Incidence of Head Contacts, Penalties, and Player Contact Behaviors in Youth Ice Hockey

Evaluating the “Zero Tolerance for Head Contact” Policy Change

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Background: To reduce the risk of concussion in youth ice hockey, Hockey Canada implemented a national “zero tolerance for head contact” (HC) policy in 2011. A previous cohort study revealed higher concussion rates after this implementation in players aged 11 to 14 years. However, it is unknown whether the elevated risk was due to higher HC rates or factors such as increased concussion awareness and reporting.

Purpose: To compare the rates of primary and secondary HCs and HC policy enforcement in elite U15 ice hockey leagues (players <15 years) before (2008-2009) and after (2013-2014) the zero-tolerance policy change.

Study Design: Cohort study; Level of evidence, 3.

Methods: A total of 32 elite U15 games before ($n_{2008\text{-}2009} = 16$; 510 players) and after ($n_{2013\text{-}2014} = 16$; 486 players) HC policy implementation were video recorded. Videos were analyzed with validated criteria for identifying HC types (primary/direct contact by players [HC1], secondary/indirect contact via boards, glass, or ice surface [HC2]) and other player-to-player contact behavior. Referee-assessed penalties were cross-referenced with the official Hockey Canada casebook, and penalty types were displayed using proportions. Univariate Poisson regression (adjusted for cluster by team game, offset by game length [minutes]) was used to estimate HC incidence rates (IRs) and incidence rate ratios (IRRs) between cohorts.

Results: A total of 506 HCs were analyzed, 261 before HC policy implementation (IR, 16.6/100 team minutes) and 245 after implementation (IR, 15.5/100 team minutes). The HC1 rate (IRR, 1.05; 95% CI, 0.86-1.28) and HC2 rate (IRR, 0.74; 95% CI, 0.50-1.11) did not significantly differ before versus after implementation. Only 12.0% and 13.6% of HC1s were penalized pre- and postimplementation, respectively. Before implementation, HC1s were commonly penalized as roughing or elbowing penalties (59%), while after implementation, HC1s were penalized with the HC penalty (76%), and only 8% as roughing or elbowing.

Conclusion: Despite implementation of the “zero tolerance for HC” policy, there was no difference in the rate of HC1s and HC2s or the proportion of HC1 penalized from before to after implementation. This research is instrumental in informing Hockey Canada’s future referee training and rule enforcement modifications.

Keywords: ice hockey; head contact; penalty; concussion; youth

Canadian ice hockey is one of the most popular youth sports, with over 500,000 youth players (<18 years) registered annually.[12] Unfortunately, ice hockey has one of the highest rates of injuries and concussions in youth.[7,23] Sport-related concussion is defined as a “traumatic brain injury induced by biomechanical forces, caused either by a direct blow to the head, face, neck or elsewhere on the body.”[20] One in 10 youth ice hockey players in body checking leagues are expected to sustain a hockey-related concussion annually, with prolonged recovery, potential underreporting, and long-term effects of concussion growing in concern.[1,6,9,31]

In ice hockey, body checking (ie, high-intensity player-to-player contact) is consistently reported as the most common

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mechanism for injury and concussion, with player-to-player contacts contributing to the highest rates of head contacts (HCs) and concussions in youth.[8,11,30] Hockey Canada defines an HC as "all contact above the shoulders, inclusive of the neck, face, and head."[14] Helmet impact telegraphy studies suggest that the largest head accelerations in college-level ice hockey result from secondary HC with the environment, with the largest being head-to-ice contact.[30] In the National Hockey League (NHL), 51.2% of concussions resulted from secondary HC with the environment.[5] Youth players in a "head-down" position not expecting a collision are potentially at an increased risk of head injuries due to higher head accelerations.[3,21,26] Further, infractions such as intentional HC, elbowing, and roughing result in abnormally high head acceleration and head impact severity.[21]

To address the dangers of HCs, in 2002 the International Ice Hockey Federation implemented a policy change in both international and Olympic levels to penalize any player-inflicted HC from an opponent.[15,25] After this policy change, the annual risk of concussion declined in the men's world championships, attributed to a decreased incidence of illegal player contacts.[29] However, player-to-player contact has remained the most common mechanism of concussion, with 66% of concussions resulting from illegal contact (eg, HC) and only 31% resulting in a penalty.[29] In 2011, the NHL, USA Hockey, and Hockey Canada implemented similar zero-tolerance policies penalizing player-inflicted HC in professional (NHL, USA Hockey, Hockey Canada) and youth (USA Hockey, Hockey Canada) leagues.[14,17] In the NHL, the concussion rate rose after the HC policy change, which may have been attributed to increased concussion awareness.[5,17] Hockey Canada's "zero tolerance for HC" policy change in 2011 across all age groups and levels of play aimed to reduce HCs and concussion rates in Canadian youth leagues.[14] The zero-tolerance rule change mandates the penalization of all player-inflicted HCs, with unintentional contact leading to a minor penalty (2-minute infraction) and intentional contact leading to a double minor (4-minute infraction) or major (5-minute infraction) penalty and a game misconduct/ejection based on the referee's discretion of severity.[14]

A previous study by our group has evaluated this zero-tolerance policy change in youth ice hockey (11-14 years).[16] We found a greater than 2-fold increase in concussion rates after this HC policy change was reported; however, it is unknown whether the increase was because of a higher incidence of HCs or other factors such as greater concussion awareness and reporting.[16] Further examination of the effect of HC policy change on primary and secondary HCs and referee HC penalty assessments was therefore warranted.

Video analysis has been used in sport research to examine various aspects of gameplay, including player physical contact (PC) behaviors.[18] To our knowledge, no previous study has used video analysis to evaluate the effect of Hockey Canada's "zero tolerance for HC" policy change on HC rates and policy enforcement by referees. Therefore, the primary objective of this video analysis study was to compare the rates of primary and secondary HCs and HC policy enforcement in elite U15 (players <15 years; previously known as elite bantam) ice hockey leagues before (2008-2009 season) and after (2013-2014 season) implementation of the zero-tolerance policy. We hypothesized that HC rates would be lower after the policy change was implemented. Secondary objectives included comparison of penalty type and player-to-player contact mechanisms before and after the HC policy change.

METHODS

Design and Participants

This prospective cohort study employed video analysis examining 32 elite (upper 30% by division of play; body checking allowed) U15 games in the 2008-2009 (n = 16 games; 510 players) and 2013-2014 seasons (n = 16 games; 486 players) in Calgary, Alberta. Ethics approval was received from our institution. Games were collected by convenience sample, and for equal comparisons 16 of the 30 games in the 2008-2009 season were randomly selected using a random-number generator. The only known difference between the cohorts was the implementation of the "zero tolerance for HC" policy. All games were filmed in the regular season between November and March, with the exception of 8 playoff games in the 2013-2014 season (see sensitivity analysis in "2013-2014 Regular Season Versus Playoff Games"). The cohort time frame was important, as the seasons studied were 2 years before and after implementation of the zero-tolerance policy in 2011. Three

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TABLE 1
Trunk Contact Definitions[a]

	Definition
Trunk physical contact	
Level 1	Very light contact between 2 stationary players
Level 2	Light contact between 2 players moving in the same relative direction
Level 3	Moderate contact between 2 players moving in the same relative direction
Level 4	Heavy contact, with 1 player forcefully exerting one's body into the opposing player, usually moving in the opposite direction. Minimum requirement of a body check
Level 5	Excessive, deliberate contact from 1 player with the intention beyond impeding the progress of the opponent, moving in the opposite direction
Other physical contact	
Limb	Contact using 1 or both upper extremities, such as pushing, punching, or holding
Stick	Contact to the body using the stick, such as slashing or hooking

[a]Based on Malenfant et al (2012).[18]

referees controlled each game, 1 head referee to enforce penalties and 2 linesmen to control nonpenalty infractions (eg, icing, face-offs). All referees were Hockey Canada certified, indicating that they participated in annual recertification courses to be educated regarding any rule changes, including the zero-tolerance policy.

Data Collection

Data from the hockey season games were collected using a standardized video recording procedure.[18] One research assistant operated the camera (Sony Handycam; Sony), positioned at the highest location near center ice, allowing for optimal video quality and the lowest chance of blind spots/areas out of frame. If there was no elevated location near center ice, the camera was positioned at one of the corners of the arena. The objective of the camera operator was to maintain the video frame location around the puck and to briefly show the scoreboard during stoppages in play for video reference points.

Outcome Measures

Once games were recorded, all video footage was analyzed in Dartfish Version 7.0 software for player-to-player contacts, HCs, and referee-assessed penalties using a previously validated criterion.[4,18] Dartfish allows for video analyzers to watch game footage on a frame-by-frame basis, tagging and coding PCs on the video clip while progressing through the game. Video analyzers included undergraduate- (n = 3) and graduate- (n = 1) level university students either with a background in youth ice hockey (n = 2) or who enjoyed watching hockey (n = 4). Before inclusion of coding,

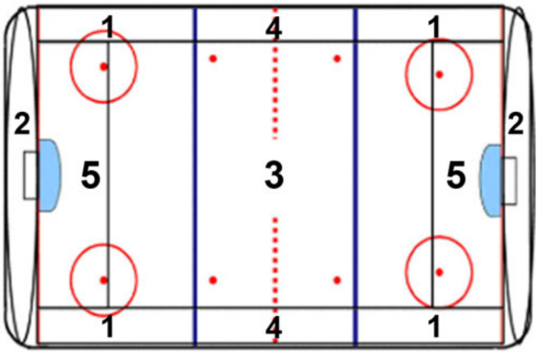

Figure 1. Representation of the zones of a hockey arena. Figure adapted from Malenfant et al (2012).[18] Reproduced with permission.

interrater reliability using percentage agreement of greater than 90% for all contact mechanisms (ie, trunk and other contacts, including limb or stick), contact intensity, and the characteristics of the contact (eg, location on ice, intentional/unintentional, contact made on the puck carrier) was reached between each assessor and a gold standard assessor (M.K.) after training.

Games were fully analyzed, and all PCs (both with and without the head involved) were included. Contacts made with the trunk were classified by severity into 5 levels (Table 1).[18] Other contacts included PC made with the limbs or stick (eg, pushing, hitting, holding, hooking). Each PC was tagged with the contact zone on the ice (Figure 1), directionality of the player giving the contact (offensive or defensive), intentionality of the contact, if the contact was on the puck carrier, and if a penalty was assessed by the referee. Penalty type was determined using the official Hockey Canada rulebook from 2008 and 2014, which included illustrations of referee signals to cross-reference penalties that were called on the ice.[13,14] HCs were classified as either primary/direct contact by opposing players (HC1) or secondary/indirect contact to the head after a collision via the boards, glass, or ice surface (HC2).

Data Analysis

After video analysis, the data were exported into Stata Version 15.1 statistical software (StataCorp).[27] Univariate Poisson regression, adjusted for cluster by team game and offset by game length (minutes), was used to estimate incidence rates (IRs) (number of contacts/100 player-minutes) and incidence rate ratios (IRRs) comparing the rate of HCs (primary), trunk contacts (secondary), penalties (overall), and penalties associated with HCs between the 2008-2009 and 2013-2014 seasons. Proportions were used to report penalty types assessed by referees and contact location on the ice. Based on previous video analysis in Canadian U15 ice hockey with body checking (2007-2008), an estimated 10 HC1s per team game of a total of 160 total PCs (eg, hooking, slashing, limb, trunk contact) per team game (6%) were assessed.[19] In order to detect a

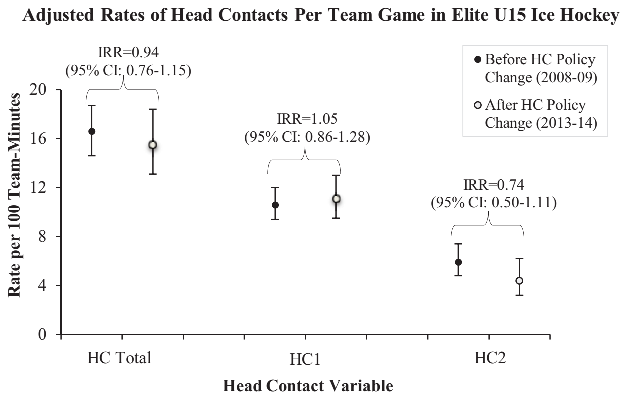

Figure 2. Incidence rates and incident rate ratios (IRRs) with 95% CIs of total head contacts (HCs), direct head contacts (HC1), and indirect head contacts (HC2) both before and after the "zero tolerance for HC" rule change, clustered by team game.

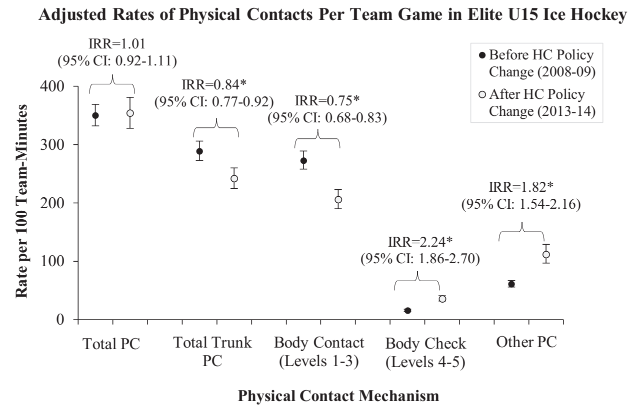

Figure 3. Incidence rates and incident rate ratios (IRRs) with 95% CIs of physical contacts (PCs) before and after the "zero tolerance for HC" rule change, clustered by team game. *Statistically significant (95% CI not spanning 1). HC, head contact.

20% difference in the proportion of total HC1s after the zero-tolerance policy in 2011, a minimum of 20 team games (10 games with an estimated >3000 PCs) were required ($\alpha = .05$; $1 - \beta = 0.8$). Given the consideration of cluster in these analyses, a conservative estimate of 32 team games (16 games with an estimated >5000 PCs) before and after implementation was used. Secondary analysis of trunk contacts was also conducted.

RESULTS

HC Incidence

In total, 506 HCs were analyzed in both cohorts from a total of 11,104 PCs. In the 16 games (32 team games) before HC policy implementation, 166 HC1s and 95 HC2s (261 HCs; 4.7% of all PCs) were coded (IR, 16.6/100 team minutes). In the 16 games (32 team games) after policy implementation, 175 HC1s and 70 HC2s (245 HCs; 4.4% of all PCs) were coded (IR, 15.5/100 team minutes). IRRs (2013-2014 season/2008-2009 season) revealed no difference in the rate of HCs, HC1s, or HC2s between cohorts (Figure 2). Trunk contacts involved the highest proportion of HCs (preimplementation, 85%; postimplementation, 74%), with levels 4 and 5 (body checks) having the highest risk of a head impact per contact (preimplementation, 32%; postimplementation, 19%). Although the decreased risk of a head impact per body check was seen after the policy change, a higher incidence of body checking emerged (Figure 3).

HC Mechanisms

Secondary analyses revealed that the total incidence of PCs did not differ between cohorts (Figure 3). The total trunk contacts were higher before policy implementation, although the difference was predominantly level 1 trunk PCs (IRR, 0.52; 95% CI, 0.45-0.59) (Figure 3). Other mechanisms, including limbs and stick contacts, were

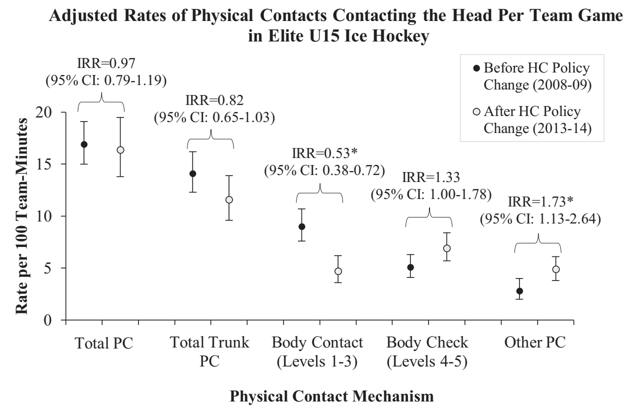

Figure 4. Incidence rates and incident rate ratios (IRRs) with 95% CIs of physical contacts (PCs) that included a head contact (HC) both before and after the "zero tolerance for HC" rule change, clustered by team game. *Statistically significant (95% CI not spanning 1).

higher after implementation (Figure 3). Most HCs were due to contact with the trunk, although after policy implementation, HCs from limb and body checks (levels 4 and 5) rose (Figure 4). In both cohorts, the majority of HCs were considered intentional (92%) and did not differ (IRR, 0.88; 95% CI, 0.71-1.09) between cohorts. The majority of HCs were delivered to the puck carrier (preimplementation, 86%; postimplementation, 68%). Similar proportions of HCs were coded for directionality between cohorts (offensive: preimplementation, 20%; postimplementation, 24%; and defensive: preimplementation, 80%; postimplementation, 76%). Most HCs occurred in zones 1 and 2 in both cohorts (zone 1: preimplementation, 29%; postimplementation, 26%; and zone 2: preimplementation, 27%; postimplementation, 27%) located along the boards, although the proportion of HCs per PC was highest in zone 4 (preimplementation, 10%; postimplementation, 6%).

2013-2014 Regular Season Versus Playoff Games

Within the 2013-2014 season, 8 playoff and 8 regular season games were included. A sensitivity analysis was conducted, and minimal differences were found with the inclusion of the playoff games in the overall analysis (Table 2). Surprisingly, there was a lower rate of penalties assessed during the playoff games compared with the regular season games (IRR, 0.47; 95% CI, 0.31-0.72).

TABLE 2
Sensitivity Analysis of the Comparison Between Regular Season and Playoff Games Within the 2013-2014 Season[a]

	Only Regular Season Games		Combined Regular Season and Playoff Games	
	IRR	95% CI	IRR	95% CI
Total HCs	1.04	0.78-1.37	0.94	0.76-1.15
HC1s	1.17	0.92-1.49	1.05	0.86-1.28
HC2s	0.79	0.45-1.41	0.74	0.50-1.11
Total PCs	1.05	0.92-1.20	1.01	0.92-1.11
Total trunk PCs	0.83[b]	0.75-0.92	0.84[b]	0.77-0.92
Non–body check (levels 1-3)	0.73[b]	0.66-0.84	0.75[b]	0.68-0.83
Body check (levels 4 and 5)	2.42[b]	1.94-3.03	2.24[b]	1.86-2.70
Other PCs	2.07[b]	1.66-2.59	1.82[b]	1.54-2.16

[a]HC, head contact; HC1, primary/direct contact; HC2, secondary/indirect contact; IRR, incidence rate ratio; PC, physical contact.
[b]Statistically significant (95% CI not spanning 1).

Penalty Incidence and Breakdown

In the 2013-2014 season, a 36% lower rate of penalties was demonstrated compared with the 2008-2009 season (IRR, 0.64; 95% CI, 0.47-0.88). The proportion of elbowing, high sticking, roughing, and HC penalties differed from pre- to postimplementation of the HC policy (Figure 5). There was no difference in the number of penalties assessed for HCs between cohorts (IRR, 1.02; 95% CI, 0.62-1.66). Preimplementation, HC1s were commonly penalized as roughing (41%), elbowing (18%), and cross-checking (14%). Postimplementation, HC1s were primarily penalized as HCs (76%), with only 8% assessed as roughing and none assessed as elbowing (Figure 6). Most HC2s from both cohorts were assessed as boarding ($n_{2008\text{-}2009} = 5$ [38%], $n_{2013\text{-}2014} = 6$ [60%]). Preimplementation, 12.7% of HCs were penalized (12.0% of HC1; 14.0% of HC2), compared with 13.8% postimplementation (13.6% of HC1; 14.3% of HC2). Only 7.3% of intentional HC1s were penalized as a double minor penalty, as stated in the official Hockey Canada casebook after the policy change. No major HC penalties were assessed.

DISCUSSION

This study was the first to examine the effect of the "zero tolerance for HC" policy change in Canadian youth hockey

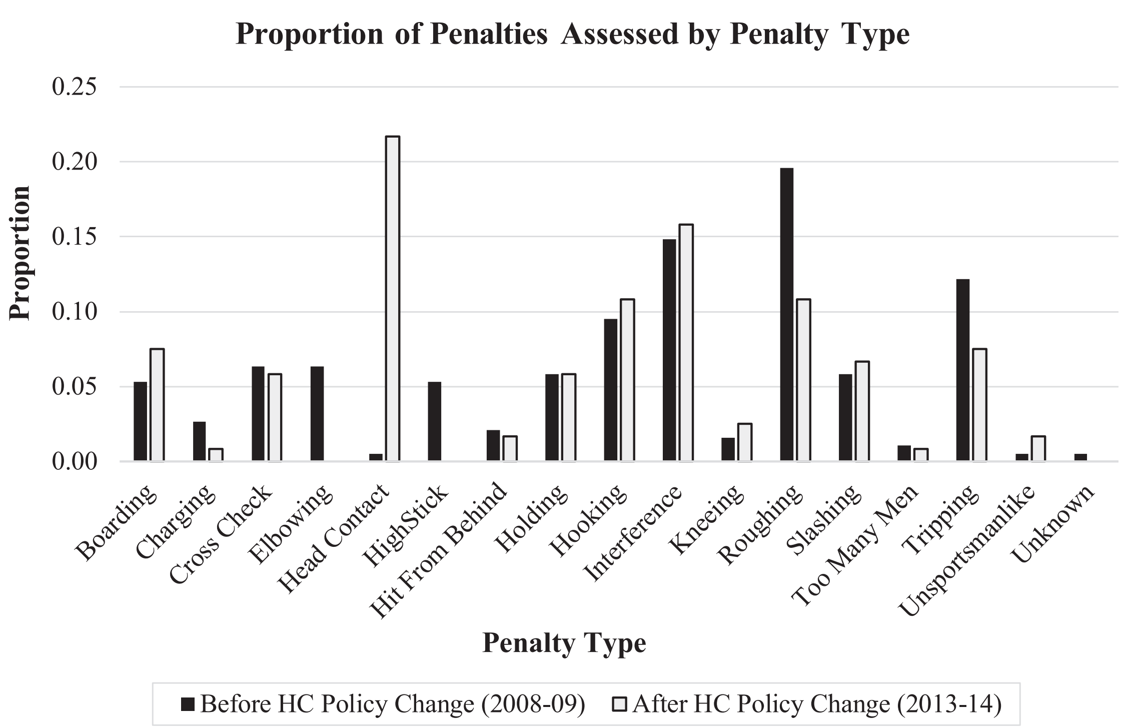

Figure 5. Proportion of penalty types assessed before and after head contact (HC) policy implementation. "Unknown" refers to penalties that occurred outside of the camera frame.

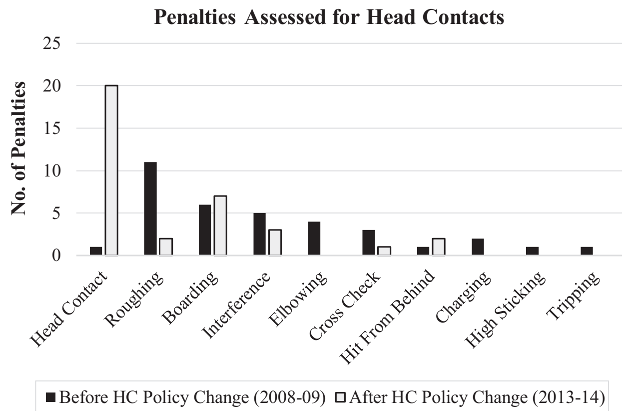

Figure 6. Penalty type assessed that included a head contact (HC) from before and after policy implementation.

on the incidence of HCs and HC policy enforcement using video analysis. In total, 506 HCs were tagged and analyzed in 32 elite U15 games where body checking was allowed. The incidences of total HCs, primary HCs (HC1s), and secondary HCs (HC2s) were similar before and after HC policy implementation. The mechanism associated with HCs was predominantly level 4 and 5 trunk contacts (body checking), similar to the findings of previous studies.[7,11] The findings of this study align with those of Krolikowski et al,[16] who reported an increased concussion rate after policy implementation. This may suggest that the higher concussion rates postimplementation could be attributed to increased awareness of concussion or higher rates of body checking (level 4 and 5 trunk contacts) and limb/stick contacts, as seen in this study. With regard to mechanism of HC, level 1 to 3 trunk contacts decreased, while body checking (level 4-5 trunk contacts) and limb/stick contacts increased after HC policy implementation. This may be a further area for referee enforcement or player safety education and coaching.

The proportion of HCs to total PCs (including trunk, stick, and limb) before (4.7%) and after (4.4%) the policy implementation were similar to that reported in 2007-2008 (6.0%) in U15 elite ice hockey leagues.[19] Overall, only 12.7% to 13.8% of all HCs were penalized in both cohorts. In 2008-2009, there was a rule for severe player-inflicted HC, but only 1 penalty was assessed.[13] Interestingly, a large proportion of HC1s in this cohort were assessed as roughing or elbowing penalties. In the 2013-2014 season, HC penalties were predominantly assessed; however, a lower rate of roughing and elbowing penalties was assessed. There was a 36% higher rate of penalties assessed in the 2008-2009 season compared with the 2013-2014 season. This lower incidence of penalties in 2013-2014 was mainly owing to the lower rate of penalties assessed in the playoff games, which may have been because of referee concerns about influencing the gameplay in the context of playoff games. Referees may have similar concerns within regular season games to a lesser extent, which informs an area for further evaluation of referee practical on-ice training.

The results of this study align with previous HC policy implementation studies. Pashby et al[22] suggested that if injuries are to decrease in youth hockey, consistent rule enforcement and severe consequences for infractions are needed. Other studies have noted that recently implemented rule changes surrounding HC do not go far enough and only partially help mitigate brain injury risks.[2,17] Many successful policy changes have been implemented in youth ice hockey, including the removal of hitting from behind and, more recently, body checking across all U13 (Pee Wee) levels.[1,28] The policy on removal of contact from behind was implemented in 1985 but was not immediately successful.[28] Modifications of this policy, stricter penalties and regulations, and increased community education, including the STOP campaign (i.e., STOP sign patch paced on the back of hockey jerseys to remind players to avoid checking from behind), have led to a steady decline in spinal injuries in youth ice hockey,[28] demonstrating that modifications and adaptations to policies are needed to create the largest impact in sport.[24] Any national policy, including the zero-tolerance policy, must be effectively implemented at the grassroots level of ice hockey to help change player behavior and the overall culture of the sport. To achieve this, stricter and more consistent enforcement of the zero-tolerance policy is needed, which may be promoted by referee training and education. Perhaps the addition of another referee or the ability of linesmen to assist with enforcing the HC policy may be warranted to ultimately increase player safety.

Our results should be interpreted within the context of the study's limitations. This study evaluated the rate of HCs and not concussions, although previous research has shown a strong association between HCs and concussion in a sports setting.[10] Video analysis provides an underestimation of all PCs on the ice, as some contacts occur outside of the frame of the camera. However, we do not believe this underestimation differed between the cohorts. Video quality differed slightly between cohorts because of technological advances in camera quality over the 5 years of the study. This may have resulted in an underestimation of PCs coded in the 2008-2009 season and a minor underestimation of the differences across all PC types. Last, the rate of penalties within the 2013-2014 cohort differed between the playoff games and regular season games. This could potentially have led to some variation in player gameplay, although contact behaviors were similar, as shown by the sensitivity analysis. Future research should explore the effectiveness of the "zero tolerance for HC" policy after more years of implementation and referee training.

CONCLUSION

Overall, the "zero tolerance for HC" Canadian national policy change in 2011 did not lead to a lower HC rate in elite U15 youth ice hockey. The proportion of HCs that were penalized did not differ between the study cohorts and accounted for 12.7% (2008-2009 cohort) and 13.8% (2013-2014 cohort) of all HCs coded during video analysis. We believe the HC policy change could be more strongly enforced by the referees. Stricter penalty assessment should be addressed and perhaps more education provided for referees. These study findings can inform Hockey Canada regarding referee training and potential future HC policy changes to increase the safety of all youth ice hockey players.

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