

Shaken Baby Syndrome and a Triple-Dose Strategy for Its Prevention

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Objectives: Inflicted traumatic brain injury associated with Shaken Baby Syndrome (SBS) is a leading cause of injury mortality and morbidity in infants. A triple-dose SBS prevention program was implemented with the aim to reduce the incidence of SBS. The objectives of this study were to describe the epidemiology of SBS, the triple-dose prevention program, and its evaluation.

Methods: Descriptive and spatial epidemiologic profiles of SBS cases treated at Children's Hospital, London Health Sciences Centre, from 1991 to 2010 were created. Dose 1 (in-hospital education): pre-post impact evaluation of registered nurse training, with a questionnaire developed to assess parents' satisfaction with the program. Dose 2 (public health home visits): process evaluation of additional education given to new parents. Dose 3 (media campaign): a questionnaire developed to rate the importance of factors on a 7-point Likert scale. These factors were used to create weights for statistical modeling and mapping within a geographic information system to target prevention ads.

Results: Forty-three percent of severe infant injuries were intentional. A total of 54 SBS cases were identified. The mean age was 6.7 months (standard deviation, 10.9 months), with 61% of infant males. The mean Injury Severity Score was 26.3 (standard deviation, 5.5) with a 19% mortality rate. Registered nurses learned new information on crying patterns and SBS, with a 47% increase in knowledge posttraining ($p < 0.001$). Over 10,000 parents were educated in-hospital, a 93% education compliance rate. Nearly all parents (93%) rated the program as useful, citing "what to do when the crying becomes frustrating" as the most important message. Only 6% of families needed to be educated during home visits. Locations of families with a new baby, high population

density, and percentage of lone parents were found to be the most important factors for selecting media sites. The spatial analysis revealed six areas needed to be targeted for ad locations.

Conclusions: SBS is a devastating intentional injury that often results in poor outcomes for the child. Implementing a triple-dose prevention program that provides education on crying patterns, coping strategies, and the dangers of shaking is key to SBS prevention. The program increased knowledge. Parents rated the program as useful. The media campaign allowed us to extend the primary prevention beyond new parents to help create a cultural change in the way crying, the primary trigger for SBS, is viewed. Targeting our intervention increased the likelihood that our message was reaching the population in greatest need.

Key Words: Shaken Baby Syndrome, Epidemiology, Evaluation, Geographic information systems.

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Shaken Baby Syndrome (SBS) is a devastating form of inflicted traumatic brain injury that occurs when a young child is violently shaken and subjected to rapid acceleration, deceleration, and rotational forces, with or without impact. This abuse results in a unique pattern of intracranial and intraocular trauma often characterized by subdural hematomas, diffuse axonal injury, and retinal hemorrhages.^{1–6} SBS is a leading cause of injury mortality and morbidity in infants. The incidence has been conservatively estimated at 25 to 31 cases per 100,000 children <1 year of age, but this does not include the less severe forms of this abuse for which medical attention is never sought.^{7,8} SBS is also one of the most devastating forms of abuse with up to 38% mortality rate.^{9–11} For survivors, their life is challenging with the lasting disability including neurologic, cognitive, developmental, and visual impairments. Nearly all survivors, whether hospitalized or in the community, will require some type of ongoing multidisciplinary care for the rest of their lives.^{12,13}

SBS can be prevented. In his seminal article on a hospital-based parental educational program on violent infant shaking, Dias et al.¹⁴ demonstrated a 47% reduction in the incidence of abusive head injuries during the study period. This comprehensive, regional program consisted of a single page of information, an 11-minute video describing the dangers of shaking a baby and a commitment statement that parents must sign committing to never shake their infant.^{14,15} The type of intervention also matters. An examination of the types of SBS prevention educational materials found varying degrees of effectiveness depending on the type of information presented and the method of delivery.¹⁶ Videos were found to

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significantly increase the likelihood of positive changes in SBS awareness over interventions which use only a brochure. In addition, video material that focused on teaching alternative behaviors had higher likelihood of increased awareness than testimonial videos.

Based on this evidence and the fact that infant crying, particularly the inconsolable distress crying unique to the first few months of life, can be a stimulus for shaking,^{17–21} the National Center on Shaken Baby Syndrome designed and produced “The Period of PURPLE Crying” (PURPLE)²² prevention materials to educate parents about normal infant crying patterns and why inconsolable crying can be frustrating. The program uses positive messages for parents rather than negative warnings about damaging consequences of shaking. PURPLE stresses infant soothing and recommends useful techniques when caring for a crying infant, especially when it becomes frustrating.^{6,15}

The developers of PURPLE recommend that it be delivered via a “triple-dose” approach consisting of in-hospital education to parents from registered nurses (RN) after birth, reinforcement from public health RN during postdelivery home visits, and finally, public education through a media campaign.^{14,15}

PURPLE was implemented at both birthing centers in London, Ontario, Canada, with the ultimate aim to reduce the incidence of SBS. The objectives of this study were to describe the epidemiology of SBS, the triple-dose prevention program, and its evaluation. Because social factors including poverty, unemployment, and low socioeconomic status have been reported as risk factors for SBS,^{23,24} we also assessed the geographical relationship between parental stress and SBS by undertaking a spatial analysis of our London SBS cases. It was our hypothesis that the incidence of SBS would be higher in geographic areas with higher proportions of households experiencing some form of socioeconomic distress.

METHODS

Epidemiology

A descriptive epidemiologic profile of SBS cases treated at Children’s Hospital, London Health Sciences Centre (LHSC), from 1991 to 2010 was created. LHSC is the regional trauma center and only Children’s Hospital in Southwestern Ontario. As such, the majority of severe SBS cases from the region would have been treated there and therefore included in this study, as the provincial standard is to transfer these cases to our center for evaluation. The SBS cases were collected prospectively through our trauma database. All cases were identified based on a combination of clinical findings, article medical records, and electronic imaging data and resulted in severe injuries with Injury Severity Score ≥ 12 . Less severe SBS cases were not included in this review. If the intent of injury was questionable on arrival to our trauma center, the case was followed until a conclusion was reached by the child abuse medical team. Children who died of SBS en route or at a referring hospital were excluded from these analyses, because their data were not available from the

coroner’s office. Descriptive statistics were calculated using PASW Statistics, version 18 (SPSS, Chicago, IL).

To test our hypothesis regarding a potential relationship between higher prevalence of SBS cases and socioeconomic distress, a geographic information system (GIS; ArcGIS 10.0, Environmental Systems Research Institute) was used to map every case according to the infant’s address, and then we compared the spatial patterning of SBS cases in relation to socioeconomic distress levels of each neighborhood. Census tract (CT) boundaries were used as proxies for neighborhood, and socioeconomic data on each CT were gathered from the 2006 Census of Canada. The year 2006 was chosen as it is the latest available Census data. Although individual households may turnover, the overall socioeconomic characteristics of neighborhoods remain relatively stable from census to census. Variables of interest included median household income, proportion of adults (aged ≥ 20 years) unemployed, and proportion of households headed by lone parents.

Intervention Materials

“PURPLE” is an acronym that represents the characteristics of infant crying in the first few months of life (Fig. 1). The PURPLE materials consist of an 11-page booklet and 12-minute DVD, both of which are available in eight different languages.¹⁵ PURPLE is a primary prevention program focused on educating parents about normal infant development, specifically, about crying patterns, which when frustrating can be the trigger for shaking. SBS and abusive head trauma are the most common causes of mortality and morbidity because of physical child abuse.¹⁵ Although this program may have the potential to affect the occurrence of repeated child abuse of other forms, it was not the focus of the PURPLE materials. Also, because the education is given to all new parents after the birth of their baby, and not targeted, there is no postintervention component of the program, specifically for abusers.

Evaluation Methods

Dose 1—In-Hospital Education

The first dose of PURPLE consisted of RNs at our two birthing centers (LHSC and St. Joseph’s Health Centre, London, ON, Canada) giving the materials to each family. The parents watched the DVD in-hospital and at home after discharge and also shared the DVD with caregivers and family. Additional discussions occurred with the RN. The RNs were trained in delivery of the program and have been provided a script to use for the discussion.¹⁵ Our impact

P	•Peak of crying
U	•Unexpected
R	•Resists soothing
P	•Pain-like face
L	•Long lasting
E	•Evening & late afternoon

Figure 1. The definition of the acronym PURPLE in the “The Period of PURPLE Crying” educational materials.

evaluation of this first dose of the program consisted of a pre-post evaluation of RN training. RN perceptions were also assessed using 7-point Likert scales to rate satisfaction and program effectiveness. A questionnaire was developed and administered in-hospital to assess parents' satisfaction with the program.

Dose 2—Public Health Home Visits

For dose 2, the hospitals collaborated with our local health unit to have their public health RNs ask whether the parents received the PURPLE materials. If they did, the RNs would ask if they had any questions and go over the materials again. If the parents had not received the education, the RNs would deliver the program and give the parents the DVD and pamphlet. A process evaluation of additional education given to new parents was undertaken.

Dose 3—Media Campaign

A SBS media campaign on normal infant crying was undertaken in London, ON. The PURPLE “normalcy media campaign” positioned infant crying as a normal developmental stage, rather than an indication of inadequate parenting or an unhealthy child. It was previously tested extensively through focus groups and intercept interviews.²⁵ To target our media campaign, we created a qualitative and spatial method consisting of a questionnaire to rate the importance of factors on a 7-point Likert scale. These SBS and media-important factors were used to create weights for statistical modeling and mapping within a GIS to target prevention advertisements. A complete description of these methods has been described elsewhere.²⁶

RESULTS

Epidemiology

From 1991 to 2010, there were 129 severe infant injuries, 43% of these were intentional. There were a total of 54 SBS cases during this time period. The mean age of cases was 6.7 (standard deviation, 10.9) months. Overall, 85% of cases were <1 year of age, with the youngest infant 17 days old. These cases were severely injured with a mean Injury Severity Score of 26.3 (standard deviation, 5.5) and a 19% mortality rate. The median Maximum Abbreviated Injury Scale for the head was 5, signifying a critical injury, which was most often a large subdural hematoma. The median Maximum Abbreviated Injury Scale in the chest was 3, signifying a serious injury, which was multiple rib fractures in all cases. A complete descriptive and injury profile is presented in Table 1.

Figure 2 displays the location of SBS cases occurring within the urbanized area of London presenting to Children's Hospital, LHSC, from 1991 to 2010. It has been overlaid on a thematic map displaying the median household income of every developed CT in the city. Additional demographic data on the parents or family of the SBS victim, including age of the parents, marital status, number of siblings, employment status, or social welfare status, were not collected as part of the trauma registry, because it is patient based and not family- or perpetrator based. Therefore, census data on median household income were used. Although the number of SBS

TABLE 1. Descriptive Analysis of SBS Cases at Children's Hospital, LHSC From 1991 to 2010

Element	Number	Percentage
Total SBS cases	54	100
Gender		
Male	34	63.0
Female	20	37.0
Type of admission		
Direct	35	64.8
Referred from region	19	35.2
D/C status		
Alive	44	81.5
Dead	10	18.5
ISS		
0–12	0	0
13–15	0	0
16–24	7	13.0
25–40	45	83.3
41–49	2	3.7
50–74	0	0
75	0	0
	Mean	SD
ISS		
All case	26.3	5.5
Survivors	26.3	6.0
Deaths	26.1	0.7
	Median	IQR
Maximum abbreviated injury scale		
Head	5	0
Face	1	0
Chest	3	1.25
Abdomen	2	0
Extremities	2	1
External	1	0

SD, standard deviation.

cases in the city was too small to conduct statistical analysis with any confidence in the results, it appears from a visual inspection of the map that the cases tend to be more heavily concentrated in low-income CTs. Thirteen of 16 SBS incidents (81.3%) took place in CTs which fell within the lowest two quintiles of median household income, whereas no reported cases took place in CTs in the highest income quintile. The map, therefore, suggests that there is an association between prevalence of SBS and neighborhood level socioeconomic factors such as income.

Dose 1—In-Hospital Education

RNs were trained on the PURPLE program including the script to use with parents and all RNs familiarized themselves with the DVD. They were also educated in normal infant crying patterns (Fig. 3; questions 2, 4). For example, it is not unusual for a normal infant to cry for 1 to 5 hours daily, with a peak during the first 2 months of life, and increased crying often in the evening.²⁷ They also learned and were tested on soothing strategies (question 3), SBS epidemiology (questions 1, 8, and 9), risk factors (questions

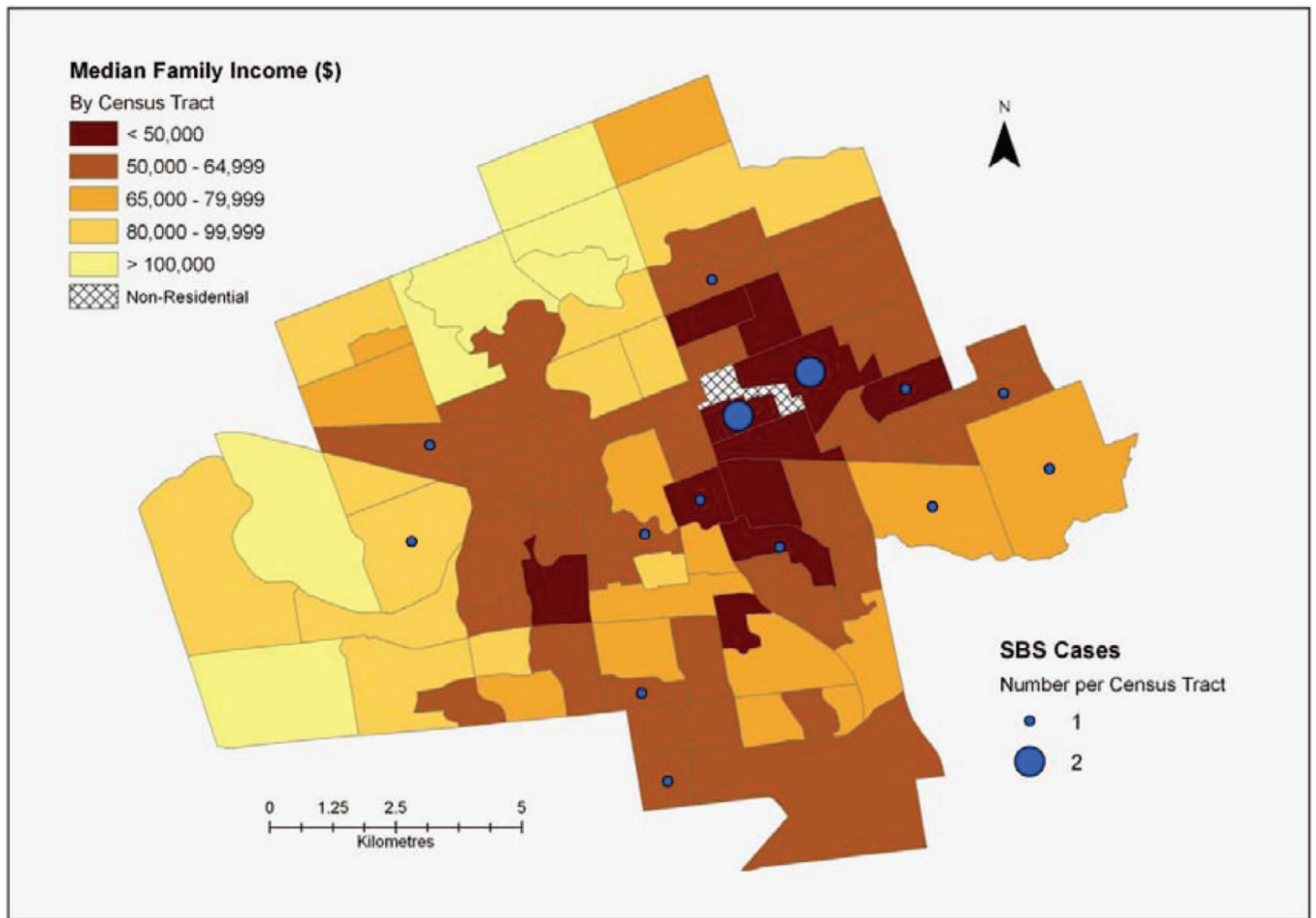


Figure 2. Number of SBS cases with median household income by Census Tract in London, Ontario.

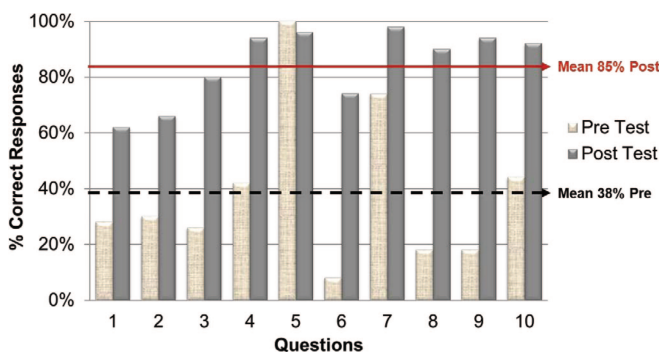


Figure 3. Pre-post test results of RN knowledge before and after PURPLE training.

5, 6, and 7), and outcomes (question 10) of SBS. Our impact evaluation of training revealed that RNs learned new information on crying patterns and SBS, with a 47% increase in knowledge posttraining (Fig. 3; $p < 0.001$).

Nearly all RNs (97%) were satisfied with the training and 88% felt they were ready to teach families following their training (median for both = 7 [interquartile range {IQR} = 1] on a 7-point Likert scale, with seven being the most

satisfied or most ready, respectively). When questioned about the level of difficulty in incorporating the PURPLE program into their daily activities, 78% of RNs felt it would be “easy” to incorporate (median = 7 [very easy]; IQR = 2). Overall, 94% felt that the program would be effective in helping parents cope with their crying infant and 93% felt it would be effective in decreasing SBS in our region (median for both = 7 [very effective]; IQR = 1).

The parents of the 10,520 births that occurred during 2008 to 2010 received the education in-hospital during these first 2 years of implementation of the program, a 93% education compliance rate. Reasons for parents not receiving the PURPLE education and materials are presented in Figure 4. Most often the parents were educated together (69%), with the mother educated alone 29% of the time. For the majority of parents, this was their first baby (45%; 35% a second baby). When the education was given, a total of 92% of parents signed a commitment statement (96% of mothers signed; 65% of fathers signed), committing to be the best advocate for their infant’s safety and to educate all caregivers about normal crying and the dangers of shaking. Nearly all parents (93%) rated the program as useful, citing “what to do when the crying becomes frustrating” as the most important message (Fig. 5).

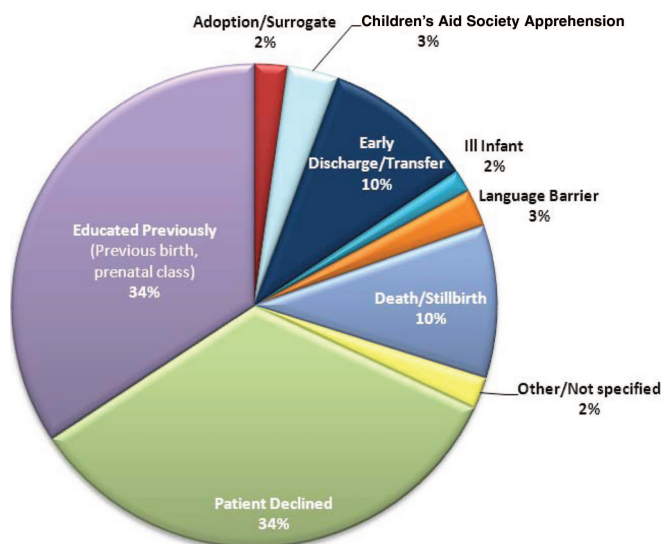


Figure 4. Reasons for parents not receiving the PURPLE education in-hospital.

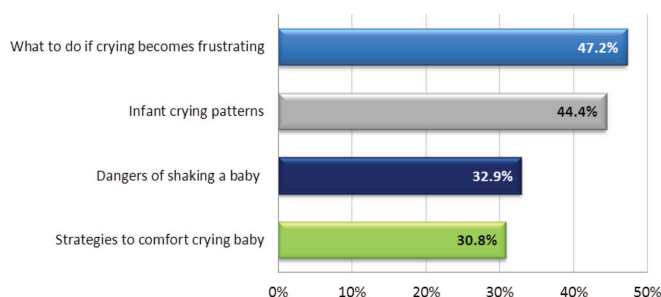


Figure 5. The “most important message” in the PURPLE program, as cited by parents.

Dose 2—Public Health Home Visits

The Middlesex-London Health Unit attempted to contact the mothers for all births occurring in their region. During the first three quarters of the 2009 fiscal year, the Middlesex-London Health Unit tracked nearly 2,000 resident families with home visits, after the birth of their baby. Of these 1,980 families, only 6.3% of families did not receive the PURPLE education and materials in-hospital and needed to be educated during their home visits. For the remaining families, the RNs reinforced the messaging and responded to any questions parents had regarding this issue.

Dose 3—Media Campaign

Locations of families with a new baby, high population density, and percentage of lone parents were identified by surveyed health professionals as the most important factors for selecting media sites. The spatial analysis revealed six areas that needed to be targeted for advertisement locations. In the end, the media outlets selected included five billboards, four core media street level posters, and six transit shelters within our six preferred areas. This was supplemented with six bus backs on city buses; two theaters screen ads that ran on a loop before the movies began to play; radio public

service announcements; five live 10-minute radio interviews with physicians, RNs, and educators on crying patterns, ways to soothe your baby, dangers of shaking; and 1,000 posters that were distributed to various locations including physician offices, walk-in clinics, day cares, and schools.

DISCUSSION

SBS is a devastating intentional injury that often results in poor outcomes for the child. In our study, 19% of children died as a result of shaking, consistent with SBS mortality rates reported in the literature (15% to 38%).^{8,19,28} The descriptive epidemiology for our SBS cases had similarities with other reported SBS reviews, with the majority of cases occurring in infants within the first year of life and more boys injured than girls.⁸ Our mean age (6.7 months) was consistent with the means in previous studies (2.2–8.7 months).^{7,8,29}

Our spatial epidemiologic analysis allowed for the identification of associations between injuries and geographic areas, to help identify high-risk populations or environments.³⁰ Previous work has demonstrated a social profile for SBS, with perpetrators aggregating to the lowest socioeconomic groups with higher social deprivation.²³ Similar to our results, Minns et al.²³ found that the majority of SBS cases (84%) occurred in the lowest two quintiles in an overall Index of Multiple Deprivation, which includes information about social demography for education, housing, employment, health, crime, income, and geographic accessibility to services. Our analysis revealed 81% of London SBS cases occurred in the lowest two quintiles of median household income, with none in the top income quintile. On the basis of these results, it appears that there is an association between neighborhood level median household income and incidence of SBS, but this does not imply a cause-effect relationship. The sample size was too low in our analysis to state with confidence that a significant relationship indeed exists. Nevertheless, our observations are in keeping with previous findings of associations of low socioeconomic status with abuse, and in particular SBS.^{23,31} It also suggests that further research should be conducted which examines the relationships between socioeconomic and neighborhood factors with the incidence of SBS. There may be common characteristics in the areas of the city that contain higher rates of poverty or unemployment and higher SBS incidence, such as lack of social supports or child care, that may be amenable to change to help focus strategies to prevent further abuse in these neighborhoods.³¹

SBS is preventable. A key feature to SBS prevention is providing education on crying patterns, because infant crying is the most common stimulus in SBS cases.⁶ The PURPLE program does exactly this and was implemented in London, Ontario, Canada, by the suggested “triple-dose” strategy,¹⁵ in-hospital, during their home visits, and through a media campaign.

After educating our RNs on SBS, normal infant crying patterns, and the PURPLE program, we demonstrated a statistically significant 47% increase in knowledge on their pre-post tests. This is critical because RNs, both in-hospital and postdischarge public health RNs, provide education to

new parents about caring for their child. The RNs used PURPLE materials and scripts to educate parents on the normality of infant crying and suggest ways to comfort a crying baby. It is emphasized that comforting may be unsuccessful and that if the crying is too frustrating, it is okay to walk away and calm down once the child is placed in a safe environment. The program also emphasizes the need for parents to tell these messages to other caregivers that will care for their infant.^{6,32} In two recent RCTs, PURPLE was found to be effective, leading to higher scores in knowledge about both early infant crying and the dangers of shaking, as well as in information sharing behaviors, all of which are considered important for the prevention of shaking.^{6,32}

An overwhelming majority of our RNs were satisfied with PURPLE and the training they received. This is similar to a recent study on another SBS prevention program, the Perinatal Shaken Baby Syndrome Prevention Program (PSBSPP).³³ This latter program's goals are similar to PURPLE, including increasing parents' knowledge about infant crying, anger, and SBS, while helping parents identify coping strategies. However, the PSBSPP uses cue cards to inform new parents, as opposed to PURPLE's DVD and pamphlet.³³ Both PURPLE, used in our study, and the PSBSPP had similarities, including the general satisfaction of RNs with their training to deliver their respective programs. However, there were also significant differences between PURPLE and PSBSPP. Nearly two thirds of RNs agreed that the PSBSPP intervention fits well with their regular activities, but approximately 70% felt that it was not easy to find an appropriate time for the intervention. This was opposite to the perception of our RNs using PURPLE, with 78% reporting it would be easy to incorporate the education into their daily activities. This variation may be related to the different mediums used in the two programs. With PURPLE, once the RNs go over the short script with the parents, they then are left to watch the DVD allowing them time to take care of other responsibilities. The use of video materials is preferred, as it has been shown to significantly increase the likelihood of positive changes in SBS awareness.¹⁶

During the first 2 years of our implementation of PURPLE, over 10,000 parents were educated. This translates into a 93% education compliance rate, which is higher than other in-hospital SBS-prevention programs, which report educating 69% to 85% of parents.^{14,33} We used the PURPLE educational materials and also included a commitment statement for parents to sign following the education, consistent with the published Dias model.¹⁴ Dias et al. found that the active parent participation by signing a commitment statement creates a type of "social contract" between parents and their community, making it a very important component of the program's success. In fact, there was a significantly lower incidence of abusive head injuries demonstrated in a previous study among those who signed the commitment statement.¹⁴ Additionally, the commitment statement allows for tracking program compliance through the returned statements. In our study, nearly all (92%) of those parents who received the education signed the commitment statement. It has been suggested that combining the RCT-tested PURPLE educa-

tional materials with the Dias process of the commitment statement could make the resulting program greater than the sum of its parts.¹⁵ To the best of our knowledge, this is the first study to report successfully implementing this combined PURPLE-Dias model.

Repeating the PURPLE education through the public health home visits and the media campaign reinforces and enhances the positive messages contained within PURPLE.¹⁵ Media campaigns are a common tool used to promote public health issues.³⁴ Previous research has shown that targeted, well-executed media campaigns can have moderate effects on the public's knowledge, attitudes, and behaviors. Given the wide reach of a mass media campaign, this approach can translate into major public health impact.³⁴ We selected media locations for our campaign through a novel qualitative and spatial method.²⁶ Using the data from our survey, the census, and the trauma registry, within a GIS, we were able to identify locations within the city with high visibility, a high percentage of families with young babies, and risk factors for SBS. This allowed for targeting our media campaign and increased the likelihood that our message was reaching the population in greatest need. The goal of this campaign was to extend the education regarding crying and the dangers of shaking beyond new parents to their friends and family, future parents, and the general public to create a cultural change in the way crying is viewed, to help decrease the stress on the parents.¹⁵ Previous research found campaigns that supplemented their media messages with intervention components (i.e., the first two doses of PURPLE) were found to have stronger effects.³⁴

This study does have limitations. First, as with all epidemiologic SBS studies, the question of definite diagnosis and case ascertainment is an issue. Although our Children's Hospital has a child abuse expert that has worked with the Trauma Program to identify SBS cases, there will always remain some cases for which intent cannot be definitively assigned.³⁵ Second, the sample of SBS cases within London was too small to undertake more sophisticated statistical analyses to further characterize high-risk populations and regions to target in our prevention programming. Finally, this study was not designed, nor do we have sufficient numbers of cases, to examine if implementing this program has resulted in a reduction in the incidence of SBS in our community. PURPLE has undergone extensive formative and impact evaluations,^{6,32} and we undertook process and impact evaluations of our implementation, but it is too early to undertake an outcome evaluation of SBS cases.

CONCLUSIONS

This study describes the successful implementing of "The Period of PURPLE Crying" via a triple-dose strategy. The program was rated as useful and increased knowledge on infant crying patterns, what to do when the crying becomes frustrating, and the dangers of shaking; key factors to SBS prevention. The media campaign allowed us to extend the primary prevention beyond new parents to help create a communal cultural shift in the way infant crying, the primary trigger for SBS, is viewed. Whether this program will ulti-

mately lead to decreases in the incidence of SBS in our region has yet to be determined, but the positive findings presented herein are promising.

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