Cumulative Risk Effect on Unintentional Injury for Chinese Rural Children: A Nested case-control study

Hui Zhang  
School of Nursing, Harbin Medical University

Fengxin Bai  
Liming Community Health Service Center of Daqing People’s Hospital

Hongling Song  
English Department, Harbin Medical University(Daqing)

Jun Yang  
School of Nursing, Harbin Medical University

Xinlong Wang  
School of Nursing, Harbin Medical University

Qingfang Ye  
School of Nursing, Harbin Medical University

Yuqiu Zhou  
✉️ 82323627@qq.com  
Harbin Medical University

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Abstract

**Background:** Childhood unintentional injuries are the leading cause of death and disability for children. Despite the risk factors that lead to injury occurrence have been identified, the relationship between cumulative risk effect of risk/protection factors on unintentional injuries are unclear. The aim of this study was to explore the cumulative risk effect on unintentional injury of rural children.

**Methods:** We used a nested case-control study design from a cohort database. Cases were children aged 6 to 14 with unintentional injury recorded, including 1,696 children which comprised 424 unintentional injury cases and matched on 1,272 control children. Risk factor index (RFI) and protection factor index (PFI) were used as dependent variables. Binary logistic regressions was used to estimate RFI, PFI and cumulative effect odds ratios (OR) with 95% confidence intervals (CI) for childhood unintentional injury. The linear regression was performed to estimate the effect between RFI, PFI, interactive effect on unintentional injury.

**Results:** The RFI had a significant difference between the two groups (p <0.01). After controlling the significant sociodemographic variables, the risk of unintentional injury increased with the RFI from 1 to 3 (OR$_{RFI(1)}$ = 0.978, 95% CI 0.739-1.296), (OR$_{RFI(2)}$ = 1.720, 95% CI 1.233-2.397), (OR$_{RFI(3)}$ = 5.162, 95% CI 3.129-8.517). While inversely it decreased with PFI increased/increasing. The linear regression indicated RFI, PFI and interactive effect were significant in the regression model, and the interactive effect of RFI$\times$PFI could be used to explain 32.2% the severity of unintentional injury.

**Conclusions:** The cumulative risk effect on unintentional injury could regulate the unintentional injury in childhood. Pediatric care providers should consider a multifactorial interventions especially for the cumulative effect of risk/protection factors for childhood unintentional injury.

**Background**

Childhood unintentional injuries are the leading cause of death and disability for children aged 0 to 14 in the world [1]. In 2017 the Global Burden of Diseases project estimates over 2 million children died from injury in the whole world, equivalent to 5,581 child deaths per day and almost four per minute[2]. Over 95% of global child injury deaths occur in low- and middle-income countries [3]. In China, thousands of children die from unintentional injury each year; the incidence rate of injury is from 19.4 to 64.3%, which is the leading cause of mortality for children between the ages 1 and 14[4]. In the United States, unintentional injury killed over 11,000 children in 2017, the equivalent of 32 child deaths per day. Over 6.7 million children were treated in the emergency department, equal to 18,603 per day and almost 13 children per minute. The financial toll of child injuries exceeded $96 billion annually [5]. Unintentional injuries threat children's health and life, and bring heavy economic and psychological burden on families and the whole society. Fang reported the overall economic burden of Chinese childhood injury was 1,014,649.1 RMB (148,666.5 USD) total, 3,348.7 RMB (490.65 USD) per capita, and 2,779.9 RMB (407.31
USD) per incident [6]. Thus, childhood unintentional injuries have become a hot and concern topic in the field of public health.

Childhood unintentional injuries are more prominent in rural areas. The unintentional injury risk of death in rural was approximately 1.95 times that compare to the urban areas [7, 8]. In Chinese rural areas, there is a special group called left-behind children whose parents has left the hometown for work in the urban while their children stay with their grandparents in rural hometown. There are 104 million children living in rural area, and 60 million of them are left behind children [9]. Studies revealed that left-behind children had higher incidence suffered from unintentional injury in China because of they had vulnerable exposure to the hazard factors [10]. Many researches indicated that the risk of unintentional injury in children is affected by children’s personal attributes (gender, the number of siblings, personnel, behavior problems), family environment (economic status and environmental facility, education of primary caregiver and supervision, the knowledge and skills for preventing injury primary care giver), as well as other factors with child’s social environment [11, 12]. Boys, with schizoid behavior problem, anxiety/depression and hyperactive, risk-taking behaviors are more likely to suffer from unintentional injury [12, 13]. Primary caregivers with low supervision, lacking knowledge or skills for preventing injuries could increase the children's risk of injury [11, 14].

Previous studies had only focused on risk factors of unintentional injuries in childhood, but few had concerned the relationship between cumulative risk effect of risk/protection factors on unintentional injuries. The occurrence of an injury event is resulted by multiple factors, not only risk factors. Rutter proposed the cumulative effect of risk factors which presented a “threshold effect”, and with the increase number of risk factors, the health problems trends a quadratic geometric multiple growth [15]. The risk cumulative effect of risk/protection factors are widely used in developmental psychology to consider the power of multiple risk factor exposure effects. Some researchers adopted the Risk Factor Index (RFI) and Protective Factor Index (PFI) to measure the cumulative effect of risk and protection factors, and their interactive effect to influence the health [16, 17]. Hence, the current study aimed to determine the relationship between cumulative risk effect of risk/protection factors and unintentional injury in rural children aged 6 to 14. We hope that our study will contribute to the understanding of the cumulative risk effect in childhood unintentional injury which take us a new point to design the effective injury prevention and intervention for childhood.

**Methods**

**Study Design, Setting and Participants**

We used prospectively collected longitudinal data from database “PCUI-Protective for Childhood unintentional injury in rural areas in Hei Longjiang Province in China” project. The PCUI project included a baseline census in 2017 conducted at 3 rural regions from Hei Longjiang Province according to the economic development level: Daqing region, Qiqihar region and Jia Musi region. Random cluster sampling was used to select 12 elementary and junior schools from these regions. The census were included sociodemographic, risk and protective factors, injury outcome data on total 3,163 children. The
data in the baseline and the second wave (12 month after the baseline) from The PCUI were used in this study.

The cases selected for our study were children aged 6 to 14 years old. In the second wave, children who had a record of unintentional injury were recruited in the case group, and the controls were similarly aged children who didn't suffer from unintentional injury over the same period. To ensure homogeneity of subjects, controls were selected from the same region and the same class. Three controls were selected from the cohort database for each case to yield a matching ratio of 3:1. Our case-control study included 424 cases of unintentional injury children in the last 12 months prior to the census. The total sample size for our study was 1696 (424 cases and 1272 controls).

Measures

Both sociodemographic (age, gender, father and mother's ages and education, primary caregiver's education and health status, left-behind children) and the characteristics of childhood unintentional injury were collected. Unintentional injury was defined as an injury that (a) was diagnosed as a non-fatal injury by physicians and received medical treatment or (b) received emergency medical treatment or assistance from teachers, parents, classmates or others, and (c) required the child to rest for more than half a day [18]. The type of injuries were classified according to ICD-10, which included fall, accidental injury, burn, cut injury, animal bite injury, injury by blunt object, poisoning, and others (drowning, electrocution, suffocation, suicide and frostbite). The severity of the injury was also collected through the numerical assessment (0 = none to 10 = extremely serious).

Risk and protection factors were identified for childhood unintentional injury in the previous study [19]. Measurement of the risk factors included strengths and Difficulties Questionnaire (SDQ) [20], injury Behavior Checklist (IBC) [21], and perceptions of risks and hazards [22]. While protection factors included parent Supervision Attributes Profile Questionnaire (PSAPQ) [23], home Observation for Measurement of the Environment (HOME) [24], and knowledge, attitude and skills for children unintentional injury (KAP) [19] were used in the census. Binary independent variables were used to analyze the risk factors and protection factors. The continuous variables were dichotomized according to the 75th percentile. Binary variables were coded as 0 when there was no risk and protective effect were coded as 1 according to the dichotomized principle [19, 25]. All dimidiate risk factors added up to the risk factor index (RFI), and protective factors formed the protection factor index (PFI) [11, 26]. The RFI and PFI was performed to centralization which was minus the standard deviation of RFI and PFI [27]. Then, the interactive effect (RFI × PFI) was conducted after the centralization of the RFI and PFI.

Statistical analysis

SPSS version 25.0 was used for the statistical analysis. Characteristics of cases and controls were described using mean value (standard deviation, SD) or frequencies and percentages. Independent sample's t-test, Chi-square and spearman correlation analyses were conducted to test univariate and
bivariate significance, and p value < 0.05 was considered a statistical significance. After centralization of PFI and RFI, binary logistic regressions was used to estimate RFI, PFI and cumulative effect odds ratios (OR) with 95% confidence intervals (CI) for childhood unintentional injury associated with risk factors, protection factors and cumulative effect. The severity of unintentional injury was normal distribution, then the linear regression was performed to estimate the effect between RFI, PFI, interactive effect on unintentional injury.

Results

Characteristics of samples

The mean age of the children were 11.03 (SD 1.95). The incidence rate of childhood unintentional injury was 20.1%. Overall, there were 116 (26.9%) children had experienced fall, 76 (17.9%) had accidental injury, 68 (16%) had animal bite injury, 58 (13.7%) had burn, 44 (10.4%) had cut injury, 35 (8.3%) had injury by blunt object, 15 (3.5%) had poisoning and 12 (3.3%) had experienced other type of injury. The severity of the injury was 2.82 (SD 2.35). The characteristics of cases and controls are presented in Table 1.
| Characteristics                      | Case group (n = 424) | Control group (n = 1272) | Statistics |
|-------------------------------------|----------------------|--------------------------|------------|
| Age (year) M (SD)                   | 10.93 (1.76)         | 11.07 (2.02)             | $t = 1.353$ |
| Gender (%)                          |                      |                          | $\chi^2 = 2.216$ |
| Boy                                 | 213 (50.2%)          | 586 (46.1%)              |            |
| Girl                                | 211 (49.8%)          | 686 (53.9%)              |            |
| Left behind children (%)            | 220 (51.9%)          | 453 (35.6%)              | $\chi^2 = 35.185^{**}$ |
| Primary caregiver (%)               |                      |                          | $F = 35.255^{**}$ |
| Mother                              | 157 (37.0%)          | 908 (71.4%)              |            |
| Father                              | 21 (5.0%)            | 115 (9.0%)               |            |
| Grandparents                        | 235 (55.4%)          | 235 (18.5%)              |            |
| Baby sister or others               | 11 (2.6%)            | 14 (1.1%)                |            |
| Primary caregiver's education       |                      |                          | $F = 6.008^*$ |
| Illiteracy                          | 27 (6.4%)            | 39 (3.1%)                |            |
| Elementary school                   | 100 (23.6%)          | 278 (21.9%)              |            |
| Junior high school                  | 233 (54.9%)          | 754 (59.3%)              |            |
| Senior high school                  | 57 (13.4%)           | 152 (11.9%)              |            |
| Above college                       | 7 (1.7%)             | 49 (3.9%)                |            |
| Health of primary caregiver         | 8.68 (2.47)          | 9.14 (3.99)              | $t = 2.232^*$ |
| Mother's age                        | 36.56 (6.00)         | 37.51 (6.00)             | $t = 2.977^*$ |
| Mother's education                  |                      |                          | $F = 0.050$ |
| Illiteracy                          | 21 (5.0%)            | 56 (4.4%)                |            |
| Elementary school                   | 81 (19.1%)           | 291 (22.9%)              |            |
| Junior high school                  | 255 (60.1%)          | 711 (55.9%)              |            |
| Senior high school                  | 53 (12.5%)           | 164 (12.9%)              |            |

Note: * means $p < 0.05$, ** means $p < 0.01$. 
| Characteristics                      | Case group (n = 424) | Control group (n = 1272) | Statistics |
|--------------------------------------|----------------------|--------------------------|------------|
| Above college                        | 14 (3.3%)            | 50 (3.9%)                |            |
| **Father’s age**                     | 38.19 (6.07)         | 39.18 (5.60)             | t = 2.944* |
| **Father’s education**               |                      |                          | F = 110.423** |
| Illiteracy                           | 5 (1.2%)             | 3 (0.2%)                 |            |
| Elementary school                    | 87 (20.5%)           | 30 (2.3%)                |            |
| Junior high school                   | 275 (64.9%)          | 953 (74.9%)              |            |
| Senior high school                   | 46 (10.8%)           | 220 (17.3%)              |            |
| Above college                        | 11 (2.6%)            | 66 (5.2%)                |            |
| Household income (per person per month in yuan) |                  |                          | F = 7.892** |
| < 1000                               | 50 (11.8%)           | 83 (6.5%)                |            |
| 1000–3000                            | 241 (56.8%)          | 442 (34.7%)              |            |
| 3001–5000                            | 97 (22.9%)           | 569 (44.7%)              |            |
| > 5000                               | 33 (7.8%)            | 178 (14.0%)              |            |

**Note:** * means p < 0.05, ** means p < 0.01.

**Risk factors, protection factors and cumulative risk effect in unintentional injury**

The number and percentage of **RFI and PFI** in the case group and control group were presented in Table 2. The RFI had a significant difference between the two groups (p < 0.01), however, the PFI had no significant differences (p > 0.05). Unintentional injury had a positive significant correlation with RFI ($r_s = 0.181, p < 0.01$) and had a negative significant correlation with PFI ($r_s = -0.051, p < 0.05$) and RFI $\times$ PFI ($r_s = -0.113, p < 0.01$). In Table 3, after controlling the significant sociodemographic variables (mother’s education, father’s education, primary caregiver, and left-behind children), the cumulative risk effect was geometric multiples in the unintentional injury occurs. The risk of unintentional injury increased with the RFI from 1 to 3 ($OR_{RFI(1)} = 0.978$, 95% CI 0.739–1.296), ($OR_{RFI(2)} = 1.720$, 95% CI 1.233–2.397), ($OR_{RFI(3)} = 5.162$, 95% CI 3.129–8.517). While inversely it decreased with PFI increasing.
Table 2
RFI and PFI in the case and control group

| Factors | Case group (n = 424) | Control group (n = 1272) | Statistics       |
|---------|----------------------|--------------------------|------------------|
| RFI (%) |                      |                          |                  |
| 0       | 119 (18.1%)          | 608 (47.8%)              | F = 85.706**     |
| 1       | 150 (35.4%)          | 454 (35.7%)              |                  |
| 2       | 87 (20.5%)           | 175 (13.8%)              |                  |
| 3       | 68 (16.0%)           | 35 (2.8%)                |                  |
| PFI (%) |                      |                          |                  |
| 0       | 282 (66.5%)          | 762 (59.9%)              |                  |
| 1       | 82 (19.3%)           | 344 (27.0%)              |                  |
| 2       | 60 (14.2%)           | 166 (13.1%)              |                  |

Note: ** means p < 0.01.

Table 3
The unintentional injury and cumulative effect of risk factors and protection factors (n = 1696)

|        | B   | df | β  | 95%CI           | p   |
|--------|-----|----|----|-----------------|-----|
|        |     |    |    | Low            | High|
| RFI    | 3   |    |    |                 |     |
| RFI(1) | -0.022 | 1 | 0.978 | 0.739 | 1.296 | 0.878 |
| RFI(2) | 0.542 | 1 | 1.720 | 1.233 | 2.397 | 0.001 |
| RFI(3) | 1.641 | 1 | 5.162 | 3.129 | 8.517 | <0.01 |
| PFI    | 2   |    |    |                 |     |
| PFI(1) | -0.293 | 1 | 0.746 | 0.555 | 1.003 | 0.052 |
| PFI(2) | 0.202 | 1 | 1.224 | 0.865 | 1.733 | 0.254 |

The severity of unintentional injury and RFI, PFI and interactive effect

In Table 4, both RFI, PFI and interactive effect were significant in the regression model. With the more increased of RFI, the more severity of childhood unintentional injury had. The effect of RFI × PFI could be used to explain 32.2% the severity of unintentional injury.
Table 4
The severity of unintentional injury and RFI, PFI and interactive effect (n = 424)

|                      | Step 1 |           | Step 2 |           | Step 3 |           |
|----------------------|--------|-----------|--------|-----------|--------|-----------|
|                      | B      | β         | p      | B         | β      | p         | B        | β      | p      |
| Constant             | 3.925  | 0.013     |        | 3.908     | < 0.01 |          | 3.930    | < 0.01 |
| RFI                  | 1.163  | 0.278     | < 0.01 | 0.526     | 0.269  | < 0.01    | 0.502    | 0.256  | < 0.01 |
| PFI                  | -0.131 | -0.053    | 0.009  | -0.175    | -0.071 | 0.001     |          |        |        |
| PFI × RFI            |        | -0.216    | -0.074 |          |        | < 0.01    |          |        |        |
| F                    | 178.277| < 0.01    |        | 92.826    | < 0.01 |          | 66.448   | < 0.01 |
| ΔR²                  | 0.072  | 0.075     | 0.080  |          |        |           |          |        |        |
| Adjusted R²          | 0.316  | 0.318     | 0.322  |          |        |           |          |        |        |

Discussion

Results from this study showed that the incidence of unintentional injury in rural children was 20.1%, which is higher than the early reports for rural children aged 5 to 16 and left behind children in China [28, 29]. Perhaps one reason is that in the case group 55.4% primary caregiver are grandparents who have poor health status and they are not suitable for supervising children. They also lacked knowledge and skills on prevention for injury. Once children suffered unintentional injury, they couldn’t respond and take correct first aid on time [29, 30]. Another reason is that different regions have different social and economic development levels. The gross domestic product (GDP) of Hei Longjiang Province is low in China [31]. The environmental facilities are not safe and the travel transport of rural areas mainly rely on the electric vehicles and agricultural locomotives [32], the fall and accidental injury are the most common unintentional injury in this study. Rural household prefer to keep animals (e.g. dog, cat, goose) protecting their courtyards, so the animal bites injury in childhood are usual. Hei Longjiang province is located in the northeast of China and its winter season is too long. the rural households need to make fires for heating, drinking water, cooking and other daily activities, so children are prone to burns [33]. Previous studies showed that boys were more likely to experience injury than girls in all age groups [34, 35]; however, there was no significant difference between boys (50.2% %) and girls (49.8%) in the case group in this study. This could be the result of different parenting patterns between boys and girls because boys are more often punished by their parents when they had risk-taking behaviors, whereas these mistakes or risk-taking behaviors would be tolerated in girls [36, 37].

Findings from this study indicated that the number of risk factor index in the case group was more than the control group. The most distribute RFI in the case group were 1(35.4%) and 2 (20.5%), while there were 0 (47.8%) and 1 (35.7%) in the control group. Among rural children, the RFI of unintentional injury is greater than the PFI, while the lack of protection factor is the cause of unintentional injury. The aim of this
research is to explore the single effect and cumulative effect of risk factors (children's behavior, parents' risk perception) and protection factors (parental supervision, parents' first aid knowledge, attitudes and skills, family environment) on the occurrence of unintentional injuries. The more prominent the children's behavioral problems and harm behaviors have, the greater parents perceived of injury risk, the more severity of childhood injury. Moreover, the children's behavioral problems and risk-taking behaviors can predict the occurrence of unintentional injury [38]. Children with behavioral problems have a high incidence of unintentional injuries. Children's behavioral problems have predictive effects on children's unintentional injuries, especially those with behavioral problems such as antisocial, aggression, anxiety/depression, hyperactivity and discipline violation [13]. The results of binary logistic regressions found that with the increased number of RFI, the risk of unintentional injury didn't add up simply, but emerged multiple growth, for example, the risk occurrence of unintentional injury was 1.76 times when RFI was 2 than RFI was 1, the risk of unintentional injury was 3 times when RFI was 3 than 2. What's more, the protective factors were found to lead to the occurrence of unintentional injury. The cumulative effect on co-occurring and multiple risk or protection factors have been concluded in children and adolescent's behavior problems which indicate the more risk factors they are exposed to, the worse the outcome is [15, 40, 41]. The cumulative effect of risk factors and protection factors played an important role in childhood unintentional injury. The linear regression analysis indicated that risk factors and protection factors had interactive effect to each other, protection factors could regulate the effect of risk factors, and with the increased number of protection factors, the effect of risk factors will be weakened.

The current study is the first to describe the relationship between exposure to cumulative effects of multiple risk/protection factors and unintentional injury in rural children through the nested case-control study. It contributes to a new view point to the risk factors and prevention strategies for the occurrence of rural childhood unintentional injury in China. Specifically, it reveals significant cumulative effect of risk and protection factors in the rural childhood injury. However, the findings still have several limitations. First, all the data were came from a longitudinal database, only a few risk factors and protection factors were investigated, some more important factors may be missed. More protection factors should be found as the cumulative effect in the future study. Second, the data were collected from primary caregivers, but social bias and recall bias would be existed when filling out the questionnaires, which could not stand for the real condition of the primary caregivers and the children. Third, the children mainly suffered from minor injury in this study who were assessed by the primary caregiver themselves. They may overestimate or underestimate the injury. Thus, the severity of injury should be recorded by medical workers or refer to the standard degree for further study. Last, the participants were all from elementary and junior schools in 3 rural regions of Hei Longjiang Province, the findings might not be generalizable to other areas of China.

**Conclusion**

The findings of this study suggest that fall, accidental injury, animal bite injury and burn are common unintentional injuries in northeast rural of China. Children's problem behavior, injury behavior and caregivers’ perceptions of risks and hazards are risk factors for childhood unintentional injury, while the
supervision of primary caregivers, home environment, the knowledge and skills of prevention injury of caregivers are the protection factors. The risk occurrence of unintentional injury is geometric multiple increase with the number of RFI, and with the increase of protection factors, the effect of risk factors will be weakened. The cumulative risk effect could regulate the unintentional injury in childhood. Pediatric care providers should understand the characteristics of unintentional injuries of children in different rural areas, so as to develop targeted interventions. Furthermore, multiple-factors interventions especially for the cumulative risk effect of risk/protection factors should be considered to increase the protection factors of childhood unintentional injury. Safety education on supervision, knowledge of prevention injury, retrofitting hazardous environment, and the first aid skills training should be adapted in the school through children to primary caregivers.

Abbreviations

RFI: Risk factor index; PFI: Protection factor index; RFI×PFI: interactive effect of RFI and PFI; OR: odds ratios; CI: confidence interval; PCUI: Protective for Childhood unintentional injury; PSAPQ: Parent Supervision Attributes Profile Questionnaire; SDQ: strengths and Difficulties Questionnaire; IBC: injury Behavior Checklist; HOME: home Observation for Measurement of the Environment; KAP: knowledge, attitude and skills for children unintentional injury

Declarations

Ethics approval and consent to participate

This study procedure was approved by the Committee of Harbin Medical University. All participants provided written informed consent. The questionnaire was treated as confidential and anonymous.

Declarations

Ethics approval and consent to participate

The study had approved by the Ethics Committee of Harbin Medical University (Daqing) and the informal consent had obtained from all the primary caregivers of the children.

Consent to publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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**Availability of data and materials**

The datasets used and/or analyzed during this study are available from the corresponding author on reasonable request. The datasets represented in the additional supporting files.

**Authors’ contributions**

YQ contributed to the study design. HZ collected the data and wrote the first draft of the manuscript, FX HL and JY collected, managed the data. HL revised the manuscript for grammars. XL and QF analyzed the data. All authors have read and approved the final version of the manuscript.

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**Authors’ Information**

1. School of Nursing, Harbin Medical University, Hei Longjiang Province, China. 2. Liming Community Health Service Center of Daqing People’s Hospital, Hei Longjiang Province, China. 3. English Department, Harbin Medical University (Daqing), Hei Longjiang Province, China.

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