

RISK FACTORS FOR HAND INJURY IN HURLING- A COHORT STUDY

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34	A	rticle Focus –
35	•	Mandatory use of head and face protection in the Irish sport of hurling over
36		the past 10 years has been accompanied by a marked improvement seen
37		in head and facial injury rates.
38	•	These improved rates have not been seen in hand injury, where rates
39		have remained high, this despite the availability of a commercially
40		available
41	•	This study was designed to investigate the rates of hurling-related hand
42		injury, to examine some of the risk factors for hurling-related hand injury,
43		and to assess player attitudes to commercially available hand protection.
44	K	ey Messages –
45	•	This work however emphasises the high incidence of hand injury, which
46		remains in hurling.
47	•	The study has attempted to highlight risk factors for this, and, we feel,
48		poses some questions as to the behavioural changes that may accompany
49		the introduction of safety equipment.
50	•	This work may encourage further investigation of this issue that may help
51		to guide future rule changes and laws.3) Strengths and Limitations.
52	St	rengths and Limitations of this study -
53	•	This study is one of the first to address player attitudes towards; and
54		acceptance of; available hand protection in hurling. It may also raise some
55		questions regarding impact of protective equipment on other parts of the
56		body.

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57	• The retrospective nature of the self recorded data obtained by telephone
58	interview but initial ED presentation was gathered prospectively with
59	follow-up performed to investigate injury causation
60	The 82% response rate which may have resulted in selection bias within
61	the responses.
62	
63	ABSTRACT
64	Objectives: Hurling is Ireland's national sport, played with a stick and ball;
65	injury to the hand is common. A decrease in head injury incidence has
66	coincided with mandatory use of helmet and face protection since 2003.
67	Similarly decreased injury rates have not occurred in hand injury. We aim to
68	assess the incidence of hurling-related hand injury based on ED presentations
69	and examine the variables, which may be associated with his incidence.
70	Design: This study utilised a retrospective cohort study design
71	Setting: This study took place at a single university hospital emergency
72	deparment. Consecutive hurling-related presentations over a 3-month period
73	were recorded.
74	Outcome measures: A follow-up telephone interview was performed with 163
75	adult players- paediatric patients were excluded to reflect voluntary versus
76	obligatory helmet use.
77	Results: The hand was most often injured n= 85 (52.1%). Hand injury most
78	commonly occurred from a blow of a Hurley n=104 (65%), fracture was
79	confirmed in 62% of cases. Two thirds of players (66.3%) had multiple
80	previous (1-5) hand injuries. A trial of commercially available hand protection
81	was noted in 95.4% of patients. At the time of injury 4.9% used hand

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82	protection. Univariate analysis of the risk factors for hand injury have shown a
83	statistically significant association between wearing a helmet and faceguard;
84	Odds Ratio (OR) 2.76 (Confidence Interval (CI) 1.42-5.37) p=0.003, prior
85	injury (OR =1.88, CI=1.46-4.94 p= 0.032), and being struck by a hurley (OR =
86	2.31 CI=1.23-5.22 p= 0.009)
87	
88	Conclusions: Hurling-related hand injury remains common. We noted low
89	uptake of hand protection. Those suffering a hand injury were twice as likely
90	to have been struck by a hurley, and nearly twice as likely to have a previous
91	hand injury, than when other body parts were injured. Recent gains in
92	management of head injury may be replicated if hand protection use were
93	obligatory.

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94 INTRODUCTION

Hurling is the national sport of Ireland and is also played throughout the world,
among members of the Irish diaspora in North America, Europe, Australia,
New Zealand, South Africa and Argentina.

Thought to predate Christianity, hurling has been a distinct Irish pastime for at least 2000 years. One of Irelands' native Gaelic sports, it shares much with Scottish shinty, cammag played on the Isle of Man, and Bandy in Wales and England. Hurling was played in Ireland in ancient times by teams representing neighboring villages. Games involved hundreds of players, which would last several hours or even days. In 1904, hurling was an unofficial demonstration sport in the St Louis Summer Olympic games and in the final; Chicago (Fenian FC) defeated St Louis (Innisfails FC). Reputedly one of the fastest team field sports, this amateur game is played by two teams of fifteen players who compete for a leather-bound ball (*sliotar*) using a metre-long piece of ash wood (hurley) as a bat (fig 1). The standard hurling pitch is 135 – 145 m long and 80 – 90 m wide. Two posts, which are set 6.4 m apart, and connected above the ground by a crossbar, form the goals at each end. A ball hit over the bar is worth one point. A ball that is hit under the bar is called a *goal* and is worth three points

Hurling differs from field hockey and lacrosse in that the *sliotar* can be caught in the hand and carried for not more than four steps, struck in the air, or struck on the ground with the Hurley. Further, when the ball is struck for longer

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distances one of the greatest arts of the games is to jump and field the ball-while opponents are free to strike the ball with their hurley (fig 1). The player may kick or slap the ball with an open hand (the hand pass) for short-range passing.

A 1984 study of Emergency Department (ED) presentations due to hurling injuries, noted that 28% of presentations were facial and head injuries and 36% were hand injuries. Nine years later following the voluntary introduction of helmet and face protection the absolute number of presentations to ED due to hurling injury had almost halved. The site of injury had also changed with 20% of presentations due to head injury and 56% due to hand injury. This apparent rise in hand injury was also noted in other studies. (1, 2)

Hand protection available at the time of study was the commercially available Ashqard[™] by O'Dare, (fig. 2) constructed of neoprene and elasticised fastenings, this apparatus focused primarily on the metacarpal bones. The authors noted relatively poor levels of use of this equipment. This despite published injury rates and recommendations. (1, 2)

This paper aims to assess the incidence of hand injury in adult hurling players based on ED presentations, and to examine the risk factors for hand injury among hurling participants.

MATERIALS AND METHODS

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Consecutive hurling-related injuries over a 3-month period presenting to the ED of a university hospital were recorded. Each patient had a questionnaire completed by their treating emergency room physician regarding the nature and circumstances of their injury and their subsequent investigations and management. From this group, adult (age >16 years) hurling injuries were recorded. A subsequent telephone interview with the adult patients was performed. Prior to performing the interview, patients were contacted by telephone to give their

to performing the interview, patients were contacted by telephone to give their
consent to their participation in the study. The subjects also received
background information about the study based on the Ethics committee
approval as well as a plain language statement. Telephone calls followed a
scripted protocol to avoid investigator bias. The questionnaire consisted of
questions focussing on:

158 — Site of injury.

- 159 Mechanism of injury.
- 160 Protective equipment in use at the time of injury.
- 161 Previous injury.
- 162 Previous use of protective equipment.
- 163 Reasons for discontinuing use of protective equipment

165 Previous injury was defined as a physical injury, suffered while playing 166 hurling, resulting in at least one game missed. To aid analysis upper limb

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injuries were classed as proximal or distal depending on the site of injurybeing proximal to and including the wrist or distal to the wrist respectively.

Ethical approval was secured from the relevant Teaching Hospitals EthicsCommittee.

173 Statistical analysis

Distributions were summarised using means (standard deviations) or medians (intra-quartile range) as appropriate. Proportions were compared using Chi square tests. Univariate associations of upper limb injury were examined using logistic regression. The presence, strength, independence, and significance of upper limb injury with the use of helmet with faceguard was quantified using logistic regression, adjusting simultaneously for age, previous hand injury, being struck dorectly by a hurley and foul play. The risk for hand injury was analysed by comparing risk factors and injury mechanism in those who had suffered a confirmed upper limb injury (n=100) and those injured elsewhere (n= 66).

RESULTS

Hurling-related injuries for 430 patients were reviewed from 3172 consecutive sports injuries presenting in the defined period. Of 199 identified and suitable adult patients, 27 subjects were uncontactable, and 9 declined to participate. The total response rate was 82% of possible subjects.

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Interviews were conducted with 17 women and 146 men (n= 163). Average
time to follow-up was 39 weeks (range 28 – 48 weeks) post injury. Patient's
ages ranged from 17-39 years (mean 23.52 years). The majority of injuries
occurred in organised competition or supervised practice, n = 155 (95%).

196 Injury site and mechanism of injury:

The most commonly injured site (Table 1) was upper extremity distal to wrist, 85 (52.1%) followed by lower limb 30 (18.4%) with 27 head injuries (16.6%). A statistically significant number of the distal upper limb injuries sustained from a blow of a hurley were fractures n=46 (62%) [P< 0.001]. The most commonly injured digits were the 1st (n= 16, 35%) and 5th (n=15, 33%), table 2. The metacarpal bones were most commonly fractured (n=17, 37%) followed by the proximal phalanges (n=15, 33%)

Table 1

Patient demographics, protection used, injury severity

Variable	Outcome
Age (Mean)	17-39yr (23.52)
Gender	
Female	17 (10%)
Male	146 (90%)
Site Injured	
Distal Upper limb	85 (52.1%)
Proximal upper limb	15 (9.2%)
Lower limb	30 (18.4%)
Axial	33 (20.3%)
Protection used:	
Helmet with faceguard	106 (65%)
Hand protection	8 (5%)
Hand Injury severity	
Fracture	74 (45.4%)
Risk Factors for Hand Injury	
Foul play	26 (15.9%)
Struck by hurley	104 (63.8%)
Previous hand injury	82 (50.4%)

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212	Previous injury:
213	Most patients had suffered at least one injury in the past, n = 116 (71.2%), two
214	thirds of patients had between 1 and 5 previous injuries (n = 108, 66.3%).
215	Eight patients (4.9%) had more than six previous injuries. Fifty percent (n =
216	82) of patients had previously suffered an upper limb injury, 39% (n = 64) had
217	suffered a prior head injury, and a fifth $(20.9\% (n = 34))$ had experienced both.
218	One third (35%) of those presenting with a fracture to the hand or fingers had
219	suffered a prior fracture to the area. A history of previous upper limb injury

220 was a risk factor for further injury of the area, OR 1.31 (1.02-1.68).

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Protection used: 222

Only 8 (4.9%) used hand protection (Ashgard[™] by O'Dare, fig. 2), while 114 223 224 (69.9%) had tried it in the past. Helmet with face protection was used by 65% 225 (n = 106). At the time of study helmet and faceguard use was voluntary in 226 adult participants. Previous trial of helmet with face-guard, and hand 227 protection was reported by 154 (94.5%), 149 (91.4%) respectively. Given this 228 high trial-rate, yet poor uptake, respondents were asked why they had 229 discontinued use. Most respondents, n=123 (75.4%), described poor utility 230 citing issues such as bulkiness and diminished dexterity. More than half, n= 231 95 (58.3%) felt protection was inadequate rendering the hand protection 232 ineffective. When asked about potential interest in new protective equipment, 233 121 (74.2%) felt they would try a newly designed glove.

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Risk factors for hand injury (table 2, 3):					
Univariate analysis of the risk factors for hand injury has shown a statistical					
significant associa	ation between prior i	niury wearing a he	lmet and fa		
and being struck	t by a nurley. The	later two relations	snips persi		
multivariate analys	multivariate analysis respectively, independent of adjusted variables.				
Table 2:					
Univaria	Univariate Analysis for risk factors for hand injury in hurling				
	Upper limb injury	OR (95% CI)	p-value		
Helmet with	Yes	2.76 (1.42-5.37)	0.003		
faceguard					
	No	1 (reference)			
Previous hand	Yes	1.88 (1.46-4.94)	0.032		
injury	No	1 (105010000)			
	INO	T (reference)			
A ge	16-24 vrs	1.05 (0.56-1.97)	0.88		
790	> 24 yrs	1.00 (0.00-1.07)	0.00		
	21 910				
Struck by a	Yes	2.31 (1.23-5.22)	0.009		
hurley					
	No	1 (reference)			
Foul play	Yes	1 01 (0 43-2 4)	0 083		
		1.01 (0.40-2.4)	0.000		

OR= Odds Ratio, CI= Confidence interval

3:

Multivariate analysis of risk factors for hand injury.

Category	OR (95% CI) for upper limb	p-value
Helmet with	3.15 (1.51-6.56)	0.002
faceguard		
Struck by a hurley	1.99 (1.24-3.8)	0.013
Age from mean	0.82 (0.4-1.68)	0.59
Previous hand injury	1.73 (0.90-2.6)	0.73
Foul Play	1.32 (0.49-3.5)	0.98

OR= Odds Ratio, CI= Confidence interval

257 Impact of hand injury:

A week or more of play was lost by 152 (93.3%) of those injured, 89 (54.6%)

lost more than 4 weeks. Due to their injuries, 71 (43.6%) people missed work,

with 26 (16%) people missing more than 4 weeks of work.

263 DISCUSSION

The incidence of head and facial injury in hurling has continued to decrease, while the relative incidence of hand injury has continued to be high at 52% of ED presentations when compared to 1993 figures (56%).(1) Despite this, only 8% of adults reported use of commercially available hand protection, this

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compared to 9.8% seen in a 2003 study.(2) No rules are enforced in this sport
regarding hand protection use. In the US the National Collegiate Athletic
Association (NCAA) dictates that gloves be worn in intercollegiate stickhandling sports (men's lacrosse, women's lacrosse, and men's ice hockey).(35) These sports have similarities to hurling. The puck or ball is not handled by
outfield players in these sports, however, making the technical requirements
of a protective glove different- offering protection without impeding play.

Previous injury patterns reported by patients may provide some insight into risk factors as 50% of patients had previously suffered an upper limb injury, 39% had suffered a prior head injury, with 21% experiencing both in the past. This study does not address why those who had suffered prior head injury but continued to play were more likely to have adopted head protection when those who had hand injury did not tend to habitually use this equipment. This may in part be due to the large emphasis placed on head protection (1, 6, 7)by the sports body and injury commentators. Little emphasis has been placed on hand injury and protection.(2) The utility and function of commercially available hand-guards may also play a role. The Ashgard[™] model was described as 'uncomfortable' and 'bulky' by players, and did not protect beyond the first phalanx, 35% of fractures were seen beyond this site (n=16). A more anatomically correct model (Mycro Long Finger Glove[™]) has been available on the market in recent times (fig 3), this protects the metacarpals, and offers greater protection for the phalanges, utilising hardened plastics over the phalanges – providing protection without loss of dexterity.

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The significant relationship of a number of risk factors such as helmet use; being struck by a hurley; and previous hand injury may represent altered behaviour on behalf of both the injured party and the party causing the injury. Many involved in the game of hurling such as players, coaches and commentators feel that the use of helmet and face protection has altered player behaviour leading to more hazardous playing style. The concept of risk 'compensation' or 'homeostasis' has been questioned following the introduction of many safety measures in many sports such as American football (8, 9), cycling (10) and even on the introduction of the automobile seatbelt. (11, 12)

The majority of the injuries reported upon in this study occurred during organised competition or supervised practice at club events. The apparent success of the introduction of head and facial protection occurred because this level of regular supervision allows the enforcement of mandatory use laws. The use of helmet and facial protection was made mandatory for first all under-18 players, then all under-21 players in 2003 and 2005 respectively. We studied our group in the period prior to 2010 when it became mandatory to wear this protection for all players. Players are not insured to train or play at their clubs without the correct protection. Mandatory use of hand protection could conceivably see the incidence of hand injury drop in a similar fashion.

This data shows the impact of upper limb and hand injury both on return to sport, or financially in terms of medical expense and time lost from work.

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Almost one-fifth of all hurling related hand injuries resulted in more than 4 weeks off from work. Though upper limb injury is often regarded as being less serious than head injury such as eye injury, studies have shown that hand is likely to take longer to return to pre-injury activity than injury to other parts of the body. (13, 14) Trybus et al. showed more than 50% of hand injuries presenting to a specialist centre suffered persistent post-traumatic disability.

(14)

Limitations of this study included the (a) retrospective nature of the self recorded data obtained by telephone interview but initial ED presentation was gathered prospectively with follow-up performed to investigate injury causation and (b) the 82% response rate which may have resulted in selection bias within the responses. This work emphasises the high incidence of hand injury, which remains in hurling. The study has attempted to highlight risk factors for this, and, we feel, poses some questions as to the behavioural changes that may accompany the introduction of safety equipment. This work may encourage further investigation of this issue that may help to guide future rule changes and laws. The sports body (Gaelic Athletic Association) should consider making the use of properly manufactured hand protection mandatory.

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350 Competing Interests:

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Conflict of Interest Statements:

359 All of the authors wish to declare that they do not now, and never have, and

360 conflict of interests pertaining to this work.

361 Contributorship:

All of the listed authors contributed significantly to this work from genesis to completion. From the conception and design of the study, data collection, and data interpretation also to the drafting and revision of the manuscript.

Data Sharing:

This study is part of a thesis being prepared for submission to the National University of Ireland for consideration for PhD- data will be available in thesis format.

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Fig 1: Hurling: Aerial Battle- the ball may be struck or caught in the air 374x243mm (300 x 300 DPI)



Figure 2: Typical action, showing players with helmet, helmet and face protection, and hand protection, the AshgardTM hand glove is shown in inset. 361x270mm (72 x 72 DPI) BMJ Open: first published as 10.1136/bmjopen-2013-002634 on 16 May 2013. Downloaded from http://bmjopen.bmj.com/ on June 7, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) . Protected by copyright, including for uses related to text and data mining, Al training, and similar technologies.

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Figure 3 the more recent Mycro Long Finger GloveTM offering greater protection to the phalanges 260x195mm (300 x 300 DPI)

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BMJ Open

Title: RISK FACTORS FOR HAND INJURY IN HURLING – A COHORT STUDY

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STROBE Guidelines Checklist:

Introduction Background/rationale: COMPLETED Aims: COMPLETED

Methods

Study design: COMPLETED Setting: COMPLETED Participants: COMPLETED Variables: NA Data sources/measurement: COMPLETED Bias: NA Study size: COMPLETED Quantitative variables: NA Statistical methods: COMPLETED

Results

Participants: COMPLETED **Descriptive data: COMPLETED** Outcome data: NA Main results: COMPLETED Other analyses: COMPLETED Discussion

Key results: COMPLETED Limitations: COMPLETED Interpretation: COMPLETED Generalizability: COMPLETED **Other information** Funding: COMPLETED



RISK FACTORS FOR HAND INJURY IN HURLING-A RETROSPECTIVE CROSS-SECTIONAL COHORT STUDY

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1 2 3 4 5 5 2 6 3 7 8 4 5	RISK FACTORS FOR HAND INJURY IN HURLING- A RETROSPECTIVE CROSS-SECTIONAL COHORT STUDY			
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37	Ar	ticle Focus –
38	•	Mandatory use of head and face protection in the Irish sport of hurling over
39		the past 10 years has been accompanied by a marked decrease in
40		presentation of head and facial injury to the ED.
41	•	These improved figures have not been seen in hand injury, where
42		presentations to the ED have remained high, this despite the availability of
43		a commercially available hand protection device.
44	•	This study was designed to quantify the occurrence of hurling-related hand
45		injury presenting to the ED, to examine some of the variables associated
46		with hurling-related hand injury. To investigate the impact these injuries
47		had on work and sports particiapation and to assess player attitudes to
48		commercially available hand protection.
49	Ke	ey Messages –
50	٠	This work emphasises the high proportion of hand injury among hurling-
51		related injury presentation to the ED, which remains in hurling.
52	•	This study highlights a number of factors related to hand injury and poses
53		some questions as to the behavioural changes that may accompany the
54		introduction of safety equipment.
55	٠	This work shows a statistically significant association between helmet and
56		face-guard use and hand injury among hurling-related injury presentation
57		to the ED.
58	S	trengths and Limitations of this study -
59	•	This study is one of the first to address player attitudes towards; and
60		acceptance of; available hand protection in hurling. A causal relationship
61		between the use of protective equipment and injury at a remote site is not

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62	established but this work poses a number of questions, which warrant
63	further study.
64	The retrospective nature of the self recorded data obtained by telephone
65	interview but initial ED presentation was gathered prospectively with
66	follow-up performed to investigate injury causation
67	The 82% response rate which may have resulted in selection bias within
68	the responses.
69	
70	ABSTRACT
71	Objectives: Hurling is Ireland's national sport, played with a stick and ball;
72	injury to the hand is common. A decrease in the proportion of head injury
73	among emergency department (ED) presentations for hurling-related injury
74	has coincided with voluntary use of helmet and face protection since 2003. A
75	similar decrease in proportions has not occurred in hand injury. We aim to
76	quantify hurling-related ED presentations and examine variables associated
77	with injury. In particular we were interested in comparing the occurrence of
78	hand injury in those using head and face protection versus those who did not.
79	Design: This study utilised a retrospective cross-sectional cohort study design
80	Setting: This study took place at a university hospital ED over a 3-month
81	period.
82	Outcome measures: A follow-up telephone interview was performed with 163
83	players aged ≥16 years- to reflect voluntary versus obligatory helmet use.
84	Results: The hand was most often injured n= 85 (52.1%). Hand injury most
85	commonly occurred from a blow of a hurley n=104 (65%), fracture was
86	confirmed in 62% of cases. Two thirds of players (66.3%) had multiple

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87	previous (1-5) hand injuries. Most patients 149 (91.4%) had tried
88	commercially available hand protection, only 4.9% used hand protection
89	regularly. Univariate analysis showed statistically significant association
90	between wearing a helmet and faceguard and hand injury; Odds Ratio (OR)
91	2.76 (95 % Confidence Interval (CI) 1.42-5.37) p=0.003. On further analysis
92	adjusting simultaneously for age, prior injury, foul play and being struck by a
93	hurley this relationship remained significant, (OR = 3.15 CI=1.51-6.56, p=
94	0.002).
95	
96	Conclusions: We report that hurling-related hand injury is common. We noted

- 97 low uptake of hand protection. We found that hand injury was significantly
- 98 associated with use of helmet and faceguard protection, independent of other
- 99 factors studied. Further studies are warranted to develop strategies to
- 100 minimise the occurrence of this injury.

Hurling is the national sport of Ireland and is also played throughout the world, among members of the Irish diaspora in North America, Europe, Australia, New Zealand, South Africa and Argentina.[1] Thought to predate Christianity, hurling has been a distinct Irish pastime for at least 2000 years, stories of the hurling feats of Irish mythological heros such as Setanta are recorded in ancient 12th century texts such as *Lebor Laignech* (The Book of Leinster).[2] One of Irelands' native Gaelic sports, it shares much with Scottish shinty,[3] cammag played on the Isle of Man, and Bando in Wales and England.[4] Hurling was played in Ireland in ancient times by teams representing neighboring villages. Games involved hundreds of players, which would last several hours or even days. In 1904, hurling was an unofficial demonstration sport in the St Louis Summer Olympic games and in the final; Chicago (Fenian FC) defeated St Louis (Innisfails FC).[5]

Reputedly one of the fastest team field sports, this amateur game is played by two teams of fifteen players who compete for a leather-bound ball (sliotar) using a metre-long piece of ash wood (hurley) as a bat (fig 1). The standard hurling pitch is 135 – 145 m long and 80 – 90 m wide. Two posts, which are set 6.4 m apart, and connected above the ground by a crossbar set at a height of 2.5 m, form the goals at each end. A ball hit over the bar is worth one point. A ball that is hit under the bar is called a goal and is worth three points.[6]

> Hurling differs from field hockey and lacrosse in that the *sliotar* can be caught in the hand and carried for not more than four steps, struck in the air, or struck on the ground with the hurley. Further, when the ball is struck for longer distances one of the greatest arts of the game is to jump and field the ballwhile opponents are free to strike the ball with their hurley (fig 1). The player may kick or slap the ball with an open hand (the hand pass) for short-range passing.

> In a 1984 study of Emergency Department (ED) presentations due to hurling injuries. Crowley et al noted that 28% of presentations were facial and head injuries and 36% were hand injuries.[7] Nine years later following the voluntary introduction of helmet and face protection the absolute number of presentations to ED due to hurling injury had almost halved.[8] The ratio of presentations of site of injury had also changed with 20% of presentations due to head injury and 56% due to hand injury. This relative rise in hand injury was also noted in a further study by Kiely.[9]

The most widely used, dedicated hand protection for hurling, commercially available was the AshgardTM glove by O'Dare (fig. 2). This is constructed of neoprene and elasticised fastenings, this apparatus focuses primarily on protecting the metacarpal bones. This was the most commonly used device at the time of our study. Anecdotally, and in discussion with other physicians caring for the hurling community, (personal communication Prof M G Molloy) we observed relatively poor levels of use of this equipment. This despite published ED injury presentations and recommendations.[8 9]

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151 This study aims to quantify the occurrence of hurling-related hand injury 152 presenting to the ED and examine the variables, which may be associated 153 with hand injury. In particular, to assess the association of helmet and facial 154 protection with the occurrence of hand injury in this population, and to 155 describe the impact that this has on time lost from play and work.

156

157 MATERIALS AND METHODS

158 Consecutive hurling-related injuries over a 3-month period, July to September, 159 in 2006 presenting to the ED of a university hospital were recorded. At the 160 time of each patient's assessment a questionnaire was completed by their 161 treating emergency room physician regarding the nature and circumstances of 162 their injury and their subsequent investigations and management.

163

164 In total 430 hurling-related inuries presented to the ED in the defined period. 165 Due to the enforcement of the use of helmet and face protection by many 166 juvenile clubs (catering for players of 16 years and younger), we excluded this 167 population (n=231). This enabled a true reflection of equipment use in the 168 adult/voluntary setting. The remaining 199 patients were contacted for a 169 telephone interview. Prior to the interview, patients were contacted by 170 telephone to give their consent to their participation in the study. Interviews 171 were completed within 90 days of initial presentation to the ED (Mean 68 days 172 (15-88)). The subjects also received background information about the study 173 based on the Ethics Committee approval as well as a plain language 174 statement. Telephone calls followed a scripted protocol to avoid investigator 175 bias. The questionnaire consisted of questions focusing on:

176	
177	— Site of injury;
178	— Mechanism of injury;
179	 Protective equipment in use at the time of injury;
180	— Previous injury;
181	 Previous use of protective equipment;
182	 Reasons for discontinuing use of protective equipment.
183	
184	Those who had tried but discontinued hand protection were given five
185	potential options as to why they discontinued use of hand protection:
186	— Discomfort
187	 Ineffective protection
188	— Limitation in performance
189	— Poor aesthetics
190	— Expense
191	Those players who had discontinued use of hand protection were asked if
192	they would consider trialling different protection if it were to become
193	commercially available.
194	Previous injury was defined as a physical injury, suffered while playing
195	hurling, resulting in at least one game missed. To aid analysis of data upper
196	limb injuries were classed as proximal or distal. A proximal upper limb injury
197	occurred at the wrist or in the upper limb proximal to the wrist (forearm, elbow
198	or shoulder) a distal upper limb injury described all upper limb injury distal to
199	the wrist. An injury which resulted from an action of an opposing player which
200	was penalised by the referee was documented as 'foul play'.

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We were particularly interested in exploring the use of protective equipment and whether or not this impacted on injury presentations to the ED. Based on the hypothesis that use of protective equipment has been linked to increased levels of "risky behaviour" we focused particularly on those with serious hand injury and whether they used helmet and face protection.

207 The study proposal was approved by the Clinical Research Ethics Committee208 of the Cork Teaching Hospitals.

210 Statistical analysis

Tests for normality were performed using Shapiro-Wilks test. All variables in the analysis were normally distributed and therefore described using means and standard deviations. Proportions were compared using Chi square tests. Univariate associations of upper limb injury were examined using logistic regression analysis. The presence, strength, independence, and significance of upper limb injury with the use of helmet with faceguard was guantified using logistic regression. This was adjusted simultaneously for age, previous hand injury, being struck directly by a hurley and foul play. Variables that were significant using Pearson chi-squared test were included in the multivariate logistic regression model as were those variables deemed clinically important. The final model examines the association of upper limb injury with use of helmet and face-guard, adjusted simultaneously for age, previous hand injury, being struck directly by a hurley and foul play. The factors associated with hand injury were analysed by comparing those with confirmed upper limb

injury (n=100) with those injured elsewhere (n= 63). Analysis was performed
using SPSS version 12 (Chicago, Illinois).

228 RESULTS

Hurling-related injuries for 430 patients were reviewed from 3172 consecutive sports injuries presenting in the defined period. Of 199 identified and suitable patients, 27 subjects were uncontactable, and 9 declined to participate. The total response rate was 82% of possible subjects. Data on 163 patients were included.

Interviews were conducted with 17 women and 146 men (n= 163). Average
time to follow-up was 39 weeks (range 28 – 48 weeks) post injury. Patient's
ages ranged from 17-39 years (mean 23.52 yr). The majority of injuries
occurred in organised competition or supervised practice, n = 155 (95%).

240 Injury site and mechanism of injury:

The most commonly injured site (Table 1) was the upper extremity distal to wrist, 85 (52.1%) followed by lower limb 30 (18.4%), with 27 head injuries (16.6%). A statistically significant number of the distal upper limb injuries sustained from a blow of a hurley were fractures n=46/74 (62%) [p< 0.001]. compared to soft tissue injury (laceration, ligamentous injury) n=28/74 (38%) [Pearson Chi square p<0.001]. The most commonly injured digits were the 1st (n= 16, 35%) and 5th (n=15, 33%), table 2. The metacarpal bones were most commonly fractured (n=17, 37%) followed by the proximal phalanges (n=15,

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 32%), the middle phalanx was least likely fractured (n=4, 8%) and the distal

phalanx was fractured in 10 cases (22%).

Table 1

Patient demographics, protection used, injury severity

Patient Characteristics	Total n=163 (%)	Hand Injury n= 100 (%)	No Hand Injury n=63 (%)	P value	
Age, yrs					
Range	17-39yr	17-33yr	17-39yr		
Mean (sd)	23.51 (4.1)	23.51 (4.2)	23.52 (4.1)		
Gender					
Female	17 (10)	10 (10)	7 (11)		
Male	146 (90)	90 (90)	56 (89)		
Site Injured					
Distal Upper limb	85 (52.1)	85			
Proximal upper limb	15 (9.2)	15			
Lower limb	30 (18.4)		30 (48)		
Axial	33 (20.3)		33 (52)		
Protection used:					
Helmet with					
faceguard	106 (65)	74	32 (51)	0.002	
Hand protection	8 (5)	4	4 (6)	NS	
Injury severity					
Fracture	74 (45.4)	60	14 (22)	<0.001	
Variables associated					
with Injury				-	
Foul play	26 (15.9)	16	10 (16)	NS	
Struck by hurley	104 (63.8)	74	30 (60)	NS	
Previous hand injury	82 (50.4)	57	25 (40)	0.03	

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Previous injury:

Most patients had suffered at least one injury in the past, n = 116 (71.2%),

two thirds of patients had between 1 and 5 previous injuries (n = 108, 66.3%).

Eight patients (4.9%) had more than six previous injuries. Fifty percent (n =

- 82) of patients had previously suffered an upper limb injury, 39% (n = 64) had
- suffered a prior head injury, and a fifth (20.9% (n = 34)) had experienced both.

One third (35%) of those presenting with a fracture to the hand or fingers had
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suffered a prior fracture to the area. A history of previous upper limb injurywas associated with further injury of the area, OR 1.31 (95% CI1.02-1.68).

Protection used:

Only 8 (4.9%) used hand protection (Ashgard[™] by O'Dare, fig. 2), while 149 (91.4%) had tried it in the past. Helmet with face protection was used by 65% (n = 106). At the time of study helmet and faceguard use was voluntary in adult participants. Previous trial of helmet with face-guard, and hand protection was reported by 154 (94.5%). Given this high trial-rate, yet poor uptake, respondents were asked why they had discontinued use. Most respondents, n=123 (75.4%), described poor utility citing issues such as bulkiness and diminished dexterity. More than half, n= 95 (58.3%) felt protection was inadequate rendering the hand protection ineffective. When asked about potential interest in new protective equipment, 121 (74.2%) felt they would try a newly designed glove.

283 Univariate associations with hand injury (table 2):

Univariate analysis of the variables associated with hand injury demonstrated a statistically significant association between prior injury, wearing a helmet and faceguard and being struck by a hurley. The later two relationships persisted on multivariate analysis respectively, independent of adjusted variables.

Univariate associations with hand injury in hurling

OR (95% CI)

2.76 (1.42-5.37)

1.88 (1.46-4.94)

1.05 (0.56-1.97)

2.31 (1.23-5.22)

1.01 (0.43-2.4)

p-value

0.003

0.032

0.88

0.009

0.983

1			
2 3 290 4 201	Table 2:		
4 291 5 292 6 293	Univ	variate associations	with
7 200		Upper limb injury	0
9	N=	n=100	
10	Helmet with	Yes n=74	2.
11 12	faceguard	No n= 26	
13 14	n=106		
15	Previous hand	Yes n= 57	1.
16	injury	No n= 43	
18 19	n=82	6	
20	<u>Ago</u>	16-24 yrs n=52	1
21	n=163	> 24 yrs n=48	
23			
24			
25 26	Struck by a hurley	Yes n=74	2.
27	n=104	No n=26	
28 29			
30			
31	Foul play	Yes n=16	1.
32 33	n=26	No n=84	
34 294 35 295 36 296 37 296 38 297 40 41 41 42 43 44 45 46 47 48 49 50	OR= Odds Ratio,	CI= Confidence inte	rval

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298 Table 3:

Logistic Regression analysis of the association of hand injury with helmet and
 faceguard use (OR, 95% CI).

Category	OR (95% CI) for Upper Limb injury	p-value
Helmet with faceguard	3.15 (1.51-6.56)	0.002
Struck by a hurley	1.99 (1.24-3.8)	0.013
Age from mean	0.82 (0.4-1.68)	0.59
Previous hand injury	1.73 (0.90-2.6)	0.73
Foul Play	1.32 (0.49-3.5)	0.98

OR= Odds Ratio, CI= Confidence interval

308 Impact of hand injury:

A week or more of play was lost by 152 (93.3%) of those injured, 89 (54.6%)

310 lost more than 4 weeks. Due to their injuries, 71 (43.6%) people missed work,

311 with 26 (16%) people missing more than 4 weeks of work.

314 DISCUSSION

We report that in this retrospective cross-sectional study of 163 hurling players presenting to a university hospital emergency department with hurling --related injury, hand injury was significantly associated with use of helmet and facial protection, independently of age, previous hand injury, being struck directly by a hurley and foul play. While in this cross-sectional study we cannot demonstrate causality, this finding raises interesting questions

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regarding the epidemiology of hurling-related hand injuries in the era ofvoluntary helmet and face protection use in hurling.

Published data on the incidence of hurling-related hand injury is sparse. The available literature however suggests that while the occurence of head and facial injury in hurling has fallen, the proportion of players presenting with hand injury remains essentially unchanged. Crowley et al. reported that 52% of ED presentations for hurling injury were injuries to the hand. Eight years later this proportion was similar at 56%,[8] and is comparable to the 62% observed in the current study. Despite hand injury being a common occurrence only 8% of adults reported use of commercially available hand protection, similar to the 9.8% reported by Kiely et al. in a 2003 study.[9] No rules are enforced in hurling regarding the use of hand protection. In the US the National Collegiate Athletic Association (NCAA) dictates that gloves be worn in intercollegiate stick-handling sports (men's lacrosse, women's lacrosse, and men's ice hockey).[10-12] These sports have many similarities to hurling. The major difference between these sports and hurling is that the puck or ball is not handled by outfield players. Therefor a bulky glove may be worn without affecting dexterity or impeding play. The technical requirements of a hand protection device in hurling therefore differ and at the time of study had not gained acceptance among those players presenting to the ED.

343 Previous injury patterns reported by patients may provide some insight into 344 the role of an individual's behaviour in exposure to further injury. We report 345 that 50% of patients had previously suffered an upper limb injury, 39% had

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suffered a prior head injury, with 21% experiencing both in the past. Sixty-five percent of this cohort wore helmet and face protection voluntarily. demonstrating risk awareness regarding potential head and facial injury. A similar usage of hand protection was not observed. Why the majority of players would adopt head and face protection while discontinuing hand protection use cannot be addressed in this cross-sectional study. This may in part be explained by the large emphasis placed on head protection [7 8 13] by the sports body and injury commentators. Little emphasis has been placed on hand injury and protection.[9] The utility and function of commercially available hand-guards may also play a role. The Ashgard[™] model was described as 'uncomfortable' and 'bulky' by players, and did not protect beyond the first phalanx, 30% of fractures were seen beyond this site (n=14). A more anatomically correct model (Mycro Long Finger Glove[™]) has been available on the market in more recent times (fig 3). This glove protects the metacarpals, and offers greater protection for the phalanges, utilising hardened plastics over the phalanges - providing protection without loss of dexterity.

The significant relationship of a number of variables such as helmet use; being struck by a hurley; and previous hand injury may represent altered behaviour on behalf of both the injured party and the party causing the injury. It could be argued that the use of helmet and face protection has altered player behaviour leading to more hazardous playing style. The concept of risk 'compensation' or 'homeostasis' has been debated following the introduction of many safety measures in many sports such as American football,[14 15]

cycling[16] and even on the introduction of the automobile seatbelt.[17 18] In American football the evolution of the helmet over 50 years from a leather helmet to a metal and plastic hardshell helmet with faceguard drastically change tackle patterns. The 'spear tackle' saw player tackle with the head rather than shoulder- this was accompanied by a dramatic rise in catastrophic brain and cervical spine injury. Banning the spear tackle and ensuring helmet specifications led to a 42% decrease in brain and spinal injury over a 5 year period.[15] It has been argued that cyclists are less likely to ride cautiously when wearing a helmet owing to their feeling of increased security.[16] A level of perceived safety has been postulated to lead to increased levels of 'risky behaviour'[18]- in hurling it could be postulated that helmet with face protection increases the likelihood that a player will attempt a more risky aerial catch such as seen in figure 1.

The majority of the injuries reported upon in this study occurred during organised competition or supervised practice at club events. The apparent success of the introduction of head and facial protection occurred because this level of regular supervision allows the enforcement of mandatory use laws. The use of helmet and facial protection was made mandatory for initially all players under-18, then all players under-21 in 2003 and 2005 respectively. We studied our group in the period prior to 2010 when it became mandatory to wear this protection for all players. Players are not insured to train or play at their clubs without the correct head and face protection. Further prospective studies evaluating the effect of hand protection on the occurrence of hurling-

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related hand injury are warranted to determine if the mandatory use of suchprotective equipment would result in a comparable decrease in injury.

This data describes the impact of upper limb and hand injury both on return to sport, and time lost from work. Almost one-fifth of all hurling related hand injuries resulted in more than 4 weeks off from work. Though upper limb injury is often regarded as being less serious than head injury such as eye injury, studies have shown that hand is likely to take longer to return to pre-injury activity than injury to other parts of the body.[19 20] Trybus et al. showed more than 50% of hand injuries presenting to a specialist centre suffered persistent post-traumatic disability.[20]

Limitations of this study included the retrospective nature of the self recorded data obtained by telephone interview, however the initial ED presentation data were gathered prospectively with follow-up performed to investigate factors associated with these inuries. The 82% response rate which may have resulted in selection bias within the responses- non-responders may have may have had different attitudes regarding hand protection. This work emphasises the high occurence of hand injury, which remains in hurling. The study has attempted to highlight factors associated with this, and, we feel, poses some important questions as to the behavioural changes that may

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419	accompany the introduction of safety equipment. Answers to these questions
420	may help to inform future decisions regarding safety equipment use in hurling.
421	
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427	
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434	design; in the collection, analysis and interpretation data; in the writing of the
435	report; and in the decision to submit the paper for publication.
436	
437	Conflict of Interest Statements:
438	All of the authors wish to declare that they do not now, and never have, and
439	conflict of interests pertaining to this work.
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2 3 4 5 6 7	492 493 494 495	Legends to figures
8 9 10 11 12 13 14 15 16 17 18 19 20	496 497 498 500 501 502 503 504 505 506 507	Legend to Fig 1, typical action in a game, a player rises to catch the <i>sliotar</i> despite the attentions of opponents, <i>courtesy of Dan Sheridan, inpho photography</i>
21 22 23 24 25 26	508 509 510 511 512 513	Legend to Figure 2: Typical action, showing players with helmet, helmet and face protection, and hand protection, the Ashgard [™] hand glove is shown in inset. <i>courtesy of Dan Sheridan, inpho photography</i>
27 28 29 30 31 32 33	514 515 516 517 518 519	Legend to Figure 3 the more recent Mycro Long Finger Glove TM offering
34 35 36 37 38 39	520 521	greater protection to the phalanges
40 41 42 43 44 45		
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Fig 1: Hurling: Aerial Battle- the ball may be struck or caught in the air 374x243mm (300 x 300 DPI)

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Figure 2: Typical action, showing players with helmet, helmet and face protection, and hand protection, the AshgardTM hand glove is shown in inset. 361x270mm (72 x 72 DPI)



Figure 3 the more recent Mycro Long Finger GloveTM offering greater protection to the phalanges 260x195mm (300 x 300 DPI)

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Title: RISK FACTORS FOR HAND INJURY IN HURLING – A COHORT STUDY

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STROBE Guidelines Checklist:

Introduction

Background/rationale: COMPLETED Aims: COMPLETED

Methods

Study design: COMPLETED Setting: COMPLETED Participants: COMPLETED Variables: NA Data sources/measurement: COMPLETED Bias: NA Study size: COMPLETED Quantitative variables: NA Statistical methods: COMPLETED

Results

Participants: COMPLETED **Descriptive data: COMPLETED** Outcome data: NA Main results: COMPLETED Other analyses: COMPLETED Discussion

Key results: COMPLETED Limitations: COMPLETED Interpretation: COMPLETED Generalizability: COMPLETED **Other information** Funding: COMPLETED

2 3 4 5 6 1 7 8 2 9 3 10 4 11 5 12 6	RISK FACTORS F RETROSPECTIVE STUDY	OR HAND INJURY IN HURLING- A CROSS-SECTIONAL COHORT
1371481591610	Authors: Éanna Falve Aiden Kellel Michael G M	ey [1,2], Paul McCrory [3], Brendan Crowley [2], ner [2], Joseph Eustace [2], Fergus Shanahan [2], lolloy [2]
17 11 18 12 19 13 20 14 21 15 22 16 23 17 24 18	Affiliations: 1. Dept. of Sport Med Dublin 9, Ireland. 2. Dept of Medicine, 0 3. Florey Neurosciend and Sports Medicir	licine, Sports Surgery Clinic, Santry Demesne, Cork University Hospital, Cork, Ireland. ces Institutes and the Centre for Health, Exercise ne, University of Melbourne, Parkville, Australia 3010
24 10 25 19 26 20 27 21 28 22 29 23 30 24 31 25 32 26 33 27	Corresponding author:	Dr Éanna Falvey, Sports Surgery Clinic, Santry Demesne, Dublin 9, Ireland Email: <u>e.falvey@mac.com</u> Tel: +353 1 5262030 Fax: +353 1 5262046
34 28 35 29 36 30 37 31 38 32	Keywords:	Hand injury, Hurling, Protective Equipment, Risk Compensation
39 33 40 34 41 35 42 36 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60	Word Count:	2,890

37 Article Focus –

38	• Mandatory use of head and face protection in the Irish sport	of hurling over
39	the past 10 years has been accompanied by a marked impre	vement
40	seendecrease in presentation of in head and facial injury rate	es<u>to the ED</u>.
41	• These improved frates igures have not been seen in hand in	jury, where
42	rates-presentations to the ED have remained high, this desp	ite the
43	availability of a commercially available hand protection devic	<u>:e.</u>
44	This study was designed to investigate the ratesquantify the	occurrence of
45	hurling-related hand injury presenting to the ED, to examine	some of the
46	risk factorsvariables associated withfor hurling-related hand	injury <u>. To</u>
47	investigate the impact these injuries had on work and sports	particiapation,
48	and to assess player attitudes to commercially available han	d protection.
49	Key Messages –	
50	• This work-however emphasises the high incidence proportio	<u>n of</u> əf hand
51	injury among hurling-related injury presentation to the ED, w	hich remains
52	in hurling.	
53	This study highlights a number of factors related to hand inju	<u>iry</u> e study has
54	attempted to highlight risk factors for this, and, we feel, and p	oses some
55	questions as to the behavioural changes that may accompar	וץ the
56	introduction of safety equipment.	
57	• This work may encourage further investigation of this issue t	hat may help 🛀
58	to guide future rule changes and lawsThis work shows a stat	<u>tistically</u>
59	significant association between helmet and face-guard use a	and hand injury
60	among hurling-related injury presentation to the ED.	
61	Strengths and Limitations of this study -	

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62	This study is one of the first to address player attitudes towards; and
63	acceptance of; available hand protection in hurling. It may also raise some
64	questions regarding impact of protective equipment on other parts of the
65	body.A causal relationship between the use of protective equipment and
66	injury at a remote site is not established but this work poses a number of
67	questions, which warrant further study.
68	• The retrospective nature of the self recorded data obtained by telephone
69	interview but initial ED presentation was gathered prospectively with
70	follow-up performed to investigate injury causation
71	• The 82% response rate which may have resulted in selection bias within
72	the responses.
73	
74	ABSTRACT
75	Objectives: Hurling is Ireland's national sport, played with a stick and ball;
76	injury to the hand is common. A decrease in the proportion of head injury
77	among emergency department (ED) presentations for hurling-related injury
70	
78	incidence has coincided with mandatory voluntary use of helmet and face
78 79	incidence has coincided with mandatory voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in
78 79 80	incidence has coincided with mandatory voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in proportions hasve not occurred in hand injury. We aim to assess the
78 79 80 81	incidence has coincided with mandatory voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in proportions hasve not occurred in hand injury. We aim to assess the incidence quantify hurling-related of hurling relat based on ED presentations
78 79 80 81 82	incidence has coincided with mandatory voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in proportions hasve not occurred in hand injury. We aim to assess the incidencequantify hurling-related of hurling relat based on ED presentations presentations and examine variables associated with injury. The may be
79 80 81 82 83	incidence has coincided with mandatory-voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in proportions hasve not occurred in hand injury. We aim to assess the incidencequantify hurling-related of hurling-relat based on ED presentations presentations and examine variables associated with injury. ^T which may be associated with his incidence In particular we were interested in comparing the
78 79 80 81 82 83 83	incidence has coincided with mandatory-voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in proportions hasve not occurred in hand injury. We aim to assess the incidencequantify hurling-related of hurling-relat based on ED_presentations presentations and examine variables associated with injury. ¹⁷ which may be associated with his incidence In particular we were interested in comparing the occurrence of hand injury in those using head and face protection versus
79 80 81 82 83 83 84 85	incidence-has coincided with mandatory-voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in proportions hasve not occurred in hand injury. We aim to assess the incidencequantify hurling-related of hurling-relat based on ED_presentations presentations and examine variables associated with injury. ¹⁷ which may be associated with his incidence In particular we were interested in comparing the occurrence of hand injury in those using head and face protection versus those who did not. ²⁷
78 79 80 81 82 83 83 84 85 86	incidence-has coincided with mandatory-voluntary use of helmet and face protection since 2003. Similarly decreased injury rates A similar decrease in proportions hasve not occurred in hand injury. We aim to assess the incidencequantify hurling-related-of hurling-relat based on ED presentations presentations and examine variables associated with injury. ^T which may be associated with his incidence In particular we were interested in comparing the occurrence of hand injury in those using head and face protection versus those who did not. ^T Design: This study utilised a retrospective <u>cross-sectional</u> cohort study design

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87	Setting: This study took place at a single-university hospital emergency	
88	deparment.ED Consecutive hurling related presentations over a 3-month	
89	period- were recorded .	
90	Outcome measures: A follow-up telephone interview was performed with 163	
91	adult players aged ≥16 years paediatric patients were excluded to reflect	
92	voluntary versus obligatory helmet use.	
93	Results: The hand was most often injured n= 85 (52.1%). Hand injury most	
94	commonly occurred from a blow of a Hurleyhurley n=104 (65%), fracture was	
95	confirmed in 62% of cases. Two thirds of players (66.3%) had multiple	
96	previous (1-5) hand injuries. A trial of commercially available hand protection	
97	was noted in 95.4% of patients Most patients 149 (91.4%) had tried	
98	commercially available hand protection, only 4.9% used hand protection	
99	regularly. Univariate analysis analysis of the risk factors for hand injury have	
100	shown ashowed statistically significant association between wearing a helmet	
101	and faceguard <u>and hand injury;</u> Odds Ratio (OR) 2.76 (<u>95 %</u> Confidence	
102	Interval (CI) 1.42-5.37) p=0.003. On further analysis adjusting simultaneously	
103	for age, prior injury, foul play and being struck by a hurley this relationship	
104	<u>remained significant, prior injury</u> (OR = <u>3.15</u> 1.88, CI= <u>1.51-6.56, 1.46-4.</u> 94-p=	
105	0.0320.002)., and being struck by a hurley (OR = 2.31 CI=1.23 5.22 p=	
106	0.009)	Formatted: English (Ireland)
107		
108	Conclusions: We report that hHurling-related hand injury iremains common	
109	We noted low uptake of hand protection. We found that hand injury was	
110	significantly associated with use of helmet and faceguard protection,	
111	independent of other factors studied. Further studies are warranted to develop	

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6 11: 7	strategies to minimise the occurrence of this injury. Those suffering a hand
8 11	injury were twice as likely to have been struck by a hurley, and nearly twice as
10 11	likely to have a previous hand injury, than when other body parts were injured.
12 11	Recent gains in management of head injury may be replicated if hand
13 14 11 15	protection use were obligatory.
$\begin{array}{c} 16\\ 17\\ 18\\ 19\\ 20\\ 21\\ 22\\ 23\\ 24\\ 25\\ 26\\ 27\\ 28\\ 29\\ 30\\ 31\\ 32\\ 33\\ 34\\ 35\\ 36\\ 37\\ 38\\ 39\\ 40\\ 41\\ 42\\ 43\\ 44\\ 45\\ 46\\ 47\\ 48\\ 49\\ 50\\ 51\\ 52\\ 3\\ 54\\ 55\\ 56\\ 57\\ 58\\ 59\\ 60\\ \end{array}$	

16	protection use were obligatory.

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117 INTRODUCTION

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119 Hurling is the national sport of Ireland and is also played throughout the world, 120 among members of the Irish diaspora in North America, Europe, Australia, 121 New Zealand, South Africa and Argentina.[1]

123 Thought to predate Christianity, hurling has been a distinct Irish pastime for at-124 least 2000 years, stories of the hurling feats of Irish mythological heros such as Setanta are recorded in ancient 12th century texts such as *Lebor Laignech* 125 126 (The Book of Leinster).[2]- One of Irelands' native Gaelic sports, it shares 127 much with Scottish shinty,[3] cammag played on the Isle of Man, and Bandoy 128 in Wales and England.[4] Hurling was played in Ireland in ancient times by 129 teams representing neighboring villages. Games involved hundreds of 130 players, which would last several hours or even days. In 1904, hurling was an 131 unofficial demonstration sport in the St Louis Summer Olympic games and in 132 the final; Chicago (Fenian FC) defeated St Louis (Innisfails FC).[5]

134 Reputedly one of the fastest team field sports, this amateur game is played by 135 two teams of fifteen players who compete for a leather-bound ball (sliotar) 136 using a metre-long piece of ash wood (hurley) as a bat (fig 1). The standard 137 hurling pitch is 135 – 145 m long and 80 – 90 m wide. Two posts, which are 138 set 6.4 m apart, and connected above the ground by a crossbar set at a 139 height of 2.5 m, form the goals at each end. A ball hit over the bar is worth 140 one point. A ball that is hit under the bar is called a *goal* and is worth three 141 points.[6]

142	
143	Hurling differs from field hockey and lacrosse in that the sliotar can be caught
44	in the hand and carried for not more than four steps, struck in the air, or struck
45	on the ground with the $\underline{h}\underline{H}$ urley. Further, when the ball is struck for longer
1 6	distances one of the greatest arts of the game <mark>s</mark> is to jump and field the ball-
17	while opponents are free to strike the ball with their hurley (fig 1). The player
48	may kick or slap the ball with an open hand (the hand pass) for short-range
49	passing.
50	In aA 1984 study of Emergency Department (ED) presentations due to hurling
51	injuries, Crowley et al noted that 28% of presentations were facial and head
52	injuries and 36% were hand injuries.[7]_Nine years later following the
53	voluntary introduction of helmet and face protection the absolute number of
54	presentations to ED due to hurling injury had almost halved.[8] The ratio of
55	presentations of site of injury had also changed with 20% of presentations due
6	to head injury and 56% due to hand injuryThis apparent <u>relative</u> rise in hand
57	injury was also noted in <u>a furtherether</u> stud <u>y by Kiely</u> ies.[9]
58	
59	Hand protection available at the time of study was the The most widely used,
60	dedicated hand protection for hurling, c-commercially available was the
61	Ashgard [™] <u>glove</u> by O'Dare , (fig. 2) <u>. This is</u> constructed of neoprene and
62	elasticised fastenings, this apparatus focuse <u>sed</u> primarily on <u>protecting</u> the
63	metacarpal bones. This was the most commonly used device at the time of
64	our study. Anecdotally, and in discussion with other physicians caring for the
	hurling community, (personal communication Prof M G Molloy) weThe authors

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166	noted observed relatively poor levels of use of this equipment. This despite
167	published ED injury presentationsrates and recommendations.[8 9]
168	
169	This study aims to quantify the occurrence of hurling-related hand injury
170	presenting to the ED and examine the variables, which may be associated
171	with hand injury. In particular, to assess the association of helmet and facial
172	protection with the occurrence of hand injury in this population, and to
173	describe the impact that this has on time lost from play and work.
174	This paper aims to assess the incidence of hand injury in adult hurling players
175	based on ED presentations, and to examine the risk factors for hand injury
176	among hurling participants.
177	
178	MATERIALS AND METHODS
179	Consecutive hurling-related injuries over a 3-monthperiod, July to
180	September, in 2006 presenting to the ED of a university hospital were
181	recorded. <u>At the time of e</u> Each patient <u>'s assessment</u> -had a questionnaire <u>was</u>
182	completed by their treating emergency room physician regarding the nature
183	and circumstances of their injury and their subsequent investigations and
184	management.
185	
186	In total 430 hurling-related inuries presented to the ED in the defined period.
187	Due to the enforcement of the use of helmet and face protection by many
188	juvenile clubs (catering for players of 16 years and younger), we excluded this
189	population (n=231). This enabled a true reflection of equipment use in the

190 adult/voluntary setting. The remaining 199 patients were contacted for a

191	
192	From this group, adult (age >16 years) hurling injuries were recorded. A
193	subsequent telephone interview with the adult patients was performed. Prior
194	to performing the interview, patients were contacted by telephone to give their
195	consent to their participation in the study. Interviews were completed within 90
196	days of initial presentation to the ED (Mean 68 days (15-88)). The subjects
197	also received background information about the study based on the Ethics
198	Ceommittee approval as well as a plain language statement. Telephone calls
199	followed a scripted protocol to avoid investigator bias. The questionnaire
200	consisted of questions focussing on:
201	
202	— Site of injury:-
203	— Mechanism of injury;-
204	 Protective equipment in use at the time of injury;-
205	— Previous injury;-
206	 Previous use of protective equipment:-
207	 Reasons for discontinuing use of protective equipment.
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209	Those who had tried but discontinued hand protection were given five
210	potential options as to why they discontinued use of hand protection:
211	<u>— Discomfort</u> Formatted: List Pa
212	— Ineffective protection Bulleted + Level: 1 Indent at: 0.5"
213	<u>— Limitation in performance</u>
214	<u>— Poor aesthetics</u>
215	<u>— Expense</u>
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216	Those players who had discontinued use of hand protection were asked if
217	they would consider trialling different protection if it were to become
218	commercially available.
219	Previous injury was defined as a physical injury, suffered while playing
220	hurling, resulting in at least one game missed. To aid analysis <u>of data</u> upper
221	limb injuries were classed as proximal or distal. A proximal upper limb injury
222	occurred at the wrist or in the upper limb proximal to the wrist (forearm, elbow
223	or shoulder) a distal upper limb injury described all upper limb injury distal to
224	the wrist. An injury which resulted from an action of an opposing player which
225	was penalised by the referee was documented as 'foul play'.depending on the
226	site of injury being proximal to and including the wrist or distal to the wrist
227	respectively.
228	We were particularly interested in exploring the use of protective equipment
229	and whether or not this impacted on injury presentations to the ED. Based on
230	the hypothesis that use of protective equipment has been linked to increased
231	levels of "risky behaviour' we focused particularly on those with serious hand
232	injury and whether they used helmet and face protection.
233	
234	Ethical approval was secured from the relevant Teaching Hospitals Ethics
235	Committee The study proposal was approved by the Clinical Research Ethics
236	Committee of the Cork Teaching Hospitals.
237	
238	Statistical analysis
239	Tests for normality were performed using Shapiro-Wilks test. All variables in
240	the analysis were normally distributed and therefore described using means
I	

and standard deviations. Distributions were summarised using means (standard deviations) or medians (intra quartile range) appropriate. Proportions were compared using Chi square tests. Univariate associations of upper limb injury were examined using logistic regression analysis. The presence, strength, independence, and significance of upper limb injury with the use of helmet with faceguard was quantified using logistic regression. This was, adjusteding simultaneously for age, previous hand injury, being struck dierectly by a hurley and foul play. Variables that were significant using Pearson chi-squared test were included in the multivariate logistic regression model as were those variables deemed clinically important. The final model examines the association of upper limb injury with use of helmet and face-guard, adjusted simultaneously for age, previous hand injury, being struck directly by a hurley and foul play. The risk forfactors associated with hand injury wereas analysed by comparing risk factors and injury mechanism in those who had suffered athose with confirmed upper limb injury (n=100) withand those injured elsewhere (n= 636). Analysis was performed using SPSS version 12 (Chicago, Illinois).

259 RESULTS

Hurling-related injuries for 430 patients were reviewed from 3172 consecutive
sports injuries presenting in the defined period. Of 199 identified and suitable
adult patients, 27 subjects were uncontactable, and 9 declined to participate.
The total response rate was 82% of possible subjects. Data on 163 patients
were included.

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Interviews were conducted with 17 women and 146 men (n= 163). Average
time to follow-up was 39 weeks (range 28 – 48 weeks) post injury. Patient's
ages ranged from 17-39 years (mean 23.52 yrears). The majority of injuries
occurred in organised competition or supervised practice, n = 155 (95%).

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271 Injury site and mechanism of injury:

272 The most commonly injured site (Table 1) was the upper extremity distal to 273 wrist, 85 (52.1%) followed by lower limb 30 (18.4%), with 27 head injuries 274 (16.6%). A statistically significant number of the distal upper limb injuries 275 sustained from a blow of a hurley were fractures n=46/74 (62%) [pP< 0.001], 276 compared to soft tissue injury (laceration, ligamentous injury) n=28/74 (38%) 277 [Pearson Chi square p<0.001]. The most commonly injured digits were the 1st 278 (n= 16, 35%) and 5th (n=15, 33%), table 2. The metacarpal bones were most 279 commonly fractured (n=17, 37%) followed by the proximal phalanges (n=15, 280 323%), the middle phalanx was least likely fractured (n=4, 8%) and the distal 281 phalanx was fractured in 10 cases (22%).

282 283 **Table 1**

284 285

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Patient demographics, protection used, injury severity

VariablePatient Characteristics	OutcomeTotal n=163 (%)	<u>Hand</u> Injury n= 100 (%)	<u>No Hand</u> Injury n=63 (%)	<u>P value</u>
Age <u>, yrs</u>				
<u>Range</u>	17-39yr	<u>17-33yr</u>	<u>17-39yr</u>	
_ <mark>(</mark> Mean <u>(sd)</u>	(23.5 <u>12 (4.1))</u>	<u>23.51 (4.2)</u>	<u>23.52 (4.1)</u>	
Gender				
Female	17 (10 <mark>%</mark>)	<u>10 (10)</u>	<u>7 (11)</u>	
Male	146 (90 <mark>%</mark>)	<u>90 (90)</u>	<u>56 (89)</u>	
Site Injured				
Distal Upper limb	85 (52.1)	<u>85</u>		
Proximal upper limb	15 (9.2)	<u>15</u>		
Lower limb	30 (18.4 <mark>%</mark>)		30 (48)	
Axial	33 (20.3%)		33 (52)	

106 (65)	<u>74</u>	<u>32 (51)</u>	0.002
8 (5 %)	4	4 (6)	<u>NS</u>
74 (45.4 %)	<u>60</u>	<u>14 (22)</u>	<u><0.001</u>
26 (15.9 <mark>%</mark>)	<u>16</u>	<u>10 (16)</u>	<u>NS</u>
104 (63.8 <mark>%</mark>)	<u>74</u>	30 (60)	<u>NS</u>
82 (50.4%)	<u>57</u>	25 (40)	0.03
	106 (65) 8 (5%) 74 (45.4%) 26 (15.9%) 104 (63.8%) 82 (50.4%)	106 (65) $\frac{74}{4}$ 8 (5%) $\frac{16}{4}$ 74 (45.4%) $\frac{60}{104}$ 26 (15.9%) $\frac{16}{74}$ 104 (63.8%) $\frac{74}{57}$	106 (65) $\frac{74}{4}$ $\frac{32 (51)}{4 (6)}$ 74 (45.4%) 60 14 (22) 26 (15.9%) 16 10 (16) 104 (63.8%) 74 30 (60) 82 (50.4%) 57 25 (40)

Previous injury:

Most patients had suffered at least one injury in the past, n = 116 (71.2%), two thirds of patients had between 1 and 5 previous injuries (n = 108, 66.3%). Eight patients (4.9%) had more than six previous injuries. Fifty percent (n = 82) of patients had previously suffered an upper limb injury, 39% (n = 64) had suffered a prior head injury, and a fifth (20.9% (n = 34)) had experienced both. One third (35%) of those presenting with a fracture to the hand or fingers had suffered a prior fracture to the area. A history of previous upper limb injury was associated with risk factor for further injury of the area, OR 1.31 (95% CI1.02-1.68).

302 Protection used:

303 Only 8 (4.9%) used hand protection (AshgardTM by O'Dare, fig. 2), while 149 304 (91.4%) had tried it in the past. Helmet with face protection was used by 65% 305 (n = 106). At the time of study helmet and faceguard use was voluntary in 306 adult participants. Previous trial of helmet with face-guard, and hand 307 protection was reported by 154 (94.5%). Given this high trial-rate, yet poor

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308 uptake, respondents were asked why they had discontinued use. Most 309 respondents, n=123 (75.4%), described poor utility citing issues such as 310 bulkiness and diminished dexterity. More than half, n= 95 (58.3%) felt 311 protection was inadequate rendering the hand protection ineffective. When 312 asked about potential interest in new protective equipment, 121 (74.2%) felt 313 they would try a newly designed glove.

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315 Risk factors for Univariate associations with hand injury (table 2, 3): 316 Univariate analysis of the risk factors variables associated with for hand injury 317 has showndemonstrated a statistically significant association between prior 318 injury, wearing a helmet and faceguard and being struck by a hurley. The later .c. 319 two relationships persisted on multivariate analysis respectively, independent 320 of adjusted variables.

23	Table 2:			
24	Univariate <u>a</u> Analy	sis for risk factors fo	r <u>ssociations with</u> ha	and injury in I
.0		Upper limb injury	OR (95% CI)	p-value
	<u>N=</u>	<u>n=100</u>		
ĺ	Helmet with	Yes <u>n=74</u>	2.76 (1.42-5.37)	0.003
	faceguard	No <u>n= 26</u>		
	<u>n=106</u>			
ĺ	Previous hand	Yes <u>n= 57</u>	1.88 (1.46-4.94)	0.032
	injury	No <u>n= 43</u>	1 (reference)	
	<u>n=82</u>			
Í	Age	16-24 yrs <u>n=52</u>	1.05 (0.56-1.97)	0.88
	<u>n=163</u>	> 24 yrs <u>n=48</u>		
Į				
I		Vac. p=74	2,21,(1,22,5,22)	0.000
	struck by a numey	$N_{0} = 26$	2.31 (1.23-5.22)	0.009
	<u>11-104</u>	110_11-20		
	Foul play	Yes <u>n=16</u>	1.01 (0.43-2.4)	0.983
	<u>n=26</u>	No <u>n=84</u>	1 (reference)	
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hand injury with helmet and faceguard use (OR, 95%)					
		Category	OR (95% CI) for <u>Uu</u> pper <u>L</u> limb injury	p-value	
ĺ		Helmet with faceguard	3.15 (1.51-6.56)	0.002	
		Struck by a hurley	1.99 (1.24-3.8)	0.013	
İ		Age from mean	0.82 (0.4-1.68)	0.59	
ĺ		Previous hand injury	1.73 (0.90-2.6)	0.73	
		Foul Play	1.32 (0.49-3.5)	0.98	
6 7 8	OR= Odds Ratio, CI= Confidence interval				
)					
)	Imp	pact of hand injury:			
)	lmp A w	p act of hand injury: veek or more of play wa	as lost by 152 (93.3%) of those in	jured, 89 (54.6	3%
) 2	Imp A w lost	pact of hand injury: veek or more of play wa t more than 4 weeks. D	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo	jured, 89 (54.6 ople missed wo	3% ⊃rŀ
9) 1 2 3	Imp A w lost	pact of hand injury: veek or more of play wa t more than 4 weeks. Do h 26 (16%) people miss	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo ing more than 4 weeks of work.	jured, 89 (54.6 ople missed wo	პ% ork
9) 1 2 3 4	Imp A w lost with	bact of hand injury: week or more of play wa t more than 4 weeks. Do h 26 (16%) people miss	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo ing more than 4 weeks of work.	jured, 89 (54.6 ople missed wo	3% ork
)) 1 2 3 4 5	Imp A w lost with	bact of hand injury: week or more of play wa t more than 4 weeks. De h 26 (16%) people miss	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo ing more than 4 weeks of work.	jured, 89 (54.6 ople missed wo	∂% ork
9 1 2 3 4 5 5	Imp A w lost with	pact of hand injury: veek or more of play wa t more than 4 weeks. Du h 26 (16%) people miss	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo ing more than 4 weeks of work.	jured, 89 (54.6 ople missed wo	3% ork
9 1 2 2 3 4 5 5 7	Imp A w lost with DIS	pact of hand injury: week or more of play wa t more than 4 weeks. Do h 26 (16%) people miss GCUSSION	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo ing more than 4 weeks of work.	jured, 89 (54.6 ople missed wo	3% ork <u>lin</u>
) 1 2 2 3 4 5 5 7 8	Imp A w lost with DIS <u>We</u> play	pact of hand injury: veek or more of play wa t more than 4 weeks. Do h 26 (16%) people miss SCUSSION e report that in this re yers presenting to a uni	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo ing more than 4 weeks of work. etrospective cross-sectional stud	jured, 89 (54.6 ople missed wo <u>y of 163 hurl</u> tment with hurl	3% ork
9 1 2 3 3 4 5 5 7 1 3 3 9	Imp A w lost with DIS <u>We</u> play re	pact of hand injury: veek or more of play wa t more than 4 weeks. Do h 26 (16%) people miss SCUSSION e report that in this re yers presenting to a uni lated injury, hand injury	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) peo ing more than 4 weeks of work. etrospective cross-sectional stud iversity hospital emergency depart was significantly associated with t	jured, 89 (54.6 ople missed wo y of 163 hurl tment with hurl use of helmet a	6% ork
i 2 3 4 5 5 3 4 5 5 6 7 1 3 9 10	Imp A w lost with DIS <u>We</u> play <u>-re</u> faci	pact of hand injury: veek or more of play wa t more than 4 weeks. Du h 26 (16%) people miss SCUSSION e report that in this re yers presenting to a uni lated injury, hand injury ial protection, independ	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) per ing more than 4 weeks of work. etrospective cross-sectional stud iversity hospital emergency depar was significantly associated with r	jured, 89 (54.6 ople missed wo <u>y of 163 hurl</u> tment with hurl use of helmet a ury, being stru	5% ork
i 22 ii iii iiii iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii	Imp A w lost with DIS <u>We</u> play <u>-re</u> faci	pact of hand injury: week or more of play wa t more than 4 weeks. Du h 26 (16%) people miss SCUSSION a report that in this re yers presenting to a uni lated injury, hand injury ial protection, independ actly by a hurley and	as lost by 152 (93.3%) of those in ue to their injuries, 71 (43.6%) per ing more than 4 weeks of work. etrospective cross-sectional stud iversity hospital emergency depar was significantly associated with the dently of age, previous hand inj foul play. While in this cross-sec	jured, 89 (54.6 ople missed wo <u>y of 163 hurl</u> tment with hurl use of helmet a ury, being stru ectional study	5% ork lin an uc

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353	regarding the epidemiology of hurling-related hand injuries in the era of
354	voluntary helmet and face protection use in hurling.
355	
356	Published data on the incidence of hurling-related hand injury is sparse. The
357	available literature however suggests that while tThe incidenceoccurence of
358	head and facial injury in hurling has continued to decrease<u>fallen</u>, while the
359	proportion of players presenting with hand injury remains essentially
360	unchanged. relative incidence of hand injury has continued to be high
361	atCrowley et al. reported that 52% of ED presentations for hurling injury were
362	injuries to the hand. Eight years later this proportion was similar at when
363	compared to 1993 figures (56%,).[8] and is comparable to the 62% observed
364	in the current study. Despite hand injury being a common occurrence this,
365	only 8% of adults reported use of commercially available hand protection,
366	similarthis compared to the 9.8% seen in areported by Kiely et al. in a 2003
367	study.[9] No rules are enforced in in this sporthurling regarding the use of
368	hand protection-use. In the US the National Collegiate Athletic Association
369	(NCAA) dictates that gloves be worn in intercollegiate stick-handling sports
370	(men's lacrosse, women's lacrosse, and men's ice hockey).[10-12] These
371	sports have many similarities to hurling. The major difference between these
372	sports and hurling is that the The puck or ball isnot handled by outfield
373	players. Therefor a bulky glove may be worn without affecting dexterity or
374	impeding play.s in these sports, however, making the technical requirements
375	of a protective glove different- offering protection without impeding play. The
376	technical requirements of a hand protection device in hurling therefore differ

377 and at the time of study had not gained acceptance among those players 378 presenting to the ED.

Previous injury patterns reported by patients may provide some insight into the role of an individual's behaviour in exposure to further injury risk factors We report thatas 50% of patients had previously suffered an upper limb injury, 39% had suffered a prior head injury, with 21% experiencing both in the past. Sixty-five percent of this cohort wore helmet and face protection voluntarily. demonstrating risk awareness regarding potential head and facial injury. A similar usage of hand protection was not observed. Why the majority of players would adopt head and face protection while discontinuing hand protection use cannot be addressed in this cross-sectional study. This study does not address why those who had suffered prior head injury but continued to play were more likely to have adopted head protection when those who had hand injury did not tend to habitually use this equipment. This may in part be due to explained by the large emphasis placed on head protection [7 8 13] by the sports body and injury commentators. Little emphasis has been placed on hand injury and protection.[9] The utility and function of commercially available hand-quards may also play a role. The Ashgard[™] model was described as 'uncomfortable' and 'bulky' by players, and did not protect beyond the first phalanx, 305% of fractures were seen beyond this site (n=146). A more anatomically correct model (Mycro Long Finger Glove[™]) has been available on the market in more recent times (fig 3)., Tthis glove protects the metacarpals, and offers greater protection for the phalanges, utilising

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401 hardened plastics over the phalanges – providing protection without loss of
402 dexterity.

The significant relationship of a number of risk factors variables such as helmet use; being struck by a hurley; and previous hand injury may represent altered behaviour on behalf of both the injured party and the party causing the injury. Many involved in the game of hurling such as players, coaches and commentators feel that their could be argued that the use of helmet and face protection has altered player behaviour leading to more hazardous playing style. The concept of risk 'compensation' or 'homeostasis' has been questioned debated following the introduction of many safety measures in many sports such as American football, [14 15] cycling [16] and even on the introduction of the automobile seatbelt.[17 18] In American football the evolution of the helmet over 50 years from a leather helmet to a metal and plastic hardshell helmet with faceguard drastically change tackle patterns. The 'spear tackle' saw player tackle with the head rather than shoulder- this was accompanied by a dramatic rise in catastrophic brain and cervical spine injury. Banning the spear tackle and ensuring helmet specifications led to a 42% decrease in brain and spinal injury over a 5 year period.[15] It has been argued that cyclists are less likely to ride cautiously when wearing a helmet owing to their feeling of increased security.[16] A level of perceived safety has been postulated to lead to increased levels of 'risky behaviour' [18]- in hurling it could be postulated that helmet with face protection increases the likelihood that a player will attempt a more risky aerial catch such as seen in figure 1.

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426	The majority of the injuries reported upon in this study occurred during
427	organised competition or supervised practice at club events. The apparent
428	success of the introduction of head and facial protection occurred because
429	this level of regular supervision allows the enforcement of mandatory use
430	laws. The use of helmet and facial protection was made mandatory for
431	initiallyfirst-all players under-18 players, then all players under-21 players in
432	2003 and 2005 respectively. We studied our group in the period prior to 2010
433	when it became mandatory to wear this protection for all players. Players are
434	not insured to train or play at their clubs without the correct head and face
435	protection. Mandatory use of hand protection could conceivably see the
436	incidence of hand injury drop in a similar fashion. Further prospective studies
437	evaluating the effect of hand protection on the occurrence of hurling-related
438	hand injury are warranted to determine if the mandatory use of such
439	protective equipment would result in a comparable decrease in injury.
440	

This data shows describes the impact of upper limb and hand injury both on return to sport, or financially in terms of medical expense and time lost from work. Almost one-fifth of all hurling related hand injuries resulted in more than 4 weeks off from work. Though upper limb injury is often regarded as being less serious than head injury such as eye injury, studies have shown that hand is likely to take longer to return to pre-injury activity than injury to other parts of the body.[19 20] Trybus et al. showed more than 50% of hand injuries presenting to a specialist centre suffered persistent post-traumatic disability.[20]

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	454	Limitations of this study included the (a) retrospective nature of the self
	455	recorded data obtained by telephone interview, however but the initial ED
	456	presentation <u>data</u> wereas gathered prospectively with follow-up performed to
	457	investigate injury causationfactors associated with these inuries. and (b)
	458	Thethe 82% response rate which may have resulted in selection bias within
21 22	459	the responses- non-responders may have may have had different attitudes
23 24 25 26	460	regarding hand protection. This work emphasises the high
	461	incidenceoccurence of hand injury, which remains in hurling. The study has
27 28	462	attempted to highlight risk factors factors associated withfor this, and, we feel,
29 30	463	poses some <u>important</u> questions as to the behavioural changes that may
31 32	464	accompany the introduction of safety equipment. Answers to these questions
33 34	465	may help to inform future decisions regarding safety equipment use in hurling.
35 36	466	This work may encourage further investigation of this issue that may help to
37 38	467	guide future rule changes and laws. The sports body (Gaelic Athletic
39 40	468	Association) should consider making the use of properly manufactured hand
41 42	469	protection mandatory.
43 44	470	
45 46	471	Acknowledgements:
47 48	472	The authors wish to thank the staff and patients at Cork University Hospital
49 50	473	Emergency Department for participating in this work. Dr P. Crowley whose
51 52	474	pioneering works in this area was the forerunner to this study. The Gaelic
53 54	475	Athletic Association for their help in collating recent data in this area.
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477	Competing Interests:	
178	There are no conflicts of interest declared by any of the authors. The study	
470	was funded from aliginal revenues by the Department of Phoumateleou	
479	Sporte & Eversion Medicine Programme Carly University Heavital Carly	
400	sports & Exercise Medicine Programme, Cork University Hospital, Cork,	
481	Ireland. The corresponding author (EF) was funded by I.C.A.R.E (Irish Centre	
482	for Arthritis Research & Education). The sponsors had no role in the study	
483	design; in the collection, analysis and interpretation data; in the writing of the	
484	report; and in the decision to submit the paper for publication.	
485		
486	Conflict of Interest Statements:	
487	All of the authors wish to declare that they do not now, and never have, and	
488	conflict of interests pertaining to this work.	
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	476 477 478 479 480 481 482 483 484 485 486 487 488 489 490	 476 477 Competing Interests: 478 There are no conflicts of interest declared by any of the authors. The study 479 was funded from clinical revenues by the Department of Rheumatology, 470 Sports & Exercise Medicine Programme, Cork University Hospital, Cork, 471 Ireland. The corresponding author (EF) was funded by I.C.A.R.E (Irish Centre 472 for Arthritis Research & Education). The sponsors had no role in the study 473 design; in the collection, analysis and interpretation data; in the writing of the 474 report; and in the decision to submit the paper for publication. 475 476 Conflict of Interest Statements: 477 All of the authors wish to declare that they do not now, and never have, and 478 conflict of interests pertaining to this work. 479 479 470

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RISK FACTORS FOR HAND INJURY IN HURLING- A CROSS-SECTIONAL STUDY

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ARTICLE SUMMARY Article Focus -Mandatory use of head and face protection in the Irish sport of hurling over the past 10 years has been accompanied by a marked decrease in presentation of head and facial injury to the ED. These improved figures have not been seen in hand injury, where presentations to the ED have remained high, this despite the availability of a commercially available hand protection device. This study was designed to quantify the occurrence of hurling-related hand injury presenting to the ED, to examine some of the variables associated with hurling-related hand injury. To investigate the impact these injuries had on work and sports participation and to assess player attitudes to commercially available hand protection. Key Messages – This work emphasises the high proportion of hand injury among hurling-related injury presentation to the ED, which remains in hurling. This study highlights a number of factors related to hand injury and poses some questions as to the behavioural changes that may accompany the introduction of safety equipment. This work shows a statistically significant association between helmet and face-guard use and hand injury among hurling-related injury presentation to the ED. Strengths and Limitations of this study -This study is one of the first to address player attitudes towards; and acceptance of; available hand protection in hurling. A causal relationship

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61	between the use of protective equipment and injury at a remote site is not
62	established but this work poses a number of questions, which warrant
63	further study.
64	The retrospective nature of the self recorded data obtained by telephone
65	interview but initial ED presentation was gathered prospectively with
66	follow-up performed to investigate injury causation
67	The 82% response rate which may have resulted in selection bias within
68	the responses.
69	
70	ABSTRACT
71	Objectives: Hurling is Ireland's national sport, played with a stick and ball;
72	injury to the hand is common. A decrease in the proportion of head injury
73	among emergency department (ED) presentations for hurling-related injury
74	has coincided with voluntary use of helmet and face protection since 2003. A
75	similar decrease in proportions has not occurred in hand injury. We aim to
76	quantify hurling-related ED presentations and examine variables associated
77	with injury. In particular we were interested in comparing the occurrence of
78	hand injury in those using head and face protection versus those who did not.
79	Design: This study utilised a retrospective cross-sectional study design
80	Setting: This study took place at a university hospital ED over a 3-month
81	period.
82	Outcome measures: A follow-up telephone interview was performed with 163
83	players aged \geq 16 years- to reflect voluntary versus obligatory helmet use.
84	Results: The hand was most often injured n= 85 (52.1%). Hand injury most
85	commonly occurred from a blow of a hurley n=104 (65%), fracture was

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86	confirmed in 62% of cases. Two thirds of players (66.3%) had multiple
87	previous (1-5) hand injuries. Most patients 149 (91.4%) had tried
88	commercially available hand protection, only 4.9% used hand protection
89	regularly. Univariate analysis showed statistically significant association
90	between wearing a helmet and faceguard and hand injury; Odds Ratio (OR)
91	2.76 (95 % Confidence Interval (CI) 1.42-5.37) p=0.003. On further analysis
92	adjusting simultaneously for age, prior injury, foul play and being struck by a
93	hurley this relationship remained significant, (OR = 3.15 95% CI=1.51-6.56,
94	p= 0.002).
95	

96 Conclusions: We report that hurling-related hand injury is common. We noted 97 low uptake of hand protection. We found that hand injury was significantly 98 associated with use of helmet and faceguard protection, independent of other 99 factors studied. Further studies are warranted to develop strategies to 100 minimise the occurrence of this injury.

Hurling is the national sport of Ireland and is also played throughout the world, among members of the Irish diaspora in North America, Europe, Australia, New Zealand, South Africa and Argentina.[1] Thought to predate Christianity, hurling has been a distinct Irish pastime for at least 2000 years, stories of the hurling feats of Irish mythological heroes such as Setanta are recorded in ancient 12th century texts such as *Lebor Laignech* (The Book of Leinster).[2] One of Irelands' native Gaelic sports, it shares much with Scottish shinty,[3] cammag played on the Isle of Man, and Bando in Wales and England.[4] Hurling was played in Ireland in ancient times by teams representing neighboring villages. Games involved hundreds of players, which would last several hours or even days. In 1904, hurling was an unofficial demonstration sport in the St Louis Summer Olympic games and in the final; Chicago (Fenian FC) defeated St Louis (Innisfails FC).[5]

Reputedly one of the fastest team field sports, this amateur game is played by two teams of fifteen players who compete for a leather-bound ball (sliotar) using a metre-long piece of ash wood (hurley) as a bat (fig 1). The standard hurling pitch is 135 – 145 m long and 80 – 90 m wide. Two posts, which are set 6.4 m apart, and connected above the ground by a crossbar set at a height of 2.5 m, form the goals at each end. A ball hit over the bar is worth one point. A ball that is hit under the bar is called a goal and is worth three points.[6]

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Hurling differs from field hockey and lacrosse in that the *sliotar* can be caught in the hand and carried for not more than four steps, struck in the air, or struck on the ground with the hurley. Further, when the ball is struck for longer distances one of the greatest arts of the game is to jump and field the ballwhile opponents are free to strike the ball with their hurley (fig 1). The player may kick or slap the ball with an open hand (the hand pass) for short-range passing.

In a 1984 study of Emergency Department (ED) presentations due to hurling injuries. Crowley et al noted that 28% of presentations were facial and head injuries and 36% were hand injuries.[7] Nine years later following the voluntary introduction of helmet and face protection the absolute number of presentations to ED due to hurling injury had almost halved.[8] The ratio of presentations of site of injury had also changed with 20% of presentations due to head injury and 56% due to hand injury. This relative rise in hand injury was also noted in a further study by Kiely.[9]

The most widely used, dedicated hand protection for hurling, commercially available was the AshgardTM glove by O'Dare (fig. 2). This is constructed of neoprene and elasticised fastenings, this apparatus focuses primarily on protecting the metacarpal bones. This was the most commonly used device at the time of our study. Anecdotally, and in discussion with other physicians caring for the hurling community, (personal communication Prof M G Molloy) we observed relatively poor levels of use of this equipment. This despite published ED injury presentations and recommendations.[8 9]

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This study aims to quantify the occurrence of hurling-related hand injury
presenting to the ED and examine the variables, which may be associated
with hand injury. In particular, to assess the association of helmet and facial
protection with the occurrence of hand injury in this population, and to
describe the impact that this has on time lost from play and work.

156

157 MATERIALS AND METHODS

158 Consecutive hurling-related injuries over a 3-month period, July to September, 159 in 2006 presenting to the ED of a university hospital were recorded. At the 160 time of each patient's assessment a questionnaire was completed by their 161 treating emergency room physician regarding the nature and circumstances of 162 their injury and their subsequent investigations and management.

163

164 In total 430 hurling-related inuries presented to the ED in the defined period. 165 Due to the enforcement of the use of helmet and face protection by many 166 juvenile clubs (catering for players of 16 years and younger), we excluded this 167 population (n=231). This enabled a true reflection of equipment use in the 168 adult/voluntary setting. The remaining 199 patients were contacted for a 169 telephone interview. Prior to the interview, patients were contacted by 170 telephone to give their consent to their participation in the study. Interviews 171 were completed within 90 days of initial presentation to the ED (Mean 68 days 172 (15-88)). The subjects also received background information about the study 173 based on the Ethics Committee approval as well as a plain language 174 statement. Telephone calls followed a scripted protocol to avoid investigator 175 bias. The questionnaire consisted of questions focusing on:

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5 6	177	— Site of injury;
7 8	178	— Mechanism of injury;
9 10	179	 Protective equipment in use at the time of injury;
11		
12 13	180	— Previous injury;
14 15	181	 Previous use of protective equipment;
16 17	182	 Reasons for discontinuing use of protective equipment.
18 19	183	
20 21 22	184	Those who had tried but discontinued hand protection were given five
22 23 24	185	potential options as to why they discontinued use of hand protection:
25 26	186	— Discomfort
27 28	187	 Ineffective protection
29 30 31	188	— Limitation in performance
32 33	189	— Poor aesthetics
34 35	190	— Expense
36 37	191	Those players who had discontinued use of hand protection were asked if
38 39 40	192	they would consider trialling different protection if it were to become
40 41 42	193	commercially available.
43 44	194	Previous injury was defined as a physical injury, suffered while playing
45 46	195	hurling, resulting in at least one game missed. To aid analysis of data upper
47 48 40	196	limb injuries were classed as proximal or distal. A proximal upper limb injury
49 50 51	197	occurred at the wrist or in the upper limb proximal to the wrist (forearm, elbow
52 53	198	or shoulder) a distal upper limb injury described all upper limb injury distal to
54 55	199	the wrist. An injury which resulted from an action of an opposing player which
56 57 58 59	200	was penalised by the referee was documented as 'foul play'.

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We were particularly interested in exploring the use of protective equipment and whether or not this impacted on injury presentations to the ED. Based on the hypothesis that use of protective equipment has been linked to increased levels of "risky behaviour" we focused particularly on those with serious hand injury and whether they used helmet and face protection.

207 The study proposal was approved by the Clinical Research Ethics Committee208 of the Cork Teaching Hospitals.

210 Statistical analysis

Tests for normality were performed using Shapiro-Wilks test. All variables in the analysis were normally distributed and therefore described using means and standard deviations. Proportions were compared using Chi square tests. Univariate associations of upper limb injury were examined using logistic regression analysis. The presence, strength, independence, and significance of upper limb injury with the use of helmet with faceguard was guantified using logistic regression. This was adjusted simultaneously for age, previous hand injury, being struck directly by a hurley and foul play. Variables that were significant using Pearson chi-squared test were included in the multivariate logistic regression model as were those variables deemed clinically important. The final model examines the association of upper limb injury with use of helmet and face-guard, adjusted simultaneously for age, previous hand injury, being struck directly by a hurley and foul play. The factors associated with hand injury were analysed by comparing those with confirmed upper limb

225	injury (n=100) with those injured elsewhere (n= 63). Analysis was performed
226	using SPSS version 12 with a 2 sided type one error rate of 0.05,

227 (Chicago, Illinois).

RESULTS

Hurling-related injuries for 430 patients were reviewed from 3172 consecutive
sports injuries presenting in the defined period. Of 199 identified and suitable
patients, 27 subjects were uncontactable, and 9 declined to participate. The
total response rate was 82% of possible subjects. Data on 163 patients were
included.

Interviews were conducted with 17 women and 146 men (n= 163). Average
time to follow-up was 39 weeks (range 28 – 48 weeks) post injury. Patient's
ages ranged from 17-39 years (mean 23.52 yr). The majority of injuries
occurred in organised competition or supervised practice, n = 155 (95%).

241 Injury site and mechanism of injury:

The most commonly injured site (Table 1) was the upper extremity distal to wrist, 85 (52.1%) followed by lower limb 30 (18.4%), with 27 head injuries (16.6%). A statistically significant number of the distal upper limb injuries sustained from a blow of a hurley were fractures n=46/74 (62%), compared to soft tissue injury (laceration, ligamentous injury) n=28/74 (38%), [Pearson Chi square p<0.001]. The most commonly injured digits were the 1^{st} (n= 16, 35%) and 5th (n=15, 33%), table 2. The metacarpal bones were most commonly fractured (n=17, 37%) followed by the proximal phalanges (n=15, 32%), the

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250 middle phalanx was least likely fractured (n=4, 8%) and the distal phalanx

251 was fractured in 10 cases (22%).

3 Table 1

Patient demographics, protection used, injury severity

Patient Characteristics	Total n=163 (%)	Hand Injury n= 100 (%)	No Hand Injury n=63 (%)	P value
Age, yrs				
Range	17-39yr	17-33yr	17-39yr	
Mean (sd)	23.51 (4.1)	23.51 (4.2)	23.52 (4.1)	
Gender				
Female	17 (10)	10 (10)	7 (11)	
Male	146 (90)	90 (90)	56 (89)	
Site Injured				
Distal Upper limb	85 (52.1)	85		
Proximal upper limb	15 (9.2)	15		
Lower limb	30 (18.4)		30 (48)	
Axial	33 (20.3)		33 (52)	
Protection used:				
Helmet with				
faceguard	106 (65)	74	32 (51)	0.002
Hand protection	8 (5)	4	4 (6)	NS
Injury severity				
Fracture	74 (45.4)	60	14 (22)	<0.001
Variables associated				
with Injury				
Foul play	26 (15.9)	16	10 (16)	NS
Struck by hurley	104 (63.8)	74	30 (60)	NS
Previous hand injury	82 (50.4)	57	25 (40)	0.03

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Previous injury:

262 Most patients had suffered at least one injury in the past, n = 116 (71.2%),

two thirds of patients had between 1 and 5 previous injuries (n = 108, 66.3%).

264 Eight patients (4.9%) had more than six previous injuries. Fifty percent (n =

- 265 82) of patients had previously suffered an upper limb injury, 39% (n = 64) had
- suffered a prior head injury, and a fifth (20.9% (n = 34)) had experienced both.

267 One third (35%) of those presenting with a fracture to the hand or fingers had

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suffered a prior fracture to the area. A history of previous upper limb injurywas associated with further injury of the area, OR 1.31 (95% CI1.02-1.68).

Protection used:

Only 8 (4.9%) used hand protection (Ashgard[™] by O'Dare, fig. 2), while 149 (91.4%) had tried it in the past. Helmet with face protection was used by 65% (n = 106). At the time of study helmet and faceguard use was voluntary in adult participants. Previous trial of helmet with face-guard, and hand protection was reported by 154 (94.5%). Given this high trial-rate, yet poor uptake, respondents were asked why they had discontinued use. Most respondents, n=123 (75.4%), described poor utility citing issues such as bulkiness and diminished dexterity. More than half, n= 95 (58.3%) felt protection was inadequate rendering the hand protection ineffective. When asked about potential interest in new protective equipment, 121 (74.2%) felt they would try a newly designed glove.

284 Univariate associations with hand injury (table 2):

285 Univariate analysis of the variables associated with hand injury demonstrated 286 a statistically significant association between prior injury, wearing a helmet 287 and faceguard and being struck by a hurley. The later two relationships 288 persisted on multivariate analysis respectively, independent of adjusted 289 variables.

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n = 100n = 63Helmet with faceguard n=10674 (69.8%)32 (30.1%)2.76 (1.42-5.37)0Previous hand injury n=8257 (69.5%)25 (30.5%)1.88 (1.46-4.94)0Age less than mean - 24yrs n=5231 (59.6%)21(40.4%)1.05 (0.56-1.97)0Struck by a hurley n=10474 (71.2%)30 (28.8%)2.31 (1.23-5.22)0Foul play n=2616 (61.5%)10(38.5%)1.01 (0.43-2.4)0		Upper limb injury	No upper limb injury	OR (95% CI)	p-value
Helmet with faceguard n=106 74 (69.8%) 32 (30.1%) 2.76 (1.42-5.37) 0 Previous hand injury n=82 57 (69.5%) 25 (30.5%) 1.88 (1.46-4.94) 0 Age less than mean - 24yrs n=52 31 (59.6%) 21 (40.4%) 1.05 (0.56-1.97) 0 Struck by a hurley n=104 74 (71.2%) 30 (28.8%) 2.31 (1.23-5.22) 0 Foul play n=26 16 (61.5%) 10(38.5%) 1.01 (0.43-2.4) 0		n =100	n = 63		
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Foul play 16 (61.5%) 10(38.5%) 1.01 (0.43-2.4) 0	n=104	74 (71.2%)	30 (28.8%)	2.31 (1.23-5.22)	0.009
n=26 16 (61.5%) 10(38.5%) 1.01 (0.43-2.4) 0	Foul play				
	n=26	16 (61.5%)	10(38.5%)	1.01 (0.43-2.4)	0.983
OR= Odds Ratio CI= Confidence interval	OR= Odds Rati		interval	1.01 (0.43-2.4)	0.96

299 Table 3:

Logistic Regression analysis of the association of hand injury with helmet and
 faceguard use (OR, 95% CI).

Category	OR (95% CI) for Upper Limb injury	p-value
Helmet with faceguard	3.15 (1.51-6.56)	0.002
Struck by a hurley	1.99 (1.24-3.8)	0.013
Age from mean	0.82 (0.4-1.68)	0.59
Previous hand injury	1.73 (0.90-2.6)	0.73
Foul Play	1.32 (0.49-3.5)	0.98

OR= Odds Ratio, CI= Confidence interval

309 Impact of hand injury:

A week or more of play was lost by 152 (93.3%) of those injured, 89 (54.6%)

311 lost more than 4 weeks. Due to their injuries, 71 (43.6%) people missed work,

312 with 26 (16%) people missing more than 4 weeks of work.

315 DISCUSSION

We report that in this retrospective cross-sectional study of 163 hurling players presenting to a university hospital emergency department with hurling --related injury, hand injury was significantly associated with use of helmet and facial protection, independently of age, previous hand injury, being struck directly by a hurley and foul play. While in this cross-sectional study we cannot demonstrate causality, this finding raises interesting questions

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regarding the epidemiology of hurling-related hand injuries in the era ofvoluntary helmet and face protection use in hurling.

Published data on the incidence of hurling-related hand injury is sparse. The available literature however suggests that while the occurrence of head and facial injury in hurling has fallen, the proportion of players presenting with hand injury remains essentially unchanged. Crowley et al. reported that 52% of ED presentations for hurling injury were injuries to the hand. Eight years later this proportion was similar at 56%,[8] and is comparable to the 62% observed in the current study. Despite hand injury being a common occurrence only 8% of adults reported use of commercially available hand protection, similar to the 9.8% reported by Kiely et al. in a 2003 study.[9] No rules are enforced in hurling regarding the use of hand protection. In the US the National Collegiate Athletic Association (NCAA) dictates that gloves be worn in intercollegiate stick-handling sports (men's lacrosse, women's lacrosse, and men's ice hockey).[10-12] These sports have many similarities to hurling. The major difference between these sports and hurling is that the puck or ball is not handled by outfield players. Therefore a bulky glove may be worn without affecting dexterity or impeding play. The technical requirements of a hand protection device in hurling therefore differ and at the time of study had not gained acceptance among those players presenting to the ED.

Previous injury patterns reported by patients may provide some insight into the role of an individual's behaviour in exposure to further injury. We report that 50% of patients had previously suffered an upper limb injury, 39% had

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suffered a prior head injury, with 21% experiencing both in the past. Sixty-five percent of this cohort wore helmet and face protection voluntarily. demonstrating risk awareness regarding potential head and facial injury. A similar usage of hand protection was not observed. Why the majority of players would adopt head and face protection while discontinuing hand protection use cannot be addressed in this cross-sectional study. This may in part be explained by the large emphasis placed on head protection [7 8 13] by the sports body and injury commentators. Little emphasis has been placed on hand injury and protection.[9] The utility and function of commercially available hand-guards may also play a role. The Ashgard[™] model was described as 'uncomfortable' and 'bulky' by players, and did not protect beyond the first phalanx, 30% of fractures were seen beyond this site (n=14). A more anatomically correct model (Mycro Long Finger Glove[™]) has been available on the market in more recent times (fig 3). This glove protects the metacarpals, and offers greater protection for the phalanges, utilising hardened plastics over the phalanges - providing protection without loss of dexterity.

The significant relationship of a number of variables such as helmet use; being struck by a hurley; and previous hand injury may represent altered behaviour on behalf of both the injured party and the party causing the injury. It could be argued that the use of helmet and face protection has altered player behaviour leading to more hazardous playing style. The concept of risk 'compensation' or 'homeostasis' has been debated following the introduction of many safety measures in many sports such as American football,[14 15]

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cycling[16] and even on the introduction of the automobile seatbelt.[17 18] In American football the evolution of the helmet over 50 years from a leather helmet to a metal and plastic hardshell helmet with faceguard drastically changed tackle patterns. The 'spear tackle' saw players tackle with the head rather than shoulder- this was accompanied by a dramatic rise in catastrophic brain and cervical spine injury. Banning the spear tackle and ensuring helmet specifications led to a 42% decrease in brain and spinal injury over a 5 year period.[15] It has been argued that cyclists are less likely to ride cautiously when wearing a helmet owing to their feeling of increased security.[16] A level of perceived safety has been postulated to lead to increased levels of 'risky behaviour'[18]- in hurling it could be postulated that helmet with face protection increases the likelihood that a player will attempt a more risky aerial catch such as seen in figure 1.

The majority of the injuries reported upon in this study occurred during organised competition or supervised practice at club events. The apparent success of the introduction of head and facial protection occurred because this level of regular supervision allows the enforcement of mandatory use laws. The use of helmet and facial protection was made mandatory for initially all players under-18, then all players under-21 in 2003 and 2005 respectively. We studied our group in the period prior to 2010 when it became mandatory to wear this protection for all players. Players are not insured to train or play at their clubs without the correct head and face protection. Further prospective studies evaluating the effect of hand protection on the occurrence of hurling-

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related hand injury are warranted to determine if the mandatory use of suchprotective equipment would result in a comparable decrease in injury.

This data describes the impact of upper limb and hand injury both on return to sport, and time lost from work. Almost one-fifth of all hurling related hand injuries resulted in more than 4 weeks off from work. Though upper limb injury is often regarded as being less serious than head injury such as eye injury, studies have shown that hand is likely to take longer to return to pre-injury activity than injury to other parts of the body.[19 20] Trybus et al. showed more than 50% of hand injuries presenting to a specialist centre suffered persistent post-traumatic disability.[20]

Limitations of this study included the retrospective nature of the self recorded data obtained by telephone interview, however the initial ED presentation data were gathered prospectively with follow-up performed to investigate factors associated with these injuries. The 82% response rate which may have resulted in selection bias within the responses- non-responders may have may have had different attitudes regarding hand protection. This work investigates hurling-related hand injury presenting to the ED (and compares to other studies gathering data by the same means), it may therefore bias the analysis toward serious injury. Two prospective studies on 74 and 127 players, revealed hand injury rates of 33% and 15.2% respectively.[21 22]

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These lower rates may represent a 'dilution' of more serious injury among less serious, minimal time loss injury. This work emphasises the high occurrence of hand injury, which remains in hurling. The study has attempted to highlight factors associated with this, and, we feel, poses some important questions as to the behavioural changes that may accompany the introduction of safety equipment. Answers to these questions may help to inform future decisions regarding safety equipment use in hurling.

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Competing Interests:

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444 Conflict of Interest Statements:

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445	All of the authors wish to declare that they do not now, and never have, and
446	conflict of interests pertaining to this work.
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3	505	Legends to figures
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12	513	Legend to Fig 1, typical action in a game, a player rises to catch the sliotar
13	514	despite the attentions of opponents courtesy of Dan Sheridan inpho
14	515	nhotography
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22	522	Legend to Figure 2. Typical action, showing players with helmot, helmot, and
23	523	Legend to Figure 2. Typical action, showing players with heimet, heimet and
24	524	face protection, and hand protection, the Ashgard ¹¹¹ hand glove is shown in
25	525	inset. courtesy of Dan Sheridan, inpho photography
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33	532	Legend to Figure 3 the more recent Mycro Long Finger Glove [™] offering
34	533	greater protection to the phalanges
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Fig 1: Hurling: Aerial Battle- the ball may be struck or caught in the air 374x243mm (300 x 300 DPI)

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Figure 2: Typical action, showing players with helmet, helmet and face protection, and hand protection, the AshgardTM hand glove is shown in inset. 119x90mm (300 x 300 DPI)



Figure 3 the more recent Mycro Long Finger GloveTM offering greater protection to the phalanges 119x90mm (300 x 300 DPI)

Title: RISK FACTORS FOR HAND INJURY IN HURLING – A COHORT STUDY

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STROBE Guidelines Checklist:

Introduction

Background/rationale: COMPLETED Aims: COMPLETED

Methods

Study design: COMPLETED Setting: COMPLETED Participants: COMPLETED Variables: NA Data sources/measurement: COMPLETED Bias: NA Study size: COMPLETED Quantitative variables: NA Statistical methods: COMPLETED

Results

Participants: COMPLETED **Descriptive data: COMPLETED** Outcome data: NA Main results: COMPLETED Other analyses: COMPLETED Discussion

Key results: COMPLETED Limitations: COMPLETED Interpretation: COMPLETED Generalizability: COMPLETED **Other information** Funding: COMPLETED



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37	Article Focus –
38	Mandatory use of head and face protection in the Irish sport of hurling over
39	the past 10 years has been accompanied by a marked decrease in
40	presentation of head and facial injury to the ED.
41	These improved figures have not been seen in hand injury, where
42	presentations to the ED have remained high, this despite the availability of
43	a commercially available hand protection device.
44	This study was designed to quantify the occurrence of hurling-related hand
45	injury presenting to the ED, to examine some of the variables associated
46	with hurling-related hand injury. To investigate the impact these injuries
47	had on work and sports particiapationparticipation and to assess player
48	attitudes to commercially available hand protection.
49	Key Messages –
50	This work emphasises the high proportion of hand injury among hurling-
51	related injury presentation to the ED, which remains in hurling.
52	This study highlights a number of factors related to hand injury and poses
53	some questions as to the behavioural changes that may accompany the
54	introduction of safety equipment.
55	This work shows a statistically significant association between helmet and
56	face-guard use and hand injury among hurling-related injury presentation
57	to the ED.
58	Strengths and Limitations of this study -
59	This study is one of the first to address player attitudes towards; and
60	acceptance of; available hand protection in hurling. A causal relationship
61	between the use of protective equipment and injury at a remote site is not

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62	established but this work poses a number of questions, which warrant
63	further study.
64	The retrospective nature of the self recorded data obtained by telephone
65	interview but initial ED presentation was gathered prospectively with
66	follow-up performed to investigate injury causation
67	The 82% response rate which may have resulted in selection bias within
68	the responses.
69	
70	ABSTRACT
71	Objectives: Hurling is Ireland's national sport, played with a stick and ball;
72	injury to the hand is common. A decrease in the proportion of head injury
73	among emergency department (ED) presentations for hurling-related injury
74	has coincided with voluntary use of helmet and face protection since 2003. A
75	similar decrease in proportions has not occurred in hand injury. We aim to
76	quantify hurling-related ED presentations and examine variables associated
77	with injury. In particular we were interested in comparing the occurrence of
78	hand injury in those using head and face protection versus those who did not.
79	Design: This study utilised a retrospective cross-sectional cohort-study design
80	Setting: This study took place at a university hospital ED over a 3-month
81	period.
82	Outcome measures: A follow-up telephone interview was performed with 163
83	players aged ≥16 years- to reflect voluntary versus obligatory helmet use.
84	Results: The hand was most often injured n= 85 (52.1%). Hand injury most
85	commonly occurred from a blow of a hurley n=104 (65%), fracture was
86	confirmed in 62% of cases. Two thirds of players (66.3%) had multiple

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87	previous (1-5) hand injuries. Most patients 149 (91.4%) had tried
88	commercially available hand protection, only 4.9% used hand protection
89	regularly. Univariate analysis showed statistically significant association
90	between wearing a helmet and faceguard and hand injury; Odds Ratio (OR)
91	2.76 (95 % Confidence Interval (CI) 1.42-5.37) p=0.003. On further analysis
92	adjusting simultaneously for age, prior injury, foul play and being struck by a
93	hurley this relationship remained significant, (OR = $3.15 \frac{95\%}{2}$ CI= $1.51-6.56$,
94	p= 0.002).
95	

97 low uptake of hand protection. We found that hand injury was significantly98 associated with use of helmet and faceguard protection, independent of other

Conclusions: We report that hurling-related hand injury is common. We noted

99 factors studied. Further studies are warranted to develop strategies to

100 minimise the occurrence of this injury.

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101 INTRODUCTION

Hurling is the national sport of Ireland and is also played throughout the world, among members of the Irish diaspora in North America, Europe, Australia, New Zealand, South Africa and Argentina.[1] Thought to predate Christianity, hurling has been a distinct Irish pastime for at least 2000 years, stories of the hurling feats of Irish mythological herosheroes such as Setanta are recorded in ancient 12th century texts such as Lebor Laignech (The Book of Leinster).[2] One of Irelands' native Gaelic sports, it shares much with Scottish shinty,[3] cammag played on the Isle of Man, and Bando in Wales and England.[4] Hurling was played in Ireland in ancient times by teams representing neighboring villages. Games involved hundreds of players, which would last several hours or even days. In 1904, hurling was an unofficial demonstration sport in the St Louis Summer Olympic games and in the final; Chicago (Fenian FC) defeated St Louis (Innisfails FC).[5]

Reputedly one of the fastest team field sports, this amateur game is played by two teams of fifteen players who compete for a leather-bound ball (sliotar) using a metre-long piece of ash wood (hurley) as a bat (fig 1). The standard hurling pitch is 135 – 145 m long and 80 – 90 m wide. Two posts, which are set 6.4 m apart, and connected above the ground by a crossbar set at a height of 2.5 m, form the goals at each end. A ball hit over the bar is worth one point. A ball that is hit under the bar is called a goal and is worth three points.[6]
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> Hurling differs from field hockey and lacrosse in that the *sliotar* can be caught in the hand and carried for not more than four steps, struck in the air, or struck on the ground with the hurley. Further, when the ball is struck for longer distances one of the greatest arts of the game is to jump and field the ballwhile opponents are free to strike the ball with their hurley (fig 1). The player may kick or slap the ball with an open hand (the hand pass) for short-range passing.

> In a 1984 study of Emergency Department (ED) presentations due to hurling injuries. Crowley et al noted that 28% of presentations were facial and head injuries and 36% were hand injuries.[7] Nine years later following the voluntary introduction of helmet and face protection the absolute number of presentations to ED due to hurling injury had almost halved.[8] The ratio of presentations of site of injury had also changed with 20% of presentations due to head injury and 56% due to hand injury. This relative rise in hand injury was also noted in a further study by Kiely.[9]

The most widely used, dedicated hand protection for hurling, commercially available was the AshgardTM glove by O'Dare (fig. 2). This is constructed of neoprene and elasticised fastenings, this apparatus focuses primarily on protecting the metacarpal bones. This was the most commonly used device at the time of our study. Anecdotally, and in discussion with other physicians caring for the hurling community, (personal communication Prof M G Molloy) we observed relatively poor levels of use of this equipment. This despite published ED injury presentations and recommendations.[8 9]

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This study aims to quantify the occurrence of hurling-related hand injury
presenting to the ED and examine the variables, which may be associated
with hand injury. In particular, to assess the association of helmet and facial
protection with the occurrence of hand injury in this population, and to
describe the impact that this has on time lost from play and work.

156

157 MATERIALS AND METHODS

158 Consecutive hurling-related injuries over a 3-month period, July to September, 159 in 2006 presenting to the ED of a university hospital were recorded. At the 160 time of each patient's assessment a questionnaire was completed by their 161 treating emergency room physician regarding the nature and circumstances of 162 their injury and their subsequent investigations and management.

163

164 In total 430 hurling-related inuries presented to the ED in the defined period. 165 Due to the enforcement of the use of helmet and face protection by many 166 juvenile clubs (catering for players of 16 years and younger), we excluded this 167 population (n=231). This enabled a true reflection of equipment use in the 168 adult/voluntary setting. The remaining 199 patients were contacted for a 169 telephone interview. Prior to the interview, patients were contacted by 170 telephone to give their consent to their participation in the study. Interviews 171 were completed within 90 days of initial presentation to the ED (Mean 68 days 172 (15-88)). The subjects also received background information about the study 173 based on the Ethics Committee approval as well as a plain language 174 statement. Telephone calls followed a scripted protocol to avoid investigator 175 bias. The questionnaire consisted of questions focusing on:

176	
177	— Site of injury;
178	— Mechanism of injury;
179	 Protective equipment in use at the time of injury;
180	— Previous injury;
181	 Previous use of protective equipment;
182	 Reasons for discontinuing use of protective equipment.
183	
184	Those who had tried but discontinued hand protection were given five
185	potential options as to why they discontinued use of hand protection:
186	— Discomfort
187	— Ineffective protection
188	— Limitation in performance
189	— Poor aesthetics
190	— Expense
191	Those players who had discontinued use of hand protection were asked if
192	they would consider trialling different protection if it were to become
193	commercially available.
194	Previous injury was defined as a physical injury, suffered while playing
195	hurling, resulting in at least one game missed. To aid analysis of data upper
196	limb injuries were classed as proximal or distal. A proximal upper limb injury
197	occurred at the wrist or in the upper limb proximal to the wrist (forearm, elbow
198	or shoulder) a distal upper limb injury described all upper limb injury distal to
199	the wrist. An injury which resulted from an action of an opposing player which
200	was penalised by the referee was documented as 'foul play'.

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We were particularly interested in exploring the use of protective equipment and whether or not this impacted on injury presentations to the ED. Based on the hypothesis that use of protective equipment has been linked to increased levels of "risky behaviour" we focused particularly on those with serious hand injury and whether they used helmet and face protection.

207 The study proposal was approved by the Clinical Research Ethics Committee208 of the Cork Teaching Hospitals.

210 Statistical analysis

Tests for normality were performed using Shapiro-Wilks test. All variables in the analysis were normally distributed and therefore described using means and standard deviations. Proportions were compared using Chi square tests. Univariate associations of upper limb injury were examined using logistic regression analysis. The presence, strength, independence, and significance of upper limb injury with the use of helmet with faceguard was guantified using logistic regression. This was adjusted simultaneously for age, previous hand injury, being struck directly by a hurley and foul play. Variables that were significant using Pearson chi-squared test were included in the multivariate logistic regression model as were those variables deemed clinically important. The final model examines the association of upper limb injury with use of helmet and face-guard, adjusted simultaneously for age, previous hand injury, being struck directly by a hurley and foul play. The factors associated with hand injury were analysed by comparing those with confirmed upper limb

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1 2

injury (n=100) with those injured elsewhere (n= 63). Analysis was performed
using SPSS version 12 with a 2 sided type one error rate of 0.05,
(Chicago, Illinois).

228

229 **RESULTS**

Hurling-related injuries for 430 patients were reviewed from 3172 consecutive sports injuries presenting in the defined period. Of 199 identified and suitable patients, 27 subjects were uncontactable, and 9 declined to participate. The total response rate was 82% of possible subjects. Data on 163 patients were included.

235

Interviews were conducted with 17 women and 146 men (n= 163). Average
time to follow-up was 39 weeks (range 28 – 48 weeks) post injury. Patient's
ages ranged from 17-39 years (mean 23.52 yr). The majority of injuries
occurred in organised competition or supervised practice, n = 155 (95%).

240

241 Injury site and mechanism of injury:

242 The most commonly injured site (Table 1) was the upper extremity distal to wrist, 85 (52.1%) followed by lower limb 30 (18.4%), with 27 head injuries 243 244 (16.6%). A statistically significant number of the distal upper limb injuries 245 sustained from a blow of a hurley were fractures n=46/74 (62%)-[p<-0.001]. 246 compared to soft tissue injury (laceration, ligamentous injury) n=28/74 (38%), 247 [Pearson Chi square p<0.001]. The most commonly injured digits were the 1st 248 (n= 16, 35%) and 5th (n=15, 33%), table 2. The metacarpal bones were most 249 commonly fractured (n=17, 37%) followed by the proximal phalanges (n=15,

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250 32%), the middle phalanx was least likely fractured (n=4, 8%) and the distal

251 phalanx was fractured in 10 cases (22%).

253 Table 1

Patient demographics, protection used, injury severity

Patient Characteristics	Total	Hand	No Hand	P value
Gliaracteristics	11-105 (78)	n= 100 (%)	n=63 (%)	
Age, yrs				
Range	17-39yr	17-33yr	17-39yr	
Mean (sd)	23.51 (4.1)	23.51 (4.2)	23.52 (4.1)	
Gender				
Female	17 (10)	10 (10)	7 (11)	
Male	146 (90)	90 (90)	56 (89)	
Site Injured				
Distal Upper limb	85 (52.1)	85		
Proximal upper limb	15 (9.2)	15		
Lower limb	30 (18.4)		30 (48)	
Axial	33 (20.3)		33 (52)	
Protection used:				
Helmet with				
faceguard	106 (65)	74	32 (51)	0.002
Hand protection	8 (5)	4	4 (6)	NS
Injury severity				
Fracture	74 (45.4)	60	14 (22)	<0.001
Variables associated				
with Injury				
Foul play	26 (15.9)	16	10 (16)	NS
Struck by hurley	104 (63.8)	74	30 (60)	NS
Previous hand injury	82 (50.4)	57	25 (40)	0.03

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Previous injury:

262 Most patients had suffered at least one injury in the past, n = 116 (71.2%),

two thirds of patients had between 1 and 5 previous injuries (n = 108, 66.3%).

- Eight patients (4.9%) had more than six previous injuries. Fifty percent (n =
- 265 82) of patients had previously suffered an upper limb injury, 39% (n = 64) had
- suffered a prior head injury, and a fifth (20.9% (n = 34)) had experienced both.

267 One third (35%) of those presenting with a fracture to the hand or fingers had

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suffered a prior fracture to the area. A history of previous upper limb injurywas associated with further injury of the area, OR 1.31 (95% CI1.02-1.68).

Protection used:

Only 8 (4.9%) used hand protection (Ashgard[™] by O'Dare, fig. 2), while 149 (91.4%) had tried it in the past. Helmet with face protection was used by 65% (n = 106). At the time of study helmet and faceguard use was voluntary in adult participants. Previous trial of helmet with face-guard, and hand protection was reported by 154 (94.5%). Given this high trial-rate, yet poor uptake, respondents were asked why they had discontinued use. Most respondents, n=123 (75.4%), described poor utility citing issues such as bulkiness and diminished dexterity. More than half, n= 95 (58.3%) felt protection was inadequate rendering the hand protection ineffective. When asked about potential interest in new protective equipment, 121 (74.2%) felt they would try a newly designed glove.

Univariate associations with hand injury (table 2):

285 Univariate analysis of the variables associated with hand injury demonstrated 286 a statistically significant association between prior injury, wearing a helmet 287 and faceguard and being struck by a hurley. The later two relationships 288 persisted on multivariate analysis respectively, independent of adjusted 289 variables.

	Upper limb injury	No upper limb injury	OR (95% CI)	p-value
	<u>n =100</u>	<u>n = 63</u>		
Helmet with				
faceguard				
n=106	74 (69.8 <u>%</u>)	32 (30.1 <u>%</u>)	2.76 (1.42-5.37)	0.003
Previous hand	>			
injury				
n=82	57 (69.5 <u>%</u>)	25 (30.5 <u>%</u>)	1.88 (1.46-4.94)	0.032
Age less than				
mean - 24 <u>yrs</u>				
n=52				
	31 (59.6 <u>%</u>)	21(40.4 <u>%</u>)	1.05 (0.56-1.97)	0.88
Struck by a				
hurley				
n=104	74 (71.2 <u>%</u>)	30 (28.8 <u>%</u>)	2.31 (1.23-5.22)	0.009
Foul play				
	16 (61.5%)	10(38.5%)	1.01 (0.43-2.4)	0.983

299 Table 3:

Logistic Regression analysis of the association of hand injury with helmet and
 faceguard use (OR, 95% CI).

Category	OR (95% CI) for Upper Limb injury	p-value
Helmet with faceguard	3.15 (1.51-6.56)	0.002
Struck by a hurley	1.99 (1.24-3.8)	0.013
Age from mean	0.82 (0.4-1.68)	0.59
Previous hand injury	1.73 (0.90-2.6)	0.73
Foul Play	1.32 (0.49-3.5)	0.98

306 OR:

OR= Odds Ratio, CI= Confidence interval

309 Impact of hand injury:

A week or more of play was lost by 152 (93.3%) of those injured, 89 (54.6%)

311 lost more than 4 weeks. Due to their injuries, 71 (43.6%) people missed work,

312 with 26 (16%) people missing more than 4 weeks of work.

315 DISCUSSION

We report that in this retrospective cross-sectional study of 163 hurling players presenting to a university hospital emergency department with hurling —related injury, hand injury was significantly associated with use of helmet and facial protection, independently of age, previous hand injury, being struck directly by a hurley and foul play. While in this cross-sectional study we cannot demonstrate causality, this finding raises interesting questions

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regarding the epidemiology of hurling-related hand injuries in the era ofvoluntary helmet and face protection use in hurling.

Published data on the incidence of hurling-related hand injury is sparse. The available literature however suggests that while the occurence of head and facial injury in hurling has fallen, the proportion of players presenting with hand injury remains essentially unchanged. Crowley et al. reported that 52% of ED presentations for hurling injury were injuries to the hand. Eight years later this proportion was similar at 56%,[8] and is comparable to the 62% observed in the current study. Despite hand injury being a common occurrence only 8% of adults reported use of commercially available hand protection, similar to the 9.8% reported by Kiely et al. in a 2003 study.[9] No rules are enforced in hurling regarding the use of hand protection. In the US the National Collegiate Athletic Association (NCAA) dictates that gloves be worn in intercollegiate stick-handling sports (men's lacrosse, women's lacrosse, and men's ice hockey).[10-12] These sports have many similarities to hurling. The major difference between these sports and hurling is that the puck or ball is not handled by outfield players. Therefore a bulky glove may be worn without affecting dexterity or impeding play. The technical requirements of a hand protection device in hurling therefore differ and at the time of study had not gained acceptance among those players presenting to the ED.

345 Previous injury patterns reported by patients may provide some insight into 346 the role of an individual's behaviour in exposure to further injury. We report

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that 50% of patients had previously suffered an upper limb injury, 39% had suffered a prior head injury, with 21% experiencing both in the past. Sixty-five percent of this cohort wore helmet and face protection voluntarily, demonstrating risk awareness regarding potential head and facial injury. A similar usage of hand protection was not observed. Why the majority of players would adopt head and face protection while discontinuing hand protection use cannot be addressed in this cross-sectional study. This may in part be explained by the large emphasis placed on head protection [7 8 13] by the sports body and injury commentators. Little emphasis has been placed on hand injury and protection.[9] The utility and function of commercially available hand-guards may also play a role. The Ashgard[™] model was described as 'uncomfortable' and 'bulky' by players, and did not protect beyond the first phalanx, 30% of fractures were seen beyond this site (n=14). A more anatomically correct model (Mycro Long Finger GloveTM) has been available on the market in more recent times (fig 3). This glove protects the metacarpals, and offers greater protection for the phalanges, utilising hardened plastics over the phalanges - providing protection without loss of dexterity.

The significant relationship of a number of variables such as helmet use; being struck by a hurley; and previous hand injury may represent altered behaviour on behalf of both the injured party and the party causing the injury. It could be argued that the use of helmet and face protection has altered player behaviour leading to more hazardous playing style. The concept of risk 'compensation' or 'homeostasis' has been debated following the introduction

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of many safety measures in many sports such as American football,[14 15] cycling[16] and even on the introduction of the automobile seatbelt.[17 18] In American football the evolution of the helmet over 50 years from a leather helmet to a metal and plastic hardshell helmet with faceguard drastically changed tackle patterns. The 'spear tackle' saw players tackle with the head rather than shoulder- this was accompanied by a dramatic rise in catastrophic brain and cervical spine injury. Banning the spear tackle and ensuring helmet specifications led to a 42% decrease in brain and spinal injury over a 5 year period.[15] It has been argued that cyclists are less likely to ride cautiously when wearing a helmet owing to their feeling of increased security.[16] A level of perceived safety has been postulated to lead to increased levels of 'risky behaviour'[18]- in hurling it could be postulated that helmet with face protection increases the likelihood that a player will attempt a more risky aerial catch such as seen in figure 1.

The majority of the injuries reported upon in this study occurred during organised competition or supervised practice at club events. The apparent success of the introduction of head and facial protection occurred because this level of regular supervision allows the enforcement of mandatory use laws. The use of helmet and facial protection was made mandatory for initially all players under-18, then all players under-21 in 2003 and 2005 respectively. We studied our group in the period prior to 2010 when it became mandatory to wear this protection for all players. Players are not insured to train or play at their clubs without the correct head and face protection. Further prospective studies evaluating the effect of hand protection on the occurrence of hurling-

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related hand injury are warranted to determine if the mandatory use of suchprotective equipment would result in a comparable decrease in injury.

This data describes the impact of upper limb and hand injury both on return to sport, and time lost from work. Almost one-fifth of all hurling related hand injuries resulted in more than 4 weeks off from work. Though upper limb injury is often regarded as being less serious than head injury such as eye injury, studies have shown that hand is likely to take longer to return to pre-injury activity than injury to other parts of the body.[19 20] Trybus et al. showed more than 50% of hand injuries presenting to a specialist centre suffered persistent post-traumatic disability.[20]

Limitations of this study included the retrospective nature of the self recorded data obtained by telephone interview, however the initial ED presentation data were gathered prospectively with follow-up performed to investigate factors associated with these inuries injuries. The 82% response rate which may have resulted in selection bias within the responses- non-responders may have may have had different attitudes regarding hand protection. This work investigates hurling-related hand injury presenting to the ED (and compares to other studies gathering data by the same means), it may therefore bias the analysis toward serious injury. Two prospective studies on 74 and 127 players, revealed hand injury rates of 33% and 15.2% respectively.[21 22]

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These lower rates may represent a 'dilution' of more serious injury among less serious, minimal time loss injury. This work emphasises the high occurenceoccurrence of hand injury, which remains in hurling. The study has attempted to highlight factors associated with this, and, we feel, poses some important questions as to the behavioural changes that may accompany the introduction of safety equipment. Answers to these questions may help to inform future decisions regarding safety equipment use in hurling.

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Competing Interests:

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Conflict of Interest Statements:

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446	All of the authors wish to declare that they do not now, and never have, and
447	conflict of interests pertaining to this work.
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12	515	Legend to Fig 1, typical action in a game, a player fises to catch the shotal
13	510	despite the attentions of opponents, courtesy of Dan Sheridan, inpro
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23	525	Legend to Figure 2: Typical action, showing players with helmet, helmet and
24	526	face protection and hand protection the Ashgard [™] hand glove is shown in
25	527	inset courtesy of Dan Sheridan innho nhotogranhy
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33	534	Logond to Figure 3 the more recent Myere Long Finger Clove TM offering
24	504	Legend to Figure 5 the more recent mycro Long Finger Glove - Offening
34 25	535	greater protection to the phalanges
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