



Florida Department of Children and Families

Executive Digest

Child Fatality Trend Analysis January 1, 2007 through June 30, 2013



3800 Esplanade Way Suite 160
Tallahassee, FL 32311
Phone – 850.222.4733



The Department of Children and Families contracted with North Highland to analyze the child fatalities reported to the Florida Abuse Hotline from January 1, 2007 to June 30, 2013. The purpose of the analysis is to confirm general trends in child fatalities, provide an initial set of key risk factors through data discovery and statistical analysis, and lay the groundwork for future advances in child welfare practice supported by predictive analytics tools and techniques.

PROJECT OVERVIEW

North Highland (NH) is the primary lead on the project, providing project management, supporting the data scientists and child welfare domain experts, as well as compiling the final report. The SAS Institute (SAS) provides sophisticated statistical analysis through their Advanced Analytics Lab. The Child Welfare Policy and Practice Group (CWG), a private, non-profit organization, provides thought leadership in achieving high quality front-line practice and improved outcomes for family and community services.

The project spanned five weeks and was limited to two primary data sources: Florida Safe Families Network (FSFSN) and the Child Death Review Database (CDR). Additionally, three secondary summary-level sources were referenced, from the Department of Health, Abuse Hotline, and Child Protective Investigators. The data population consisted of reports to the Hotline about a child fatality that contained allegations of abuse or neglect as factors leading to the child's death. The population included both the children whose families did - as well as those who did not - have prior agency involvement in protective investigations. The child fatalities were compared to the entire FSFN population of children who were involved in child protective investigations from January 1, 2007 and June 30, 2013.

It was agreed that the following would apply to any data provided by DCF:

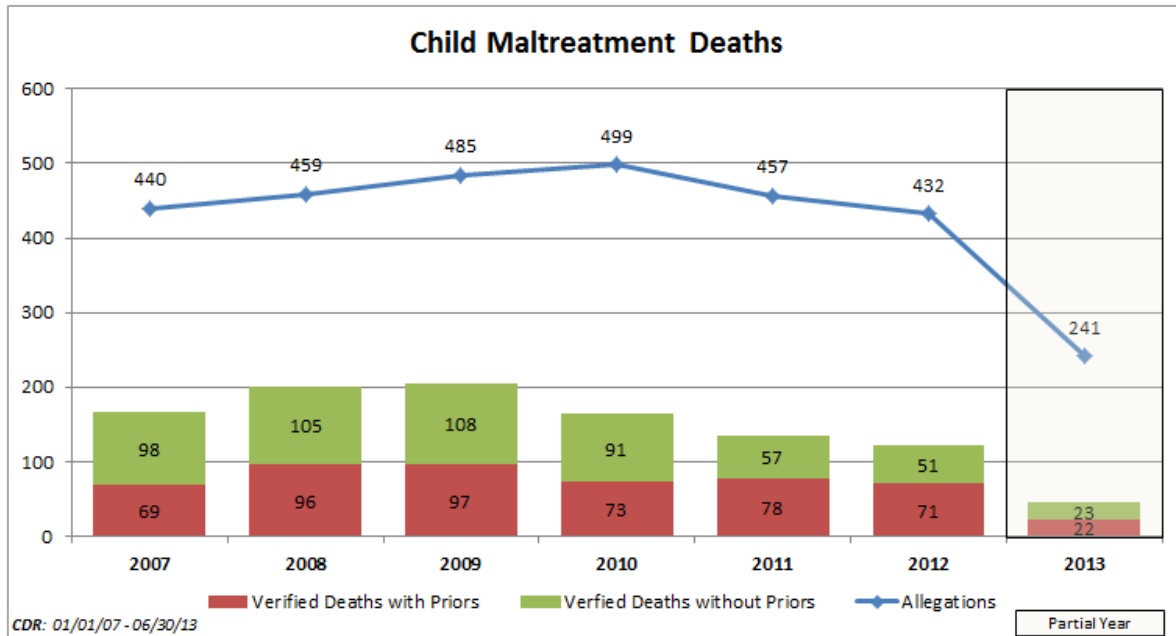
- No Personally Identifiable Information (PII)
- No text fields as they may contain PII
- No filtering/manipulation by DCF (other than date range, death allegations, and assorted aggregate counts)
- Data sources are deemed reasonably accurate and known limitations of the data was considered as part of the analysis.

Interviews with several child protection individuals in the medical, legal, community-based care, law enforcement, prevention and quality assurance professions yielded rich information about strategies that further informed the data findings in this report.

GENERAL TRENDS

As part of the analysis of data, general trends were captured to set a baseline for the incident of maltreatment deaths from January 1, 2007 through June 30, 2013, and as

backdrop for the statistical modeling. Please note that 2013 is a partial year, as indicated on the chart, with 6 months of data, as opposed to the 12 months of data for other years.



As the chart illustrates, since 2010 there has been a slight downward trend in both alleged and verified¹ child fatalities due to maltreatment. The majority of those allegations (ranging between 55% and 66%) were regarding children who had no prior involvement with DCF. This is consistent with national patterns.

The Type of Death shows a considerably higher rate of Neglect deaths (ranging from 80% to 84%) as compare to Abuse and all others - and the trend has remained steady from 2007 to 2012. This is also consistent with national patterns.

The majority of maltreatment deaths fall into two categories: Asphyxiation and Drowning. Based on this fact, our trend analysis and the Analytics Modeling focused on these two categories of Neglect as well as the Abuse category. Both Asphyxiation and Abuse showed a downward trend since 2010. By contrast, the number of deaths due to Drowning remained essentially steady during the period.

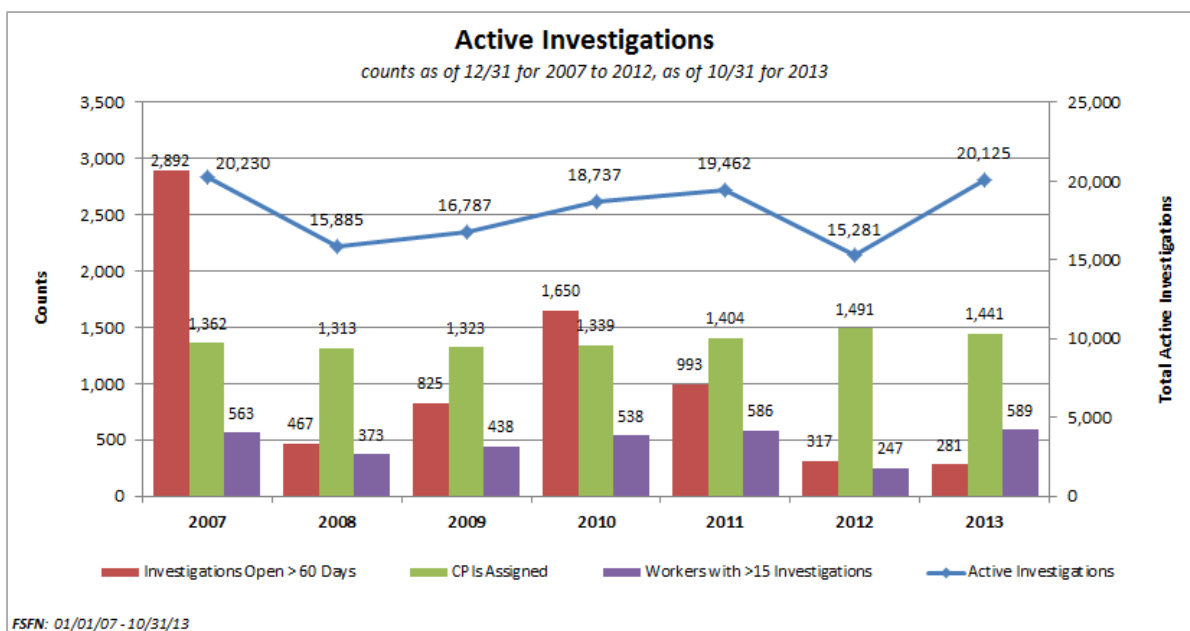
The agency also reviews a population of children fatalities that are reported but do not contain any allegation of child abuse or neglect as a factor contributing to the deaths. Tracking these deaths was developed as a part of the CDR in 2009². These are children who

¹ Once a child death investigation is concluded, it is closed as verified, not substantiated, or no indicators. "Verified" indicates a preponderance of credible evidence exists to determine that the specific harm or threat of harm was a result of abuse, abandonment or neglect

² One such death indicated for 2008 is included as it was reported during calendar year 2009

may have been receiving community-based care services and died due to natural causes or who came into foster care as medically complex children whose parents did not have the capacity to take care of their needs. They also include children whose families were involved in an active child protection investigation at the time of a child's death. Examples include children who die in car accidents, sudden unexplained infant deaths, acute asthma attacks or other circumstances that do not involve any suspicions of abuse or neglect. The agency is required by law to review these deaths despite the absence of any allegation of abuse or neglect.

In our trend analysis, we also examined the total number of births and child deaths in Florida, utilizing data from the Department of Health's Vital Statistics data source, finding that both have remained near stable, exhibiting a very slight and slow decline. We also considered the total number of active child protective investigations, which, other than a dip in 2012, show an increasing trend since 2008. We reviewed investigator workload, as measured by the number of active investigations, noting that approximately 40% of Child Protective investigators (CPIs) were assigned to 15 or more active investigations.



ANALYTICS RESULTS

When reading the following chart, factors in red above the 0-axis line are negative risk factors that increase the odds of death while those below (in green) are positive risk factors that reduce the odds of death. Also, note that the y-axis is a logarithmic scale where intervals are in orders of magnitude rather than a standard linear scale.

The chart below contains the risk factors that are statistically significant across all alleged maltreatment deaths. These fourteen factors were identified by running statistical models against a large set of variables considering whether elements like gender, ethnicity, number of siblings, etc. increase or decrease the odds of death. With each modeling iteration, the variables that were not statistically significant were removed from the model (e.g., being female does not increase the odds of dying due to maltreatment) and the more impactful variables were made the focus (e.g., having in-home visits does greatly reduce the odds of death). This process was repeated until the model was narrowed down to the factors in the chart below. Given all else being equal:

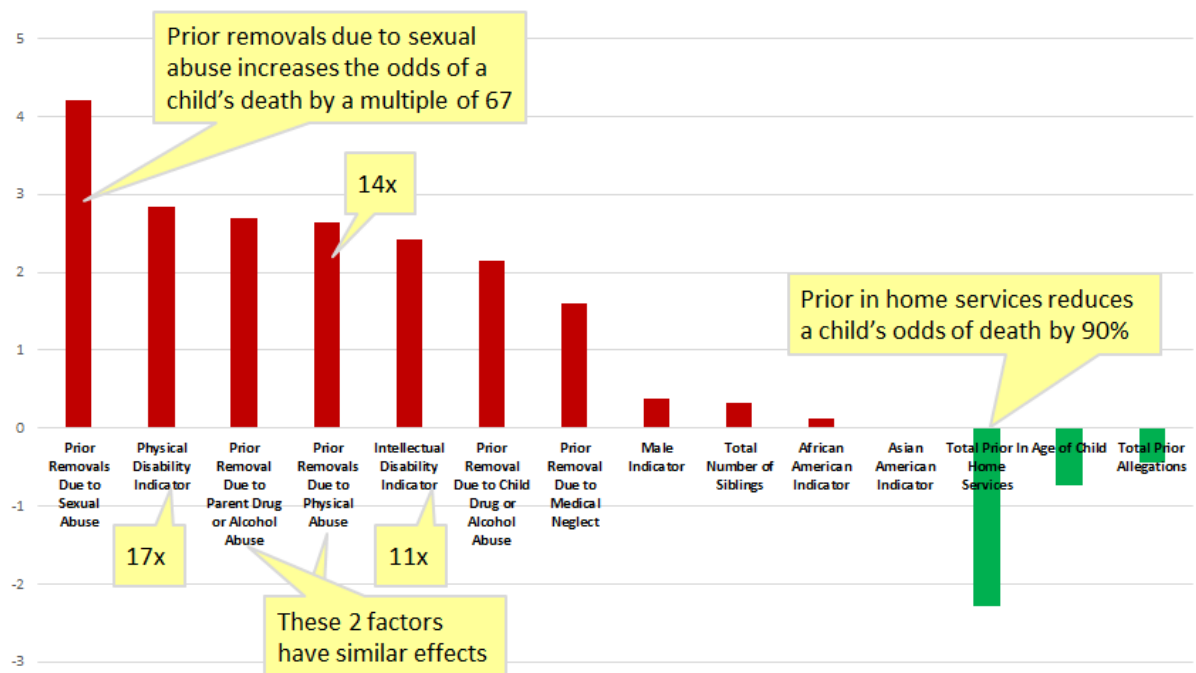
- Prior **in-home services** reduce the odds of death by **90%**

This would indicate that visits to the home have a positive impact on keeping children safe. To lower a child's risk of death, more in-home services would be recommended.

This effect was observed in the Abuse and Drowning categories. It was not statistically significant in the Asphyxiation category.

Baseline Risk Factors for All Child Deaths

Effect of Each Variable



- Each instance of a **prior removal due to physical abuse** increases the odds of death by a **multiple of 14**

This effect was observed in the Abuse category. It was not statistically significant in the Asphyxiation and Drowning categories.

- The impact of each **prior removal due to parents who have abused alcohol or drugs** increases the odds of deaths by a multiple of nearly 15. This effect is similar for **prior removal due to physical abuse**.

This effect was strongest in the Asphyxiation category, followed by Drowning. It exhibited less of an effect, though still statistically significant, in the Abuse category.

- The child having a physical disability increases the odds of death by a **multiple of 17**

This effect was observed in the Abuse and Other Neglect categories. It was not statistically significant in the Asphyxiation, and Drowning categories. It should be noted that both the physically disabled and intellectually disabled risk factors were based on very small data sets of child fatalities.

- Each instance of **prior removal due to sexual abuse** increases the odds of death by a **multiple of 67**

This effect was observed in the Drowning category. It was not statistically significant in the Asphyxiation and Abuse categories. It should be noted that this risk factor was based on a very small data set of child fatalities.

- **75% of all child deaths occur between 0 and 2 years of age**

The effect of the child's age as a risk factor was observed across the board, and strongest in the Asphyxiation category.

OBSERVATIONS AND RECOMMENDATIONS

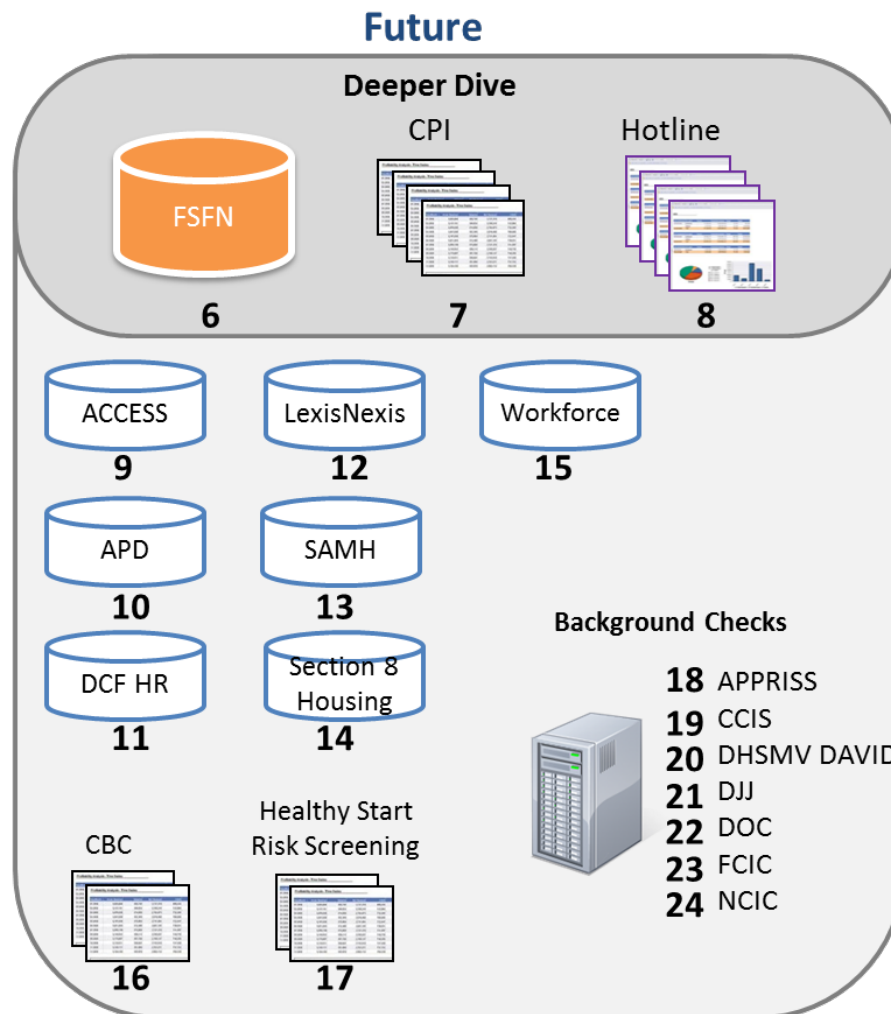
During the course of the project, opportunities data and process improvements were noted including:

1. **Reliable Data Entry** – increase the number of consistent field values (i.e. drop-box choices), rather than reliance on free-form text data.
2. **Ambiguous Field Names and Values** – rename fields and values that can be confusing to the users, leading to incorrect data capture.
3. **Historical Tracking** -- add tracking in key areas, such as investigator assignments and household member, for a full record of involvement with a child over time.
4. **Training and Document Review** – provide additional training for data accuracy and consistency, and for clarity on use of new functions (#1 - #4 above).
5. **Community-Based Care (CBC) Reporting** – improve CBC reporting to be more robust, readily accessible, and supportive of ad-hoc reporting and analytics needs.

THE PATH FORWARD:

ROADMAP TO PREDICTIVE ANALYTICS AS A TOOL FOR IMPROVED PRACTICE

In order to produce a comprehensive predictive model, a Child Welfare Heightened Risk analytics model should be developed to improve Child Welfare and Family Safety practices, to support CPIs, CBCs, and DCF management. By incorporating a wider set of data, a richer and more meaningful analysis can be done. Some of the sources used in the Child Fatality Trend Analysis would be expanded as well as inclusion of new sources that could indicate risk factors like financial hardship, substance abuse or mental health stresses on the family, or household members with a history of crime or violence. These data sources are illustrated in the following diagram, and the potential uses of the data is described in Section 8 of this report.



Ultimately, being able to determine which children are at a greater risk would offer an additional tool for DCF to better assess and provide for the safety of the children they serve.



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Change Record

Date	Author	Version	Change Reference
11/14/13	North Highland	0.01	Creation of document outline
11/16/13	North Highland	0.02 – 0.05	Content creation
11/18/13	North Highland	0.06	Baseline version provided to DCF for review
11/20/13	North Highland	0.07	Revisions
11/21/13	North Highland	0.08	Revisions
11/21/13	North Highland	0.09	Revisions
11/22/13	North Highland	1.00	Final Draft
11/21/13	North Highland	2.00	Final Draft - revised
11/26/13	North Highland	2.00	Final Draft - revised
11/27/13	North Highland	6.00	Final Draft - revised
12/02/13	North Highland	7.00	Final Draft - revised
12/02/13	North Highland	8.00	Final Draft - revised
12/02/13	North Highland	9.00	Final Draft - revised
12/05/13	North Highland	10.00	Final Draft - revised
12/05/13	North Highland	11.00	Final Draft - revised
12/06/13	North Highland	12.00	Final Draft - revised

Review

Name	Role	Date
DCF Team	Client Review	11/25/13
DCF Team	Client Review	11/27/13

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1 Executive Summary

The Department of Children and Families contracted with North Highland to analyze the child fatalities reported to the Florida Abuse Hotline from January 1, 2007 to June 30, 2013. The purpose of the analysis is to confirm general trends in child fatalities, provide an initial set of key risk factors through data discovery and statistical analysis, and lay the groundwork for future advances in child welfare practice supported by predictive analytics tools and techniques.

GENERAL TRENDS

Since 2010 there has been a ***slight downward trend in both alleged and verified¹ child fatalities due to maltreatment.*** The majority of those allegations (ranging between 55% and 66%) were regarding children who had no prior involvement with DCF. This is consistent with national patterns.

We also considered ***the total number of active child protective investigations,*** which, other than a dip in 2012, ***show an increasing trend*** since 2008.

ANALYTICS RESULTS

The significant risk factors were identified by running statistical models against a large set of variables considering whether elements such as gender, ethnicity, number of siblings, etc. increase or decrease the odds of death. With each modeling iteration, the variables that were not statistically significant were removed from the model (e.g., being female does not increase the odds of dying due to maltreatment) and the more impactful variables were made the focus (e.g., having in-home visits does greatly reduce the odds of death.) This process was repeated until the model was narrowed down to the factors described in section 6.2. Given all else being equal, the most significant key risk factors that were found include:

- Prior **in-home services** ***reduce*** the odds of death by **90%**
- Each instance of a **prior removal due to physical abuse** ***increases*** the odds of death by a ***multiple of 14***
- The impact of each prior removal due to **parents who have abused alcohol or drugs** ***increases*** the odds of deaths by a ***multiple of nearly 15***
- The child having a **physical disability** ***increases*** the odds of death by a ***multiple of 17***

¹ Once a child death investigation is concluded, it is closed as verified, not substantiated, or no indicators. "Verified" indicates a preponderance of credible evidence exists to determine that the specific harm or threat of harm was a result of abuse, abandonment or neglect

- Each instance of a **prior removal due to sexual abuse** increases the odds of death by a ***multiple of 67***
- **75%** of all child deaths occur between **0 and 2 years of age**

OBSERVATIONS AND RECOMMENDATIONS

During the course of the project, opportunities for data and process improvements were noted including:

1. **Reliable Data Entry** – increase the number of consistent field values (i.e. drop-box choices), rather than reliance on free-form text data.
2. **Ambiguous Field Names and Values** – rename fields and values that can be confusing to the users, leading to incorrect data capture.
3. **Historical Tracking** -- add tracking in key areas, such as investigator assignments and household member, for a full record of involvement with a child over time.
4. **Training and Document Review** – provide additional training for data accuracy and consistency, and for clarity on use of new functions (#1 - #4 above).
5. **Community-Based Care (CBC) Reporting** – improve CBC caseworker reporting to be more robust, readily accessible and supportive of ad-hoc reporting and analytics needs.

THE PATH FORWARD: ROADMAP TO PREDICTIVE ANALYTICS AS A TOOL FOR IMPROVED PRACTICE

In order to produce a comprehensive predictive model, a Child Welfare Heightened Risk analytics model should be developed to improve Child Welfare and Family Safety practices to support CPIs, CBCs, and DCF management. By incorporating a wider set of data, a richer and more meaningful analysis can be done. Some of the sources used in the Child Fatality Trend Analysis would be expanded as well as inclusion of new sources that could indicate risk factors like financial hardship, substance abuse or mental health stresses on the family, or household members with a history of crime or violence.

Ultimately, being able to determine which children are at a greater risk would offer an additional tool for DCF to better assess and provide for the safety of the children they serve.

2 Background: The Child Fatalities Investigation Process

Child deaths are reported to the Department of Children and Families (DCF) in order to determine whether or not a caretaker was wilfully responsible for - or in some manner contributed to - the death of a child.

As required by Florida statutes, suspicious child deaths are reported to the Hotline with many of the reports called in by law enforcement or medical personnel. Quite often, these professionals are the first responders in the death of a child through 911 calls or emergency rooms.

The investigative process begins once the Hotline alerts the county investigations' office of a reported child death. The child's family is interviewed by a Child Protective Investigator (CPI). The CPI also speaks to law enforcement and medical professionals and reviews any available prior history about the child and his/her family. Even though a law enforcement investigation may be ongoing, CPIs are charged with making a determination as to the safety of other siblings in the home and whether the family could benefit from additional supports and community resources.

Once an investigation into a child death is completed, it is classified as directed by DCF's statewide Child Maltreatment Index: verified, not substantiated, or no indicators for abuse or neglect. Often these deaths are not verified as being due to abuse or neglect as it cannot be concluded that a parent or caretaker wilfully acted (or failed to act) in a way that resulted in the child's death.

Child death cases that have Verified findings of abuse or neglect are examined by the Statewide Child Abuse Death Review Team. The team consists of 17 appointees with expertise in child welfare from a wide range of professions. An annual report is submitted to the Governor and the Legislature with recommendations such as changes in law, professional training and specific initiatives focused on the prevention of child deaths. The annual reports can be viewed on the Department of Health's website at: www.floridahealth.gov.

3 Project Overview

The Department of Children and Families contracted with North Highland to analyze child fatalities reported to the Florida Abuse Hotline from January 1, 2007 to June 30, 2013. The purpose of the analysis is to confirm general trends in child fatalities, provide an initial set of key risk factors through data discovery and statistical analysis, and lay the groundwork for future advances in child welfare practice supported by predictive analytics tools and techniques.

3.1 The Team

North Highland (NH) is the primary lead on the project, providing project management, supporting the data scientists and child welfare domain experts, and compiling the final report. NH has a long history with the State of Florida with an established working relationship with the Department of Children and Families (DCF). NH has provided management consulting services for over 20 years and has extensive experience in analytics and Business Intelligence.

Statistical Analysis Solutions (SAS), founded in 1976, is the leader in business analytics software and services and is a respected thought leader in Business Intelligence and Predictive Analytics. They have domain expertise in Child Welfare Data analytics as well as extensive experience with the State of Florida and provided sophisticated statistical analysis through their Advanced Analytics Lab.

The Child Welfare Policy and Practice Group, a private, non-profit organization, has direct experience nationally as well as with Florida's child protection investigations and social services delivery system. They are recognized as thought leaders in achieving high quality front-line practice and improved outcomes for family and community services.

3.2 Scope

The project spanned five weeks and was limited to two primary DCF data sources: Florida Safe Families Network (FSFSN) and the Child Death Review database (CDR). Additionally, three secondary summary-level sources were referenced: Department of Health, Abuse Hotline, and Child Protective Investigators. The data population consisted of reports to the Hotline about a child fatality that contained allegations of abuse or neglect as factors leading to the child's death. The population included both the children whose families did - as well as those who did not - have prior agency involvement in protective investigations. The child fatalities were compared to the entire FSFN population of children who were involved in child protective investigations from January 1, 2007 and June 30, 2013.

3.3 Data

The following parameters were applied to all data provided by DCF:

- No Personally Identifiable Information (PII)
- No text fields as they may contain PII
- No filtering/manipulation by DCF (other than date range, death allegations, and assorted aggregate counts)
- Data sources are deemed reasonably accurate and known limitations of the data was considered as part of the analysis.

FSFN was sourced for the majority of records with data extracts focused on children with a death alleged to have been due to abuse or neglect by a parent or caretaker in an investigation between 01/01/2007 and 06/30/2013 (a partial year identified in the visualization of the trends). A variety of data elements were obtained in order to support the analysis. Those elements included:

- Allegations of Maltreatment
- Demographics
- Family Support Services
- Geography
- In-Home Services
- Out-of-Home Providers
- Participant Relationships
- Removals

Additionally, the CDR provided more details around child deaths that were either difficult to retrieve from FSFN or did not exist in a specified data field in FSFN. The CDR was implemented in 2009 so records were extracted from 01/01/2009 to 06/30/13 along with spreadsheets for 2007 and 2008 prior to the development of CDR. Files included information for:

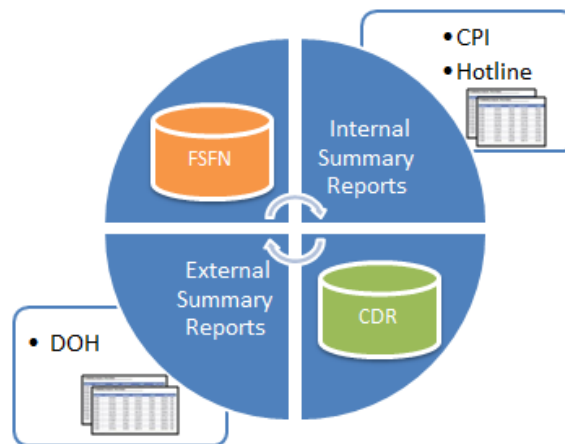
- Cause of Death
- Contributing Factors
- Demographics
- Domestic Violence History
- Geography
- Manner of Death
- Mental Health History of the Caregiver
- Perpetrator
- Prior History Flags and Counts
- Services at Time of Death
- Special Needs Child

- Substance Abuse History
- Type of Maltreatment

3.4 Data Sources

The Florida Safe Families Network (FSFN) and Child Death Review database were the primary databases utilized. Along with the primary data sources, a few additional data points were collected:

- Child Protective Investigators (CPI)
CPI summary information was provided for 01/01/2007 to 10/31/2013 and included counts by year and county for active investigations, primary CPIs assigned to active investigations, and average workload per CPI. The data provided was a snapshot in time as of December 31st of each year.
- Florida Abuse Hotline
Summary information was collected for 01/01/2007 – 06/30/2013 including counts for Child Abuse Reports, Investigations, Reports Alleging Child Death due to Abuse or Neglect, and Child Abuse Reports screened in vs. screened out
- Department of Health (DOH)
Vital statistics were retrieved from the website for years 2007 – 2012.



3.5 Interviews

Interviews with several child protection individuals in the medical, legal, community-based care, law enforcement, prevention and quality assurance professions yielded rich information about strategies that further informed the data findings in this report.

One notable discussion linked the problem of child abuse as a public health issue concern as documented in the Adverse Childhood Experiences Study (ACES) conducted by the Centers

for Disease Control and Prevention and Kaiser Permanente's Health Appraisal Clinic in San Diego. The study assessed the association between childhood maltreatment (e.g., physical abuse, sexual abuse, neglect) and its impact on health and general well-being as an adult. Those early experiences often result in increased rates of teen pregnancy, mental disorders, addictions, and poor physical health.

In July 2010, the Florida Child Abuse Prevention and Permanency Plan issued by the Executive Office of the Governor acknowledged ACES as one of the foundational principles of its prevention plan.

Information about the Healthy Families Florida program highlighted the concept of early engagement with parents of newborn as a successful strategy to prevent maltreatment. Parents voluntarily participate in order to better address their newborns needs and help them thrive.

Several innovative approaches to the development of a predictive model designed by utilizing demographic information such as zip codes relative to the use of governmental support services were also offered as a potential approach to reach a family before a crisis occurs.

Child welfare experts who conduct thorough case work practice analysis on both child fatality investigations and the general population of families served by the agency were also interviewed.

For more details on the interviews, please see Appendix 9.1.

4 Data Discovery Methodology

When analyzing data and building a model, it is common practice to begin with a relatively short project to gather basic data, analyze the limited set of data and then determine, based on results, the next course of action. This initial project is often termed a “Data Discovery” project, as in this case. During the whole process, the North Highland team was in constant communication with the client in order to address any questions or concerns about the data (see Appendix 9.2). Our process included six distinct steps:

1. **Business Understanding**
The goals of the project were reviewed with the client before beginning any work. This allowed the team to set expectations and confirm the objective of the analysis. In this case, the analysis would provide hard facts on child deaths in the state of Florida, determine if this is an increasing or declining trend, and develop an analytical model to provide insights into any overarching correlations.
2. **Data Understanding**
The data sources were narrowed down to FSFN, CDR, CPI summary data, Florida Abuse Hotline summary data, and DOH Vital Statistics. The initial data extracts were provided so the SAS analyst could begin profiling the data (assessing its reliability, determining if columns were well populated, uncovering anomalies, etc.) A preliminary model was developed to test assumptions and propositions.
3. **Data Preparation**
During this stage, any outstanding data sets were collected, data transformations made as needed, and the data transferred into the data model format. Based on the knowledge gathered in the prior step, attributes were selected for the model to use for analysis in order to determine factors such as the significance of the child’s age, gender, etc.
4. **Modeling**
At this point, several statistical analyses were employed to understand the significant drivers in the data. Additionally, optimization routines were run in order to improve the model (see Appendix 9.2).
5. **Evaluation**
After the model reached a point of completion, the data was reviewed to establish the quality of the model. Once the SAS analyst was confident in the model, insights about the data were derived (e.g., yes, the child’s age is a significant factor) and some records were randomly selected to verify those results.

6. Deployment

Once the model was validated, the final results were reviewed with the team for a final checkpoint. This step gave the client an opportunity to confirm the understanding of the results as well as help guide on future analytical needs. Once reviewed, the final report was written and presented.

5 General Trends

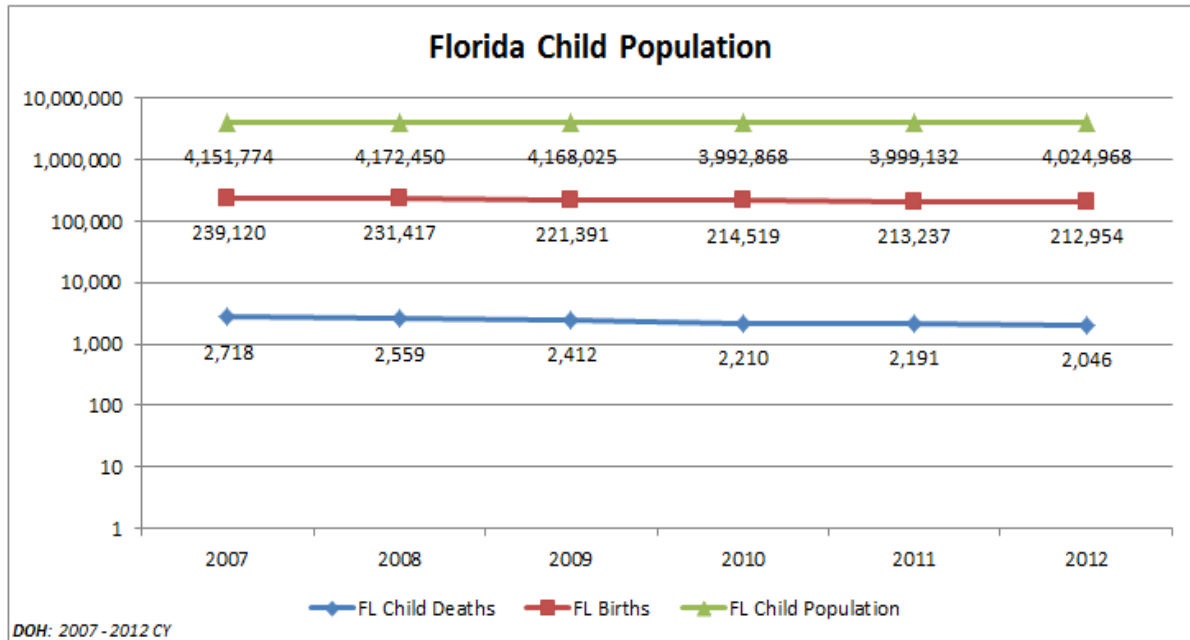
As part of the analysis of data, general trends were captured to set a baseline for the incident of maltreatment deaths from January 1, 2007 through June 30, 2013, and as backdrop for the statistical modeling.

5.1 Florida Child Population

According to the Vital Statistics from the Department of Health, the population of children has remained fairly steady in the State of Florida from 2007 through 2012. During that period, there has been a slight and slow decline in both the number of births and child deaths. The decline in births is reflected at the national level where, according to the Center for Disease Control, the US experienced a record low in 2012, marking a decline for the fifth year in a row². Additionally, the incident of child maltreatment deaths has shown a slight decline nationally though it should be noted the manner of reporting varies by state.³

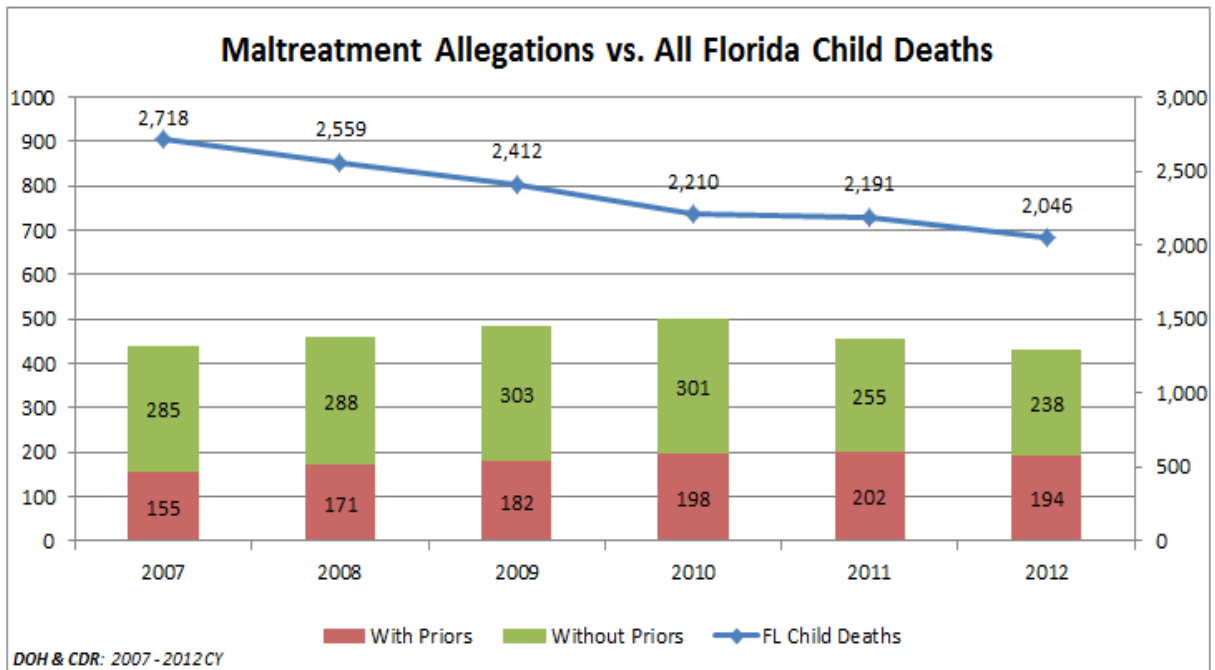
² Centers for Disease Control and Prevention *Recent Trends in Births and Fertility Rates Through December 2012* Available from http://www.cdc.gov/nchs/data/hestat/births_fertility_december_2012/births_fertility_december_2012.htm

³ U.S. Department of Health and Human Services, Administration for Children and Families, Administration on Children, Youth and Families, Children's Bureau. (2012). Child Maltreatment 2011. Available from <http://www.acf.hhs.gov/programs/cb/research-data-technology/statistics-research/child-maltreatment>



5.2 Maltreatment Allegations

On average, Florida conducts approximately 200,000 maltreatment investigations each year concerning approximately 300,000 children. Child fatalities reported to the Hotline that contained an allegation of abuse or neglect reached a slight peak in 2010 with 499 reports. It has since then exhibited a slight decline. The majority of the child fatalities illustrated below were regarding children who had no prior involvement with the Agency (55% – 66% across the six years).



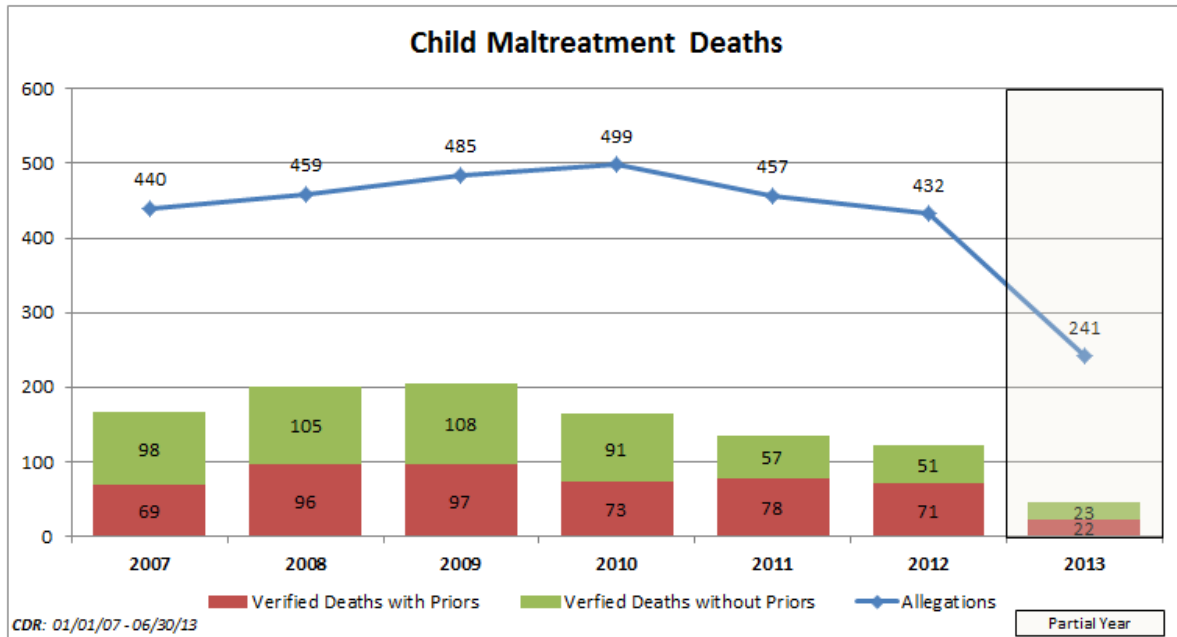
5.3 Verified Maltreatment Allegations

Once a child death investigation is concluded, it is closed as Verified, Not Substantiated, or No Indicators for abuse or neglect as determined by the guidelines provided in a statewide Child Maltreatment Index for the classification of all allegations of abuse or neglect. Investigations of child fatalities that have Verified findings of abuse or neglect are statutorily required to be referred to the Statewide Child Abuse Death Review team, an independent review body administered through the Department of Health.

- **Verified:** a preponderance of credible evidence exists to determine that the specific harm or threat of harm was a result of abuse, abandonment or neglect
- **Not Substantiated:** there is credible evidence, but it does not meet the standard of being a “preponderance” to support the harm or threat of harm (preponderance means the greater weight of the evidence, or more likely than not to have occurred)

- **No Indicators:** no credible evidence to support a finding

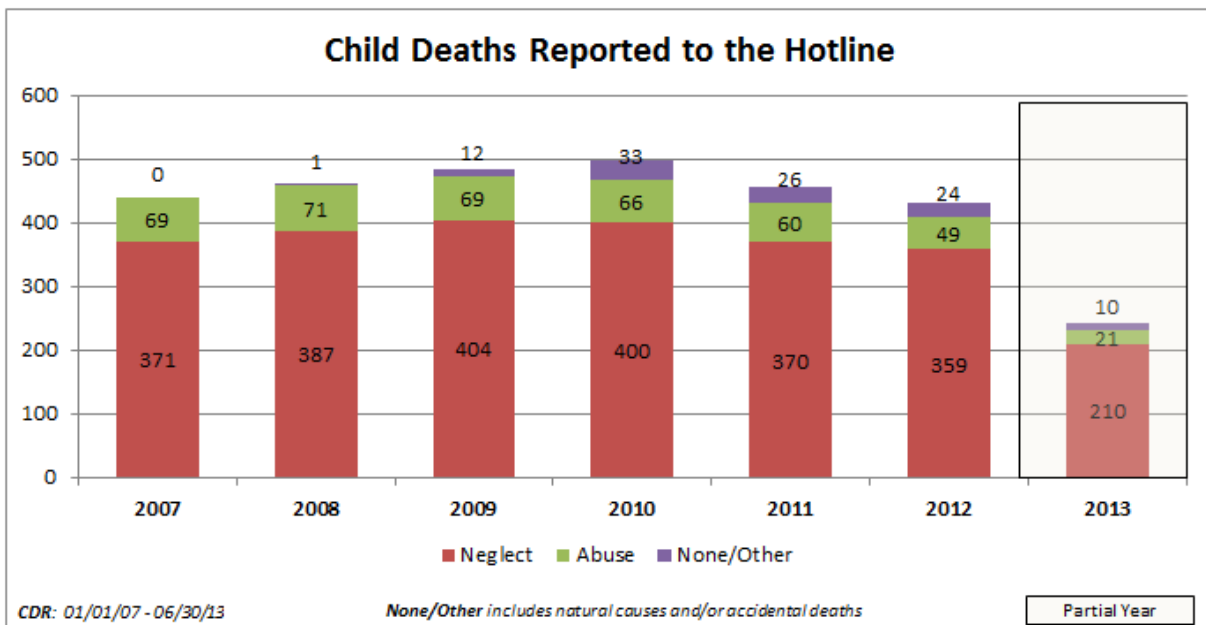
When considering only death with Verified maltreatment, the percentage of children with no prior involvement averages 51% over the course of 6 ½ years. It is important to note that while verified deaths are trending downward, there are still twenty (20) open cases for 2012.



5.4 Alleged Maltreatment Deaths

The Type of Death maltreatment shows a considerably higher rate of Neglect deaths as compared to Abuse and all others - and the trend has remained steady from 2007 to 2012. These rates fall in line with the national data showing Neglect deaths averaging well over 70%.⁴

The agency also reviews a population of children fatalities that occur but do not contain any allegation of child abuse or neglect as a factor contributing to the deaths. They are illustrated in the "None/Other" category on the featured chart. Tracking these deaths was developed as a part of the CDR in 2009⁵. These are children who may have been receiving community-based care services and died due to natural causes or who came into foster care as medically complex children whose parents did not have the capacity to take care of their needs. They also include children whose families were involved in an active child protection investigation at the time of a child's death. Examples include children who die in car accidents, sudden unexplained infant deaths, acute asthma attacks or other circumstances that do not involve any suspicions of abuse or neglect. The agency is required by law to review these deaths despite the absence of any allegation of abuse or neglect.

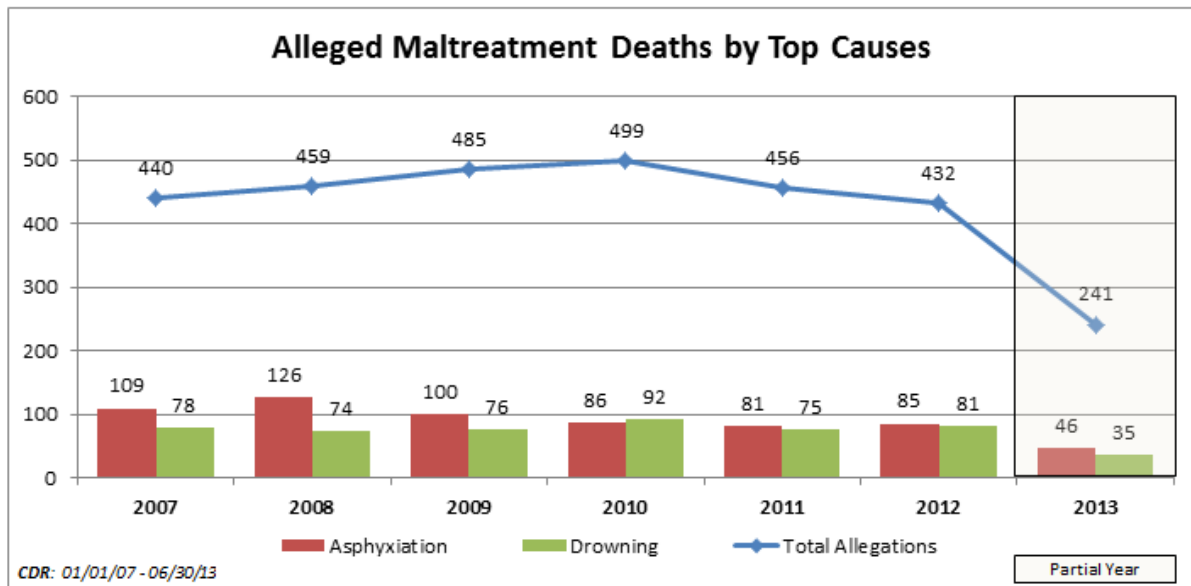


⁴ Centers for Disease Control and Prevention Recent Trends in Births and Fertility Rates Through December 2012 Available from http://www.cdc.gov/nchs/data/hestat/births_fertility_december_2012/births_fertility_december_2012.htm

⁵ One such death indicated for 2008 is included as it was reported during calendar year 2009

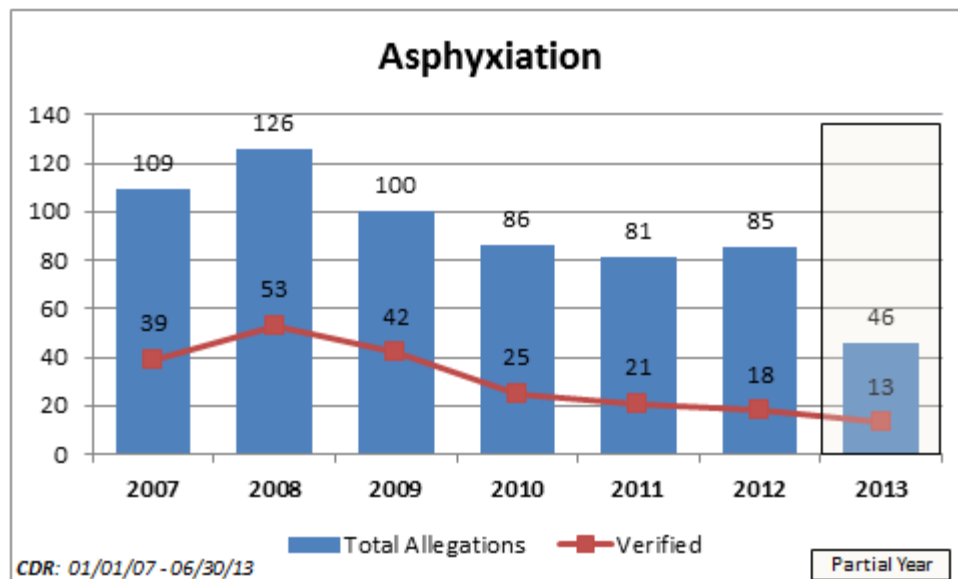
5.5 Top Causes

Common causes of child maltreatment deaths fall into 2 categories: Asphyxiation and Drowning.



5.6 Asphyxiation Deaths

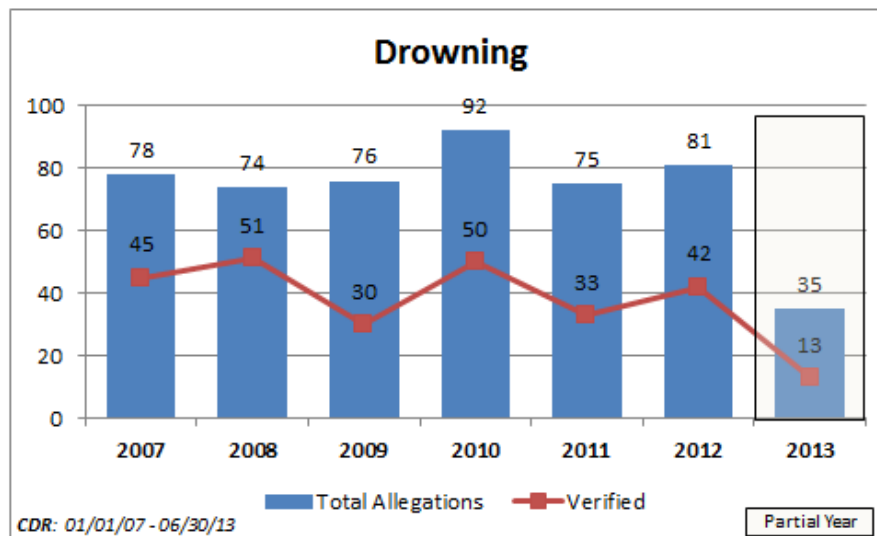
In the majority of cases, asphyxiation is due to co-sleeping and/or an unsafe sleep environment (e.g. placing an infant to sleep on a couch, futon, adult bed or sleeping arrangement other than crib or bassinette. The CDC reports that the leading cause of injury death in the U.S. for children less than one year old is unintentional asphyxiation (~1,000 infant deaths annually). They further note there has been a fourfold increase in accidental asphyxiation and strangulation during sleep episodes since 1986 and the majority of deaths have been linked to an unsafe sleep environment.⁶



⁶ Centers for Disease Control and Prevention *Suffocation Deaths Associated with Use of Infant Sleep Positioners — United States, 1997–2011* Available from <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6146a1.htm>

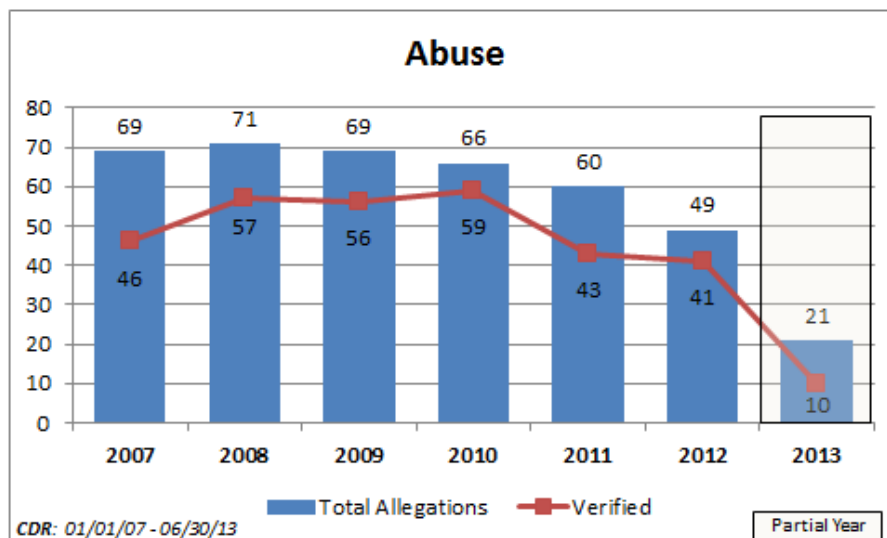
5.7 Drowning Deaths

Allegations of drowning maltreatment peaked in 2010 but have otherwise remained steady since 2007. The number of verified drowning deaths shows no significant pattern.



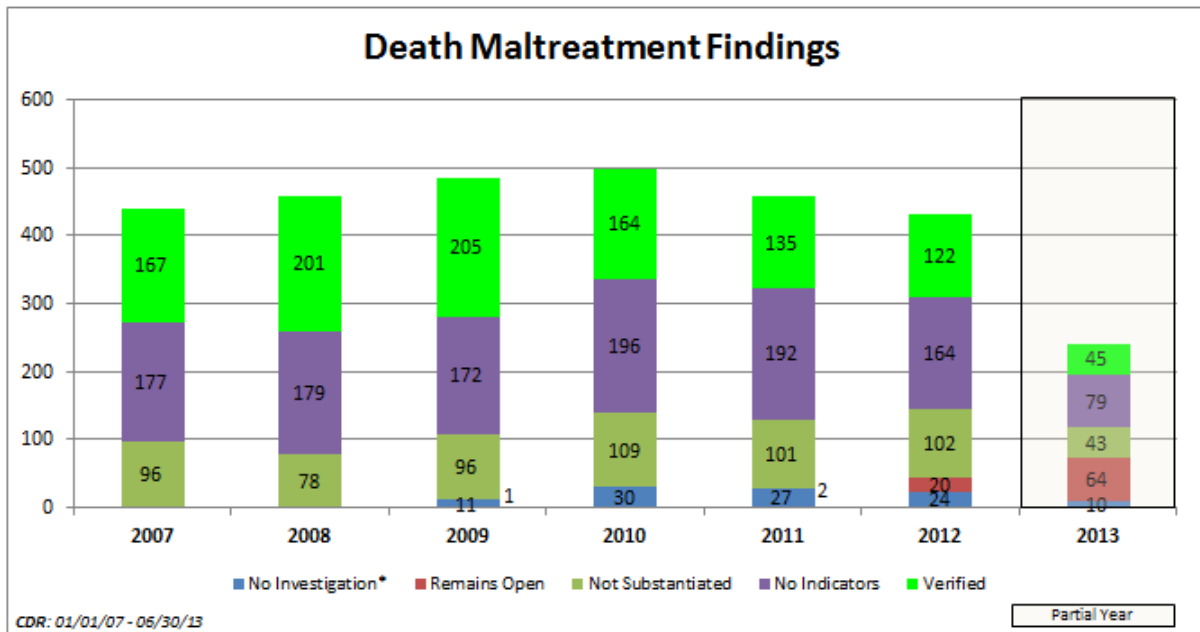
5.8 Abuse Deaths

Similar to deaths by asphyxiation, the number of abuse deaths (both allegations and those that have been verified) have slowly trended downward over the last few years.



5.9 Findings for Alleged Maltreatment Deaths

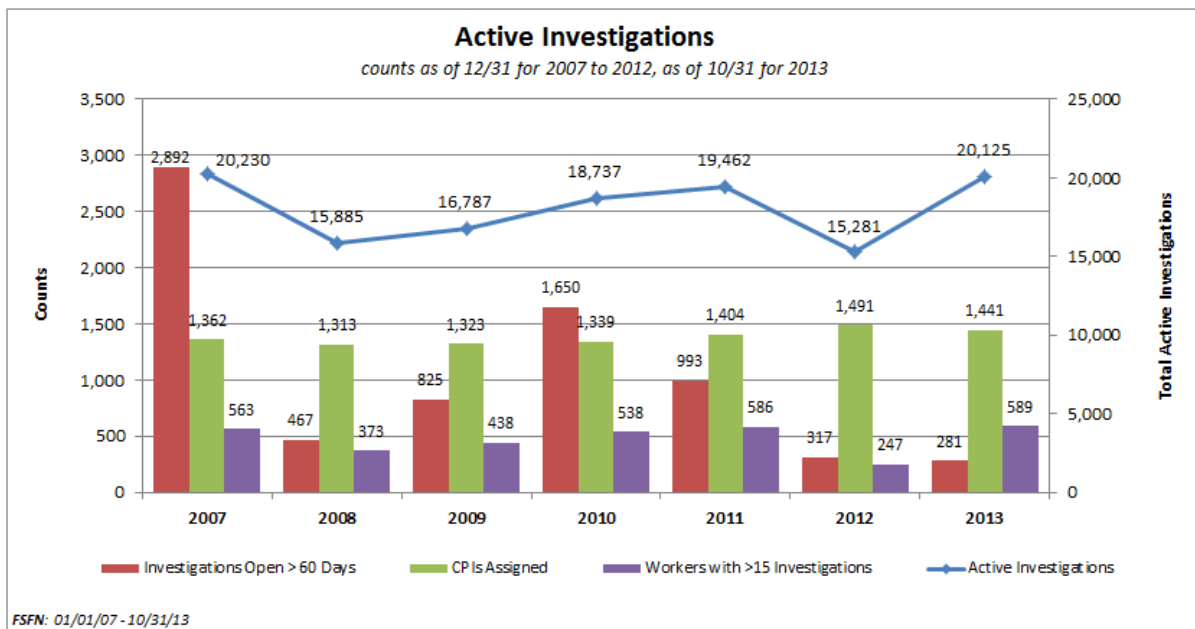
During the 6 ½ year period, the majority of alleged maltreatments were found with No Indicators (38%) followed closely by Verified at 34% and the remaining 21% of allegations Not Substantiated. Deaths due to Verified abuse or neglect have decreased steadily since 2009.



5.10 Active Investigations

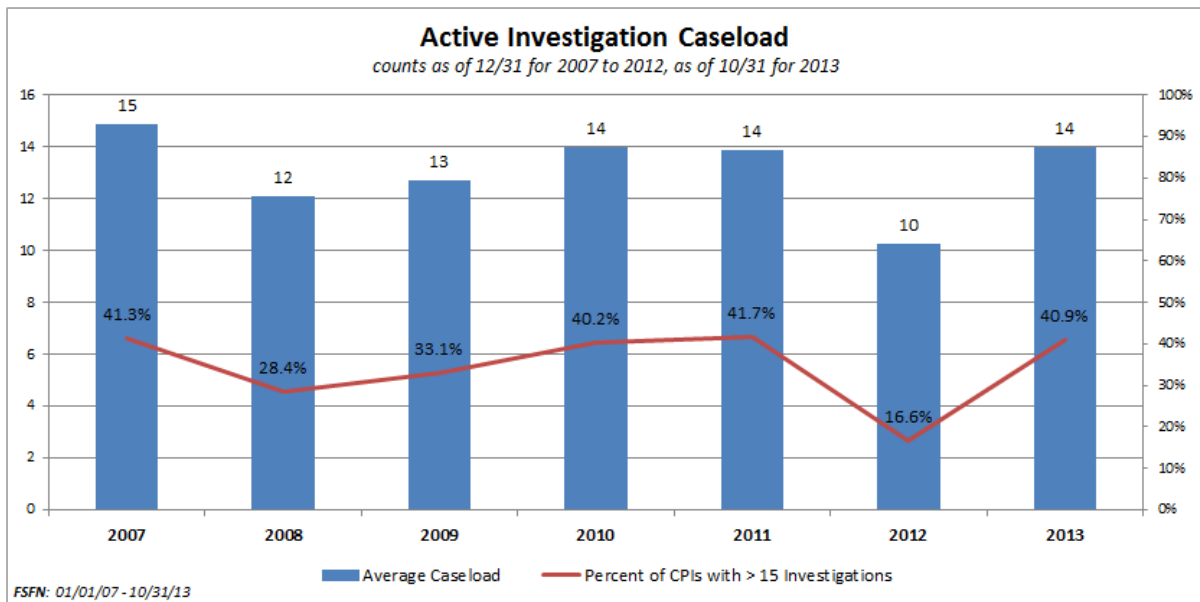
Child Protective Investigators (CPIs) are called into action when the Abuse Hotline submits a child death report to the county investigative office for investigation. Even though a criminal law enforcement investigation may be ongoing, CPIs are charged with making a determination as to the safety of other siblings in the home and whether the family could benefit from additional supports and community resources.

A limited amount of CPI data was provided during the course of this analysis. The data consisted of summary level information from a point in time capture (December 31st of each year). The number of investigators assigned to an investigation appears fairly steady with a dip in active investigations at the end of 2012.



5.11 Active Investigator Caseload

When reviewing the caseload of investigators, the percent of CPIs assigned to fifteen or more (15+) investigations and average investigative caseload follows the trend line set by total active investigations in the prior slide.



6 Analytics Results

6.1 Model Methodology

In order to help DCF understand risk factors around child deaths, SAS created an array of logistic regression models that leveraged data from the agency's case management system and the department's Child Death Review Database. For each model, SAS considered 873,059 children that were part of an investigation within the agency's case management system between January 1, 2007 and June 30th, 2013. Of those children, 3013 deaths occurred due to different causes and manners.

- It used a binary outcome looking at result: children investigated by the agency – deceased and not deceased
- Effects are reported as likelihoods and odds ratios
- Multiple iterations were applied and statistically insignificant variables were gradually removed
- Finally, factors were measured against a relatively neutral baseline case: white female child with an allegation who did not die. The model coefficients for a white female child were selected to allow for an ease of visualization and interpretation of the data.

SAS created a logistic regression model for each of the following:

- 1) All Deaths – all causes and manners were considered
- 2) All Deaths due to Abuse – only deaths with abuse as the manner were considered
- 3) All Deaths due to Drowning – only deaths with drowning as the cause were considered
- 4) All Deaths due to Suffocation/Asphyxiation – only deaths with a cause of Suffocation/Asphyxiation were considered

Each model considered a number of inputs including:

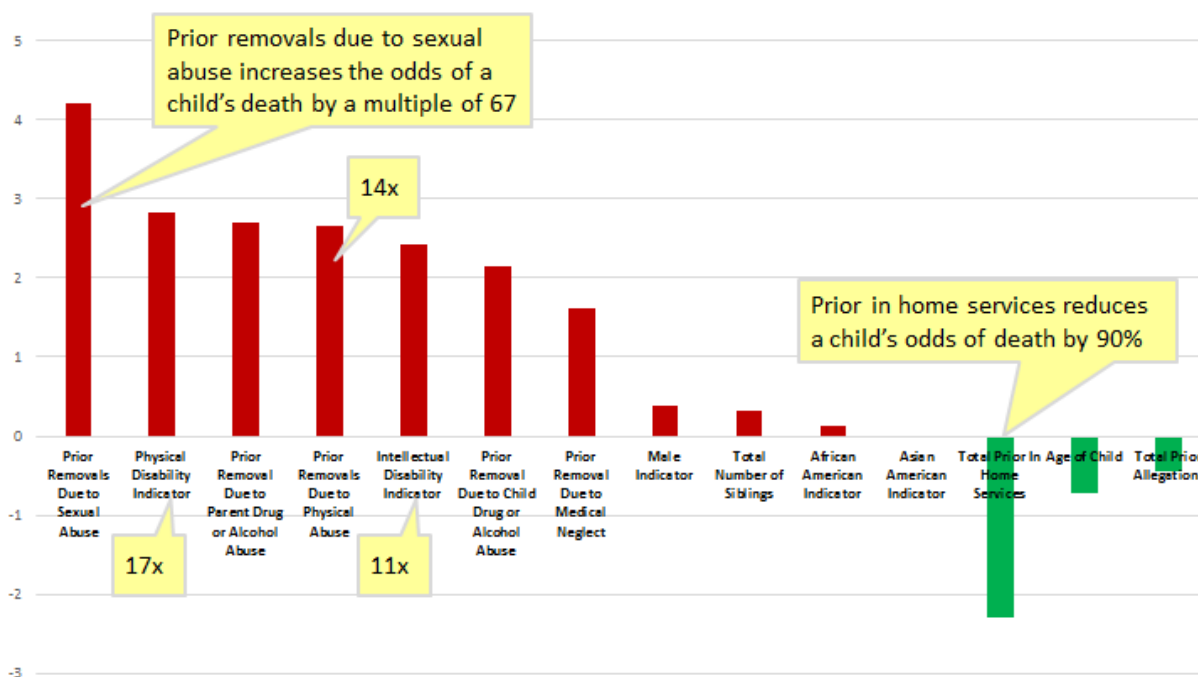
Variables Considered		
Child is Male	Child is Asian	Child is African American
Child's Age	Prior Removals Involving Sexual Abuse	Child has Developmental Disability
Total Previous Allegations	Total Prior Family Services	Child is Physically Disabled
Total Prior In-Home Services	Prior Removals Involving Neglect	Child is African American
Number of Siblings	Prior Removals Involving Parent Drug Abuse	Prior Removals Involving Medical Neglect
Prior Removal Involving Physical Abuse	Prior Removals Involving Physical Neglect	Prior Removals Involving Sexual Exploitation
Prior Removals Involving Sexual Exploitation		

These variables were considered as they were trying to measure the inherent characteristics of each child along with the effect of the Florida Department of Children and Families' involvement in the child's life. Additional detail on the model is included in Appendix 9.2. The risk factors noted in the following charts are essentially the ratio of two odds. For example, if the general odds of a child not dying are 3 to 1 and the odds of dying due to a particular factor are 6 to 1 then that factor increases odds of death by 2 (6 divided by 3). When reading the following charts, factors in red above the 0-axis line are negative risk factors that increase the odds of death while those below (in green) are positive risk factors that reduce the odds of death. Also, note that the y-axis is a logarithmic scale where intervals are in orders of magnitude rather than a standard linear scale.

6.2 Baseline Factors for All Child Deaths

The first step entailed running all variables in order to see which risk factors were statistically significant in order to create a list of Baseline.

Baseline Risk Factors for All Child Deaths Effect of Each Variable



Given all else being equal:

- The total prior in-home services reduces the odds of death by **90%**

This would indicate that visits to the home have a positive impact on keeping children safe. To lower a child's risk of death, more in-home services would be recommended.

- Each instance of a prior removal due to physical abuse increases the odds of death by a multiple of 14
- The child having a physical disability increases the odds of death by a multiple of 17
- The child having an intellectual disability increases the odds of death by a multiple of 11

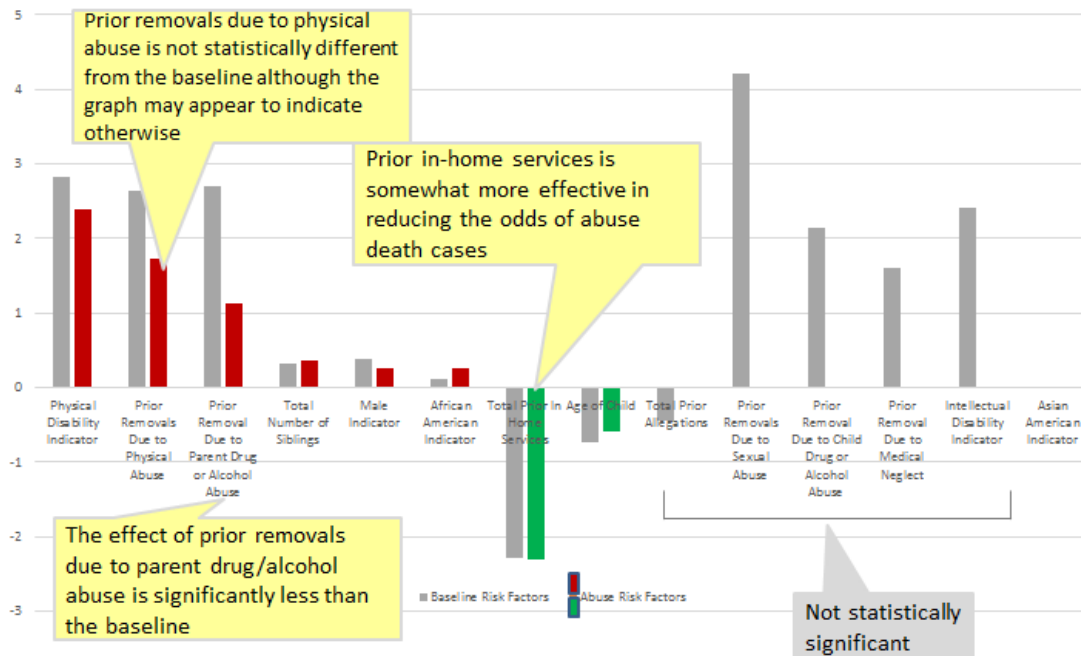
Additionally, the impact of each prior removal due to parents who have abused alcohol or drugs has a similar impact to that of each prior removal due to physical abuse, by a multiple of nearly 15.

6.3 *Baseline Risks vs. Death Due to Abuse*

Once the baseline was determined, additional factors were overlaid to uncover any correlations beginning with deaths due to Abuse. In the chart below, the bars above the 0-axis are negative risk factors that increase the odds of death while those below are positive risk factors that reduce the odds of death. The columns in gray are effects that are statistically significant to the baseline but not statistically significant for abuse. Keep in mind that this chart compares the factors found in the baseline (all deaths) to Abuse deaths in order to determine if any baseline factors are stronger or weaker when considering Abuse.

- The effect of prior in-home services is similar to baseline, again demonstrating the positive impact these services play in reducing the odds of death due to abuse
- While the effect from prior removals due to physical abuse appears reduced from the baseline, the difference in impact is not statistically significant
- Given all else being equal, the effect of prior removals due to parental drug and/or alcohol abuse is significantly less than the baseline
- Once everything else is accounted for, the following effects are not statistically significant for deaths due to abuse:
 - A child having an intellectual disability
 - Previous allegations

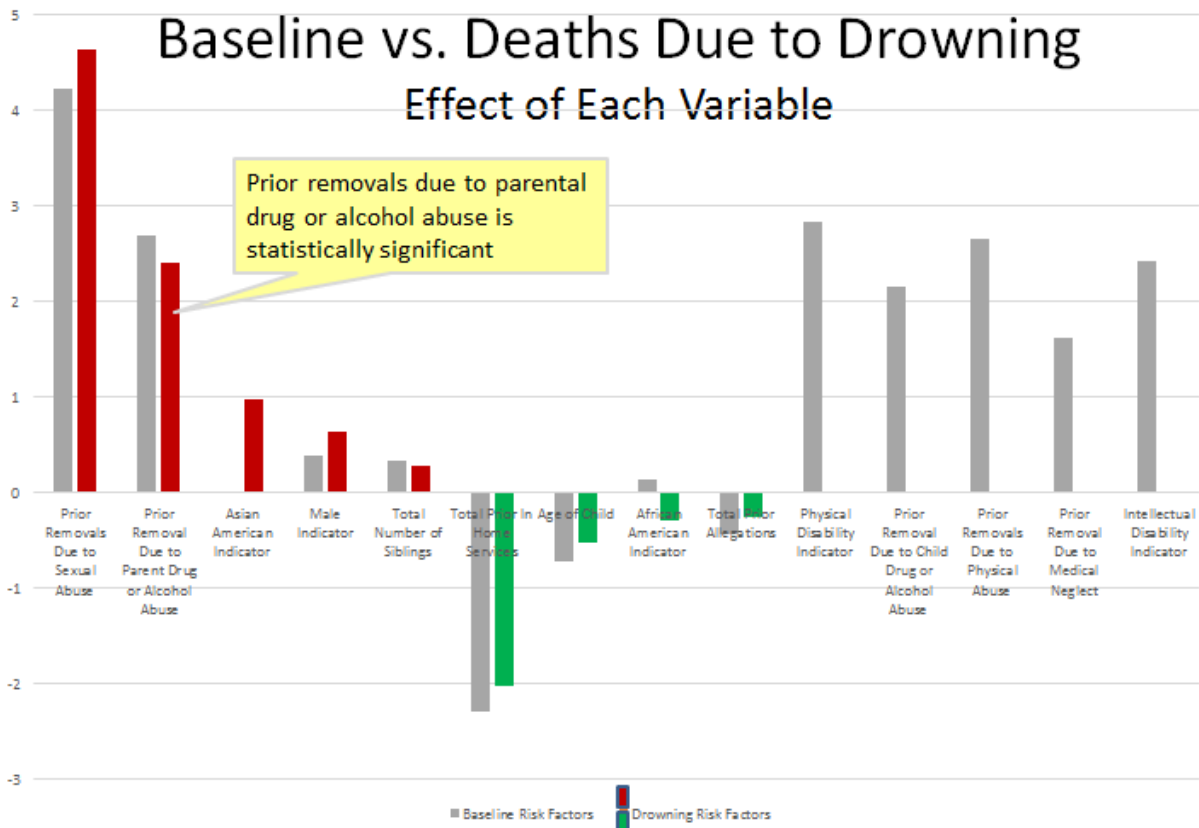
Baseline vs. Deaths Due to Abuse Effect of Each Variable



6.4 Baseline Risks vs. Death Due to Drowning

When looking at how death due to drowning compares to the baseline:

- The effect of prior in-home services is similar to that of the baseline
- Prior removals due to parental drug or alcohol abuse is statistically significant

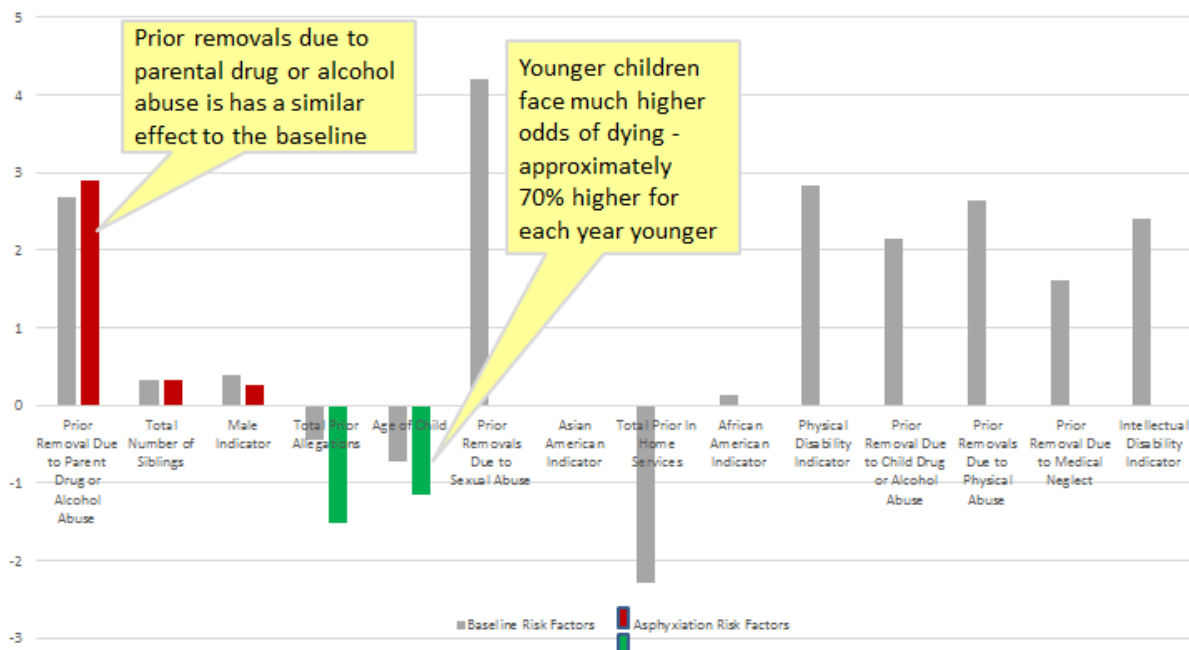


6.5 Baseline Risk Factors vs. Death Due to Asphyxiation

Asphyxiation is a major cause of death in young children and the model bears this out.

- Given all else being equal, each year of age reduces the odds of death by asphyxiation. For every additional year that a child is alive, their odds of death is reduced by 68%.
- Prior removals due to parents abusing drugs or alcohol is statistically significant and have the strongest effect in this model

Baseline vs. Deaths Due to Asphyxiation Effect of Each Variable

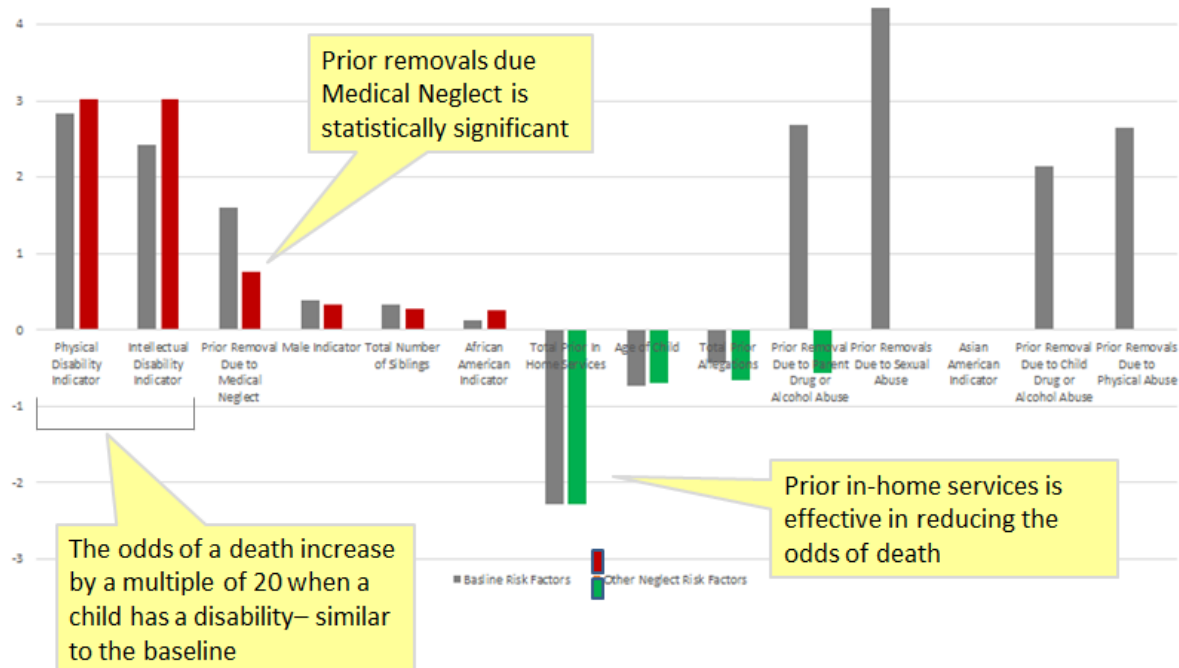


6.6 Baseline Risk Factors vs. Death Due to Other Neglect (excludes Asphyxiation, Drowning, and Abuse)

While this project focused on Abuse Maltreatment and the main causes of death (Asphyxiation and Drowning), an additional model was run to review all other Neglect deaths that did not fall into those categories. The various causes of death within Other Neglect were not explored due to time constraints and would merit further investigation in the future.

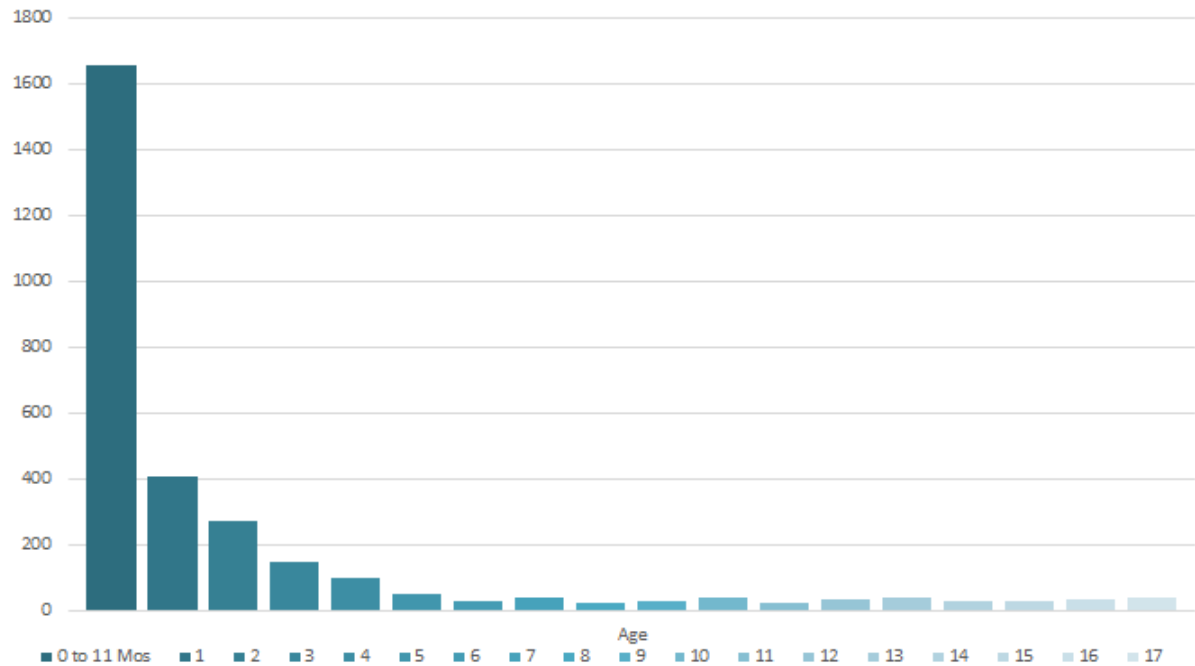
- The odds of death increase by 20 when a child has a physical or intellectual disability. These effects are similar to the baseline.
- Prior removals due to Medical Neglect is statistically significant
- Once again, we see that prior in-home services is a mitigating factor (i.e., reduces the odds of a child's death)
- Prior Removal Due to Parent Drug or Alcohol Abuse has a variance different from the baseline and needs further research to identify the cause of this effect

Baseline vs. Other Neglect (excludes Asphyxiation, Drowning & Abuse) Effect of Each Variable



6.7 Younger Children Deaths

75% of all child deaths occur between the ages of 0 and 2 years of age. Please see Appendices 9.5 and 9.6 for a further breakdown by Age and Seasonality (counts by month).



7 Observations and Recommendations

During the course of the project, some opportunities for data and process improvements were noted.

1. **Reliable Data Entry**
By its very nature, typing entries into a system can be fraught with errors. Whenever possible, if the values for a field are consistent and unchanging, a drop-down box is preferred. This improves the accuracy of the data entered and makes for cleaner reporting and analysis. It also reduces time spent on researching and correcting those errors.
2. **Ambiguous Field Names and Values**
Some fields are named in such a way that a user can be easily confused by what the correct response should be. For example, in the CDR the field “No Hotline Report” populated with the value “False” indicates there is a report. By renaming the field to “Hotline Report” and using a drop-down with yes/no values, it becomes clear to the user how to respond.
3. **Historical Tracking**
There are several fields in FSFN that only indicate current status, e.g., current investigator or current household member. This prevents reporting on everyone who has been involved in a child’s life. If the historical values were captured, the system could readily list, for example, all the investigators who have been assigned to a child.
4. **Training and Document Review**
Users often enter the wrong values in the wrong fields or fail to complete all the necessary fields. A new round of training and a review of supporting documentation would help reduce errors such as mistakenly entering Manner of Death values in Cause of Death in the CDR.
5. **Improved Community-Based Care (CBC) Reporting**
Because CBCs provide a community-based service delivery model, independent of DCF, it can be difficult to get information, particularly ad hoc requests. Caseworker reporting that is more robust and readily accessible is needed. Having access to certain information would alert when, for example, a child may need a more experienced caseworker. Common data needs include caseload, turnover rates, level of experience, and all other factors, all of which impacts the analysis of how well a child is being served.

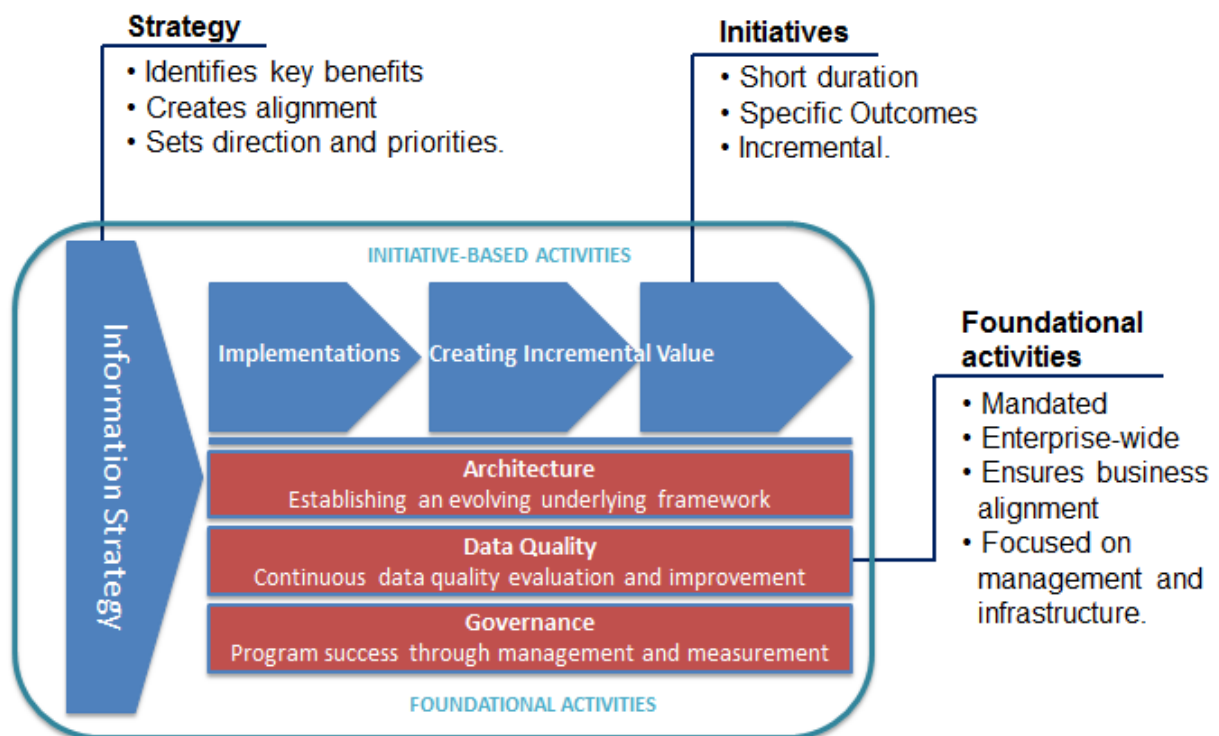
8 Executive-Level Roadmap

In order to develop a comprehensive predictive model, a broader set of data must be collected so that a Heightened Risk Model could be developed to support CPIs, CBCs and DCF management. By incorporating a wider set of data, a richer and more meaningful analysis can be done. Some of the sources used in the Child Fatality Trend Analysis would be expanded as well as inclusion of new sources that could indicate risk factors like financial hardship, substance abuse or mental health stresses on the family, or household members with a history of crime or violence.

Ultimately, being able to alert to which children are a greater risk would offer an additional tool for DCF to better assess and provide for the safety of the children they serve.

8.1 Roadmap Strategy and Execution

The graphic below outlines the activities and methodologies for building out a robust analytics environment.



Business Analytics requires different tools, resources, and database structures than Business Intelligence:

- **Tools** – Business Analytics requires a toolset that provides advanced statistical modeling capabilities.

Business Analytical tools continue to evolve in the marketplace. Typically most organizations have a solid infrastructure that can be enhanced to include business analytics through careful planning. Data visualization and discovery tools can add value in conjunction with this approach and can deliver business value early on earning credibility and enhancing rapport with the business.

- **Resources** – Business Analytics requires resources that understand advanced statistical modeling and can program such models using statistical modeling tools. The resources must also know how to mine data to identify valuable business insights.

Resources to support business analytics are highly skilled and universally in great demand. Simply adding staff for analytics is not the same as hiring specifically for these roles. These resources typically command a higher pay grade and/or job classification leaning towards upper management

- **Data Sources** – Business Analytics doesn't require a 'Big Data' technology. What Analytics DOES require is data that is structured differently than a traditional data model. A Business Analytics group will need resources to help create and transform data into the right structure for use with regression analysis.

Data supporting Business Analytics can be utilized in a federated approach (the data lives at its Online Transaction Processing (OLTP) or Online Analytical Processing (OLAP) source) that can include or exclude Big Data. This largely depends upon the number of transaction sets, the level of detail of data required, and the complexity of the business solution.

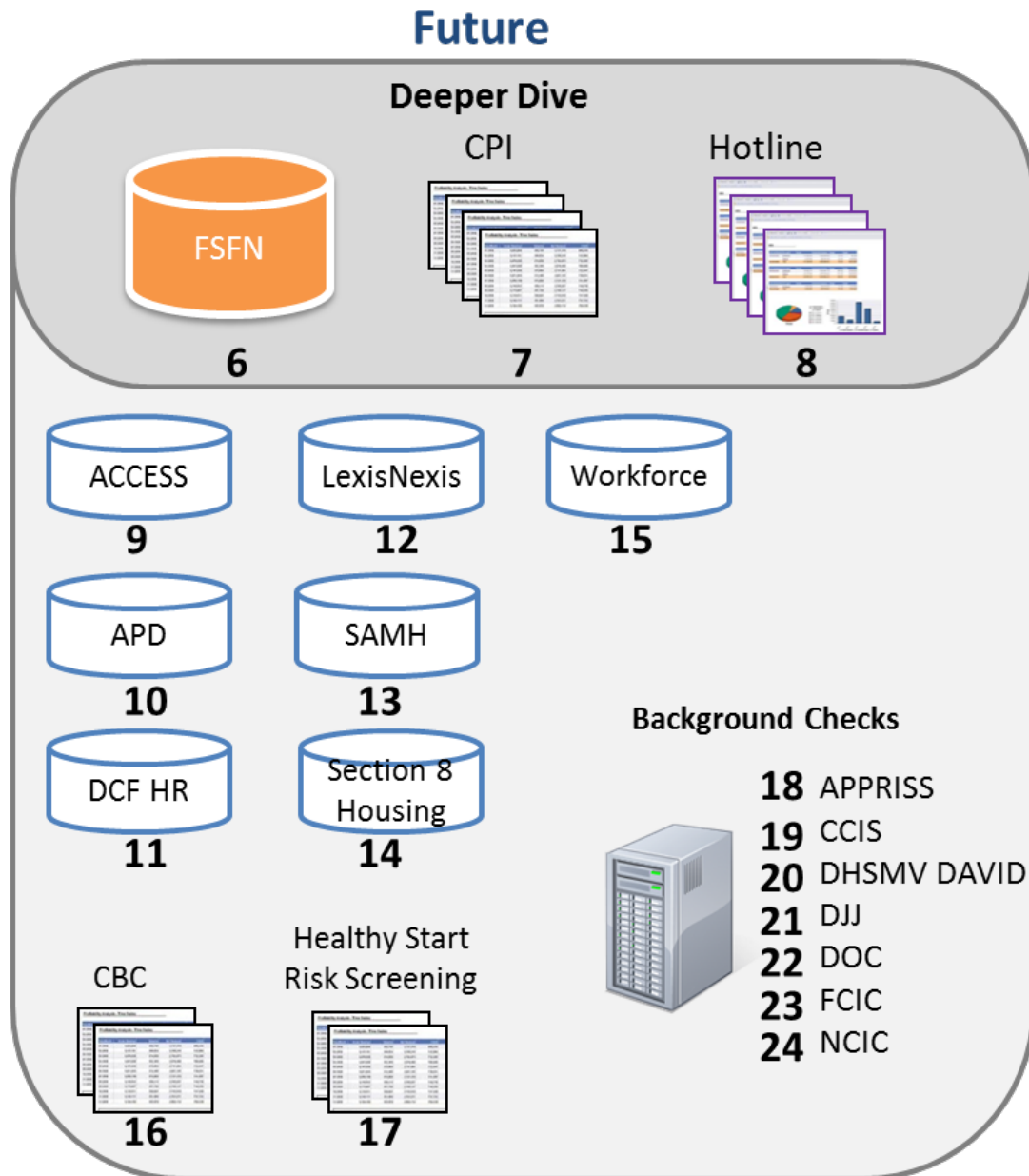
8.2 Current Data Sources

Listed below are the data sources used for the Child Fatality Trend Analysis:

#	Data Source	Description
1	Florida Safe Families Network (FSFN)	<ul style="list-style-type: none"> Limited extract focused on children with an allegation of death due to abuse or neglect in an investigation between 01/01/2007 and 06/30/13 Data includes: Allegations, Demographics, Family Support Services, Geography, In-Home Services, Intakes, Out-of-Home Placements, Out-of-Home Providers, Participants (Case, Intake, Investigation), Relationship and Removals
2	Child Death Review Database (CDR)	<ul style="list-style-type: none"> Provides additional information regarding child death investigations from 01/01/2009 to 06/30/13 including Cause of Death, Manner of Death, Date of Death, Age at Death, and County of Death Spreadsheets provided for 2007 – 2008 (data prior to CDR implementation)
3	Child Protective Investigators (CPI)	<ul style="list-style-type: none"> Summary data for CPI counts from 01/01/2007 – 06/30/13 Includes counts for active investigations, primary workers assigned to active investigations, and average workload
4	Florida Abuse Hotline	<ul style="list-style-type: none"> Counts for 01/01/2007 – 06/30/2013 including Child Abuse Reports, Investigations, Reports Alleging Child Death due to Abuse or Neglect, and Child Abuse Reports screened in vs. screened out
5	Department of Health Vital Statistics	<ul style="list-style-type: none"> Vital statistics for 2007 – 2012

8.3 Roadmap Data Sources

The following diagram illustrates the data sources needs to support a deeper analysis, beginning with a broader set of data from the sources already utilized for the Child Fatality Trend Analysis. Additionally, the table below provides a brief description of the potential usage of these data sources to develop a Child Welfare Heightened Risk analytics model:



#	Data Source	Description
6	Deeper Dive: Florida Safe Families Network (FSFN)	<ul style="list-style-type: none"> Expand the universe of data beyond child death records
7	Deeper Dive: Child Protective Investigators (CPI)	<ul style="list-style-type: none"> Collect more CPI data beyond summary level
8	Florida Abuse Hotline	<ul style="list-style-type: none"> Gather detailed data beyond summary level

These data sources would provide information on potential risk factors:

#	Data Source	Description
9	Automated Community Connection to Economic Self Sufficiency (ACCESS)	<ul style="list-style-type: none"> Public assistance data including Medicaid, Temporary Assistance to Needy Families (TANF), and Supplemental Nutrition Assistance Program (SNAP) Assessment of financial hardship
10	Agency for Persons with Disabilities (APD)	<ul style="list-style-type: none"> Data on adults with developmental disabilities Inform which families have adults with disabilities or special needs
11	DCF Human Resources	<ul style="list-style-type: none"> CPI tenure information and experience level Provide guidance on whether a more difficult cases would need a more experienced caseworker
12	LexisNexis	<ul style="list-style-type: none"> Financial data, household members, and employment Ascertain financial hardship as well as a fuller picture of household members
13	Substance Abuse Mental Health (SAMH)	<ul style="list-style-type: none"> Determine if a household has alcohol, drug or mental health stressors
14	Section 8 Housing	<ul style="list-style-type: none"> Alert to families with children seeking housing Gauge financial hardship

#	Data Source	Description
15	Workforce Florida	<ul style="list-style-type: none"> Provides job training and other support for those seeking employment or wishing to improve their skillset Potential measure of financial difficulties
16	Community-Based Care (CBC)	<ul style="list-style-type: none"> Collect data regarding active cases, number of primary workers assigned to active cases, average workload, tenure, experience, etc.
17	Healthy Start Risk Screening	<ul style="list-style-type: none"> Assessments could help alert DCF to families at risk

The following are used for background checks run during the course of an investigation:

#	Data Source	Description
18	Appriss	<ul style="list-style-type: none"> Jail Booking System
19	Comprehensive Case Information System (CCIS)	<ul style="list-style-type: none"> Advises of any court case information statewide and maintained by the county Clerks of Court
20	Driver and Vehicle Information Database (DHSMV DAVID)	<ul style="list-style-type: none"> System maintained by the Department of Highway Safety and Motor Vehicles (DHSMV) Data retrieved from Driver's License information: Photo, Address, Signature
21	Department of Juvenile Justice (DJJ)	<ul style="list-style-type: none"> Search for Delinquency records
22	Department of Correction (DOC)	<ul style="list-style-type: none"> Checks for criminal offenders and those on probation or paroled
23	Florida Crime Information Center (FCIC)	<ul style="list-style-type: none"> Florida database used to check for criminal records including convicted sex offenders, criminal convictions, and parolees/supervised release
24	National Crime Information Center (NCIC)	<ul style="list-style-type: none"> National database used to check for criminal records including convicted sex offenders, criminal convictions, and parolees/supervised release

9 Appendix

9.1 Interviews

- Dr. Randell Alexander
State Medical Director, DOH Child Protection Team

Dr. Alexander is a respected expert in the field of child maltreatment and has done extensive research on the subject, and he is often called upon to testify in significant cases involving child abuse.

He was able to provide insight from the perspective of a medical professional about the incident of child abuse and how certain factors lead to higher risk for maltreatment, especially for younger children who have less touch points outside their families.

Dr. Alexander highlighted the work on the Adverse Childhood Experiences Study (ACES) conducted by the Centers for Disease Control and Prevention and Kaiser Permanente's Health Appraisal Clinic in San Diego. The study assessed the association between childhood maltreatment (e.g., physical abuse, sexual abuse, neglect) and its impact on health and general well-being as an adult. Those early childhood experiences often result in increased rates of teen pregnancy, mental health disorders, addictions, and poor physical health.

In July 2010, the Florida Child Abuse Prevention and Permanency Plan issued by the Executive Office of the Governor acknowledged ACES as one of the foundational principles of its prevention plan.

- Carol McNally
Healthy Families Florida, Executive Director

Ms. McNally is the Executive Director of Healthy Families Florida (part of The Ounce of Prevention Fund) which was created in 1998 with the goal of creating stable homes with self-sufficient members. Parents voluntarily participate in order to better address their newborns needs and help them thrive.

The program uses a tool to assess a family's risk of abuse and neglect. As a course of this project, the metrics were reviewed to help determine what other information might inform any future predictive model.

- Lin Pelter
DCF QA Manager

Ms. Pelter works for DCF and provided insights into the activities that the CPIs perform from the opening of an investigation to its completion. She reviewed the QA process and all the steps in an investigation needed to fully assess if a child is at risk. She also shared several documents for background information around Quality Assurance Standards for Case Management Services, the Florida Abuse Hotline, and Child Protective Investigations.

- Stephen Pennypacker, Esq.
DCF Assistant Secretary for Programs

Though new to his role at DCF, Mr. Pennypacker has been with the agency since 2006 and recently served as Deputy Director and the Training Director for Children's Legal Services and the Interstate Compact on the Placement of Children (ICPC) Deputy Compact Administrator for the State of Florida. He shared the risk factors that he has seen play a significant role in children who have been neglected or abused.

- Lisa Rivera
Operations Review Specialist, Child Fatality Prevention Specialist

Ms. Rivera has been with the department for 17 years, is a Child Fatality Prevention Specialist and does the QA review process for the Suncoast region. She shared the process that is followed whenever there is a report of a child death. She also spoke to the challenges investigators face as well as the risk factors that are likely to turn up in the course of a child death investigation.

- Shawn Salamida
Partnership for Strong Families, President and CEO

Mr. Salamida has over 20 years' experience in children's services. His agency is responsible for managing child welfare services in North Central Florida and he also serves on the Board of Directors for the Florida Coalition for Children.

He discussed how his agency analyzed the high rate of foster care in one city, looking at the correlation of demographics and geography. Using that information, they were able to develop strategies for improvement by first targeting at the zip code level and then moving to broader neighborhoods. Using this approach they were able to provide early support and intervention before a family reached a crisis.

- Major Connie Shingledecker
Investigations Bureau Chief, Manatee County

Major Shingledecker has extensive experience in law enforcement, particularly in crimes against children and serves on the Statewide Child Abuse Death Review committee. She provided in-depth insights into what trends the committee has seen over the last eleven years including the changing popularity of various drugs and how it impacts child maltreatment (drugs that tend to make users sleep result in more incidents of co-sleeping deaths) and the economic impacts on child welfare (increased incidents of murder-suicide). She stressed the importance of being able to measure the success of behavior modification programs in order to fine-tune the services provided.

9.2 Model Methodology

For this model, SAS considered 873,065 children as the population of interest. Within that population of children, there were 3013 deaths as documented in the Florida Child Death Review database. The children in the model were chosen as they had the following characteristics:

- 1) Died between January 1, 2007 and June 30, 2013
- 2) Had sufficient data to be included in the model

In order to model children's deaths and the many underlying risk factors of the child deaths that occurred in Florida within the model, SAS chose to utilize logistic regression with reference coding of binary inputs to measure the impact of a number of variables on odds of a child's death.

For more information on Logistic Regression, see below:

Logistic Regression

Binary responses (for example, success and failure), ordinal responses (for example, normal, mild, and severe), and nominal responses (for example, major TV networks viewed at a certain hour) arise in many fields of study. Logistic regression analysis is often used to investigate the relationship between these discrete responses and a set of explanatory variables. Texts that discuss logistic regression include Agresti (2002), Allison (1999), Collett (2003), Cox and Snell (1989), Hosmer and Lemeshow (2000), and Stokes, Davis, and Koch (2000).

For binary response models, the response, Y , of an individual or an experimental unit can take on one of two possible values, denoted for convenience by 1 and 2 (for example, $Y = 1$ if a disease is present, otherwise $Y = 2$). Suppose \mathbf{x} is a vector of explanatory variables and $\pi = \Pr(Y = 1 \mid \mathbf{x})$ is the response probability to be modeled. The linear logistic model has the form

$$\text{logit}(\pi) \equiv \log\left(\frac{\pi}{1-\pi}\right) = \alpha + \boldsymbol{\beta}'\mathbf{x}$$

where α is the intercept parameter and $\boldsymbol{\beta} = (\beta_1, \dots, \beta_s)'$ is the vector of s slope parameters. Notice that the LOGISTIC procedure, by default, models the probability of the **lower** response levels.

The logistic model shares a common feature with a more general class of linear models: a function $g = g(\mu)$ of the mean of the response variable is assumed to be linearly related to the explanatory variables. Since the mean μ implicitly depends on the stochastic behavior of the response, and the explanatory variables are assumed to be fixed, the function g provides the link between the random (stochastic) component and the systematic (deterministic) component of the response variable Y . For this reason, Nelder and Wedderburn (1972) refer to $g(\mu)$ as a link function. One advantage of the logit function over other link functions is that differences on the logistic scale are interpretable regardless of whether the data are sampled prospectively or

retrospectively (McCullagh and Nelder; [1989](#), Chapter 4). Other link functions that are widely used in practice are the probit function and the complementary log-log function. The LOGISTIC procedure enables you to choose one of these link functions, resulting in fitting a broader class of binary response models of the form

$$g(\pi) = \alpha + \beta' \mathbf{x}$$

For ordinal response models, the response, Y , of an individual or an experimental unit might be restricted to one of a (usually small) number of ordinal values, denoted for convenience by $1, \dots, k, k+1$. For example, the severity of coronary disease can be classified into three response categories as 1=no disease, 2=angina pectoris, and 3=myocardial infarction. The LOGISTIC procedure fits a common slopes cumulative model, which is a parallel lines regression model based on the cumulative probabilities of the response categories rather than on their individual probabilities. The cumulative model has the form

$$\log(\Pr(Y \leq i | \mathbf{x})) = \alpha_i + \beta' \mathbf{x}, \quad i = 1, \dots, k$$

where $\alpha_1, \dots, \alpha_k$ are k intercept parameters, and β is the vector of slope parameters. This model has been considered by many researchers. Aitchison and Silvey ([1957](#)) and Ashford ([1959](#)) employ a probit scale and provide a maximum likelihood analysis; Walker and Duncan ([1967](#)) and Cox and Snell ([1989](#)) discuss the use of the log odds scale. For the log odds scale, the cumulative logit model is often referred to as the **proportional odds** model.

For nominal response logistic models, where the $k+1$ possible responses have no natural ordering, the logit model can also be extended to a **multinomial** model known as a **generalized** or **baseline-category** logit model, which has the form

$$\log \left(\frac{\Pr(Y = i | \mathbf{x})}{\Pr(Y = k+1 | \mathbf{x})} \right) = \alpha_i + \beta_i' \mathbf{x}, \quad i = 1, \dots, k$$

where the $\alpha_1, \dots, \alpha_k$ are k intercept parameters, and the β_1, \dots, β_k are k vectors of slope parameters.

These models are a special case of the **discrete choice** or **conditional logit** models introduced by McFadden ([1974](#)).

The LOGISTIC procedure fits linear logistic regression models for discrete response data by the method of maximum likelihood. It can also perform conditional logistic regression for binary response data and exact logistic regression for binary and nominal response data. The maximum likelihood estimation is carried out with either the Fisher scoring algorithm or the Newton-Raphson algorithm, and you can perform the bias-reducing penalized likelihood optimization as discussed by Firth ([1993](#)) and Heinze and Schemper ([2002](#)). You can specify starting values for the parameter estimates. The logit link function in the logistic regression models can be replaced by the probit function, the complementary log-log function, or the generalized logit function.

Any term specified in the model is referred to as an **effect**. The LOGISTIC procedure enables you to specify categorical variables (also known as **classification** or **CLASS variables**) and continuous variables as explanatory effects. You can also specify more complex model terms such as interactions and nested terms in the same way as in the GLM procedure. You can create complex **constructed effects** with the [EFFECT](#) statement. An effect in the model that is not an interaction or a nested term or a constructed effect is referred to as a **main effect**.

The LOGISTIC procedure allows either a full-rank parameterization or a less-than-full-rank parameterization of the CLASS variables. The full-rank parameterization offers eight coding methods: effect, reference, ordinal, polynomial, and orthogonalizations of these. The effect coding is the same method that is used in the CATMOD procedure. The less-than-full-rank parameterization, often called **dummy coding**, is the same coding as that used in the GLM procedure.

The LOGISTIC procedure provides four effect selection methods: forward selection, backward elimination, stepwise selection, and best subset selection. The best subset selection is based on the likelihood score statistic. This method identifies a specified number of best models containing one, two, three effects, and so on, up to a single model containing effects for all the explanatory variables.

The LOGISTIC procedure has some additional options to control how to move effects in and out of a model with the forward selection, backward elimination, or stepwise selection model-building strategies. When there are no interaction terms, a main effect can enter or leave a model in a single step based on the *p*-value of the score or Wald statistic. When there are interaction terms, the selection process also depends on whether you want to preserve model hierarchy. These additional options enable you to specify whether model hierarchy is to be preserved, how model hierarchy is applied, and whether a single effect or multiple effects can be moved in a single step.

Odds ratio estimates are displayed along with parameter estimates. You can also specify the change in the continuous explanatory main effects for which odds ratio estimates are desired. Confidence intervals for the regression parameters and odds ratios can be computed based either on the profile-likelihood function or on the asymptotic normality of the parameter estimators. You can also produce odds ratios for effects that are involved in interactions or nestings, and for any type of parameterization of the CLASS variables.

Various methods to correct for overdispersion are provided, including Williams' method for grouped binary response data. The adequacy of the fitted model can be evaluated by various goodness-of-fit tests, including the Hosmer-Lemeshow test for binary response data.

Like many procedures in SAS/STAT software that enable the specification of CLASS variables, the LOGISTIC procedure provides a [CONTRAST](#) statement for specifying customized hypothesis tests concerning the model parameters. The CONTRAST statement also provides estimation of individual rows of contrasts, which is particularly useful for obtaining odds ratio estimates for various levels of the CLASS variables. The LOGISTIC procedure also provides testing capability through

the [ESTIMATE](#) and [TEST](#) statements. Analyses of LS-means are enabled with the [LSMEANS](#), [LSMESTIMATE](#), and [SLICE](#) statements.

You can perform a conditional logistic regression on binary response data by specifying the [STRATA](#) statement. This enables you to perform matched-set and case-control analyses. The number of events and nonevents can vary across the strata. Many of the features available with the unconditional analysis are also available with a conditional analysis.

The LOGISTIC procedure enables you to perform exact logistic regression, also known as exact conditional logistic regression, by specifying one or more [EXACT](#) statements. You can test individual parameters or conduct a joint test for several parameters. The procedure computes two exact tests: the exact conditional score test and the exact conditional probability test. You can request exact estimation of specific parameters and corresponding odds ratios where appropriate. Point estimates, standard errors, and confidence intervals are provided. You can perform stratified exact logistic regression by specifying the [STRATA](#) statement.

Further features of the LOGISTIC procedure enable you to do the following:

- control the ordering of the response categories
- compute a generalized R^2 measure for the fitted model
- reclassify binary response observations according to their predicted response probabilities
- test linear hypotheses about the regression parameters
- create a data set for producing a receiver operating characteristic curve for each fitted model
- specify contrasts to compare several receiver operating characteristic curves
- create a data set containing the estimated response probabilities, residuals, and influence diagnostics
- score a data set by using a previously fitted model

The LOGISTIC procedure uses ODS Graphics to create graphs as part of its output. For general information about ODS Graphics, see Chapter 21, [Statistical Graphics Using ODS](#). For more information about the plots implemented in PROC LOGISTIC, see the section [ODS Graphics](#).

For more examples and discussion on the use of PROC LOGISTIC, see Stokes, Davis, and Koch (2000), Allison (1999), and SAS Institute Inc. (1995).⁷

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http://support.sas.com/documentation/cdl/en/statug/63347/HTML/default/viewer.htm#statug_logistic_sect001.htm

9.3 Statistical Appendix

Model for All Child Deaths

Variable	Effect (Model Coefficient)	Odds Ratio	Pr>ChiSquare
Male Indicator	0.3832	1.47	<.0001
Age of Child	-0.7307	0.48	<.0001
Total Prior Allegations	-0.4367	0.65	<.0001
Total Prior In Home Services	-2.2871	0.10	<.0001
Total Number of Siblings	0.3256	1.38	<.0001
Prior Removals Due to Physical Abuse	2.6451	14.08	<.0001
Prior Removals Due to Sexual Abuse	4.2092	67.30	<.0001
Prior Removal Due to Child Drug or Alcohol Abuse	2.1416	8.51	0.0216
Prior Removal Due to Parent Drug or Alcohol Abuse	2.6907	14.74	<.0001
Prior Removal Due to Medical Neglect	1.6084	4.99	0.0044
African American Indicator	0.1233	1.13	0.0017
Intellectual Disability Indicator	2.4122	11.16	<.0001
Physical Disability Indicator	2.8322	16.98	<.0001

Odds Ratio Calculation

$$e^{\beta}$$

Where β is a model parameter/coefficient.

Model for Abuse Deaths

Variable	Effect (Model Coefficient)	Odds Ratio	Pr>ChiSquare
Male Indicator	0.2576	1.29	0.0115
Age of Child	-0.5828	0.56	<.0001
Total Prior In Home Services	-2.3138	0.10	<.0001
Number of Siblings	0.3679	1.44	<.0001
Prior Removal Due to Physical Abuse	1.7376	5.68	0.0107
Prior Removal Due to Parent Drug or Alcohol Abuse	1.1256	3.08	0.0038
African American Indicator	0.2547	1.29	0.0128
Physical Disability Indicator	2.3985	11.01	<.0001

Odds Ratio Calculation

e^{β}

Where β is a model parameter/coefficient.

Model for Drowning Deaths

Variable	Effect (Model Coefficient)	Odds Ratio	Pr>ChiSquare
Male Indicator	0.6344	1.885890268	<.0001
Age of Child	-0.5361	0.585025408	<.0001
Total Prior Allegations	-0.2701	0.76330316	<.0001
Total Prior In Home Services	-2.0271	0.131716947	<.0001
Number of Siblings	0.2759	1.317716086	0.0036
Prior Removal Due to Sexual Abuse	4.6219	101.6870541	<.0001
Prior Removal Due to Parental Drug or Alcohol Abuse	2.3995	11.01766617	<.0001
Asian American Indicator	0.9784	2.660196521	0.0066
African American Indicator	-0.3008	0.740225803	0.0021

Odds Ratio Calculation

e^{β}

Where β is a model parameter/coefficient.

Model for Asphyxiation Deaths

Variable	Effect (Model Coefficient)	Odds Ratio	Pr>ChiSquare
Male Indicator	0.2601	1.297059786	0.0021
Age of Child	-1.1496	0.316763449	<.0001
Total Prior Allegations	-1.5189	0.218952602	<.0001
Number of Siblings	0.3184	1.374926122	<.0001
Prior Removals Due to Parent Drug or Alcohol Abuse	2.8883	17.96274696	<.0001

Odds Ratio Calculation

$$e^{\beta}$$

Where β is a model parameter/coefficient.

9.4 Baseline Model Support

Model Support for All Child Deaths

Child Deaths - African American		Child Deaths - Intellectual Disability		Child Deaths - Physical Disability	
Year	Total Deaths	Year	Total Deaths	Year	Total Deaths
2007	170	2007	6	2007	12
2008	164	2008	3	2008	8
2009	186	2009	1	2009	5
2010	188	2010	1	2010	4
2011	175	2011	3	2011	7
2012	156	2012	2	2012	4
2013	93	2013	2	2013	3

Support for Abuse Model

Death By Abuse – Female Victims		Deaths by Abuse – Male Victims		Death by Abuse - Physically Disabled	
Year	Total Deaths	Year	Total Deaths	Year	Total Deaths
2007	31	2007	38	2007	2
2008	34	2008	37	2008	1
2009	28	2009	40	2009	0
2010	28	2010	38	2010	0
2011	24	2011	36	2011	2
2012	22	2012	27	2012	0
2013	8	2013	13	2013	0

Child Deaths by Abuse - African American Victims		Death by Abuse - Intellectual Disability		Child Deaths by Abuse	
Year	Total Deaths	Year	Total Deaths	Year	Total Deaths
2007	21	2007	1	2007	68
2008	27	2008	0	2008	71
2009	28	2009	0	2009	69
2010	27	2010	0	2010	66
2011	27	2011	0	2011	60
2012	22	2012	0	2012	49
2013	9	2013	0	2013	21

*1 case in 2009 with Unknown Gender

Support for Drowning Model

Death by Drowning	
Year	Total Deaths
2007	77
2008	74
2009	76
2010	92
2011	75
2012	81
2013	34

Death by Drowning - African American Victims	
Year	Total Deaths
2007	23
2008	16
2009	26
2010	25
2011	19
2012	22
2013	10

Death by Drowning - Intellectual Disability	
Year	Total Deaths
2007	1
2008	0
2009	1
2010	0
2011	0
2012	0
2013	0

Death by Drowning - Female Victims	
Year	Total Deaths
2007	26
2008	28
2009	26
2010	25
2011	33
2012	24
2013	14

Death by Drowning - Male Victim	
Year	Total Deaths
2007	52
2008	46
2009	50
2010	67
2011	42
2012	57
2013	21

Death by Drowning - Physical Disability	
Year	Total Deaths
2007	1
2008	1
2009	1
2010	0
2011	0
2012	0
2013	0

Support for Asphyxiation Model

Death by Asphyxiation	
Year	Total Deaths
2007	109
2008	126
2009	100
2010	86
2011	80
2012	85
2013	46

Death by Asphyxiation - African American Victims	
Year	Total Deaths
2007	47
2008	46
2009	44
2010	31
2011	31
2012	23
2013	12

Death by Asphyxiation - Female Victims	
Year	Total Deaths
2007	41
2008	62
2009	32
2010	36
2011	29
2012	34
2013	15

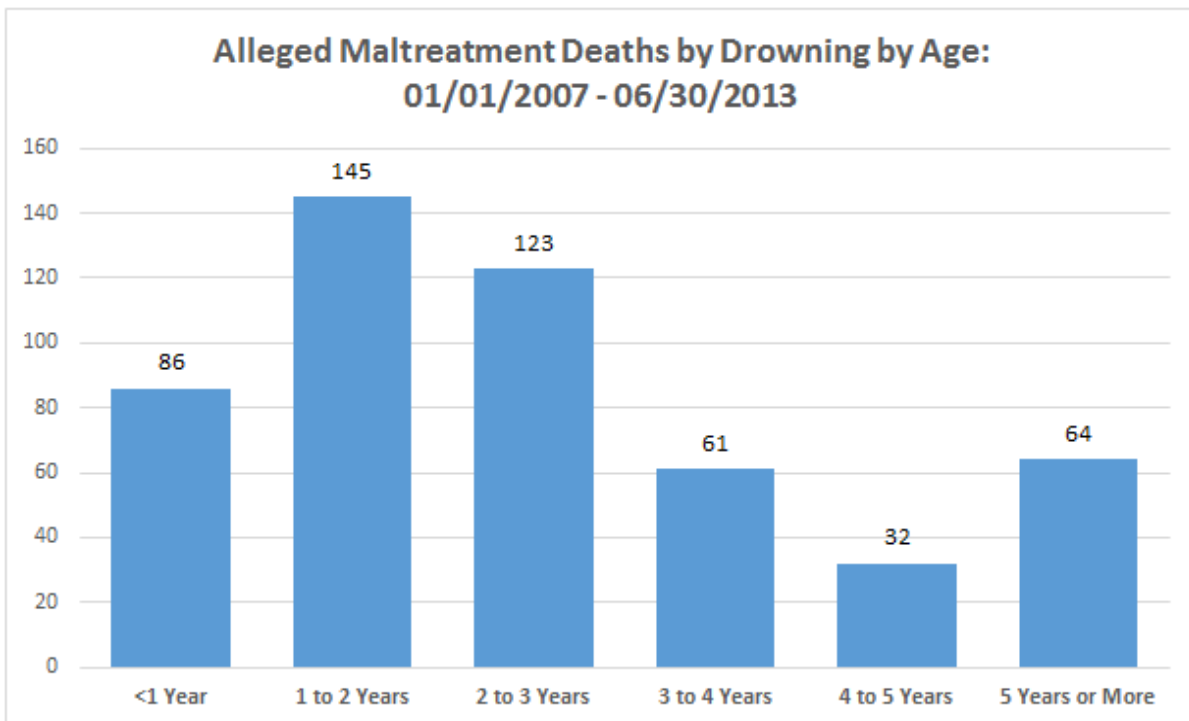
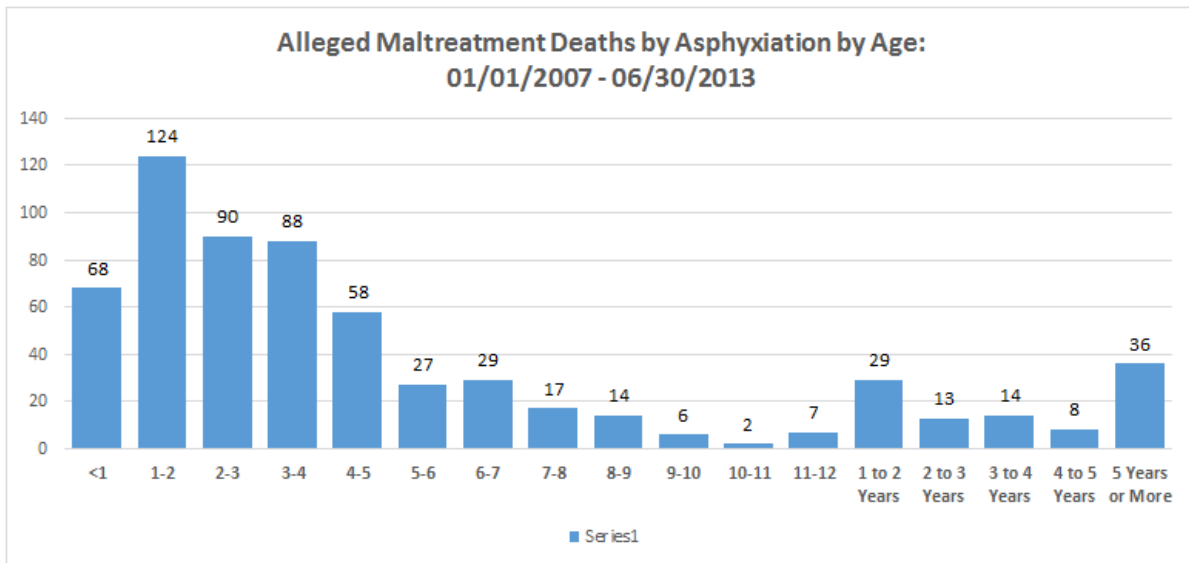
Death by Asphyxiation - Male Victims	
Year	Total Deaths
2007	68
2008	64
2009	67
2010	50
2011	52
2012	51
2013	31

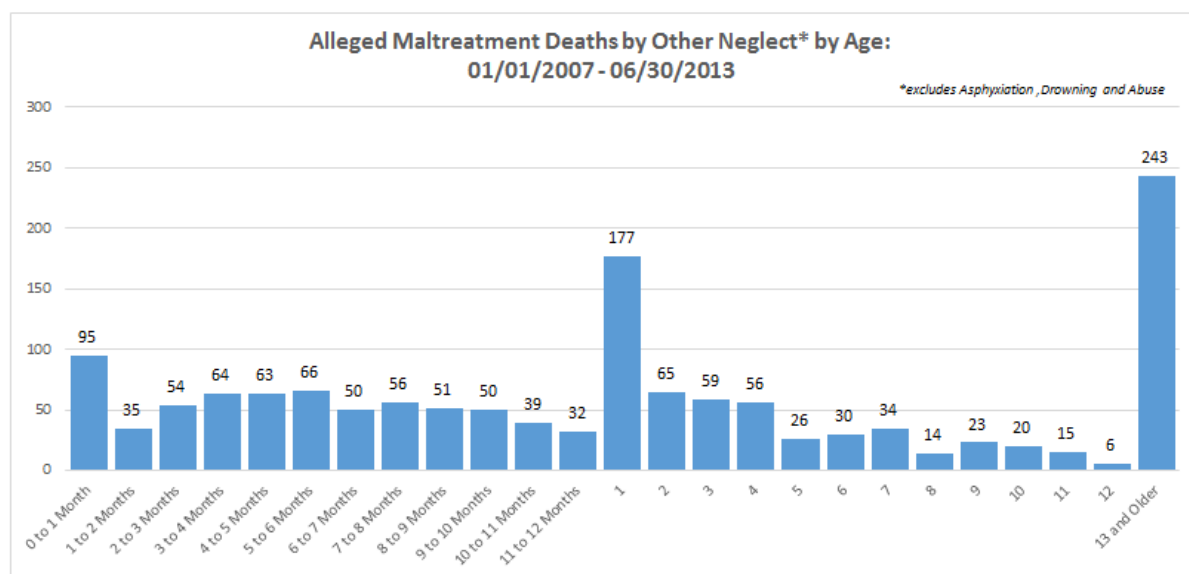
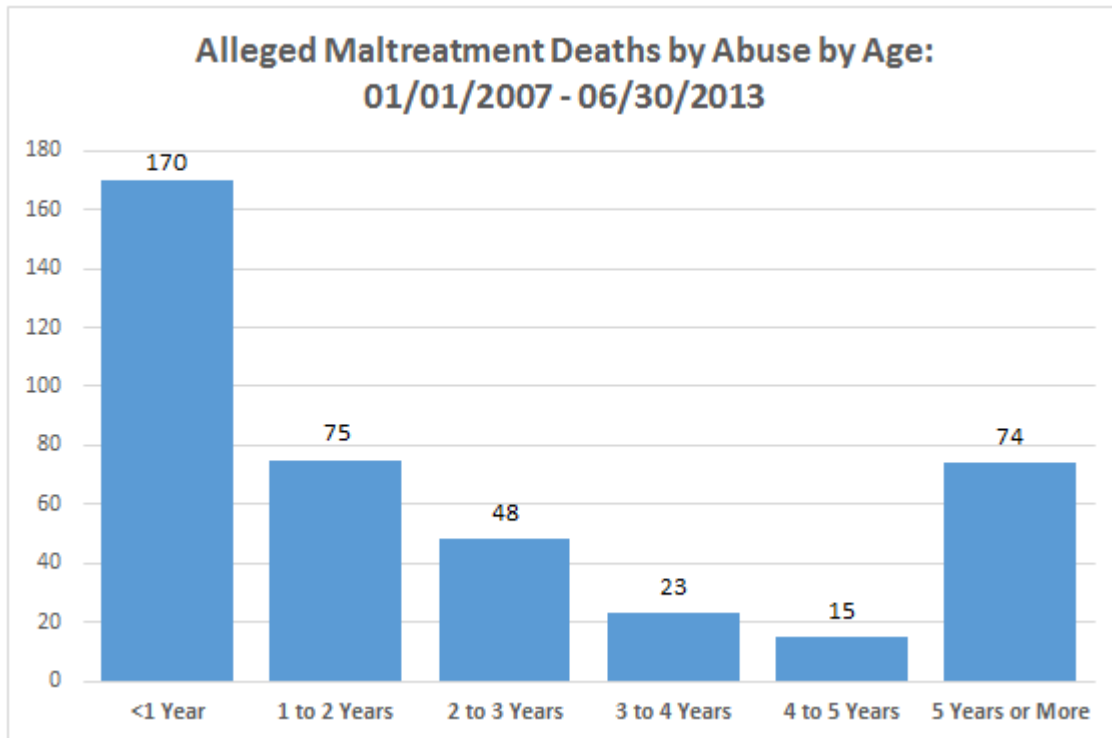
Death by Asphyxiation - Intellectual Disability	
Year	Total Deaths
2007	0
2008	0
2009	0
2010	0
2011	0
2012	0
2013	0

Death by Asphyxiation - Physical Disability	
Year	Total Deaths
2007	0
2008	0
2009	1
2010	0
2011	0
2012	0
2013	0

9.5 Age Charts

The following charts show the incident of death by age range for Asphyxiation, Drowning, Abuse and Other Neglect (excluding Asphyxiation and Drowning).





9.6 Seasonality Charts

The following charts show the incident of death by month for overall and by Asphyxiation, Drowning, Abuse and Other Neglect (excluding Asphyxiation and Drowning).

