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UNDERSTANDING PEDIATRIC INJURY IN COLLIER COUNTY, FLORIDA: A MIXED METHODS ANALYSIS

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Background: The current trauma system in Collier County disperses injured pediatric patients to trauma centers outside the County. There is a critical gap in knowledge in the epidemiology of the County's pediatric trauma patients.

Purpose: To understand injury patterns in children ages 0-17 years in Collier County and identify challenges in transporting injured children to definitive care.

Methods: This is a cross sectional, descriptive study using a sequential mixed-methods design. A thorough review of the literature and interviews of key stakeholders were conducted in August 2017. Data obtained from the interviews was used to develop a causal loop diagram using Vensim modeling (version 7.2). De-identified hospital and EMS database from January 1, 2012 to April 20, 2018 was analyzed. Descriptive statistics were calculated for age, gender, ethnicity, race, reason for transport, refusal of care, mechanism of injury, disposition and zone of injury variables. Statistical analyses were conducted using SPSS version 25 and R 3.3.1.2. Statistical significance was set at $\alpha < 0.05$.

Results: 5,297 records were evaluated. 95% of the pediatric EMS calls were trauma related. 90% of injured children received care at the County's acute care hospitals. 7/10,000 children per year were trauma alerts transported out of the County. Bad weather was the main factor impeding transport outside the County. No data is available on outcomes of trauma alert patients who received care outside the County.

Discussion: Our County lacks data on trauma services and outcomes for pediatric patients, despite population growth. Severe weather impedes the transfer to TCs, keeping these patients at the local hospitals. There is insufficient evidence to demonstrate that the current management of injured children in the County provides the best outcomes. This study concludes with a series of recommendations to develop a local trauma database, integrate services and mature into a robust and organized system.

Background | Injury is the leading cause of mortality in children living in Collier County, Florida¹. This County, located in Southwest Florida, has 4 acute care hospitals and no designated Trauma Center (TC)². The current trauma system disperses Collier County trauma patients to TCs located outside the County. Pediatric patients are often transported to 2 hospitals prior to arriving to their final destination for definitive care.

Data on pediatric injury in the County is scarce and insufficient to measure challenges in processes, structure and outcomes. There are no injury databases in the local hospitals. The community has expressed concerns regarding the separation of families and the stress that injury brings to the patients and their caretakers, as they are moved out of the County³. However, lack of data on pediatric trauma impairs the ability to bring resources to the County.

Motor vehicle accidents are the most common cause of injury deaths in children ages 5-17 years¹. Despite

prevention programs and active education, the fatal injury-age adjusted rates for the County continue to rise¹.

Since the opening of a 24-hour pediatric emergency room 6 years ago, more injured patients are arriving at the acute care facilities, thus creating new challenges for the treatment and rehabilitation of these children. In addition, weather challenges such as fires and heavy rains impair the use of the transport helicopter, therefore, severely injured patients are taken to the local acute care hospitals.

Purpose

Our goal was to understand the current pediatric injury patterns in Collier County and the challenges that are encountered in getting them transported to the definitive care facility.

Methods | *Quantitative and Qualitative Data Collection and Integration.* The qualitative component of the study included data from 15 key stakeholders in

a focus group and the quantitative component included a secondary data analysis from two sources, the NCH healthcare system emergency department visits and from the Collier County EMS database.

The qualitative data included opinions collected from the focus group session regarding the factors and challenges affecting pediatric trauma care in the County. This author led a discussion about the current trauma system for pediatric injured patients and the participants wrote and voiced their opinions. An additional focus group session with the EMS leadership team, a hospital representative and the director of the Safe & Healthy Children's Coalition provided opinions and comments regarding the data analysis results as an internal validation of our understanding of the data collected. Key variables were extracted from the interviews.

Data sources: Our data sources included Florida Charts Vital Statistics, Collier County department of Children and Families, Collier County EMS database, NCH healthcare systems medical records, CDC WISQARS, US Census data and personal interviews with key stakeholders ⁴⁻⁷.

Setting: Collier County, Florida and NCH Healthcare systems emergency rooms in Collier County. NCH is an accredited institution in Collier County, which provides general medical and surgical care. The North campus has a 24-hr pediatric Emergency Room, which receives approximately 18,000 annual visits. This healthcare system has two of the four acute care hospitals in the County. The Emergency Room providers are pediatricians and adult emergency physicians. Advanced Trauma Life Support Training certificate for these providers has been optional. Pediatric surgery services were introduced on April 2017.

Sample

1. Focus group: We used purposive sampling, in which we invited all first responders, health care providers, coalition leaders, and administrators to participate in a focus group related to pediatric injury in Collier County.
2. Secondary data analysis:
 - NCH Emergency Rooms: We used a convenience sample from hospital visits to the three NCH healthcare systems emergency departments from November 9, 2017 to April 30, 2018.

- EMS Collier County: We used a convenience sample provided by Collier County EMS from January 1, 2012 to April 30, 2018 of all EMS calls related to pediatric injury.

Measures

1. Focus group: We invited representatives of multiple agencies from the County to participate in a focus group. We interviewed 15 actors. Notes were taken and participants wrote in their own words their opinions. We had several questions as guide (Table 1).
2. Stakeholder analysis: The analysis was done by identifying each stakeholder into 5 main groups: (1) those influential in policy making, (2) those who can make operational decisions, (3) those who can provide input to the process (4) those who can provide a reaction and (5) a group for interest.
3. Identification of key variables: common themes and topics were identified and collected from interviews and written comments by stakeholders.
4. Descriptive analysis: Study measures included self-reported and chart measures. These included age, gender, ethnicity, race, zip code of residency, zip code of injury, type of injury, mode of transport, reason for transport, refusal of care, mechanism of injury, diagnosis, mode of arrival, and disposition. Ethnicity was defined as Hispanic, Non-Hispanic and Unknown. Race was defined as White, Black/African American (AA), American Indian or Alaskan Native, Asian or Pacific Islander, Other and Unknown. We clustered Zip Codes into various geographical areas to facilitate identification of communities and injury location. Zip codes were classified as follows: Naples (34102, 34103, 34104, 34105), North Naples (34108, 34109, 34110, 34119), Golden Gate (34114, 34116, 34117, 34120), East Naples (34112, 34113), Immokalee (34142, 34143), Marco Island (34145) Ochopee (34141) and Other.

Procedures

Human Subjects' Protection

The NCH Institutional Review Board granted exemption for their data analysis. All data were de-identified for statistical analysis.

Table 1. *Questions discussed in focus groups*

1. What is their role within the trauma system in Collier County?
2. How do they interact and with whom?
3. What research is required?
4. What are the barriers affecting their jobs?
5. What are the barriers affecting transport of injured pediatric patients?
6. What are the aspects of trauma that they would like to learn more about?

Data Collection

Focus group: The focus group was conducted on August 30, 2017. Written recording of the conversations was done. All participants provided verbal consent to participate in the discussion. All notes from participants and written recordings were analyzed for common themes.

NCH data: Prospectively collected data from November 9, 2017 to April 30, 2018 were obtained from medical records from NCH healthcare systems emergency room visits for children < 18 years old. Demographic, injury patterns, geographic area, and treatment data were analyzed.

EMS data: Prospectively collected data from January 1, 2012 to April 30, 2018 were obtained from Collier County EMS database. Demographic, injury patterns, transport patterns and disposition data were analyzed.

Data analysis

Descriptive statistics were calculated for all study variables. This included mean and standard deviation for continuous measures and counts and percentages for categorical variables. All statistical analyses were conducted using SPSS version 25 and R version 3.3.1.2⁸⁻⁹. The causal loop diagram was created using Vensim 7.2 software¹⁰.

Results | I. Focus group: There were 15 participants representing the following areas: Children's Advocacy Center, Collier County Sheriff's Office, NCH healthcare Pediatrics, North Collier Fire District, Greater Naples Fire, Collier County EMS, Johns Hopkins All Children's Hospital, NCH Quality Director, NCH Safe & Healthy Children's Coalition, NCH Administration and NCH Emergency Room.

Pre-hospital trauma setting

Topic: Need for research All of the participants agreed that trauma research was needed.

Topic: Data needs Four respondents expressed interest in obtaining information on the "persons present at the time of injury" and the "location of injury". Two participants reported the need to further investigate "co-sleeping" as a factor leading to trauma. Three participants reported the need for demographic

information and care given by first responders at the scene.

Topic: Challenges Thirty three percent of the participants reported confusion on where to take the patients and one participant voiced: "We just don't know where to take the pediatric patients"

One participant expressed that physicians at receiving facilities frequently say: "Shouldn't be coming to me" One participant expressed frustration on patient's refusal for care.

Hospital trauma setting

Topic: Triage Two participants responded that it is important to know the Level of trauma care that the receiving hospital has. One participant wrote concerns about the triage system at the hospital upon patient's arrival: "Injury Severity Score, who is calculating? Need a trained professional in accurate ISS" Another wrote: "they need to use pediatric Glasgow Coma Scale" Three participants voiced the need for routine substance abuse screening for trauma patients upon arrival.

Topic: Mechanism of Injury Two participants voiced the need to "evaluate co-sleeping and parental drug overdose" as a mechanism of injury for suffocation victims.

Topic: Disposition in hospital and feedback One participant expressed lack of feedback on patient disposition once they go to the hospital. One participant voiced the need to have information on who notifies Department of Children and Families in some trauma cases.

II. Identification of key variables and analysis of the trauma system:

Trauma services in Collier County are provided by various groups of stakeholders in a decentralized system. The seriously injured patients are transported out of the County under the current protocol, but exceptions occur if the transport systems are not available or incapacitated due to hostile weather patterns. The EMS system has NCH North campus as backup for pediatric care but could use any of the other 3 acute care facilities if needed. Figure 1 represents the causal loop diagram created to illustrate the complex dynamic of transporting patients and the effects on other systems within the County.

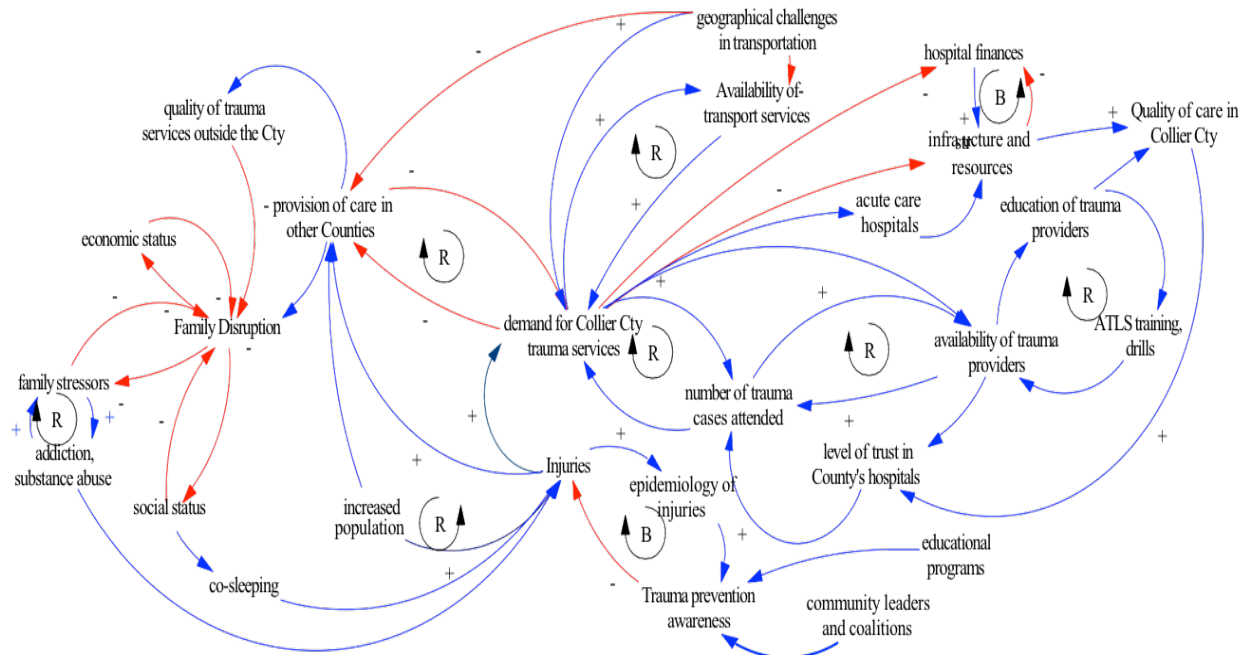
We identified four major subsystems (Fig. 2). The system is not linear, and its complexity is due to multiple factors occurring at various times.

- a. The *healthcare service subsystem* is responsible for providing care to injured patients in Collier County. This subsystem is responsible for the organization, planning, management and distribution of the healthcare resources. These include physicians, nurses, technicians, social workers, physical therapists, equipment, infrastructure, 24/7 services, trauma centers, acute care hospitals, emergency rooms, nutrition services, discharge planning and rehabilitation. There is a balancing loop in the healthcare system, which illustrates how the hospital infrastructure and finances is affected by the increased demand to keep trauma patients in the County. The increased demand for services will force the hospital to upgrade their infrastructure and resources, including physicians and ancillary facilities. The quality of care of trauma services in the County have a reinforcing loop. As the number of trauma cases increase in the County, additional providers, training, drills and education programs will be needed in order to secure a level of care that the community can trust.
- b. The *community subsystem* represents the entire community that uses the health services. It includes the population, cultural diversity, addictions, behaviors, beliefs, demand for services, family disruptions and habits. The community also involves those who care for injured children (families, relatives), and who are guardians of children who sustain injuries. Within the community, we observed both balancing and reinforcing loops. The increase in population is leading to more injuries, which is stressing the system. An increase in injuries requires more transports outside the County; this is leading to major burden in the families, disruption of their economic condition, missing employment days, and increased stress. Another reinforcing loop is observed in the epidemiology of injuries. By understanding the epidemiology, the community can be educated on trauma and prevention awareness, and injury events can be decreased.
- c. The *transportation subsystem* is responsible for providing initial care and transportation to the

injured children to the place where they will get care. It is responsible for the organization and distribution of equipment, ambulances, helicopters, pilots, flight nurses, paramedics, Sheriff's deputies, firemen and women, communications, drills, education and training. This subsystem is involved in anticipating disasters and mass casualties, maintaining certification in advanced resuscitation skills and knowledge. We identified reinforcing loops for transport services. As the demand for trauma services increases in the County, the demand for prompt transportation is needed. The availability of the transport systems is directly affected by the demand. In addition, geographical and weather challenges pose a new stress on the system, as the transporters are in need to deliver patients to the County hospitals, which are not fully prepared to deal with severely injured patients.

- d. The *management subsystem* is composed of EMS, Fire Department, Department of Health, Sheriff's office and other agencies directly related to the operational organization and supervision of transport and health care systems. They monitor and supervise quality and quantity of rescues, treatments and transports. They keep constant supervision on other subsystems by collaboration and the provision of manpower, funds and infrastructure. The management subsystem is of extreme importance in the day-to-day operations of the transport and health care systems. They also influence the community with education and maintenance of accountability of the other subsystems. There are reinforcing loops within this subsystem, as upgrades of all services must be done as a response to increases in the demand of trauma services in the County. This brings also competition between the two main key responders, EMS and North Collier Fire Control and Rescue District regarding service areas and distribution of rescues.

We identified additional key external agents that in our analysis are considered to be out of our boundaries. These include the Federal government, the Florida government, the coalitions, the foundations and other funding agencies that provide the needed funds for sustaining the subsystems. These will not be considered in our analyses.

Figure 1. Causal loop diagram illustrating factors influencing the trauma system in Collier County, Florida

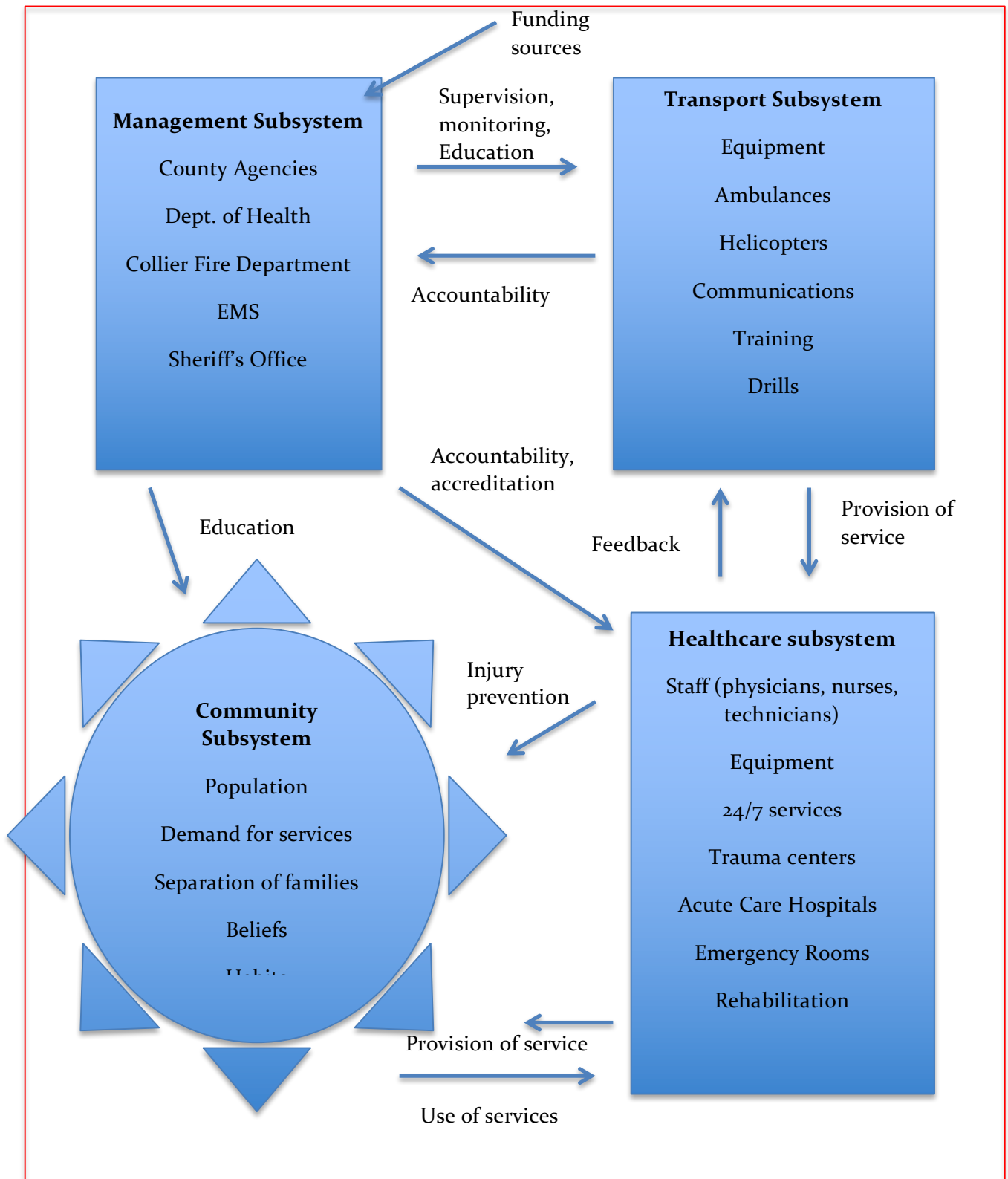
The causal loop diagram is a diagram that expresses cause and effect and illustrates the relationships that exist among the key variables. The creation of the diagram tells the story. The relationship between the variables is shown with arrows, pointing at the direction of influence. A positive sign on a line indicates that the change in one variable will lead to a change in the same direction of the other variable. A negative sign means that the change of one variable will be an opposite change on the other variable. The feedback loop created by the connection of variables could be reinforcing, depicted as “R” or balancing, depicted as “B”. A reinforcing loop means that there is a positive feedback system, with either growing or declining action. The balancing loops “keep things in equilibrium”.

IV. NCH data: There were 317 medical records reviewed of patients cared for at the three NCH emergency rooms in Collier County, Florida from November 9, 2017 to April 30, 2018. Ages ranged from 6 months to 17 years. Mean age was 10.2 yrs. Fifty nine percent were males. Approximately 16% of the cases were in the 0- 5 years’ category, 23% in 5-9 years, 37% in 10-14 years and 22% in 15-17 years. Seventy six percent were White, 12.6% were Black/AA and 11% were Other or Unknown. Sixty-three percent were Non-Hispanic. The mortality due to injury was 0.6% during this period. Ninety-seven percent of the patients were treated in the ER and discharged home. Closed head injury the most common injury observed, and the most common mechanism of injury was falls, followed by struck by object.

Seventy-nine percent of the patients were “walk-ins” and only 3% were brought by ambulance. We examined the injury types by location. Unfortunately, 80% of the cases had missing Zip code data of the injury location. This prompted the request for data from Collier County EMS.

V. EMS data: There were 5, 297 records available for analysis from January 1, 2012 to April 30, 2018. Eighty-five percent of the calls attended by EMS were due to trauma (N=4518). Six percent of those trauma cases were classified as severely injured Trauma alerts based on EMS triage criteria. Patients ranged from 0-17 years of age, with a mean age of 10.5 years. Fifty-seven percent were males. Most of the injuries occurred in streets/highways and at home.

Figure 2. *Interactions among subsystems and key variable*



The residential areas of Golden Gate, Immokalee and Naples had the highest frequencies of trauma injuries over the entire study period. There were a significant proportion of patients (non-trauma alerts) who refused EMS services; most of them were members of the Immokalee and Golden Gate communities.

The most seriously injured patients (trauma alerts) were transported to the regional TC, but since 2015, number of cases going to all NCH Emergency Rooms increased. There are approximately 50 trauma alert cases transported out of the County every year, with an approximate crude rate of 72/100,000 population. Fifty percent of those patients were transported by EMS were taken to Lee Memorial, a Level II trauma center and 50% to the helicopter zone. We do not have information on how many of those patients were transported from the Level II TC to a pediatric trauma center. The non- trauma alert pediatric patients have been increasing in number and most of them are being transported to NCH North campus hospital.

Discussion | Timely access of injured children to the adequate level of care is vital in determining their outcomes¹¹⁻¹⁵. Despite a structured trauma system in the State of Florida, there are still Trauma Service Areas, like Collier County, without their own trauma Center; requiring the provision of care to most injured children by the local non-trauma hospitals. This correlates with data published in 2006 by Densmore et al, in which an analysis of the 2000 Kid's Inpatient Database reported that nearly 90% of injured children in 27 states received care at non-pediatric trauma centers¹². Although the current network provides for provision of care within one hour to a Trauma Center, weather changes in the County impede the safe transportation of children to the adequate centers. The EMS data showed that approximately 50 children are being transported out of the County, but we lack data from other first responders regarding these transfers. This lack of data is a national problem.

In the US, the main source of trauma data, the National Trauma Data Bank®, only collects data from the trauma centers and do not offer information on acute care hospitals or rural area hospitals providing pediatric trauma care¹⁶.

The state of Ohio is an exception, as by law, it collects data from almost 87% of all hospitals including non -trauma centers¹⁷. The Ohio Trauma Registry began their data collection in 1999 by group of trauma stakeholders. It started as an official 501 (c)(3) "Foundation" and later changed to the Central Ohio Trauma System Registry. This registry has proven effective in collecting data that allows measuring outcomes, improving the delivery of care, facilitating access and evaluating emergency medical services¹⁷. It has been shown that pediatric patients have better outcomes when they are treated in Level I and Pediatric trauma centers compared to non -trauma

centers¹¹⁻¹⁵. Given that we are observing a significant number of children being transported to our non-trauma centers, we must work diligently to upgrade our resources, infrastructure and protocols to provide the best care possible in Collier County.

Understanding the system

Collier County has a complex trauma system as we learned from our interviews, close loop diagram and data analyses. Using systems thinking, we can identify several issues that merit attention within each subsystem.

Measuring Outcomes: Since the conception of the first trauma registry in 1969 in Cook County, trauma data has been collectively obtained by institutions with the goal of identifying life threatening injuries, treatment outcomes, cost and evaluating effectiveness of prevention programs¹⁴. In the setting of the new law passed this year, Collier County will be assigned to Lee County's trauma service area and all patients will be directed to their Level II Trauma Center¹⁸. It will be important to develop a standardized trauma database collection system among the County's acute care facilities. A trauma registry or surveillance system can provide information for quality monitoring, evaluation, public health surveillance, and measure the economic and social impact of pediatric injury in the County and the State.

Potential consequences of this database development depend on the degree in which each institution is compliant with its completion. As we could gather from the NCH data, the information was limited. Similarly, the Florida Department of Health does not require acute care hospitals to report all injuries, making data collection a difficult task. Integration of EMS and Fire Department data would be important to measure response times, types of resuscitation, location of injuries, setting of the injuries, and challenges in transporting patients to their appropriate trauma center. Ideally, a well-structured organization such as the Collier County Department of Health or the private sector could take the lead and manage this data collection as they currently do with other diseases, such as sexually transmitted diseases. Unintended consequences could be the need for additional financial and sustainable resources to keep up with the financial cost of sustaining a database and its infrastructure.

Additionally, scheduled trauma conferences, discussion of morbidity and mortality and continued education and training should be mandatory policy in each institution. As we have no information on outcomes, we do not know if the current practice patterns by the clinicians are optimal for pediatric trauma care.

Developing Structure: At the County level, the institutions could increase their investment in the resources available to the community at the hospital

level and at the community clinics. These resources should include educational and prevention programs, as well as clinicians in after- hours clinics that could serve as liaison to the main hospitals. This would be particularly important in those areas identified from our study with higher proportions of injuries, such as Immokalee and Golden Gate communities.

The hospitals must create mandatory policies for all physicians caring for trauma patients to have the proper credentialing, including Advanced Trauma Life Support training. As we observed from our data, injured children are often being transported to the adult emergency rooms, which are managed by adult physicians. There is no standardized protocol for initial care of the injured child in the Emergency Room and it depends on the training of the particular emergency room physician available during the child's visit. We also observed that children are arriving to the acute care hospitals in the County due to weather challenges or transportation problems. Protocols should be standard for all trauma patients as recommended by the American College of Surgeons¹⁹. Facilitating the Process: One of the main concerns from the first responders was the variable response of physicians upon receiving injured children in their emergency rooms. All acute care hospitals should develop a standardized protocol and agree upon the management of the acutely injured children who require being cared for at their institution. Pre-arrival communication and trauma alerting should be standard for all hospitals to allow the teams to get ready and organized. Transfer agreements should be established and formalized to minimize speculation of where to send the patient or rejection from trauma center providers. A leadership team including surgeons, pediatricians, acute care physicians and ancillary services should be established as to facilitate the development of policies and procedures.

Limitations | This study has several limitations, particularly those related to retrospective studies. There is a possibility of selection bias, as we had a convenient and sample available that might not truly represent the epidemiology of pediatric trauma in the

County. Unfortunately, acute care hospitals are not required to keep a database on non-trauma alert cases, making it difficult to assess the impact of trauma visits to these hospitals.

There are potential recall and misclassification biases due to the fact that we collected information from the chart. Miscoding of variables is possible, and we might not have captured the entire injury data of patients visiting other emergency rooms in the County. Enforcing a data collection system would be ideal at the local hospital level, but this will require financial and human resources that are not currently available. There is no data on social determinants or on the context of the situations that were leading to injuries that could be acting as confounders. Furthermore, the temporal relationship of these events is impossible to assess. We do not have information on transport time of those patients who were transferred out, nor we have any information on those patients who were taken out of the County.

Despite our limitations, this study is the first analysis of the epidemiology of pediatric trauma in the County. It adds information on the characteristics of pediatric injuries and highlights the need for additional information.

Conclusion | Childhood trauma must be conceptualized and highlighted as a major factor of morbidity and mortality in children in Collier County. The current evidence reflects the need for data that can accurately reflect the epidemiology of pediatric trauma in the County. If possible, data should be population based and not hospital based. Studies are needed to examine the various components of the County's trauma system and how are they integrated in the community. The goal for these studies should include (1) the evaluation of first responder protocols and how they impact the care of injured children at the scene, their triage criteria and response times; (2) the evaluation of transport systems for inter-hospital transfers within and outside of the County, and (3) the evaluation of risk factors in those communities with higher proportions of injured children.

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