A Surrogate for the Truth:

Reexamination of North Dakota Traumatic Brain Injury Syndromic Data

Presented to NSSP CoP Data Quality Committee on March 13, 2020

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North Dakota Department of Health

Timeline

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| Request | Syndrome | Data Quality |

Aug 2019

Nov 2019

Feb 2020

Built TBI Syndrome for data request from TBI Coalition.

Presented TBI Syndrome to NSSP CoP Syndrome Definition Committee.

Renewed Interest in TBI Syndrome TBI query and SPSS syntax used for analysis. Why was there an increase in Shaken Baby Syndrome?

Reanalyzed TBI Syndromic Data to understand why Shaken Baby Syndrome increased and explore spatial distribution of TBI Chief Complaint (CC) quality.

ESSENCE Query Definition:

^[;/]S02.0^,OR,^[;/]S020^,OR,^[;/]S02.1^,OR,^[;/]S021^,OR,^[;/]S02.1[09]^,OR,^[;/]S021[09]^,OR,^[;/]S02.8^,OR,^[;/]S028^,OR,^[;/]S02.91^,OR,^[;/]S0291^,OR,^[;/]S04.02^,OR,^[;/]S0402^,OR,^[;/]S04.03[az]^,OR,^[;/]S0403[az]^,OR,^[;/]S04.04[az]^,OR,^[;/]S0404[az]^,OR,^[;/]S06[az]^,OR,^[;/]S06[az]^,OR,^[;/]S07.1^,OR,^[;/]S071^,OR,^[;/]T74.4^,OR,^[;/]T744^,OR,^[;/]S01[az]^,OR,^[;/]S01[az]^,OR,^[;/]S02.3^,OR,^[;/]S023^,OR,^[;/]S02.7^,OR,^[;/]S027^,OR,^[;/]S07.0^,OR,^[;/]S070^,OR,^[;/]S07.8^,OR,^[;/]S078^,OR,^[;/]S07.9^,OR,^[;/]S079^,OR,^[;/]S09.7^,OR,^[;/]S097^,OR,^[;/]S09.8^,OR,^[;/]S098^,OR,^[;/]S09.9[az]^,OR,^[;/]S099[az]^,OR,^[;/]T90.1^,OR,^[;/]T901^,OR,^[;/]T90.2^,OR,^[;/]T902^,OR,^[;/]T90.4^,OR,^[;/]T904^,OR,^[;/]T90.5^,OR,^[;/]T905^,OR,^[;/]T90.8^,OR,^[;/]T908^,OR,^[;/]T90.9^,OR,^[;/]T909^,OR,^skull fractur^,OR,^skull fx^,OR,(,(,^fractur^,OR,^fx^,OR,^injur^,OR,^hit^,),AND,(,^fac[ia][ai]lbone^,OR,^orbit^,OR,h[ea][ae]d,OR,skull,OR,^optic ch[ia][ai]sm^,OR,^optic tract^,OR,^optic pathway^,OR,^visual cort^,OR,^intracran,OR,^intracr[ai][ia]n^,OR,^br[ia][ai]n,OR,h[ea][ae]d,),),OR,(,(,^crush^,OR,^injur^,OR,^multiple^,),AND,(,^skull^,OR,^face,OR,^fac[ia][ai]l^,OR,^fac[ia][ai]l
bone^,OR,h[ea][ae]d,),),OR,(,(,open^,OR,^w[ou][uo]nd^,OR,blow,OR,jolt^,OR,traum^,OR,impact,OR,^force,OR,penetrat^
injur^,OR,contus[io][oi]n,OR,b[le][el]d^,OR,hematom^,OR,hemorrhag^,OR,coupcontrecoup,OR,contus[io][oi]n,),AND,(,br[ia][ai]n,OR,h[ea][ae]d,OR,skull,),),OR,(,(,^h[ea][ae]d injur^,OR,^skull fract^,OR,^skull fx,),AND,(,^fall^,OR,^fell^,OR,^traffic^,),OR,^br[ai][ia]n,AND,(,bleed,OR,concussion,OR,h[ea][ae]d trauma^,OR,DAI,OR,diffuse axonal injur^,OR,second impact syndrom^,OR,TBI,OR,^tr[au][ua]matic injur^,),OR,(,(,^shak^,OR,^shook^,),AND,(,^baby^,OR,^infant^,),OR,SID,OR,^shaken infant syndrome^,)

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Traumatic Brain Injury

A **traumatic brain injury** (TBI) is caused by a blow, bump or jolt to the head that disrupts normal function of the brain. Mild TBI may affect brain cells temporarily while more serious TBI result in bruising, torn tissues, bleeding and other physical damage to the brain. These injuries can result in long-term complications or death.

The degree of damage can depend on several factors, including the nature of the injury and the force of impact.

Common **events causing TBI** include the following:
* Falls
* Vehicle-related collisions
* Violence
* Sports injuries
* Explosive blasts or other combat injuries

People **most at risk** of TBI include:
* Children, especially newborns to 4-year-olds
* Young adults, especially those between ages 15 and 24
* Adults age 60 and older
* Males in any age group

Violence

SBS

Falls

Vehicle-Related Collisions

Traumatic Brain Injury

Explosive blast, combat injuries

Sports injuries
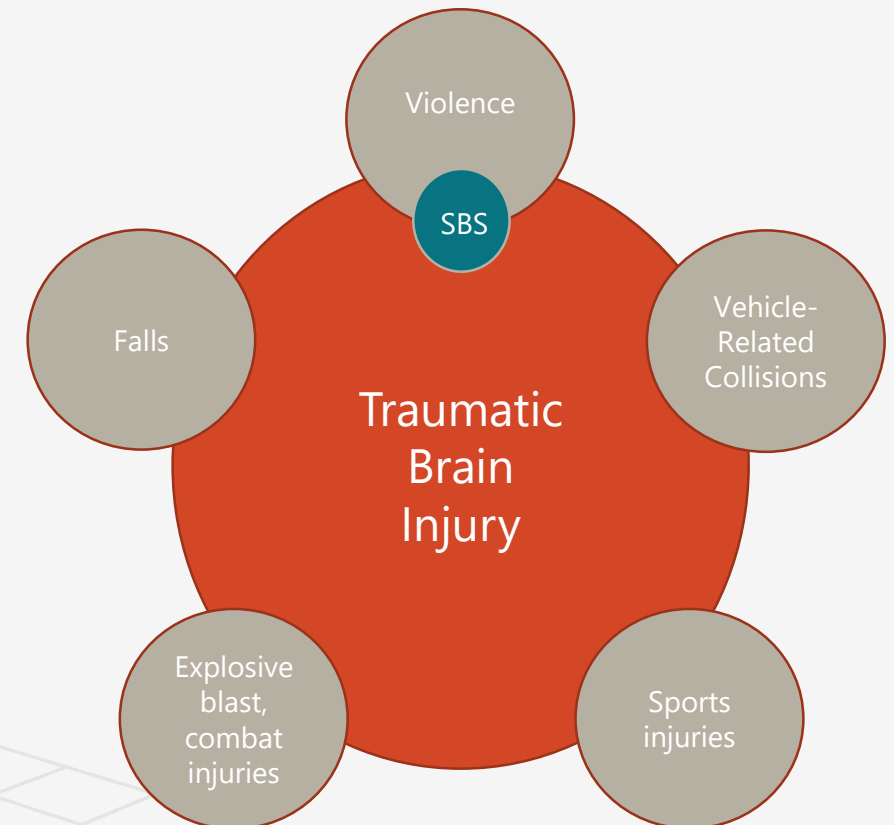
Shaken Baby Syndrome

Shaken Baby Syndrome: "Shaken infant syndrome" — also known as abusive head trauma, shaken impact syndrome, inflicted head injury or whiplash shake syndrome — is a serious brain injury resulting from forcefully shaking an infant or toddler.

Symptoms: Severe cases of SBS, babies may exhibit unresponsiveness, loss of consciousness, breathing problems (irregular breathing or not breathing), and/or no pulse. Babies suffering with lesser damage from SBS may show signs of irritability, uncontrollable crying, lethargy, poor feeding and swallow coordination, vomiting (no apparent reason), change in sleeping pattern, and/or convulsions or seizures.

Consequences: SBS can result in blindness, hearing loss, mental or developmental delays, cerebral palsy, severe motor dysfunction, spasticity, seizures, and/or death.

Prevention: Helping people understand the dangers of shaking a baby, including the risk factors and triggers for SBS.
Provide support to overstressed parents and caregivers.

* In ND, SBS is not reportable but violent deaths (homicide) are. If a SBS case results in death, it is reportable.

The Truth
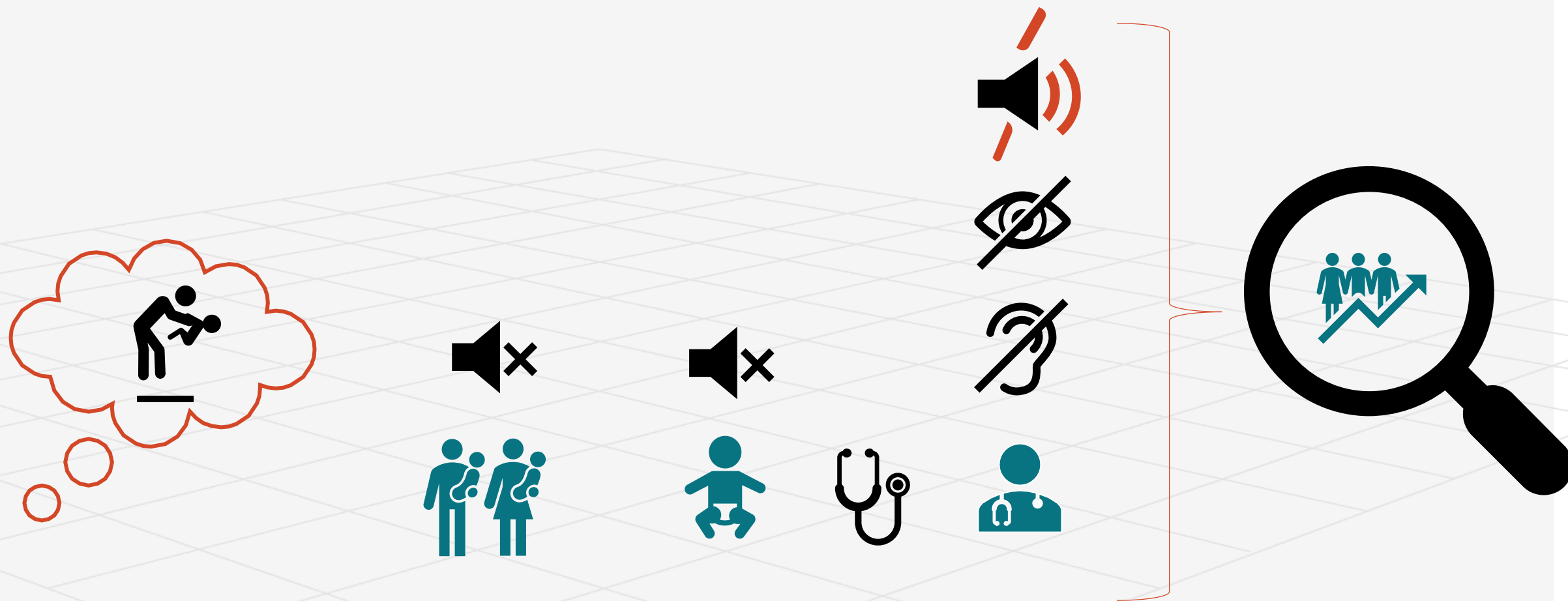
We depend on quality of data: CC from what the doctor writes about the interaction between the patient and doctor and what the final "diagnosis" is of the doctor based on the medical evidence, expertise, and professional judgement.

Methods

SBS Inclusion criteria (pulled data from ESSENCE TBI QUERY):

Patient (pt) is 0-5 years old (inclusive criteria)

Chief Compliant (CC)or Discharge Diagnosis (DD) is clearly indicative and states baby was shaken, or an incident of shaking pt occurred, or discharge codes for shaken baby syndrome (SBS).

Shaking baby or infant was intentional.

Patient Disposition: patient is discharged, transferred or admitted.

SBS Exclusion criteria (pulled data from ESSENCE TBI QUERY):

Physical abuse-related injuries, falls, being struck by object were excluded as non-SBS, but as traumatic injury to brain.

Discharge diagnosis for "brain swelling, subdural hematoma or hemorrhage" <u>alone</u> without indication of "shaking" or "abuse" mentioned were excluded. We assumed that for patients 0-5 there are numerous events/causes that result in "brain swelling, subdural hematoma or hemorrhage, or concussions, or contusions, fractures of the skull".

Chief complaints that mentioned "shaky" or variations of the word and were asserted to mean other conditions: "shaky from cold" or "shaky breathing" were excluded.

Records mentioning other family members being evaluated for SBS.

TBI Inclusion criteria (pulled data from ESSENCE TBI QUERY):

*based on ESSENCE Syndrome Definition

TBI Exclusion criteria (pulled data from ESSENCE TBI QUERY):

Zip codes not provided, Zip codes outside ND

1 TBI Syndromic Data: pulled out the data from ESSENCE based on TBI Syndrome definition;

Used SPSS to extract number of SBS events, syntax to search for words "Shaken", "Shook", "Baby", "Infant", and ICD-10 codes "T744" & "T749" (unspecified child maltreatment) within the variables "CCDD"; "ChiefComplaintOrig", and "Discharge Diagnosis".

2 Vital Records: Manner of death is "homicide" or "manslaughter" and cause of death specific injuries rather than "Shaken Baby Syndrome". Will obtain Trauma Registry data as well.

3 We manually inspected the data in addition to the syntax to verify the cases for each year.

** Had we used this exclusion; we would have missed more cases.

Patient disposition: Whether patient was admitted/transferred: we trusted doctor judgement to be fair if this was serious event related to shaking related injuries; patients that were discharged were excluded.

4 Median CC statistically significant areas where CC was "less informative" using the variable: Length CC Original; Pt Zip code
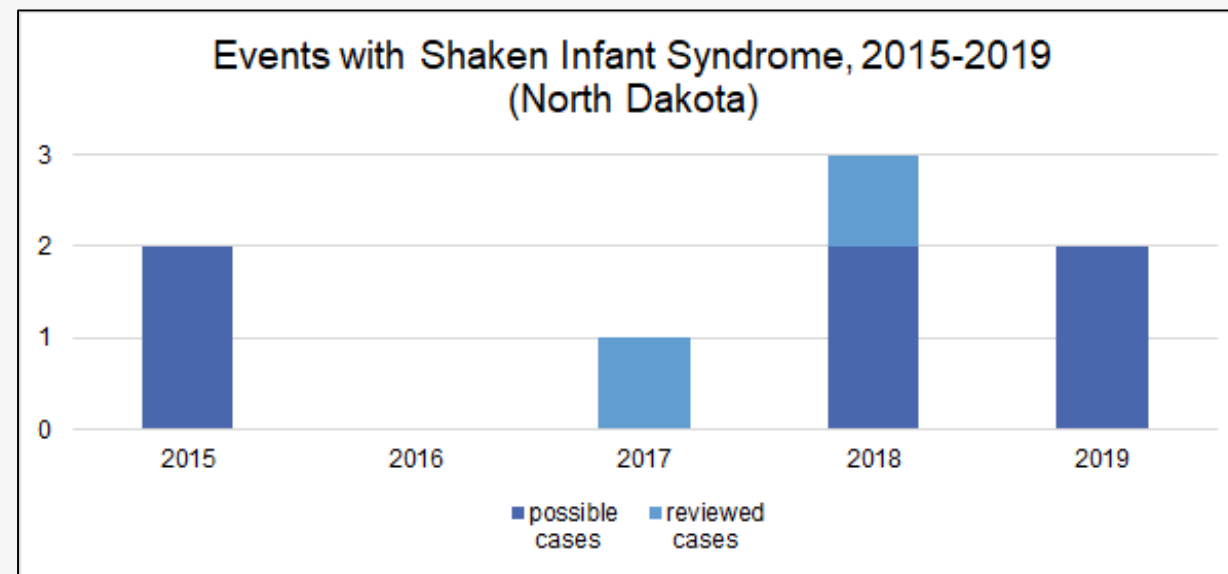
Used RStudio

SBS Findings

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Sample Output:

CCDD * shaken infant syndrome and codes * Disposition Category Crosstabulation

Count

Disposition Category			shaken infant syndrome and codes	Total
			1	
DISCHARGED	CCDD	| ;T744XXD;	1	1
		HYDROCEPHALIC INFANT HAD REVISION OF SHUNT ON THURSDAY DEVELOPED A COUGH FOR PAST 1 1 1 2 GOUPY EYE COUGH INCREASED HERE TO HAVE IT CHECKED OUT CHILD WAS SHAKEN NOVEMBER HAS A GTUBE NAUSEA | ;J06.9;	1	1
		███████STATES 20 MINUTES AGO ████████FELL WAS HOLDING INFANT████ STATES PATIENT S HEAD HIT GROUND ██████████STATE PATIENT CRIED FELL ASLEEP PATIENT SLEEPING AT TRIAGE CLOSED HEAD INJURY | ;S72331A;W19XXXA;	1	1
		NEURO CHANGES NEUROLOGICAL CHANGES | ;G919; R5383;R569;T744XXA; D649;	1	1

Events with Shaken Infant Syndrome, 2015-2019 (North Dakota)

legend: possible cases, reviewed cases

1) For 2015-2019 ESSENCE query brought 670 TBI cases in children 0-5;

2) Search from SPSS narrowed down to 22 cases;

3) Visual inspection resulted in having 8 cases (6 possible – that do not contain ICD-10 codes but the context of the CCDD points to the case; 2 reviewed – contain ICD-10 codes and description points to the case)

Findings – Spatial Analysis (Area Level)
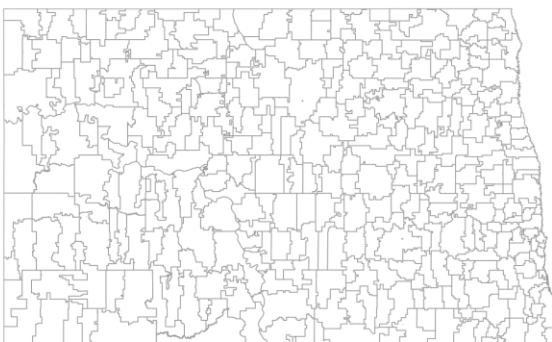
Large Scale Variation of Median CC
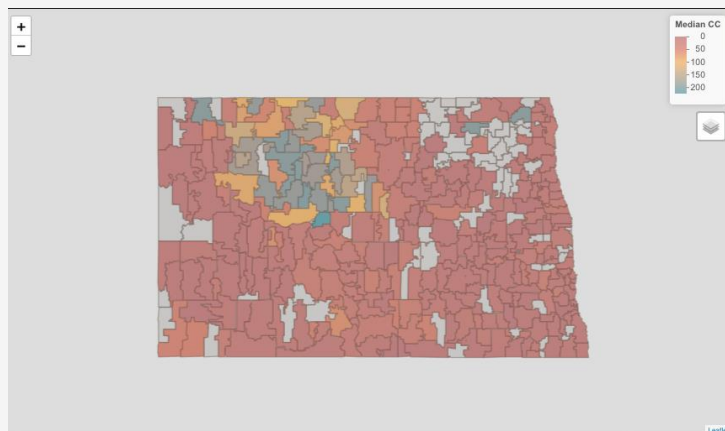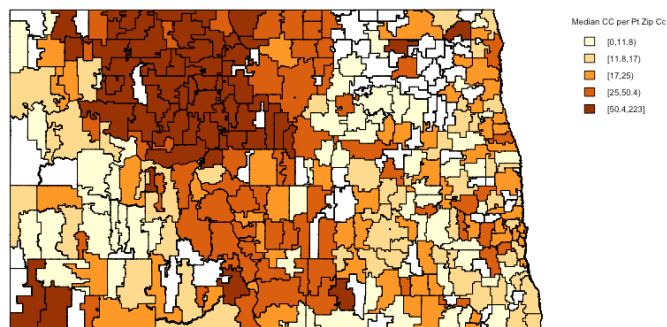
TBI Syndrome Median CC Characters per Pt. Zip code (Rstudio Leaflet and Choropleth)

Spatial dependence for spatial area level data

Significant Spatial Clustering?

North Dakota Zip Codes

North Dakota - Sharing a Boundary Neighbor Structure Queen Adjacency (Zipcodes)
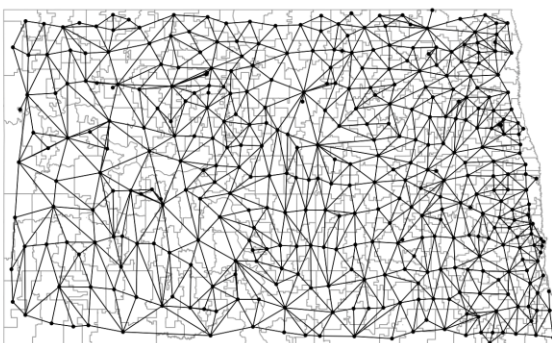

Small Scale Spatial Variation of Median CC

```
            Monte-Carlo simulation of Moran I

data:  as.numeric(tbigeo$medcc)
weights: nb2listw(tbigeo_nb, style = "B")
omitted: 2, 5, 7, 10, 12, 23, 24, 40, 43, 47, 49, 50, 54, 68, 73, 75, 77, 79, 81, 84, 86, 89, 91, 9
5, 98, 102, 103, 105, 106, 107, 109, 110, 112, 117, 119, 122, 124, 126, 128, 129, 131, 135, 137, 13
8, 140, 142, 148, 151, 152, 153, 154, 160, 162, 165, 182, 189, 190, 195, 197, 198, 206, 207, 211, 2
21, 228, 233, 242, 243, 254, 260, 284, 285, 290, 292, 300, 311, 312, 343, 345, 372, 374, 381
number of simulations + 1: 1000


statistic = 0.67665, observed rank = 1000, p-value = 0.001
alternative hypothesis: greater
```


Moran's I Correlogram for ND Median CC Zip Code
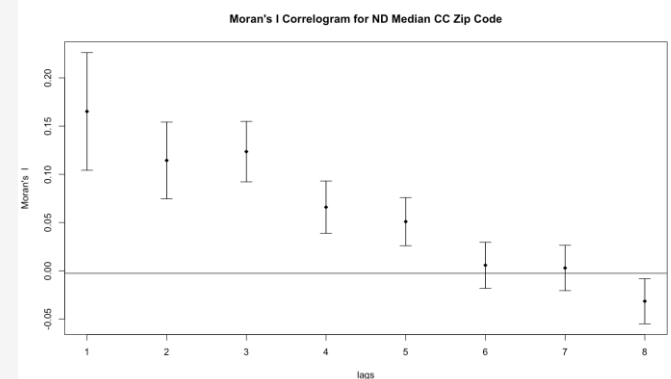
Moran's I Correlogram

* Median CC per Pt zip code

* Moran's I for spatial correlation: spatial similarity

* Did zip codes with high Median CC tend to cluster?

Discussion

More things to consider:

1 Spatial Analysis: Consider other variables that could predict "Informative CC":

- Use a Poisson Regression to model "Informative CC" with covariates: "MinutesFromVisitToDischarge" (length of visit in minutes), "ModeOfArrival" (ems visit vs walk in), "HomeFacilityDistance" (distance from home to facility)

  - Univariate results: to understand each variable in the model for association/correlation with informative

TBI/All ESSENCE data: Poisson regression model

Length of CC (Median)= **Age** + **Gender** + **pt race** + **MinutesFromVisitToDischarge** (length of visit in minutes) + **ModeOfArrival** (ems visit vs walk in) + **HomeFacilityDistance** (distance from home to facility) + **offsetLog** (pop or #visits)

2 ICD-10 codes for initial visits, subsequent or sequalae visits

3 Severity level of injury due to SBS (adults with a TBI or children)

4 Why were some CCs abruptly cut (particularly long CC)?

Further Directions

Onward

1 SBS: Create a syndrome definition based on symptoms for SBS to include: extreme fussiness, difficulty staying awake, breathing problems, poor eating, vomiting, pale or bluish skin, seizures, paralysis, coma, blindness, paralysis, deafness, learning disabilities, coordination problem, developmental disabilities, physical injury to child's body, blood work (to rule out metabolic and genetic disorders) x-ray (for intentional or abuse, fractures), MRI (detailed image of brain, brain bruising or signs of low oxygen; but this is difficult to perform on child who is moving or unstable) CT scan (cross section of body and of brain), etc.

2 Establish relationship between frontend ESSENCE users, vendors and providers **to improve the quality of care for all North Dakotans** through improving quality of capturing the patient-doctor interaction in the CC and DD.

3 Improve data quality for TBI Syndrome or ALL ESSENCE data.

References

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National Center for Injury Prevention and Control, Division of Violence Prevention (2020, March 5) *Preventing Abusive Head Trauma*. Retrieved from CDC: https://www.cdc.gov/violenceprevention/childabuseandneglect/Abusive-Head-Trauma.html

With Much Gratitude

- Office of the State Epidemiologist

- Department of Geographic Information Systems & Census Office

- Division of Injury and Violence Prevention

- Community of Practice (DQC, Syndrome Def.)

- Michael Thomas, MS, Georgia Department of Public Health*

- Mentors*