Contextual Determinants of Childhood Injury: A Systematic Review of Studies With Multilevel Analytic Methods

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Background. The definition of injury that underpins the contemporary approach to injury prevention is an etiological definition relating to bodily damage arising from transfer of energy to tissues of the body beyond the limits compatible with physiological function. Causal factors proximal to the energy transfer are nested within a more complex set of contextual determinants. For effective injury control, understanding of these determinants is critical.

Objectives. The primary aims of this study were to describe the area-level determinants that have been included in multilevel analyses of childhood injury and to quantify the relationships between these area-level exposures and injury outcomes.

Search methods. We conducted a systematic review of peer-reviewed, English-language literature published in scientific journals between January 1997 and July 2014, reporting studies that employed multilevel analyses to quantify the eco-epidemiological causation of physical unintentional injuries to children aged 16 years and younger. We conducted and reported the review in accordance with the PRISMA guidelines.

Selection criteria. We included etiological studies of causal risk factors for unintentional traumatic injuries to children aged 0 to 16 years. Methodological inclusion criteria were as follows:

- Epidemiological studies quantifying the relationship between risk factors (at various levels) and injury occurrence in the individual;
- Studies that recognized individual exposure and at least 1 higher level of exposure with units at lower levels or microunits (e.g., individuals) nested within units at higher levels or macrounits (e.g., areas or neighborhoods);
- Injury outcomes (dependent variable) examined at the individual level; and
- Central analytic techniques belonging to the following categories: multilevel models, hierarchical models, random effects models, random coefficient models, covariance components models, variance components models, and mixed models.

We combined criteria from the checklist described by the Cochrane Effective Practice and Organization of Care Review Group with factors in the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement, and we used several quality assessment items from other injury-related systematic reviews to create a quality assessment checklist for this review.

Data collection and analysis. Two authors independently extracted data and selected analysis features for the included studies by using preformatted tables. They extracted information as reported in the articles. We determined statistical significance of estimates and effects by using the conventional threshold, $P < .05$. Any differences in the information extracted were resolved by discussion between authors and by specifically rereading and rechecking the facts as reported in the relevant articles. We tabulated results from the final multilevel model(s) in each of the included articles with key aspects summarized in text. Interpretations of the results and identification of key issues raised by the collated material are reported in the Discussion section of this article.

Main results. We identified 11 967 articles from the electronic search with only 14 being included in the review after a detailed screening and selection process. Nine of the 14 studies identified significant fixed effects at both the area and individual levels. The area-level variables most consistently associated with child injury rates related to poverty, education, employment, and access to services. There was some evidence that injury rates were lower in areas scoring well on area-level summary measures of neighborhood safety. There was marked variation in the methods used and in the mapping of measured variables onto the conceptual model of ecological causation.

Author conclusions. These results help establish the scope for the public policy approach to injury prevention. More consistent reporting of multilevel study results would aid future interpretation and translation of such findings. (*Am J Public Health.* 2015;105:e37–e43. doi:10.2105/AJPH.2015.302883)

PLAIN-LANGUAGE SUMMARY:
Injury remains the leading cause of childhood deaths in many parts of the world. Part of the variation in child injury rates between populations can be explained by the different social and physical environments within which children live. We reviewed the current state of knowledge in this area.

We examined 14 qualifying research articles relevant to the area of interest. Results of the review show that features of the social and physical environments most consistently associated with child injury rates involve neighborhood safety, poverty, levels of education, and access to services. Because there have been so few research projects conducted on this topic, and because of the wide variation in the methods used, existing knowledge does not offer a strong basis for explaining how the environments in which children live influence their risk of injury.

Public policy offers great potential (e.g., through allocation of public resources, activities of social institutions, design of public spaces) to facilitate solutions to the problem of injury. Although the evidence provided by this review is somewhat limited in scope, what it does provide is critically important for the development of future research and future public policy initiatives.

The definition of injury that underpins the contemporary approach to injury prevention is an etiological definition relating to bodily damage arising from transfer of energy to tissues of the body beyond the limits compatible with physiological function.[1,2] Causal factors proximal to the energy transfer are nested within a more complex set of contextual determinants.[3] For effective injury control, understanding of these contexts is critical.[4]

The most common characterization of the context in which energy transfer occurs has been in terms of the social determinants of health literature.[5] A systematic review of all articles published between 1960 and 2002 that quantified the role of socioeconomic determinants of injury identified 10 studies with data analyzed only at the individual level, 5 that used area-level analysis, and only 1 study that employed multilevel statistics.[6] Overall, authors reported a strong, inverse association between socioeconomic status and unintentional injuries, but noted varied patterns depending on injury cause, setting, population, and level of analyses.[6] There was also a general consensus among authors that the mixed results across the published literature may have been because the role of context as a determinant of injury was more nuanced than could be detected by the coarse measurements and methods used, and that the field needed to develop further in terms of measurement, conceptualization of cause, and analytic sophistication if it were to adequately describe the complex causal pathways.

Since 2002, several qualitative efforts have been made to apply and adapt the developing concepts of ecological public health to the specific issue of injury causation.[7–10] In 2010, Pickett et al. noted that the field of injury control research was starting to benefit from a recent application of the multilevel concept of injury causation, stated a priori, to guide more innovative etiological modeling.[11] However, to date there remain few accounts in the literature of quantitative studies whose primary aim has been to elucidate ecological causation by using appropriate multilevel statistics. To the authors' knowledge, there have been no published studies that have delineated the relevant multilevel causal factors for a given injury type and then developed, implemented, and evaluated a whole-of-population injury prevention program based on this eco-epidemiological framework.

Interest in the need to understand the context within which injury occurs has been heightened by developments in the public policy approach to injury prevention. Public policy has long been an important tool for injury prevention practitioners, as the logical final step in the progression from knowledge to practice (e.g., the mandated use of child car seats and bike helmets to ensure widespread uptake). More recently, injury prevention practitioners have formally explored policy frameworks and approaches, such as Kingdon's streams approach,[12] that focus on the public domain, and on how and why policy issues rise and fall from the government agenda.[13] In their explanation of road safety as a social issue, Johnson et al.[14] discuss the role of public constituency, committed societal leadership, safety climate, an appropriate infrastructure, cooperation and coordination among all stakeholders, and a long-term perspective as critical elements of societal intervention to eliminate serious injury and death from road transport. In epidemiological terms, these social institutions are the area-level factors in a multilevel causal model of road crash injury that when optimized by practitioner action become components of the overall preventive intervention.

Activities of social institutions, allocation of public resources, and design of public spaces are specified by public policy. Policy has a more direct influence on area-level than on individual-level factors. Thus, understanding the relationship between these area-level factors, the downstream individual-level behaviors, and the risk of child injury may be helpful in maximizing the effectiveness of child injury interventions at the population level.

As the basis for encouraging further the development of an ecological approach to injury prevention, we have undertaken a systematic review to identify, collate, and synthesize the current quantitative evidence from studies that have used formal multilevel statistical methods to examine the causation of childhood injury. The primary aims of this study were to describe the multilevel determinants of childhood injury represented in the included studies and to quantify the relationships between these multilevel level exposures and injury outcomes.

METHODS

We searched the Ovid Medline and EMBASE databases for peer-reviewed, English-language literature published in scientific journals between January 1997 and July 2014 that employed multilevel analyses and eco-epidemiological models examining causal risk factors for physical unintentional injuries to children aged 16 years and younger.

Search Strategy

The search strategies for the 2 electronic databases are outlined in Appendices 1 and 2 (available as supplements to the online version of this article at http://www.ajph.org). We combined terms for children with those for unintentional injuries, multilevel models, and socioeconomic determinants or contextual factors. We mapped search terms to MESH terms or subject headings and grouped synonyms together by using Boolean operators. We applied etiological risk filters (best mix of sensitivity and specificity) where available.

We also sought additional studies that we considered potentially relevant as identified from the citation sections of recovered articles. The rationale to search for studies published from 1997 onward was influenced by the pivotal 1996 publication "Choosing a future for epidemiology: from black box to Chinese boxes and eco-epidemiology,"[15] and by the fact that the systematic review published by Cubbin and Smith[6] covered the territory from 1960 to 2002, and identified only 1 article (published in 1999 and included in our review) that reported the findings from a study that had applied a multilevel design.[16] Our main search was conducted in July 2013 and repeated in July 2014.

Study Selection

Included in the review were etiological studies of causal risk factors for unintentional traumatic injuries to children.

Inclusion criteria.

- Epidemiological studies quantifying the relationship between risk factors (at various levels)

and injury occurrence in the individual;
- Studies of the risk of injury for children, defined as aged 0 to 16 years;
- Analysis that must have recognized individual exposure and at least 1 higher level of exposure with units at lower levels or microunits (e.g., individuals) nested within units at higher levels or macrounits (e.g., areas or neighborhoods);
- Primary outcome (dependent variable) that must have been examined at the individual level;
- Primary outcome that must have covered unintentional injuries but may have represented a broader injury grouping (e.g., all injuries combined) or may have included additional injury types considered separately (e.g., violence-related injuries); and
- Analytic technique used to consider the association between exposure and injury outcome that must explicitly have taken into account the multiple levels of exposure involved (i.e., multilevel models, hierarchical models, random effects models, random coefficient models, covariance components models, variance components models, and mixed models [defined by Diez Roux[17]]).

Exclusion criteria. We excluded all descriptive, qualitative, and intervention studies as well as all secondary studies including editorials, commentaries, case reports, opinion pieces, and reviews. We applied the following specific exclusion criteria:

- Studies addressing only risk factors for intentional injuries;
- Studies that included children but in which the child category could not be isolated from the adult category in the reported findings;
- Any study in which the outcome measures were not objectively defined and measured;
- Population average models, marginal models, and covariance pattern models, because they do not provide for the separation of contextual and individual-level effects, or assessment of the degree of variation present between and within areas or neighborhoods, as multilevel models do; and
- Studies relying on mixed models that only accounted for correlation between lower-level units within higher-level units by modeling the correlations themselves (e.g., as an appropriate way to accommodate a cluster sampling survey design), rather than by allowing for random effects or random coefficients.

The flowchart outlining the steps taken in study selection is presented in Appendix 3 (available as a supplement to the online version of this article at http://www.ajph.org). We downloaded results of the database searches into Endnote ×6 (Thomson Reuters, New York, NY) and then excluded duplicate articles. Two reviewers (R. J. M., F. J. C.) initially screened all titles. Three authors (R. J. M., T. M. D., F. J. C.) then screened the abstracts for all titles considered to be potentially relevant together with articles in which there was uncertainty with respect to the relevance of the title and decided which articles should remain. Two authors (R. J. M., F. J. C.) retrieved the full texts of potentially relevant studies and independently assessed them against the inclusion criteria. At each level of screening, we resolved any differences in opinion by consensus. The flow diagram for retrieval of included studies is presented in Appendix 4 (available as a supplement to the online version of this article at http://www.ajph.org).

Quality Assessment

We combined criteria from the checklist described by the Cochrane Effective Practice and Organization of Care Review Group with factors in the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement for observational studies, and we used several quality assessment items from a number of injury-related systematic reviews to create a quality assessment checklist for this review, shown in Appendix 5 (available as a supplement to the online version of this article at http://www.ajph.org).[18–21]

We used the checklist as a guide to standardize and critique each of the studies for formative review, not to score and rank (or exclude) the studies on the basis of quantitative assessment.

Data Extraction and Synthesis

Two authors (R. J. M., S. R. K.) independently extracted data and selected analysis features for the included studies by using preformatted tables. They extracted information as reported in the articles. They determined statistical significance of estimates and effects with the conventional threshold $P < .05$. Authors resolved any differences in the information extracted by discussion between them, and by specifically rereading and rechecking the facts as reported in the relevant articles.

We tabulated results from the final multilevel model(s) in each of the included articles with key aspects summarized in text. Interpretations of the results and identification of key issues raised by the collated material are reported in the Discussion section of this article.

Selected Definitions

We defined a fixed effect here as the influence of a consistently measurable or classifiable factor, with measurements or classes covering a range or set for which estimates and inferences are specifically of interest. (It may be noted that the influence of a factor can alternatively be considered a random effect, and modeled instead as a variance component.)

We defined a cross-level interaction primarily as an interaction between a fixed-effect factor at the area level and one at the individual level. In the context of multilevel modeling, such an interaction would typically be interpreted as the modification of the effect at the individual level based on the value or class of the factor at the area level.

RESULTS

We identified 11 967 articles from our initial electronic search. We identified a further 8 articles from citation lists. Following removal of 3337 duplicates, we excluded 8447 during an initial review of titles and abstracts. The main reasons for exclusion at the abstract level was that the study cohort comprised only intentional injuries, focused on mental health secondary to injuries, did not use a multilevel analytic approach, did not address the issue of causation, or was not focused on children. We retrieved the full text for the remaining 191 articles. Of these, only 33 conceptualized their research in multilevel terms, and after final detailed examination of the article against all the inclusion and exclusion conditions, we found 14 articles to have satisfied the criteria and we included these in the systematic review.[16,22–34] Articles describing research conceptualized in multilevel terms but that were ultimately not included in the review are listed in Appendix 6 (available as a supplement to the online version of this article at http://www.ajph.org), together with the reasons for not including them.

Study Methods

Appendix 7 (available as a supplement to the online version of this article at http://www.ajph.org) summarizes the methodological and population characteristics of the included studies. Of the included articles, 7 were cohort studies,[24,25,28,29,31,32,34] 4 were cumulative incidence studies,[16,22,23,30] and 3 were random sample surveys.[26,27,33] Most studies had substantial overall sample sizes (i.e., 10 studies with numbers greater than 7000 at the individual level[16,22,23,26,28–33] and 4 studies with numbers between 1000 and 2500 at that level).[24,25,27,34]

All but 4 of the studies included 2 levels of exposure (i.e., 1 area or neighborhood level and 1 individual level).[16,23,25–28,30,32–34] Two of the studies with 3 levels of exposure had time point of follow-up entered in the model as an additional level (i.e., repeated measures analysis),[29,31] leaving 2 studies that considered area, family, and child as 3 distinct levels.[22,24] Area- or neighborhood-level variables that were considered throughout the included articles were most commonly conventional socioeconomic variables (e.g., income, education, social deprivation, lone parent status, poverty). Additional area-level variables present in some studies included the violent crime rate (n = 1), degree of urbanization or population density (n = 5), municipal safety measures (n = 1), and geographical access to medical care (n = 2).

One study considered the additional social constructs of social fragmentation, social cohesion, and proportion of immigrants,[32] and another study was specifically focused on quantifying street connectivity as an area-level risk factor.[33] Several of the studies noted the effect of defined area units without further articulating that unit area was thought to be the factor responsible for the effect. For the majority of the studies, family-level characteristics were combined in the analysis with individual exposure into 1 level of exposure. This was largely an analytic necessity (even if it breached the conceptual model) because in most instances (1) there were insufficient children per family to support another level of analysis and (2) there was insufficient information about individual-level exposure to distinguish that from family characteristics. In accordance with the study selection criteria, all studies included in the review relied on analyses that enabled the estimation of fixed and random effects of the multiple levels of exposure on injury outcomes.

Study Quality

We judged the overall methodological quality (and reporting) of the studies to fall within the range of fair to good, per the criteria described previously. The study settings were clearly described, as were the study inclusion and exclusion criteria, and the sampling techniques were sound.

The major limitation in study design common to all articles was the lack of concordance between the ecological model on which the articles were based and the patchy inclusion of variables at the area and family level. The second major limitation seen in most articles was the construction of neighborhood variables in terms of aggregations of family- or individual-level factors obtained from census-level data, rather than use of neighborhood variables that were truly area-level in nature. The area-level measures of socioeconomic status that were used in the studies were most challenged by this flaw. Examples of variables that did demonstrate truly area-level features included the community safety index, geographical access to services, and urbanization. There were no variables in any of the models relating to the higher-level social institutions such as societal leadership, governance, capacity, and organizational or community partnership that have been found to be critical underlying and policy-actionable components of a complex causal pathway for childhood health and well-being.

Furthermore, the measured range of exposure at the area level may in some instances have been too narrow to allow detection of area-level effects. Because area-level determinants are structural, they may often be similar across the different areas in a given city or region. Thus, by design, some studies may have effectively "controlled" for area-level influences, and thus may not have been able to observe the full area-level effect. Other important limitations observed in the studies included self-reported injury information and sample sizes at the area level potentially insufficient to enable adequate exploration of the studied effects.

Appendix 8 (available as a supplement to the online version of this article at http://www.ajph.org) summarizes the statistical issues relating to each of the included articles. The table highlights the extent of the inconsistency in the manner in which the results were reported. Some fixed effects reported as statistically significant in the included articles refer to 1 or more separate categories of a multicategory factor (i.e., a classification variable) that was found to be individually significant, even though the factor may not have been found to be significant overall. Simpson et al.,[26] for example, in the multilevel model with sport or recreational injuries as the outcome, reported 2 nonreferent categories of the area-level income index to be significant and 1 category to be nonsignificant at $\alpha = 0.05$; no overall P value was reported for this index. Given the apparent borderline significance of 2 of the 3 nonreferent categories, it is conceivable that the composite effect might have been nonsignificant. Another example appears in the report by Li et al.[30] in which in the full model for children aged 0 to 14 years, 1 nonreferent category of the neighborhood-level affluence index was found to be significant and 2 nonreferent categories were found to be nonsignificant at $\alpha = 0.05$. Again, no overall P value was reported (or can be definitively inferred) for this index.

Little information was provided to guide understanding of the apportionment between area and individual levels of both unexplained and explained variation. The apportionment of unexplained variation is of interest at the outset of the modeling process as an indication of the general potential to detect area-level effects, and also at the culmination of the modeling process as an indication of remaining potential to detect area-level effects not measured by the study data (and perhaps more important for studies that fail to detect any area-level effects). The apportionment of explained variation is of interest for studies that detect both area-level and individual-level effects, as an indication of the relative importance of the associated factors at each level. Columns 2 and 4, respectively, in Appendix 8 (available as a supplement to the online version of this article at http://www.ajph.org) summarize the lack of reporting of these 2 aspects of the analyses.

Study Results

The key results of each of the reviewed articles are outlined here, followed by a synthesis that summarizes the findings. Full results from each of the articles for both area- and individual-level variables are tabulated in Appendix 9 (available as a supplement to the online version of this article at http://www.ajph.org).

Nine of the 14 studies demonstrated significant fixed effects at both the area and individual levels. In Reading et al.,[16] area deprivation was found to have a statistically significant effect in a model for emergency department–treated unintentional injuries (odds ratio [OR] = 1.03; 95% confidence interval [CI] = 1.01, 1.05 per unit increase in deprivation score) and also in a model restricted to moderate-to-severe injuries (OR = 1.04; 95% CI = 1.01, 1.08 per unit increase); both models also detected several significant effects at the individual level. In Haynes et al.[22] for the same injury outcomes, the effect of area deprivation was again found to be significant (and of similar magnitude) along with several significant individual-level factors.

In Sellström et al.,[23] municipal-level safety measures were found to have a significant effect on injury hospitalizations (OR = 1.20; 95% CI = 1.05, 1.36 for average vs many measures and OR = 1.33; 95% CI = 1.15, 1.49 for few vs many measures) among children aged 1 to 6 years but not among those aged 7 to 15 years; 1 significant individual-level effect was detected for each age group. The study by Kendrick et al.[24] involving models with area, family, and individual levels reported significant effects at all 3 levels for primary care and emergency department injuries and significant effects at the area and family levels for hospitalized injuries.

Simpson et al.[26] considered injuries among school-age children in grades 6 to 10 classified by severity (any medically attended injury, hospitalized injury) and alternately by selected cause (sport or recreational, fighting). This study detected significant effects at the area level for the hospitalized injury category (OR = 1.64; 95% CI = 1.05, 2.56 for highest vs lowest percentage of lone-parent families; OR = 2.11; 95% CI = 1.36, 3.28 for highest vs lowest percentage of residents with less than high-school education) and for the sport or recreational injury category (OR = 0.80; 95% CI = 0.67, 0.96 for next-to-lowest vs highest income category and OR = 0.81; 95% CI = 0.68, 0.97 for next-to-highest vs highest), and detected significant effects at the individual level for all 4 injury categories.

The study by Pattussi et al.[27] found social capital to have a significant effect at the area level (OR = 0.55; 95% CI = 0.32, 0.81 per unit increase in social capital index) and detected 1 significant effect at the individual level in a model for dental injuries among boys; in a corresponding model for girls a significant effect was detected only at the individual level. The study by Kim et al.[28] found urbanization to have a significant area-level effect in each of 2 final models for fatal injuries (relative risk [RR] = 1.34; 95% CI = 1.22, 1.47 for urban vs metro and RR = 1.59; 95% CI = 1.37, 1.83 for rural vs metro); several significant individual-level effects were also detected in these models. Each final model also included 1 significant cross-level interaction. Although this was not the first among the included studies to consider cross-level interactions between predictors, it was the first among them to unequivocally report such interactions as significant.

In Li et al.,[30] area-level affluence was found to be significant in a model for injury hospitalizations and deaths (OR = 1.13; 95% CI = 1.06, 1.21) for most vs least deprived), along with multiple individual-level factors. The study by Mutto et al.[34] found urbanization to have a significant area-level effect in a model for school-related injuries (OR = 6.85; 95% CI = 1.42, 33.15 for periurban vs rural and OR = 4.08; 95% CI = 1.12, 18.67 for urban vs rural) and detected significant individual-level effects associated with age and gender. One or more significant cross-level interactions may also have been detected, but corresponding estimates were not reported.

The findings from 9 studies that reported statistically significant effects at both area and individual levels have been described. Results of the remaining studies were not as consistent in the reported findings. The study by Laflamme et al.[32] found significant area-level effects for economic deprivation, social fragmentation, receipt of social benefit, and immigration to be associated with motor vehicle occupant injury hospitalizations but not with pedestrian or cyclist injuries. Effects associated with individual-level factors were not reported for the final models. The study by Mecredy et al.[33] considered medically treated street injuries among children aged 11 to 15 years, and found a significant area-level effect associated with street connectivity but no significant individual-level effects. In a second study by Kendrick et al.,[25] several area-level predictors were available but the multilevel models ultimately did not include an area level; these predictors were evidently not found to be significant in any event.

The study by Reading et al.[31] involved a 3-level model (area, individual, and repeated measurement). In contrast with earlier studies by the same research team, this study found no significant area-level effects independent of individual-level risk factors. The authors suggested that this might be attributable, at least in part, to the availability of more direct measures of risk factors at the child, parent, or household level. The study by Haynes et al.,[29] which covered the same population as the study by Reading et al.,[31] did not report effect estimates but instead assessed the influence of area definition (i.e., how neighborhoods are conceptually and geographically characterized) on the ability to detect area-level effects in multilevel models. The study concluded that area definition generally had minimal influence.

Because of wide variations in the conceptualization and measurement of the risk factors and injury outcomes it was not possible to summarize the overall results of the collected studies in terms of either the risk factors per se or the magnitude and significance of the associations between these factors and the examined outcomes. Within these limitations, most studies showed that area-level poverty or advantage has an independent effect on injury outcome. Education, employment, and connectedness of parents were found to be significant area determinants as were access to services and poor scores on measures of neighborhood safety. As described previously, the RRs and ORs for these area-level effects (when found to be significant) generally ranged from slightly exceeding unity to approximately 2.

DISCUSSION

The main finding of this review is that there are identifiable and statistically significant associations between area-level factors and the risk of childhood injury, independent of the effect of individual-level factors. Guidelines to encourage more consistent reporting of multilevel study results would aid future interpretation and translation of these critical findings.

Limitations and Strengths

The findings of the review need to be considered within the context of several methodological limitations. Given the comprehensive nature of this review topic and the lack of consistency, clarity, and application of the terminology used across studies, it is possible we did not identify every published English-language article reporting results of a multilevel analysis of unintentional child injury. Multilevel models are known in the literature under a variety of names and are described in terms with more than 1 meaning.[14] Being restricted to only research published in the English language, we may have missed otherwise eligible research published in the non-English literature. Our review shows a consistent but not universal finding in favor of the existence of area-level influences on child injury but also that the quality and subject matter varied considerably among articles. With the proportion of the world's scientific literature published in English, it is unlikely that there are more qualifying articles in non-English literature than the small number of English-language articles we identified, and so we feel the balance of our conclusion is unlikely to be shifted had the non–English-language articles been included. The same argument would be relevant for evidence in the gray literature that also was not included in our search. These assumptions, however, have not been tested and for this reason our findings need to be considered in that light.

A strength of our review was that we used known articles to develop, test, and refine our electronic search strategy. We do believe that our search has identified the critical material, and that our interpretation of this literature would not be substantively affected by the addition of any articles we may have missed.

The implications of the main findings of this review on the practice of injury prevention are profound, in that it provides empirical support for a shift from an injury-prevention framework that focuses primarily on individual-level factors to one that concurrently addresses factors across multiple levels. A public policy approach to ecological injury prevention is grounded in the ecological model of injury causation, for which the review has provided some support.

The small number of articles meeting the inclusion criteria suggests that this is a field still under development. For this area of inquiry to grow most efficiently, it is important for there to be consistency in the reporting of results. Fixed effects estimates were the most consistently reported components of the multilevel modeling processes used in the reviewed studies. Reporting of other analysis results (such as the estimated apportionment of explained variation attributable to predictors at the different levels, and intraclass correlations or variance partition coefficients that help characterize the apportionment of unexplained variation across levels) was much less consistent. Also inconsistently reported were the results of sequential formulation of the multilevel models, 1 level at a time. Individuals clustered within higher-level categories often have differential access to resources, different levels of education, different prevalence of hazards, and, thus, different individual risk of injury. That is, in addition to having an independent effect on injury outcome, area-level variables may also be underlying determinants of the individual-level variables in the model (i.e., the individual-level variable is in the causal pathway between area and outcome). Reporting of sequential model building by level could contribute to the identification of such influences.

Conclusions

Injury remains the leading cause of childhood deaths in many parts of the world. Part of the variation in child injury rates within populations can be explained by area-level determinants. The specific findings described in this article help establish the scope for a public policy approach to injury prevention, aimed at effecting structural changes, and thereby achieving population-level reductions in childhood injury. There is a need for improved conceptualization and measurement of area and neighborhood factors to ensure that they are of a form that facilitates mapping to public policy solutions. More consistent reporting of multilevel study results would aid future interpretation and translation of these important findings. An increased program of research aimed at quantifying the ecological causation of injury could provide an important supplement to the evidence base to inform public policy solutions. ■

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***Note**. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.*

Contributors

All authors contributed equally to all aspects of the research and article preparation, including concept development, data extraction synthesis and interpretation, and writing.

Human Participant Protection

The research included only a review of summary results that had been previously published in scientific journals, and only used information already in the public domain. No human participants or animals were involved in this research.

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