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METHODOLOGIC ISSUES

The properties of the International Classification of the External Cause of Injury when used as an instrument for injury prevention research

D Scott, J Harrison, D Purdie, C Bain, J Najman, J Nixon, A B Spinks, R J McClure

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See end of article for authors' affiliations

Correspondence to: Professor R McClure, School of Medicine, Griffith University, University Drive, Measdowbrook, Queensland, Australia 4131; r.mcclure@griffith.edu.au

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Objective: To demonstrate properties of the International Classification of the External Cause of Injury (ICECI) as a tool for use in injury prevention research.
Methods: The Childhood Injury Prevention Study (CHIPS) is a prospective longitudinal follow up study of a cohort of 871 children 5–12 years of age, with a nested case crossover component. The ICECI is the latest tool in the International Classification of Diseases (ICD) family and has been designed to improve the precision of coding injury events. The details of all injury events recorded in the study, as well as all measured injury related exposures, were coded using the ICECI. This paper reports a substudy on the utility and practicability of using the ICECI in the CHIPS to record exposures. Interrater reliability was quantified for a sample of injured participants using the Kappa statistic to measure concordance between codes independently coded by two research staff.
Results: There were 767 diaries collected at baseline and event details from 563 injuries and exposure details from injury crossover periods. There were no event, location, or activity details which could not be coded using the ICECI. Kappa statistics for concordance between raters within each of the dimensions ranged from 0.31 to 0.93 for the injury events and 0.94 and 0.97 for activity and location in the control periods.
Discussion: This study represents the first detailed account of the properties of the ICECI revealed by its use in a primary analytic epidemiological study of injury prevention. The results of this study provide considerable support for the ICECI and its further use.

Meaningful and reliable classification of injury event information is an essential prerequisite for injury prevention. However the complexity of events that result in injury information provides a considerable challenge for any system aiming to be both useful and easy to use.

Classifications of injuries (for example, fracture, burn) and external causes of injuries (for example, fall, motor vehicle crash) were distinguished in the sixth revision of the International Classification of Diseases.[1] The ICD External Causes classification has been used widely since then. It was expanded through revisions 7 to 10 of the ICD, but its structure remains largely unchanged.

Limitations of this classification have been reported since at least the 1980s, prompting development of alternative systems, first at national and regional level and then internationally. The International Classification of External Causes of Injury (ICECI) arose out of meetings on injury surveillance held under the auspices of the World Health Organization (WHO) during the 1990s. Assessment and comparison of existing systems led to the conclusion that it was feasible and desirable to develop an internationally harmonized classification of external causes of injury designed to meet the needs of injury researchers and prevention practitioners and to reflect contemporary best practice for injury surveillance and an international consensus about how external causes can be described. Drafts were released in 1998 and 2001, and the ICECI was adopted as a Related Classification in the WHO Family of International Classifications in 2003. The current version (1.2) was released in 2004. The full ICECI data dictionary is available online at http://www.iceci.org/.

The ICECI has conceptual and structural characteristics that distinguish it from the external causes classification of the ICD.

- *Conceptual*. The ICECI is based on an explicit model of injury occurrence. Injurious events are described in terms of underlying and direct mechanisms of injury, mediated by objects and substances, and occurring in a context that can be characterized in terms of place, activity, and other conceptual dimensions. Certain common types of injury event have additional distinctive characteristics (for example, vehicle type for transportation events and perpetrator for interpersonal violence).
- *Structural*. The ICECI is (1) multi-axial, (2) hierarchical, and (3) modular.

(1) The numerous concepts ("axes") in the ICECI model are, as far as possible, each represented in a separate subclassification. This allows numerous factors to be recorded independently of one another. (2) Many of the subclassifications comprising the ICECI can be used at two or three levels of detail, for data collection or reporting. The more detailed levels can be collapsed to the less detailed. (3) Groups of ICECI items form modules on topics such as transport, sport, and violence. This structure provides flexibility, as users can opt to employ all or some parts of the system, depending on purposes and resources.

While the ICECI was developed primarily for injury surveillance, it also lends itself to being used in any circumstance where specific coding of injury events is important, including some injury research. The ICECI has

Abbreviations: CHIPS, Childhood Injury Prevention Study; ICD, International Classification of Diseases; ICECI, International Classification of the External Cause of Injury.

been used in hospital and emergency department surveillance systems as well as in descriptive research.[2–8] These studies have included the translation of Korean death certificate data,[1 2] the implementation of a hospital based surveillance system of intentional injuries in Palestine[4] and Jamaica,[5] the description of sport and injury episodes in the US,[6] developments of occupational injury hazard scenarios,[7] and the comparison of Canadian hospital surveillance data to the experience of injury in the general Canadian youth population.[8] To date, however, there have been no published studies which focus on evaluating the practicability, validity, and reliability of this tool for use as a research instrument.

We conducted a cohort study of 871 children followed for a period of 12 months and used the ICECI as an essential measure of injury event and exposure measurement. In this paper we describe our experience with using the ICECI and present both a qualitative and quantitative assessment of its use in this circumstance. The strengths and weaknesses of the ICECI will be presented, in particular with its innovative use in measuring exposure to injury.

METHODS

This section is divided into four sections. First, the ICECI will be described. Second, the methods of the Childhood Injury Prevention Study in which the ICECI was extensively used will be presented. In the final two sections we will present the methods by which we assessed the practicability and the reliability of the instrument.

The International Classification of the External Cause of Injury

In the core module of the ICECI system the injury event is considered in five dimensions; Intent, Mechanism, Object, Place, Activity (table 1). The injury event is assigned a code in each if these dimensions. The combination of these codes tells a story of how the injury occurred, where it occurred, what the injured person was doing at the time of injury, what object(s) caused the injury, and whether the injury was intentional or unintentional. Within each of these dimensions, categories are provided at two or three levels of detail. The more detailed levels allow the injury event to be described with greater specificity, and the hierarchical structure of the classification helps a coder to find the appropriate category.

The ICECI model of injury events distinguishes two phases: underlying and direct. The direct phase is when injury is sustained (for example, when a person lands on something at the end of a fall from a roof). The underlying phase is when events were put into motion so that the direct phase would occur (for example, working unrestrained on a slippery roof). The distinction between the phases is more obvious in some events than others, and some injury events are much more complex than this simple model implies. Nevertheless, the model provides a useful basis for separate consideration of ''what went wrong'' and ''how injury was sustained''. More specialized models and methods can be used to investigate the underlying phase (for example, analytic epidemiology; Root Cause Analysis) or the direct phased (for example, injury biomechanics) in greater depth.

For example, an injury event which is described in words as ''a child tripped over the family dog while kicking the ball during a play game of soccer in the grassy back yard of his own home, and fell, sustaining a cut lip and broken tooth when he struck against a nearby garden chair'' is coded by ICECI as described below.

As many readers will be more familiar with the ICD-10 than the ICECI, to aid comparison with the ICECI, we note that the event presented in table 2 would be coded in the standard WHO version of ICD-10 as follows: W01.01, meaning ''Accidental fall on same level from slipping, tripping and stumbling at home while engaged in sport'', OR W22.01 meaning ''Striking against or struck by other* objects at home while engaged in sport (*other than sports equipment)''. The Australian clinical modification, ICD-10-AM, from the third edition, allows the type of sport to be specified as soccer, because it incorporates a detailed type of sport classification, based closely on ICECI item S1.

Table 1 Data elements of the ICECI

Dimension	Signifier	Explanation
Intent	nn	The role of human purpose 1 level
Mechanism	nn.nn	The way the injury was sustained 2 levels This can be broken down further into: Underlying (involved at the start of the injury event) Direct (producing actual physical harm Intermediate (other mechanisms involved in the injury event)
Object	nn.nnnn	The matter, material, or thing involved in the injury event. This is again broken into underlying, direct, and intermediate levels
Place	nn.n.x	Where the injured person was when the injury occurred Using other modules this can be taken to 3 or 4 levels
Activity	n.n.n.nn.n	Type of activity the injured person was engaged in when the injury occurred Using other modules (such as sporting) this can be broken down further to 5 levels

The most obvious characteristic of the ICECI classification, in comparison with the ICD external causes classification, is its greater specificity, both in terms of the dimensions of the injury event that can be coded, and in the coding of the dimensions covered by both systems. Consequently, ICECI coding produces a categorical summary of an injury event that typically has greater fidelity than is usually provided by ICD external causes.

The Childhood Injury Prevention Study

Childhood Injury Prevention Study (CHIPS) is a prospective longitudinal follow up study of a cohort of children 5–12 years of age in Brisbane, Australia. The aim of this study was to quantify the elements of the causal pathway relating socioeconomic status and increased risk of injury. A case crossover element was included within the cohort to obtain data on transitory exposures. Ethics approval for the study was provided by the University of Queensland in August 2000, and by the Queensland Department of Education and the Catholic Education Department in March 2000.

The methods of CHIPS have been reported previously.[9 10] Children were randomly selected using primary schools within the Brisbane metropolitan area as the primary sampling frame. For consenting participants, baseline data obtained included an initial interview conducted in the child's home and a one week diary of the child's location and activities (available on request from authors). Study subjects were provided with a set of injury event data collection forms (available on request from authors) during the baseline interview and trained regarding completion requirements. For each injury sustained during the year, parents completed the form and returned it to the project team. Information was requested on each reported injury event, including how, when, and where it occurred, and other circumstantial aspects. In accordance with the case crossover design, parents reporting injuries for their children were also asked for

Table 2 Example ICECI coding for "a child tripped over the family dog while kicking the ball during a play game of soccer in the grassy back yard of his own home, and fell, sustaining a cut lip and broken tooth when he struck against a nearby garden chair"

Dimension	Instance	ICECI category label	ICECI code
Underlying			
Mechanism	Tripped over	Falling/stumbling by tripping on same level	C2 1.5.1
Object	The family dog	Dog	C3 13.04.01
Direct			
Mechanism	Struck against	Contact with static object	C2 1.2.2
Object	Garden chair	Other specified chair, sofa	C3 5.02.98
Intent	Implied	Unintentional	C1 1
Place	Grassy backyard	Home	C4 1
		Outdoors	P1 1
		Garden, yard	P2 14
		At injured person's home	P4 1
Activity	Kicking the ball during a play game of soccer	Other specified sports and exercise during leisure time (physical activities similar to organised sports activity, but not under the auspices of a sports federation, club, or similar organisation)	C5 4.8
		Team ball-sports: soccer—outdoor	S1 1.12
		Phase of activity: during competition/participation	S3 4

similar information regarding the activity and circumstances of the same child on the same weekday and time of day in the preceding week. The function of this component of the study, where cases acted as their own controls, was to identify transient factors responsible for the injury

Practicability of the ICECI

The injury event forms captured information pertinent to the five main dimensions covered by the ICECI core module: Intent, Mechanism, Object, Place, and Activity. Parents were asked to report information in the form of a text string about each of these aspects of each event. The text was later coded by a research assistant.

The ICECI was also used to code information about the case crossover comparison period for each injury event. Parents were asked to record text strings describing the location and activity of the child seven days before the day of injury, during the period of the day in which the injury was sustained.

The practicability of using the ICECI to code information from the injury questionnaires and the case control period exposure was evaluated by assessing whether an ICECI code appropriate to the case was available, whether problems arose in finding and applying an ICECI code, whether there were any events that could not be coded, whether the codes available covered the range of interest of the researchers in the context of the research question, the length of the process, and whether the data could be input and extracted.

Reliability

A formal interrater reliability substudy was conducted between the two coders who conducted the majority of ICECI coding for CHIPS. Of the total sample of injured cases in the first year of the study 318 of these forms were randomly selected and independently coded by the two research assistants. Both coders had extensive training in the use of the ICECI. Coder 1 (AS) is a psychology graduate with honours and Coder 2 (DS) has a registered nursing background with an MPH. Both coders have had considerable previous experience coding injuries using a number of other systems. Concordance was estimated for the overall codes, and the subelements of the codes, using both percentage agreement and the Kappa statistic. Significance levels for the Kappa values were obtained using the χ^2 test and the threshold of 0.05. Data entry and analysis was performed using Statistical Package for Social Science (SPSS) Version 12.0.and Microsoft Excel.

Table 3 Intercoder agreement by dimension

Injury event	Kappa value
Intent	0.93
Place	0.38
Activity	0.31
Object	
Direct	0.95
Contributing	0.86
Mechanism	
Direct	0.92
Contributing	0.95
Control period	
Place	0.97
Activity	0.94

All kappa values statistically significant at $p<0.05$.

RESULTS

Practicability

There were 871 study participants who completed a baseline exposure survey and were followed prospectively for a period of 12 months. There were 563 injuries and 563 exposure details from injury crossover periods recorded over the course of the study. There were no event details which could not be coded using the ICECI and no exposure times for which location and activity could not be coded. The range of options available to code the information was sufficient to cover the range of recorded injuries. Mean time taken to code the injury and control event questionnaire was six minutes.

The following two examples (edited for brevity and to ensure anonymity) of actual injury event reports are included here to illustrate the capacity of the ICECI to capture the complex essence of the injury event with ease and apparent face validity.

The first example involved a child in a park who had dismounted from his bike, removed his helmet, tied his pet dog to the wheel, and was resting on the ground beside it. His brother threw a stick and the dog took off after it. The child had a cut to his head from where the bike hit him. The ICECI was able to capture all the relevant information in the codes (Mechanism—contact with moving object, Underlying Object—dog, Direct object—pedal cycle, Place—public park, Activity—vital activity (resting)) Less competent coding systems may have inappropriately reduced the event to simply a dog or cycle related injury which would not have accurately described the relevant event.

Table 4 Levels of agreement within mechanism code

	Signifier	Kappa value
Direct mechanism		
Full code	nn.nn	0.92
Level 1	nn.	0.97
Level 2	.nn	0.92
Indirect mechanism		
Full code	nn.nn	0.95
Level 1	nn.	0.95
Level 2	.nn	0.95
Intermediate mechanism		
Full code	nn.nn	0.10

All kappa values statistically significant at $p<0.05$.

In the second example a child opened a thermos of tea on the floor of the back seat of a car. When she put the lid back on the tea leaked and burnt her foot. The suggested ICECI coding for this injury is (Mechanism—contact with hot liquid; Underlying object—kitchen container, Direct object—hot drink, Place—roadway, Activity—traveling, Mode of transport—light transport vehicle.) Thus the ICECI allows for the place of injury to be a car but also to allow for the fact that it is not a transport related injury. A less competent coding system may simply have recorded this as a transport related injury or a burn.

Reliability

The interrater concordance, considered within the five dimensions, is summarized in table 3. All kappa values were statistically significance. Concordance was extremely high in all categories other than location and activity. Where the dimensions could be coded in further detail by use of sublevels, agreement at each of these levels was assessed as summarized in tables 4–7 and presented below.

Mechanism: The mechanism of injury showed high levels of agreement both on the complete code (direct mechanism kappa 0.92, indirect mechanism kappa 0.95 and within the code levels with both level 1 and 2 showing kappa values of greater than 0.9 (table 4). Intermediate mechanism did not appear to be a reliable component of the score with a kappa score of 0.10

Object: The direct object causing the injury showed good levels of agreement with kappa statistics all above 0.95 in all levels. in the indirect object and intermediate objects the agreement was lower but still above 0.75 at all levels (table 5).

Place: The lowest levels of intercoder agreement were in the location of the injury event (0.37) (table 6).

Activity: Levels of disagreement in this variable occurred at level 3 and often were over subtle differences—for example, whether or not a concrete undersurface in a school eating area should be coded as ''brick, concrete, concrete block nec'' (16.0208) or ''Floor—tile, brick, concrete'' (14.0305). Within the activity code the sporting module was used to obtain high levels of detail about the activities of each child. The kappa for the entire, seven digit code was 0.31 and the concordance within the code was much higher both in the individual levels and across the levels (table 7).

Table 5 Agreement within object causing injury code

	Signifier	Kappa value
Direct object		
Full code	nn.nnnn	0.95
Level 1	nn.	0.95
Level 2	.nn	0.95
Indirect object		
Full code	nn.nnnn	0.86
Level 1	nn.	0.88
Level 2	.nn	0.87
Intermediate mechanism		
Full code	nn.nnnn	0.80
Level 1	nn.	0.75
Level 2	.nnnn	0.78

All kappa values statistically significant at $p<0.05$.

Table 6 Intercoder agreement within location code

	Signifier	Kappa value
Full code	n.n.nn	0.38
Level 1	n.	0.99
Level 2	n.n	0.99
Level 3	.nn	0.98

All kappa values statistically significant at $p<0.05$.

Table 7 Intercoder agreement within activity code

	Signifier	Kappa value
Full code	n.n.nn.nn.n	0.31
Level 1	n.	0.92
Level 2	n.n	0.89
Level 2	.n	0.90
Level 3	n.n.nn	0.83
Level 3	.nn	0.94
Level 4	n.n.nn.nn	0.77
Level 4	.nn	0.90
Level 5	.n	0.94

All kappa values statistically significant at $p<0.05$.

DISCUSSION

This study represents the first detailed account of the properties of the ICECI revealed by its use in a primary analytic epidemiological study of injury prevention. ICECI, as used in the CHIPS, was found to be useful and practicable, and appears to have the potential for use in other research studies. The codes are set out in a way that allows researchers to code to a high level of detail but aggregate as required by the research numbers or research question. Furthermore, it has proven reliable and easy to use in injury event and non-injury event situations. On the basis of the work described, its superiority to other systems cannot be directly assessed, as formal comparative evaluations were not performed.

The dimensions of the injury code which showed the least reliability between coders were location of injury and activity being undertaken when injured. This would appear to be a product of the large number of choices available to coders. Thus while there was a categorical difference between coders that resulted in measured disagreement the large choice of codes meant that the material difference in meaning between the codes was slight. For example, a child playing sport on a Saturday morning with a ''coach'' present may be interpreted by one coder as an ''organized'' sport and another as a ''school'' sport. There was similar opportunity for error when coding ''object'' at the finest level of detail. For example in one case a coding discrepancy revolved around whether an eel that had bitten a child should be ''fish'' (13.0501) or ''other marine animal'' (13.0598). However, overall, the ICECI appears has achieved an appropriate balance between detail and practicability.

Although instances of ambiguity were found in the ICECI, such as those detailed above, we emphasize that these were uncommon, and that the events described in most of the CHIPS cases were coded without such difficulties. The latest version on the ICECI (v 1.2; CHIPS was based on an earlier version) includes several developments that should further reduce the occurrence of the kind of problems exemplified in the study. These include revised item definitions and inclusion and exclusion terms, and an introductory chapter and glossary providing discussion and definition of key concepts and terms. Subcategories have been added to the Activity item that are intended to ease coding of sport-like activities by avoiding broad terms such as ''formal'' and ''informal'' sport, providing specific examples, and allowing for instances in which information available to the coder is not sufficient to draw this distinction.

In this study, we have shown that two aspects of the ICECI classification system can be employed to capture information about non-injured children as well as about injured children, in a prospective study. These aspects are Place and Activity. It is noteworthy that these terms, in the ICECI, refer to very much more detailed and specific classifications than the similarly named aspects of the external causes chapter of ICD-10. In the ICD-10, these items provide, respectively, 10 and seven categories, and the items are designated for use with subsets of all types of external causes. In ICECI version 1.2 the core Place item has 76 categories, and this is supplemented by a Place module, comprising about 50 categories in seven items. Similarly, the 22 category ICECI core Activity item is supplemented by numerous additional items and categories in the Sport and Occupation modules. The greater range of items and categories in the ICECI provides the potential to record more aspects of place and activity than the ICD items (for example, whether indoors or outdoors), and more specific types of places and activities (for example, stairs in an apartment that is not the injured person's own home, rather than ''home''; or during cardiovascular training for field hockey, rather than ''sport''), and to do so with great flexibility (that is, the numerous elements of the ICECI can be used where relevant because they are not tied together as complex codes).

Inherent to these characteristics of the ICECI is the potential for variations between coders. This is manifest in the lower kappa scores for full (that is, complex) Place and Activity coding than for any of the conceptual elements of these items, or for other items with fewer categories. We think that many of the differences between full place and activity codes that contribute to this rating are minor. We envisage a method for analysis that weight differences in relation to their degree and importance, but developing this was beyond the scope of the present investigation.

IMPLICATIONS FOR PREVENTION

The illustration provided by its use in a research project has demonstrated the ICECI's usefulness, face validity, and reliability. Of particular note is its capability to code events which provide exposure to the risk of injury despite no injury having occurred. Although this study does not provide definitive validation of the ICECI, it does support the extension of the use of the ICECI from surveillance to research data collection.

This project considered some aspects of the utility and performance of the ICECI when used in a special study. Further work of this type is required. Investigation is also required into the utility and performance of this classification system when applied to administrative data, such as hospital attendances or admissions, and deaths.

Key points

- The ICECI is the latest tool in the International Classification of Diseases family and has been designed to improve the precision of coding of injury events in injury surveillance systems.
- The usefulness of this tool for analytic epidemiological research has not previously been examined.
- The results of this study provide considerable support for extending the use of the ICECI and recognizing its usefulness for categorizing injury for research purposes.

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Authors' affiliations

D Scott, Queensland Injury Surveillance Unit, Mater Children's Hospital, Brisbane, Queensland, Australia
J Harrison, Centre for Injury Research Studies, University of Adelaide, Australia
D Purdie, Queensland Institute of Medical Research, Brisbane, Queensland, Australia
C Bain, J Najman, A B Spinks, School of Population Health, University of Queensland, Brisbane, Queensland, Australia
J Nixon, School of Medicine, University of Queensland, Queensland, Australia
R J McClure, School of Medicine, Griffith University, Brisbane, Queensland, Australia

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