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Neonatal Abstinence Syndrome: Effectiveness of Targeted Umbilical Cord Drug Screening in Determining Risk of Withdrawal

Alecia Karr
mrs.karr2012@gmail.com

Neonatal Abstinence Syndrome: Effectiveness of Targeted Umbilical Cord Drug Screening in Determining Risk of Withdrawal

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By: Alecia J. Karr, BSN, RN

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Abstract

Neonatal Abstinence Syndrome (NAS) is a condition in which an infant experiences withdrawal from uterine exposure to various substances such as caffeine, nicotine, amphetamines, THC, opioids, benzodiazepines, and other types of substances. Depending on the severity of the symptoms, these infants may experience a longer hospital stay and may need treatment and monitoring in the neonatal intensive care unit (NICU), resulting in an increase in healthcare costs. The objective of this project was to determine if targeted drug screening of newborns was effective in determining infants at risk of NAS based on a positive screening result. This study utilized a retrospective, cross-sectional electronic health record (EHR) review of infants born between September 1st, 2015 and September 1st, 2016 who met criteria for umbilical cord drug screening. Rates of umbilical cord drug screening and screening results were compared to risk factors associated with targeted drug screening criteria to determine which risk factor criteria were predictive of a positive umbilical cord drug screening result. The EHR records of 340 infants met criteria. Risk factors associated with targeted drug screening criteria were not significantly sensitive nor specific in predicting infants at risk of NAS based on positive drug screen results. In order to truly identify all infants at risk for withdrawal, universal screening is recommended.

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Dr. Leslie K Scott PhD, APRN, PPCNP-BC, CDE, MLDE – Committee Chair

Dr. Nicole F. Garritano, DNP, APRN, CPNP-AC – Committee Member

Kara Smith, RN, MSN, NE-BC – Committee Member/Clinical Mentor

Dedication

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Neonatal Abstinence Syndrome: Is Targeted Umbilical Cord Drug Screening Effective in Determining Risk of Withdrawal?

Background

Neonatal Abstinence Syndrome (NAS) is a growing health problem in the United States. "Between 2004 and 2014, the incidence of NAS in the United States increased from 1.5 per 1000 hospital births to 8.0 per 1000 hospital births, a more than fivefold increase" (Winkelman, Villapiano, Kozhimannil, Davis, & Patrick, 2018). NAS is a condition in which an infant experiences withdrawal from uterine exposure to various substances such as caffeine, nicotine, amphetamines, THC, opioids, benzodiazepines, and other types of substances. Depending on the severity of the symptoms, these infants may experience a longer hospital stay and may require treatment and monitoring in the neonatal intensive care unit (NICU), resulting in an increase in healthcare costs. When comparing healthcare costs from 2004 to 2014 of infants with NAS covered by Medicaid, there was an annual increase in cost from $65.4 million in 2004 to $462 million in 2014. Over this ten-year period, there was over $2 billion in additional costs for infants with a NAS diagnosis (Winkelman et al., 2018). NAS can lead to withdrawal symptoms within the first 12-72 hours of life that include central nervous system (CNS) disturbances, vasomotor dysregulation, gastrointestinal disturbances, and hyperirritability such as tremors, fever, tachypnea, excoriation, diaphoresis, high-pitched crying, lack of sleep, vomiting, diarrhea, and more severe symptoms such as seizures and respiratory distress (American College of Obstetricians and Gynecologist, 2017; McQueen & Murphy-Oikonen, 2016; Timpson, Killoran, Maranda, Picarillo, & Bloch-Salisbury, 2018). There are also long-term effects from NAS. Infants who developed NAS were at an increased risk for problems with their vision,

behavior, cognition, sleep, and ear infections as they matured (Maguire et al., 2016). There is also a strong association between substance abuse disorder and child maltreatment, with 40-56% of parents having abused or neglected their child when using substances (Maguire et al., 2016). In a study described by Maguire et al. (2016), the incidence of child abuse was doubled when a parent had a substance use disorder. NAS is a condition which not only affects an infant at birth, but also throughout their lifetime as these problems continue to develop.

Determination of risk for NAS can be evaluated in a number of ways in regard to drug screening mothers and/or infants (Terplan & Minkoff, 2017). Drug screening can be performed on maternal or infant blood, urine, or hair as well as infant meconium, umbilical cord, or placenta (McQueen & Murphy-Oikonen, 2016; Price, Collier, & Wright, 2018). Screening can be selective, where drug testing is performed only if certain criteria are met. This may include validated questionnaires provided to the mother or may be based on admission of a history of substance use or abuse, placental abruption, precipitous labor, limited or no prenatal care, or behavior suggestive of substance use in the mother or withdrawal in the infant. Drug screening can also be universal, where all mothers or infants are chosen for drug screening. According to Terplan and Minkoff (2017), selective drug screening is more cost-effective because it allows the physician to narrow down those mothers who are at greatest risk of substance abuse, which improves efficiency and specificity. However, the disadvantage with selective drug screening is the decision to test may be based on bias or judgment and mothers and infants can be missed. In a study described by Terplan and Minkoff (2017), black women and poor women were more likely than others to be reported to social services, and infants of black women were more likely to be drug screened. “Universal testing avoids the risk of implicit bias and has the advantage of simplicity” (Terplan & Minkoff, 2017, p. 165). This also avoids relying on a woman’s honesty in

her substance abuse history to decide whether an infant is screened and monitored for withdrawal. Often, women are scared to admit information about their drug use history due to fear of being reported to social services or having legal action taken against them (Truog, 2015).

In the state of Kentucky, where this research was conducted, the incidence of NAS has increased thirty-sevenfold from 2000-2013, with 0.4 cases per 1000 live births in 2000 and 15.0 cases per 1000 live births in 2013 (National Institute on Drug Abuse, 2018). When looking at the incidence of NAS across the 28 states included in an analysis by the National Institute on Drug Abuse (2018), the overall United States average was 6.0 cases per 1000 live births. In an analysis by the Kentucky Department for Public Health (2016), the most common substances used by mothers during pregnancy were buprenorphine (58.4%), other opiates (35.2%), THC (22.8%), heroin (20.4%), amphetamines (14.4%), and benzodiazepines (14.2%). In this same report, the Kentucky Department for Public Health (2016) stated that outcomes for NAS included child fatalities due to unsafe sleep habits as well as nonaccidental head trauma. "Because babies with NAS can have irritability and feeding problems for months after discharge, they are likely to be at higher risk for these deaths" (Kentucky Department for Public Health, 2016, p. 11). With the continued rise in NAS diagnoses due to substance abuse in pregnancy in the United States and especially the commonwealth of Kentucky, it is imperative that a plan be made to identify which infants are most at risk of withdrawal.

The goal of targeted drug screening of newborns is to identify newborns at risk of NAS by using risk factors often associated with maternal substance use. Early identification of infants at greatest risk of NAS can help determine infants who would benefit from early intervention/treatment. The objective of this project was to determine if targeted drug screening of newborns was effective in determining infants at risk of NAS. An additional aim was to

compare Finnegan scores of infants who were positive to those who were negative to determine the significance of Finnegan scoring in assessing signs of withdrawal. This project sought to compare positive drug screening results to the associated selective drug screening criteria in order to determine which screening criteria were most predictive of a positive result.

Theoretical Framework

The theoretical framework chosen for this project was the John Hopkins Nursing Evidence-Based Practice (JHNEBP) Model, which uses a three-step process to provide and apply the latest and best research to nursing practice and patient care (John Hopkins University & Medicine, 2020). The three steps in this process are called PET: practice question, evidence, and translation. The first step in this model is presenting a practice question. The purpose of the practice question is to present the problem and find a focused and specific question that can guide what kind of study or evidence is needed to move forward. For this project, the practice question was: What is the best way to identify which infants are at risk of NAS? The next step in the JHNEBP Model is to search for the evidence and resources that can answer the practice question. By doing a thorough literature review, gaps in literature can be found and the practice question can be shaped to find the best type of study that is needed. For this project, the literature review revealed gaps in the research comparing targeted screening protocols to universal screening protocols at the same facility as well as identifying which targeted drug screening criteria were the most accurate in determining a positive result. The last step in the JHNEBP Model is translation, which uses the practice question and literature review to decide on what type of study to perform (John Hopkins University & Medicine, 2020). For this project, there were two different pathways to take when considering the practice question. When considering the gap in literature where targeted screening and universal screening had not been performed

and compared at the same facility, the first translation was to do a prospective study. This study would have consisted of implementing a universal screening protocol at a facility that already did risk-based screening, and then comparing the additional infants that were found to be at risk of NAS. The second translation was to perform a retrospective medical record review where risk-based criteria were compared to the number of positive results in order to determine the sensitivity of risk-based screening. Due to the limitations in funding for universal screening and the need for informed consent from every parent, a retrospective literature review was chosen to determine the efficacy of a targeted screening protocol. The JHNEBP Model provided a straight forward straightforward approach to identifying the best study for this practice question and ensured that the latest research would be used to support this project (John Hopkins University & Medicine, 2020).

Review of Literature

The studies included in this literature review demonstrated a variety of information supporting the use of umbilical cord drug screening and early identification of infant's at risk of withdrawal. One study utilized a systemic literature review, ten studies utilized a cohort analysis, one utilized a comparison study, one a cross-sectional study, and three studies utilized a survey (see Appendix A). Of the sixteen studies retrieved for this review, five examined hospital practices and protocols regarding drug-screening criteria and efficacy of drug testing (Bogen et al., 2017; Miller et al., 2014; Murphy-Oikonen et al., 2010; Wexelblatt et al., 2015; Wood et al., 2017), four examined whether umbilical cord screening and meconium screening was equivalent (Colby, 2017; Colby et al., 2019; Labardee et al., 2017; Palmer et al., 2017), and four examined the prevalence of maternal substance abuse (Buchi et al., 2013; Kreshak et al., 2016; Lange et al., 2016; Schauberger et al., 2014). Of the remaining studies, two examined the maternal risk factors

associated with the highest prevalence of positive drug screenings (Son et al., 2018; Wood et al., 2014), and one study examined the effects of race on maternal targeted screening (Ellsworth et al., 2010).

Most of the studies described the problem of increased substance abuse in pregnancy and the importance of proper screening to identify infants at-risk of withdrawal. Of those studies that compared hospital protocols and policies regarding maternal and infant drug screening, researchers found that a larger percentage of hospitals performed targeted screening as opposed to universal screening. Bogen et al. (2017) found that 90% of 76 hospitals from 34 states used risk-based screening compared to 3% that used universal screening. Miller et al. (2014) found that among 31 Maryland hospitals, 48% used targeted screening compared to 45% who used universal screening. Wood et al. (2017) found that in 69 Iowa hospitals, 90% used targeted screening and 0% used universal screening. Studies described maternal risk factors associated with targeted drug screening and included criteria such as a positive history of maternal drug screening at delivery or during pregnancy, a history of substance use disorder before pregnancy, limited or no prenatal care, maternal legal involvement, prior Child Protective Services (CPS) involvement, other offspring not in custody, placental abruption, preterm labor, maternal tobacco or alcohol use, HIV positive status, HbsAg positive status, Hepatitis C positive status, history of gonorrhea or syphilis, fetal demise, precipitous delivery, intra-uterine growth restriction (IUGR), unintended delivery outside of the hospital, and acting intoxicated during office visits or on admission to the hospital (Bogen et al., 2017; Buchi et al., 2013; Colby, 2017; Ellsworth et al., 2010; Fonti et al., 2016; Miller et al., 2014; Murphy-Oikonen et al., 2010, Son et al., 2018; Wexelblatt et al., 2015, Wood et al., 2014). Although screening by risk factors can reduce cost, bias has been found to exist in how providers determine who should be screened. A study by

Ellsworth et al. (2010) identified 565 mothers that met criteria for targeted screening protocols, but only 20.7% of these women were actually screened. Of those screened appropriately, infants born to black mothers were three times more likely to be screened compared to white mothers. In assessing infants of mothers who did not meet any criteria for screening, infants of black mothers were four times more likely to be screened not having any risk factors.

Researchers found that maternal drug testing not only revealed substance use during pregnancy, but showed women were not always honest in their self-reports of substance use due to fear of discrimination and legal retribution. Risk factors alone did not always determine whether a woman would have a positive result. When studying the prevalence of substance use by pregnant women in the office setting, Kreshak et al. (2016) and Schauberger et al. (2014) found that 13-30% of women tested positive for one or more substances in urine samples. Of those samples found to be positive, marijuana and opioids had the highest prevalence. Three studies examined the difference in maternal self-reports and risk factors in comparison to universal infant drug screening results (Lange et al., 2014; Murphy-Oikonen et al., 2010; Wexelblatt et al., 2015). Lange et al. (2014) found that detection of alcohol in meconium samples was four times higher than what was admitted in maternal self-reports, Murphy-Oikonen et al. (2010) found that mothers failed to admit drug use in 27% of positive urine samples and 24% of positive meconium samples, Wexelblatt et al. (2015) found that 20% of opioid-positive urine drug screenings of infants occurred in mothers without standard risk factors.

Of the four studies that examined the equivalence of meconium drug screening to umbilical cord screening, only one study found that umbilical cord screening was not as sensitive as meconium screening. Colby (2017) studied 217 subjects and found that 45 samples had a positive result in meconium and not umbilical cord and 17 samples had a positive result in

umbilical cord and not meconium. It was determined by this study that umbilical cord had a lower sensitivity but had >90% specificity in all but one drug class. Colby et al. (2019) used a sample of 501 infants and found that umbilical cord was more sensitive to amphetamines, barbiturates, and benzodiazepines than meconium and determined that umbilical cord and meconium was discordant. Labardee et al. (2017) studied 197 specimens and found that nine oxycodone and eight opiate results were found in meconium but not detected in umbilical cord and two methamphetamine results were found in umbilical cord but not detected in meconium. This study expressed the benefit of umbilical cord collection to nursing workflow and timing of collection. Meconium may take 24 hours or more for the infant to pass and collect, while umbilical cord is available immediately after delivery. This allows an easier collection by the nurse, less chance of missing a sample and allows the sample to be sent to the laboratory sooner. Palmer et al. (2017) sampled 2072 infants and found that umbilical cord and meconium testing did not differ significantly, and umbilical cord testing was better because it decreased missed collections, increased detection of iatrogenic medications provided during labor, decreased tampering of the sample, and eliminated insufficient sample volume.

Agency Description

This project took place on the Birthplace unit of Hardin Memorial Hospital in Elizabethtown, Ky. Hardin Memorial Hospital is a 300-bed hospital in Central Kentucky that includes six labor and delivery suites, fourteen postpartum couplet rooms, a newborn nursery, and a level II NICU with seven beds (Hardin Memorial Health, 2019). The Birthplace unit, which includes all these areas, is the ninth busiest newborn delivery unit in Kentucky and includes over 1,600 annual live births. The population of this study was all infants born between

September 1, 2015 and September 1, 2016 at Hardin Memorial Hospital who underwent umbilical cord drug screening as a result of a targeted drug screening policy.

"The mission of Hardin Memorial Health is to exceed the physical, emotional, and spiritual needs of our patients, their families, our physicians, and our staff through the delivery of high-quality, comprehensive care to the people and communities we serve" (Hardin Memorial Health, 2019, para. 4). The vision of this organization is to be the leading choice of residents who live within the community as a result of relentless quality improvement. Hardin Memorial Hospital values the ability to succeed in this mission as well as be guided by this vision as a way to achieve respect, integrity, collaboration, excellence, and stewardship (Hardin Memorial Health, 2019). This DNP project supported the mission and vision of the organization by seeking to improve patient outcomes and quality of care in the newborn. With the only level II NICU in Central Kentucky, the main objective of this project was to assess the efficacy of a current targeted drug screening policy in order to better identify those infants who may be at-risk of NAS.

The key stakeholders included the national, state, and local governments, behavioral health professionals, hospital social workers, child protective services (CPS), OB/GYNs, pediatricians, neonatologists, nurses, laboratories, and leadership. Government agencies use the project data to update information on NAS prevalence and recommendations for screening across the United States. Behavioral health professionals and social workers at the hospital offer resources and treatment to the mother. The social workers and CPS work together on each case where there is a positive screening result to assess the need for custody changes, home visits, or follow-up after discharge. OB/GYNs, pediatricians, neonatologists, and nurses are stakeholders related to their direct care of these patients. OB/GYNs provide information on maternal risk

factors and are updated on any positive results found so that they can provide appropriate care to the mother. Neonatologists and pediatricians screen, treat, and follow up with these infants. The laboratories are kept up to date on the timing and specificity and sensitivity of the results. Lastly, the project findings inform leadership about the need for permanent policy changes as well as to share this research with other delivery hospitals in order to provide recommendations for infant screening.

The largest facilitator to the implementation of this project was the ease of access to the data, since this was a medical record review. The policy that this project was evaluating was one that was already in place and was being followed by the providers and nursing staff. There was no education or training needed and no informed consent needed, only approval through the research committee within the hospital and the IRB. Another facilitator was the support from leadership, providers, and nursing staff in making this project a success and determining which targeted screening criteria was the most accurate in identifying at-risk infants.

The largest barrier to this project was availability of resources at this facility for a formal research project such as this. Although this hospital has a research committee, this often consists of quality improvement initiatives and does not include formal research where IRB approval is needed. Due to this, there were limited people within the facility who understood how the process worked or what steps were required to move forward. Many meetings had to be scheduled and questions asked from several leadership individuals to find out what was needed to advance this project forward. Another barrier to this project was the ability of IT to run the report that specifically isolated the population chosen. When having IT run the requested reports, this either included all infants born within this time period or a select number of infants that had samples missing. This created a lengthy process of reviewing every infant record over the one-

year period to make sure no data was missed. Also, drug screen results had to be scanned into the medical record during the years chosen for this review, rather than being uploaded electronically, so some of the results were not readily available. Until the time when the result was automatically loaded into the medical record, many of the drug screening results had to be found through the umbilical cord drug screening laboratory.

Project Design

This project was a cross-sectional medical record review. This study involved collecting data on all infants born between September 1st, 2015 and September 1st, 2016 who met criteria for umbilical cord drug screening based on targeted screening criteria. This criteria included the following maternal risk factors: history of or current drug use, minimal prenatal care, precipitous labor, severe mood swings, unexplained sores on skin, abruptio placentae, inappropriate behavior, myocardial infarction, poor dentition, unexplained fetal demise, cerebrovascular accidents, late prenatal care, no prenatal care, repeated spontaneous abortions, or unexplained severe hypertension. These criteria also included the following infant risk factors: myocardial infarction in a healthy term newborn, urogenital anomalies, abnormal neurological behaviors, necrotizing enterocolitis in a healthy term newborn, cardiovascular accident in a healthy term newborn, or unexplained intrauterine growth restriction (IUGR), pediatrician (MD) order, preterm less than 36 weeks, and a prior history with CPS (see Appendix B). The following demographics were collected on each infant: gender, race/ethnicity, age of mother, and gestation at birth. The following admission, assessment, and discharge information was collected on each infant: need for NICU admission for NAS treatment with morphine therapy, average Finnegan score, highest Finnegan score, and length of stay. The following outcomes were measured for each infant: individual targeted screening criteria met for mother, individual targeted screening

met for infant, and the result of the drug screen (see Appendix C). Nominal data included the gender of the infant, the race of the infant, the infant and maternal drug screening criteria met, the result of the drug screening, and whether the infant was admitted to the NICU for treatment. Ordinal data included the gestation of the infant, length of stay, the highest Finnegan score, and the average Finnegan score. Interval data included the age of the mother. The population was found by having IT run a report on all infants born between these dates that had Finnegan scoring performed as well as all infants born within these dates that had an umbilical cord sent for drug screening. Data for this study was accessed using the electronic health record (EHR). Data analysis was quantitative and included frequency distributions for nominal data, and the means, standard deviations, and ranges for continuous variables. SPSS analysis was used to run a two-sample t-test to determine the significance of Finnegan scoring, and sensitivity and specificity was used to compare the number of positive and negative results to each risk factor.

Project Methods

The method used for this study was a retrospective cross-sectional design that compared umbilical cord drug screening rates and results to risk factors associated with targeted drug screening criteria in order to determine which risk factors were the best predictor of a positive umbilical cord drug screening result. In order to measure this, the sensitivity and specificity were calculated for each of the risk factors (Table 3). In addition, the average and highest Finnegan scores were compared using a two-sample t-test to assess whether the difference in scores were significant when comparing those of a positive drug screen to those of a negative drug screen (Table 4). The mean, median, standard deviation, and ranges were collected for all continuous variables and the frequency and percentages were collected for each nominal variable (Tables 1 and 2).

Procedures

IRB Approval

An IRB application was submitted to the University of Kentucky's IRB as well as Baptist Health Lexington's IRB. Baptist Health Lexington is the IRB required for studies taking place at Hardin Memorial Hospital. Both applications were approved in September 2019.

Sample

The sample size included 340 infants that met criteria for drug screening for one or more reasons listed in Appendix B. The positivity report listed in Table 5 shows that 341 umbilical cords were tested during the chosen timeframe, but only 340 infants were used for the sample size after performing the medical record review. The sample included all infants born between September 1st, 2015 to September 1st, 2016 who underwent umbilical cord drug screening as a result of the targeted drug screening policy. Infants born prior to September 1st, 2015 and after September 1st, 2016 and those infants that did not meet umbilical cord drug screening criteria were excluded from this study.

Measures and Instruments

A medical record review was performed to collect the data on the sample and all information was found in the electronic health records of the infants. The nominal data collected included the gender of each infant, the race of each infant, whether the infant was admitted to the NICU for NAS treatment (i.e. morphine therapy), the results of the drug screening and whether the infant did or did not meet criteria for the following risk factors: history of drug use, minimal prenatal care, late prenatal care, no prenatal care, precipitous labor, severe mood swings, unexplained sores on skin, abruptio placentae, inappropriate behavior, myocardial infarction, poor dentition, unexplained fetal demise, cerebrovascular accident, repeated spontaneous

abortions, unexplained severe hypertension, myocardial infarction in healthy term newborn, urogenital anomalies, abnormal neuro behaviors, necrotizing enterocolitis in healthy term newborn, cardiovascular accident in health term newborn, unexplained intrauterine growth restriction (IUGR), preterm less than 36 weeks, previous history of CPS, and pediatrician (MD) order. The continuous variables measured were maternal age, gestation of the infant at birth, length of hospital stay, highest Finnegan score, and average Finnegan score (Appendix C).

Implementation

In order to implement this project, a medical record review was performed. Since this project was a retrospective study that included a medical record review only, a waiver of informed consent was approved by the IRB.

Results

The average maternal age for the 340 infants chosen for this project was 26 years old (SD = 5.71) and the average gestation at birth was 38.1 weeks (SD = 2.60). The mean for the average Finnegan score was 1.2 (SD = 1.39) and the mean for the highest Finnegan score was 3.5 (SD = 3.23). The average length of stay for infants was 3.79 days (SD = 5.55), and the median number of days was 2 days (Table 1). The difference between the mean and median for length of stay is inconsistent with short stays for most infants, with longer stays for a small subset. If an infant was preterm or required morphine therapy in the NICU, the length of stay was as high as 50 days. The median was chosen to provide a better reflection of the number of days most infants stayed in the hospital, as a least half of the infants stayed for two or fewer days.

The sample had a total of 164 (48.2%) males and 176 (51.8%) females. There was a total of 263 (77.6%) Caucasian infants, 55 (16.2%) African American infants, 15 (4.4%) Hispanic infants, 1 (0.3%) Native American infant, and 5 (1.5%) infants listed as “other”. Of the 340

infants in the sample, seven (2.1%) required morphine therapy for withdrawal treatment and were admitted to the NICU. When treating infants with morphine in the NICU for high Finnegan scores, the infant or mother must have tested positive for opiates. Out of the 341 umbilical cord samples reported in the positivity report, 40 (11.7%) were positive for opiates (Table 5). When considering that only opiate withdrawal infants received morphine therapy for NAS symptoms, a total of 17.5% of opiate-positive infants required treatment with morphine.

A total of 77 (22.6%) infants tested positive for the following substances: amphetamines, cocaine, opiates, cannabinoids, methadone, and benzodiazepines (Table 5). The maternal and infant risk factors used to drug screen all infants at this facility (Appendix B) showed 113 (33.2%) mothers had a history of drug use (Table 2). Nearly 28% of the mothers had either minimal, late, or no prenatal care prior to delivery. Precipitous labor, placental abruption, and recurrent spontaneous abortions were noted criteria in 18.8% of the births. Inappropriate behavior or severe mood swings were identified as screening criteria in 5.6% of those who were tested. One in ten had poor maternal dentition or unexplained sores on the skin as criteria for screening. Infant findings were listed as criteria in 8.8% of those who were tested. Five percent of infants were drug screened based on a pediatrician or neonatologist order. Several of the criteria used for targeted screening were not found with any of those who were screened. Those risk factors not identified were maternal myocardial infarction, unexplained fetal demise, maternal cerebrovascular accident, unexplained severe maternal hypertension, myocardial infarction in a healthy term newborn, necrotizing enterocolitis in a healthy term newborn, and cerebrovascular accident in a healthy term newborn.

Based on the number of risk factors found in the medical record, 16 (4.7%) infants had no risk factors, 275 (80.9%) infants had one risk factor, 43 (12.6%) had two identified risk factors,

and 6 (1.8%) infants had three risk factors present. A total of 291 (85.6%) infants had zero to one risk factors and 49 (14.4%) infants had more than one risk factor.

Two-sample t-tests were used to compare the average Finnegan scores and the highest Finnegan scores between those infants that tested positive and those that tested negative (Table 4). The mean average Finnegan score for those infants that tested positive was 1.5 and the mean average Finnegan score for those that tested negative was 1.1. Based on the two-sample t-test performed, it was found that the difference in these averages was statistically significant. The mean highest Finnegan score for those infants that tested positive was 4.46 and the mean highest Finnegan score for those that tested negative was 3.22. Based on the two-sample t-test performed, it was found that the difference in the highest Finnegan scores was statistically significant (Table 4).

In the context of risk factor assessment, sensitivity is the percentage of women with a positive drug screen who were also positive for the corresponding risk factor. On the other hand, specificity is the percent of those with a negative drug screen who were also negative for the presence of the given risk factor. The risk factor with the highest sensitivity was maternal history of drug use, with a sensitivity of 51.9 (specificity 72.7) (Table 3). Minimal prenatal care had a sensitivity of 14.3 (specificity 85.9), late prenatal care had a sensitivity of 13.0 (specificity 87.8), precipitous labor had a sensitivity of 10.4 (specificity 90.8), poor dentition had a sensitivity of 10.4 (specificity 89.4), and the remaining risk factors had sensitivities of less than 10%. The highest specificity was 100, which was found with cardiovascular accident in the mother and healthy term newborn, necrotizing enterocolitis in healthy term newborn, myocardial infarction in the mother and healthy term newborn, unexplained fetal demise, and maternal cerebrovascular accident; the sensitivity for all these risk factors was zero, as none of the mothers had any of

these risk factors. Given the number of possible risk factors, it was also considered that those infants with positive drug screens were more likely to have more than one risk factor. The sensitivity of having more than one risk factor was 20.8 and the specificity was 87.5 (Table 3).

Discussion

The sensitivity of a screening test is the ability of a test to detect a true positive. It is the probability that someone with a positive drug screen will be flagged as high-risk using a given risk factor. When a test has a high sensitivity, there are very few false negative results (Maxim, Niebo, & Utell, 2014). The specificity of a screening test is the ability of a test to detect a true negative. It is the probability that those infants not exposed to drugs in utero will be negative on the identified risk factor as well. When a test has a high specificity, there are very few false positive results (Maxim et al., 2014). The best test would be one with 100% sensitivity and specificity because this would result in no error in the outcome, but this is not achievable in practice. Therefore, the most desirable test is one that has both high sensitivity and high specificity (Maxim et al., 2014).

When considering the risk factors used to screen infants for NAS, the highest sensitivity was 51.9% for history of drug use. Using the presence of having two or more risk factors as an evaluation tool was associated with only 20.8% sensitivity. The remainder of the risk factors were less than 15% sensitive. This sensitivity is far from 100% and is very low, which means there is a much higher risk of false negatives. In this context, a false negative would be a participant who had a positive drug screen but who was not positive for a given risk factor. The values for the specificities were much higher, with 20 out of the 24 risk factors being above 90%. Infants with multiple risk factors had a specificity of 87.5%. The lowest specificity was 72.7% for history of drug use, which means there is a relatively low risk of false positives with all of

these risk factors. A false positive in this study would have occurred if a participant had a negative drug screen but was positive for a particular risk factor.

In using these data to identify whether risk factors are effective in evaluating risk of withdrawal, none of the risk factors were very sensitive in indicating positive drug screening results. In order to truly assess the number of positive results that are being missed, universal screening would have to be performed and compared between those who met risk factor screening and those who did not. Although it is more expensive to test every infant, it would allow a better determination of whether risk factors are efficient in finding all those infants at risk of NAS. It would also identify those risk factors most strongly linked to NAS outcomes.

Another comparison considered differences in Finnegan scores between positive drug screening and negative drug screening. The Finnegan scoring tool is the most commonly used scoring system for evaluating infants with NAS (Pomar et al., 2017). Developed in 1975, it consists of 21 scored items or symptoms involving the central nervous system, the autonomic nervous system, and the gastrointestinal system. Higher scores are consistent with NAS (Appendix D). The recommendation for practice with the Finnegan tool is to consider further monitoring and initiation of pharmacological treatment if the infant has three consecutive scores of eight or more or two consecutive scores of 12 or more (Pomar et al., 2017).

While performing the medical record review, it was noted that many infants with negative drug screens had high Finnegan scores. This could have been due to the infant withdrawing from other medications not tested on the 9-panel drug screen ordered for these screenings or it may have been due to the subjective nature of Finnegan scoring and the various people scoring the infant throughout the hospitalization. In performing a two-sample t-test on the average Finnegan scores and the highest Finnegan scores, it was found that the average Finnegan

score and highest Finnegan scores were significantly higher for the positive result group relative to those whose drug screens were negative. This suggests that, on average, there is a significant association between Finnegan scoring and drug screen results, even though some in the negative group had relatively high scores and some in the positive group had relatively low ones.

Implications for Practice, Education, Policy, and Future Research

This project was started with advocating for universal drug screening. Due to the cost associated with screening all infants, the first step was proving that risk-based screening is not effective. By assessing the sensitivity and specificity of each risk factor, it was shown that these criteria are not very effective at determining those infants at risk of NAS. As stated in the literature review, risk-based screening may be based on bias or judgment and mothers are not always honest in their history (Terplan and Minkoff, 2017). This leads to infants being discharged without being screened for withdrawal symptoms, where they may reach the peak of withdrawal at home. By providing universal screening, there is a standardized process and no infant is missed and sent home without help.

Another area for improvement with NAS is increasing the hospital length of stay. Although infant's met criteria for drug screening and the umbilical cord samples had not yet resulted, most infants were discharged after two days of birth. Most substances have a withdrawal onset of 24-72 hours and a total duration in the body of 2-30 days (Kocherlakota, 2014). It is important to keep infants for the most appropriate amount of time to properly assess their readiness for discharge. While performing the medical record review, there were many infants that had high Finnegan scores throughout the hospital stay and were still discharged at two days of life. In a management plan recommended by Kocherlakota (2014), Finnegan scoring should begin within 24 hours of birth and occur every 3-4 hours. If scores remain consistently at

or below eight, the infant should continue to be observed for 3-5 more days before being discharged.

The current policy at this facility states that infants who are exposed to opiates should be monitored for 4-5 days for signs of withdrawal. The hospital cost per day at this facility is $1054.00 for those infants outside of the NICU. With 252 infants being discharged at or before 2 days of life (n=340), this would have resulted in an increase in cost of $265,608 - $796,824 if the length of stay was extended to 3-5 days. Although this would result in an increase in healthcare costs at this facility, this would decrease infant withdrawal at home and would allow social services to get involved before an infant is discharged home with a parent that tested positive for a substance. Not only would this prevent the negative physical effects of withdrawal but would also prevent the infant from discharging home to an environment that could place the infant in additional harm. If an infant presents to the hospital after discharge with severe NAS or nonaccidental trauma due to the social environment, this would result in an increase in healthcare costs overall as well as negative long term outcomes for the child. Since the umbilical cord processing time can take 3-6 days after birth, it is important to consider each infant's Finnegan scores and the substances in which he or she is withdrawing from before deciding on a discharge date.

The future of this research involves replicating this study at other facilities with other risk factors to see if other criteria might be a better predictor of a positive drug screening. Each facility differs in their criteria, and there might be better efficacy with other risk factors. The current policy at this facility no longer includes infants less than 36 weeks and never included an MD order or previous history with CPS, although this was noted in some of the medical records. The sensitivity of preterm infants and MD order was 0% while history of CPS was 2.6%.

Perhaps preterm infants should not automatically be screened, and the MD should communicate other criteria for screening before placing this order. A previous history with CPS was found to be a risk factor at other facilities when performing the literature review and, although it was not very sensitive in this study, CPS often asks for a drug screening when reviewing these cases. This might be a risk factor that this facility should consider adding. If other facilities can replicate this research and find that their criteria are not very sensitive or specific, then universal screening may be the next step.

The future of this research is to compare universal screening to risk-based screening in order to determine how many infants are missed with risk-based screening alone. Although this would result in higher drug screening costs, all infants would be screened and scored for NAS in order to assess for signs of withdrawal and to provide treatment when necessary. By standardizing the approach to infant drug screening, no infants at risk of NAS would be missed. This would allow researchers to prove which type of screening is more effective and hospitals could begin to either standardize the risk criteria used or could begin providing universal screening.

Limitations

One limitation of this study is the small sample size. Some risk criteria were not experienced by any participants in the study; a larger sample size would allow a better quantification of the sensitivity and specificity of each risk factor. In addition, not all risk factors were noted in the medical records of each infant. If a drug screening was performed after the infant was born, this was often not noted in the chart as to why. Without documentation of why an umbilical cord was sent for testing, there is no way to measure how effective the result was. During the time frame chosen for this review, the hospital also utilized a 9-panel umbilical cord

drug screening compared to the 13-panel drug screening used now. This could have resulted in negative drug screening results for those infants that were actually positive for these additional substances (oxycodone, meperidine, tramadol, and buprenorphine). Although the same infants would have been tested based on the risk factors associated, this might have resulted in more positive drug screenings. Some infants had multiple risk factors chosen, while others did not. Another limitation is not knowing whether more than one risk factor was not chosen because the infant did not have more than one risk factor or because only one option was chosen to trigger the infant drug screening.

One of the greatest limitations to this study was the lack of funding to support universal drug screening of all infants. Universal drug screening was supported by the pediatric and leadership team of the department, but the resources were not available to support this increase in drug screening cost. At this facility, the cost of a 13-panel umbilical cord drug screening is $177.00. This cost is not billed to the patient, but is paid for by the hospital because this testing is performed at another laboratory outside of the hospital's network. With a hospital average of 1600 live births a year, this would result in over 1200 additional umbilical cord drug screenings. The increase in this cost would be over $220,000. In order to properly identify all those potential NAS infants that are being missed by risk-based screening, universal screening would need to be implemented and compared to risk-based screening. Without the resources to fund this project, there is no data to support the need for universal screening or the evidence to prove that it is more efficient in finding all infants at risk of NAS.

Conclusion

Early identification of infants at greatest risk of NAS can help determine those who would benefit from early intervention/treatment. The main goal of this project was to determine

if risk-based screening was efficient in determining a positive drug screening result. Without universal screening, more sensitive and specific risk-based screening is important in determining which infants are at greatest risk and need additional monitoring to assess for signs of withdrawal. Based on the statistical analysis, the risk factors associated with this project were not sensitive in finding positive infants. Maternal history of drug use was the only risk factor that had a high enough sensitivity to suggest significance. In order to be more efficient at scoring and monitoring infants with NAS, there must be a better process in place for identifying those that are at greatest risk. With more research on risk-based screening and more resources available to implement and study universal screening, there will continue to be advancements in identifying infants with NAS. With such significant side effects associated with withdrawal, it is important that this research continue and that infants be protected from suffering. In addition, understanding and identifying substance use in pregnancy can also provide more resources to the mother for help and sobriety. NAS involves family-centered care for both the infant and the mother, and proper screening is the first step in helping them in their journey to recovery.

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Appendix A – Literature Review

Type of Study	Number of Studies	Authors
Systemic Literature Review	1	Lange, Shield, Koren, Rehm, & Popova, 2014
Cohort Analysis	10	Colby, 2017; Colby, Adams, Morad, Presley, & Patrick, 2019; Ellsworth, Stevens, & D'Angio, 2010; Kreshak et al., 2016; Murphy-Oikonen, Montelpare, Southon, Bertoldo, & Persichino, 2010; Palmer, Wood, & Krasowski, 2017; Schauberger, Newbury, Colburn, & Al-Hamadani, 2014; Son, Guiahi, Heyborne, 2018; Wexelblatt et al., 2015; Wood et al., 2014
Comparison Study	1	Labardee et al., 2017
Cross-sectional Study	1	Buchi, Suarez, & Varner, 2013
Survey	3	Bogen, Whalen, Kair, Vining, & King, 2017; Miller, Lanham, Welsh, Ramanadhan, & Terplan, 2014; Wood, Smith, & Krasowski, 2017

Appendix B – Drug Screening Criteria

Targeted Drug Screening Criteria at Hardin Memorial Hospital	
Maternal Considerations	Infant Considerations
History or Current Drug Abuse	Myocardial Infarction in Healthy Term Newborn
Minimal Prenatal Care	Urogenital Anomalies
Precipitous Labor	Abnormal Neuro Behaviors
Severe Mood Swings	Necrotizing Enterocolitis in Healthy Term Newborn
Unexplained Sores on Skin	Cardiovascular Accident in Healthy Term Newborn
Abruptio Placentae	Unexplained Intrauterine Growth Restriction (IUGR)
Inappropriate Behavior	Preterm Less than 36 Weeks
Myocardial Infarction	Pediatrician (MD) order
Poor Dentition	
Unexplained Fetal Demise	
Cerebrovascular Accidents	
Late Prenatal Care	
No Prenatal Care	
Repeated Spontaneous Abortions	
Unexplained Severe Hypertension	

Appendix C – Data Collection

Measures	Description	Level of Measurement	Data Source
Demographics			
Gender of Infant	Male vs Female	Nominal	Electronic Health Records
Race/Ethnicity of Infant	Caucasian, African American, Hispanic, Native American, Other	Nominal/Categorical	Electronic Health Records
Maternal Age	Age in years	Interval/Ratio	Electronic Health Records
Gestation	Gestation by weeks	Ordinal	Electronic Health Records
Admission, Assessment, and Discharge Information			
Need for NICU admission	Was infant admitted to the NICU for NAS treatment (i.e. morphine therapy)?	Nominal	Electronic Health Records
Finnegan Score	Highest Finnegan Score	Ordinal	Electronic Health Records
Finnegan Score	Average Finnegan Score	Ordinal	Electronic Health Records
Length of Stay for Infants	Average Length of Stay in Days	Ordinal	Electronic Health Records
Outcomes			
History of Drug Use	Yes/No	Nominal	Electronic Health Records
Minimal Prenatal Care	Yes/No	Nominal	Electronic Health Records
Late Prenatal Care	Yes/No	Nominal	Electronic Health Records
No Prenatal Care	Yes/No	Nominal	Electronic Health Records
Precipitous Labor	Yes/No	Nominal	Electronic Health Records
Severe Mood Swings	Yes/No	Nominal	Electronic Health Records
Unexplained Sores on Skin	Yes/No	Nominal	Electronic Health Records
Abruptio Placentae	Yes/No	Nominal	Electronic Health Records
Inappropriate Behavior	Yes/No	Nominal	Electronic Health Records
Myocardial Infarction	Yes/No	Nominal	Electronic Health Records
Poor Dentition	Yes/No	Nominal	Electronic Health Records
Unexplained Fetal Demise	Yes/No	Nominal	Electronic Health Records

Cerebrovascular Accident	Yes/No	Nominal	Electronic Health Records
Repeated Spontaneous Abortions	Yes/No	Nominal	Electronic Health Records
Unexplained Severe Hypertension	Yes/No	Nominal	Electronic Health Records
Myocardial Infarction in Healthy Term Newborn	Yes/No	Nominal	Electronic Health Records
Urogenital Anomalies	Yes/No	Nominal	Electronic Health Records
Abnormal Neuro Behaviors	Yes/No	Nominal	Electronic Health Records
Necrotizing Enterocolitis in Healthy Term Newborn	Yes/No	Nominal	Electronic Health Records
Cardiovascular Accident in Healthy Term Newborn	Yes/No	Nominal	Electronic Health Records
Unexplained Intrauterine Growth Restriction (IUGR)	Yes/No	Nominal	Electronic Health Records
Preterm Less than 36 Weeks	Yes/No	Nominal	Electronic Health Records
Previous History with CPS	Yes/No	Nominal	Electronic Health Records
Pediatrician (MD) Order	Yes/No	Nominal	Electronic Health Records
Result of Drug Screen	Positive/Negative	Nominal	Electronic Health Record

Appendix D – Finnegan Scoring

NEONATAL ABSTINENCE SCORING SYSTEM

SYSTEM	SIGNS AND SYMPTOMS	SCORE	AM						PM						COMMENTS
CENTRAL NERVOUS SYSTEM DISTURBANCES	Continuous High Pitched (or other) Cry	2													Daily Weight:
	Continuous High Pitched (or other) Cry	3													
	Sleeps <1 Hour After Feeding	3													
	Sleeps <2 Hours After Feeding	2													
	Sleeps <3 Hours After Feeding	1													
	Hyperactive Moro Reflex	2													
	Markedly Hyperactive Moro Reflex	3													
	Mild Tremors Disturbed	1													
	Moderate-Severe Tremors Disturbed	2													
	Mild Tremors Undisturbed	3													
	Moderate-Severe Tremors Undisturbed	4													
	Increased Muscle Tone	2													
	Excoriation (Specific Area)	1													
	Myoclonic Jerks	3													
	Generalized Convulsions	5													
METABOLIC/VASOMOTOR/RESPIRATORY DISTURBANCES	Sweating	1													
	Fever 100.4°-101°F (38°-38.3°C)	1													
	Fever > 101°F (38.3°C)	2													
	Frequent Yawning (>3-4 times/interval)	1													
	Mottling	1													
	Nasal Stuffiness	1													
	Sneezing (>3-4 times/interval)	1													
	Nasal Flaring	2													
	Respiratory Rate >60/min	1													
	Respiratory Rate > 60/min with Retractions	2													
GASTRO-INTESTIONAL DISTURBANCES	Excessive Sucking	1													
	Poor Feeding	2													
	Regurgitation	2													
	Projectile Vomiting	3													
	Loose Stools	2													
	Watery Stools	3													
TOTAL SCORE															
INITIALS OF SCORER															

Hudak et al. (2012)

Table 1. Means, medians, standard deviations and ranges for selected continuous variables: (N =340).

Variable	Mean	Median	Standard Deviation	Actual Range
Maternal Age	26.07	25.00	5.71	15 – 44
Gestation at Birth	38.14	39.00	2.60	20.1 – 42.0
Average Finnegan Score	1.20	0.75	1.39	0 – 9.43
Highest Finnegan Score	3.50	3.00	3.23	0 – 17
Length of Hospital Stay	3.79	2.00	5.55	0 – 50

Table 2. Frequency distributions for selected categorical variables (N=340)

Variable	Frequency	Percent (%)
Gender		
Male	164	48.2
Female	176	51.8
Race		
Caucasian	263	77.6
African American	55	16.2
Hispanic	15	4.4
Native American	1	0.3
Other	5	1.5
Need for NICU Admission for NAS Treatment?		
Yes	7	2.1
No	333	97.9
Result of Drug Screen		
Positive	77	22.6
Negative	263	77.4
History of Drug Use		
Yes	113	33.2
No	227	66.8
Minimal Prenatal Care		
Yes	48	14.1
No	292	85.9
Late Prenatal Care		
Yes	42	12.4
No	298	87.6
No Prenatal Care		
Yes	4	1.2
No	336	98.8
Precipitous Labor		
Yes	32	9.4
No	307	90.6
Severe Mood Swings		
Yes	2	0.6
No	338	99.4
Unexplained Sores on Skin		
Yes	7	2.1
No	333	97.9
Abruptio Placentae		
Yes	9	2.6
No	331	97.4
Inappropriate Behavior		
Yes	17	5.0
No	323	95.0
Myocardial Infarction in Mother		
Yes	0	0
No	340	100.0
Poor Dentition		
Yes	36	10.6
No	304	89.4

Unexplained Fetal Demise		
Yes	0	0
No	340	100.0
Cerebrovascular Accident in Mother		
Yes	0	0
No	340	100.0
Repeated Spontaneous Abortions		
Yes	23	6.8
No	317	93.2
Unexplained Severe Hypertension		
Yes	0	0
No	340	100.0
Myocardial Infarction in Healthy Term Newborn		
Yes	0	0
No	340	100.0
Urogenital Anomalies		
Yes	1	0.3
No	339	99.7
Abnormal Neuro Behaviors		
Yes	11	3.2
No	329	96.8
Necrotizing Enterocolitis in Health Term Newborn		
Yes	0	0
No	340	100.0
Cerebrovascular Accident in Healthy Term Newborn		
Yes	0	0
No	340	100.0
Unexplained Intrauterine Growth Restriction		
Yes	7	2.1
No	332	97.6
Preterm Less than 36 Weeks		
Yes	4	1.2
No	336	98.8
Pediatrician (MD) Order		
Yes	16	4.7
No	324	95.3
Number of Risk Factors		
0	16	4.7
1	275	80.9
2	43	12.6
3	6	1.8
Multiple Risk Factors		
0-1	291	85.6
>1	49	14.4

Table 3. Sensitivity and specificity for each risk factor relative to outcome of postnatal drug screen (N = 340).

Risk Factor in Mother	Sensitivity (%)	Specificity (%)
History of drug use	51.9	72.7
Minimal Prenatal Care	14.3	85.9
Late Prenatal Care	13.0	87.8
No Prenatal Care	2.6	99.2
Precipitous Labor	10.4	90.8
Severe Mood Swings	1.3	99.6
Unexplained Sores on Skin	0	97.3
Abruptio Placentae	1.3	97.0
Inappropriate Behavior	2.6	94.3
Myocardial Infarction in Mother	0	100.0
Poor Dentition	10.4	89.4
Unexplained Fetal Demise	0	100.0
Cerebrovascular Accident in Mother	0	100.0
Repeated Spontaneous Abortions	5.2	92.8
Unexplained Severe Hypertension	0	100.0

Risk Factor in Infant	Sensitivity (%)	Specificity (%)
Myocardial Infarction in Healthy Term Newborn	0	100.0
Urogenital Anomalies	0	99.6
Abnormal Neuro Behaviors	1.3	96.2
Necrotizing Enterocolitis in Health Term Newborn	0	100.0
Cardiovascular Accident in Healthy Term Newborn	0	100.0
Unexplained Intrauterine Growth Restriction	1.3	97.7
Preterm Less Than 36 Weeks	0.0	98.5
Previous History with CPS	2.6	98.1
Pediatrician (MD) Order	0.0	93.9

Multiple Risk Factors in Mother and/or Infant	Sensitivity (%)	Specificity (%)
>1 Risk Factors	20.8	87.5

Table 4. Comparison of Average and Highest Finnegan Scores for Positive and Negative Drug Screening Results

	Mean	Standard Deviation	|t|	p	Significant?
Average Finnegan Score					
Negative Result	1.1	1.27	2.0	.049	Yes
Positive Result	1.5	1.70			
Highest Finnegan Score					
Negative Result	3.22	2.94	2.6	.012	Yes
Positive Result	4.46	3.93			

Table 5. Positivity report for umbilical cord drug screenings performed from 9/1/15 – 9/1/16.

POSITIVITY REPORT - UMBILICAL CORD

Report Date Range 9/1/2015 - 9/1/2016

Hardin Memorial Hospital

	TOTAL	POSITIVE	% POSITIVE
AMPHETAMINES	341	5	1.5
Amphetamine		5	1.5
Methamphetamine		3	.9
MDA		0	.0
MDMA		0	.0
MDEA		0	.0
COCAINES	341	3	.9
OPIATES	341	40	11.7
Morphine		31	9.1
Hydromorphone		4	1.2
Codeine		2	.6
6-MAM		0	.0
Hydrocodone		10	2.9
Meconin		0	.0
PHENCYCLIDINE	341	0	.0
CANNABINOIDS	341	33	9.7
BARBITURATES	341	0	.0
Butalbital		0	.0
Amobarbital		0	.0
Pentobarbital		0	.0
Secobarbital		0	.0
Phenobarbital		0	.0
METHADONE	341	3	.9
Methadone		3	.9
EDDP		3	.9

	TOTAL	POSITIVE	% POSITIVE
BENZODIAZEPINE	341	1	.3
Midazolam		0	.0
Oxazepam		0	.0
Alprazolam		1	.3
Temazepam		0	.0
Nordiazepam		0	.0
Diazepam		0	.0
PROPOXYPHENE	341	0	.0
Propoxyphene		0	.0
Norpropoxyphene		0	.0
OXYCODONE	8	0	.0
Oxymorphone		0	.0
Oxycodone		0	.0
MEPERIDINE	8	0	.0
Meperidine		0	.0
Normeperidine		0	.0
TRAMADOL	8	0	.0
BUPRENORPHINE	0	0	.0
Buprenorphine		0	.0
Norbuprenorphine		0	.0
ETHYL GLUCURONIDE	0	0	.0
COTININE	0	0	.0