use variables that changed hands fewer times and may have experienced less opportunity for the introduction of error.
3. An initial hurdle in creating this report was identifying potential Navajo cases among cases in the Four Corners region. All American Indian cases with a home community in Navajo Nation were included. The small number of American Indian cases with homes outside Navajo Nation were evaluated on a case-by-case basis and excluded from the dataset if there was reason to believe they were members of another tribe. The possibility of racial misclassification in the surveillance data adds another complication to this task.
4. Because all of the individuals included are cases, conclusions about risks of infection cannot be made. This could perhaps be overcome by using census data with demographic and housing information.
5. Due to the relatively small sample size, it is difficult to move beyond description and make inferences about risks of mortality. At most, possible associations of interest are highlighted for future investigation.
6. Detailed exposure information was only available for 56 of the 108 cases. While the information may shed light on some interesting patterns, conclusions about risk factors should be made with care.
7. It is very difficult to know for certain how and where an individual was exposed to the virus. They may have experienced several possible routes of transmission or report no known exposure. This report summarizes modes and locations of possible exposure to mice rather than exposure to the virus.

CONCLUSIONS

Conclusions

This report provides a brief summary of 108 potentially Navajo HPS cases between November 1992 and May 2016. Women appear to have a higher risk of mortality compared to men. This difference is largest among women in the 40-49, 50-59, and 60-69 age groups. Approximately half of cases occurred in Eastern Agency. Most cases had exposure to mice in or around the home. Many cases lived in mobile homes, at altitudes between 6000 and 7000 feet, and in piñon/juniper woodland and/or high desert areas.

Disease surveillance conducted by a tribal entity would reduce many of the limitations listed above. Because state and federal entities are unable to collect tribal-specific information, identifying Navajo cases relied on estimates and some subjective decision-making. Tribal-specific data would decrease this subjectivity and could help standardize the variables collected across cases. It would also decrease the number of times data needs to be shared or confirmed across health agencies, streamlining the process of creating reports. Information collected by tribal entities would benefit investigations of infectious diseases more broadly and many other public health topics. Combined with the data being collected by the NEC's Navajo Nation Health Survey, it may be possible to draw further conclusions about risk factors.

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