Helmet Effectiveness in Skiers and Snowboarders

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Outline

- Background and Significance
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- Methods
  - Helmet effectiveness at preventing head injuries
    - Case-control
      - Injured controls
      - Uninjured controls
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- Results
  - Helmet effectiveness at preventing head injuries
    - Case-control
      - Injured controls
      - Uninjured controls
    - Case-crossover (matched interval)
  - Helmet use and behavior change
- Limitations
- Conclusions and future directions

Cette présentation a été effectuée le 4 décembre 2003, au cours de la journée « La prévention des traumatismes dans les loisirs et les sports, ça fait partie du jeu » dans le cadre des Journées annuelles de santé publique (JASP) 2003. L'ensemble des présentations est disponible sur le site Web des JASP, à l'adresse http://www.inspq.qc.ca/jasp/archives/.

Background - Participation

- Canadian Ski Council Estimates – 1999-00
  - 11% of Canadians ski; 4% snowboard
    - 4 million Canadians
    - 16 to 17 million visits to ski areas per year

Background - Injuries

- Quebec Ski Patrol Data (98/99)
  - Skier injuries = 9.5% head; 1.27% neck
  - Snowboarders = 12.6% head; 1.7% neck
- CHIRPP Data (98/99)
  - Skier injuries = 15% head; 3.3% neck
  - Snowboarder injuries = 11.3% head; 2.1% neck
- Rate ~ 0.2 - 0.6 per 1000 visits (Hagel et al, in press, Cadman and Macnab, 1996)
- 22% of head injuries result in LOC or signs of concussion (Macnab, 1996)
- 5 deaths in Quebec last season (worst since 1985)

Background

- Proportion/rate increasing (CPSC, 1999; Deibert, et al, 1998; Hagel et al, 2003; Hagel et al, in press)
  - Increased % snowboarding?
  - Prevalence of snowparks?
  - Increase in hill users?

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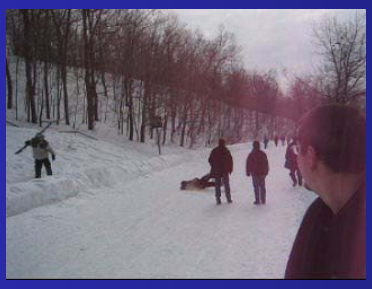


Background

- Helmets effective in cycling but…
  - American Medical Association (Josephson, 1998)
    - "...no epidemiological data exist on the degree of protection afforded by currently available skiing helmets"
    - Head-Neck-Helmet interaction?
  - Macnab et al (2002) case-control study (age <13)
    - 44% (OR: 0.56; 95% CI: 0.31 to 1.01) reduction in head injury risk with helmet use
    - no increased risk of neck injury
    - Limitations:
      - Only adjusted for activity and age
      - Risk Compensation: Increased aggressiveness/less caution?
- Unanswered questions…

Purpose

- To determine the effect of helmet use on the risk of head and neck injuries in skiers and snowboarders using:
  - Case-control methods
  - Case-crossover methods
- To determine if helmet users adopt more risk taking behaviors as measured by injury severity and injury circumstances
  - Case-control methods

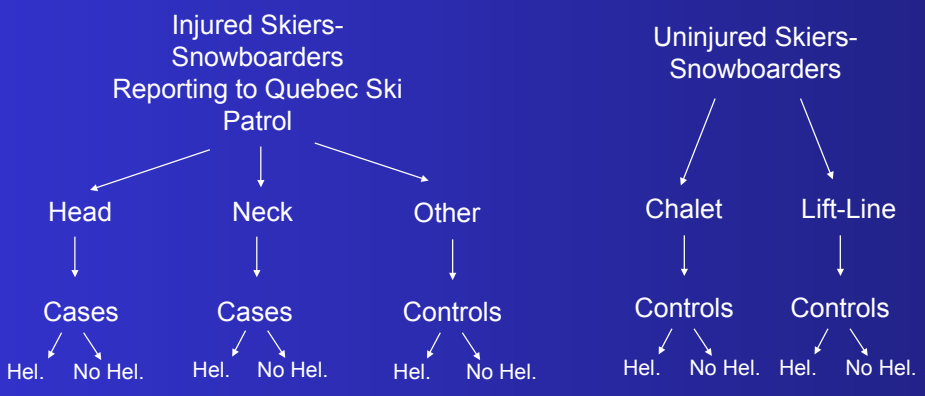
Methods – Case Definition

- Cases: skiers-snowboarders who reported to the ski patrol at 19 Quebec ski areas and had an Accident Report Form (ARF) completed for a:
  - head injury: “an injury to those areas of the head that a helmet might reasonably be expected to protect – the forehead, scalp, ears, skull, brain, and brain stem.” Thompson et al (1989)
  - Facial injury
  - Neck including cervical spine injury
- Ski areas chosen because they are largest in Quebec and therefore produce most injuries

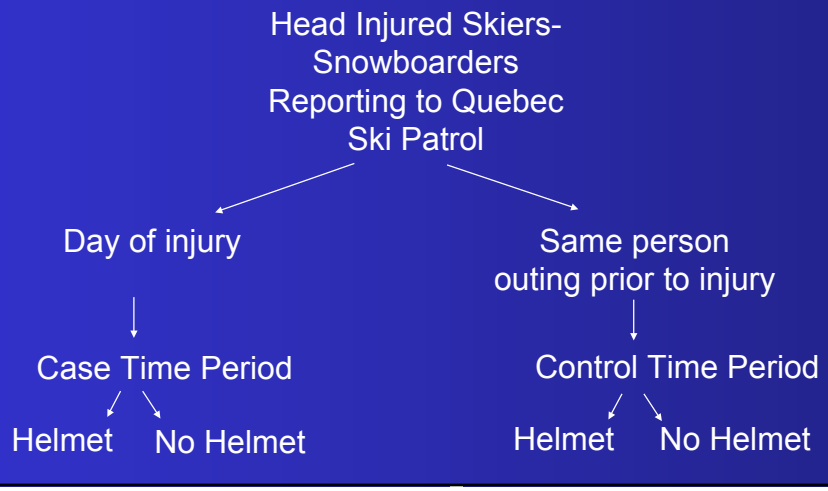
Methods – Controls

- Injured Controls
  - Injured skiers-snowboarders who reported to a ski patroller at one of the 19 hills with an injury, other than to the head or neck (e.g., arm, leg, trunk)
- Uninjured Controls
  - Chalet interviews of skiers-snowboarders at the 19 hills
  - Unobtrusive lift-line observations of skiers-snowboarders at selected ski areas

Methods – Case-Control Design



Methods – Case-Crossover Design



Methods – Injured Case-Control Data Collection

- Ski Patrol ARFs sent to Quebec Secrétariat au Loisir et au Sport November 2001 to April 2002
- Copied and sent to Montreal Children's Hospital
- Identify and select cases
- For each case, 3 injured controls matched on:
  - Ski hill
  - Activity (ski-snowboard)
  - Injury date (nearest available)
  - Age (nearest available)
  - Sex
- Name, address, phone number on each form used to send questionnaire/call (proxy if under 15)
- Max. of 5 follow-up telephone calls to non-responders

Methods – Ski Patrol ARF information

- Demographics
- Skiing ability/experience
- Lessons
- Type of participation
- Injury circumstances
- Equipment details
  - helmet use
- Transport/Evacuation details
- Injury type(s)/body region(s) (3)

Methods – Uninjured controls data collection

- Chalet Interviews
  - Skier-boarder coming from slopes interviewed, wait for 1 person to pass by, interview next
  - Same questions as injured excluding injury data
- Lift-line observations at 5 areas (two RAs)
  - Half-hour increments: every 5th person approaching lift recorded:
    - Age (<15, 15-25, 36-64, 65+)
    - Sex
    - Activity
    - Helmet and wrist-guard use

Methods – Mail Questionnaire/Telephone Interview/Chalet Survey

All Interviews

General Characteristics

- **Age**
- **Sex**
- **Ability**
- **Experience**
- **Lessons**
- **Education**
- **Past head or neck injury**
- **Participation**
- **Caution assessment**
- **Helmet use**

Mail Quest. / Tel. Int.

Injury Circumstances

- **Hours participation**
- **Non-helmet equipment damage**
- **Self-reported speed**
- **Mechanism**
- **Other protective equipment**
- **Run difficulty**
- **Supervision**

Injury Severity Indicators

- **Worst Injury**
- **Hospital Admission**
- **Duration of Convalescence**

Helmet Use

- **Damage**
- **Rent/borrow**
- **Facial protection**
- **Outing prior to injury**
- **Helmet use throughout season**

Methods - Risk Compensation

- Compare severity of injury and injury circumstances for helmet users and non-users among non-head, non-neck injured
  - Matched case-control methods
    - Cases – Injury Severity
      - Ambulance evacuated
      - Hospital admitted
      - Period of convalescence >6 days
    - Cases – Crash circumstances
      - Non-helmet equipment damage
      - Fast self-reported speed
      - Hill difficulty relative to usual participation
      - Jumping mechanism of injury
- Rationale
  - If no behavior change with helmet use then no association between helmet use and injury severity or crash circumstances

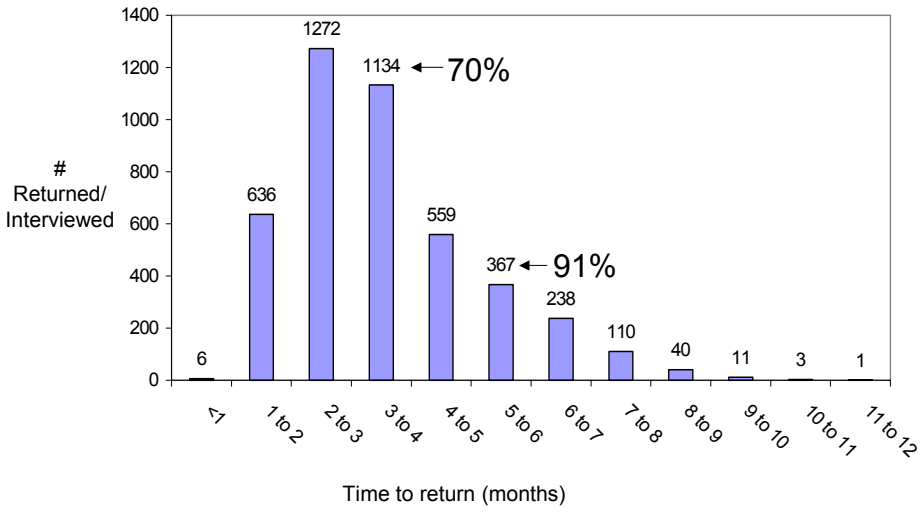
Methods – Quality of Information

- Injured series
  - Helmet use
    - Kappa to measure agreement between Ski Patrol ARF and mail questionnaire-telephone interview
    - Predictive Values (ARF='Gold Standard')
      - Prob. (H+ on ARF given H+ on MQ - TI)
  - Covariates
    - Kappa
- Uninjured series
  - Helmet use and covariates
    - Kappa for consistency of reporting between original interview at ski area and follow-up telephone interview

Results – Response Rates

- Injured series
  - 6243 eligible injured: 1576 head, brain, face, or neck injured cases and 4667 controls
  - 70% overall response rate
    - 3470 mail questionnaires
    - 907 telephone interviews
    - 1 fax
  - 20% of non-responders = refusals
- Uninjured series
  - 57% response rate
    - 25% to 89% depending on ski area

Time From Injury to Questionnaire Return/Interview



Results - Outcomes

- 693 ski patrol reported head-brain injuries
  - 469 isolated head-brain injuries (with or without associated facial injury)
    - Potentially severe head injuries
      - 152 (32.4%) evacuated by ambulance
- 131 ski patrol reported neck injuries
  - 41 isolated neck injuries
    - Potentially severe neck injuries
      - 23 (56.1%) evacuated by ambulance
- 3295 injured controls
- 530 chalet controls
- 1318 lift-line observations

Results – Head Injury & Helmet Use

	All Head Injured		Potentially Severe Head Injured		Injured Control	
	No.	%	No.	%	No.	%
Wearing helmet						
No	518	74.8	115	75.7	2366	71.8
Yes	175	25.3	37	24.3	929	28.2
Helmet use by age						
<15						
No	110	42.8	**46**	**67.7**	**665**	**52.1**
Yes	147	57.2	**22**	**32.4**	**612**	**47.9**
15 to 25						
No	243	84.7	45	80.4	983	83.0
Yes	44	15.3	11	19.6	202	17.0
≥26						
No	129	86.6	26	86.7	718	86.3
Yes	20	13.4	4	13.3	114	13.7

Results – Neck Injury & Helmet Use

	All Neck Injured		Potentially Severe Neck Injured		Injured Control	
	No.	%	No.	%	No.	%
Wearing helmet						
No	87	66.4	14	60.9	2366	71.8
Yes	44	33.6	9	39.1	929	28.2
Helmet use by age						
<15						
No	33	50.8	8	57.1	665	52.1
Yes	32	49.2	6	42.9	612	47.9
15 to 25						
No	38	77.6	5	62.5	983	83.0
Yes	11	22.5	3	37.5	202	17.0
≥26						
No	16	94.1	1	100.0	718	86.3
Yes	1	5.9	-	-	114	13.7

Results – Case vs. Injured Control

Outcome	Exposure	Matched OR (95% CI)	Adjusted OR (95% CI)
HEAD			
Any head vs. injured control	Helmet use	0.8 (0.6 to 1.0)	0. 7* (0.6 to 0.9)
Potentially severe head vs. injured control	Helmet use	0.7 (0.4 to 1.1)	0.4** (0.2 to 0.8)
NECK			
Any neck vs. injured control	Helmet use	1.1 (0.7 to 1.8)	0.6*** (0.3 to 1.2)
Potentially severe neck vs. injured control	Helmet use	1.3 (0.4 to 4.0)	-

*Backward selection: adjusted for age, sex, days of participation
**Forward selection: adjusted for age, sex, days of participation, other protective equipment
***Forward selection: adjusted for age, sex, days of participation

Results – Case vs. Chalet Control

Outcome	Exposure	Crude OR (95% CI)	GEE Adjusted OR (95% CI)
HEAD			
Any head vs. chalet control	Helmet use	1.4 (1.1 to 1.8)	1.0** (0.7 to 1.4)
Potentially severe head vs. chalet control	Helmet use	1.3 (0.9 to 2.0)	1.1*** (0.7 to 1.5)
NECK			
Any neck vs. chalet control	Helmet use	2.1 (1.4 to 3.2)	1.7*** (1.0 to 2.8)
Potentially severe neck vs. chalet control	Helmet use	2.7 (1.1 to 6.3)	1.2*** (0.5 to 3.0)

*Generalized estimating equations; **Controlled for all covariates; ***forward model selection strategy

Results - Case vs. Lift Control

Outcome	Exposure	Crude OR (95% CI)	GEE* Adjusted OR (95% CI)
HEAD			
Any head vs. lift control	Helmet use	0.7 (0.6 to 0.9)	1. 1** (0.9 to 1.2)
Potentially severe head vs. lift control	Helmet use	0.7 (0.5 to 1.0)	0.3*** (0.1 to 0.9)
NECK			
Any neck vs. lift control	Helmet use	1.1 (0.7 to 1.5)	1.8**** (1.0 to 3.4)
Potentially severe neck vs. lift control	Helmet use	1.3 (0.6 to 3.1)	2.5*** (1.4 to 4.6)

*Generalized estimating equations; **Adjusted for age, sex, activity, day of week and temperature; ***No other adjustment but GEE; ****Adjusted for age, sex

Results – Case-Crossover

Any Type of Participation on Day of Injury

Any head injury on day of injury

		Previous Outing: Helmet	Previous Outing: No Helmet	MH-OR (95% CI)
Index Outing	Helmet	159	**13**	0.6 (0.3 – 1.2)
	No Helmet	**22**	448	

Results – Risk Compensation

Non-head-neck Injured Outcome	Exposure	Matched OR (95% CI)	Adjusted OR (95% CI)
Evacuated by ambulance	Helmet use	1.1 (0.8 to 1.6)	1.2* (0.8 to 1.7)
Admitted to hospital	Helmet use	0.7 (0.5 to 0.9)	0.8** (0.5 to 1.2)
Restricted daily activities >6 days	Helmet use	0.6 (0.5 to 0.8)	0.9** (0.7 to 1.3)
Non-helmet equipment damage	Helmet use	1.4 (0.9 to 2.2)	1.2^{+} (0.7 to 2.0)
Fast self-reported speed	Helmet use	1.3 (1.0 to 1.7)	1.1** (0.7 to 1.7)
Participation on a more difficult run	Helmet use	0.7 (0.5 to 1.0)	1.3** (0.8 to 2.1)
Jumping as cause of injury	Helmet use	1.9 (1.4 to 2.4)	1.2** (0.8 to 1.8)

*Adjusted for age, sex; **Adjusted for age, sex, activity, ability, days of participation, lessons, education, seasons of experience, past head-neck injury; $^{+}$Adjusted for age, sex, seasons of experience

Results – Information Quality

- Injured series
  - Helmet use
    - Kappa = 0.88 (95% CI: 0.87 to 0.90)
    - PPV = 87%; NPV = 99% (ARF=gold std.)
  - Covariates
    - Kappas ranged from 0.45 to 0.98
- Uninjured series
  - Helmet use
    - Kappa = 0.68 (95% CI: 0.44 to 0.92)
  - Covariates
    - Kappas ranged from 0.46 to 1.0

Limitations

- Selection bias
  - Not all injured report to ski patrol: missed different in a way related to helmet use and head injury and not captured by covariates
  - Sensitivity analysis – addition of non-responders did not change results
  - Chalet controls low response rate
    - Helmet users under-represented compared with lift-line observations
- Misclassification bias
  - Kappas: Moderate to almost perfect agreement for injured series
  - Lower agreement for chalet controls
    - Under-reporting of helmet use in chalet controls?
- Confounding
  - Relevant covariates from ski-snowboard and bicycle helmet literature captured and controlled in any head-helmet use relation
- Sample size
  - Restrict to severe head-neck injury only (particularly neck)

Conclusions and Future Directions

- Strongest comparisons indicate helmets prevent head injuries with no increased risk of neck injury
- Helmets do not result in behavior change
- Future directions
  - confirmatory studies in emergency department and hospital setting
  - severe ski-snowboard injury risk factors (hospital admission, etc.)
  - educational campaign including proper helmet wearing

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Thank you

Questions?