Title

Clinical and Socioeconomic Differences in Methamphetamine-Positive Burn Patients

Journal
Journal of Burn Care & Research, 40(6)

ISSN
1559-047X

Authors
Solomon, Eve A
Greenhalgh, David G
Sen, Soman
et al.

Publication Date
2019-10-16

DOI
10.1093/jbcr/irz102

Peer reviewed

Clinical and Socioeconomic Differences in Methamphetamine-Positive Burn Patients

Eve A. Solomon, BA,* David G. Greenhalgh, MD, FACS,† Soman Sen, MD, FACS,† Tina L. Palmieri, MD, FACS, FCCM,† and Kathleen S. Romanowski, MD, FACS†

Previous research on burn patients who test positive for methamphetamines (meth) has yielded mixed results regarding whether meth-positive status leads to worse outcomes and longer hospitalizations. We hypothesized that meth-positive patients at our regional burn center would have worse outcomes. We reviewed burn admissions from January 2014 to December 2017 and compared total patients versus meth-positive, and matched meth-negative versus meth-positive for total BSA burn, length of stay (LOS), intensive care unit (ICU) days, days on ventilator, discharge status (lived/died), number of operating room (OR) visits, number of procedures, socioeconomic status, comorbidities, and discharge disposition. Of 1363 total patients, 264 (19.4%) were meth-positive on toxicology screen. We matched 193 meth-positive patients with meth-negative controls based on TBSA burn, age, and inhalation injury. In the total population comparison, meth-positive patients had larger burns (15.6% vs 12.2%; *P* = .004), longer LOS (17.8 vs 14.3 days; *P* = .041), and fewer operations/TBSA (0.12 vs 0.2; *P* = .04), and lower socioeconomic status. Meth-positive patients were less likely to be discharged to a skilled nursing facility, and more likely to leave against medical advice. In the matched patients, we found no significant differences in LOS or OR visits/TBSA burn. Meth-positive patients have lower socioeconomic status, larger burns, and longer LOS compared to the total burn population. Methamphetamine use, by itself, does not appear to change outcomes. Methamphetamine use leads to larger burns in a population with fewer resources than the general population.

Methamphetamine (meth) use and production declined after the 2005 Congressional Combat Methamphetamine Act, which limited sales of pseudoephedrine, an essential ingredient in meth production, but this trend has reversed, due to an increase in meth importation from Mexico.[1] The amount of seized imported meth has tripled in the last 5 years.[2] Admissions to substance abuse treatment services for primary methamphetamine/amphetamine use have also increased, fluctuating from 6 and 9% of all admissions.[3] Overall, the Center for Disease Control estimated that there were 1,713,000 persons in the United States aged 12 years or older using meth in 2015, at a rate of 0.6 per 100 persons.[4]

Meth-positive patients commonly sustain burn injuries, often a result of intoxication-related accidents or explosions during meth production in home laboratories, where volatile, combustible products are used to make meth in small spaces. A 2013 Michigan-based study shows that burns due to illicit meth production requiring hospital admission have increased despite deterrents intended to curtail production.[5] In 2010, the national incidence of burns resulting from meth manufacture and requiring emergency department or inpatient services was 5651, almost twice that of 2003, with the estimated national annual cost burden more than doubling over the same period.[6] With the rise in meth-positive burn-injured patients across the nation, we ask: does their meth-positive status influence what is required for these patients to receive successful burn care?

Studies have been inconclusive on the influence of methamphetamine use on burn-injured patients. Previous studies examining resuscitation fluid requirements reported mixed results: two separate retrospective case–control studies with 30 patients each concluded that meth-positive patients required two-to-three times more resuscitation fluid volume than the average burn patient,[7,8] while another case–control study of 22 patients found that meth-positive patients have the same fluid requirements as their meth-negative counterparts when using a slightly hypertonic fluid for resuscitation.[9] This same study also found no difference in length of stay, ventilator days, hospitalization charges, or mortality rate.[9] Another retrospective review also concluded there was no difference in predicted resuscitation fluid volume, total BSA (TBSA) burn, mortality, length of stay (LOS), or number of surgical procedures, but found increased actual resuscitation volume, inhalation injury, and complications in meth-positive patients.[10] Yet another study focused on burn patients injured in methamphetamine laboratory explosions found that meth-positive patients had larger TBSA burns, larger third-degree burns, increased incidence of inhalation injury, increased frequency of complications, and increased overall mortality; however

*University of California, Davis Medical School, Sacramento; †Department of Burn Surgery, University of California, Davis, Sacramento

Funding. The project described was supported by the National Center for Advancing Translational Sciences, National Institutes of Health, through grant number UL1 TR001860. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

Conflict of interest statement. None declared.

Author Contributions. All authors have made equal contributions to the conception, design, analysis, interpretation, drafting, and revision of the manuscript for this study.

Address correspondence to Kathleen Romanowski, MD, FACS, Department of Burn Surgery, University of California, 2425 Stockton Blvd. Suite 718, Sacramento, CA 95817. Email: ksromanowski@ucdavis.edu

doi:10.1093/jbcr/irz102

when results were adjusted for age, burn size, and inhalation injury, there was no significant difference.[11] A retrospective study of 660 total patients concluded that meth-positive patients had larger burns, higher rates of inhalation injury, and more nonthermal trauma, required longer lengths of stay, and were less likely to be insured,[12] while another study of similar size found no significant difference in clinical outcomes among patients injured in accelerant-related burns who had a history of drug abuse and those who did not.[13] Finally, in Australia, a case study described anecdotal aggressiveness and irritability in meth-positive patients after receiving ketamine during dressing changes.[14]

Using a database of burn-injured patients admitted to our burn unit over 4 years, we examined the total burn-injured population, and a subset population of matched meth-positive and meth-negative patients, examining how measures of injury severity, burn management, and socioeconomic data varied among matched and unmatched meth-positive and meth-negative patients; we hypothesized that meth-positive patients would have worse outcomes.

METHODS

Following institutional review board approval, a retrospective chart review of 1363 patients (age >18 years) who sustained burns and were admitted to our regional burn center from January 2014 to December 2017 was performed. Data were collected on all patients for TBSA burn size, LOS, intensive care unit (ICU) days, days on ventilator, discharge status (lived/died), number of operating room (OR) visits, number of procedures, socioeconomic status, comorbidities, and discharge disposition. Census data based on zip codes from the 2007–2011 American Community Survey (5-year estimates) was used to determine markers of socioeconomic status for patients including high school graduation rate, household and per capita income, labor force participation, and poverty level.[15]

In order to observe the effects of meth-positivity with and without the contribution of burn severity, we did two comparisons: meth-positive versus total meth-negative patients; and matched meth-positive versus meth-negative patients. We defined meth-positive as patients who tested positive for methamphetamines on toxicology screen and did not take prescription amphetamines, including dextroamphetamine (Dexedrine), dextroamphetamine/amphetamine combination (Adderall), or methylphenidate (Ritalin, Concerta). We excluded one patient on these criteria. Our practice is to obtain urine toxicology for all burn-injured patients. Consent is not required for urine toxicology, and if toxicology screens were not obtained on some patients, it was due to inadvertent error. Of 264 meth-positive patients on toxicology screen, 175 also had a positive gas chromatography test for methamphetamines; the remaining patients did not receive gas chromatography. Meth-negative patients were those who did not test positive for meth on toxicology screen or had no toxicology screen. All matched meth-negative patients had a negative toxicology screen.

Of the 1363 patients we included, 264 or 19.4% were meth-positive on their admission toxicology screen. Of these, 193 meth-positive patients were matched with 193 meth-negative patients based on age, TBSA burn, and inhalation injury. Some meth-positive patients were unable to be matched because we could not find a meth-negative counterpart with a negative urine toxicology screen and similar inhalation injury, burn size, and age. Gender and number of OR visits were also considered during the matching process whenever possible. Patient discharge status (lived/died) was hidden from the reviewers during the matching process.

Values are expressed as mean ± SD. R statistical package (www.r-project.org) was used to analyze the data. The *t* test was used to assess significant difference between meth-positive and meth-negative means.

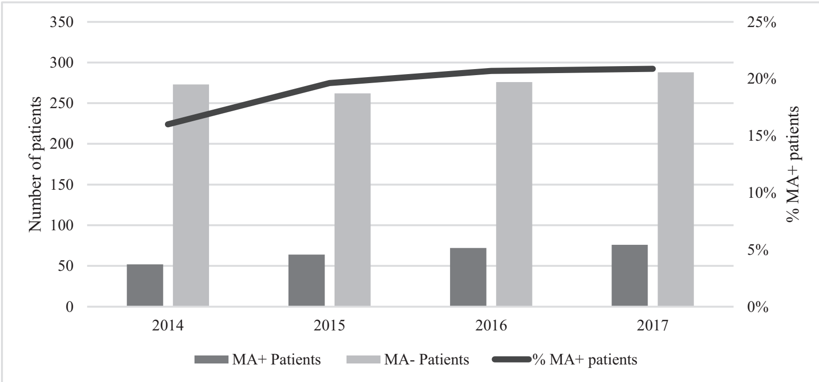
RESULTS

Of the 1363 patients admitted with a burn injury from January 2014 to December 2017, a total of 264 patients tested positive for meth on urine toxicology screen. During this period, our regional burn center saw a rise in the number of methamphetamine-positive burn-injured patients admitted to our service. In 2017, more than 20% of all burn-injured patients tested positive for methamphetamines on urine toxicology screen (Figure 1).

The average burn size in the total population was 12.9 ± 16.7% TBSA (Table 1). Meth-positive patients had larger burns (15.6 ± 17.0% vs 12.2 ± 16.5%; $P = .004$), and longer lengths of stay in the hospital (17.8 ± 25.5 days vs 14.3 ± 21.9 days; $P = 0.041$) (Table 1). Meth-positive patients were younger (42 ± 11.6 years vs 46 ± 18.1 years; $P < .0001$) and a greater percentage of meth-positive patients were male (81.5% male) than meth-negative patients (72.7% male; $P = .002$).

Following burn injury and admission, there were no statistical differences in the number of days that meth-positive patients spent on a ventilator, number of OR visits, or number of procedures. However, after controlling for TBSA burn size, meth-positive patients had fewer OR visits per TBSA burn (0.12 ± 0.41 vs 0.2 ± 1.17; $P = .04$), and fewer procedures per TBSA burn (0.35 ± 1.1 vs 0.55 ± 2.5; $P = .05$). Meth-positive patients spent slightly longer in the ICU than meth-negative patients but there was no statistical difference in time spent in the ICU (15.9 ± 25.2 days vs 12.6 ± 21.6 days; $P = .076$). There was no statistical difference in the number of procedures or OR visits per length of stay, vent days/TBSA burn, or LOS/TBSA burn.

Compared to the total population, there was statistical difference in measures of meth-positive patients' discharge status (Table 2). Meth-positive burn-injured patients were less likely to be discharged to a skilled nursing facility (SNF), with only 3.4% ($n = 9$), compared with 6.5% ($n = 76$) of meth-negative patients discharged to a skilled nursing facility ($P = .02$). Meth-positive patients were more likely to leave against medical advice at 3.4% ($n = 10$), while less than 0.1% ($n = 9$) of meth-negative patients left against medical advice ($P = .03$). Of note, 82% of meth-positive patients were discharged home with no services, compared to 76% of meth-negative patients, though this did not reach statistical difference ($P = .075$). There was no statistical difference in the proportion of meth-positive patients who were transferred to another hospital, inpatient psychiatric or rehabilitation facilities, another acute burn facility, long-term care facility, or discharged home with home services. A higher percentage of meth-negative patients



Year	MA+ Patients	MA- Patients	Total Patients	% MA+
2014	52	273	325	16%
2015	64	262	326	20%
2016	72	276	348	21%
2017	76	288	364	21%
Total	**264**	**1099**	**1363**	**19%**

Figure 1. Methamphetamine-positive burn admissions per total adult burn admissions at our regional burn center (2014–2017)

Table 1. Burn injury outcomes in meth-positive patients vs total adult population (January 2014–December 2017)

	Meth-positive Mean	Meth-positive SD	Meth-negative Mean	Meth-negative SD	Total Population Mean	Total Population SD	*P*
Age	42	12	46	18	45	17	**.00001**
TBSA - third degree	6	13	5	14	5	14	.738
TBSA - second and third degree	16	17	12	16	13	17	**.004**
Mortality	1	0	1	0	1	0	.164
Length of Stay	18	26	14	22	15	23	**.040**
LOS/TBSA	2	3	3	7	2	7	.094
Ventilator Days	6	20	4	16	4	17	.105
Ventilator Days/TBSA	0	1	0	1	0	1	.221
OR Visits	1	2	1	1	1	2	.487
OR Visits/TBSA	0	0	0	1	0	1	**.041**
OR/LOS	0	0	0	0	0	0	.207
Number of Procedures	4	9	3	8	4	8	.605
Procedures/TBSA	0	1	1	2	1	2	**.045**
Procedures/LOS	0	0	0	0	0	0	.896
ICU Days	16	25	13	22	13	22	.076

ICU, intensive care unit; *LOS*, length of stay; *OR*, operating room; *TBSA*, total BSA.
The bolded values are those that are statistically significant at a $p < .05$ level.

were discharged to jail or prison (meth-positive = 0% vs meth-negative = 0.55%; $P = .014$), or transferred to another service (meth-positive = 0% vs meth-negative = 0.36%, $P = .05$). There was no statistical difference in the number of meth-positive patients who died in the hospital (meth-positive = 3.02% vs meth-negative = 4.74%; $P = .164$). Fewer meth-positive patients had private insurance, with 23% of meth-negative patients owning private insurance versus 9% of meth-positive patients ($P < .0001$).

Meth-positive patients varied from their meth-negative counterparts in their comorbidities (Table 3). A greater percentage of meth-positive patients were current smokers (meth-positive = 54% vs meth-negative = 29%; $P < .0001$) and suffered from drug dependence (meth-positive = 81% vs meth-negative = 16%; $P < .0001$). Fewer meth-positive patients had congestive heart failure (meth positive = 0% vs meth-negative = 2%; $P = 0.02$), hypertension requiring medication (meth-positive = 15% vs meth-negative = 23%; $P = .002$), were obese (meth-positive = 3% vs meth-negative = 7%; $P = .005$), were classified as "functionally dependent health status" (meth-positive = 2% vs meth-negative = 4%; $P = .009$), had diabetes mellitus (meth-positive = 8% vs meth-negative = 13%; $P = .007$), required dialysis (meth-positive = 0% vs meth-negative = 0.5%; $P = .025$), and were wheelchair dependent (meth-positive = 0% vs meth-negative = 1%; $P = .0003$).

Census data (2011) was used as a socioeconomic marker for patients based on their home zip codes (Table 4). Meth-positive patients were more often from neighborhoods with lower levels in all measures of socioeconomic status. In zip codes that meth-positive patients listed as their home address, 80 ± 11.7% of

Table 2. Discharge disposition for meth-positive patients vs total population (January 2014–December 2017)

Discharge Disposition	Meth-positive (%)	*n*	Meth-negative (%)	*n*	Total Population (%)	*n*	*P*
Died in Hospital	3.0	8	4.7	52	4.4	60	.164
Discharged Home (Prior Living Situation) With No Home Services	82.2	217	77.5	851	78.4	1068	.075
Discharged Home with Home Services	1.5	4	1.2	13	1.2	17	.691
Discharged to Jail or Prison	0.0	0	0.5	6	0.4	6	**.014**
Discharged/Transferred to Long-Term Care Facility	0.4	1	0.6	7	0.6	8	.561
Discharged/Transferred to Skilled Nursing Facility/Nursing Home	3.4	9	6.6	73	6.0	82	**.016**
Left Against Medical Advice or Discontinued Care	3.4	9	0.9	10	1.4	19	**.032**
Transferred to another service	0.0	0	0.4	4	0.3	4	**.045**
Transferred as Inpatient to Another Acute Burn Facility	0.0	0	0.1	1	0.1	1	.318
Transferred as Inpatient to Another Hospital (Nonburn)	1.9	5	3.4	37	3.1	42	.138
Transferred to Inpatient Psychiatry Unit	1.1	3	0.8	9	0.9	12	.658
Transferred to Inpatient Rehabilitation Facility	3.0	8	3.2	35	3.2	43	.886
Total		264		1098		1362	

The bolded values are those that are statistically significant at a $p < .05$ level.

Table 3. Comorbidities for meth-positive patients vs total population (January 2014–December 2017)

Comorbidity	Meth-positive	Meth-negative	Total population	*P*
Alcoholism	18%	15%	15%	.174
Arthritis	0%	1%	1%	.561
Chemotherapy for Cancer Within 30 days	0%	0%	0%	.157
Cirrhosis	0%	0%	0%	.318
Congenital Anomalies	0%	0%	0%	.083
Congestive Heart Failure	0%	2%	1%	**.019**
Currently Requiring or On Dialysis	0%	0.5%	0%	**.025**
Current Smoker	54%	29%	34%	**8E-13**
Cerebral Vascular Accident/residual Neurological Deficit	0%	3%	2%	**1E-07**
Dementia	0%	0%	0%	.157
Diabetes Mellitus	8%	13%	12%	**.008**
Disseminated Cancer	0%	0%	0%	.318
Do Not Resuscitate (DNR) Status	0%	0%	0%	NA
Drug Dependence	81%	16%	29%	**5E-79**
Functionally Dependent Health Status	2%	4%	4%	**.009**
History of Myocardial Infarction Within Past 6 Months	0%	0%	0%	.318
Hypertension Requiring Medication	15%	23%	22%	**.002**
Major Psychiatric Illness	20%	17%	17%	.320
Obesity	3%	7%	6%	**.004**
Other	18%	29%	27%	**.0001**
Prehospital Cardiac Arrest with Resuscitative Efforts	0%	0%	0%	.318
Respiratory Disease	13%	13%	13%	.937
Unknown	0%	0%	0%	.083
Wheel Chair Dependent	0%	1%	1%	**.0003**

The bolded values are those that are statistically significant at a $p < .05$ level.

the population had a high school education or higher (vs 82 ± 10.5% for meth-negative patients), mean household income was lower ($61,385 ± 19,968 vs $68,170 ± 19,596), median household income was lower ($47,321 ± 15,857 vs $54,142 ± 16,861), labor force participation was lower (59 ± 7.93% vs 61.4 ± 7.6%), percent poverty by family was higher (15.1 ± 9.84% vs 12.3% ± 7.4%), and percent poverty for all individuals was higher (19.7 ± 10.29% vs 16.3 ±8.24; $P \leq .015$ for all).

Among the matched patients, there was no significant difference in TBSA burn size, mortality, length of stay, LOS/

Table 4. Socioeconomic status data for meth-positive patients vs total adult population (January 2014–December 2017)

Socioeconomic Data Measure	Meth-positive: Mean	Meth-positive: SD	Matched Meth-negative: Mean	Matched Meth-negative: SD	Total Population: Mean	Total Population: SD	P
High school or Higher (%)	80.152	11.657	82.206	10.527	81.820	10.773	**.015**
Median Household income ($)	47,321.357	15,857.931	54,136.161	16,854.265	52,861.894	16,876.776	**1.75E-08**
Mean Household income ($)	61,385.727	19,968.423	68,163.587	19,587.801	66,898.313	19,827.944	**5.29E-06**
Per Capita Income ($)	23,448.022	8489.675	25,477.375	8255.259	25,097.184	8333.878	**.001**
Labor Force Participation (%)	59.001	7.927	61.403	7.578	60.951	7.699	**3.97E-05**
Poverty by Family (%)	15.045	9.842	12.287	7.430	12.802	8.004	**9.04E-05**
Poverty by All people (%)	19.689	10.290	16.313	8.238	16.947	8.756	**5.38E-06**

The bolded values are those that are statistically significant at a $p < .05$ level.

Table 5. Burn injury outcomes in matched meth-positive patients vs meth-negative controls (January 2014–December 2017)

	Meth-positive Mean	Meth-positive SD	Meth-negative Mean	Meth-negative SD	Total Population Mean	Total Population SD	P
Age	40.4	11.8	41.0	14.0	40.7	12.9	.604
TBSA - third degree	7.0	14.5	7.9	14.6	7.5	14.6	.564
TBSA - second and third degree	18.9	18.1	18.6	18.3	18.7	18.2	.883
Mortality	1.0	0.2	0.9	0.2	0.9	0.2	.360
LOS	20.9	29.0	23.3	30.9	22.1	29.9	.428
LOS/TBSA	1.4	1.8	1.5	1.4	1.5	1.6	.811
Ventilator Days	8.1	23.2	9.1	26.8	8.6	25.0	.683
Ventilator Days/TBSA	0.2	0.7	0.2	0.5	0.2	0.6	.744
OR Visits	1.0	2.0	1.2	2.1	1.1	2.0	.349
OR Visits/TBSA	0.0	0.1	0.0	0.0	0.0	0.1	.722
OR/LOS	0.1	0.2	0.1	0.1	0.1	0.2	.833
Number of Procedures	4.8	9.8	7.2	13.5	6.0	11.8	.051
Procedures/TBSA	0.2	0.4	0.2	0.3	0.2	0.3	.503
Procedures/LOS	0.3	0.5	0.3	0.5	0.3	0.5	.229
ICU Days	18.8	28.4	22.0	31.7	20.4	30.1	.314

ICU, intensive care unit; *LOS*, length of stay; *OR*, operating room; *TBSA*, total BSA.

TBSA burn, ventilator days, ventilator days/TBSA burn, OR visits, OR visits/TBSA burn, OR/LOS, procedures/TBSA burn, procedures/LOS, or ICU days (Table 6). Number of procedures approached but did not reach significance with meth-positive patients having fewer procedures, at an average of 4.8 ± 9.8 procedures (vs 7.2 ± 13.5; $P = .051$; Table 5). Matched meth-positive patients were more often current smokers (meth-positive = 52% vs meth-negative = 33%; $P < .0001$), and drug dependent (meth-positive = 85% vs meth-negative = 22%; $P < .0001$). There were no other statistical differences in comorbidities for matched patients (Table 6). There were no statistical differences in discharge status or discharge disposition between meth-positive and meth-negative patients (Table 7). More meth-positive patients were discharged home with no services (meth-positive = 78% vs meth-negative = 69%; $P = .065$) and left against medical advice (meth-positive = 3.6% vs meth-negative = 1%; $P = .092$), and fewer meth-positive patients were transferred to another hospital (nonburn facility) (meth-positive = 2% vs meth-negative = 5.7%; $P = .066$), though these measures did not reach statistical significance. However, there was statistical difference in every measure of socioeconomic status, with lower measures for education, poverty, and income for meth-positive patients than their matched meth-negative counterparts ($P \leq .022$ for all; Table 8).

DISCUSSION

Patients who tested positive for Methamphetamine were from neighborhoods with socioeconomic status when compared

Table 6. Comorbidities for meth-positive patients vs meth-negative controls (January 2014–December 2017)

Comorbidity	Meth-positive	Meth-negative	Total Population	P
Alcoholism	18%	18%	18%	.895
Chemotherapy for Cancer Within 30 Days	1%	0%	0%	NA
Current Smoker	52%	33%	42%	**8.17E-05**
Diabetes Mellitus	7%	11%	9%	.162
Drug Dependence	85%	22%	54%	**1.93E-45**
Functionally Dependent Health Status	2%	0%	1%	NA
Hypertension Requiring Medication	14%	18%	16%	.330
Major Psychiatric Illness	21%	22%	22%	.711
Obesity	4%	7%	5%	.117
Other	16%	25%	20%	**.016**
Respiratory Disease	10%	10%	10%	.000
Wheel Chair Dependent	1%	0%	0%	NA

The bolded values are those that are statistically significant at a $p < .05$ level.

Table 7. Discharge disposition for meth-positive patients vs meth-negative controls (January 2014–December 2017)

Discharge Disposition	Meth-positive (%)	*n*	Meth-negative (%)	*n*	Total Population (%)	*n*	P
Died in Hospital	4.2	8	6.2	12	5.2	20	.360
Discharged Home (Prior Living Situation) With No Home Services	77.7	150	69.4	134	73.6	284	.065
Discharged Home with Home Services	2.1	4	1.6	3	1.8	7	.704
Discharged to Jail or Prison	0.0	0	0.5	1	0.3	1	NA
Discharged/Transferred to Long-Term Care Facility	0.5	1	1.0	2	0.8	3	.563
Discharged/Transferred to Skilled Nursing Facility/Nursing Home	5.2	10	7.3	14	6.2	24	.400
Left Against Medical Advice or Discontinued Care	3.6	7	1.0	2	2.3	9	.092
Transferred to Inpatient Rehabilitation Facility	4.2	8	5.2	10	4.7	18	.630
Transferred as Inpatient to Another Hospital (Nonburn)	2.1	4	5.7	11	3.9	15	.066
Transferred to Inpatient Psychiatry Unit	0.5	1	2.1	4	1.3	5	.178
Total		193		193		386	

to both matched meth-negative controls and the entire burn population. They also had larger burns and increased lengths of stay when compared to the total population of patients at our burn unit. A higher percentage of meth-positive patients left against medical advice and fewer were discharged to skilled nursing facilities, despite having more severe injuries. These findings indicate a deficit in postdischarge care for these patients, who are already at a disadvantage because they come from lower socioeconomic backgrounds and have a history of drug use. When we controlled for burn severity through matching patients based on TBSA burn, inhalation injury, and age, methamphetamine use, alone, did not alter patients' outcomes. This suggests that the main burden of methamphetamine use in burn-injured patients is that it leads to larger TBSA burns in a population with fewer resources than the general population.

Myers et al identified individuals who suffered burn injuries within from the National Inpatient Sample and Nationwide Emergency Department Sample from 2003 to 2010 and found that the incidence of meth-related burns has risen nationwide from 1.1 per 100,000 discharges in 2003 to 1.8 per 100,000 discharges in 2010, with the estimated annual cost burden at $81,770,455 in 2010.[6] Methamphetamine use is a problem that specifically impacts our community—it was the primary drug of choice for 38% of all admissions to Detox, Outpatient & Residential Services (1508 out of 3969 admissions) in FY 2016–2017 in our county.[16] Twenty percent of burn-injured patients at our institution tested positive for methamphetamines from 2014 to 2017.

Various studies have tackled the question of how meth-positive status may influence a patient's needs while receiving burn care. These have mostly been small sample-size studies, ranging from 11 (Juern et al) to 34 matched meth-positive patients (Danks et al), and up to 54 unmatched meth-positive patients who were compared to a total population of 660 (Burke et al).[9,12,17] To the best our knowledge., this is the largest study to date to investigate methamphetamine use

Table 8. Socioeconomic status data for meth-positive patients vs meth-negative controls (January 2014–December 2017)

Socioeconomic Data Measure	Meth-positive: Mean	Meth-positive: SD	Matched Meth-negative: Mean	Matched Meth-negative: SD	Total Population: Mean	Total Population: SD	*P*
Highschool or Higher (%)	79.9	12.1	84.1	9.8	82.0	11.2	**.001**
Median Household income ($)	47,139.5	15,216.6	56,132.6	19,836.6	51,716.4	18,256.7	**4.40E-06**
Mean Household income ($)	60,781.5	18,402.3	70,769.8	23,224.6	65,864.8	21,552.4	**1.63E-05**
Per Capita Income ($)	23,090.5	8051.4	26,457.6	9187.2	24,799.0	8796.6	**.0004**
Labor Force Participation (%)	58.8	8.3	60.8	7.5	59.8	7.9	**.022**
Poverty by Family (%)	15.0	10.3	11.3	6.2	13.2	8.7	**.000**
Poverty by All people (%)	20.0	10.8	15.7	7.8	17.8	9.6	**4.83E-05**

The bolded values are those that are statistically significant at a $p < .05$ level.

in burn-injured patients, with 264 total meth-positive adult patients, and 193 matched meth-positive patients.

Santos et al retrospectively matched 15 meth-positive patients who had been injured in meth lab explosions with 45 meth-negative counterparts and noted poor follow-up after hospital discharge among meth-positive patients.[8] In a retrospective review of burn-injured patients, Danks et al identified 31 meth-positive patients out of 507 total burn patients over 3 years and found that of the 18 patients who received formal clinical dependency consults, only two elected to receive treatment for their dependency.[17] In a case review of nine patients burned during the methamphetamine manufacturing process, O'Neill et al found that two patients left against medical advice, five were discharged home earlier than anticipated due to aggressive behavior, and only two attended scar management follow-up appointments.[14] Leung et al found that among patients injured in accelerant-related burns, there was no difference in clinical outcomes amongst patients with and without a history of drug abuse.[13] We find that more meth-positive patients leave the hospital against medical advice and fewer are discharged to a skilled nursing facility. This could be related to the insurance status of these patients, only 9% of whom owned private insurance, compared to nearly a quarter of meth-negative patients. Meth patients are not receiving the same level of postdischarge care as their meth-negative counterparts, possibly due to lack of resources, addiction, or perceived stigma. A Washington study in 2008 looked at burn-injured homeless patients over 11 years and found that 59.4% were also drug users, compared to just 13.1% of nonhomeless patients.[18] While this chart review did not specifically look at homelessness status, it is likely that some of our meth-positive patients are suffering from homelessness and other complicating life circumstances in addition to dealing with substance-use and burn injury. It is also worth noting that while every patient on our service receives a social work consult, we do not currently offer referrals for postdischarge addiction treatment or counseling unless the patient or family members request it.

Warner et al compared 15 meth-positive patients with age- and TBSA-matched meth-negative patients and found that meth-positive patients had higher mortality; in their study, all meth-positive patients with burns greater than or equal to 40% TBSA died, while meth-negative patients with 40% or greater TBSA had a 60% mortality rate.[7] Blostein et al matched 29 meth-positive burn and trauma patients with meth-positive counterparts. Mortality did not differ based on meth status in the studies by Jeurn or Blostein. Spann et al compared 19 meth-positive burn-injured patients with a total population of 789 and found that mortality was greater in meth-positive patients, but no significant difference was found once they adjusted for age, burn size, and inhalation injury.[11] Santos found that mortality was elevated but not significantly different in meth-positive patients.[8] We found that meth-positive patients did not have significantly higher mortality than meth-negative patients in either the matched or total population groups. However, this finding is based on discharge status, which only includes in-hospital mortality and we were unable to track postdischarge mortality in this retrospective study. Given that meth-positive patients are being discharged with less support, further research on the long-term mortality and other outcomes of these patients is still needed.

Santos found that meth-positive patients had longer lengths of stay, higher hospital charges, and greater inhalation injury.[8] Blostein did not find an increased LOS and attributed a nonsignificant but slightly longer LOS to more days on ventilator support and larger TBSA burns in meth-positive patients.[10] Burke et al found that their 54 matched meth-positive patients did not have greater TBSA burns, but did have greater inhalation injury, presence of nonthermal trauma, and LOS. We found greater LOS in meth-positive patients than in the general population, but no difference in our matched population, confirming the findings in Blostein and Burke and suggesting that greater LOS is associated with burn size.

Number of surgical procedures did not differ in Blostein.[10] In our study, we found that meth-negative patients had more procedures than meth-positive patients when unmatched, and number of procedures approached significance in our matched group, with meth-negative patients having more procedures. Meth-positive patients, while more badly burned, are having fewer procedures than their meth-negative counterparts. The reason for this was not entirely clear in our current study.

When we initiated this study, we hypothesized that matched meth-positive patients would have worse outcomes than their meth-negative counterparts. We were surprised to find that they did not require more procedures, ventilation days, OR visits, ICU days, or have higher mortality. The main difference between the two groups was that meth-positive patients suffered worse injuries and did worse in every measure of socioeconomic status, based on zip codes. While they may initially appear to have the same outcomes as meth-negative patients, they are returning from their hospital stays to worse socioeconomic conditions and are less likely to have the same level of follow-up after they leave the hospital, although actual rates of follow-up were not examined in this study.

One of the limitations of this study was its retrospective nature. We were unable to measure levels of methamphetamines or determine length of time between the patient's last use of methamphetamines and burn injury. The window for methamphetamine detection on urine toxicology screen is between 1 and 4 days for a single dosage, and up to a week for consistent use. The effects of methamphetamine last from 4 to 12 hours, depending on the dosage injected or inhaled.[19] It is therefore impossible to differentiate between meth-positive patients who were actively high on methamphetamines at the time of injury or admission and those who had recently used methamphetamines. We were also unable to track patients' outcomes after they were discharged from the hospital, which is a direction for future research.

Another limitation of our study is that not every burn-injured patient received a urine toxicology screen upon admission. While it is our standard of care for every patient to receive a urine toxicology screen upon admission, some patients did not receive one. We hypothesize that this is due to some combination of accidental omissions, low urine output in some burn-injured patients, and miscommunication between the emergency medicine and burn surgery teams. In the total population analysis, we classified as "meth-negative" those patients who either did not receive a toxicology screen or tested negative on toxicology screen. It is possible that patients who did not receive a toxicology screen did not present as suspected meth-users, but we cannot rule out the possibility that some meth-positive patients may be included in our meth-negative group. Our matched patient population only included meth-negative controls that had tested negative for methamphetamines on toxicology screen. We had a total of 264 meth-positive patients during our 4-year study but were only able to match 193 of them because of our matching criteria, which required a negative toxicology screen and included TBSA, inhalation injury, age, and whenever possible, burn etiology and number of OR visits.

While meth-positive patients' physiology may not differ from that of meth-negative patients, they represent a special group with different life circumstances from the general population and should be provided additional resources to ensure they successfully recover from burn injury. As providers, we must consider how we can support these patients with adequate inpatient and follow-up care, whether it be addiction counseling, social work services, or follow-up care facilitation. Further public policy initiatives are needed to better control methamphetamine use and preparation in order to prevent burns associated with these activities. While the 2005 Congressional Combat Methamphetamine Act may have limited sales of pseudoephedrine, an essential ingredient in meth production, it also led to increased meth importation from Mexico,[1] and a rise of one-pot meth production, which causes burn injury as detailed by Davidson et al[5].

To better understand how we can help meth-positive burn-injured patients receive the best care for them, we should further investigate what happens to these patients once they leave the hospital by measuring frequency of follow-up, enrollment in drug rehabilitation programs, and identification of other obstacles associated with low-socioeconomic status that may prevent them from seeking care.

CONCLUSIONS

Meth-positive patients have lower socioeconomic status, larger burns, and longer LOS compared to the typical burn population. A greater percentage of them leave the hospital against medical advice and fewer are discharged to a skilled nursing facility. They are suffering worse injuries than their meth-negative counterparts, and while their clinical outcomes are not altered by their meth-positive status, it is likely that they are leaving the hospital with less support than meth-negative patients. Methamphetamine use, by itself, does not lead to worse outcomes, but it does lead to larger burns in a population with fewer resources and less education than the general population.

REFERENCES

1. Robles F. Meth, the forgotten killer, is back. And it's everywhere. [online] Nytimes.com; 2019, accessed 8 Dec. 2019; available from https://www.nytimes.com/2018/02/13/us/meth-crystal-drug.html
2. CBP Enforcement Statistics FY2018 | U.S. Customs and Border Protection; 2018, accessed 13 Jan. 2019; available from https://www.cbp.gov/newsroom/stats/cbp-enforcement-statistics
3. Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. Treatment Episode Data Set (TEDS): 2005–2015. National admissions to substance abuse treatment services. BHSIS Series S-91, HHS Publication No. (SMA) 17–5037. Rockville (MD): Substance Abuse and Mental Health Services Administration; 2017.
4. Centers for Disease Control and Prevention. Annual surveillance report of drug-related risks and outcomes — United States, 2017. Surveillance Special Report 1. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services; 2017, accessed 8 Dec. 2019; available from https://www.cdc.gov/drugoverdose/pdf/pubs/2017cdc-drug-surveillance-report.pdf
5. Davidson SB, Blostein PA, Walsh J, Maltz SB, Elian A, VandenBerg SL. Resurgence of methamphetamine related burns and injuries: a follow-up study. Burns. 2013;39:119–25.
6. Myers J, Lehna C. Estimating the national cost burden from burns resulting from methamphetamine manufacturing. J Burn Care Res. 2015;36:e226–7.
7. Warner P, Connolly JP, Gibran NS, Heimbach DM, Engrav LH. The methamphetamine burn patient. J Burn Care Rehabil. 2003;24:275–8.
8. Santos AP, Wilson AK, Hornung CA, Polk HC Jr, Rodriguez JL, Franklin GA. Methamphetamine laboratory explosions: a new and emerging burn injury. J Burn Care Rehabil. 2005;26:228–32.
9. Juern J, Peltier G, Twomey J. Slightly hypertonic saline and dextran-40 in resuscitation of methamphetamine burn patients. J Burn Care Res. 2008;29:319–22.

10. Blostein PA, Plaisier BR, Maltz SB et al. Methamphetamine production is hazardous to your health. J Trauma. 2009;66:1712–7; discussion 1717.
11. Spann MD, McGwin G Jr, Kerby JD et al. Characteristics of burn patients injured in methamphetamine laboratory explosions. J Burn Care Res. 2006;27:496–501.
12. Burke BA, Lewis RW II, Latenser BA et al. Methamphetamine-related burns in the cornbelt. J Burn Care Res. 2008;29:574–9.
13. Leung LTF, Papp A. Accelerant-related burns and drug abuse: challenging combination. Burns. 2018;44:646–50.
14. O'Neill TB, Rawlins JM, Rea S, Wood FM. Methamphetamine laboratory-related burns in Western Australia–why the explosion? Burns. 2011;37:1044–8.
15. Data Access and Dissemination Systems (DADS) American fact finder. Factfinder.census.gov; 2010, accessed 8 Jan. 2019. available from https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml
16. Sabillo L. Methamphetamine symposium (Issue brief). Sacramento County Division of Behavioral Health Services website; 2017, accessed 12 Jan. 2018; available from http://www.dhs.saccounty.net/BHS/Documents/Alcohol-Drug-Services/MA-ADS-2017-01-01-Methamphetamine-Symposium-Session-1.pdf
17. Danks RR, Wibbenmeyer LA, Faucher LD et al. Methamphetamine-associated burn injuries: a retrospective analysis. J Burn Care Rehabil. 2004;25:425–9.
18. Kramer CB, Gibran NS, Heimbach DM, Rivara FP, Klein MB. Assault and substance abuse characterize burn injuries in homeless patients. J Burn Care Res. 2008;29:461–7.
19. Buddy T. How long does meth stay in your system? (Medical review by Richard Fogoros, MD) Verywell mind. 2018, accessed 8 Jan. 2019. available from https://www.verywellmind.com/how-long-does-methamphetamine-stay-in-your-system-80283