

Using GIS to Map Agricultural Injuries and Level 1 Trauma Units: Providing a Vision for Comprehensive Care and Prevention Strategies

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Learning Objectives

Identify The primary causes of traumatic injury in agricultural workers.

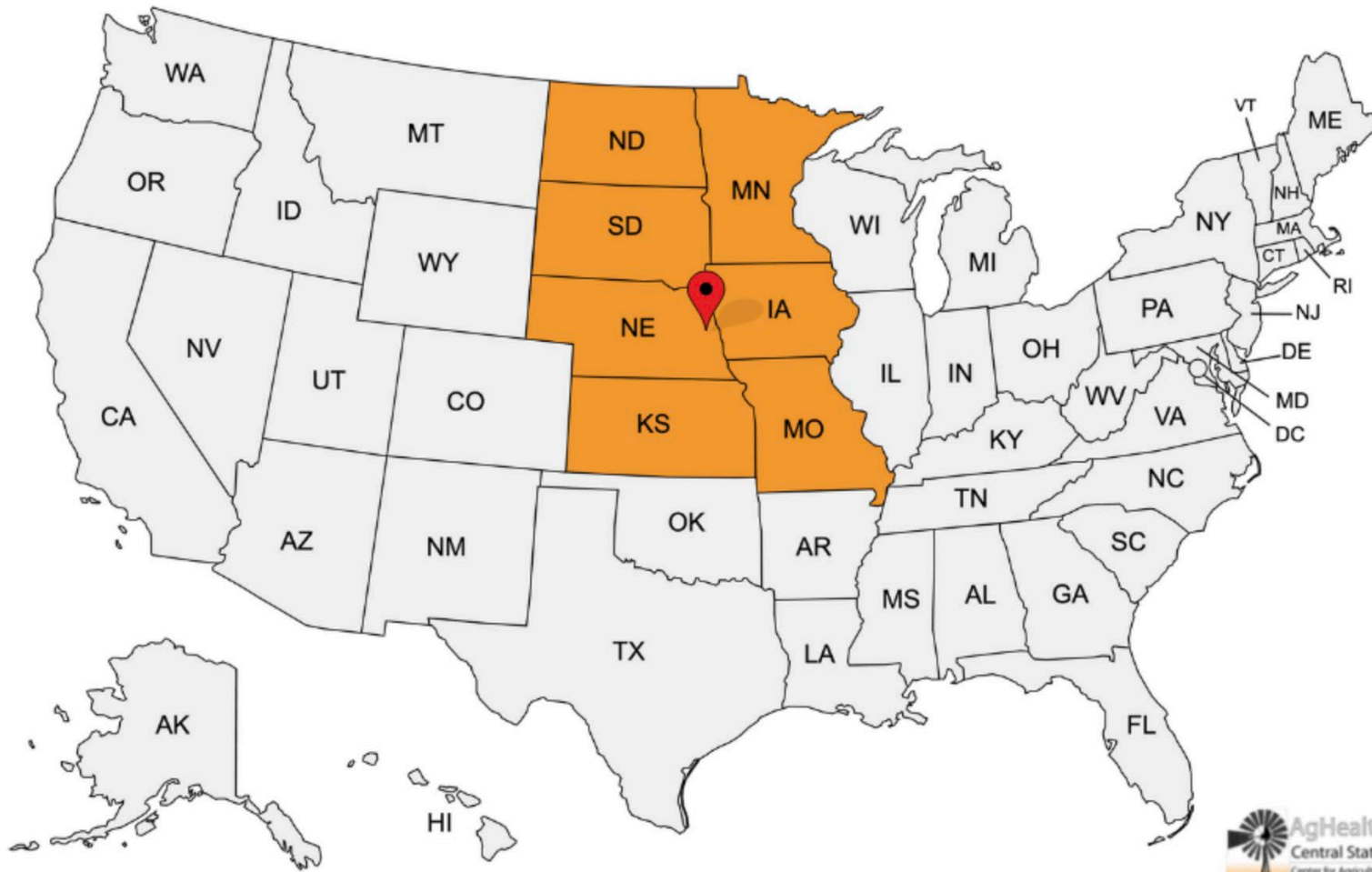
Recognize How age, gender and other factors play a role in increasing the risk for agricultural injury.

Describe Prevention measures that will reduce the risk of injury.

Disclosures: Nothing to disclose

Central States Center for Agricultural Safety and Health (CS-CASH)
NIOSH Funded Agricultural, Forestry and Fishing Safety Center
UNMC College of Public Health







Agricultural Fatalities

Agricultural Worker Fatality Rate - 20.0 per 100,000

All other industries combined- 3.6 per 100,000¹



¹NIOSH 2023

Agricultural Injuries



In 2021 the annual injury rate of self-employed farmers and ranchers in the CS-CASH 7-states region was **15 injuries/100 operators¹**.



¹Rautiainen 2022.

Young Agricultural Workers and Children Living on the Farm



A child dies in an agriculture-related incident about every 3 days and 33 children are treated for ag-related injuries each day.

Young workers are 7.8 times more likely to be fatally injured in agriculture when compared to all other industries combined (14.57 per 100,000 FTE vs 1.87 per 100,000 FTE)





The Causes

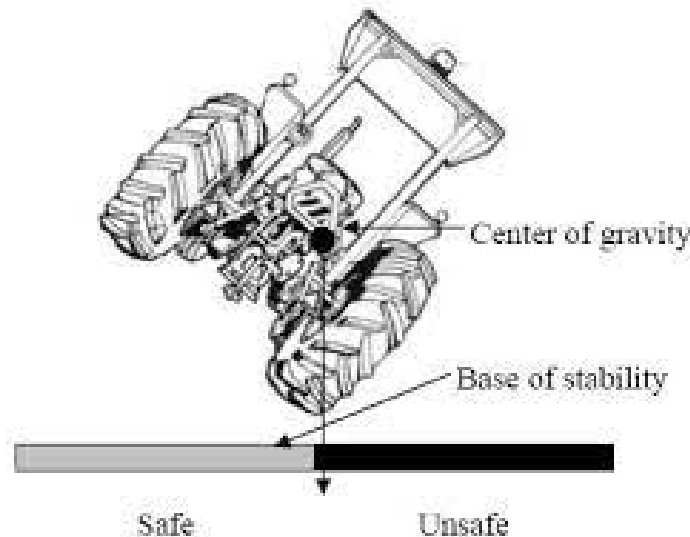
Two common types of ag incidents - rollovers and entanglements



Tractor Rollovers

Primary Source of Agricultural Fatalities¹

- Rollovers Account for 76% of All Fatalities
- High Center of Gravity, Rear Wheel Drive, Improper Loading, Operation on Uneven Terrain
- 80% of deaths caused by tractor overturns involve experienced operators.
- 1 in 7 farmers involved in tractor overturns is permanently disabled.
- 7 of 10 farms will go out of business within 5 years following a tractor-related fatality.

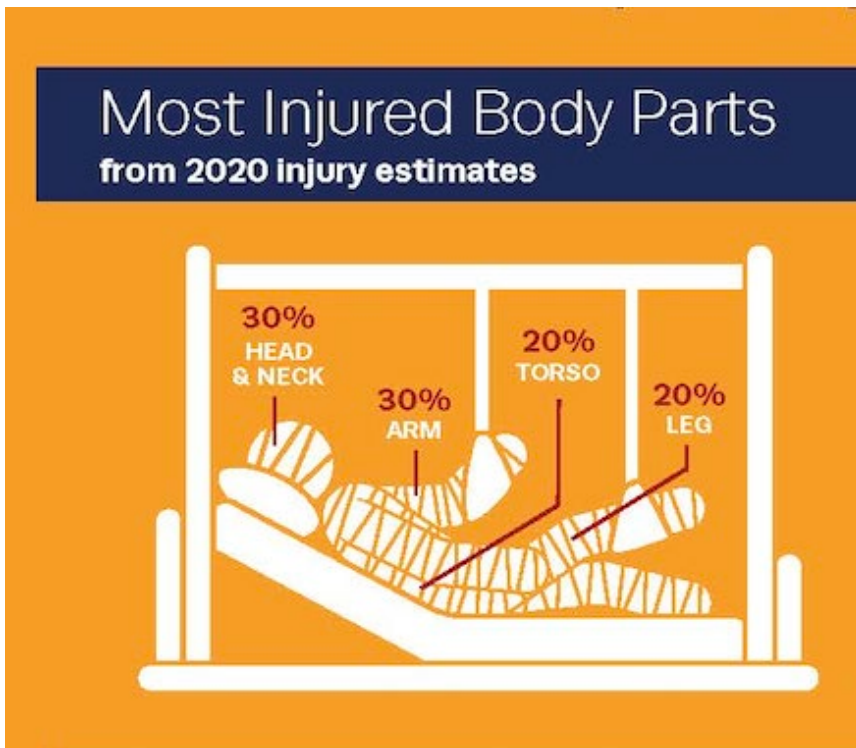


(¹Reynolds and Groves, 2000)



All Terrain Vehicle Rollovers

Agriculture accounts for 59% of ATV-related injuries¹
ATV's account for an estimated 95,000 ER visits each year².



⚠ WARNING

**UNDER
16**

Operating this ATV if you are under the age of 16 increases your chance of severe injury or death.

NEVER operate this ATV if you are under age 16.

¹(Neves et al., 2018)

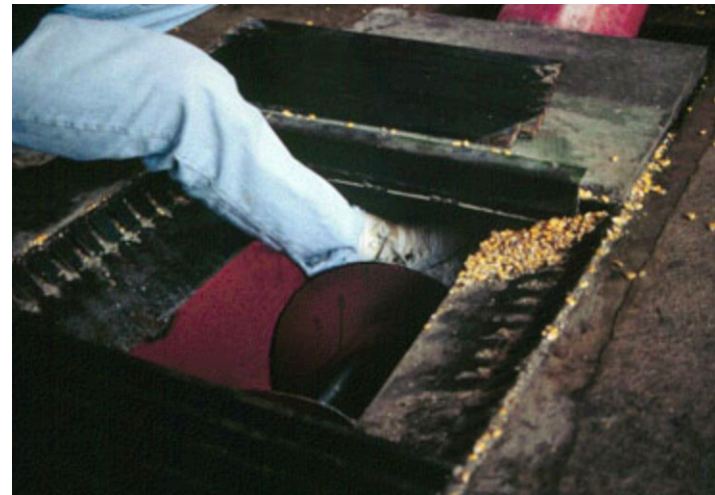
²<https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/ATV-Safety-Information-Center>.



Machinery Entanglements

A body part or material is caught in a moving part of equipment (wrap point) resulting in a person becoming pinched, crushed, or wrapped in the machine part.

Examples – tractor power take and grain bin augers



Fatality Assessment and Control Evaluation



Promoting productive workplaces
through safety and health research / **NIOSH**

Farm Youth Died When He Became Entangled in an Unguarded PTO Shaft

[Print](#)

Investigation: # 03MI052

SUMMARY



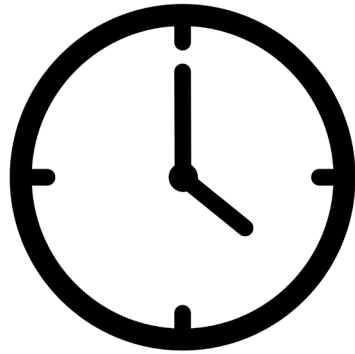
Figure 1. Clothing entangled on bolt on PTO tractor stub shaft

On May 23, 2003, a 13-year-old farm youth was killed when he became entangled in an unguarded rotating power take-off (PTO) shaft at the rear of his narrow front Farmall Model M tractor. (See [Figure 1](#)) The youth and his teenage cousin were raking hay in a field that had been cut a few days prior on an adjoining property. Both were driving narrow front Farmall Model M tractors equipped with a non-PTO powered hay rake designed for attachment to the tractor's drawbar. Neither tractor had a PTO master shield installed. The victim's tractor was ahead of his cousin's tractor and as he had already finished raking, had driven the tractor up near the barn. The victim's tractor had an owner-modified extension lever to

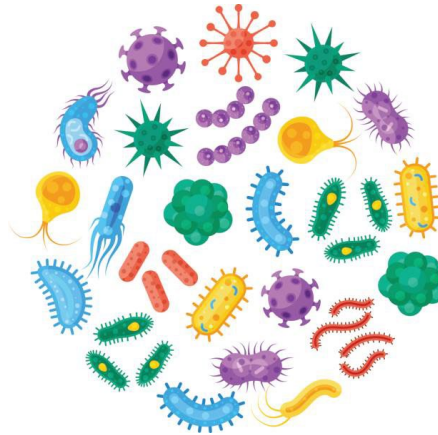


Triad of T's in Agriculture

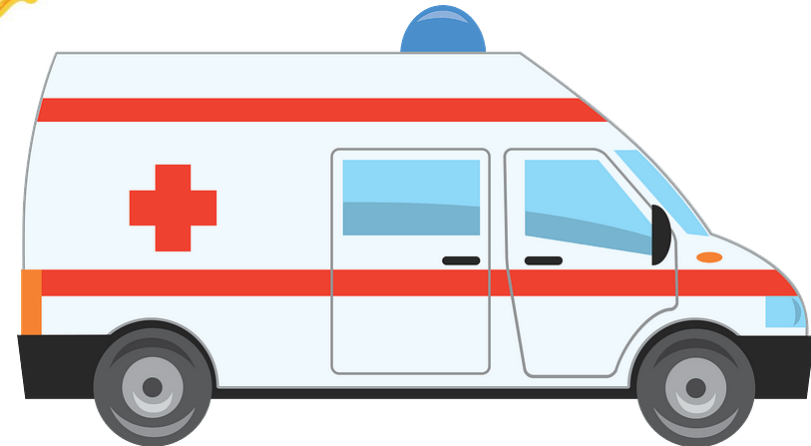
-Time



-Trash



-Trauma

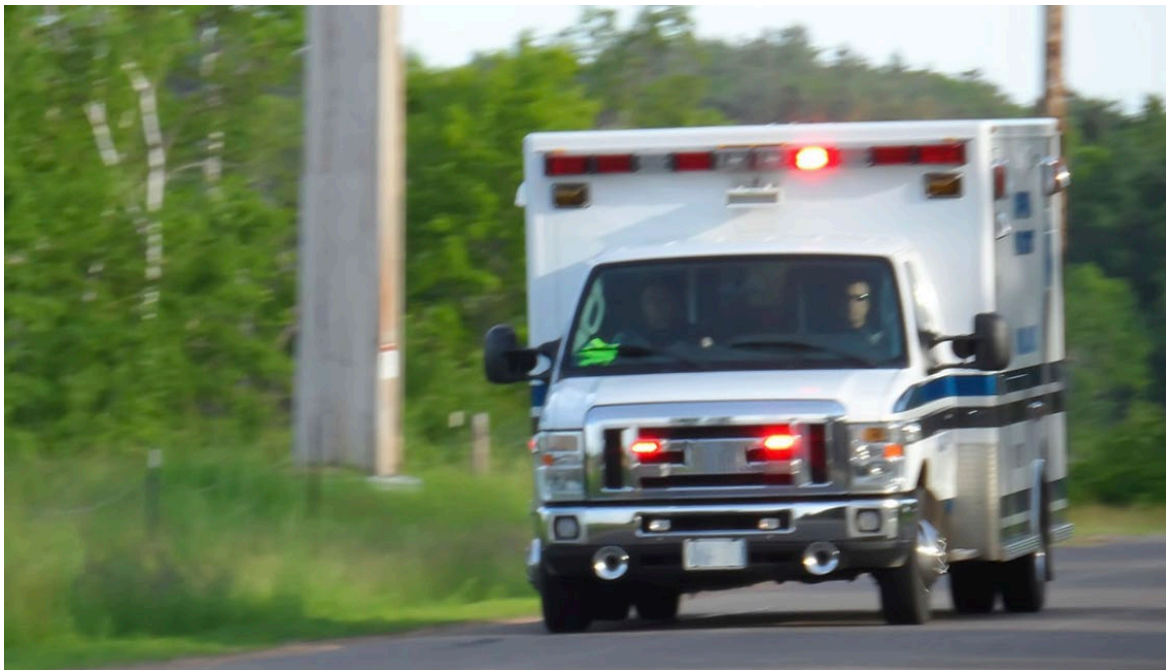




Research Question

Andrew Schissel, MPH (Student Capstone research)

Does Distance to Level 1 Trauma Unit Affect the Outcome (Injury vs. Fatality) of Tractor Rollover, ATV Rollover, and Equipment Entanglement Incidents?





Data Collection and Preparation

- CS-CASH ag injury and fatality News Clipping Database (2012-2022)
- CS-CASH 7-states region (ND, SD, MN, IA, NE, KS, MO)
- Removed Incidents That Didn't Meet Inclusion Criteria

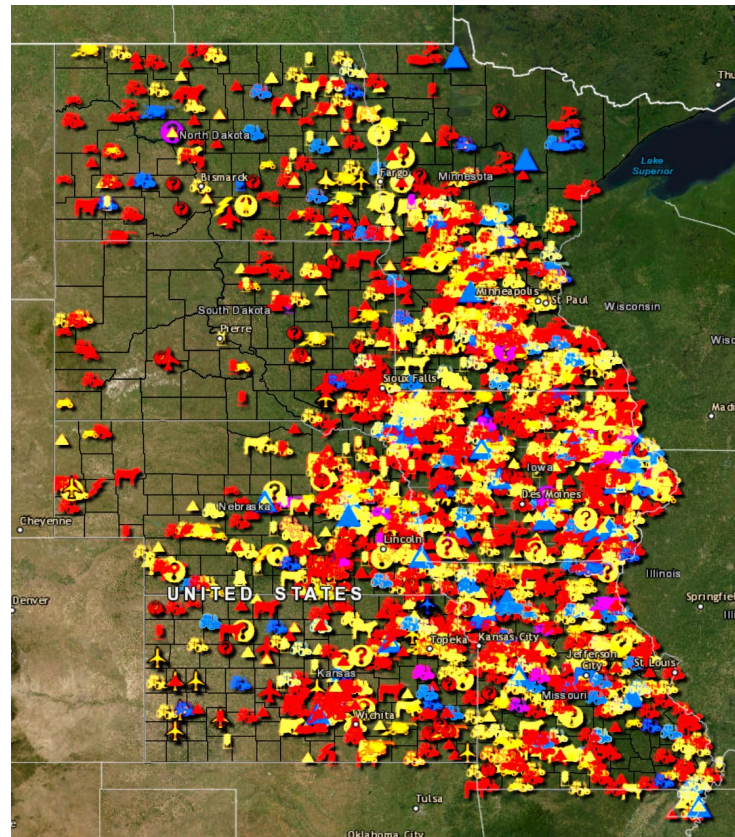
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|----|-----------|---------------|--------------|---|---|-----|-----|----------------|------------|-------------|----------|----------|-----------|----------|---|
| 1 | date | accident_type | Fatality_Inj | headline | short_incident_description | sex | age | city | state | county | zip_code | latitude | longitude | miles | |
| 2 | 4/7/2012 | ATV Rollover | Injury | Greeley boy injured Saturday | Operator pinned under UTV in unspecified farm-relate | M | | 14 Spalding | Nebraska | Greeley | 68665 | 41.68878 | -98.3669 | 127.4403 | |
| 3 | 4/19/2012 | ATV Rollover | Injury | Area man injured in ATV crash in rural Princeton | ATV crash while doing chores on farm | M | | Princeton | Iowa | Scott | 52768 | 41.67333 | -90.3431 | 62.29892 | |
| 4 | 4/20/2012 | ATV Rollover | Fatality | ATV death evokes painful memories | Operator of ATV with passenger pinned underneath w/ M | | | 8 Berlin | North Dakc | LaMoure | 58415 | 46.37833 | -98.4878 | 83.18135 | |
| 5 | 4/22/2012 | ATV Rollover | Injury | Leigh woman injured in accident | Operator of ATV pinned underneath when it rolled in c F | | | 29 Leigh | Nebraska | Colfax | 68643 | 41.70523 | -97.2381 | 72.3211 | |
| 6 | 5/10/2012 | ATV Rollover | Fatality | 7-year-old dies in farm accident | Operator of 4-wheeler that overturned while doing ch/ M | | | 7 La Motte | Iowa | Jackson | 52054 | 42.29529 | -90.621 | 64.72508 | |
| 7 | 6/21/2012 | ATV Rollover | Fatality | Teen dies from ATV injuries | Operator of ATV left of pickup that turned left colliding F | | | 15 Adams | North Dakc | Walsh | 58210 | 48.42139 | -98.0742 | 122.3527 | |
| 8 | 8/5/2012 | ATV Rollover | Fatality | Turtle Lake girl dies in ATV crash | Unspecified injuries from ATV incident on family farm | F | | 10 Turtle Lake | North Dakc | McLean | 58575 | 47.51944 | -100.891 | 194.6111 | |
| 9 | 1/16/2013 | ATV Rollover | Injury | Operator of ATV pinned underneath when it overturne | Semi-pedestrian accident occurs in Talmage | M | | Osawatomo | Kansas | Miami | 66064 | 38.49889 | -94.9509 | 40.42122 | |
| 10 | 5/9/2013 | ATV Rollover | Injury | Son ahead of father on ATV herding cattle when father | St. Francis rancher survives accident | M | | 72 Saint Franc | Kansas | Cheyenne | 67756 | 39.77139 | -101.801 | 161.8021 | |
| 11 | 7/15/2013 | ATV Rollover | Fatality | Passenger pinned under UTV that overturned into gully | Life claimed Mon | F | | 66 Neligh | Nebraska | Antelope | 68756 | 42.13 | -98.0292 | 121.9708 | |
| 12 | 8/15/2013 | ATV Rollover | Injury | Psng in ATV checking field compliance thrown from A | Woman falls into a sinkhole | F | | 28 Ste. Genevi | Missouri | Ste. Genevi | 63670 | 37.97694 | -90.0486 | 44.53357 | |
| 13 | 4/5/2014 | ATV Rollover | Injury | Day Tapia injured in ATV accident | Firefighter and police dispatcher on ATV uphill monito | M | | 51 Arkansas | C Kansas | Cowley | 67005 | 37.06528 | -97.0397 | 45.6648 | |
| 14 | 4/5/2014 | ATV Rollover | Injury | Day Tapia injured in ATV accident | Firefighter and police dispatcher on ATV uphill monito | F | | 33 Arkansas | C Kansas | Cowley | 67005 | 37.06528 | -97.0397 | 45.6648 | |
| 15 | 4/14/2014 | ATV Rollover | Injury | Man airlifted to Bismarck hospital after ATV accident | Unspecified ATV incident at grain and feed enterprise | M | | 52 Dickinson | North Dakc | Stark | 58602 | 46.88361 | -102.789 | 279.9328 | |
| 16 | 5/1/2014 | ATV Rollover | Fatality | Anselmo man killed in ATV accident while moving cattl | Unspecified ATV incident while moving cattle | M | | 82 Anselmo | Nebraska | Custer | 68813 | 41.61889 | -99.8642 | 203.2 | |
| 17 | 5/20/2014 | ATV Rollover | Fatality | Aurelia killed when ATV rolls | Trapped when ATV overturned onto operator while sp/ F | | | 55 Aurelia | Iowa | Cherokee | 51005 | 42.71247 | -95.4382 | 103.8466 | |
| 18 | 7/19/2014 | ATV Rollover | Injury | Four minor accidents reported | Operator of ATV owned by irrigation firm ejected after M | | | Ithaca | Nebraska | Saunders | 68033 | 41.15996 | -96.5406 | 29.99705 | |
| 19 | 1/31/2015 | ATV Rollover | Injury | Two injured in ATV accident Saturday | Side-by-side ATV overturned traveling at high speed th M | | | 29 North Platt | Nebraska | Lincoln | 69103 | 41.13251 | -100.764 | 235.2106 | |
| 20 | 1/31/2015 | ATV Rollover | Injury | Two injured in ATV accident Saturday | Side-by-side ATV overturned traveling at high speed th F | | | 29 North Platt | Nebraska | Lincoln | 69103 | 41.13251 | -100.764 | 235.2106 | |
| 21 | 2/24/2015 | ATV Rollover | Injury | Greeley man injured | Operator injured when ATV flipped while working with M | | | Greeley | Nebraska | Greeley | 68842 | 41.54806 | -98.5308 | 134.0591 | |
| 22 | 5/15/2015 | ATV Rollover | Injury | Man injured in ATV accident | Operator of ATV that overturned after striking ditch in M | | | 7 Leota | Missouri | Clatsop | 63450 | 38.71061 | -92.1401 | 53.70514 | |

GIS Mapping

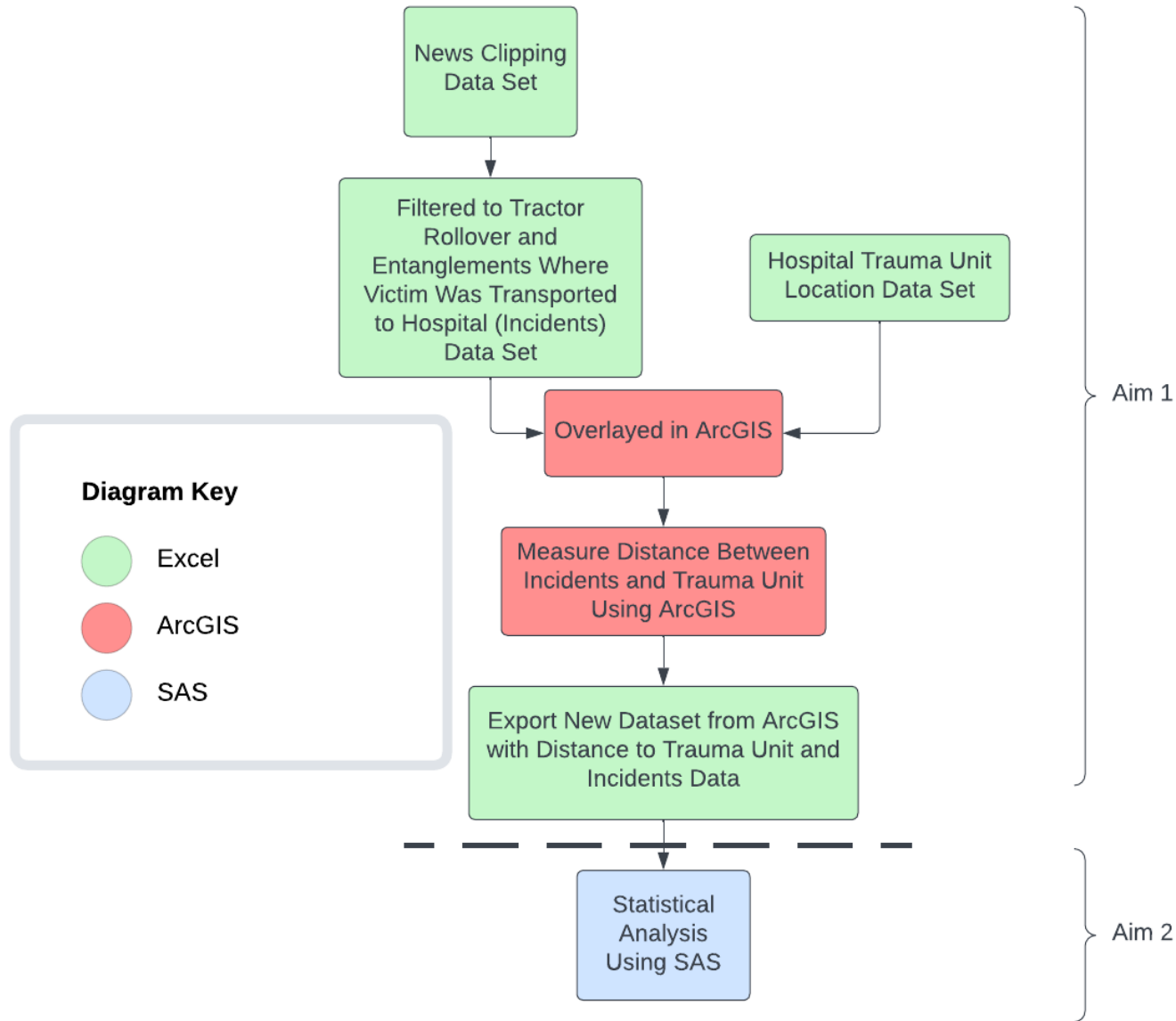
Used ArcGIS software

Mapped agricultural injuries and fatalities involving tractors, all-terrain and utility vehicles and entanglements.

Layered Level 1 Trauma Units onto the map of incidents.



Generation of Dataset for Statistical Analysis





Statistical Analysis

- Normality testing on variables of interest
 - distance and age
- Wilcoxon Rank Sum Test
 - Independent Variable: distance to Level 1 Trauma Unit
 - Dependent variable: incident outcome
- Age compared between incident outcome
- Chi Square Test comparing distribution of outcome between categorical miles and gender

Demographics



| Table 1: Dataset Descriptives | |
|---|--------------------|
| Age | Measure |
| Median (IQR) | 51.0 (38.0) |
| Gender (n,%) | |
| Female | 32 (10.5%) |
| Male | 272 (89.5%) |
| State Incidence (n, %) | |
| Iowa | 70 (22.7%) |
| Kansas | 19 (6.1%) |
| Minnesota | 76 (24.7%) |
| Missouri | 64 (20.8%) |
| Nebraska | 40 (13.0%) |
| North Dakota | 28 (9.1%) |
| South Dakota | 11 (3.6%) |
| Distance to Level 1 Trauma Unit (miles) | |
| Median (IQR) | 70.8 (45.2) |
| Outcome (n, %) | |
| Injury | 241 (78.3%) |
| Fatality | 67 (21.7%) |

Distance by Outcome



Table 2: Distance to Level 1 Trauma Unit by Outcome

| Region/State | Injury | | Fatality | | p-value* |
|--------------|--------|---------------|----------|---------------|----------|
| | N | Median (IQR) | N | Median (IQR) | |
| Overall | 241 | 70.8 (46.3) | 67 | 73.8 (50.8) | 0.54 |
| Iowa | 46 | 65.8 (28.7) | 24 | 68.8 (27.2) | 0.68 |
| Kansas | 18 | 59.3 (50.8) | 1 | 245.9 (-) | - |
| Minnesota | 66 | 68.9 (40.6) | 10 | 61.9 (38.5) | 0.95 |
| Missouri | 49 | 53.4 (32.4) | 15 | 59.7 (44.1) | 0.96 |
| Nebraska | 33 | 155.1 (151.4) | 7 | 122.0 (112.5) | 0.32 |
| North Dakota | 22 | 86.9 (84.9) | 6 | 139.1 (71.1) | 0.22 |
| South Dakota | 7 | 183.5 (79.1) | 4 | 214.4 (93.3) | 1.00 |

*Wilcoxon Rank Sum p-value



Other Variables of Interest

| Variable | Injury | | Fatality | | p-value |
|--------------------------|----------|--------------|----------|--------------|---------|
| | N | Median (IQR) | N | Median (IQR) | |
| Age | 169 | 46.0 (36.0) | 65 | 58.0 (31.0) | 0.006* |
| Gender | N | % | N | % | 0.38^ |
| Female | 23 | 9.7% | 9 | 13.4% | |
| Male | 214 | 90.3% | 58 | 86.6% | |
| Categorical Miles | | | | | 0.38^ |
| 0-49.99 | 66 | 27.4% | 12 | 17.9% | |
| 50.00-74.99 | 69 | 28.6% | 24 | 35.8% | |
| 75.00-99.99 | 50 | 20.8% | 13 | 19.4% | |
| 100+ | 56 | 23.2% | 18 | 26.9% | |

*Wilcoxon Rank Sum p-value

^Chi Square p-value

Recap



No observed significant differences in distance to Level 1 Trauma Unit between outcomes ($p=0.54$)

No significant association between categorical miles to Level 1 Trauma Unit and incident outcome ($p=0.38$)

Another study found an 8% increase in odds of death for every 5-mile increase in distance to nearest trauma center¹.

Age was found to be associated with outcome ($p=0.006$)

-Median age injury incidents - 47 years

-Median age fatal incidents - 58 years

Average age of agricultural producer is 57.5 years with 34% age 65 years and older².

Recap (cont.)



No significant association between gender and outcome (p=0.38)

Males accounted for 90% of those involved in incidents

The odds of a male being injured in any agricultural incident was found to be 1.68 times that of females¹

The average distance to a level 1 trauma unit (7 states) was found to be 71 miles (injury) and 74 mi (fatality)

Nebraska – 155 miles (injury); 122 miles (fatality)

Nebraska advanced trauma units.

| Level | Facility Name | City | Trauma Coordinator | Contact Number |
|--------------------|---|-------------|----------------------|------------------------|
| Level I | CHI Health Creighton University Medical Center Bergan | Omaha | Katie Pierce, RN | (402) 398-6353 |
| Level I | Nebraska Medicine | Omaha | Karen Saxton, RN | (402) 552-3997 |
| Pediatric Level II | Children's Hospital & Medical Center | Omaha | Jessica Lee, RN | (402) 955-7262 |
| Level II | Bryan Medical Center West | Lincoln | Mackenzie Gasper, RN | (402) 481-4145 |
| Level II | CHI Health Good Samaritan Hospital | Kearney | Rena Jacobson, RN | (308) 865-7684 |
| Level II | Regional West Medical Center | Scottsbluff | Susan Wilson, RN | (308) 635-3711 ext.234 |

¹Jadhav et al., 2015

Study Limitations



Data availability

- Newsclip data – we need a better data source for agricultural traumatic injuries– **Let's talk!**
 - **Bias toward regions with media coverage.**
- Size of dataset – 241 injuries and 67 fatalities.
- Limited scope - tractor, ATV/UTV overturns and entanglement.
- Limited to Level 1 trauma unit.
- Limited information regarding trauma care at the scene.
-



Recommendations



Continue and expand agricultural trauma training and education for **first responders**.

- Conferences like this one!
- Dr. Eric Ernest and Dr. Aaron Yoder provide ag trauma education during the CS-CASH Agricultural Health and Safety Course each summer (36 AMA, Nursing and CEU credits – free of charge).

Train agricultural workers in first aid.

- Bring Stop the Bleed and CPR to agricultural workplaces and rural community events.

Provide rural fire and rescue departments with incident training and tools.

- Grain bin entrapment response
- Anhydrous and farm chemical response
- Suicide prevention training (QPR)

Recommendations (cont.)



Focused education to older agricultural workers.

- Ingress and egress from equipment (slips, trips and falls)
- Heat illness
- Hearing loss
- Vision impairment
- Ergonomics
- Medications
- Sleep hygiene
- Improving balance
- Reducing Stress
- Respiratory Protection
- Safeguards for grandkids
-





Selected References

- Consumer Product Safety Commission. (2021). *OHV & ATV Safety*. <https://www.cpsc.gov/s3fs-public/2021-Report-of-Deaths-and-Injuries-Involving-Off-Highway-Vehicles-with-more-than-Two-Wheels.pdf>
- Donham, K. J., Yoder, A., & Grafft, L. (2016). Acute Injuries in Agriculture. In *Agricultural Medicine* (pp. 379–412). <https://doi.org/https://doi.org/10.1002/9781118647356.ch11>
- Halvorson, J. (2023). *2022 Census of Agriculture Impacts the Next Generations of Farmers*. USDA NASS Public Affairs. <https://www.usda.gov/media/blog/2023/02/22/2022-census-agriculture-impacts-next-generations-farmers#:~:text=The average age of farm,years from 2012 to 2017>
- Jarman, M. P., Curriero, F. C., Haut, E. R., Porter, K. P., & Castillo, R. C. (2018). Associations of distance to trauma care, community income, and neighborhood median age with rates of injury mortality. *JAMA Surgery*, *153*(6), 535–543.
- Neves, H., Brazile, W., & Gilkey, D. P. (2018). *ATVs and agriculture: A review of the literature*.
- NIOSH. (2023). *Agricultural Safety*. <https://www.cdc.gov/niosh/topics/aginjury/default.html#print>
- Reynolds, S. J., & Groves, W. (2000). Effectiveness of roll-over protective structures in reducing farm tractor fatalities. *American Journal of Preventive Medicine*, *18*(4, Supplement 1), 63–69. [https://doi.org/https://doi.org/10.1016/S0749-3797\(00\)00142-2](https://doi.org/https://doi.org/10.1016/S0749-3797(00)00142-2)



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THANK YOU!

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