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# Factors Impacting the Likelihood of Death in Patients with Small TBSA Burns

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MedStar Washington  
Hospital Center

*The Burn Center*   
*MedStar Health*

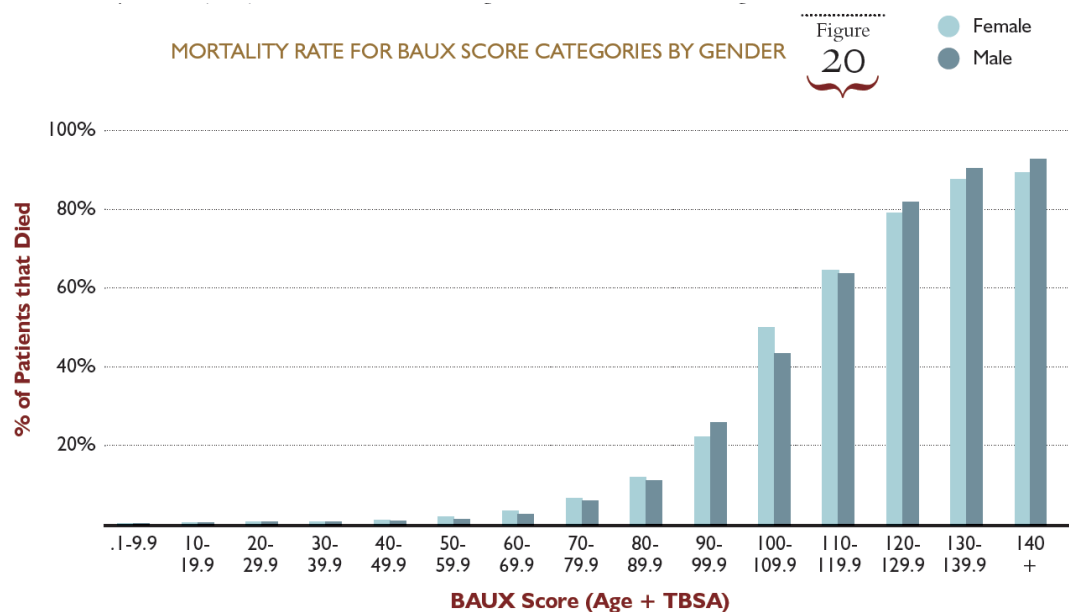


# Disclosures

- No conflicts of interest

# Burn Mortality

- Burn size influences mortality
- Survivability of large burns has improved over several decades



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# Burn Survival Predictors

- **Baux Score** = **TBSA** + Age
- **R-Baux Score** = **TBSA** + Age + (17xR)
  - R=1 for inhalation injury
- **P-Baux Score** = **TBSA** – Age + (18xR)
  - R=1 for inhalation injury
- **BISS** =  $\exp(-6.34 + 0.0031 \times (\text{ISS} \times \text{age}) + 0.033 \times \text{TBSA})$
- **FLAMES** =  $-8.285 + (0.045 \times \text{age}) + (0.157 \times \text{APACHE II score}) + (0.062 \times \text{partial thickness TBSA}) + (0.104 \times \text{full thickness TBSA}) + (-1.214 \times \text{sex})$ 
  - Sex=1 for male, 0 for female

# Small Burns and Deaths

- A small population of patients with  $\leq 10\%$  TBSA burns do not survive.
- Inhalation injury is a predicted culprit.
- Are there other influencers of outcome?

Table 9 MORTALITY RATE BY AGE GROUP AND BURN SIZE (EXPRESSED AS THE NUMBER OF DEATHS OVER THE TOTAL NUMBER OF PATIENTS IN THAT GROUP)

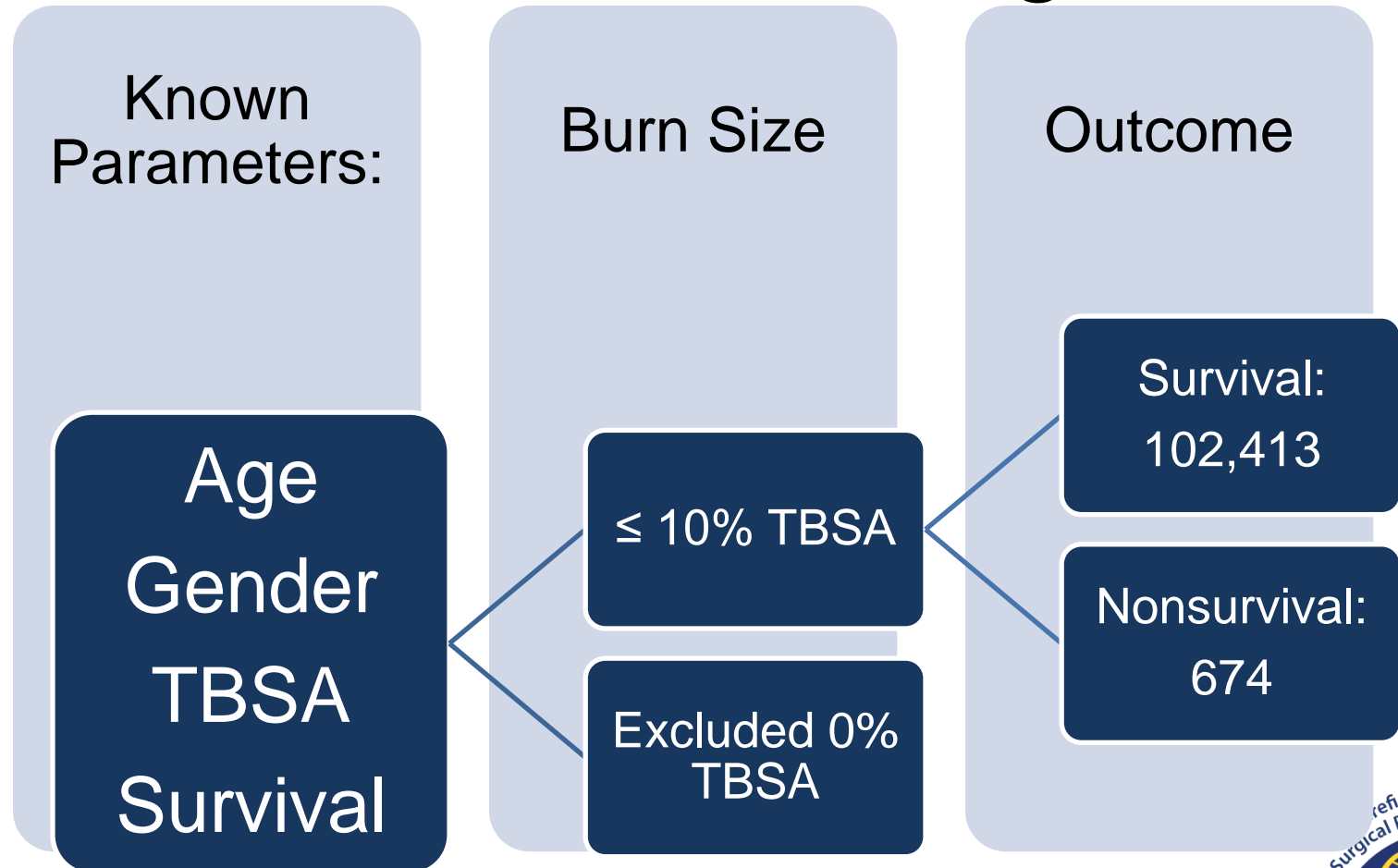
	Burn Size (% TBSA)										
Age Group	0.1 - 9.9	10 - 19.9	20 - 29.9	30 - 39.9	40 - 49.9	50 - 59.9	60 - 69.9	70 - 79.9	80 - 89.9	> 90	Total
Birth - 9	0.3	1.8	6.9	9.4	24.7	28.8	44.9	50.0	70.4	91.7	2.9
Died/Total	15/5558	26/1456	30/435	21/224	24/97	21/73	22/49	21/42	19/27	33/36	232/7997
1 - 1.9	0.0	0.4	0.6	2.7	8.5	16.7	28.6	20.0	25.0	75.0	0.2
Died/Total	0/10136	7/1998	2/338	3/112	4/47	3/18	6/21	2/10	1/4	3/4	31/12688
2 - 4.9	0.1	0.2	0.8	5.3	7.9	19.7	9.3	25.0	60.0	45.5	0.8
Died/Total	9/7687	3/1575	3/379	10/190	8/101	13/66	4/43	7/28	18/30	10/22	85/10121
5 - 15.9	0.1	0.3	1.1	2.3	4.3	5.1	11.6	13.8	49.0	60.0	0.7
Died/Total	8/10524	6/2134	7/640	7/301	8/186	6/117	10/86	8/58	24/49	21/35	105/14130
16 - 19.9	0.1	0.4	1.1	3.3	5.2	9.4	14.3	18.5	58.3	66.7	1.1
Died/Total	7/5404	5/1190	4/370	5/152	6/115	6/64	6/42	5/27	14/24	22/33	80/7421
20 - 29.9	0.2	0.6	1.6	6.2	12.4	19.5	25.2	43.5	60.0	77.0	1.6
Died/Total	23/14854	19/3368	18/1103	31/503	31/249	30/154	32/127	30/69	48/80	67/87	329/20594
30 - 39.9	0.3	0.9	2.9	6.7	11.0	25.3	34.7	51.1	68.9	94.3	2.3
Died/Total	35/12629	27/3057	29/993	32/479	29/264	40/158	41/118	46/90	51/74	82/87	412/17949
40 - 49.9	0.4	1.5	4.8	10.9	23.1	42.3	37.6	62.9	74.7	91.0	3.2
Died/Total	50/14033	51/3414	57/1179	65/596	74/321	85/201	53/141	44/70	65/87	101/111	645/20153
50 - 59.9	0.8	3.7	10.1	21.2	39.7	53.0	67.8	81.6	87.8	89.6	5.4
Died/Total	82/10463	96/2602	93/922	83/392	96/242	79/149	78/115	62/76	65/74	86/96	820/15131
60 - 69.9	2.0	6.5	19.1	42.9	52.5	67.0	85.7	90.2	100.0	89.6	8.3
Died/Total	115/5714	99/1533	96/502	100/233	63/120	61/91	42/49	46/51	30/30	43/48	695/8371
70 - 79.9	4.0	15.4	34.0	59.2	74.5	84.4	88.0	92.9	90.0	90.6	14.9
Died/Total	132/3268	138/898	119/350	109/184	73/98	54/64	44/50	26/28	18/20	29/32	742/4992
80 or Greater	6.9	28.7	63.9	77.2	89.0	96.7	86.7	93.5	97.1	100.0	24.9
Died/Total	154/2225	210/731	179/280	105/136	73/82	58/60	39/45	29/31	34/35	27/27	908/3652
Total	0.6	2.9	8.5	16.3	25.4	37.5	42.6	56.2	72.5	84.8	3.6
Died/Total	630/102495	87/23956	637/7491	571/3502	489/1922	456/1215	377/886	326/580	387/534	524/618	5084/14399

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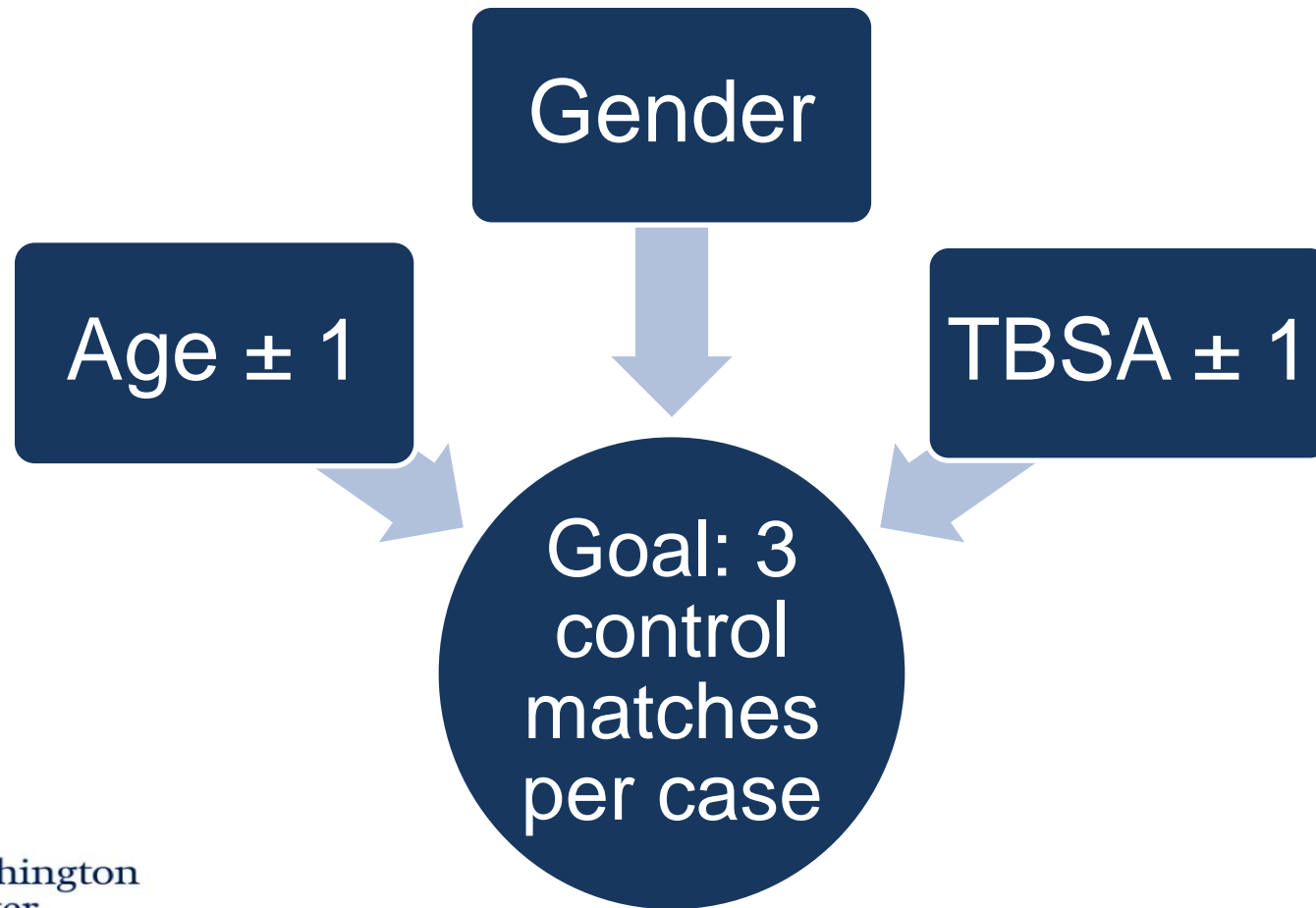
# Methods

- NBR Dataset 2002-2011
- Excluded patients lacking information on:
  - Age
  - Gender
  - TBSA
  - Survival at time of discharge

# Case Matching

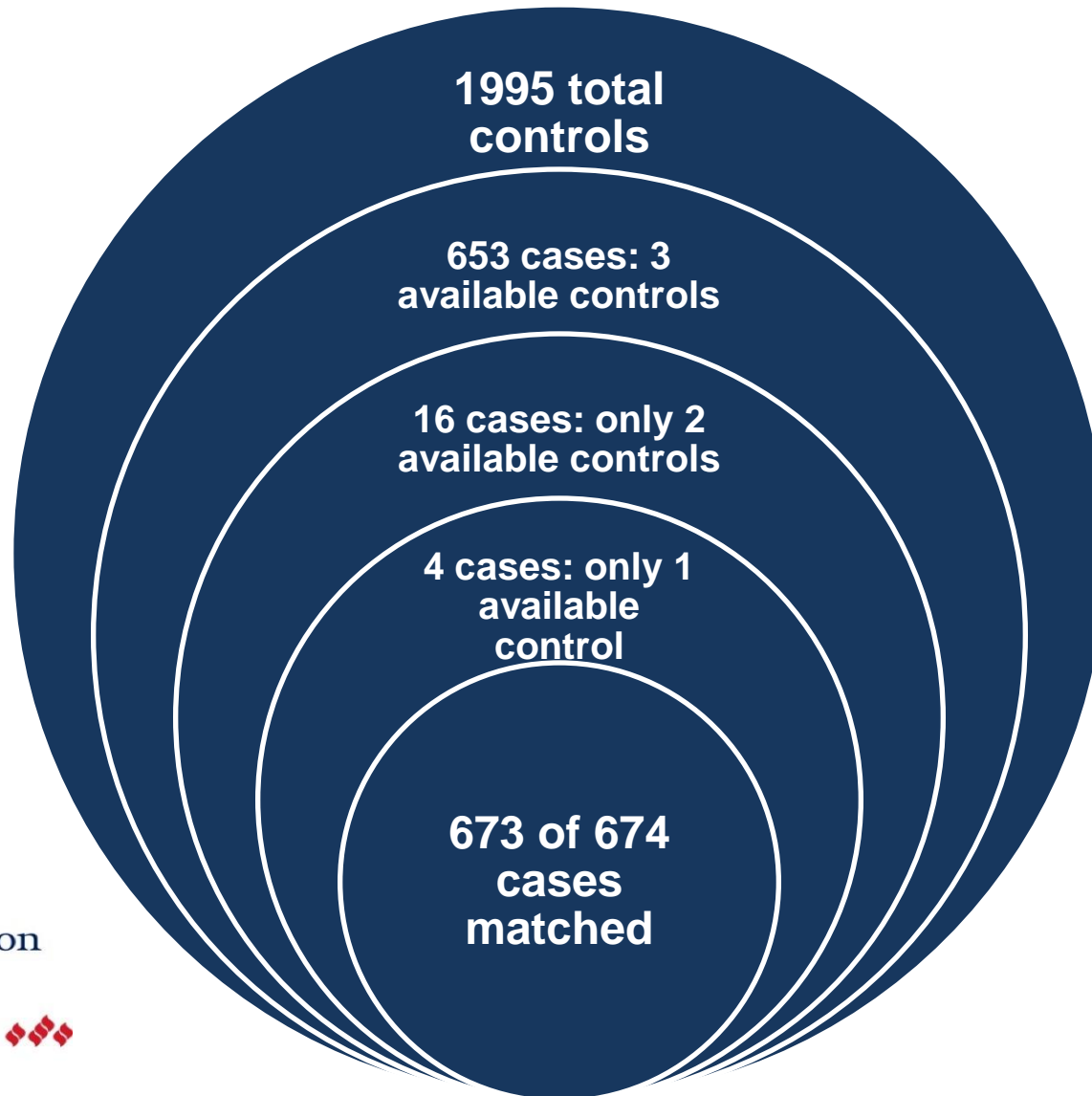


# Case Matching





# Case Matching

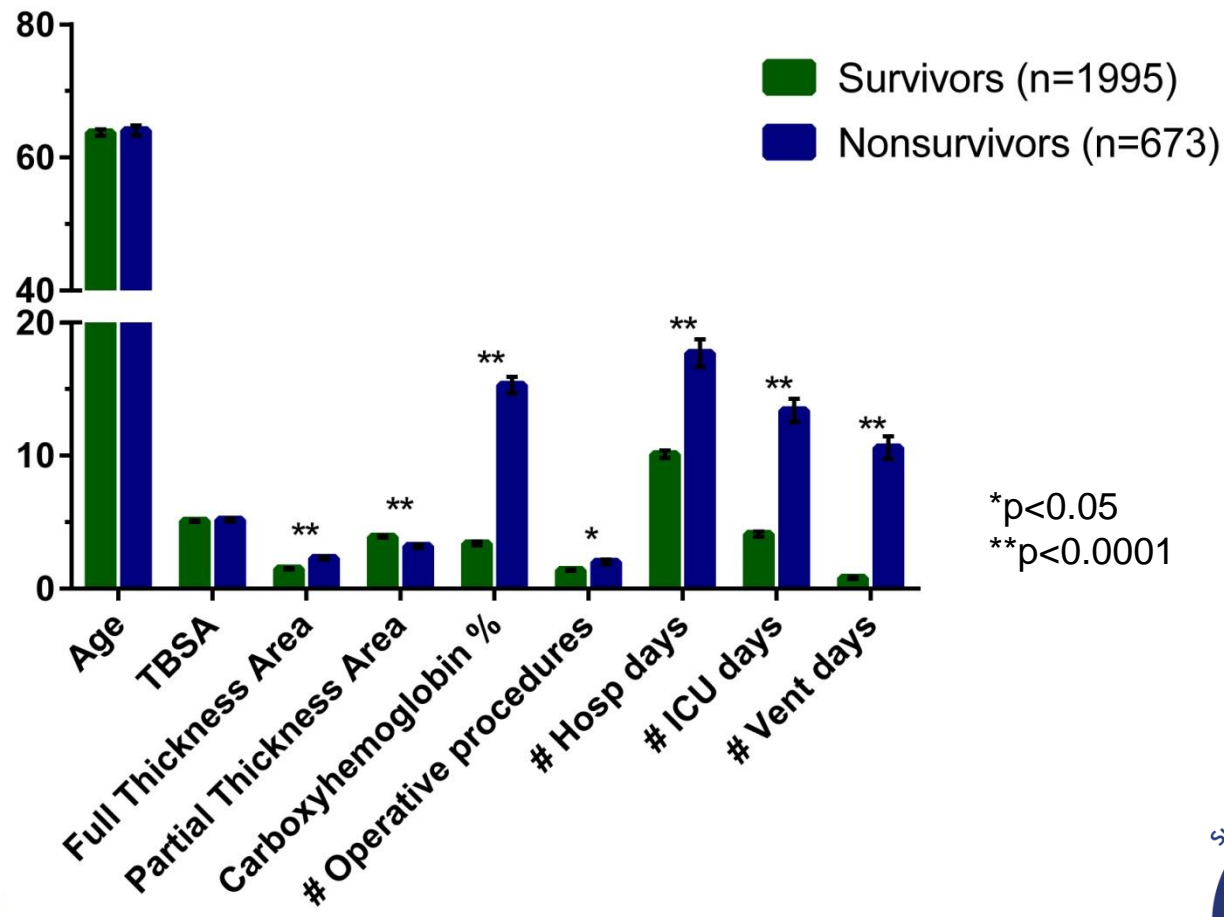


  
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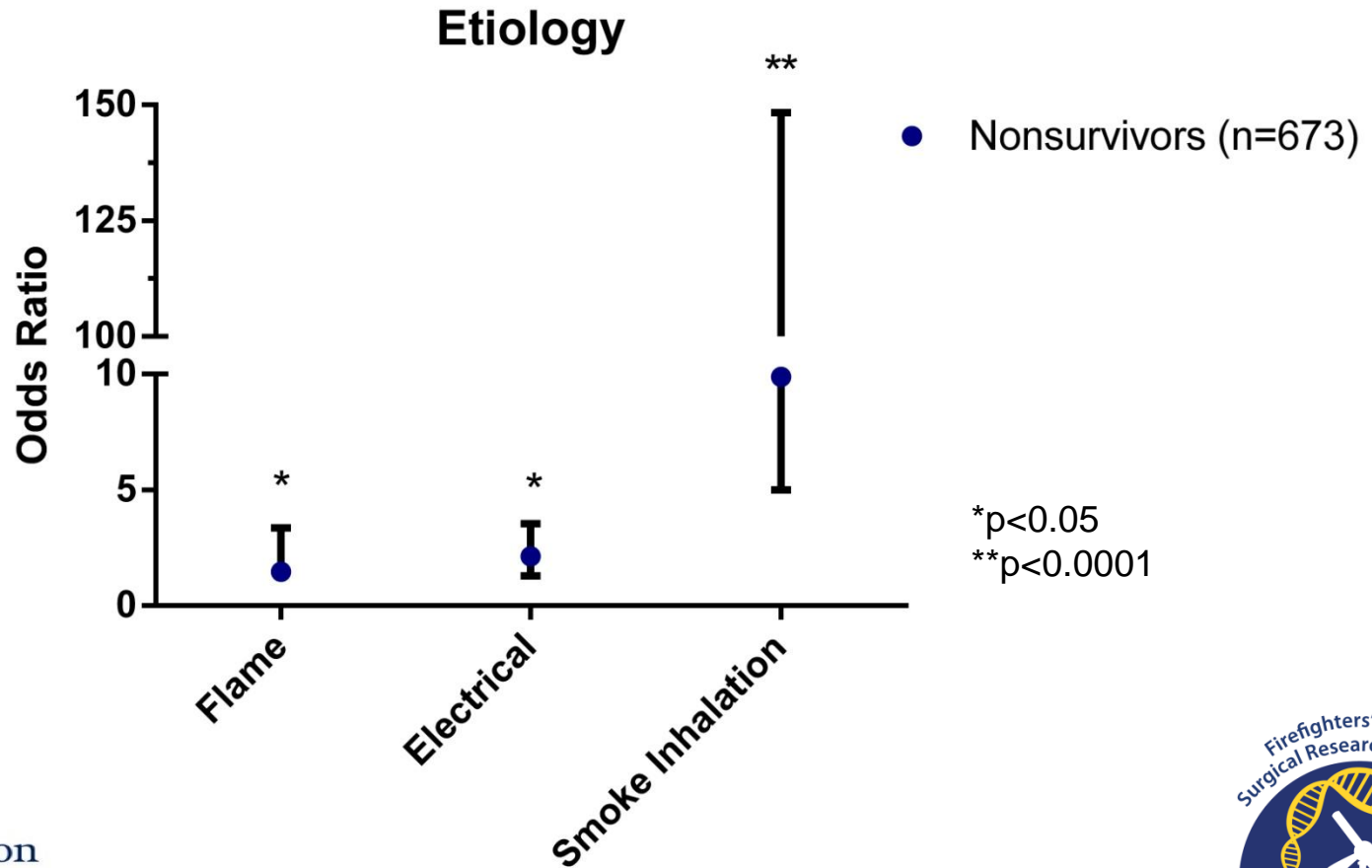
The Burn Center   
MedStar Health



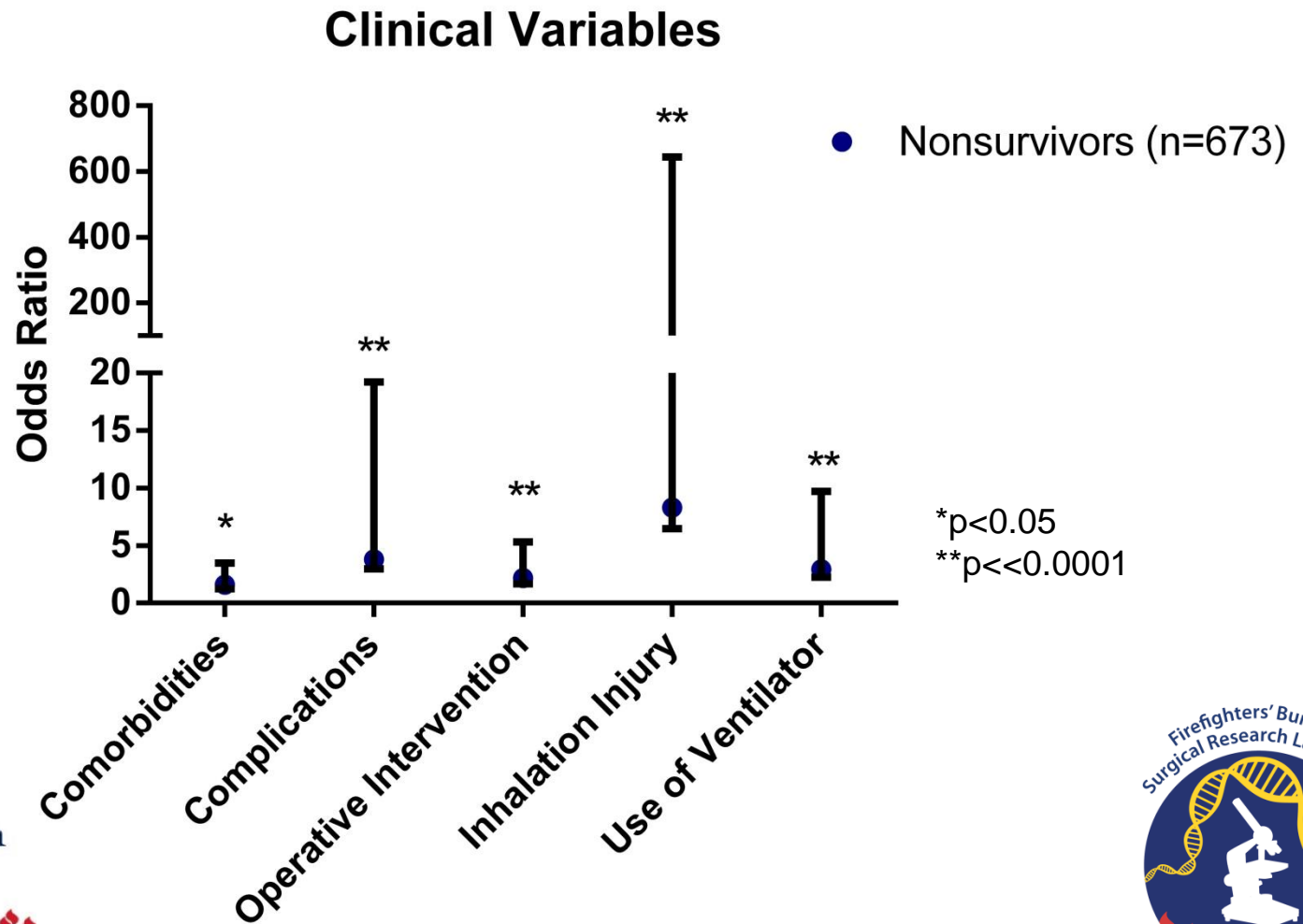
# Numerical Variables of Interest



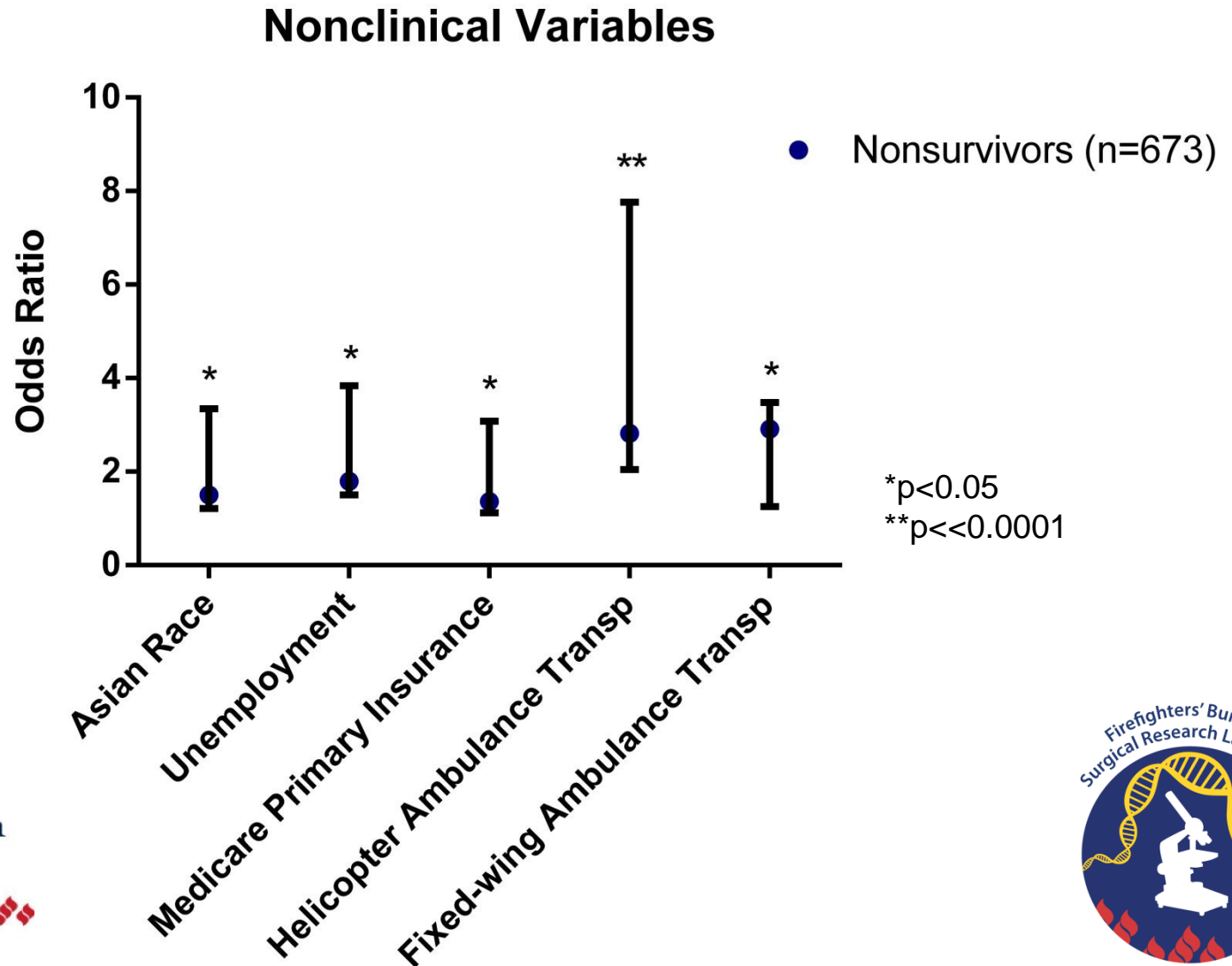
# Categorical Variables of Interest



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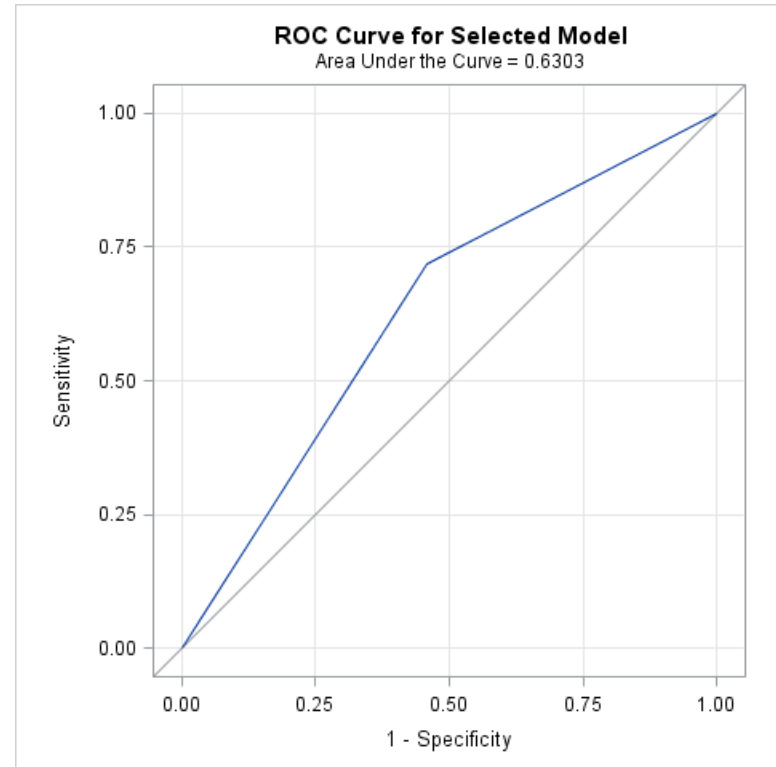


# Multivariate Analysis of Contributing Variables

Variable	P-value	Odds ratio	AUC	HLGoF
Presence of Complication	<0.0001	3.023 (2.306, 3.964)	0.6303	N/A

# Complications

- Presence of complication
  - OR = 3.023



# Multivariate Analysis of Contributing Variables

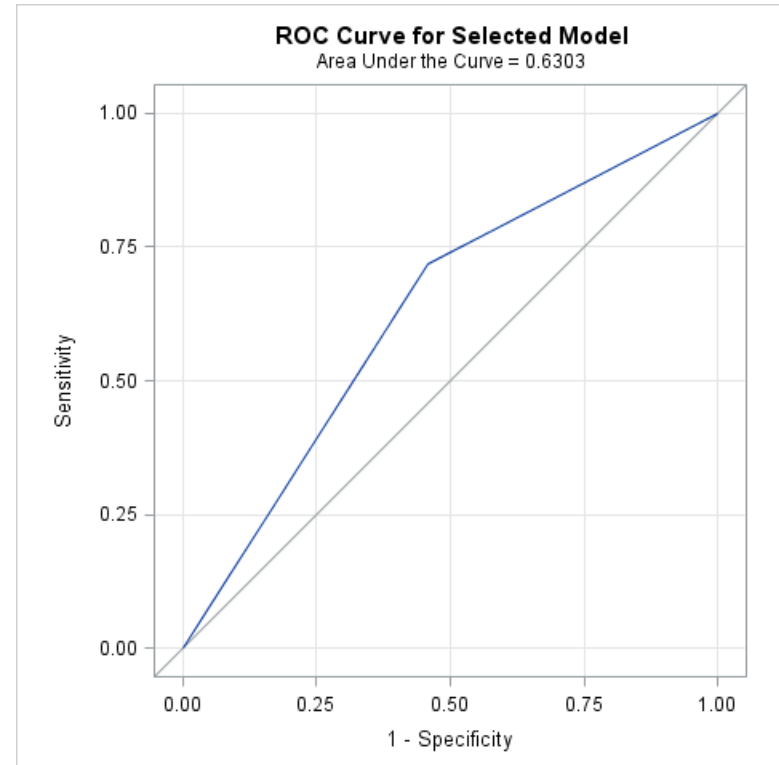
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**No change when adjusting for comorbidities.**



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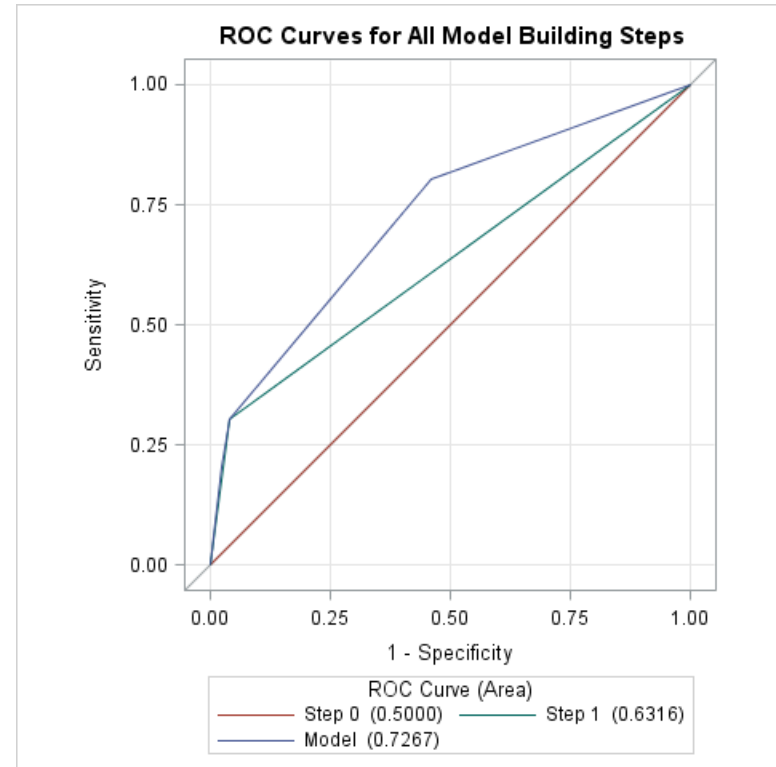
**No change when adjusting for comorbidities.**

# Multivariate Analysis of Contributing Variables

Variable	P-value	Odds ratio	AUC	HLGoF
Presence of Complication	<0.0001	2.977 (2.198, 4.033)	0.7267	0.5217
History of Inhalation Injury	<0.0001	9.988 (6.391, 15.608)	0.6313	

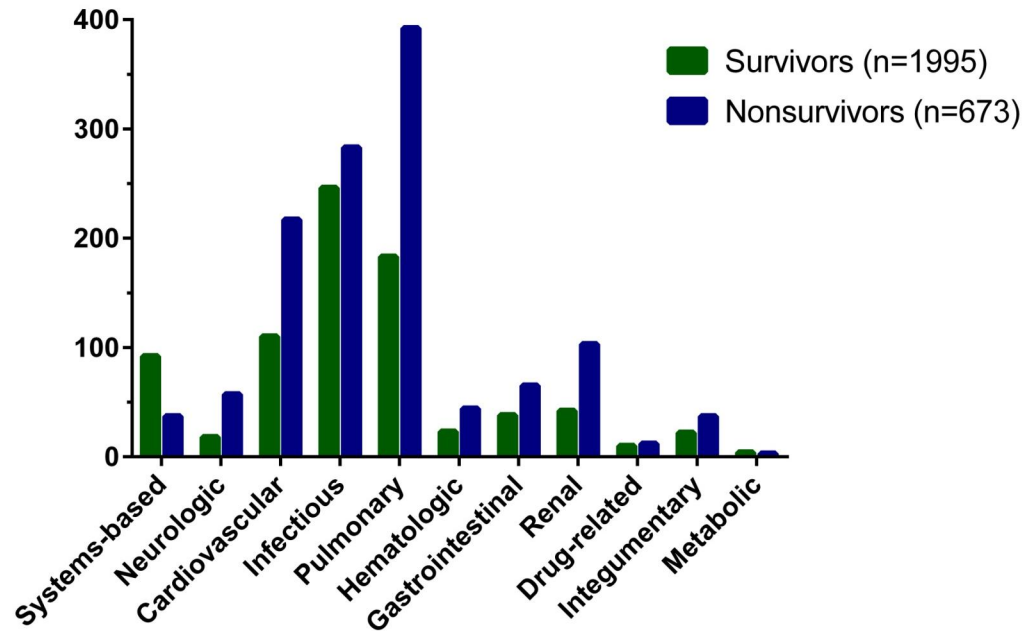
# Complications and Inhalation Injury

- History of inhalation injury
  - OR = 9.988
- Presence of complication
  - OR = 2.977

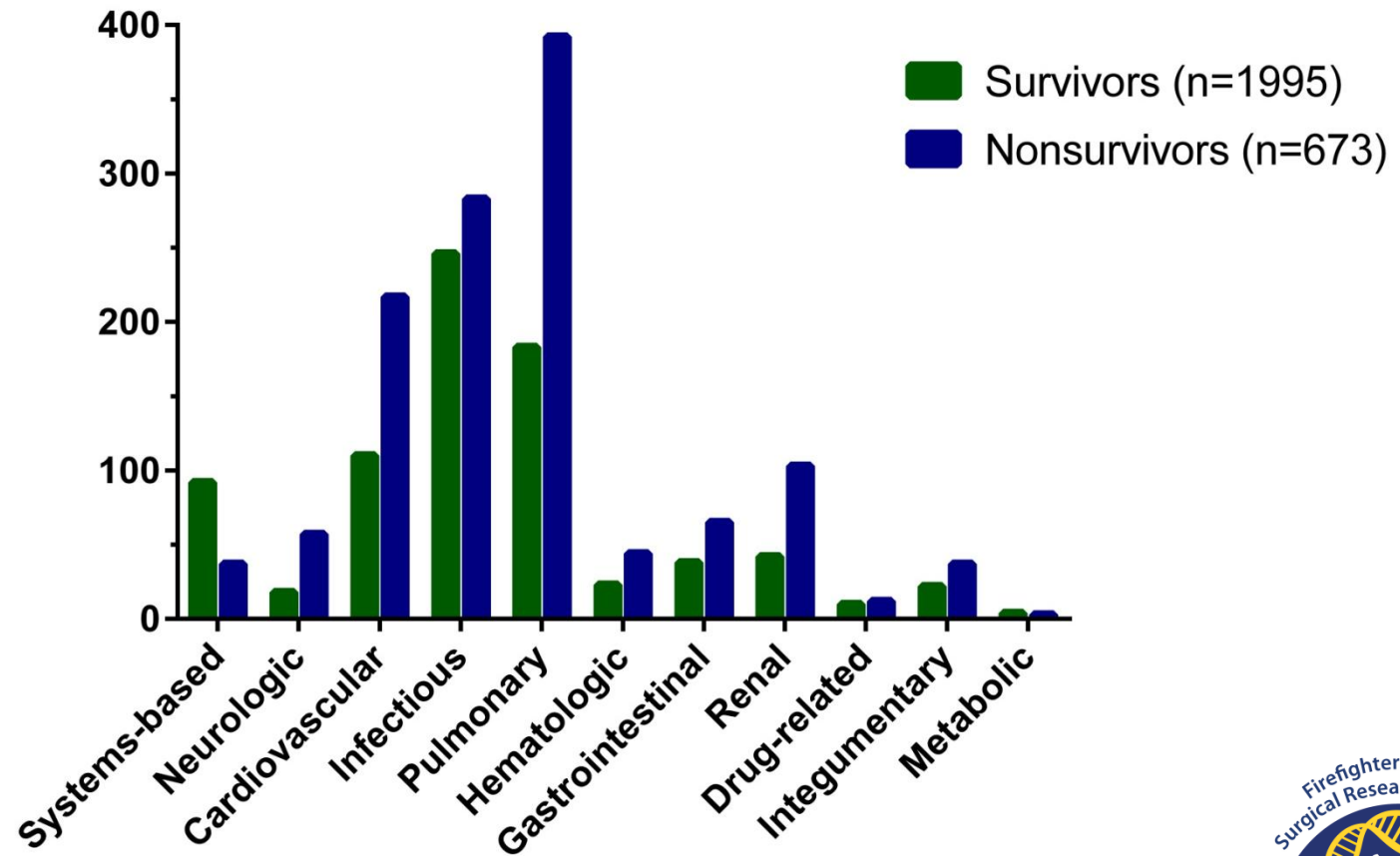


# Complications

- **2038** identifiable complications
- **788** complications among **survivors**
- **1250** complications among **nonsurvivors**



# Complications

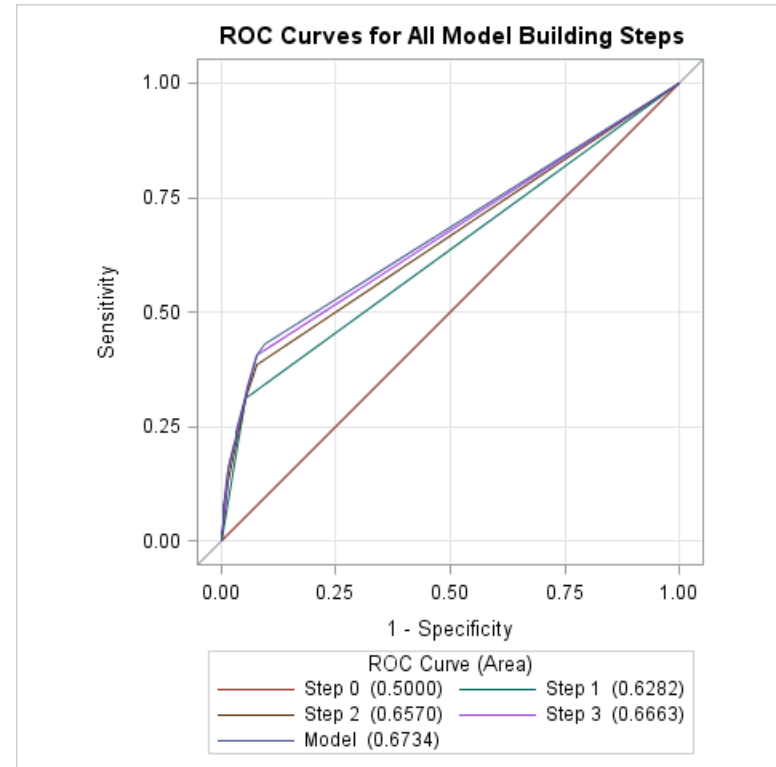


# Multivariate Analysis of Complication Types

Variable	P-value	Odds ratio	AUC	HLGoF
Pulmonary	<0.0001	4.593 (3.427, 6.157)	0.6282	0.0003
Cardiovascular	<0.0001	3.103 (2.217, 4.344)	0.6570	
Neurologic	<0.0001	4.999 (2.466, 10.135)	0.6663	
Infectious	0.0125	1.625 (1.110, 2.378)	0.6734	

# Complications

- Pulmonary
  - OR = 4.593
- Cardiovascular
  - OR = 3.103
- Neurologic
  - OR = 4.999
- Infectious
  - OR = 1.625



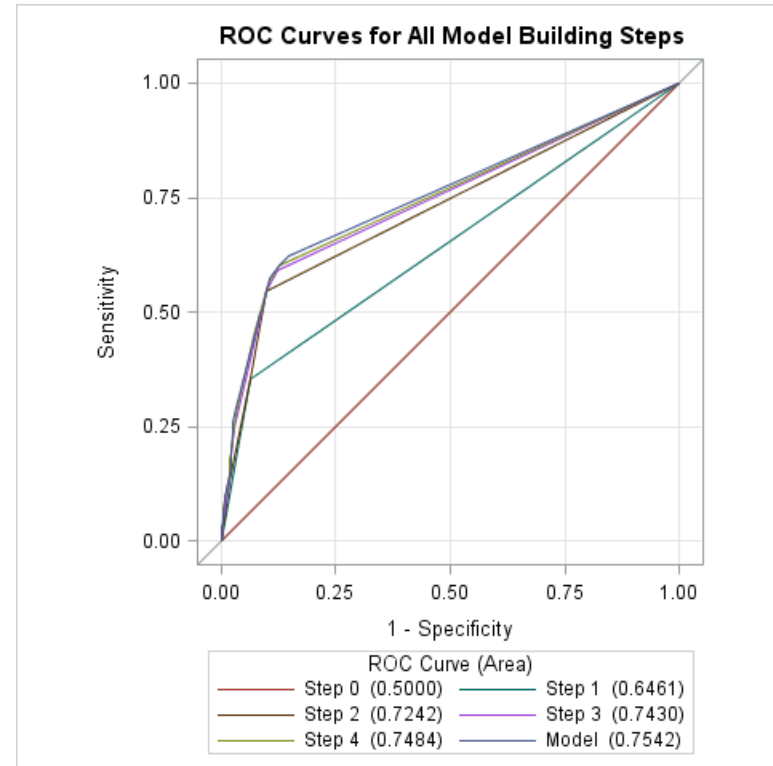
# Multivariate Analysis of Complication Types

Variable	P-value	Odds ratio	AUC	HLGoF
Inhalation injury	<0.0001	6.609 (5.063, 8.267)	0.6461	0.0001
Pulmonary	<0.0001	3.326 (2.407, 4.594)	0.7242	
Cardiovascular	<0.0001	3.322 (2.241, 4.616)	0.7430	
Neurologic	0.0001	4.458 (2.093, 9.496)	0.7484	
Renal	0.0119	1.621 (1.112, 2.362)	0.7542	



# Complications

- Inhalation Injury
  - OR = 6.609
- Pulmonary
  - OR = 3.326
- Cardiovascular
  - OR = 3.322
- Neurologic
  - OR = 4.458
- Renal
  - OR = 1.621

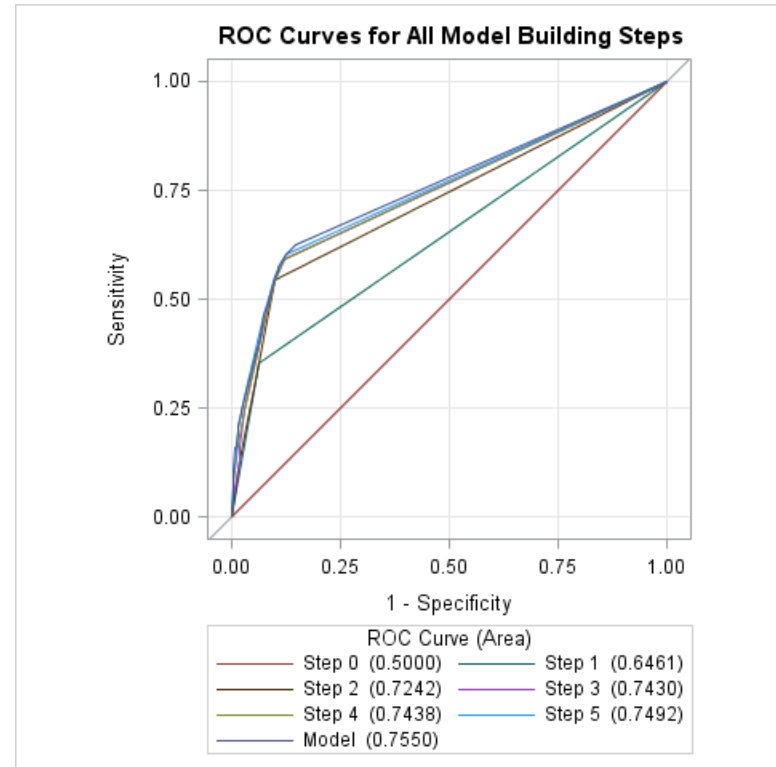


# Multivariate Analysis of Complication Types

Variable	P-value	Odds ratio	AUC	HLGoF
Cardiovascular	<0.0001	2.942 (2.944, 4.234)	0.7430	0.1484
Neurologic	0.0002	4.174 (1.948, 8.944)	0.7492	
Renal	0.0189	1.561 (1.076, 2.264)	0.7550	

# Complications

- Cardiovascular
  - OR = 2.942
- Neurologic
  - OR = 4.174
- Renal
  - OR = 1.561



# Survival Rate in the NBR

- Overall survival rate for burns treated at US burn centers ~96%
- Still have a consistent death rate of ~0.6% among those with <10% TBSA burns

Table 9 MORTALITY RATE BY AGE GROUP AND BURN SIZE (EXPRESSED AS THE NUMBER OF DEATHS OVER THE TOTAL NUMBER OF PATIENTS IN THAT GROUP)

Age Group	Burn Size (% TBSA)										Total
	0.1 - 9.9	10 - 19.9	20 - 29.9	30 - 39.9	40 - 49.9	50 - 59.9	60 - 69.9	70 - 79.9	80 - 89.9	> 90	
Birth - .9	0.3	1.8	6.9	9.4	24.7	28.8	44.9	50.0	70.4	91.7	2.9
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80 or Greater	6.9	28.7	63.9	77.2	89.0	96.7	86.7	93.5	97.1	100.0	24.9
Died/Total	100/1455	100/345	100/155	100/155	100/155	100/155	100/155	100/155	100/155	100/155	100/155
Total	0.6	2.9	8.5	16.3	25.4	37.5	42.6	56.2	72.5	84.8	3.6
Died/Total	100/1455	100/345	100/155	100/155	100/155	100/155	100/155	100/155	100/155	100/155	100/155

Outcome  
■ Lived (96.3%)  
■ Died (3.7%)

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# Neurologic Complications

- Electrical injury
  - May cause nerve paralysis, cognitive dysfunction, spinal cord injury
- Anoxic brain injury
  - Associated inhalation injury
- Stroke
  - Associated cardiovascular complications
- Burn-induced cerebral inflammation



<http://www.atsdr.cdc.gov>

# Cardiovascular Complications

- Arrhythmia
- Myocardial infarction
- Burn-induced myocardial injury
  - Associated AKI



<http://www.atsdr.cdc.gov>

# Renal Complications

- Acute kidney injury
  - Often associated with burn shock
- Inflammation-induced renal injury
- Even moderately decreased kidney function impacts outcomes



<http://www.atsdr.cdc.gov>

# Pulmonary Complications

- Inhalation injury
  - Well known poor prognostic factor
  - Often leads to mechanical ventilation
  - Increased risk of pulmonary infection
  - Inhalation injury plus pneumonia increases mortality



<http://www.atsdr.cdc.gov>



# Deaths in Burns $\leq 10\%$ TBSA

- Complications are associated with death in low TBSA burns
- Average age of study population: 64 years
  - Older populations are known to suffer more complications during hospitalization

# Deaths in Burns $\leq 10\%$ TBSA

- Special attention to complications associated with death in small burns:
  - Neurologic
  - Cardiovascular
  - Renal
  - Pulmonary
- Pulmonary complications are associated with inhalation injury

# Acknowledgements

American Burn Association

DC Firefighters' Burn Foundation

Lauren Moffatt, PhD

Jeffrey Shupp, MD

Marion Jordan, MD, FACS



# Case Matching

Matching Variable	Case	Control	p-value
Average age	64.05±20.33	63.75±20.29	0.736 (ns)
Average TBSA	5.16±2.99	5.09±2.96	0.598 (ns)
# males/total	401/673 (59.6%)	1204/1995 (60.4%)	0.838 (ns)
# females/total	272/673 (40.4%)	791/1995 (39.6%)	0.801 (ns)

# Numerical Variables of Interest

Variable	Case average (SD)	Control average (SD)	t-test p-value
Carboxyhemoglobin (%)	15.3 (16.1)	3.4 (6.4)	<0.0001
# Ventilator days	10.6 (21.8)	0.8 (3.6)	<0.0001
# ICU days	13.4 (22.8)	4.1 (9.1)	<0.0001
# Hospital days	17.7 (26.6)	10.1 (12.4)	<0.0001
# Operative procedures	2.0 (4.7)	1.4 (2.2)	0.0083
Cumulative full-thickness TBSA (%)	2.3 (2.8)	1.5 (2.5)	<0.0001
Cumulative partial-thickness TBSA (%)	3.2 (3.0)	3.9 (3.1)	<0.0001

# Numerical Variables of Interest

Variable	Case average (SD)	Control average (SD)	t-test p-value
Carboxyhemoglobin (%)	15.3 (16.1)	3.4 (6.4)	<0.0001
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# Operative procedures	2.0 (4.7)	1.4 (2.2)	0.0083
Cumulative full-thickness TBSA (%)	2.3 (2.8)	1.5 (2.5)	<0.0001
Cumulative partial-thickness TBSA (%)	3.2 (3.0)	3.9 (3.1)	<0.0001

# Categorical Variables of Interest

Variable	Categories Associated with Cases	Odds ratio associated with case	95% confidence interval	Chi-square p-value
Etiology category	Flame	1.46	1.21, 3.36	0.0051
	Electrical	2.14	1.29, 3.64	0.0029
	Smoke inhalation	9.88	5.00, 148.36	<0.0001
Inhalation injury	History of inhalation injury	8.30	6.47, 643.68	<0.0001
Comorbidities	History of comorbidity	1.61	1.25, 3.49	0.0011
Complications	Occurrence of complication	3.80	2.96, 19.21	<0.0001
Operative intervention	History of operative intervention	2.17	1.67, 5.31	<0.0001
Ventilator days	History of ventilator days	2.93	2.27, 9.70	<0.0001
Race	Asian	1.50	1.21, 3.35	0.0081
Transportation	Helicopter ambulance	2.82	2.05, 7.76	<0.0001
	Fixed-wing ambulance	2.91	1.25, 3.48	0.0103
Employment	Unemployed	1.80	1.35, 3.84	0.0298
Primary insurance	Medicare	1.36	1.12, 3.08	0.0267



# Comorbidities and Complications

Components of model		Significant Variable	Odds ratio associated with case	95% CI	p-value	Area under the ROC	HLGoF test
1. 2.	Comorbidity Complication	Presence of complication	3.023	2.306, 3.964	<0.0001	0.6303	N/A
1. 2. 3.	Comorbidity Complication Comorbidity-complication interaction	Presence of complication	3.023	2.306, 3.964	<0.0001	0.6303	N/A
1. 2. 3.	Comorbidity Complication Comorbidity-complication interaction	Presence of inhalation injury	9.988	6.391, 15.608	<0.0001	0.6313	0.5217
4.	Inhalation injury	Presence of complication	2.977	2.198, 4.033	<0.0001	0.7267	0.5217
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5.	Complication-inhalation injury interaction						

# Comorbidities, Complications, and Inhalation Injury

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2.	Complication						
3.	Comorbidity-complication interaction						
1.	Comorbidity	<b>Presence of inhalation injury</b>	9.988	6.391, 15.608	<0.0001	0.6313	0.5217
2.	Complication	<b>Presence of complication</b>	2.977	2.198, 4.033	<0.0001	0.7267	0.5217
3.	Comorbidity-complication interaction						
4.	Inhalation injury						
1.	Comorbidity	Presence of inhalation injury	9.988	6.391, 15.608	<0.0001	0.6313	0.5217
2.	Complication						
3.	Comorbidity-complication interaction	Presence of complication	2.977	2.198, 4.033	<0.0001	0.7267	0.5217
4.	Inhalation injury						
5.	Complication-inhalation injury interaction						

# Comorbidities, Complications, and Inhalation Injury

Components of model		Significant Variable	Odds ratio associated with case	95% CI	p-value	Area under the ROC	HLGoF test
1. 2.	Comorbidity Complication	Presence of complication	3.023	2.306, 3.964	<0.0001	0.6303	N/A
1. 2. 3.	Comorbidity Complication Comorbidity-complication interaction	Presence of complication	3.023	2.306, 3.964	<0.0001	0.6303	N/A
1. 2. 3.	Comorbidity Complication Comorbidity-complication interaction	Presence of inhalation injury	9.988	6.391, 15.608	<0.0001	0.6313	0.5217
4.	Inhalation injury	Presence of complication	2.977	2.198, 4.033	<0.0001	0.7267	0.5217
1. 2. 3.	Comorbidity Complication Comorbidity-complication interaction	Presence of inhalation injury	9.988	6.391, 15.608	<0.0001	0.6313	0.5217
4. 5.	Inhalation injury Complication-inhalation injury interaction	Presence of complication	2.977	2.198, 4.033	<0.0001	0.7267	0.5217

# Complications

Complication category	# in Case group	# in Control group	Total
Systems-based	37	92	129
Neurologic	57	18	75
Cardiovascular	217	110	327
Infectious	283	246	529
Pulmonary	392	183	575
Hematologic	44	23	67
Gastrointestinal	65	38	103
Renal	103	42	145
Drug-related	12	10	22
Integumentary	37	22	59
Metabolic	3	4	7
<b>Total</b>	1250	788	2038

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