

Emily Putnam-

Hornstein*

Daniel Webster

Barbara Needell

Joseph Magruder

Center for Social Services Research,
School of Social Welfare, University
of California at Berkeley, Berkeley,
CA, USA

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‘This article reports results from child-level matches completed between the state’s child protective service records and vital birth records’

A Public Health Approach to Child Maltreatment Surveillance: Evidence from a Data Linkage Project in the United States

Historically, data concerning children reported for abuse or neglect in the US have been compiled by child protective service agencies and analysed independently from other sources of information. Yet these data suffer from the notable limitations of being both narrow in scope (i.e. containing a limited set of variables) and narrow in coverage (i.e. capturing data for only those children who are reported). In order to extend an understanding of children reported for maltreatment, the California Department of Social Services, in partnership with the University of California at Berkeley, is pursuing a ‘public health’ oriented approach to the surveillance of child maltreatment through linkages between child protective service records and population-based sources of data. As an example of the information that can be generated through linked records, this article reports results from child-level matches completed between the state’s child protective service records and vital birth records. The cumulative percentage of children reported for abuse or neglect before the age of five is examined based on maternal and child characteristics at birth. This is followed by a discussion of record linkages as a means of furthering a public health approach to child maltreatment. Copyright © 2011 John Wiley & Sons, Ltd.

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Public health efforts in the US have historically focused on the study and prevention of communicable disease transmission (Sleet *et al.*, 2004). Only in the latter half of the 20th century were unintentional injuries recognised as threats to health that could

* Correspondence to: Emily Putnam-Hornstein, Center for Social Services Research, School of Social Welfare, University of California at Berkeley, 16 Haviland Hall, #7400 Berkeley, CA 94720, USA. E-mail: eputnamhornstein@berkeley.edu

be controlled and prevented through epidemiological study, improvements to the social environment and health promotion campaigns. More recently, child maltreatment has also begun to be recognised as a social problem that also lends itself to a public health framework of study and subsequent prevention activities (O'Donnell *et al.*, 2008; Zimmerman and Mercy, 2010).

A key feature of a 'public health approach' is the ability to utilise surveillance data both as a tool for the identification and tracking of the health threat at the population level and as a means of determining risk and protective factors among subgroups, information that can then be used to develop targeted prevention and intervention programmes. Unfortunately, administrative child protective services data, often used to study victims of child maltreatment, are both incomplete and serve as a poor source of surveillance information (Sedlak and Broadhurst, 2010). Beyond the fact that this administrative data source captures only those children who are officially reported for maltreatment, these data suffer from other notable limitations. Because child protection databases were designed for administrative reporting purposes, the variables they typically contain are limited to those associated with billing and other management tasks (Brady *et al.*, 2001). Absent are more descriptive measures of case characteristics, such as family-level variables, that may confound apparent associations (e.g. race often emerges as a risk factor for maltreatment only when socioeconomic data are not available) (Putnam-Hornstein and Needell, 2011). Also missing is information on aetiological risk factors that predate a first report of maltreatment, or outcomes following contact with child protective services, both of which could be used to inform and improve decision-making.

This article presents findings arising from an ongoing child welfare record linkage project in California, US. These linkages were pursued with the simple goal of compiling data and generating new knowledge concerning children and families reported to the state's child protective services system. Yet linkages with vital records also provide a method for population-level surveillance of reported maltreatment, a key feature of public health campaigns. In the sections that follow, we discuss the rationale for including child maltreatment among public health problems, provide a general overview of a public health framework, describe the process of linking records and present examples of information generated.

Child Maltreatment within a Public Health Framework

In the US, child welfare systems were developed in a manner largely consistent with a traditional medical model of case identification, assessment and treatment (Waldfoegel, 1998). While child welfare agencies continue to play a critical role in efforts to

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‘Integrated child safety campaigns may be a more successful and efficient means of improving child safety’

ensure the wellbeing of children, it has become increasingly clear that the child welfare system is poorly suited to addressing the broader social and economic causes of child maltreatment and is not easily adapted to prevention-focused efforts (Berrick, 2009). Certainly, a number of compelling arguments exist as to why child maltreatment should be included under a broader public health umbrella (Zimmerman and Mercy, 2010).

First, even after maltreatment ends, the consequences of abuse or neglect are often far-reaching, with adverse effects associated with a child’s physical, cognitive, social and emotional development commonly observed among victims of maltreatment (Felitti *et al.*, 1998; Glaser, 2000; Springer *et al.*, 2007; Wulczyn *et al.*, 2005). While on the one hand disheartening, this growing body of scientific evidence suggests that preventing child maltreatment may be an effective strategy for promoting health and reducing disease burdens later in life – objectives of most public health agendas (Thacker, 2006).

Second, while child protective service agencies have been shown to have contact with only a fraction of children affected by maltreatment in the US (Sedlak and Broadhurst, 1996, 2010), public health agencies fall within a large health infrastructure with ready access to a broad population of young children and their families. Maternal and child health programmes offer opportunities to reach children who may be at risk of maltreatment, but are unknown to child protective services agencies, and to do so under less stigmatised and adversarial circumstances (Zimmerman and Mercy, 2010).

Third, public health approaches rely on epidemiologic methods for studying the incidence of social problems over time, across places and populations (Thacker *et al.*, 1989). These methods lend themselves well to the resource-constrained environments within which child protection agencies must function, potentially informing the allocation of limited services to those populations at greatest risk (Wulczyn, 2009).

Finally, overlapping risk factors for unintentional (or accidental) injuries and intentional (or maltreatment related) childhood injuries suggest that integrated child safety campaigns may be a more successful and efficient means of improving child safety (Peterson and Brown, 1994; Putnam-Hornstein, 2011). Although public health has been most effective in promoting health through passive campaigns targeting environmental changes (e.g. child safety tops on toxic substances), it also has an established track record in the reduction of harm to children through the employment of education, policy and intervention programmes focused on behaviour modifications (e.g. the use of bicycle helmets). Lessons learned from successful public health efforts may translate well to maltreatment prevention.

A Public Health Framework

Although definitions of public health differ, constant is a focus on the protection and promotion of health and wellbeing at a population level, with prevention figuring prominently into strategies (Dunn and Hayes, 1999; Thacker, 2006; Wilson, 1920). As reflected in Figure 1, the study of child abuse and neglect within a public health framework can be conceptualised as a four-step process, the objectives of which are to: (1) define the problem through data collection and surveillance efforts; (2) uncover possible causes through the identification of risk and protective factors; (3) develop and test interventions in order to discover the most efficacious means of addressing the problem; and (4) implement and monitor prevention and control strategies (Peden *et al.*, 2008; Sleet *et al.*, 2003).

Step One: Surveillance

Surveillance serves as the first step towards the control and prevention of an identified health threat. Surveillance is defined as the ongoing collection, analysis and interpretation of outcome data for use in the planning, implementation and interpretation of population health (Thacker *et al.*, 1989). Described not as ‘an end unto itself, but rather a tool’, public health surveillance efforts are typically initiated for the purposes of detecting and describing a problem that can then be monitored for geographic and temporal trends in its occurrence (Thacker and Berkelman, 1988, p. 185).

Step Two: Identification of Risk and Protective Factors

Surveillance provides ongoing information as to the scope and magnitude of the health threat. The next step in a public health framework involves identifying both those factors that place individuals at risk, as well as those that serve to protect them. Public health tends to rely on ecological models, allowing risk and protective factors to be considered at both the individual and contextual levels (Diez-Roux, 2000).

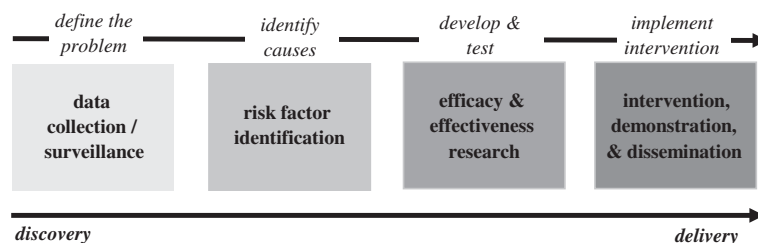


Figure 1. Public health framework (adapted from Sleet *et al.*, 2003).

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‘Surveillance serves as the first step towards the control and prevention of an identified health threat’

‘Surveillance provides ongoing information as to the scope and magnitude of the health threat’

‘The third step in a public health framework involves the development and testing of prevention strategies’

‘The final step involves the implementation of effective programmes at the community level’

‘A serious limitation in lodging an effective public health response’

Step Three: Development and Testing of Interventions

After surveillance efforts have been used to define and parameterise the scope of the problem, with risk and protective factors identified, the third step in a public health framework involves the development and testing of prevention strategies. Although public health is focused on the health of the entire population, prevention programmes are targeted at different segments of the population. Primary prevention programmes are directed at the general population in a universal fashion. Secondary prevention programmes are more narrowly targeted towards populations identified as having one or more risk factors associated with the problem. Tertiary prevention efforts focus on individuals for whom the problem has already occurred, with the goal of minimising negative effects and preventing its recurrence.

Step Four: Implementation of Effective Prevention and Control Strategies

Steps one to three contribute to the development of comprehensive evidence-based prevention programmes. The final step involves the implementation of effective programmes at the community level. Dissemination is a key feature of this step and continued surveillance is required over time. Within this framework, the cycle returns to surveillance upon the widespread adoption of a prevention programme in order to assess its efficacy across the full population.

Study Objectives: Improved Surveillance

The lack of reliable information as to the number of children affected by child abuse and neglect has been identified as a serious limitation in lodging an effective public health response (Leeb *et al.*, 2008). Incomplete data: (1) prevent the threat of child maltreatment from being considered in the context of other, more easily measured, public health problems; (2) limit the identification of those groups that are at greatest risk and stand to benefit the most from targeted services; and (3) restrict our ability to track changes in the incidence and prevalence of maltreatment over time, which in turn complicates efforts to then monitor the effectiveness of child maltreatment prevention and intervention activities.

The record linkages described in this article are conceptualised within the earlier described four-step public health framework: linked records serve to generate new information contributing to the surveillance of children reported for possible maltreatment by identifying risk and protective factors present at birth. Through

record linkages between vital birth and child protective services data this study provides a population-level view of children reported for maltreatment during the first five years of life in California. It should be noted that although there exists a limited body of research based on linked child protection and birth records arising from US and European studies (Murphy *et al.*, 1981; Needell and Barth, 1998; Sidebotham and Heron, 2006; Spencer *et al.*, 2006; Wu *et al.*, 2003), to the best of our knowledge, this is the first US-based study to extend this method of population-based data linkage and inquiry to all children reported to child protective services up to the age of five, and to include all children reported, regardless of whether the allegation of maltreatment was substantiated.

Methodology

All analyses are based on child-level linkages established between administrative child protective services data from California and statewide vital birth records. In total, this study captures over two million children, 293 441 of whom were reported for possible abuse or neglect before the age of five.

Data Sources

Birth Data

Single-year birth cohort datasets (1999 to 2002) were created from encrypted files received from the California Department of Health. In total, 2 112 277 children were born in the state during these four years and are reflected in the analysis that follows.

Child Protective Services Data

A dataset consisting of all unique children referred to California's child welfare system who were both born between 1999 and 2002 and reported for maltreatment before the age of five was created by downloading a child-level file from California's statewide administrative child welfare data collection system. While some unknown fraction of reported children was born outside of California and therefore did not meet the study criteria, the field capturing the state or country of birth contained data in only one per cent of all cases. For those children for whom it was explicitly coded that the child was born outside of California, that information was treated as reliable and those records were dropped. In addition, for those records with a child Social Security number (SSN) recorded (54% of all records), the first three digits of the SSN were examined and the record was dropped if the numbers indicated it was a non-California birth according to published state digit assignments.

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'This study captures over two million children'

'In total, 2 112 277 children were born in the state during these four years and are reflected in the analysis'

‘Based entirely on the secondary analysis of data collected during the normal course of agency operations’

Ethical Approval

This study did not involve any direct contact with human subjects: it was based entirely on the secondary analysis of data collected during the normal course of agency operations, as required by state and federal laws pertaining to registering births and child maltreatment reports. Because personal identifiers were used to link child records across multiple data sources, however, approvals from two separate Committees for the Protection of Human Subjects were requested and granted: California’s Health and Human Services and the University of California at Berkeley.

Record Linkages

Linkage Methodology

Record linkage entails ‘the bringing together of information from two records that are believed to relate to the same entity’ (Herzog *et al.*, 2007, p. 81). In this project, probabilistic linkage strategies (with clerical review) were employed. In probabilistic linkage, two records do not need to agree exactly on a set of linkage variables to be deemed a match. Rather, a statistical model is utilised to compute a numerical value that captures the similarity of two records based on the probabilities of agreement and disagreement for the specified match variables. This strategy has become increasingly sophisticated over the last decade and has been verified as a superior method for linking files that do not have a common unique identifier, as was true of these data (Campbell *et al.*, 2008).

‘All record linkages were completed using Link Plus’

Linkage Software

All record linkages were completed using Link Plus, an ‘open source’ (i.e. free and in the public domain) linkage software developed by the US Centers for Disease Control and Prevention (2010).

‘Several non-unique matching variables were used to identify individual children common to the two files being linked’

Blocking Variables

Blocking variables serve to ‘partition the database into a large number of small segments so that the number of pairs being compared is of a reasonable size’ (Herzog *et al.*, 2007, p. 125). Link Plus utilises an ‘or’ blocking methodology in which record comparisons are made between two files only if they contain identical values on at least one of the specified blocking variables. In performing these linkages, the child’s first name, the child’s last name, the child’s date of birth, maternal SSN and paternal SSN were used.

Matching Variables

Several non-unique matching variables were used to identify individual children common to the two files being linked. In

addition to the blocking variables (also utilised as matching variables), the child's middle name, gender and ethnicity were used, as were maternal and paternal names and dates of birth. Link Plus provides several options for using partial, value-specific and 'fuzzy' matching methodologies. More technical details of completed linkages are available upon request.

Data Preparation

Prior to performing any linkages, all blocking and matching variables were systematically reviewed, cleaned and standardised. Data reviews were conducted by running frequency distributions to identify clearly errant values in both numeric and string variables. All variables were coded and formatted according to the same conventions.

Match Rates

Record linkage amounts to 'messy-data analysis' (Winkler, 2001, p. 8) and notwithstanding the increasingly sophisticated probabilistic algorithms for automated record linkages, a determination of whether two records truly match often requires the judgement of a human reviewer (Clark, 2004). Based on a prior analysis of vital record birth files, including a close manual examination of a one per cent random sample of comparison pairs falling within each ten-point weight strata, an upper-bound score was established above which all paired records were deemed a match and a lower-bound score was utilised to reject all paired records falling below a given threshold. A clerical review was conducted to determine the match status of those record pairs falling in the designated 'grey area'. Among pairs falling towards the upper end of this grey area, the clerical review was relatively cursory. As the scores dropped, the reviews became increasingly thorough and included manual searches of the full birth file to rule out alternative matches. The count and percentage of child welfare records that were successfully matched to a birth record are reported in Table 1.

Overall, 85 per cent of child welfare records meeting the earlier described criteria were matched to a birth record. Among those child welfare records for which no birth record match was identified, missing data were much more common. In addition,

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'A clerical review was conducted to determine the match status of those record pairs falling in the designated grey area'

'Overall, 85 per cent of child welfare records meeting the earlier described criteria were matched to a birth record'

Table 1. Counts and percentages of child protective service (CPS) records successfully linked to a birth record

Birth year	Birth records	Successful linkages	CPS records
1999	519 596	72 630 (84.6%)	85 823
2000	532 964	73 880 (85.2%)	86 777
2001	529 089	73 721 (85.1%)	86 693
2002	531 035	74 374 (85.3%)	87 232

‘Successfully matched children were more likely to have had an allegation of maltreatment substantiated’

successfully matched children were more likely to have had an allegation of maltreatment substantiated (38% vs 16%) and less likely to have been evaluated out over the telephone (9% vs 26%), reflecting the greater information present in the child protective service record (and therefore the greater likelihood of establishing a match) when the child’s involvement with the child welfare system was more extensive. No differences in unmatched and matched children were observed by the type of child maltreatment allegation (e.g. neglect, physical abuse, sexual abuse, emotional abuse, at-risk of abuse/other abuse).

Analysis

Based on the linked dataset, the cumulative percentage of children born in California between 1999 and 2002 and reported to child protective services before the age of five was computed and stratified by child and maternal characteristics gleaned from the birth record. The nature and disposition of the abuse or neglect allegation as reflected in the child welfare record were also examined.

‘Eight child and maternal variables from the birth record were used to identify group-level differences in the rates of contact with child protective services’

Birth Record Variables

Eight child and maternal variables from the birth record were used to identify group-level differences in the rates of contact with child protective services.

1. Sex: A child’s sex was derived directly from the birth record (male, female).
2. Health: Child health was coded as a binary variable indicating a health risk present at birth based on either a birth weight of <2500 grams or the presence of one or more birth abnormalities (risk present, none).
3. Birth payment method: The expected source of payment for the birth was used to create a rough proxy for family socioeconomic status based on a dichotomous coding of Medi-Cal coverage, California’s means-tested public health insurance programme that provides healthcare services for low-income individuals (Medi-Cal, other).
4. Maternal race/ethnicity: Race/ethnicity was coded into five categories based on the first identified race and a Hispanic identifier variable (non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Asian/Pacific Islander). Since Native American children were less than one per cent of all births, these children were re-coded as race ‘missing’.
5. Maternal age: A mother’s age at the time of birth was coded into a variable with four levels (<20 years, 20–24 years, 25–29 years, 30+ years).
6. Maternal education: A four-level variable for maternal education was constructed based on years of school completed: < high school, high school degree, some college, college+.
7. Paternity establishment: California Health and Safety Code Section 102425 (2011) prohibits the release of marital status by the California Department of Public Health, yet also states

‘A four-level variable for maternal education was constructed based on years of school completed’

that 'If the parents are not married to each other, the father's name shall not be listed on the birth certificate unless the father and the mother sign a voluntary declaration of paternity at the hospital before the birth certificate is prepared.' Thus, the absence of established paternity in the record was used as a lower-bound estimate of non-marital births and an indicator of an apparent lack of substantial paternal involvement (missing, established).

8. Birth order: The child's position in a maternally defined birth order was stratified based on whether or not the child was first born (first born, second or higher in birth order).

Results

Cumulative Percentage of Children Reported for Maltreatment by Characteristics at Birth and Disposition Type

Table 2 reports the cumulative percentage of children reported to child protective services by the age of five, with these children then further stratified by maltreatment disposition. In California, allegations of abuse or neglect are either evaluated out or assigned one of three dispositions: unfounded, inconclusive, or substantiated. Children coded as evaluated out were included in an allegation of maltreatment that was not investigated by CPS. Children with an allegation classified as unfounded received an investigation, but the evidence gathered in the investigation was insufficient to conclude that the child had been maltreated. Similarly, a classification of inconclusive is used when there is evidence suggesting the child may have been maltreated, or is at risk of maltreatment, but the evidence is still insufficient to declare the child maltreated. In both of these situations, formal child welfare services are unlikely to have been provided, although there may have been a referral for community-based services. Finally, a substantiated disposition is the classification used when there is sufficient evidence under state law to make a finding of maltreatment (or risk of maltreatment). There is the greatest range of services provided after an allegation is substantiated. At one extreme a child and family may receive no follow-up services. At the other extreme a child may be placed in out-of-home foster care. For those children who were reported more than once, the most severe disposition was used.

Between 1999 and 2002, over two million children were born in California and 293 441 (13.9%) were referred for possible maltreatment before the age of five. By their fifth birthday, the same fraction of male and female children had been reported at least once (13.9%). Nearly 18 per cent of children with a health risk present at birth had been identified as possible victims of

'If the parents are not married to each other, the father's name shall not be listed on the birth certificate'

'Nearly 18 per cent of children with a health risk present at birth had been identified as possible victims of maltreatment'

Table 2. Cumulative percentage of children born in California between 1999 and 2002 and reported to child protective services before the age of five by characteristics at birth and allegation disposition

	Children reported	Allegation disposition ²			
	all children	evaluated out	unfounded	inconclusive	substantiated
	n = 293 441 %	n = 25 344 %	n = 86 507 %	n = 71 252 %	n = 110 338 %
Full population ¹	13.9	1.2	4.1	3.4	5.2
Sex					
male	13.9	1.2	4.1	3.4	5.2
female	13.9	1.2	4.1	3.4	5.2
Health					
risk present	17.9	1.4	4.4	3.8	8.3
none	13.4	1.1	4.1	3.3	4.9
Birth payment method					
Medi-Cal	21.6	1.6	6.0	5.1	8.8
other	8.5	0.9	2.7	2.1	2.7
Maternal race/ethnicity ³					
Black	29.7	2.3	7.8	7.6	12.1
White	13.4	1.4	3.5	3.1	5.4
Hispanic	14.1	1.1	4.6	3.5	5.0
Asian/Pacific Islander	5.8	0.6	1.7	1.4	2.0
Maternal age at birth					
<20 yrs	25.4	2.3	6.8	6.8	9.5
20–24 yrs	18.3	1.6	5.2	4.6	7.0
25–29 yrs	12.2	1.0	3.8	2.9	4.5
30+ yrs	9.5	0.8	3.0	2.1	3.6
Maternal education					
<high school	19.9	1.4	4.7	5.7	8.0
high school degree	17.5	1.6	4.3	5.0	6.6
some college	11.1	1.2	2.8	3.5	3.6
college+	3.3	0.4	0.8	1.2	0.8
Paternity					
missing	33.7	2.2	7.7	7.5	16.3
established	11.8	1.1	3.7	2.9	4.0
Birth order					
second or higher	16.0	1.2	4.8	3.8	6.3
first born	10.6	1.2	3.1	2.7	3.5

¹Differences across variable levels are statistically significant ($p < 0.001$) for all variables except sex.

²Allegation disposition coded as the most severe disposition received by the age of five.

³Missing and other race/ethnicity were 1.6 per cent of the total.

maltreatment. Over 21 per cent of children whose birth payment method was Medi-Cal had been reported to child protective services compared with less than nine per cent of children who had some other form of insurance coverage.

Almost one (29.7%) out of every three children born to Black mothers in California had been reported to child protective services during the first five years of life. The proportions were notably lower for other ethnic groups, with 13.4 per cent of children born to White mothers, 14.1 per cent of children born to Hispanic mothers and only 5.8 per cent of children born to Asian/Pacific Islander mothers reported for maltreatment by the age of

five. One out of every four children born to a teenage mother was reported for possible maltreatment during the first five years of life. This was true of less than one in ten children whose mother was 30 or older at the time of birth. Over 19 per cent of children born to mothers whose education concluded before the completion of high school had been reported for maltreatment compared with 11.1 per cent of children born to mothers with at least some college education and three per cent of children born to mothers with a college degree. One out of every three children born without established paternity was reported to child protective services for maltreatment. Roughly 11 per cent of first-born children had been reported for maltreatment by the age of five versus 16 per cent of children falling higher in the birth order.

Table 2 also reports the cumulative percentages of children with a substantiated, inconclusive, unfounded or evaluated out allegation of maltreatment. By the age of five, 5.2 per cent of all children born in California had been identified as substantiated victims of abuse or neglect. Another 3.4 per cent had received an investigation in which the evidence surrounding the allegation of maltreatment was deemed 'inconclusive'. Just over four per cent were reported and received an investigation, but the allegation was unfounded; and 1.2 per cent of children were reported, but the allegation of maltreatment was 'evaluated out' without a formal in-person investigation.

Over eight per cent of children with a health risk present at birth and 8.8 per cent of children whose births were covered by Medi-Cal were identified as substantiated victims of maltreatment. Just over twelve per cent of all Black children born in California were identified as maltreated before their fifth birthday, with the allegation deemed inconclusive for another 7.6 per cent. Just under ten per cent of all children born to teenage mothers were identified as maltreatment victims; 16 per cent of children without an identified father were substantiated as victims of abuse or neglect before the age of five.

The overall substantiation rate and the rates by ethnic group were similar to those observed in an earlier study of the 1999 California birth cohort in which the authors found that 5.2 per cent of all children experienced a substantiated allegation of maltreatment before their fifth birthday (Magruder and Shaw, 2008). The rates reported in that study varied from 1.7 per cent for children of Asian/Pacific Islander mothers, 4.4 per cent among children born to Hispanic mothers, 5.5 per cent for children born to White mothers to 12.3 per cent for children of Black mothers.

Cumulative Percentage of Children Reported for Maltreatment by Characteristics at Birth and Allegation Type

Table 3 reports the cumulative percentage of children reported to child protective services by the age of five, stratified by

'One out of every three children born without established paternity was reported to child protective services for maltreatment'

'By the age of five, 5.2 per cent of all children born in California had been identified as substantiated victims of abuse or neglect'

'Just under ten per cent of all children born to teenage mothers were identified as maltreatment victims'

Table 3. Cumulative percentage of children born in California between 1999 and 2002 and reported to child protective services before the age of five by characteristics at birth and allegation type

	Children reported	Allegation type ²				
	all children	risk/other	emotional	neglect	physical	sexual
	n = 293 441	n = 53 627	n = 32 457	n = 154 883	n = 37 926	n = 14 548
	%	%	%	%	%	%
Full population ¹	13.9	2.5	1.5	7.4	1.8	0.7
Sex						
male	13.9	2.5	1.5	7.5	2.0	0.4
female	13.9	2.6	1.5	7.3	1.6	0.9
Health						
risk present	17.9	2.6	1.5	11.0	2.1	0.7
none	13.4	2.5	1.5	6.9	1.7	0.7
Birth coverage						
Medi-Cal	21.6	3.8	2.1	12.2	2.6	0.9
other	8.5	1.7	1.1	3.9	1.2	0.6
Maternal race/ethnicity ³						
Black	29.7	4.8	2.4	17.3	3.8	1.4
White	13.4	1.8	1.2	7.9	1.6	0.8
Hispanic	14.1	3.0	1.8	6.8	1.8	0.7
Asian/Pacific Islander	5.8	1.2	0.9	2.5	0.9	0.2
Maternal age at birth						
<20 yrs	25.4	3.0	2.9	14.7	3.6	1.2
20–24 yrs	18.3	3.1	2.1	9.9	2.5	0.9
25–29 yrs	12.2	2.6	1.4	6.1	1.5	0.6
30+ yrs	9.5	2.1	1.0	4.8	1.1	0.5
Maternal education						
<high school	19.9	3.7	2.1	10.9	2.4	0.8
high school degree	17.5	3.0	1.9	9.4	2.3	0.9
some college	11.1	2.1	1.4	5.2	1.6	0.8
college+	3.3	0.7	0.5	1.3	0.5	0.3
Paternity						
missing	33.7	4.3	2.2	22.2	3.8	1.2
established	11.8	2.2	1.5	5.8	1.6	0.6
Birth order						
second or higher	16.0	3.4	1.6	8.5	1.9	0.7
first born	10.6	1.2	1.4	5.6	1.7	0.7

¹Differences across variable levels are statistically significant ($p < 0.001$) for all variables except sex.

²Allegation type coded as the most severe allegation received by the age of five according to California's maltreatment severity hierarchy.

³Missing and other race/ethnicity were 1.6 per cent of the total.

'Neglect was the most prevalent form of maltreatment among children reported to child protective services before the age of five'

maltreatment allegation type. For those children who had more than one maltreatment allegation, California's allegation hierarchy was used and the most severe allegation was examined. This hierarchy is reflected in the table reading from left to right, with risk/other abuse considered the least extreme, and sexual abuse the most extreme, forms of maltreatment, respectively. Neglect was the most prevalent form of maltreatment among children reported to child protective services before the age of five (7.4%), followed by risk of maltreatment (2.5%), physical abuse (1.8%), emotional abuse (1.5%) and sexual abuse (0.7%). As reported in Table 2, there were notable variations in the

distribution of children reported across the variable levels for all maltreatment types. Falling at one extreme were children without an identified father at birth, 22.2 per cent of whom were reported for neglect before the age of five. At the other end of the neglect spectrum were children born to a mother with a college degree or higher, only 1.3 per cent of whom were reported. Across all maltreatment types, higher levels of maternal education were consistently protective against maltreatment, as was increasing maternal age. The cumulative percentage of Black children reported was greater than other racial groups for all forms of maltreatment – from risk of abuse or neglect to sexual abuse.

Discussion

Recent calls originating from all corners of the globe have been made for child maltreatment to be studied in the context of a public health framework. In 1998, the World Health Organization's Regional Office for Europe concluded 'it is essential to consider child abuse and neglect from a comprehensive public health perspective' and argued that 'child protection strategies need to be incorporated into main stream health and health-related services at all levels' (p. 9). Less than a year later, the World Health Organization issued a press release in which they stated, 'abused children suffer a wide variety of physical, emotional and developmental problems which can hamper their ability to live healthy and productive lives...it is a public health issue of vital importance for [the World Health Organization], and it represents a challenge for the next millennium' (The World Health Organization, 1999). Researchers from Australia (O'Donnell *et al.*, 2008) recently posed the question: 'Is it time to consider a public health approach, using population-based measures of child abuse and neglect to accurately describe the epidemiology of population risk and protective factors?' (p. 325). Further, the US Centers for Disease Control and Prevention (2010) have identified child maltreatment as a 'critical' and 'significant' public health problem that warrants a comprehensive prevention strategy. If the history of public health reads as a continuous redefining of what is deemed unacceptable (Open Systems Group, 1984), the fact that child maltreatment is finally being incorporated in its folds is an unambiguously positive sign. In this article, we describe and advance a public health approach to the study of child maltreatment by providing critical surveillance information in the form of child protective service records linked to population-based vital birth records. Linkages with universally collected data at birth serve to aid in the identification of those groups that are at greatest risk and stand to benefit the most from targeted services.

'It is essential to consider child abuse and neglect from a comprehensive public health perspective'

'It is a public health issue of vital importance for [the World Health Organization], and it represents a challenge for the next millennium'

'Linkages with universally collected data at birth serve to aid in the identification of those groups that are at greatest risk and stand to benefit the most'

‘A very high risk group of children who could be readily targeted for services from the day of birth’

‘Linkages across successive birth cohorts allow for the examination of population-level trends’

Although a number of studies have documented that children residing in single-parent families face a heightened risk of maltreatment, information concerning a child's family configuration is not available in California's administrative child protective service records. Through birth record linkages, we were able to determine that although only nine per cent of the more than 2.1 million children born in California were missing paternity information, 33.7 per cent of these children were reported for maltreatment before the age of five. The information gleaned from these record linkages not only provides important (and otherwise unavailable) information about the characteristics of children reported to child protective services, but because these data originate in the birth record, it also serves to identify a very high risk group of children who could be readily targeted for services from the day of birth.

Another surveillance shortcoming common to administrative child welfare data surrounds the ability to place the threat of child maltreatment in the context of other, more easily measured, public health problems. The record linkages reported in this article allow for child maltreatment to be considered in terms of the full population of children born in the state – serving to frame the problem in magnitude and scope. All told, 14 per cent of children born in California between 1999 and 2002 were identified as possible victims of maltreatment before reaching their fifth birthday and over five per cent of all children were substantiated as victims of abuse or neglect. Notable variations based on easily measured sociodemographic characteristics such as poverty (22% of children covered by Medi-Cal were reported), maternal education (one out of every five children born to a mother with less than a high school degree was reported), and paternity establishment (over one third of children without established paternity were reported) allow a more nuanced picture to emerge. What is clear is that the burden of child abuse and neglect is a far from uncommon threat to the health and well-being of children.

Finally, even if the ability to track changes in the ‘true’ incidence and prevalence of maltreatment over time remains limited in the context of administrative child welfare data, linkages across successive birth cohorts allow for the examination of population-level trends in the presence of risk factors associated with child abuse and neglect. In light of the multitude of parental risk factors associated with child maltreatment, it certainly stands to reason that various health promotion strategies might lead to reductions in the incidence and prevalence of child maltreatment. For example, effective teen pregnancy prevention programmes could shift the population of children born to mothers who are at high risk of contact with child protective services. In California, 25.4 per cent of children born to teenage

mothers were subsequently identified as possible victims of maltreatment compared with only 9.5 per cent of children born to mothers over the age of 30. Although residual efforts to provide services to young mothers of newborns have been shown to prevent some child maltreatment and improve child wellbeing (Olds *et al.*, 1999), it is unknown whether even modest declines in teen birth rates may prove more impactful as a method for lowering the prevalence of child maltreatment. Linkages with population-based data offer an opportunity to monitor population-level trends with corresponding shifts in the rates of contact with child protective service agencies.

Conclusion

In this article, we discuss the limitations of administrative data collected for children reported for possible abuse or neglect and provide an example of record linkages as a means of generating information useful for the surveillance of child maltreatment within a public health framework. In California, recent efforts to extend our understanding of child maltreatment have included the record linkages with vital statistics birth data reported here, as well as linkages with vital death records (Putnam-Hornstein, 2011). Birth record linkages allow the sociodemographic characteristics of children reported for maltreatment to be considered within the context of the full population of children born in California, while also contributing basic variables (e.g. the child's birth weight, paternity information) missing from child protective service records. Death record linkages offer an opportunity to examine premature child death as a possible outcome following a report to child protective services. Future efforts to introduce additional linkages with other administrative social services data are likely to yield still more information that might be fruitfully applied to the surveillance and prevention of child abuse and neglect.

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'To monitor population-level trends with corresponding shifts in the rates of contact with child protective service agencies'

'Future efforts to introduce additional linkages with other administrative social services data are likely to yield still more information'

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