

# Spatial Analysis of Opioid-Related Mortality and EMS Administration of Naloxone in Oklahoma



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# Overview

- The issue(s) and their importance
- Legislative changes to decrease opioid-related mortality
- Oklahoma State Department of Health (OSDH) response and programs
- GIS Applications



# Opiate Misuse, Abuse, and Death

- Nationally, unintentional poisoning deaths are the leading cause of injury deaths in the US<sup>1,2</sup>
- Nationally, unintentional poisoning deaths surpassed motor vehicle crashes (MVC) in 2008<sup>1,2</sup>
- In Oklahoma, 78% of unintentional poisoning deaths involve some form of prescription drug, and 90% of involve some form of opioid painkiller<sup>3</sup>



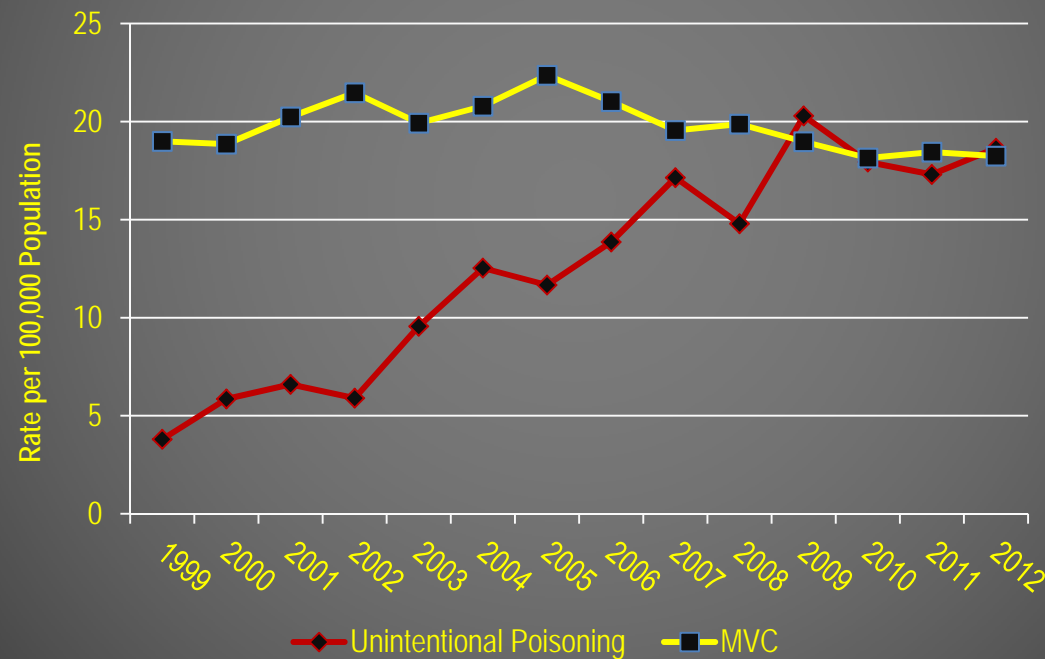
Source: [www.axisresidentialtreatment.com](http://www.axisresidentialtreatment.com)





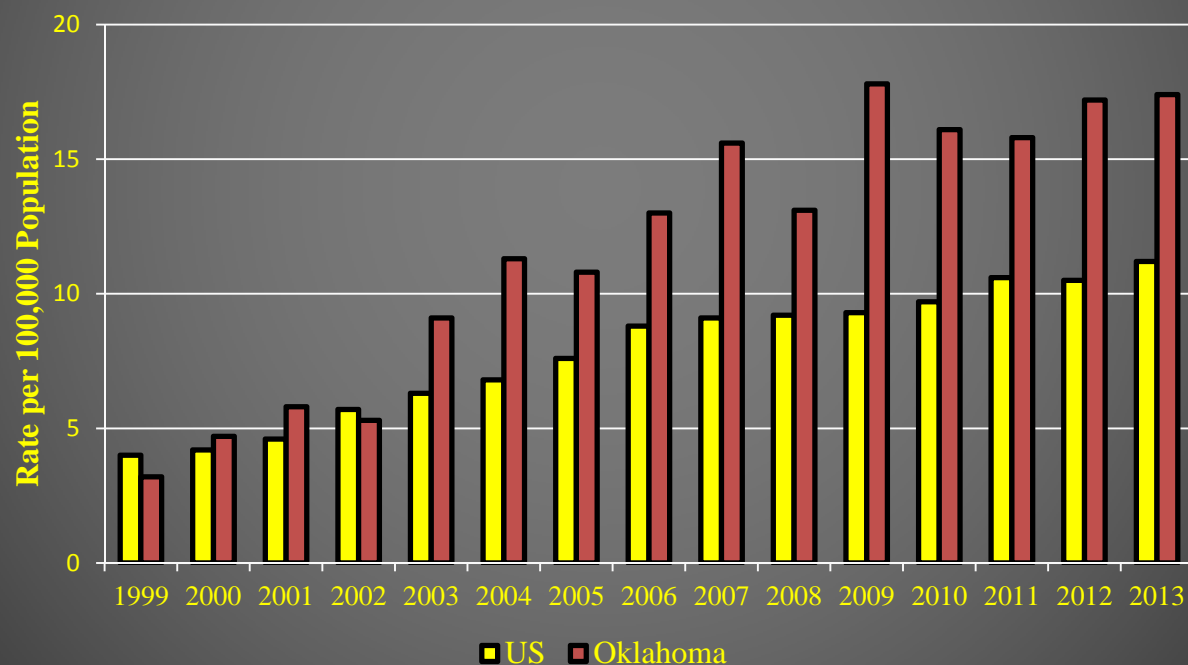
# Unintentional Poisoning Deaths in Oklahoma (1999-2012)

Figure 2. Age-adjusted Unintentional Poisoning and Motor Vehicle Crash Death Rates, Oklahoma, 1999-2012



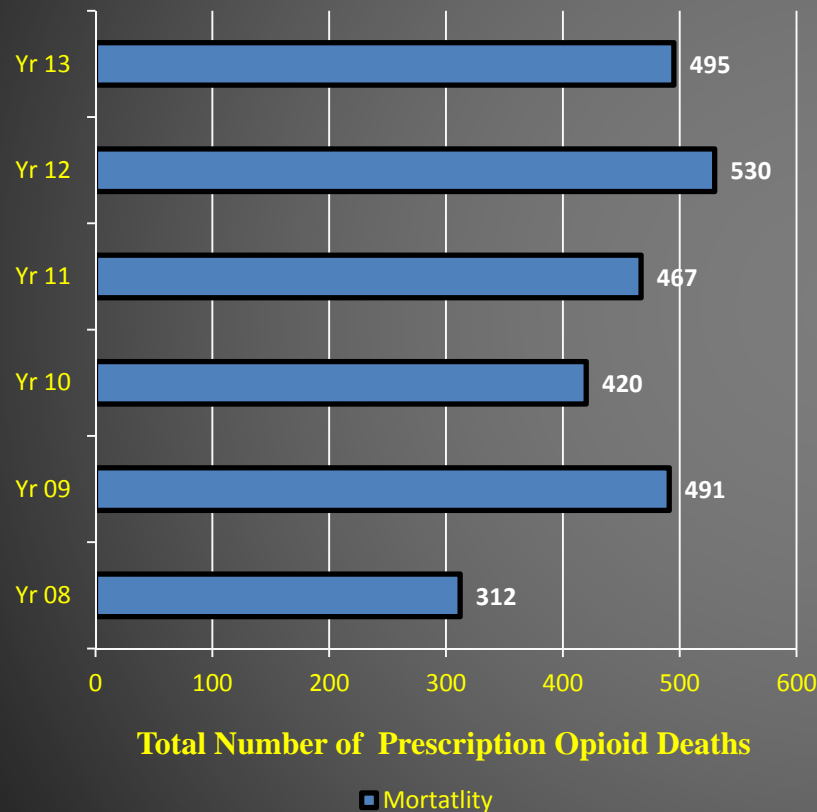
# Unintentional Poisoning Deaths in Oklahoma (1999-2013)

Figure 3. Age-Adjusted Unintentional Poisoning Death Rates, Oklahoma and the United States, 1999-2013



# Opiate-Related Mortality in Oklahoma (2008-2013)

**Figure 1. Opioid Prescription Mortality, Oklahoma  
(All Intents)**



**Table 2. Opioid Related Mortality, Oklahoma (2008-2013)**

	Year					
	2008	2009	2010	2011	2012	2013
Population	3,668,976	3,717,572	3,759,263	3,785,534	3,815,780	3,850,568
Opioid Related Mortality	312	491	420	467	530	495
Cumulative Incidence Rate (Per 10,000)	0.85	1.32	1.12	1.23	1.39	1.29

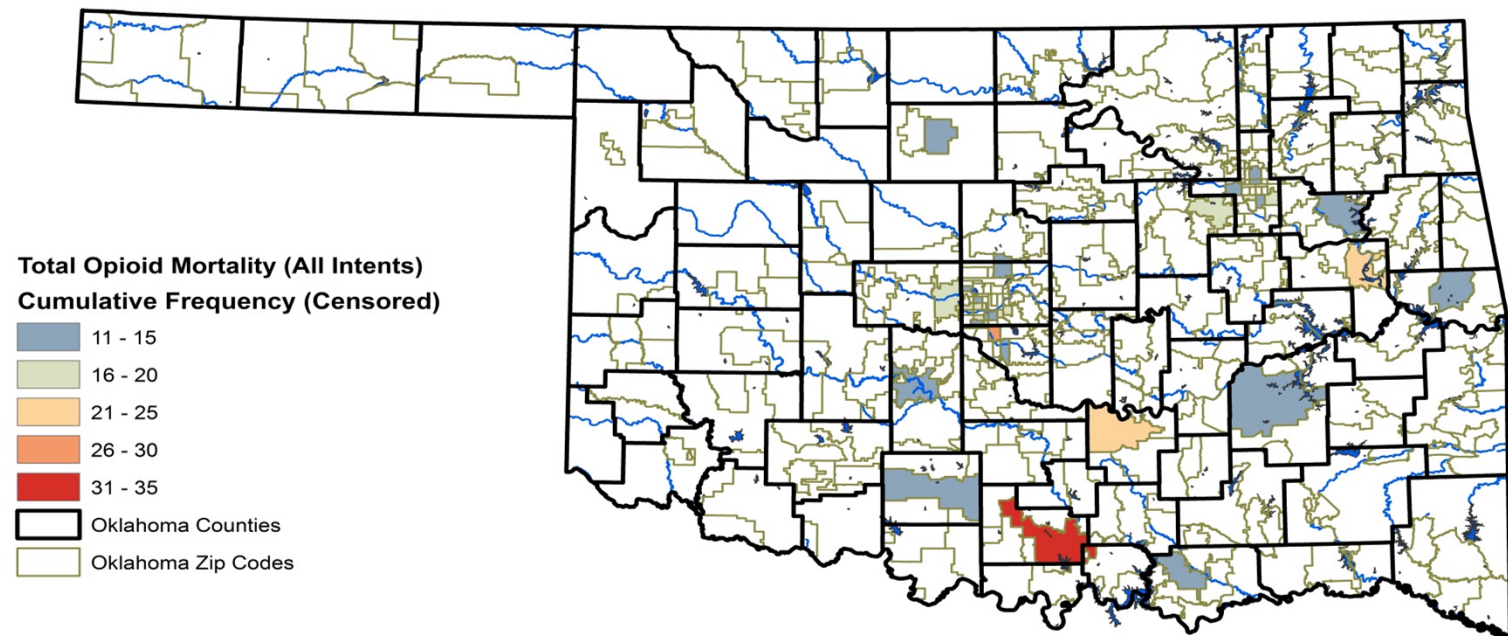
\*Decedents were identified by using underlying cause(s) of death codes X40-X44, X60-X64, X85, Y10-Y14 and a multiple cause(s) of death code in T40.0-T40.4

Source: OSDH Injury Prevention Service



# Opiate-Related Mortality in Oklahoma

Figure 4. Opioid Mortality by Zip Code, Oklahoma  
(2011-2013)



**Data Source:** OSDH Emergency Systems EMS Information Systems (OKEMSIS) and OSDH Injury Prevention Service

**Notes:** During this time naloxone was only administered in the prehospital setting by Paramedic level providers.

Decedents were identified by using underlying cause(s) of death codes X40-X44, X60-X64, X85, Y10-Y14 and a multiple cause(s) of death code in T40.0-T40.4.

**Created:** 03.17.2015

**Created by:** Johnnie L. Gilpen Jr. MS NREMT-I (johnnieg@health.ok.gov)

**Projection/Coordinate System:** NAD 1983 State Plane Oklahoma North FIPS 3501



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# Legislative Efforts To Decrease Preventable Opioid-Related Mortality



# Common Opioid Drugs

In efforts to curb opioid dependency

The DEA changed the rules concerning hydrocodone combination (HC) medicines (10/03/2014) – *All HC medications are now Schedule II drugs because they are highly abused with a propensity to result in “severe psychological or physical dependence”*<sup>4</sup>

Table 1. List of Common Opioid Drugs

Type	Generic Name	Trade Name	Street Name		
Prescription	<b>Codeine</b>	Paveral®	Captain Cody	Cody	Threes
	<b>Fentanyl Citrate</b>	Actiq Oralet®	China Girl	He-man	
		Duragesic®	China town	Jackpot	
		Fentora®	China White	King ivory	
		Ionsys®	Apache	Murder 8	
		Onsolis®	Dance Fever	Per-o-pops	
		Sublimaze®	Goodfellas	Lollipops	
			Great bear		
	<b>Hydrocodone Bitartrate</b>	Hycodan®	Hydro	Norco	Vikes
		Robidone®			
	<b>Hydromorphone Hydrochloride</b>	Dilaudid®	D	Dust	Juice
		Dilaudid - HP®	Dillies	Footballs	
	<b>Meperidine</b>	Demerol®	Peth		
		Pethadol®			
	<b>Methadone Hydrochloride</b>	Dolophine®	Methadose®	Dollies	Fizzies
	<b>Morphine Sulfate</b>	Astramorph PF®	Kadian®	"God's drug"	How's
		Avinza®	MS Contin®	Block	M
		Depo-Dur®	MSIR®	Cube	Mister blue
		Duramorph®	Oramorph SR®	Dreamer	M.S.
		Embeda®	RMS®	Emsel	Miss Emma
		Epimorph®	Roxanol®	First Line	Mojo
		Infumorph®	Statex®	Goma	Morf
	<b>Oxycodone Hydrochloride</b>	OxyContin®	Hillbilly heroin	Ox	Pills
		Percolone®	Kicker	Oxicotton	40
		Endocodone®	OC's	Oxy 80's	40-bar
		OxyFast®	Os	Oxycet	80
	<b>Oxycodone Hydrochloride/ ASA</b>	Percodan®	Percs	Perks	Pink spoons
	<b>Pentazocine Hydrochloride</b>	Talwin®	Tall		
Illegal	<b>Heroin</b>		Aunt Hazel	Helen	Herone
			Big H	Hell dust	HRN
			Big Harry	Henry	Mexican horse
			Capital H	Hazel	Mexican mud
			Good H	Helen	White boy
			H	Hell dust	White horse
			H Caps	Henry	White junk
			Harry	Hero	White nurse
			Harry Jones	Hero of the underworld	White stuff
	<b>Opium</b>		Big O	Block	Gum
			Black Stuff	Dover's powder	Hop





# Administration of Opiate Antagonists by First Responders

- Effective November 2013, Oklahoma House Bill 1782 provided statutory revisions to ***Administration of opiate antagonists (§63-1-2506.1)***
- Administration of opiate antagonists states that:  
*First responders shall have the authority to administer, without prescription, opiate antagonists when encountering an individual exhibiting signs of an opiate overdose.*





# Opioid Antagonist?



# Naloxone Hydrochloride aka - Narcan®

- Naloxone hydrochloride injection, USP
- Commonly referred to by its trade name Narcan®
- The first-line prehospital & emergency department treatment to reverse the resulting effects of opioid toxicity/depression<sup>5</sup>
- Can be administered:
  - Intravenously (IV)
  - Intramuscular (IM)
  - Subcutaneous (SubQ)
  - Intranasally (IN)



Source: <http://www.gannett-cdn.com><sup>D</sup>



# Significance of the Legislative Changes

- Prior to the November 2013 legislative changes, only paramedic licensed providers could administer naloxone in the prehospital environment



Source: <http://www.mountaininside-medical.com>



# Oklahoma EMS

- Levels of EMS licensure
  - Emergency Medical Responder (EMR)
  - Basic EMT (EMT-B)
  - Intermediate EMT (EMT-I/ I-85)
  - Advanced EMT (EMT-A) *[Not currently recognized in OK]*
  - Paramedic (NRP) or (EMT-P)
- License EMS personnel in
  - EMR's = 1,530
  - EMT-B's = 5,050
  - EMT-I's = 760
  - Paramedics = 2,722





# Oklahoma EMS

- Levels of EMS agency licensure
  - Emergency Medical Response Agencies (EMRA)
  - Basic Service
  - Intermediate Service
  - Paramedic Service
- 158 Oklahoma Ground EMS Agencies
  - Basic Services = 95
  - Intermediate Services = 33
  - Paramedic Services = 30
  - + EMRA's = 152



## Oklahoma State Department of Health's (OSDH) Response to the Legislative Change Regarding Naloxone Administration

- Revise the State EMS protocol to reflect the 2013 legislative changes
- Develop a naloxone education and distribution program for high risk/high need Oklahoma EMS agencies and EMRA's
- Identify high risk/high need EMS agencies and EMRA's
- Conduct a baseline assessment of naloxone administration by EMS agencies and EMRA's



# OSDH's Emergency System's Program Tasking

- Identify high risk/high need areas within the state as targets for naloxone education and distribution program using an evidence-based needs assessment
- Conduct a baseline assessment of naloxone administration EMS agencies and EMRA's





## Study Objective

- Develop baseline data regarding naloxone administration by EMS Providers in Oklahoma prior to June 4<sup>th</sup>, 2014 EMS protocol change



# EMS Naloxone Baseline Data Components

- The baseline should include:
  - Basic epidemiological descriptors such as:
    - Age groups
    - Gender
    - Race and ethnicity
    - Patient disposition and outcome of those who received naloxone



# EMS Naloxone Baseline Data Components

- The base line should include:
  - Geospatial epidemiological descriptors such as:
    - Spatial distribution of opioid-related mortality
    - Spatial distribution of opioid-related hospital discharge data
    - Spatial distribution of EMS emergency service call's (ESC) locations described by:
      - Zip code
      - EMS Coverage area



## Study Population and Time Period

- The study identified all ESC's from the 1<sup>st</sup> of January, 2011 through the 3<sup>rd</sup> of June 2014 where naloxone was administered to the patient during the service call
- The study identified all opioid-related deaths as classified by the Oklahoma Office of the Chief Medical Examiner from the 1<sup>st</sup> of January, 2011 through the 31<sup>st</sup> of December, 2013 where they were used to assess opioid-related mortality



# Institutional Review Board Approval

- Exempt Research:
  - 4. Research involving the collection or study of existing (i.e. on the shelf, already collected and/or banked prior to the date the study is to start) data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.
  - The data was obtained from statutorily required reporting by all EMS agencies
  - Comprised of multi-year statewide data



## Study Design

- The study design was a case-series and involved the retrospective review of EMS data that included only instances in which naloxone use was documented by EMS providers



# Case Definition(s)

## ***Naloxone Administration:***

- The administration of naloxone to a patient regardless of the route, dosage, or number of times the drug is administered during a single EMS ESC
- Each individual case identified in the Oklahoma EMS Information System (OKEMSIS) database of naloxone administration represents a single naloxone administration event
- If an individual received multiple doses of naloxone during a specific ESC, regardless of the number of doses of naloxone received, it is considered to be a single naloxone administration event
- If an individual receives naloxone during more than one ESC, each is considered to be a single naloxone administration event (Patient x = 10 ESC's)
- Administration is subdivided according route: intramuscular (IM), intravenous (IV), Subcutaneous, or intranasal (IN)





# Case Definition(s)

## Naloxone “Save”:

- **Known Reversal** is any individual who has a:
  - suspected or known history of past opioid/ narcotic use and/or misuse; or
  - suspected recent (i.e., last 2-3 hours) opioid/ narcotic use; and
  - Altered mental status; and/ or
  - Unresponsiveness; and/ or
  - Shock; and/ or
  - Bradypnea (Adults < 12 breaths per minute); and/or
  - Mioiosis; and/or
  - GCS less than or equal to 8 ( $GCS \leq 8$ ); and
  - *the Pt's respirations increase, LOC increases, etc. within minutes of administration;*



# Case Definition(s)

Naloxone “Save”:

- *Potential reversal with unknown etiology* is defined as a patient with the following:
  - suspected or known history of past opioid/narcotic use and/or misuse; or
  - suspected recent (last 2-3 hours) opioid/ narcotic use; and
  - Altered mental status; and/ or
  - Unresponsiveness; and/ or
  - Shock; and the LOC increases, etc. within minutes of administration;
  - however, there is no physiological documentation of the patients vital signs (i.e., respiratory rate, pulse rate, pupil reactivity) prior to the administration of naloxone.



## Case Definition(s)

### ***Opioid Mortality:***

- Any death that was categorized as being related to opioid use and/or misuse regardless of the intent (i.e., intentional overdose (suicide), accidental overdose, adverse reaction to medication, etc.)
- Decedents were identified by using underlying cause(s) of death codes X40-X44, X60-X64, X85, Y10-Y14 and a multiple cause(s) of death code in T40.0-T40.4



## Data Source(s)

- Emergency Service Call (ESC) data:
  - OSDH Oklahoma Emergency Medical Service Information System (OKEMSIS)
- Opioid Mortality data:
  - CDC WISQARS and OSDH Injury Prevention Service Unintentional Poisoning Fatality Surveillance System Database abstracted from Medical Examiner reports



## Study Methods

1. Map the geospatial distribution of all EMS agency coverage areas by license level using ESRI ArcInfo 10.2 (Redlands, CA) GIS mapping software suite
2. Identify the percentage of time each EMS agency had paramedic coverage prior to protocol changes using the OSDH's EMS information system (OKEMSIS) database
3. Map the geospatial distribution of all EMS agencies that had 90 percent or greater paramedic coverage 24/7



## Study Methods

4. Calculate the cumulative frequency and incidence rate of naloxone administration by EMS according to:
  - Zip code
  - EMS agency coverage area
5. Map the geospatial distribution of naloxone administration by cumulative frequency and incidence rate according to:
  - Zip code
  - EMS agency coverage area



## Study Methods

6. Compared the geospatial relative risk (RR) of receiving naloxone during a ESC calculated by SatScan™ 9.4 (Boston, MA) geospatial scan statistic to the geospatial distribution of opioid-related deaths by zip code to identify high risk/high need target locations





## Spatial Scan Statistic – SatScan

- SatScan™ software was developed by Martin Kulldorff and the Information Management Services, Inc. and funded by the National Cancer Institute
- [www.satscan.org](http://www.satscan.org)
- 



# Spatial Scan Statistic – SatScan

- The software was designed to:
  - Perform geographical surveillance, to detect spatial or space-time disease clusters, and to see if they are statistically significant
  - Test whether a disease is randomly distributed over space, over time, or over space and time
  - Evaluate the statistical significance of disease cluster alarms
  - Perform repeated time-periodic disease surveillance for early detection of disease outbreaks



# Spatial Scan Statistic – SatScan

- Data Types and Methods
  - Uses either a Poisson-based model, where the number of events in a geographical area is Poisson-distributed, according to a known underlying population at risk; or
  - A Bernoulli model, with 0/1 event data such as case and controls



# Spatial Scan Statistic – SatScan

- Data Types and Methods
  - The data were aggregated at the zip code level
  - The program:
    - Adjust for the inhomogeneous population density and for any number of confounding variables (e.g., age);
    - Searches for geographical clusters without having to predefine their size or location the method ameliorates the problem of preselection bias;



# Spatial Scan Statistic – SatScan

- Data Types and Methods
  - The likelihood-ratio-based test statistic takes multiple testing into account and delivers a single  $p$ -value for the test of the null hypothesis ( $RR=1$ )
  - If the null hypothesis is rejected ( $RR<1$  or  $RR>1$ ), the approximate location of the cluster that caused the rejection can be identified
  - The general location can be pinpointed (eg., census centroid); however, the exact boundaries remain uncertain
  - The location of the cluster is therefore described by its ‘approximate location’ (eg., zip code centroid)



# Spatial Scan Statistic – SatScan

- Expected outcomes
  - Identify higher than expected clusters of naloxone administration by prehospital EMS providers ( $RR>1$ ); and
  - Identify clusters of lower or no use areas for naloxone administration ( $RR<1$ )
- Once these clusters have been identified, they can be spatially correlated to areas with known opioid mortality
- The information could then be used to identify a multi-tiered approach to the education and subsequent distribution of naloxone to high risk/high need EMS agencies



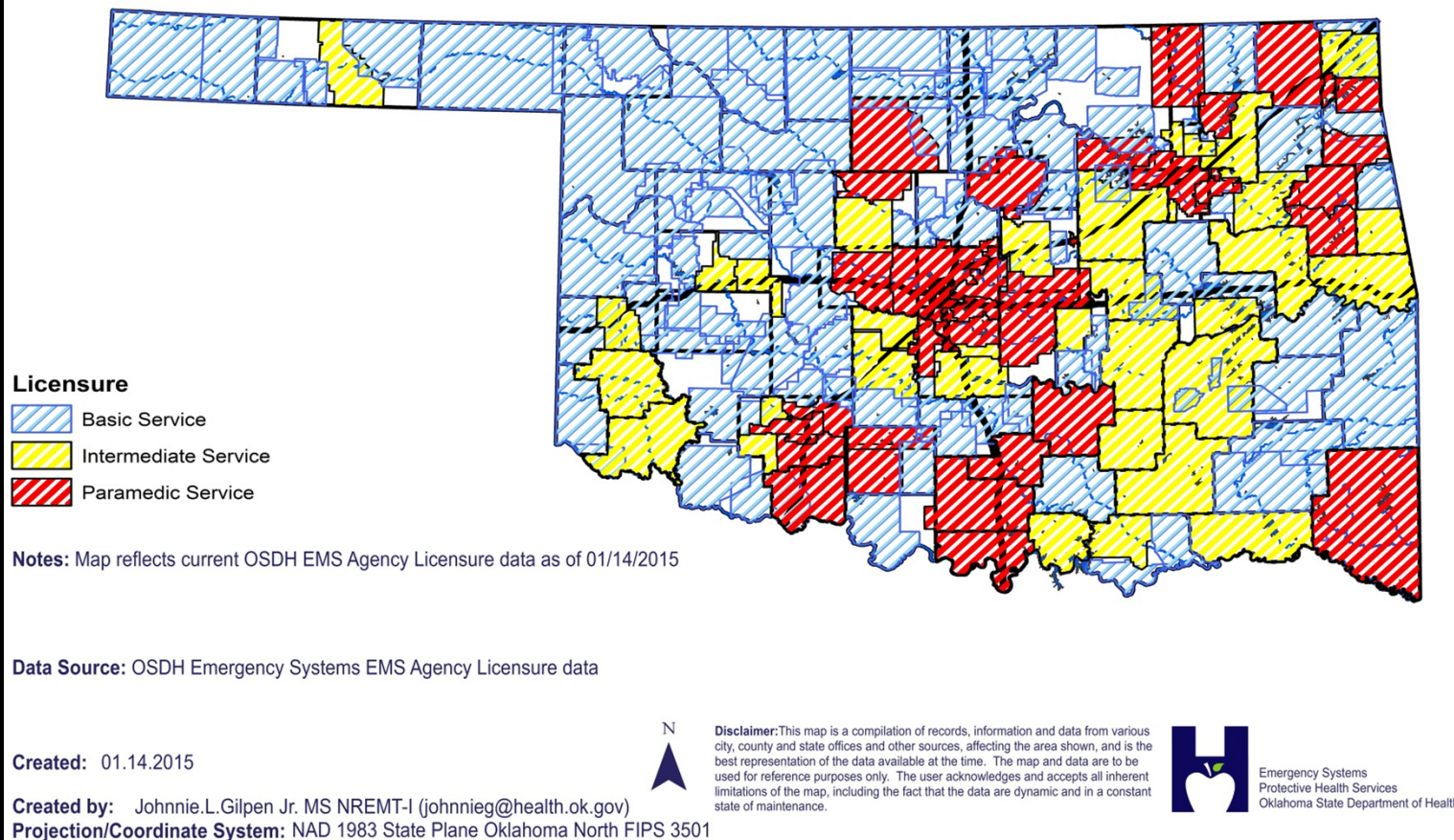
# Study Results





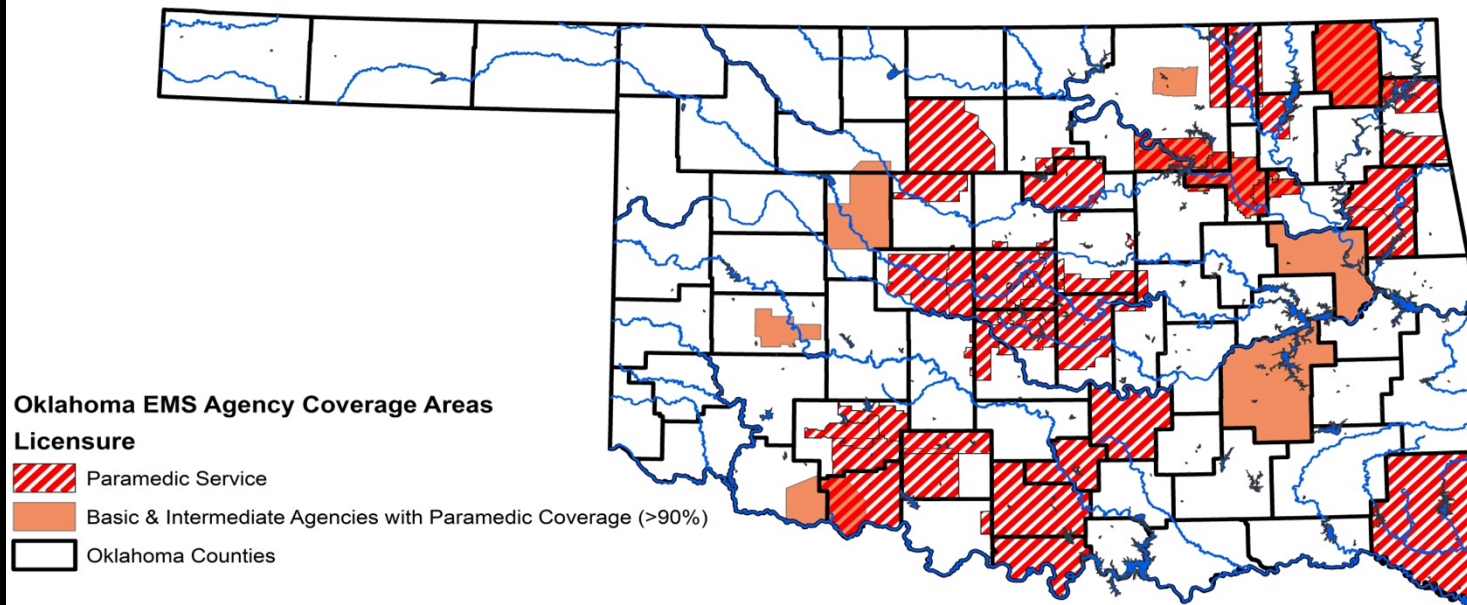
# Geospatial Distribution of Oklahoma EMS Agencies by Licensure Level

Figure 5. Oklahoma EMS Agency Coverage Areas, 2015



# Geospatial Distribution of EMS Agencies with at least 90% Paramedic Coverage

Figure 6. Oklahoma EMS Agencies with Paramedic Level Coverage Prior To Naloxone Protocol Changes (06/03/2014)



**Notes:** Map reflects current OSDH EMS Agency Licensure data as of 10/01/2014

**Data Source:** OSDH Emergency Systems EMS Agency Licensure data

**Created:** 03.03.2015

**Created by:** Johnnie.L.Gilpen Jr. MS NREMT-I (johnnieg@health.ok.gov)

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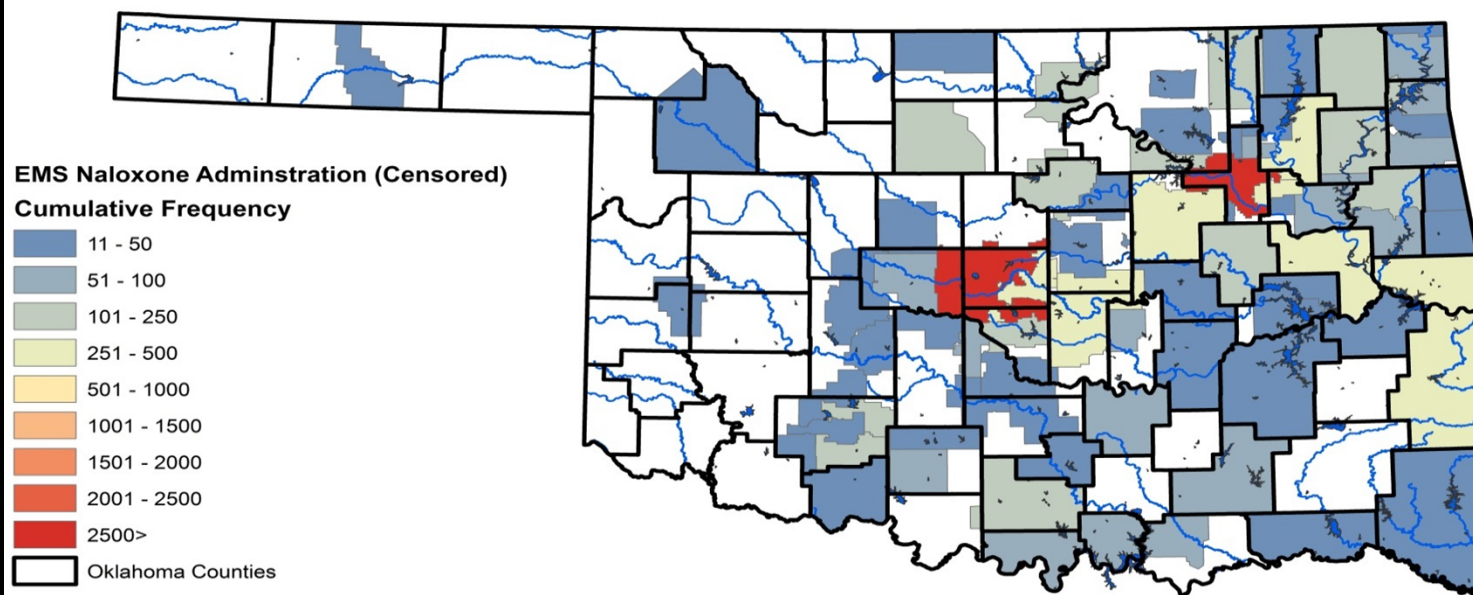
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# Cumulative Frequency of Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*

Figure 7. Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*



**Data Source:** OSDH Emergency Systems EMS Information System (OKEMSIS)

**Notes:** During this time naloxone was only administered in the prehospital setting by Paramedic level providers.

\* Data is from 01/01/2011 through 06/03/2014

**Created:** 03.19.2015

**Created by:** Johnnie L. Gilpen Jr. MS NREMT-I (johnnie.gilpen@health.ok.gov)

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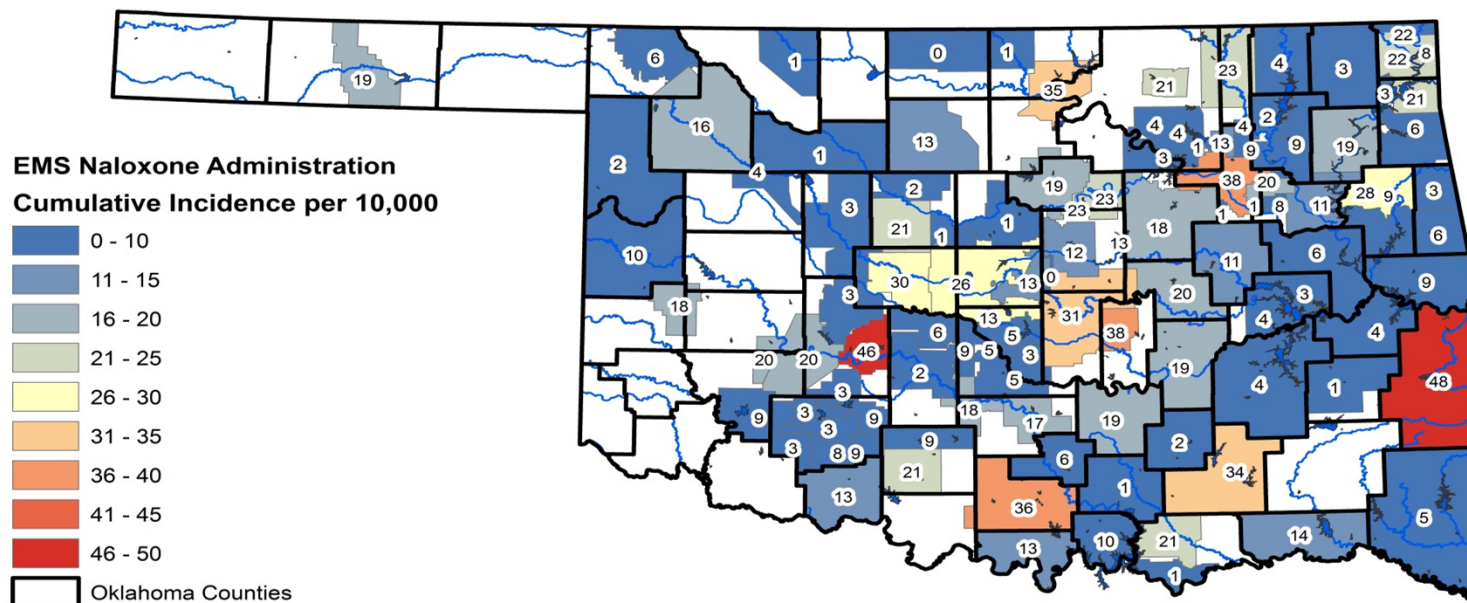


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# Incidence Rate of Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*

Figure 8. Naxolone Administration by EMS Agencies, Oklahoma (2011-2014)\*



**Data Source:** OSDH Emergency Systems EMS Agency Licensure data

**Notes:** During this time naloxone was only administered in the prehospital setting by Paramedic level providers.

\* Data is from 01/01/2011 through 06/03/2014

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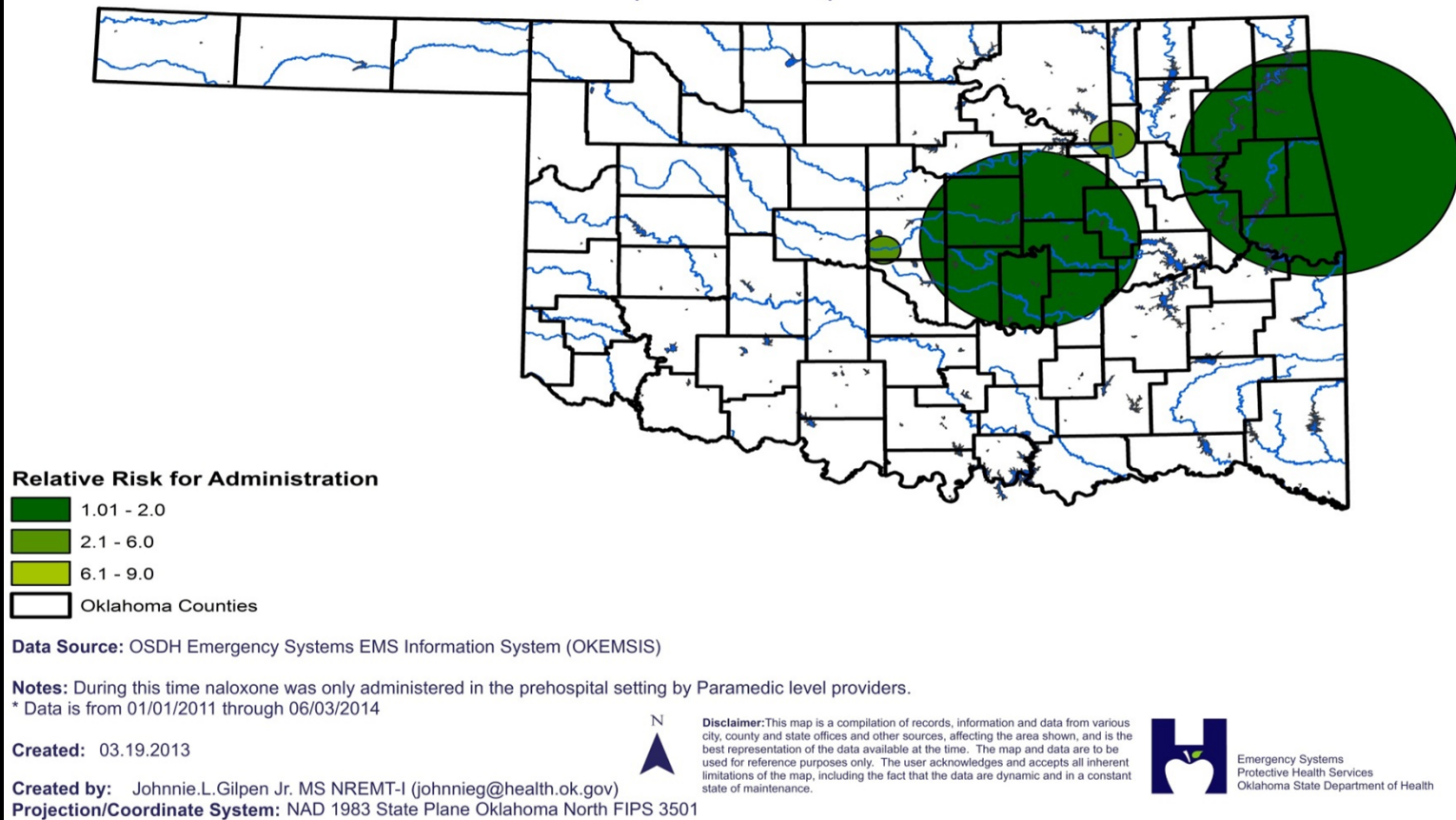


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# Naloxone Administration by EMS, Higher-than-Expected Clusters

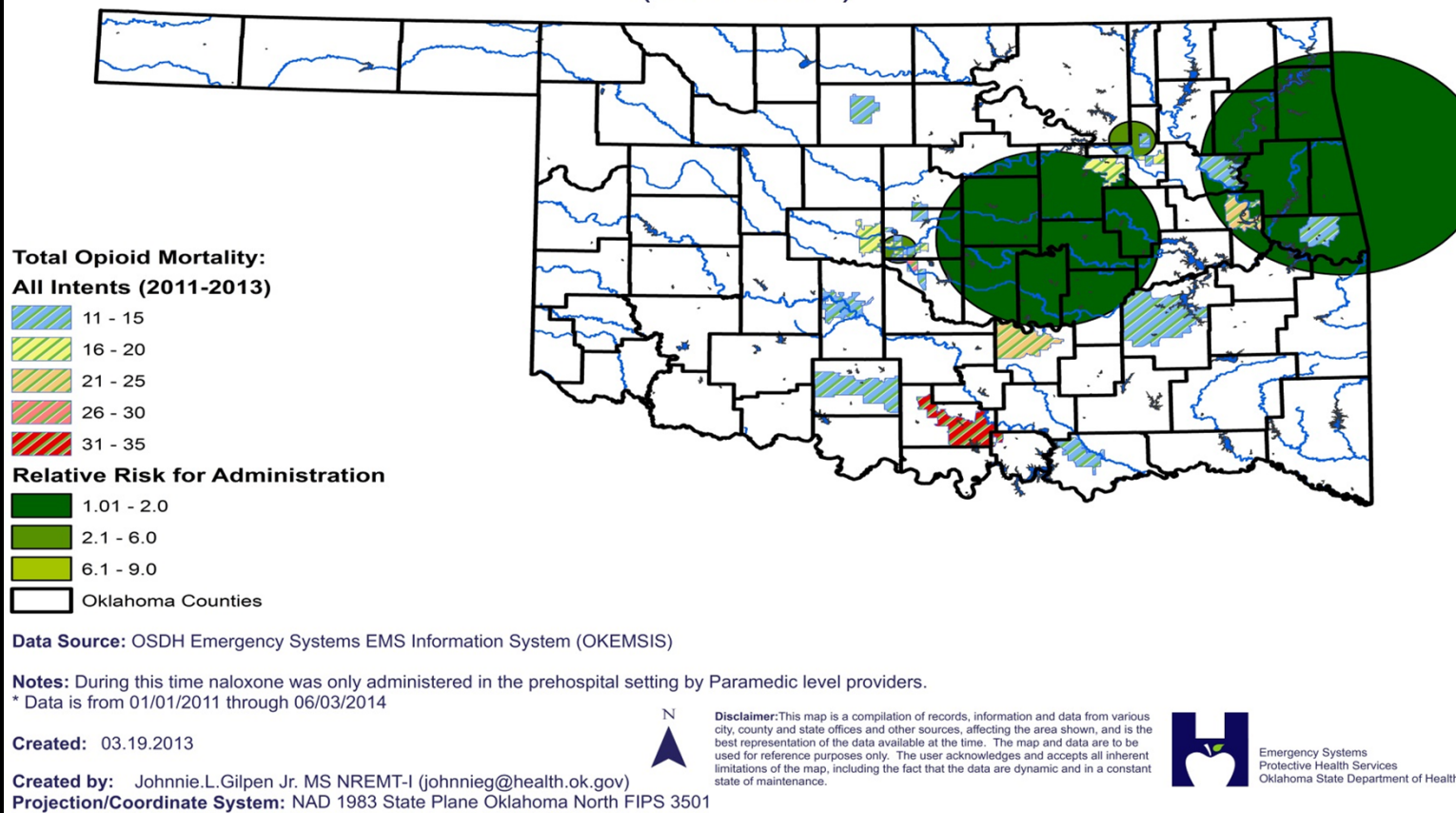
Figure 9. Spatial Clustering by Zipcode for Higher than Expected Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*





# Naloxone Administration by EMS, Higher-than-Expected Clusters vs Opioid Mortality

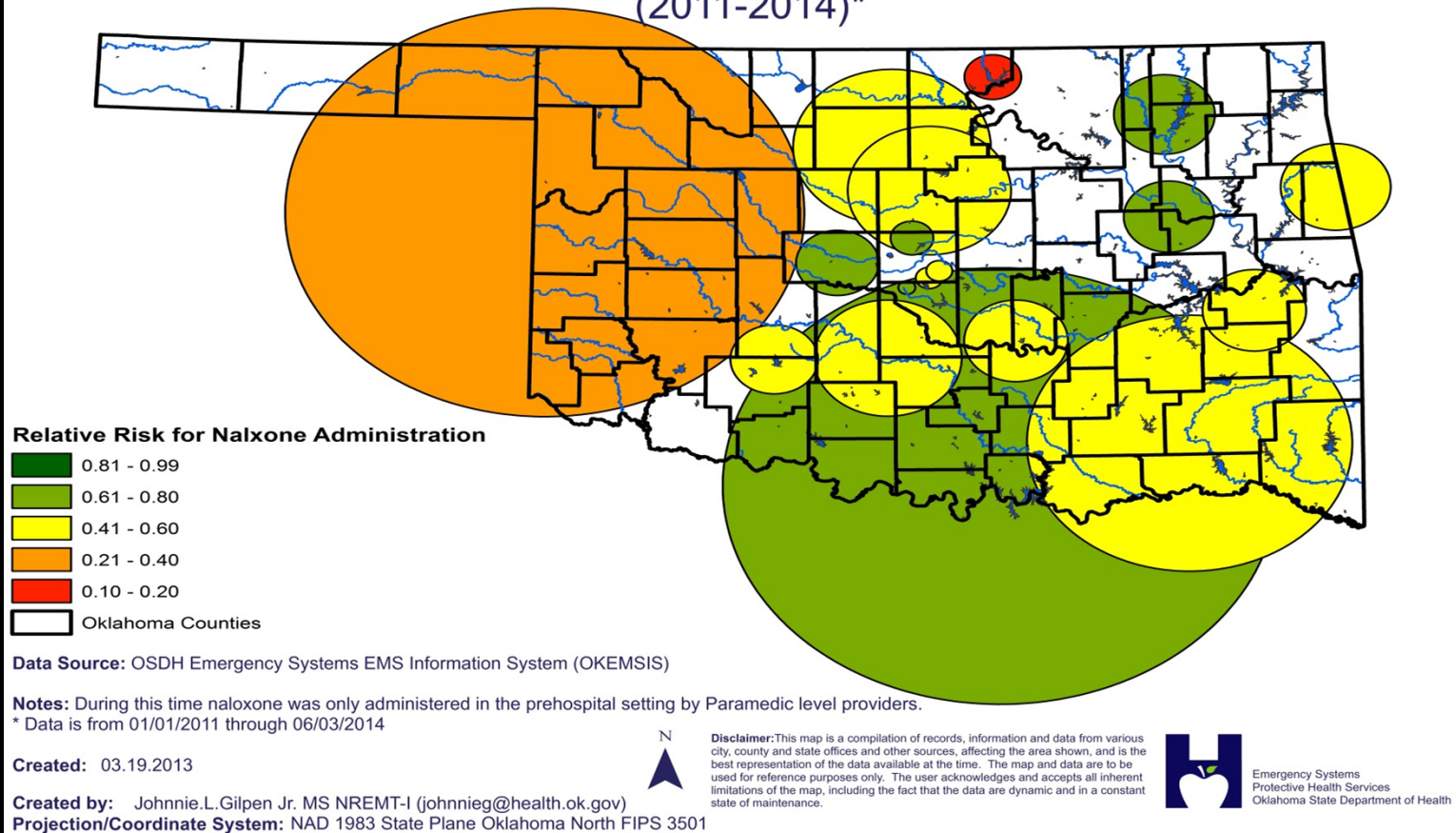
Figure 10. Spatial Clustering by Zipcode for Higher than Expected Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*





# Naloxone Administration by EMS, Lower-than-Expected Clusters

Figure 11. Spatial Clustering by Zipcode for Lower than Expected Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*



# Naloxone Administration by EMS, Lower-than-Expected Clusters

Figure 11. Spatial Clustering by Zipcode for Lower than Expected Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*

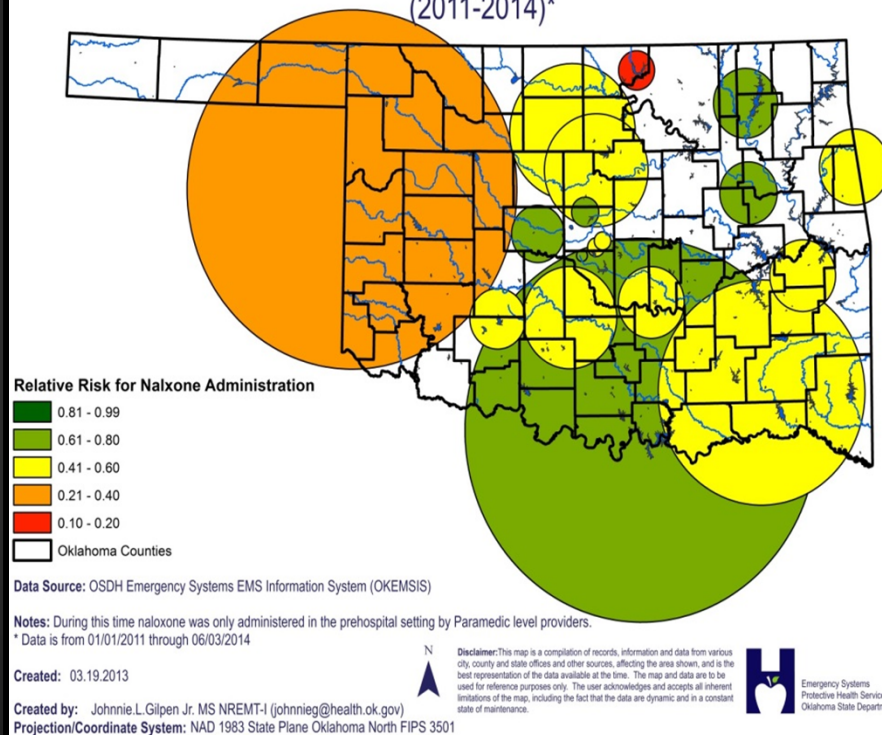
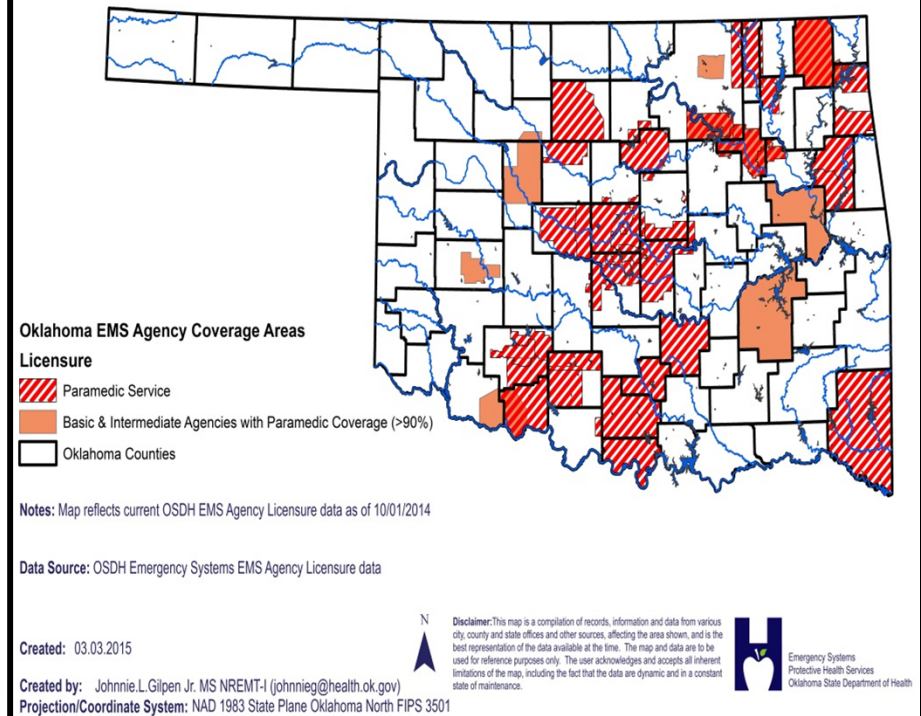


Figure 6. Oklahoma EMS Agencies with Paramedic Level Coverage Prior To Naloxone Protocol Changes (06/03/2014)





# Naloxone Administration by EMS, Lower-than-Expected Clusters

Figure 11. Spatial Clustering by Zipcode for Lower than Expected Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*

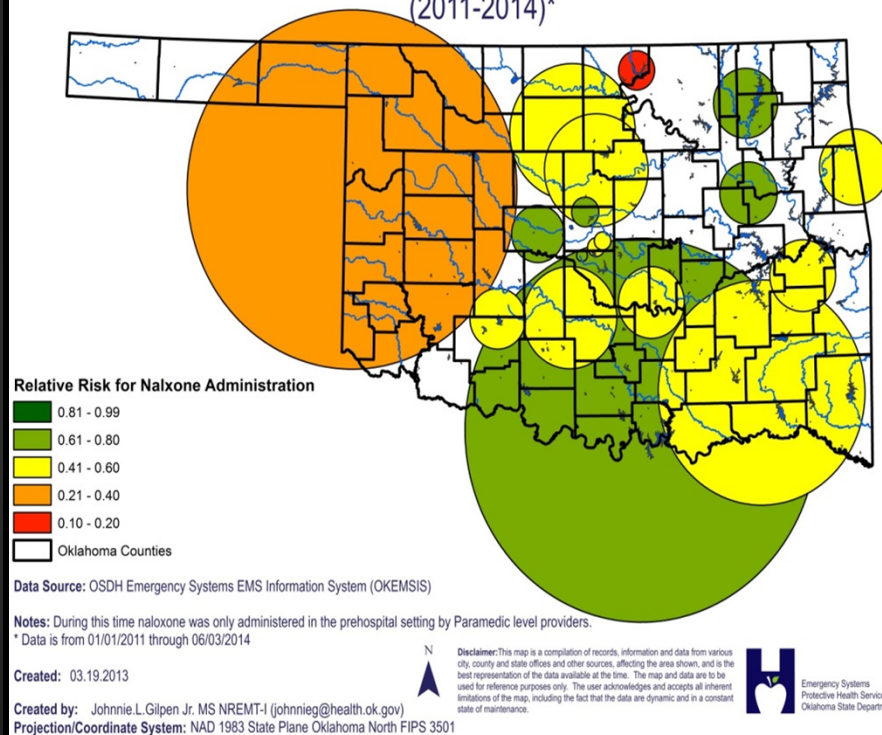
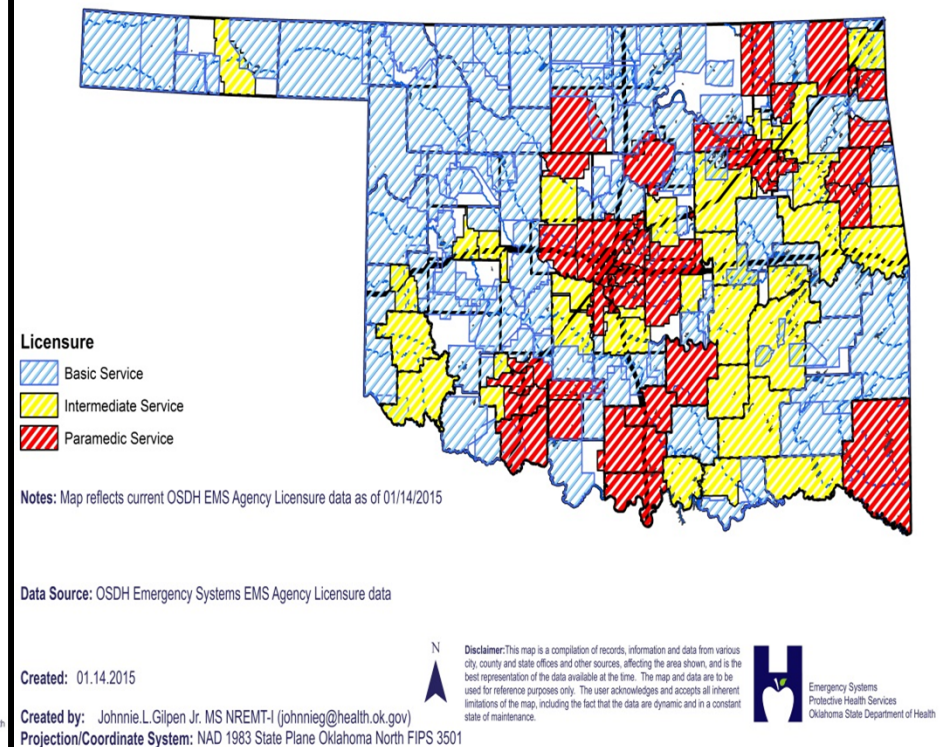
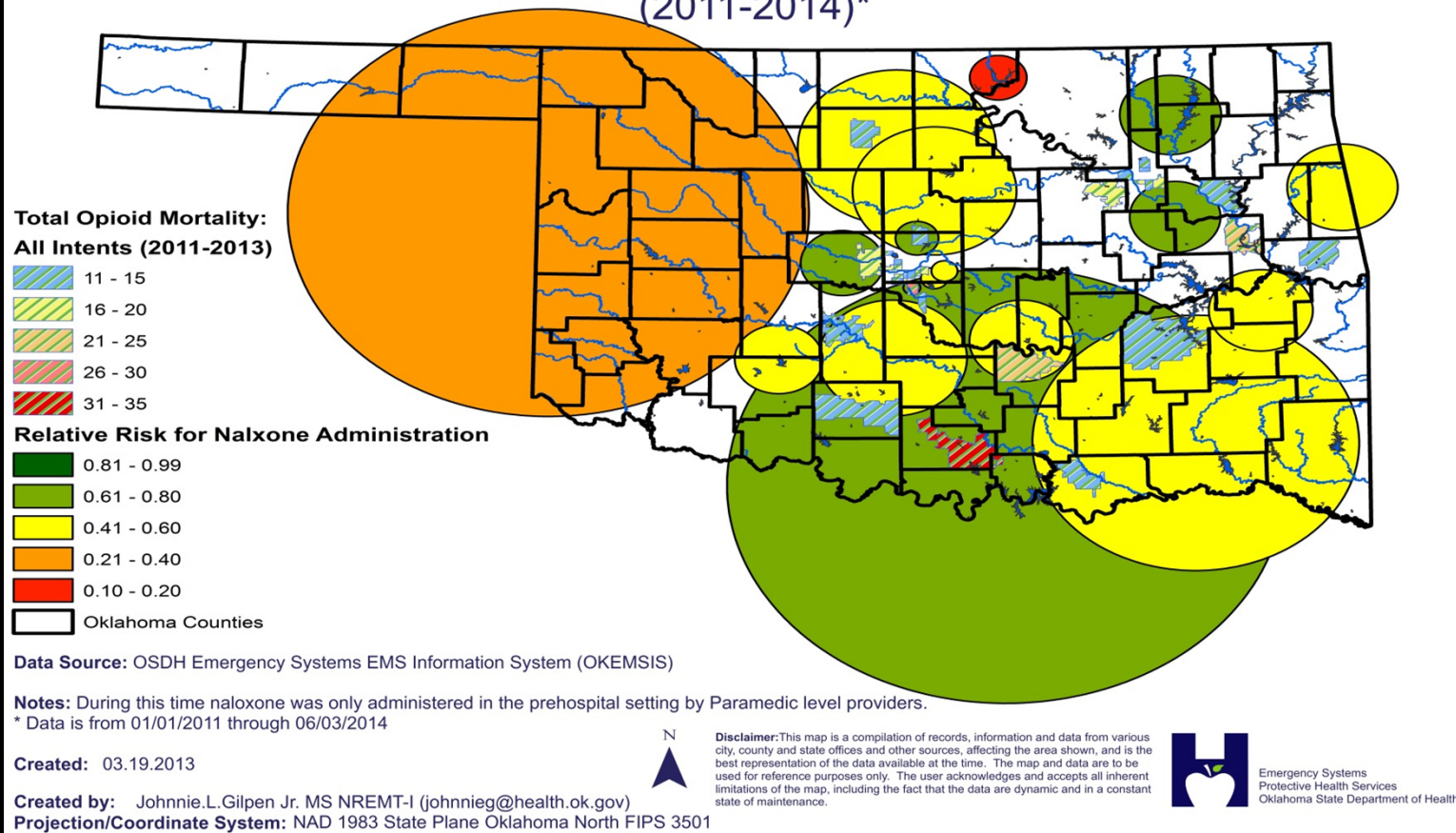


Figure 5. Oklahoma EMS Agency Coverage Areas, 2015



# Naloxone Administration by EMS, Lower-than-Expected Clusters vs Opioid Mortality

Figure 12. Spatial Clustering by Zipcode for Lower than Expected Naloxone Administration by EMS Agencies, Oklahoma (2011-2014)\*



## Discussion

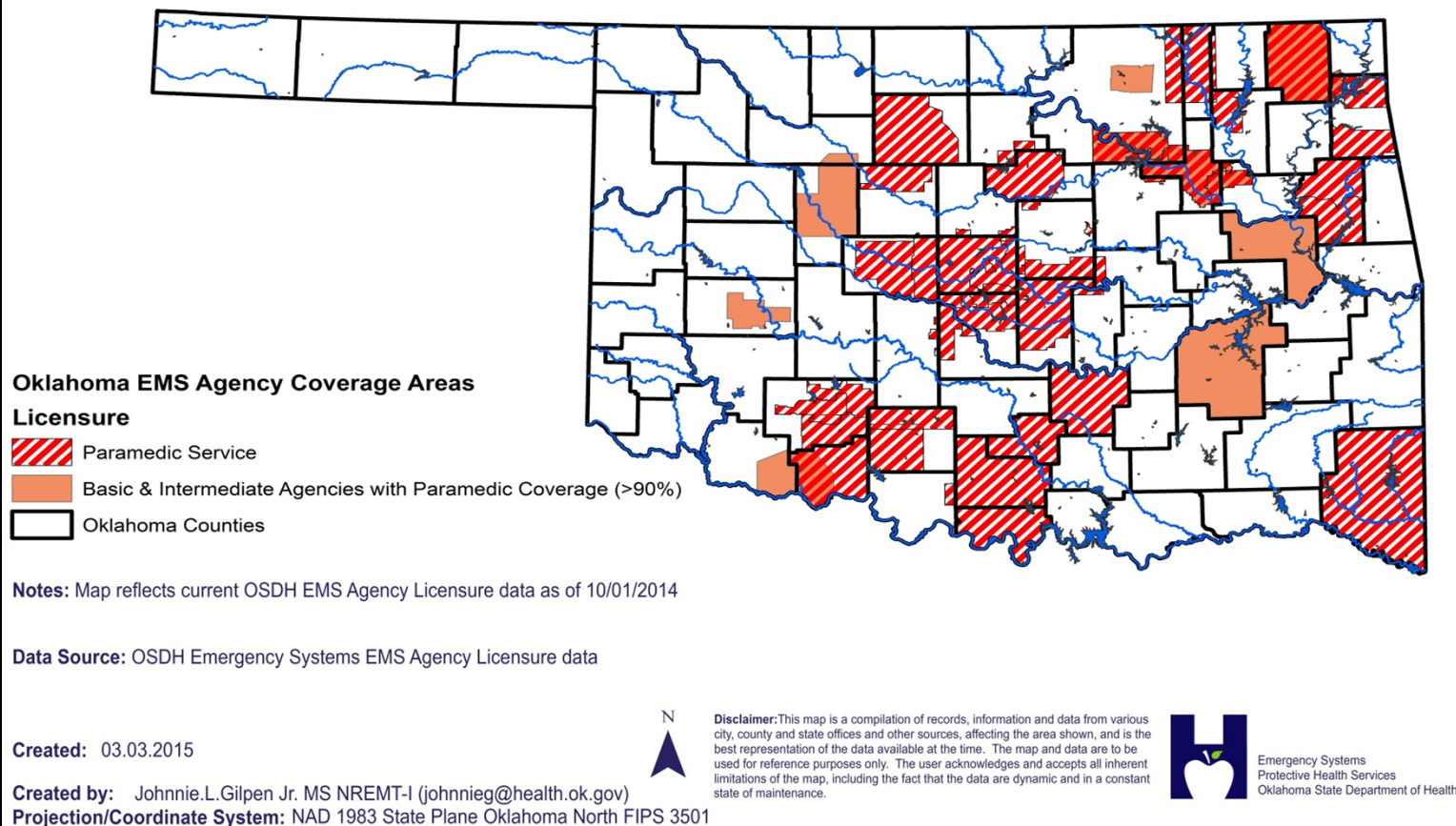
- The clusters of lower-than-expected correlated with many of the 85 basic and 25 intermediate licensed EMS agencies that had less than 90% paramedic level coverage
- The results provide a baseline that can be used to assess the impact of increased naloxone availability among all EMS provider levels ; and
- The impact that the naloxone education and administration program has on decreasing opioid-related mortality over time





# Review: Where We Started

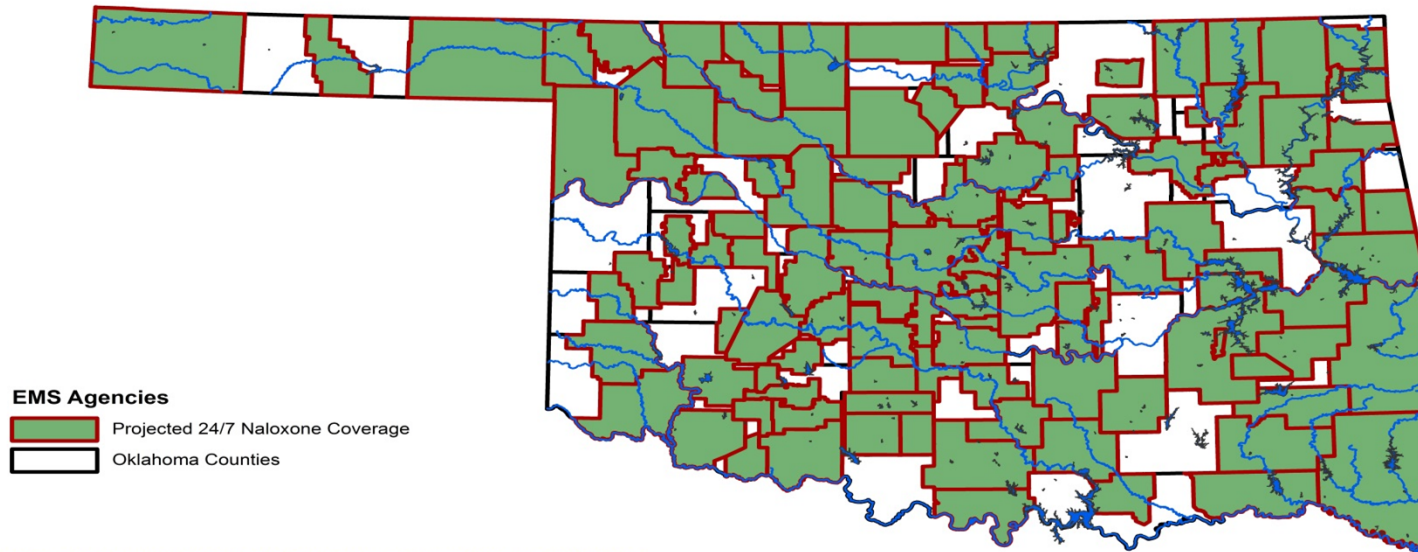
Figure 6. Oklahoma EMS Agencies with Paramedic Level Coverage  
Prior To Naloxone Protocol Changes (06/03/2014)





# Where We are Today

Figure 12. Oklahoma EMS: Projected 24/7/365 Narcan Coverage by EMS  
Based On Agencies Trained  
(As of 04/01/2015)



**Notes:** Map reflects current OSDH EMS Agency Licensure data as of 10/01/2014

**Data Source:** OSDH Emergency Systems EMS Agency Licensure data

**Created:** 04.01.2015

**Created by:** Johnnie.L.Gilpen Jr. MS NREMT-I (johnnieg@health.ok.gov)

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## Study Limitations

- The study data were obtained by retrospective review of EMS data and only instances in which naloxone use was documented were included
- It is possible that naloxone administration was underestimated because of inconsistent medication administration reporting



## Conclusions

- Analysis of spatial risk distribution was useful for identifying EMS agencies that would benefit from the Naloxone Training and Administration for EMS Personnel Program

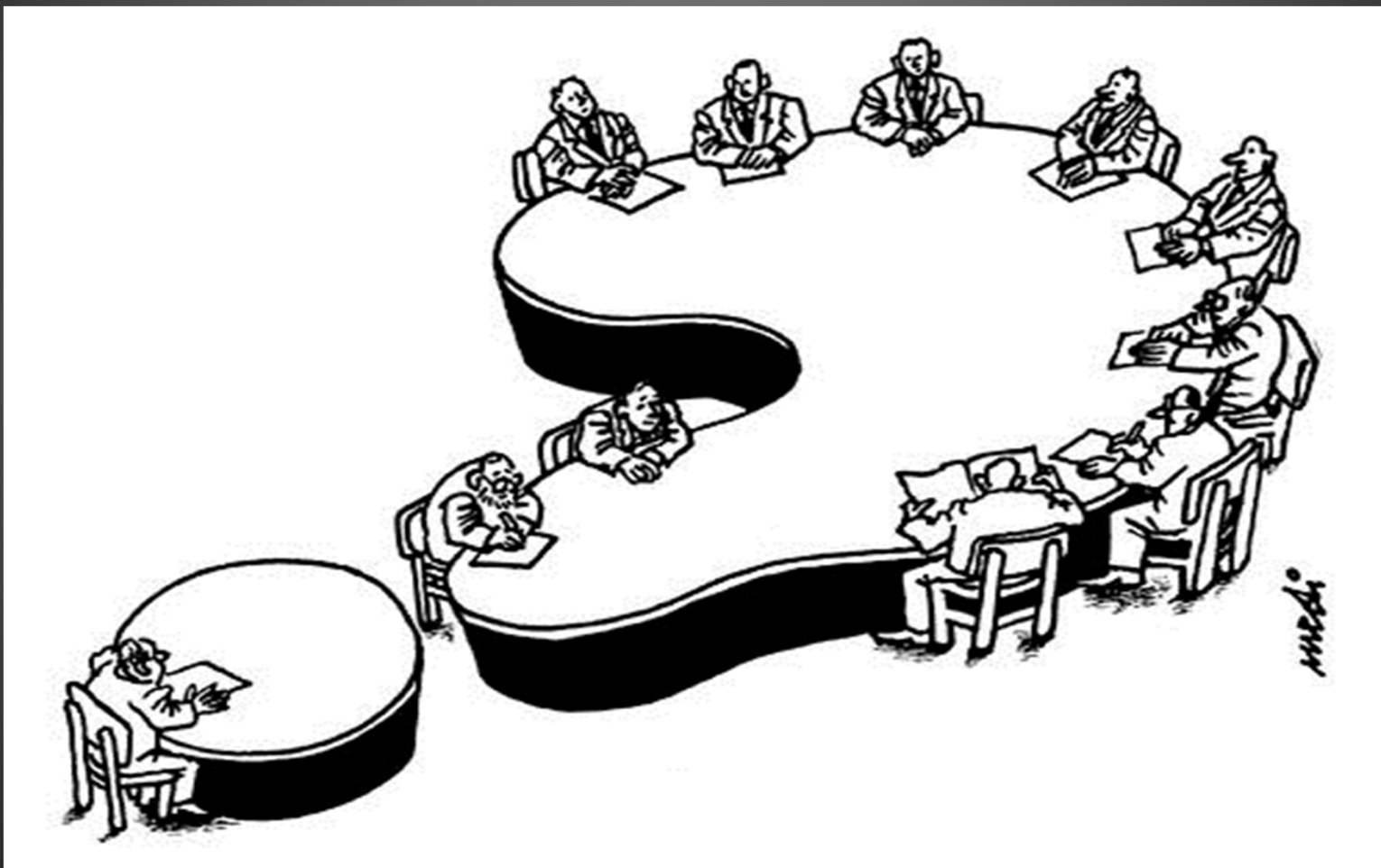


# Summary

- The issue(s) and their importance
- Legislative changes to decrease opioid-related mortality
- OSDH response and programs
- GIS Applications



# Questions



# Acknowledgements

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Avy M. Redus MS‡

Rachel Jantz MPH‡

\* Emergency Systems, Protective Health Services

† Office of Scientific and Research Integrity

‡ Injury Prevention Service

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