MARICOPA COUNTY DEPARTMENT OF PUBLIC HEALTH
DIVISION OF DISEASE CONTROL
OFFICE OF EPIDEMIOLOGY

HEAT-ASSOCIATED DEATHS IN MARICOPA COUNTY, AZ REPORT FOR 2010

December 2011

Acknowledgements

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- Maricopa County Office of the Medical Examiner (OME)
- Maricopa County Office of Vital Registration
- Arizona Department of Health Service, Office of Vital Registration
- National Weather Service (NWS)
- Maricopa Association of Governments (MAG)
- Local hospitals (infection preventionists, emergency departments, social worker staff)

Background

In July 2005, Maricopa County (MC) experienced exceptionally high temperatures that contributed to 45 deaths, 35 occurring over 9 consecutive days. Temperatures reached 116° F and three excessive heat warnings were issued during this month. To track these deaths, the Maricopa County Department of Public Health (MCDPH) created a novel and effective approach for surveillance of heat-associated deaths and has continued to use this system annually. The enhanced heat surveillance season begins in May and ends in October.

Method

Surveillance data is obtained from the following sources:

1. The Maricopa County Office of the Medical Examiner (OME) forwards suspected heat-related deaths to the MCDPH and provides data including demographics, preliminary information regarding how the death occurred and the circumstances of death.

2. The Arizona Department of Health Services has a vital records database containing death certificates. MCDPH searches this database looking for causes of death associated with environmental heat. A SAS program looks for the key phrases and International Classification of Disease-10 (ICD-10) codes listed below.

Key Phrases
HEAT EXPOSURE
ENVIRON
EXHAUSTION
SUN
HEAT STRESS
HEAT STROKE
HYPERTHERMIA

ICD 10 Code	**Corresponding Definition**
X30	Exposure to excessive natural heat
T67.X	Effects of heat and light
P810	Environmental hyperthermia of newborn

3. Hospital and media reports can sometimes initiate a heat death investigation, for example, if a child is reportedly left in a hot car.

Once data are received, analysis of the information is required to identify only those deaths caused as a result of environmental heat. Environmental heat is heat generated by the climate (sun, humidity, etc.) rather than heat from man-made sources such as ovens or manufacturing equipment. Heat-associated deaths are categorized based on the classification criteria listed below:

> **Heat-caused (HC) deaths** are those in which environmental heat was directly involved in the sequence of conditions causing deaths. These are cases that mention heat or heat exposure in Part I of the death certificate causes of death (diseases or conditions in the direct sequence causing death), for cause of death variables (*cod_a, cod_b, cod_c, or cod_d).* County of death: Maricopa.
>
> **Heat-related (HR) deaths** are those in which environmental heat contributed to the deaths but was not in the sequence of conditions causing these deaths. These are cases that mention heat exposure in Part II of the death certificate causes of death (diseases and conditions contributing but not directly resulting in the death sequence), but not in any of the Part I death variables (*cod_a, cod_b, cod_c, or cod_d*). County of death: Maricopa.
>
> **Part I of the death certificate:**
> *cod a* – immediate cause (final disease or condition resulting in death)
> *cod b, cod c, cod d* – sequentially listed conditions if any leading to the cause listed on cod a.
>
> **Part II of the death certificate:** Other significant conditions contributing to death but not resulting in the underlying cause given in part I.

Death certificate data, in combination with the OME notes, are used to produce the information that is contained in this report. Total case count, demographics, residency, drug/alcohol use, and years lived in Arizona are directly retrieved from death certificate data. Place of death, place of death occurrence, air conditioning use, and homelessness are retrieved based on explicit notations made in the death certificate and/or OME notes.

Homelessness is defined as having an address on the death certificate (DC) that matches a homeless shelter, government agency, business, or an intersection. Cases are also classified as homeless if there is an indication on the death certificate. If the address is listed as unknown on the death certificate then an examination of the medical examiner's notes is made to determine if there is a reference to an address - if none, then the person is classified as homeless. If the address is listed as out of jurisdiction then time spent in Arizona, as provided by the death certificate, is taken into consideration.

Once classification is completed, the data are summarized for the production and dissemination of reports. Reports are generated weekly during the season and posted to the MCDPH website which can be found at: http://www.maricopa.gov/publichealth/Services/EPI/Reports/heat.aspx.

Results

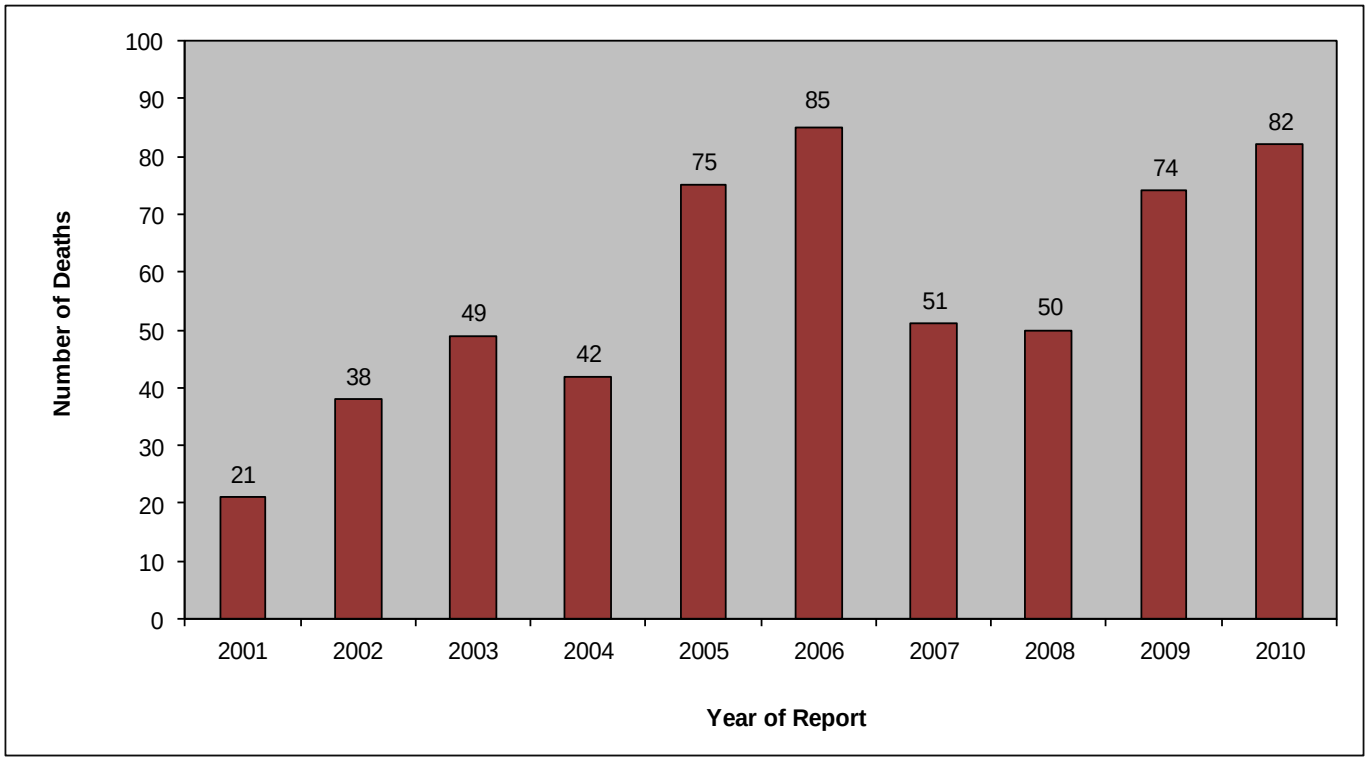
Table 1. On average, over 100 suspect heat-caused/heat-related deaths (heat-associated deaths) were investigated each year from 2006 through 2010 totaling 588 cases over the five year period. Of these cases, 58% were confirmed as being heat-associated deaths. In 2010, 58% of the investigated cases were also confirmed as heat-associated deaths.

Table 1. Heat-Associated Deaths Reported in Maricopa County: 2006-2010

Cases	2006	%	2007	%	2008	%	2009	%	2010	%	TOTAL	%
Total Reported	104	100	131	100	97	100	114	100	142	100	588	100
Confirmed	85	82	51	39	50	52	74	65	82	58	342	58
Ruled Out	19	18	80	61	47	48	40	35	60	42	246	42

Graph 1. The number of heat-associated deaths reported in 2010 was 82, indicating the second highest year in ten years. The graph shows that after a decline in 2007 and 2008, heat mortality increased for two consecutive years. Cases increased from 2009 to 2010 by 11%.

Graph 1. Heat-Associated Deaths by Year, Maricopa County: 2001-2010*

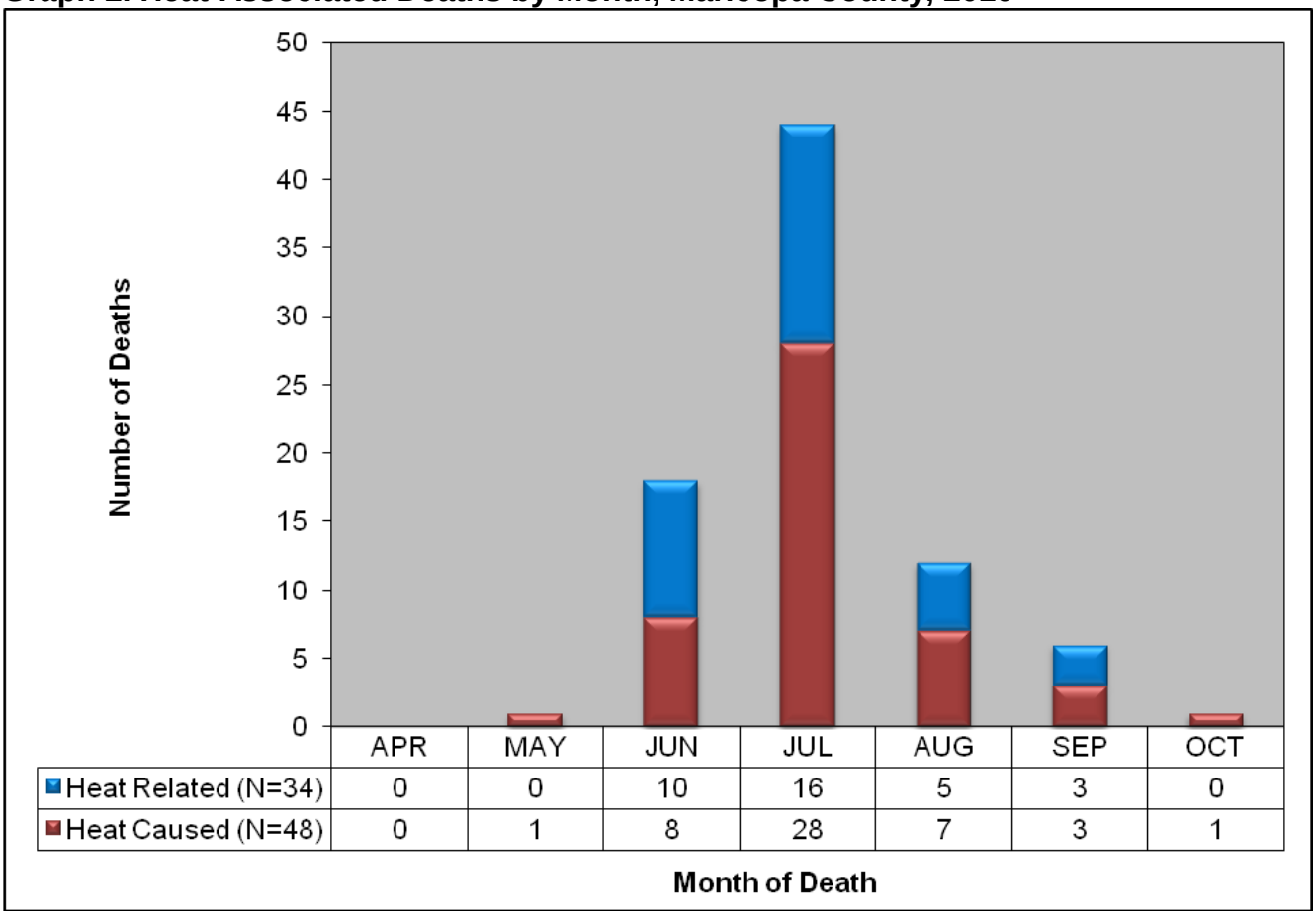


Data Sources: Maricopa County, Office of Vital Registration and Office of Medical Examiner; Arizona Department of Health Services, Office of Vital Registration

*These numbers are for 2010 deaths reported as of 7/12/11.

Graph 2. In 2010, July was the most deadly month for heat-associated deaths with more than half of the year's 82 deaths occurring in this month. The majority of all deaths were classified as heat-caused (48, 58.5%), with the remainder classified as heat-related (34, 41.5%).

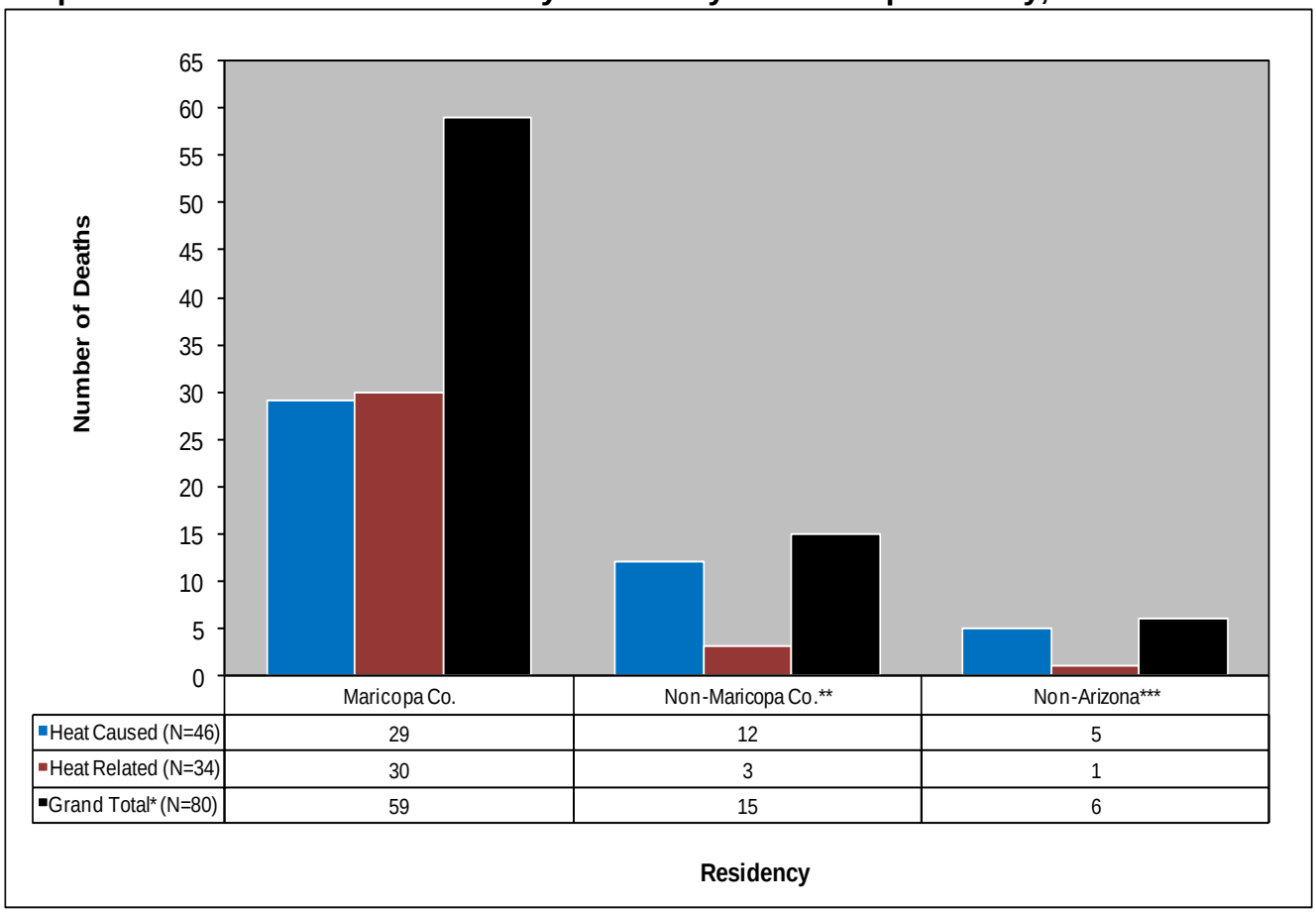
Graph 2. Heat-Associated Deaths by Month, Maricopa County, 2010



	APR	MAY	JUN	JUL	AUG	SEP	OCT
Heat Related (N=34)	0	0	10	16	5	3	0
Heat Caused (N=48)	0	1	8	28	7	3	1

Graph 3. Residency was identified for 80 heat-associated deaths in 2010. (The two cases for which residency could not be established were excluded from this graph). Most of the cases (59, 74%) were Maricopa County residents. Nineteen percent of the 80 cases resided in Arizona in a county other than Maricopa. Eight percent were residents of other states or countries.

Graph 3. Heat-Associated Deaths by Residency* in Maricopa County, 2010

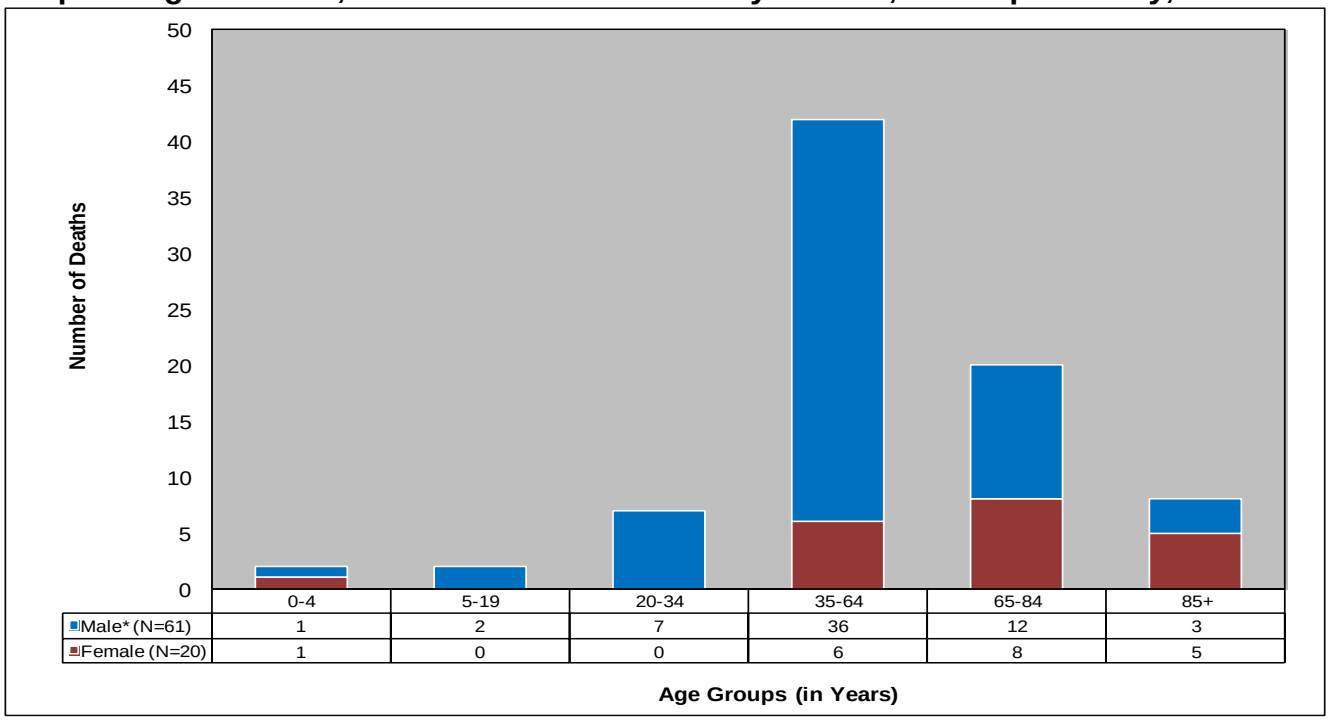


	Maricopa Co.	Non-Maricopa Co.**	Non-Arizona***
Heat Caused (N=46)	29	12	5
Heat Related (N=34)	30	3	1
Grand Total* (N=80)	59	15	6

*Excludes two cases where residency could not be established
**Non-Maricopa residents include Gila County (1), Pinal County (1), and other unidentified AZ counties (13)
***Non-Arizona residents include two US residents (IL and PA) and four non-US residents (three from Mexico and one from Scotland)

Graphs 4-5. The majority of heat-associated deaths were males (61, 75.3%). Most male cases, for which age was known, were under the age of 65 (46, 75.4% of male cases). In contrast, most female cases were 65 and older, (13, 65.0% of female cases). [For more detailed results on age, See Appendix, Table A]

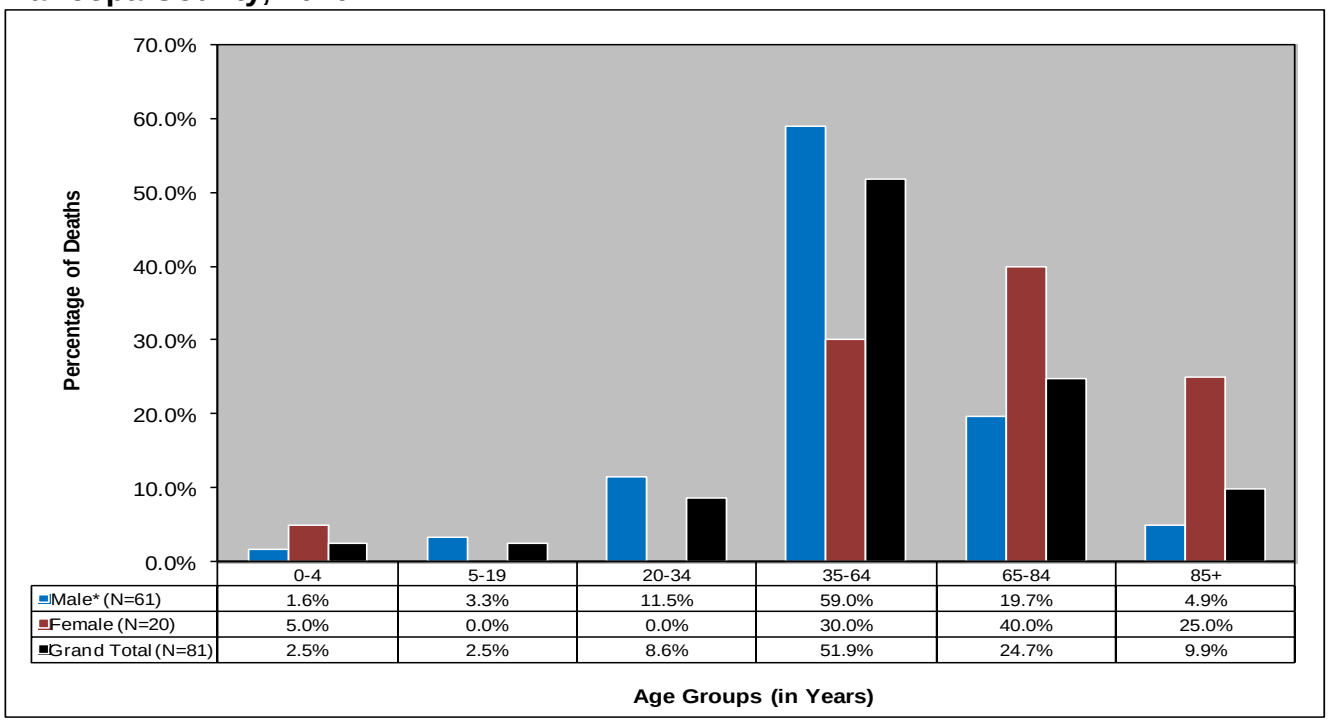
Graph 4. Age at Death, Heat-Associated Deaths by Gender, Maricopa County, 2010



	0-4	5-19	20-34	35-64	65-84	85+
Male* (N=61)	1	2	7	36	12	3
Female (N=20)	1	0	0	6	8	5

*One male case excluded, age unknown

Graph 5. Percentage of Heat-Associated Deaths by Age Group and Gender for Maricopa County, 2010

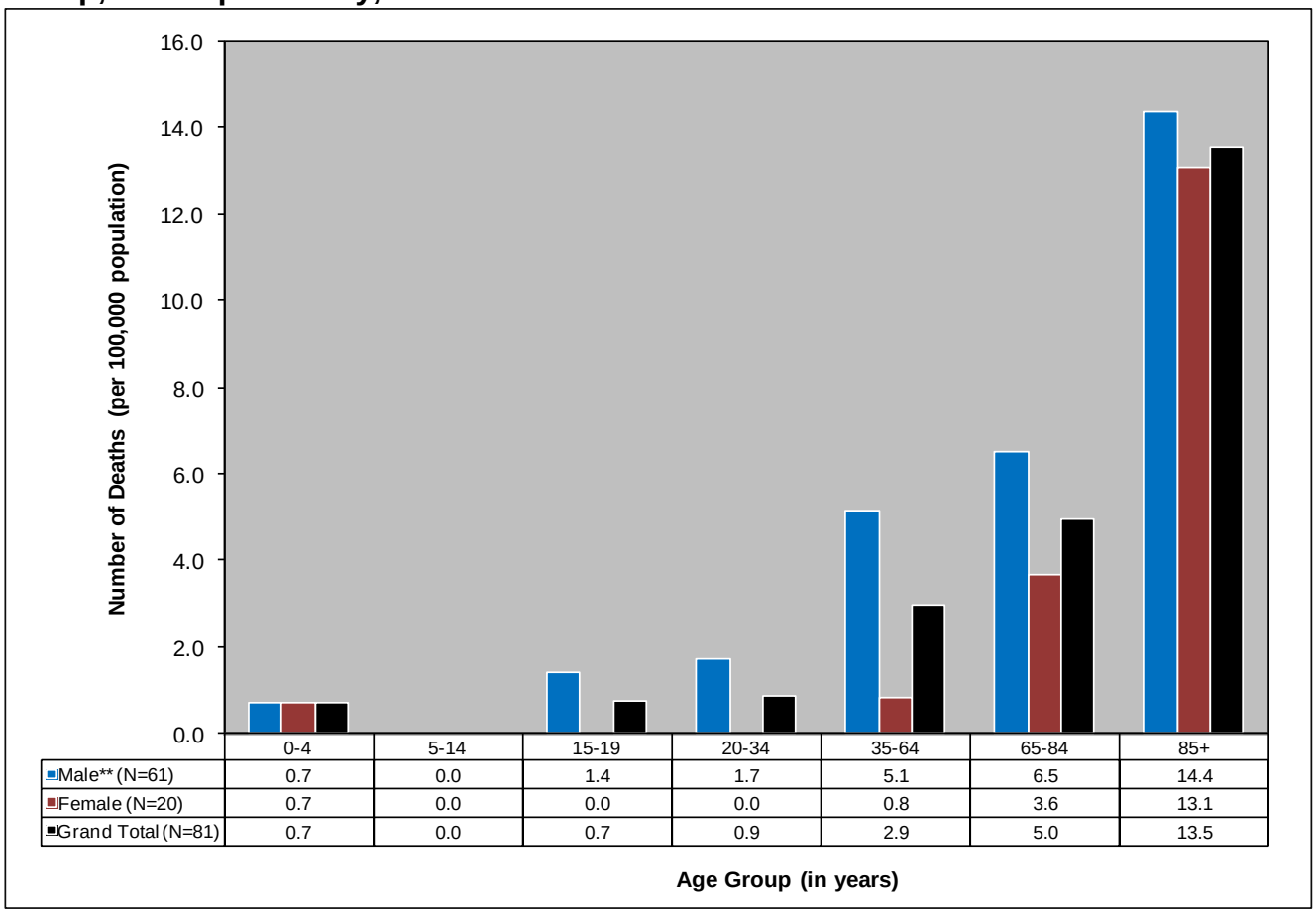


	0-4	5-19	20-34	35-64	65-84	85+
Male* (N=61)	1.6%	3.3%	11.5%	59.0%	19.7%	4.9%
Female (N=20)	5.0%	0.0%	0.0%	30.0%	40.0%	25.0%
Grand Total (N=81)	2.5%	2.5%	8.6%	51.9%	24.7%	9.9%

*One male case excluded, age unknown

Graph 6. The pattern for heat-associated deaths by age is different for males and females. The data show that for women, the likelihood of heat-associated deaths begins to increase in the 35-64 year-old age group and is greater for each subsequent age category. For men, the rates for heat-associated deaths are quite high for the 35-64 and the 65-84 age groups and are much higher than those for females. However, for the 85+ age group, the rates for females and males are comparable. [See Appendix, Table B]

Graph 6. Heat-Associated Death Rates per 100,000 Population by Gender and Age Group, Maricopa County, 2010

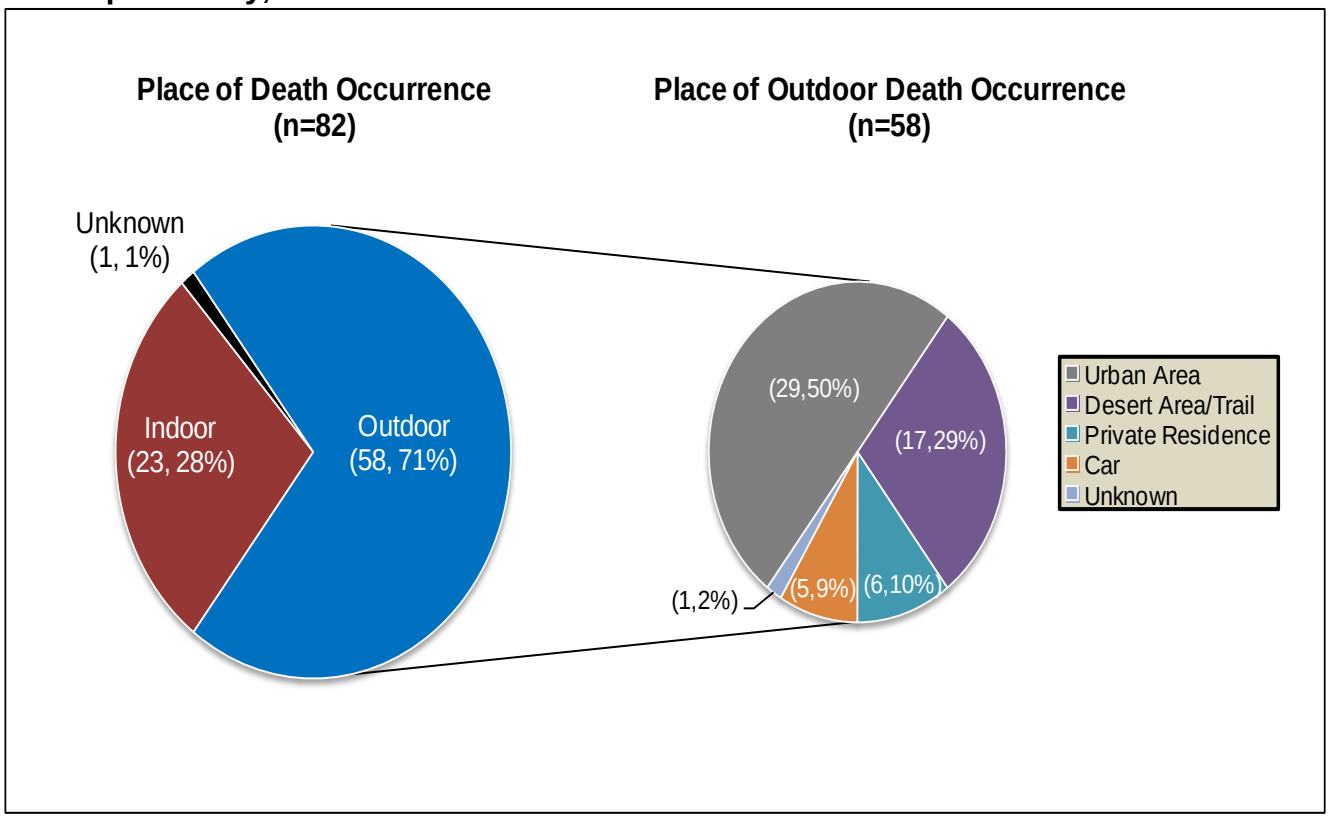


	0-4	5-14	15-19	20-34	35-64	65-84	85+
Male** (N=61)	0.7	0.0	1.4	1.7	5.1	6.5	14.4
Female (N=20)	0.7	0.0	0.0	0.0	0.8	3.6	13.1
Grand Total (N=81)	0.7	0.0	0.7	0.9	2.9	5.0	13.5

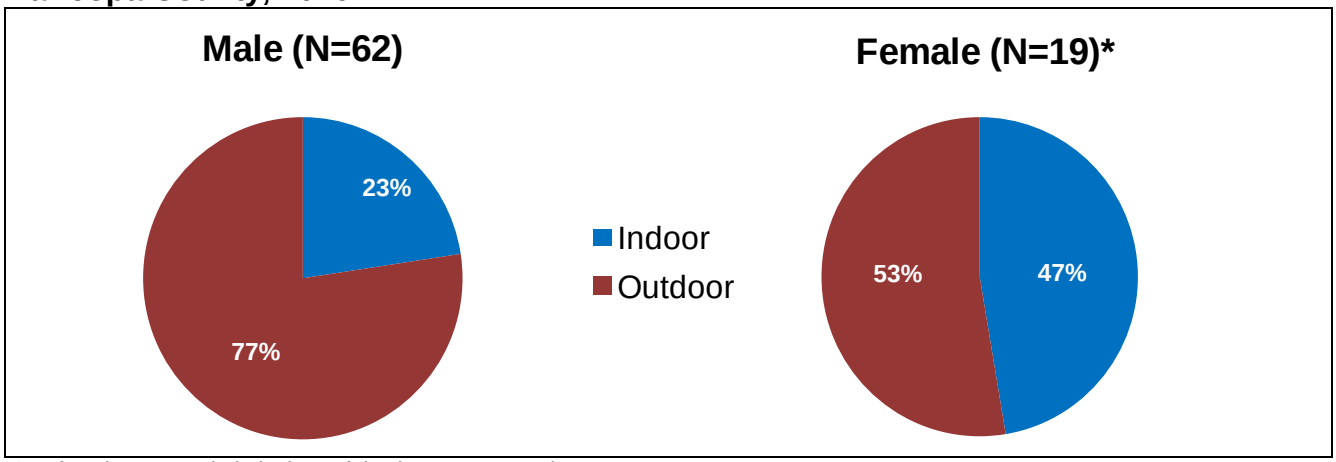
*Based on Maricopa County census population estimates for 2010
**One male case excluded, age unknown

Graphs 7- 9. Graph 7 illustrates that 71% of heat deaths in 2010 occurred outdoors. These deaths most often occurred in urban areas (50%), including streets, parking lots, fields, alleys, or businesses. Males are more likely to die outdoors and a larger proportion of females die indoors than males (Graph 8). Twenty-eight percent of deaths occurred indoors and all but one of the indoor deaths occurred at a private residence. Where the death occurred indoors, 43% did not have air conditioning in use (Graph 9). In the other 57% of indoor deaths, it is not known whether or not air conditioning was in use, so the percentage of indoor deaths without air conditioning may actually be higher. [See Appendix, Tables C-E]

Graph 7. Heat-Associated Deaths by Place of Occurrence and Place of Outdoor Death, Maricopa County, 2010

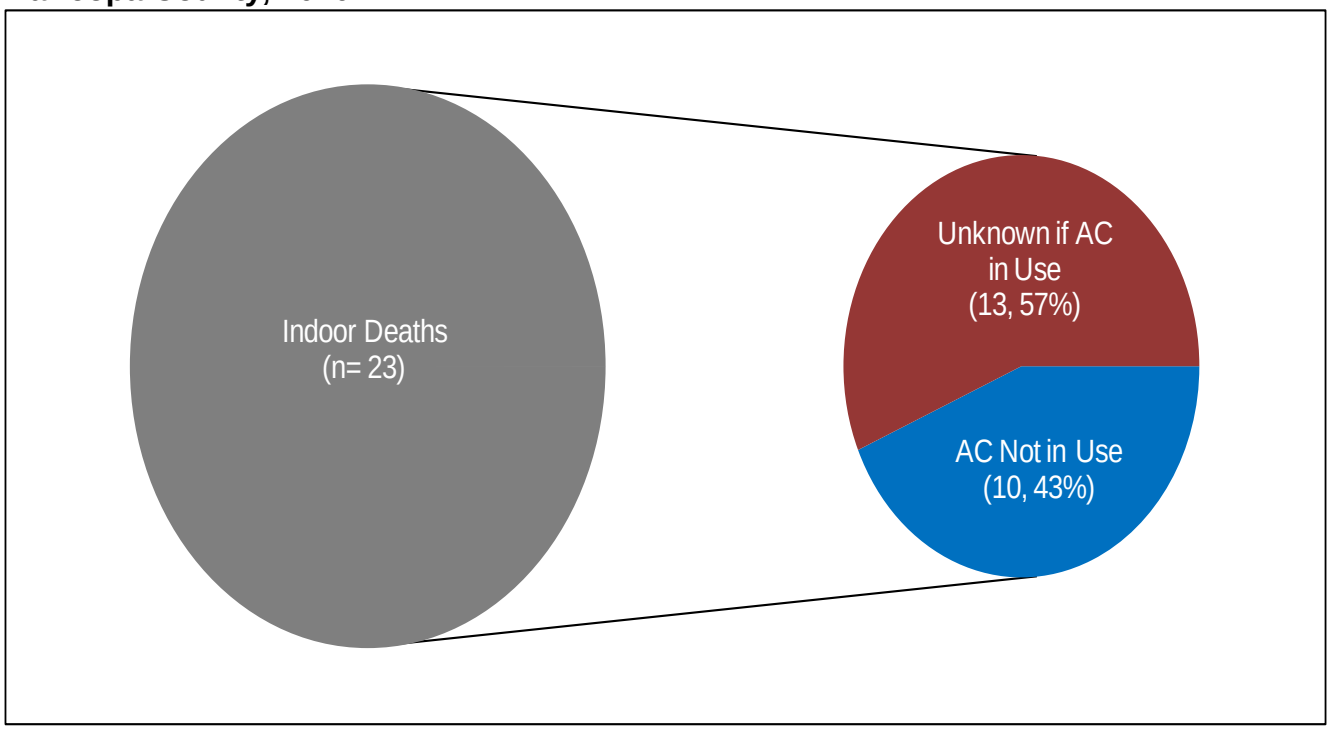


Graph 8. Heat-Associated Deaths by Gender and Place of Death Occurrence, Maricopa County, 2010



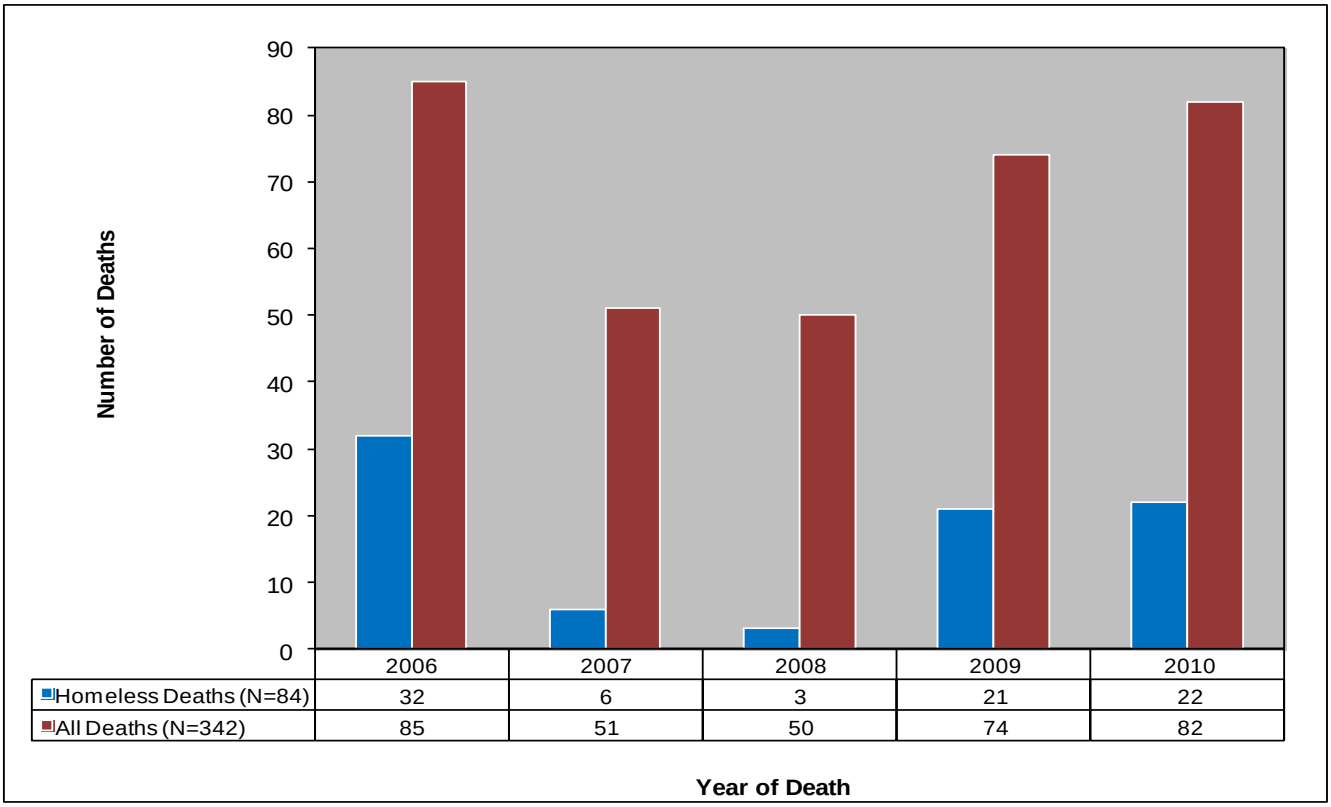
*One female case excluded, place of death occurrence unknown

Graph 9. Heat-Associated Deaths by Use of Air Conditioning (Indoor Only), Maricopa County, 2010



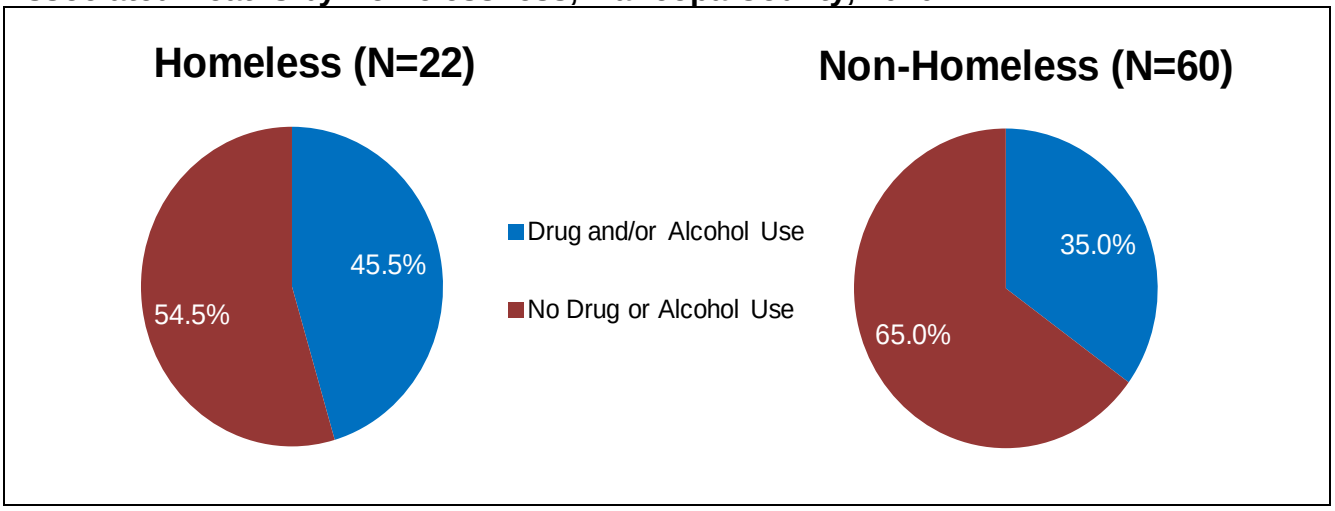
Graphs 10-11. In 2006, 32 heat-associated deaths (38% of the total) were among homeless persons. In 2007, homeless heat deaths decreased to 6 (12%) and 3 (6%) in 2008. In 2009, there were 21 (28%) heat-associated deaths in homeless persons and in 2010 that number increased to 22 (27%) (Graph 10). Graph 11 shows that of the 22 homeless individuals who died in 2010, 45.5% of the homeless decedents were using drugs or alcohol upon their death, which is comparable to 35.0% of the non-homeless. [See Appendix, Table F]

Graph 10. Homeless Heat-Associated Deaths, Maricopa County, 2006-2010



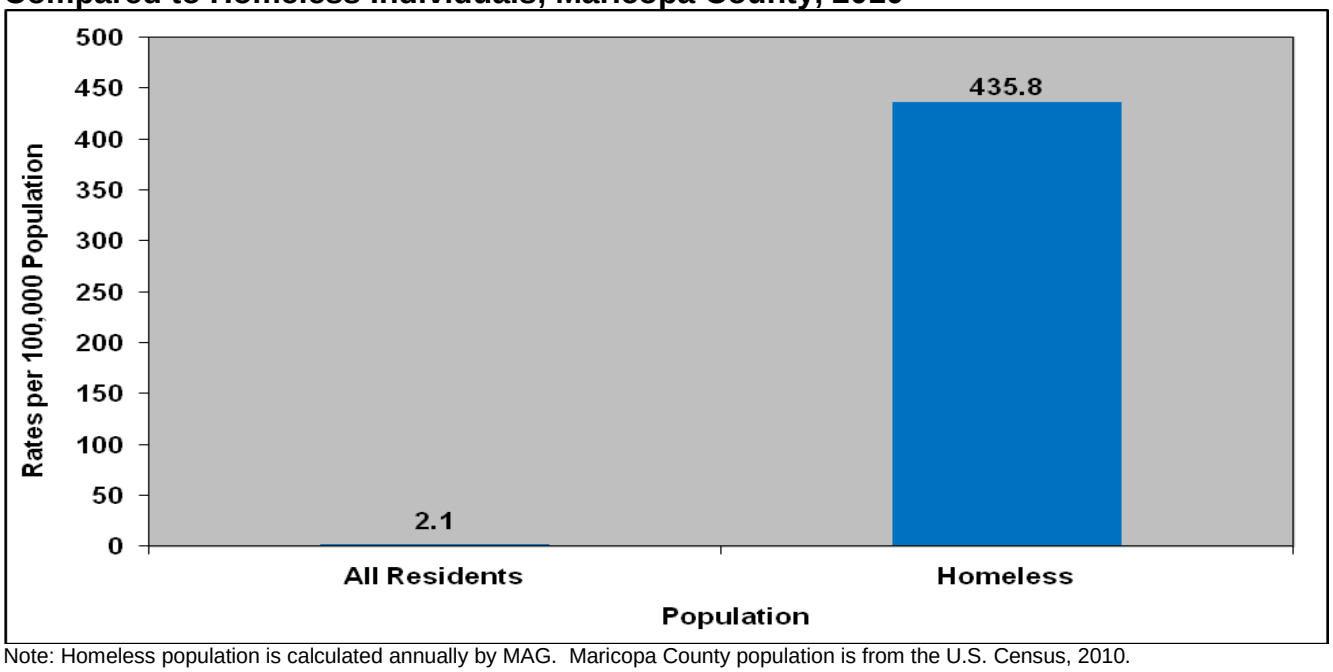
	2006	2007	2008	2009	2010
Homeless Deaths (N=84)	32	6	3	21	22
All Deaths (N=342)	85	51	50	74	82

Graph 11. Drug and Alcohol Use, as Mentioned on the Death Certificate for Heat-Associated Deaths by Homelessness, Maricopa County, 2010



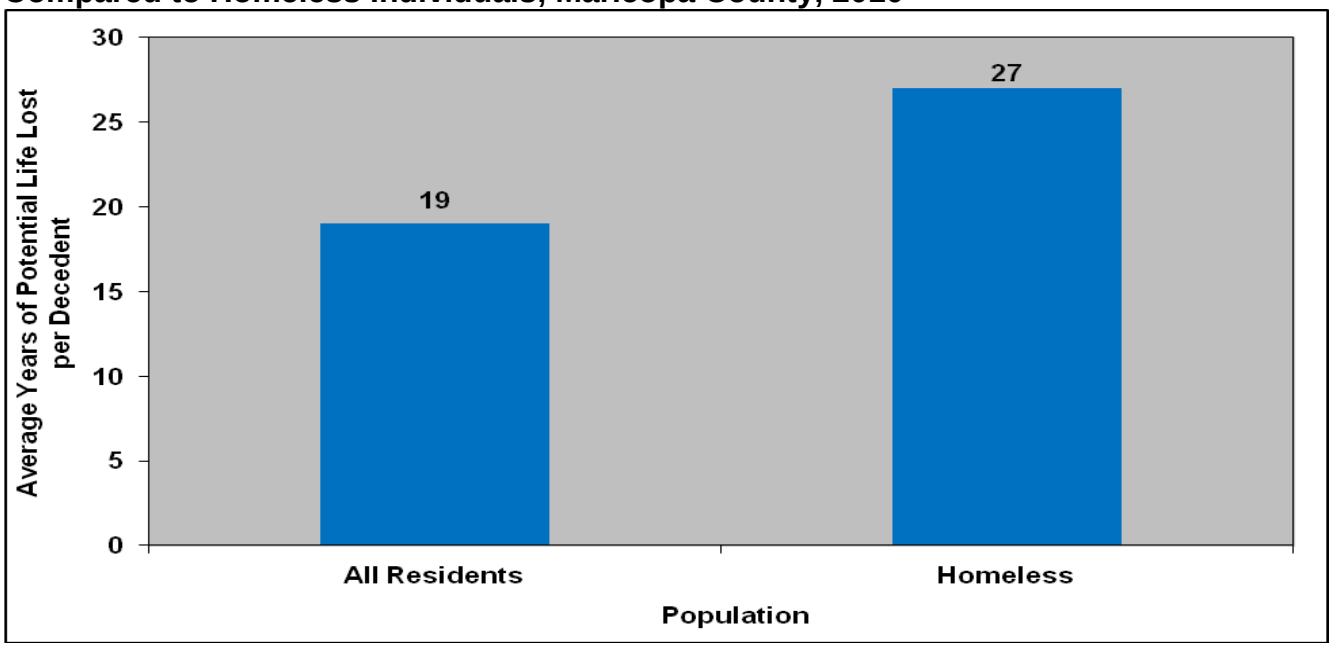
Graphs 12-13. The homeless population is disproportionately at risk for heat-associated mortality and was more adversely affected by heat. In 2010, the heat-associated death rate for homeless individuals was 435.8 per 100,000 homeless individuals compared to 2.1 per 100,000 general population for all Maricopa County residents (Graph 12). The relative risk for a homeless individual was 203. Graph 13 shows that the average years of potential life lost was 1.42 times greater in homeless individuals compared to all residents (27 and 19 years, respectively).

Graph 12. Heat-Associated Death Rates per 100,000 population, All Residents Compared to Homeless Individuals, Maricopa County, 2010



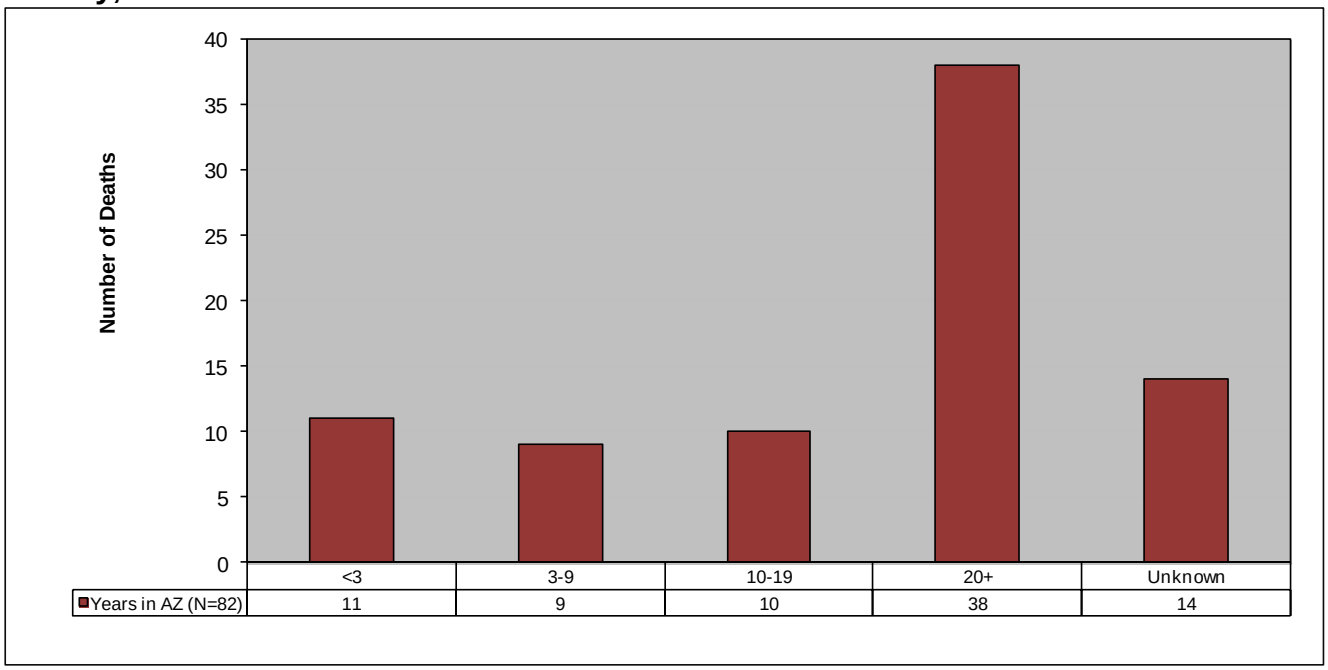
Note: Homeless population is calculated annually by MAG. Maricopa County population is from the U.S. Census, 2010.

Graph 13. Years of Potential Life Lost for Heat-Associated Deaths, All Residents Compared to Homeless Individuals, Maricopa County, 2010



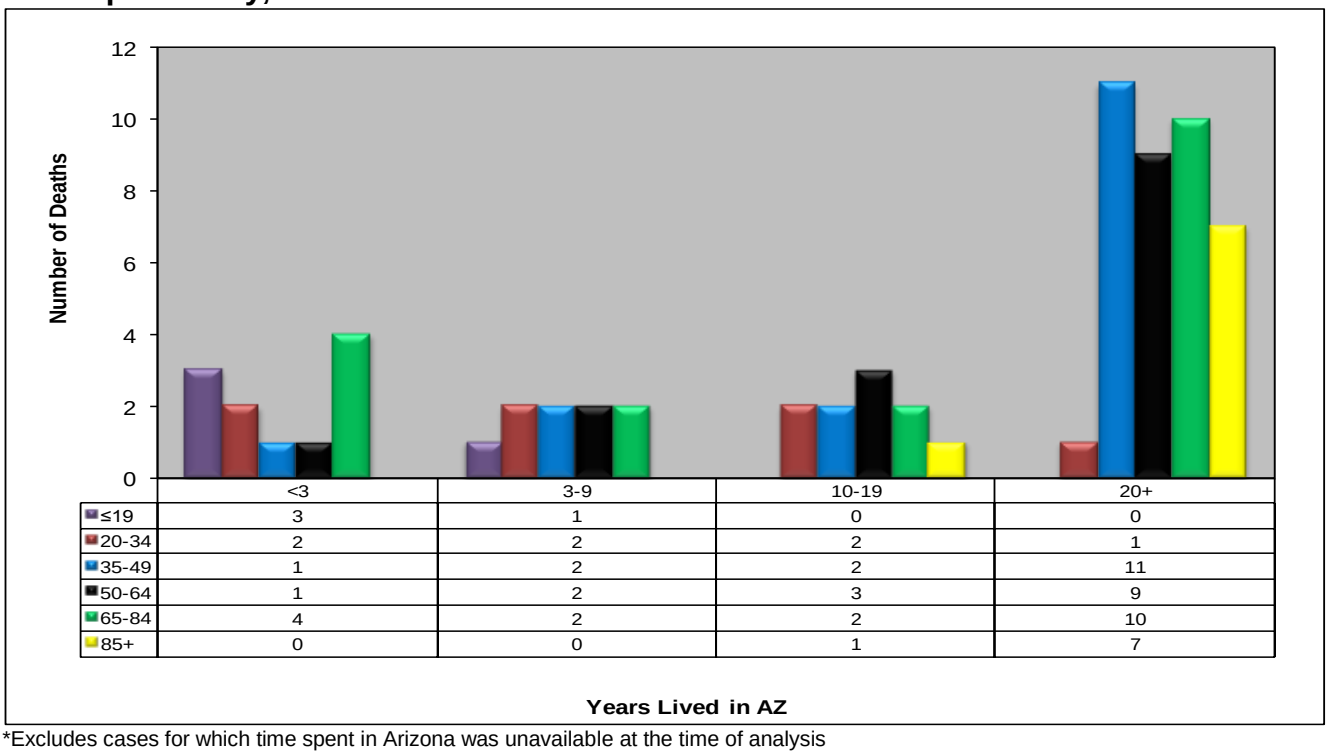
Graphs 14-15. For cases where time spent in Arizona was known (68 decedents), 56% (38/68) resided in Arizona for 20 years or more (Graph 14). Additionally, almost all decedents (57/68, 84%) had lived in Arizona for at least 3 years. This pattern was not due solely to the age of the decedents as individuals from the various age groups can be seen in most of the "Years in Arizona" categories (Graph 15).

Graph 14. Heat-Associated Deaths by Years of Lifetime Spent in Arizona, Maricopa County, 2010



	<3	3-9	10-19	20+	Unknown
Years in AZ (N=82)	11	9	10	38	14

Graph 15. Heat-Associated Deaths* Years of Lifetime Spent in Arizona by Age Group, Maricopa County, 2010



	<3	3-9	10-19	20+
≤19	3	1	0	0
20-34	2	2	2	1
35-49	1	2	2	11
50-64	1	2	3	9
65-84	4	2	2	10
85+	0	0	1	7

*Excludes cases for which time spent in Arizona was unavailable at the time of analysis

Conclusions – Heat-Associated Deaths 2010

1. The number of heat-associated deaths increased in 2010 over each of the previous three years.

2. The vast majority of heat-associated deaths were heat-caused (as opposed to heat-related). This means that the majority were deaths in which environmental heat was directly involved in the sequence of conditions causing death.

3. The vast majority of heat-associated deaths occurred during the month of July.

4. Most heat-associated deaths occurred among males 35-64 years of age.

5. Two of the deaths were in children less than five years old.

6. Heat-associated deaths among women tended to occur among those 65 years old and older while deaths among men tended to occur among those under 65 years old.

7. The majority of heat-associated deaths occurred outdoors; half of these outdoor deaths occurred in urbanized areas.

8. Of the heat-associated deaths that occurred indoors, all but one occurred at a private residence. For some of these indoor deaths, the air conditioning unit was non-functioning or one that was not in use. (The remaining indoor deaths air conditioning status is unknown, suggesting that there may have been other instances when the air conditioning was not in use.)

9. Heat-associated deaths among males were more likely to occur outdoors, while among females, deaths occurred both indoors and outdoors. The deaths in this category may be recreational and/or occupational, but most death certificates do not provide this information, so the activity just prior to death is unknown.

10. Homeless individuals are more vulnerable to increased environmental temperatures. Approximately one in four heat-associated deaths in 2010 was an individual identified as homeless. Since 2008, the number and proportion of homeless deaths have increased.

11. Most decedents (for whom residency length was known) were residents of Maricopa County or Arizona.

12. Most of the decedents were not newcomers – fewer than one in seven lived in Arizona for less than three years.

Future Plans

One of the goals of the MCDPH heat surveillance program is to obtain more detailed information pertaining to the circumstances surrounding heat-associated mortality. Ideally, the program would like to obtain data on race, air conditioning status and activity just prior to death (e.g. working, exercising, etc.). Program staff would also like to perform analyses such as additional risk factors, temperature variation, and geographic distribution.

Importantly, the ultimate goal of heat-associated death surveillance is to eliminate or reduce heat-associated deaths. Although the number of heat-associated deaths for 2010 increased over previous years, community partners and the MCDPH responded to heat warnings more efficiently and effectively than ever before. For example, the coalition provided cooling and hydration stations during a particularly long period of excessive heat.

To learn more about services provided for cooling and hydration during the summer months, or how you can help, please visit:

http://www.maricopa.gov/publichealth/Programs/Heat/default.aspx

http://www.cir.org/

APPENDIX

Table A. Heat-Associated Deaths by Gender and Age, Maricopa County, 2010

Age Group	2010 (N=82)					
	Male		Female		Total	
	#	%	#	%	#	%
0-4	1	1.6	1	5.0	2	2.4
5-19	2	3.2	0	0.0	2	2.4
20-34	7	11.3	0	0.0	7	8.5
35-64	36	58.1	6	30.0	42	51.2
65-84	12	19.4	8	40.0	20	24.4
85+	3	4.8	5	25.0	8	9.8
Unknown	1	1.6	0	0.0	1	1.2
All Ages	62	100.0	20	100.0	82	100.0

Table B. Heat-Associated Death Rates per 100,000 Population (and Counts) by Gender and Age, Maricopa County, 2010

Ages (in years)	Male	Female	Male/ Female
0-4	0.7 (1)	0.7 (1)	0.7 (2)
5-14	0 (0)	0 (0)	0 (0)
15-19	1.4 (2)	0 (0)	0.7 (2)
20-34	1.7 (7)	0 (0)	0.9 (7)
35-64	5.1 (36)	0.8 (6)	2.9 (42)
65-84	6.5 (12)	3.6 (8)	5.0 (20)
85+	14.4 (3)	13.1 (5)	13.5 (8)
Unknown	NA (1)	NA (0)	NA (1)
All Ages	**3.3 (62)**	**1.0 (20)**	**2.1 (82)**

Table C. Heat-Associated Deaths by Indoor or Outdoor Occurrence, Age, and Gender Maricopa County, 2010

Age Group	2010 (n=82)								
	Indoor			Outdoor			Unknown		
	Male	Female	**Total**	Male	Female	**Total**	Male	Female	**Total**
0-4	0	0	0	1	1	2	0	0	0
5-14	0	0	0	0	0	0	0	0	0
15-19	0	0	0	2	0	2	0	0	0
20-34	3	0	3	4	0	4	0	0	0
35-64	4	3	7	32	3	35	0	0	0
65-84	5	4	9	7	3	10	0	1	1
85+	2	2	4	1	3	4	0	0	0
Unknown	0	0	0	1	0	1	0	0	0
Total	**14**	**9**	**23**	**48**	**10**	**58**	**0**	**1**	**1**

Table D. Heat-Associated Deaths by Place Death Occurred and Age, Maricopa County, 2010

Age (in years)	Private Residence		Business		Desert Area	Parking Lot	Street	Field	Car	Alley	Trail	Unknown	Total
	In	Out	In	Out									
0-4	0	0	0	0	0	0	0	0	2	0	0	0	2
5-14	0	0	0	0	0	0	0	0	0	0	0	0	0
15-19	0	0	0	0	2	0	0	0	1	0	0	0	3
20-34	3	0	0	0	2	0	0	1	2	0	0	0	8
35-64	6	1	1	3	7	8	5	4	0	4	0	1	40
65-84	9	4	0	0	3	1	1	1	0	0	0	1	20
85+	4	1	0	0	2	0	1	0	0	0	0	0	8
Unkown	0	0	0	0	1	0	0	0	0	0	0	0	1
Total	**22**	**6**	**1**	**3**	**17**	**9**	**7**	**6**	**5**	**4**	**0**	**2**	**82**

Table E. Heat-Associated Deaths by Use of Air Conditioning and Age Group, (Indoor Only) Maricopa County, 2010

Age group	Air conditioning not in use or broken	Unknown if air conditioning in use or broken	Total
<1	0	0	0
1-4	0	0	0
5-14	0	0	0
15-19	0	0	0
20-34	1	2	3
35-64	3	4	7
65-84	4	5	9
85+	2	2	4
Unknown	0	0	0
Total	**10**	**13**	**23**

Table F. Drug and Alcohol Use, as Mentioned on the Death Certificate for Heat-Associated Deaths, by Homelessness, Maricopa County, 2010

2010		
Transient	**Drug and/or Alcohol Use**	**No Drug or Alcohol Use**
Yes (22, 26.8%)	10 (45.5%)	12 (54.5%)
No (60, 73.2%)	21 (35.0%)	39 (65.0%)
Total (82,100%)	31 (37.8%)	51 (62.2%)