

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

Injury pattern in a Chinese ski resort in the host city of 2022 Winter Olympic Games

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-037834
Article Type:	Original research
Date Submitted by the Author:	20-Feb-2020
Complete List of Authors:	Chen, Nayun; Peking University Third Hospital, Institute of Sports Medicine Yang, Yuping; Peking University Third Hospital, Institute of Sports Medicine Ao, Yingfang; Peking University Third Hospital,
Keywords:	SPORTS MEDICINE, PUBLIC HEALTH, Orthopaedic sports trauma < ORTHOPAEDIC & TRAUMA SURGERY

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 Injury pattern in a Chinese ski resort in the host city of 2022 Winter

5
6
7 2 Olympic Games

8
9 3 Chen Nayun^{1*}, Yang Yuping^{1*}, Ao Yingfang¹

10
11
12 4 1. Peking University Third Hospital, Peking University Institute of Sports

13
14 5 Medicine

15
16
17 6 * They contribute equally to this article.

18
19
20 7 Corresponding Arthur: Ao Yingfang

21
22 8 E-mail: aoyingfang@163.com

23
24
25 9 Running title: Injury pattern in Chinese ski resort

26
27 10 Word Count : 3323

28
29
30 11

31
32
33 12

34
35
36 13

37
38
39 14

40
41
42 15

43
44
45 16

46
47
48 17

49
50
51 18

52
53
54 19

55
56
57 20

58
59
60 21

22

1
2
3
4 23 Abstract

5
6 24 Objective: This study is to investigate the current injury pattern in
7
8
9 25 skiing/snowboarding population in China, and to provide evidence for better
10
11
12 26 practice in mountainside hospital near ski resort.

13
14 27 Design: A retrospective cohort study

15
16
17 28 Methods: A retrospective study was performed in WanLong Ski Resort in
18
19
20 29 ChongLi. The data of all injured skiers and snowboarders seen in the clinic of
21
22
23 30 Wanlong Ski Resort in season 2018-2019 was collected. Patients information
24
25 31 including gender, age, equipment, ski level, injury type was analyzed.

26
27 32 Results: A total of 753 sports injuries were recorded. The estimated incidence
28
29
30 33 of injury was 1.94 per 1000 skier days. 453 cases (60.2%) were associated with
31
32
33 34 skiing. The mean age of skiers was older than snowboarders (35.1 ± 14.5 vs.
34
35 35 29.0 ± 8.9 , $p<0.01$). Self-inflicted accident took up 67.9% of all injuries. The most
36
37
38 36 common type of injury in skiers was lower extremity injuries; while in
39
40
41 37 snowboarders, it was upper extremity injuries. Head and cervical injury was
42
43 38 identified in 13.7% of skiers and 13.6% of snowboarders.

44
45 39 Conclusion: The incidence of skiing/snowboarding injury in China is similar to
46
47
48 40 previous studies. The injury pattern differs according to different sports and
49
50
51 41 cause of injury.

52
53 42 Key words: Sports injury, Skiing, Snowboarding

54
55
56 43 Article summary

57
58 44 A booming of Chinese skiing and snowboarding population has been seen
59
60

1
2
3
4 45 since China was selected to host the 2022 Winter Olympics in 2015.

5
6 46 Contradicted to the boom is the insufficient knowledge of the current injury

7
8
9 47 pattern in winter sports population in China, and lack of capability dealing with

10
11
12 48 traumatic patients in mountainside hospitals in major ski town. This study is to

13
14
15 49 investigate the current injury pattern in skiing/snowboarding population in China,

16
17
18 50 and to provide evidence for better practice in mountainside hospital near

19
20
21 51 popular ski resorts.

22
23 52 Strengths and limitations of this study

24
25 53 ·The collection of injury cases was nearly thorough due to the regulations in

26
27
28 54 the ski resort.

29
30 55 ·The severity of injury and accurate diagnosis were not recorded, patients

31
32
33 56 were not followed up for their prognosis.

34
35 57 ·Although medical providers in ski resort have collected injury cases as

36
37
38 58 through as possible, there were still patients who went to local or superior

39
40
41 59 hospitals without primary care in ski resort clinics, or did not receive any type

42
43
44 60 of medical help for mild injuries.

45
46
47 61

48
49
50 62

51
52
53 63

54
55
56 64

57
58
59 65

60
61
62 66

1. Introduction

Skiing and snowboarding are popular winter sports world-wide but have a substantial risk of sports injuries, with reported incidence of 1.35 injuries per 1000 skier/snowboarder days in recreational skiers¹ and 6.9 injuries per 1000 runs (or 26.8 injuries per 100 athletes per season)² in professional alpine skiers. In the latest Winter Olympic Games in PyeongChang, 12% of the athletes incurred at least one injury, equaling 12.6 injuries per 100 athletes over the 17-day period³.

Since Beijing was selected to host the 2022 Winter Olympics, a booming of skiing and snowboarding population in China has been seen, from 8 million in 2015 to 13.2 million in 2018 (industry annual report, 2019). Undoubtedly, hospitals close to ski resorts have confronted a sharp increase of burden of traumatic patients in winter. Unfortunately, large-scale ski resorts are often located in areas away from major cities, with nearby hospitals incapable to ingest large number of patients or manage severe injuries. In order to address this dilemma, local hospital should extend scale, set up specific department and recruit talents according to the injury pattern in Chinese ski resorts.

The purpose of our study is to explore the injury pattern of skiers and snowboarders in China, and to provide the primitive data to guide the reform of the hospital near the venues of the 2022 Winter Olympics.

2. Patients and Methods

1
2
3
4 88 The present study was carried out at Wanlong Ski Resort in Chongli, China.
5
6 89 It is the biggest ski resort in northern China according to the annual number of
7
8
9 90 visitors (over 388 thousand visits in the season of 2018-2019), with an average
10
11
12 91 ski season of more than 150 days.

13
14 92 Prior to the season of 2018-2019, the Wanlong Ski Resort reinforced their
15
16
17 93 first-aid patrol and clinics by means of reformation, including:

18
19 94 1. Enroll more patrol members to inspect for potential risk and off-piste injured
20
21
22 95 skiers, and to response to rescue calls as quickly as possible;

23
24 96 2. Employ one registered general practitioner and one nurse as primary care
25
26
27 97 provider to manage mild injury and other common diseases, refer patients to
28
29
30 98 local hospital and to carry out basic life support for life-threatening injuries;

31
32 99 3. Record every injury that is seen by patrol or doctor, including basic
33
34
35 100 information and specific information such as the cause of injury, the location of
36
37
38 101 the accident, type of injury, etc.

39
40 102 This retrospective study was based on these records. Besides patient's name,
41
42
43 103 gender and age, we also recorded ski equipment, skiing level, the date and
44
45
46 104 time of injury, the cause of injury, the location of the accident and the type of
47
48
49 105 injury. Ski equipment was classified into skis and snowboards. Special
50
51
52 106 equipment, such as cross-country skis, skiboards, was rare in China and not
53
54
55 107 seen in recorded injured people. Patients were asked to report their years of
56
57
58 108 participation in the sports, according to which, beginner (first season), medium

1
2
3
4 109 (1-5 years), advanced (5-10 years) and expert (≥ 10 years) were assigned to
5
6 110 each patient.
7
8

9 111 The date of injury was divided into weekdays and weekends/holidays
10
11 112 according to the Chinese government holiday arrangement. The business hour
12
13 113 of Wanlong Ski Resort is 8:00-16:00, so we split the time of injury into 4 periods
14
15 114 with 2 hours each, morning (first 2 hours of business), noon, afternoon and late
16
17 115 afternoon (last 2 hours of business). According to the subjective description of
18
19 116 injury scene, we summarized 2 types of causes of injury: self-inflicted, defined
20
21 117 as falling or crashing without any body contact with others; and crash, defined
22
23 118 as crashing involving 2 or more people. The location of the accident was also
24
25 119 collected, and was categorized into beginner trail, medium trail and advanced
26
27 120 trail according to the official data of slope inclination angle.
28
29
30
31
32
33
34

35 121 We categorized the type of injury into 4 groups: (1) head/cervical, (2) torso,
36
37 122 (3) upper extremity, and (4) lower extremity. Whether patients have multi-part
38
39 123 injuries was also recorded, while each injured body part was counted in one of
40
41 124 the above groups. Acromioclavicular joint injuries were classified as upper limb
42
43 125 injury, while other clavicle injuries were classified as torso injuries.⁴ Injuries
44
45 126 involving gluteal region were classified as torso injury.
46
47
48
49

50 127 This study was approved by Peking University Third Hospital Medical
51
52 128 Science Research Ethics Committee.
53
54

55
56 129 Statistical analysis
57
58
59
60

1
2
3
4 130 All statistical analysis was performed with SPSS (v 24.0; IBM Corp). Chi-
5
6
7 131 squared test was used to compare categorical variables. Wilcoxon signed-rank
8
9 132 test was used for non-parametric data. Student t test was used for parametric
10
11
12 133 data. $P < 0.05$ was considered statistically significant.

134 3. Results

135 Demographic

136 During the season of 2018-2019, there were 388606 visits and 753 sports
137 injuries recorded in Wanlong Ski Resort. There were other 2 skiers suffered
138 from fatal cardiac arrest, and not included in our study. The estimated incidence
139 of injury was 1.94 per 1000 skier days.

140 Among these injuries, 453 cases (60.2%) were associated with skiing. The
141 mean age of skiers was 35.1 ± 14.5 years, whereas the mean age of
142 snowboarders was 29.0 ± 8.9 years ($p < 0.01$). There were 68 patients (9.3%)
143 under the age of 15, 22 patients (3.0%) over the age of 60. There was no
144 significant difference in the sex profile in both groups, with 63.4% of skiers male
145 and 62.6% of snowboarders male. 32.8% of the injured were beginners, while
146 38.3% of them were medium level, 19.0% were advanced, and 10.0% were
147 expert. Table 1 shows more detailed demographic profiles of these injuries.

148 The features of injury

149 The season of 2018-2019 in Wanlong Ski Resort lasted for 158 days, from
150 2018/11/1-2019/4/7, consisting of 107 weekdays and 51 weekends/holidays
151 according to the Chinese government arrangement. The average daily number

1
2
3
4 152 of injuries was 3.38 on weekdays and 7.65 on weekends/holidays. Within a day,
5
6
7 153 9.7% of the injury happened in the first 2 hours of business, 31.6% in noon,
8
9 154 22.0% in afternoon, and 36.7% in the last 2 hours of business.

10
11
12 155 Self-inflicted accident took up 67.9% of all injuries. The percentage of injuries
13
14 156 happened on beginner, medium and advanced trail were 15%, 27.8% and 57.2%
15
16
17 157 respectively. On beginner and advanced trail, the self-inflicted accident resulted
18
19 158 in significantly more injuries than crash accident, while on medium trail, the
20
21
22 159 percentage was similar. (Table 2)

23
24
25 160 The type of injury showed different patterns between skiers and
26
27 161 snowboarders. More than half of the patients injured while skiing sustained
28
29
30 162 lower extremity injuries, while the most common injury in snowboarders was
31
32
33 163 upper extremity injury. Head and cervical injury was identified in 13.7% of skiers
34
35 164 and 13.6% of snowboarders. multipart injury took up 5.3% in skiers and 3.4%
36
37
38 165 in snowboarders. (Table 3)

39 40 166 4. Discussion

41
42
43 167 The history of skiing industry in China is relatively short compared with
44
45 168 European and North American countries. The skiing population in China
46
47
48 169 concentrates in developed areas; however, the condition of terrain and climate
49
50
51 170 in these areas are not suitable for large-scale ski resort. These environmental
52
53
54 171 and socioeconomic factors bestow some specific characteristics on this novel
55
56 172 sport in China. Inevitably, these characteristics are closely related to the injury
57
58
59 173 pattern in Chinese skiers and snowboarders.

1
2
3
4 174 We found the incidence of sports injuries of recreational skiing and
5
6 175 snowboarding to be 1.94 per 1000 skier days in China, which is similar to
7
8
9 176 reported injury incidence of 1.35-3.7 per 1000 skier days in European and
10
11
12 177 North American countries.⁵⁻⁷
13

14 178 The mean age of injured visitors was 32.5±12.9 years (range 3-73 years),
15
16
17 179 with 9.3% younger than 15 year-old and 3.0% older than 60 year-old. The
18
19
20 180 mean age of skiers was older than snowboarders, which is consistent with
21
22 181 other studies.^{5,8} Suezie K et al.⁵ conducted a study where they listed the top
23
24 182 10 injuries in adult and children/adolescent skiers and snowboarders. They
25
26
27 183 found the overall injury pattern was similar between adults and children.
28
29
30 184 However, wrist injury and lower extremity fracture were more likely to be seen
31
32
33 185 in young injured snowboarders. In young skiers, anterior cruciate ligament
34
35 186 tear was not prevalent, while tibial fracture was the fifth common injuries in
36
37
38 187 children and adolescent skiers. In china, winter vocation for teenage students
39
40
41 188 lasts for about 4 weeks around Chinese New Year, which creates a peak of
42
43 189 teenage visitors to Chongli in January and February. Our results showed
44
45
46 190 sports injury in teenagers concentrate in these two months, and took up
47
48 191 nearly 9% of all injures.

49
50 192 Our results showed no significant difference in the sex profile between
51
52
53 193 skiers and snowboarders, with male comprising the majority of the injured
54
55
56 194 cases. Previous studies found female skiers are more susceptible to lower
57
58 195 extremity injury, especially knee injuries, with nearly 50% of injured females
59
60

1
2
3
4 196 suffer from knee injury.⁹ However, the present study found no predominance
5
6 197 of female in lower extremity injuries in both sports groups. Paolo G et al.¹⁰
7
8
9 198 found that men experienced more severe injuries than women, which may
10
11
12 199 result from higher speed, body weight and trail difficulty in men.
13

14 200 Due to the small number of participants in other winter sports, such as cross-
15
16 201 country, mountaineering, telemark and skiboarding, we divided the injured
17
18
19 202 visitors from Wanlong Ski Resort into 2 categories: skiing and snowboarding.
20
21
22 203 In fact, none of the injuries in our study took place during sports other than
23
24 204 skiing or snowboarding. Snowboarding accounted for nearly 40% of the injured
25
26
27 205 population in the latest season. Based on the previously published data, an
28
29
30 206 increase of the percentage of snowboarders in total and injured winter sport
31
32
33 207 population has been noticed.^{5,11} Derived from skateboarding in 1970s, this
34
35 208 young sport appeals to more young people and at the same time, reshapes the
36
37
38 209 injury profile. In a study conducted in Big Sky area in United States,
39
40
41 210 snowboarders took up 42.8% of injured visitors in the 2009-2010 season, while
42
43
44 211 the number was 23.0% during the ski seasons from 1995-2000.¹¹ A number of
45
46 212 research have found that snowboarders had significantly more injuries to the
47
48
49 213 head, spine and upper extremity when compared with skiers, whereas skiers
50
51
52 214 sustained significantly more lower extremity injures.^{5,8} Our results revealed the
53
54
55 215 same patterns, with higher rate of head, upper extremity injuries in
56
57
58 216 snowboarders, and lower rate of lower extremity injuries. The injury severity in
59
60 217 different sports was also compared in a study where the authors found the

1
2
3
4 218 percentage of mild, moderate and severe injuries in skiing to be 41%, 44% and
5
6 219 15% respectively, while the percentage in snowboarding to be 34%, 53% and
7
8
9 220 13%.⁷ Concerning to head injury, Chad C.W et al. ⁸ found there was no
10
11 221 significant difference in Glasgow Coma Scale between skiers and
12
13
14 222 snowboarders with head injury.

15
16
17 223 Beginners and medium level skiers (63.5%) and snowboarders (81.4%)
18
19 224 made up the majority of injured visitors; while in skiing population, advanced
20
21
22 225 and expert skiers also took a remarkable portion of injuries. When comparing
23
24 226 the type of injury between different level groups, no significant difference was
25
26
27 227 found in neither skiers or snowboarders. In a study involving 19, 539 injured
28
29
30 228 snowboarders in Japan, proportions of the trunk and multiple injuries were
31
32
33 229 found to increase with increase in skill level; the injury severity was also found
34
35 230 to increase with skill level.¹² Another study found no relationship between skill
36
37
38 231 level and injury severity in skiing and snowboarding population once
39
40 232 unconscious patients (who cannot report their skill level) were ruled out.¹⁰

41
42
43 233 Over two thirds of the injuries were self-inflicted, which is similar to the
44
45 234 reported rate of self-inflicted injury on Austrian ski slopes.¹³ Although the
46
47
48 235 density of skiers/snowboarders on the slope in China is greater than in other
49
50 236 countries, the composition of injury shares the same pattern, yet no available
51
52
53 237 studies provide evidence of the influence factors of self-inflicted and crash
54
55
56 238 injury rate.¹⁴ The cause of injury was also found to be related with the type of
57
58
59 239 injury in both skiers and snowboarders. Head injury took up a significantly
60

1
2
3
4 240 more portion in crash accident than in self-inflicted accident. In skiers, lower
5
6 241 extremity injury had the highest rate in both self-inflicted accident and crash
7
8
9 242 accident, while the rate was significantly higher in self-inflicted accident than
10
11 243 in crash accident (Table 4). In snowboarders, upper extremity injury was no
12
13
14 244 longer the most frequent injury in crash accident (Table 5).

15
16
17 245 The injury incidence calculated in our study is reported incidence in a ski
18
19 246 resort clinic, which means the local hospital will be confronting potentially more
20
21
22 247 traumatic cases. According to the government report, the total number of visits
23
24
25 248 in ski resorts in Chongli hit nearly 1 million in the last season, which means an
26
27 249 estimated number of more than 2,000 sports injuries in one season. From an
28
29
30 250 epidemiological view, the present study provides strategies that can unload the
31
32
33 251 burden and should be applied to other mountainside hospitals. First, establish
34
35 252 pediatric orthopedic department to cope with the pediatric patients who take up
36
37
38 253 nearly 10% of the whole injury population. Second, establish department of
39
40 254 neurosurgery and oral and maxillofacial surgery in order to deal with the head
41
42
43 255 injury. Third, rearrange the worktime schedule according to the time-related
44
45
46 256 pattern of winter sports injury to increase effectiveness with limited manpower.
47
48 257 Fourth, set up cardiovascular department to provide emergent care for major
49
50
51 258 adverse cardiovascular events.

52
53 259 There existed several limitations in this study. First, the severity of injury and
54
55
56 260 accurate diagnosis were not recorded, patients were not followed up for their
57
58
59 261 prognosis. Second, although medical providers in ski resort have collected
60

1
2
3
4 262 injury cases as through as possible, there were still patients who went to local
5
6 263 or superior hospitals without primary care in ski resort clinics, or did not receive
7
8
9 264 any type of medical help for mild injuries. Currently, we are conducting a large-
10
11 265 scale survey on the demography of Chinese winter sports participants, and a
12
13
14 266 prospective research of winter sports injury in skiing population in China to fill
15
16
17 267 the gap of epidemiological study of winter sports injury in China.

18 19 268 5. Patient and public involvement

20
21
22 269 It was not appropriate to involve patients or the public in the design, or
23
24
25 270 conduct, or reporting, or dissemination plans of our research.

26 27 271 6. Acknowledgement

28
29
30 272 The medical director of Wanlong Ski Resort, Zhang Jinwei, provided help in
31
32
33 273 the collection of injury data.

34 35 274 7. Funding

36
37
38 275 This work was supported by the National Key Research and Development
39
40
41 276 Program of China [2018YFF0301100].

42 43 277 8. Conflicts of interest

44
45 278 The author states no conflicts of interest.

46 47 279 9. Author Contributions

48
49
50 280 Chen Nayun carried out the data analysis and drafted the manuscript. Yang
51
52
53 281 Yuping carried out the design of patient information registration chart, and
54
55
56 282 helped to draft the manuscript. Ao Yingfang conceived of the study, and
57
58
59 283 participated in its design.
60

1
2
3
4 284 10. Reference

- 5
6 285 1. Ekeland A, Johnson RJ, Shealy J, Senner V, Dean SW. Skiing and
7
8
9 286 boarding injuries on Norwegian slopes during two winter seasons.
10
11 287 Journal of ASTM International. 2010;7(4).
12
13
14 288 2. Haaland B, Steenstrup SE, Bere T, Bahr R, Nordsletten L. Injury rate
15
16
17 289 and injury patterns in FIS World Cup Alpine skiing (2006-2015): have the
18
19 290 new ski regulations made an impact? *Br J Sports Med*. 2016;50(1):32-
20
21
22 291 36.
23
24
25 292 3. Soligard T, Palmer D, Steffen K, et al. Sports injury and illness incidence
26
27 293 in the PyeongChang 2018 Olympic Winter Games: a prospective study
28
29 294 of 2914 athletes from 92 countries. *Br J Sports Med*. 2019;53(17):1085-
30
31
32 295 1092.
33
34
35 296 4. Asadollahi S, Bucknill A. Acute medial clavicle fracture in adults: a
36
37
38 297 systematic review of demographics, clinical features and treatment
39
40 298 outcomes in 220 patients. *J Orthop Traumatol*. 2019;20(1):24.
41
42
43 299 5. Kim S, Endres NK, Johnson RJ, Ettlinger CF, Shealy JE. Snowboarding
44
45 300 injuries: trends over time and comparisons with alpine skiing injuries. *Am*
46
47
48 301 *J Sports Med*. 2012;40(4):770-776.
49
50
51 302 6. Langran M, Selvaraj S. Snow sports injuries in Scotland: a case-control
52
53 303 study. *Br J Sports Med*. 2002;36(2):135-140.
54
55
56 304 7. Stenroos A, Handolin L. Incidence of Recreational Alpine Skiing and
57
58 305 Snowboarding Injuries: Six Years Experience in the Largest Ski Resort
59
60

- 1
2
3
4 306 in Finland. *Scand J Surg*. 2015;104(2):127-131.
5
6 307 8. Wasden CC, McIntosh SE, Keith DS, McCowan C. An analysis of skiing
7
8
9 308 and snowboarding injuries on Utah slopes. *J Trauma*. 2009;67(5):1022-
10
11 309 1026.
12
13
14 310 9. Ruedl G, Linortner I, Schranz A, et al. Distribution of injury mechanisms
15
16
17 311 and related factors in ACL-injured female carving skiers. *Knee Surg*
18
19 312 *Sports Traumatol Arthrosc*. 2009;17(11):1393-1398.
20
21
22 313 10. Girardi P, Braggion M, Sacco G, De Giorgi F, Corra S. Factors affecting
23
24 314 injury severity among recreational skiers and snowboarders: an
25
26
27 315 epidemiology study. *Knee Surg Sports Traumatol Arthrosc*.
28
29 316 2010;18(12):1804-1809.
30
31
32 317 11. Coury T, Napoli AM, Wilson M, Daniels J, Murray R, Milzman D. Injury
33
34 318 patterns in recreational alpine skiing and snowboarding at a
35
36
37 319 mountainside clinic. *Wilderness Environ Med*. 2013;24(4):417-421.
38
39
40 320 12. Ogawa H, Sumi H, Sumi Y, Shimizu K. Skill level-specific differences in
41
42 321 snowboarding-related injuries. *Am J Sports Med*. 2010;38(3):532-537.
43
44
45 322 13. Ruedl G, Philippe M, Sommersacher R, Dunnwald T, Kopp M, Burtscher
46
47 323 M. [Current incidence of accidents on Austrian ski slopes]. *Sportverletz*
48
49 324 *Sportschaden*. 2014;28(4):183-187.
50
51
52 325 14. Ruedl G, Kopp M, Burtscher M, Bauer R, Benedetto K. [Causes and
53
54 326 factors associated with collisions on ski slopes]. *Sportverletz*
55
56 327 *Sportschaden*. 2013;27(2):100-104.
57
58
59
60

328

329

330 Tables and Figures

331 Table 1. Details of injured skiers and snowboarders

	Skiers (n=453)	Snowboarders (n=294)	P value
Sex, n (%)			
Male	281 (63.3%)	184 (62.6%)	0.846
Female	163 (36.7%)	110 (37.4%)	
Age, y	35.1±14.5	29.0±8.9	<0.01*
Skill level, n (%)			
Beginner	110 (29.5%)	101 (37.5%)	<0.01*
Medium	127 (34.0%)	118 (43.9%)	
Advanced	85 (22.8%)	37 (13.8%)	
Expert	51 (13.7%)	13 (4.8%)	

332

333 Table 2. Cause and location of accident

	Self-inflicted (n=486)	Crash (n=226)	P value
Beginner trail	93	18	<0.01*
Medium trail	103	87	
Advanced trail	292	121	

334

335 Table 3. Type of injuries in skiers and snowboarders

	Skiers (n=417)	Snowboarders (n=265)	P value
Head and cervical	57 (13.7%)	36 (13.6%)	<0.01*
Torso	83 (19.9%)	63 (23.8%)	
Upper extremity	79 (18.9%)	125 (47.2%)	

Lower extremity	222 (53.2%)	50 (18.9%)
Multipart	22 (5.3%)	9 (3.4%)

336

337 Table 4. The relationship between cause of injury and type of injury in skiers

	Head and cervical	Torso	Upper extremity	Lower extremity	Multipart injury	P value
Self- inflicted	21	53	53	171	9	<0.01
Crash	31	26	24	48	12	

338

339 Table 5. The relationship between cause of injury and type of injury in
340 snowboarders

	Head and cervical	Torso	Upper extremity	Lower extremity	Multipart injury	P value
Self- inflicted	17	39	107	37	3	<0.01
Crash	19	22	16	12	6	

341

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	5-6
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	NA
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-8

1	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
2			(b) Report category boundaries when continuous variables were categorized	NA
3			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
4				
5				
6				
7				
8				
9	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
10				
11	Discussion			
12				
13	Key results	18	Summarise key results with reference to study objectives	9
14	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
15				
16	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
17				
18				
19	Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
20				
21	Other information			
22	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13
23				
24				

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.

北京大学第三医院医学科学研究伦理委员会
Peking University Third Hospital Medical Science Research Ethics Committee
伦理审查批件
Ethical Review Approval Notice

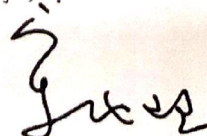

(2019) 医伦审第 (516-01) 号

项目编号	IRB00006761-M2019456	
临床试验项目名称	中国滑雪人群滑雪运动损伤研究	
项目来源	研究者自发	
试验类型	流调类	
产品名称	通用名：无	商品名：无
药物注册分类		期别：
CFDA 药物临床试验批件号		
申办者/资助企业	无	
CRO 公司	无	
临床试验单位及专业 / 科室	北京大学第三医院 / 运动医学研究所	
主要研究者及职称	敖英芳 主任医师	
我院第二主要研究者	无	
组长单位	北京大学第三医院	
其他参加研究/合作单位 (必要可附表)		
审查文件 (必要可附表)	签名页 1- 试验方案及参考文献 版本号2.0 版本日期2019.11.27 2- 知情同意书豁免申请 3- 保密说明 4- 质量管理方案 5- 项目风险的预评估及风险处置预案 版本号1.0 版本日期2019.11.20 6- 经费来源保障说明 大众滑雪爱好者人口学调查问卷 版本1.0 2019.11.20	



--	--

(2019) 医伦审第 (516-01) 号

投票结果	同意1票	作必要修改后同意0票	转会议审查0票
审查决定	同意		
审查声明	<p>确认伦理委员会组成和执行符合根据中华人民共和国国家食品药品监督管理总局2003年颁布实施的《药物临床试验质量管理规范》、ICH-GCP、卫计委2016年颁布实施的《涉及人的生物医学研究伦理审查办法》以及《赫尔辛基宣言》和国际医学科学组织委员会颁布的《人体生物医学研究国际道德指南》的伦理原则。</p> <p>A statement confirming that the Ethics Committee is organized and operates according to Good Clinical Practice which is passed by CFDA in 2003, ICH-GCP, Biomedical Research Ethics Review involving human which is passed by Ministry of Health in 2007, Helsinki Declaration and ethical principles of International ethical guidelines for biomedical research involving human subjects which is passed by Council for International Organizations of Medical Science (CIOMS).</p>		
审查意见	该研究符合伦理审查要求，同意开展。		
跟踪审查频率	12 个月		
伦理审查批件有效期	2019年12月24日~2020年12月23日 (请在有效期内启动实施，过期应重新申请审批)		
说明	<p>1. 本批件将在各研究中心及其伦理委员会备案。如果对方案在本机构的可行性(包括研究者的资格与经验、设备与条件等)有不同意见,请及时与本伦理委员会联系。</p> <p>2. 如对临床试验方案、知情同意书的任何修改,主要研究者更换,应及时通知伦理委员会,重新审查,获得批准后执行。</p> <p>3. 如发生严重不良事件以及影响研究风险受益比的非预期不良事件,研究者应在获知24小时内报告本伦理委员会。</p> <p>4. 暂停/提前终止/完成临床试验,请及时通知伦理委员会。</p> <p>5. 发现严重违反方案情况应及时报告伦理委员会。</p> <p>6. 完成临床试验后,请提交结题报告。</p> <p>7. 请按照批件要求的跟踪审查频率及时向伦理委员会递交跟踪审查报告。</p>		
主任委员 (签字):			签发日期:
			

Please wait...

If this message is not eventually replaced by the proper contents of the document, your PDF viewer may not be able to display this type of document.

You can upgrade to the latest version of Adobe Reader for Windows®, Mac, or Linux® by visiting http://www.adobe.com/go/reader_download.

For more assistance with Adobe Reader visit <http://www.adobe.com/go/acrreader>.

Windows is either a registered trademark or a trademark of Microsoft Corporation in the United States and/or other countries. Mac is a trademark of Apple Inc., registered in the United States and other countries. Linux is the registered trademark of Linus Torvalds in the U.S. and other countries.

BMJ Open

Injury patterns in a large-scale ski resort in the host city of 2022 Winter Olympic Games: a retrospective study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-037834.R1
Article Type:	Original research
Date Submitted by the Author:	04-Jun-2020
Complete List of Authors:	Chen, Nayun; Peking University Third Hospital, Institute of Sports Medicine Yang, Yuping; Peking University Third Hospital, Institute of Sports Medicine Ao, Yingfang; Peking University Third Hospital,
Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Public health
Keywords:	SPORTS MEDICINE, PUBLIC HEALTH, Orthopaedic sports trauma < ORTHOPAEDIC & TRAUMA SURGERY

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 Injury patterns in a large-scale ski resort in the host city of 2022 Winter

5
6
7 2 Olympic Games: a retrospective study

8
9 3 Chen Nayun^{1*}, Yang Yuping^{1*}, Ao Yingfang¹

10
11
12 4 1. Peking University Third Hospital, Peking University Institute of Sports

13
14 5 Medicine

15
16
17 6 * They contribute equally to this article.

18
19
20 7 Corresponding Author: Ao Yingfang

21
22 8 E-mail: aoyingfang@163.com

23
24
25 9 Running title: Injury pattern in Chinese ski resort

26
27
28 10 Word Count : 3203

1
2
3
4 23 Abstract

5
6 24 Objective: The aim of the study is to investigate the current injury patterns in
7
8
9 25 skiing/snowboarding population in China, and to provide evidence for better
10
11
12 26 practice in mountainside hospital near ski resort.

13
14 27 Design: Retrospective study

15
16
17 28 Methods: A retrospective study was performed in Wanlong Ski Resort in
18
19
20 29 Chongli. The data of all injured skiers and snowboarders treated in the resort
21
22
23 30 clinic during season 2018-2019 was collected. Patients information, including
24
25 31 sex, age, equipment, ski level, injured body part was analyzed.

26
27 32 Results: A total of 753 sports injuries were recorded. The estimated incidence
28
29
30 33 of injury was 1.94 per 1000 skier days. 453 cases (60.2%) were associated
31
32
33 34 with skiing. The mean age of skiers was older than snowboarders (35.1 ± 14.5
34
35 35 vs. 29.0 ± 8.9 , $p < 0.01$). Injury not involving others took up 67.9% of all injuries.
36
37
38 36 The most common injured body part in skiers was lower extremity injuries;
39
40 37 while in snowboarders, it was upper extremity injuries. Head and cervical
41
42
43 38 injury was identified in 13.7% of skiers and 13.6% of snowboarders.

44
45 39 Conclusion: The incidence of skiing/snowboarding injury in China is similar to
46
47
48 40 previous studies. The injury pattern differs according to different sports and
49
50
51 41 cause of injury.

52
53 42 Key words: Sports injury, Skiing, Snowboarding

54
55
56 43 Strength and limitations of this study:
57
58
59
60

1
2
3
4 44 1. Since Beijing was selected to host the 2022 Winter Olympics, skiing and
5
6 45 snowboarding population in China has risen rapidly. The present study is the
7
8
9 46 first epidemiological study investigating the injury patterns in Chinese ski
10
11
12 47 resort.

13
14 48 2. This study provided evidence for restructuring the local hospital in the host
15
16
17 49 city of 2022 Winter Olympic Games.

18
19 50 3. Several limitations exist in this study. The severity of injury and accurate
20
21
22 51 diagnosis were not recorded, patients were not followed up for their
23
24
25 52 prognosis. There were still patients who went to local or superior hospitals
26
27
28 53 directly, or did not receive any type of medical help for mild injuries. In this
29
30 54 case, the incidence of injury may be underestimated.

31
32 55

33
34 56

35
36 57

37
38 58

39
40 59

41
42 60

43
44 61

45
46 62

47
48 63

49
50 64

51
52 65

53
54
55
56
57
58
59
60

1
2
3
4 665
6 677
8
9 68 1. Introduction

10
11 69 Skiing and snowboarding are popular winter sports world-wide but have a
12
13
14 70 substantial risk of sports injuries, with reported incidence of 0.5-1.35 injuries
15
16
17 71 per 1000 skier/snowboarder days in recreational skiers/snowboarders¹⁻³ and
18
19 72 6.9 injuries per 1000 runs (or 26.8 injuries per 100 athletes per season)⁴ in
20
21
22 73 professional alpine skiers in recent years. In the latest Winter Olympic Games
23
24 74 in PyeongChang, 12% of the athletes incurred at least one injury, equaling
25
26
27 75 12.6 injuries per 100 athletes over the 17-day period⁵.

28
29
30 76 The history of skiing industry in China is relatively short compared with
31
32
33 77 European and North American countries. Since Beijing was selected to host
34
35
36 78 the 2022 Winter Olympics, skiing and snowboarding population in China has
37
38 79 risen from 8 million in 2015 to 13.2 million in 2018 (industry annual report,
39
40
41 80 2019). The skiing population in China concentrates in developed areas;
42
43 81 however, large-scale ski resorts in China are often located in areas far away
44
45
46 82 from major cities. Undoubtedly, hospitals close to ski resorts have been
47
48
49 83 confronted an increasing amount of injured skiers and snowboarders; yet they
50
51
52 84 are incapable to ingest large number of patients or manage the treatment of
53
54 85 severe injuries.

55
56 86 To the best of our knowledge, there is no epidemiological study
57
58
59 87 investigating current injury patterns in recreational skiers and snowboarders in
60

1
2
3
4 88 China. The purpose of the study is to explore the injury patterns of skiers and
5
6 89 snowboarders in China by investigating the largest ski resort in the host city of
7
8
9 90 2022 Winter Olympic Games, and to provide the primitive data to guide the
10
11 91 restructure of the hospital near the venues of the 2022 Winter Olympic
12
13
14 92 Games.

17 93 2. Patients and Methods

19 94 The data of this retrospective study was collected from the resort clinic of
20
21
22 95 Wanlong Ski Resort in Chongli during ski season 2018-2019 (Figure 1). The
23
24
25 96 resort clinic is responsible for treating mild injury and other common diseases,
26
27 97 transferring patients to local hospital, carrying out basic life support for life-
28
29
30 98 threatening injuries, and recording every injury that is seen by patrol or clinic
31
32
33 99 staff.

35 100 Besides patient's name, sex and age, we also recorded equipment, skill
36
37 101 level, the date and time of injury, the cause of injury, the slope difficulty and
38
39
40 102 the injured body part. Equipment was classified into skis and snowboards.
41
42
43 103 Special equipment, such as cross-country skis, skiboards, was rare in China
44
45
46 104 and not seen in recorded injured people. According to self-reported years of
47
48 105 participation in skiing and snowboarding, patients were classified as beginner
49
50
51 106 (first season), medium (1-5 years), advanced (5-10 years) and expert (≥ 10
52
53 107 years). The date of injury was divided into weekdays and weekends/holidays
54
55
56 108 according to the Chinese government holiday arrangement. The business
57
58 109 hour of Wanlong Ski Resort is 8:00-16:00, so we split the time of injury into 4
59
60

1
2
3
4 110 periods with 2 hours each, morning (first 2 hours of business), noon,
5
6 111 afternoon and late afternoon (last 2 hours of business). According to the
7
8
9 112 subjective description of injury scene, we summarized 2 types of causes of
10
11 113 injury: not involving others, defined as falling or crashing without any body
12
13 114 contact with others; and involving others, defined as crashing involving 2 or
14
15 115 more people. The slope difficulty was also collected and categorized into
16
17 116 beginner trail, medium trail and advanced trail according to the official data of
18
19 117 slope inclination angle. Injured body part was categorized into the following 4
20
21 118 anatomical body regions: (1) head/cervical, (2) torso, (3) upper extremity, and
22
23 119 (4) lower extremity. Acromioclavicular joint injuries were classified as upper
24
25 120 limb injury, while other clavicle injuries were classified as torso injuries.⁶
26
27 121 Injuries involving gluteal region were classified as torso injury. Whether
28
29 122 patients have multi-part injuries was also recorded, while each injured body
30
31 123 part was counted in one of the above groups. The relationship between
32
33 124 injured body part and sex, age, equipment and cause of injury was further
34
35 125 determined by subgroup analysis.

36
37 126 This study was approved by Peking University Third Hospital Medical
38
39 127 Science Research Ethics Committee.

40 41 128 Statistical analysis

42
43 129 All statistical analysis was performed with SPSS (v 24.0; IBM Corp). Sex,
44
45 130 skill level and injured body part were compared between skiers and
46
47 131 snowboarders using Chi-squared test. Injured body part and slope difficulty
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4 132 were compared between injury involving others and injury not involving others
5
6 133 using Chi-squared test. Student t test was used to compare age between
7
8
9 134 skiers and snowboarders. When there is missing data, the available case was
10
11 135 analyzed to determine difference between groups. $P < 0.05$ was considered to
12
13 136 indicate statistical significance.

137 3. Results

138 Demographic

139 During the season of 2018-2019, there were 388606 visits and 753 sports
140 injuries recorded in Wanlong Ski Resort. The estimated incidence of injury
141 was 1.94 per 1000 skier days.

142 Among these injuries, 453 cases (60.2%) were associated with skiing. The
143 mean age of skiers was 35.1 ± 14.5 years, whereas the mean age of
144 snowboarders was 29.0 ± 8.9 years ($p < 0.01$). There were 78 patients (10.4%)
145 under 18 years old, 22 patients (3.0%) over the age of 60. There was no
146 significant difference in the sex profile between skiers and snowboarders, with
147 63.4% of skiers and 62.6% of snowboarders being male. Among the whole
148 injury population, 32.8% were beginners, while 38.3% of them were medium
149 level, 19.0% were advanced, and 10.0% were expert. Table 1 shows more
150 detailed demographic profiles of these injuries.

151

152 The features of injury

1
2
3
4 153 The season of 2018-2019 in Wanlong Ski Resort lasted for 158 days, from
5
6 154 2018/11/1-2019/4/7, consisting of 107 weekdays and 51 weekends/holidays
7
8
9 155 according to the Chinese government arrangement. The average daily
10
11
12 156 number of injuries was 3.38 on weekdays and 7.65 on weekends/holidays.

13
14 157 Within a day, 9.7% of the injury occurred in the first 2 hours of business,
15
16
17 158 31.6% in noon, 22.0% in afternoon, and 36.7% in the last 2 hours of business.

18
19 159 The percentage of injuries happened on beginner, medium and advanced
20
21
22 160 trails were 15%, 27.8% and 57.2% respectively. Accident not involving others
23
24
25 161 took up 67.9% of all injuries. On beginner and advanced trails, the accident
26
27
28 162 not involving others resulted in significantly more injuries, while on medium
29
30
31 163 trail, the proportion of accident involving others or not was similar. (Table 2)

32
33 164 The injured body part showed different patterns between skiers and
34
35
36 165 snowboarders. More than half of the patients injured while skiing sustained
37
38
39 166 lower extremity injuries, while the most common injury in snowboarders was
40
41
42 167 upper extremity injury. Head and cervical injury was identified in 13.7% of
43
44
45 168 skiers and 13.6% of snowboarders. multipart injury took up 5.3% in skiers
46
47
48 169 and 3.4% in snowboarders (Table 3). The cause of injury was also found to
49
50
51 170 be related with the injured body part in both skiers and snowboarders. Head
52
53
54 171 injury took up a significantly more portion in accident involving others. In
55
56
57 172 skiers, lower extremity injury had the highest rate in both accident involving
58
59
60 173 others and accident not involving others, while the rate was significantly
174 174 higher in accident not involving others (Table 4). In snowboarders, upper

1
2
3
4 175 extremity injury was no longer the most frequent injury in accident involving
5
6 176 others (Table 5). The correlation between age, sex, skill level and injured
7
8
9 177 body part was not significant. (Supplementary Tables 1-6)
10
11
12 178

13 14 179 4. Discussion

15
16
17 180 The aim of the present study is to explore the injury patterns of skiers and
18
19 181 snowboarders in China by investigating the largest ski resort in the host city of
20
21
22 182 2022 Winter Olympic Games, and to provide the primitive data to guide the
23
24
25 183 restructure of the hospital near the venues of the 2022 Winter Olympic
26
27 184 Games.
28

29 30 185 31 32 186 Injury incidence

33
34
35 187 It is found that the incidence of sports injuries of recreational skiing and
36
37 188 snowboarding is 1.94 per 1000 skier days in Wanlong ski resort, which lies
38
39
40 189 between the reported injury incidence of 0.5-3.7 per 1000 skier days in
41
42
43 190 European and North American countries in recent years.^{1,7-9} According to the
44
45 191 government report, the total number of visits in ski resorts in Chongli hit nearly
46
47
48 192 1 million in the 2018-19 ski season, which means an estimated number of
49
50
51 193 2,000 sports injuries. The injury incidence calculated in our study is based on
52
53 194 data collected from ski resort clinic, which means the local hospital will be
54
55
56 195 confronting potentially more traumatic cases.
57

58 196
59
60

1
2
3
4 197 Injury patterns
5

6 198 The mean age of injured visitors was 32.5 ± 12.9 years (range 3-73 years),
7
8
9 199 with 10.4% younger than 18 years old and 3.0% older than the age of 60.
10

11 200 The mean age of skiers was older than snowboarders, which is consistent
12
13
14 201 with other studies.^{7,10} In china, winter vacation for teenage students lasts for
15
16
17 202 about 4 weeks around Chinese New Year, which creates a peak of teenage
18
19
20 203 visitors to Chongli in January and February. The results showed sports
21
22 204 injury in teenagers concentrate in these two months, and took up nearly
23
24
25 205 11% of all injures. The incidence of ski injury was reported higher in
26
27
28 206 teenagers than in adults.¹¹ Suezie K et al.⁷ conducted a study where they
29
30
31 207 listed the top 10 injuries in adult and children/adolescent skiers and
32
33
34 208 snowboarders. They found the overall injury patterns were similar between
35
36
37 209 adults and children. However, wrist injury and lower extremity fracture were
38
39
40 210 more likely to be seen in young injured snowboarders. In young skiers,
41
42
43 211 anterior cruciate ligament tear was not prevalent, while tibial fracture was
44
45
46 212 the fifth common injuries in children and adolescent skiers.

47 213 No significant difference was shown in the sex profile between injured
48
49
50 214 skiers and snowboarders. Previous studies found female skiers are more
51
52
53 215 susceptible to lower extremity injury, especially knee injuries, with nearly
54
55
56 216 50% of injured females suffer from knee injury.¹² The present study found
57
58
59 217 similar rate of female suffering from lower extremity injuries in skiing
60
218 population; however, there was no significant difference in injured body part

1
2
3
4 219 between males and females in both sports groups. Paolo G et al.¹³ found
5
6 220 that men experienced more severe injuries than women, which may result
7
8
9 221 from higher speed, body weight and trail difficulty in men.
10

11 222 Due to the small number of participants in other winter sports, such as
12
13 223 cross-country, mountaineering, telemark and skiing, we divided the
14
15 224 injured visitors from Wanlong Ski Resort into 2 categories: skiing and
16
17 225 snowboarding. Snowboarding accounted for nearly 40% of the injured
18
19 226 population in the latest season. Based on the previously published data, an
20
21 227 increase of the percentage of snowboarders in total and injured winter sport
22
23 228 population has been noticed.^{7,14} Derived from skateboarding in 1970s, this
24
25 229 young sport appeals to more young people and at the same time, reshapes
26
27 230 the injury profile. In a study conducted in Big Sky area in United States,
28
29 231 snowboarders took up 42.8% of injured visitors in the 2009-2010 season,
30
31 232 while between 1995 and 2000 only 23.0% of injured people were
32
33 233 snowboarders.¹⁴ Many studies reported that snowboarders had significantly
34
35 234 more injuries to the head, spine and upper extremity when compared with
36
37 235 skiers, whereas skiers sustained significantly more lower extremity
38
39 236 injuries.^{7,10,15} The present study revealed the same patterns, with higher rates
40
41 237 of head, upper extremity injuries in snowboarders, and lower rates of lower
42
43 238 extremity injuries. In a study comparing injury severity in different sports, the
44
45 239 authors reported that the percentage of mild, moderate and severe injuries in
46
47 240 skiing were 41%, 44% and 15% respectively, while the percentage in
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4 241 snowboarding were 34%, 53% and 13%.⁹ Maat SC et al. ¹⁵reported that skiers
5
6 242 were more seriously injured with Injury Severity Scale (ISS) higher than 9.
7
8

9 243 Beginners and medium level skiers (63.5%) and snowboarders (81.4%)
10
11 244 made up the majority of injured visitors. When comparing the injured body
12
13 245 part between different level groups, no significant difference was found in
14
15 246 neither skiers nor snowboarders. In a study involving 19539 injured
16
17 247 snowboarders in Japan, proportions of the trunk and multiple injuries were
18
19 248 found to increase with higher skill level; the injury severity was also found to
20
21 249 increase with skill level.¹⁶ Another study found no relationship between skill
22
23 250 level and injury severity in skiing and snowboarding population once
24
25 251 unconscious patients (who cannot report their skill level) were ruled out.¹³
26
27
28
29

30
31 252 Over two thirds of the injuries did not involve others, which is lower than
32
33 253 the reported rate of self-inflicted injury on Austrian ski slopes.³ The
34
35 254 difference are likely attributed to the higher density of skiers/snowboarders
36
37 255 on the slope in China compared with other countries, which is implied by the
38
39 256 fact that the rate of crash accident was extremely high on medium trails.
40
41 257 Yet, no available studies provide conclusive evidence of the influence
42
43 258 factors of self-inflicted and crash injury rate.¹⁷ The cause of injury was also
44
45 259 found to be related with the injured body part in both skiers and
46
47 260 snowboarders. Head injury took up a significantly more portion in accident
48
49 261 involving others. Sport-specific injuries, such as shoulder injury in
50
51 262 snowboarding and knee injury in skiing,⁷ were more frequent in accident not
52
53
54
55
56
57
58
59
60

1
2
3
4 263 involving others. These findings can be attributed to different injury
5
6 264 mechanism prevalent in various traumatic setting, with non-contact injury
7
8
9 265 often causing ligament and tendon sprains or tears, contact injury causing
10
11 266 bony injury and concussion.¹⁸
12
13

14 267

17 268 Strategies to local hospital

19 269 From an epidemiological view, the present study provides strategies that
20
21
22 270 can guide the restructure of local hospital and unload the burden in winter
23
24 271 season. First, establish pediatric orthopedic department to cope with the
25
26
27 272 pediatric patients who take up nearly 11% of the whole injury population,
28
29
30 273 especially the surge during winter vacation in China. Second, establish
31
32 274 department of neurosurgery and department of oral and maxillofacial surgery
33
34
35 275 in order to deal with the head and face injury, which took up to 15% of all
36
37
38 276 injuries. Third, rearrange the worktime schedule according to the time-related
39
40 277 “tide” of winter sports injury to increase effectiveness with limited manpower.
41
42
43 278 For example, change weekends into work days and set other rest days in
44
45 279 winter season to cope with the traumatic cases in weekend which are twice as
46
47
48 280 many as in weekdays. Fourth, build up communication and cooperation
49
50
51 281 network with nearby ski resorts to allow access to critical patient’s information
52
53 282 in advance and guide prehospital care. Up to now, the local hospital in
54
55
56 283 Chongli has reinforced its orthopedics and sports medicine department by
57
58 284 seeking cooperation with superior hospitals in Beijing. An evidence-based
59
60

1
2
3
4 285 restructure of local hospital may increase the accessibility to health care for
5
6 286 injured skiers and snowboarders in nearby ski resorts.
7
8

9 287 Several limitations exist in this study. First, the severity of injury and
10
11 288 accurate diagnosis were not recorded, patients were not followed up for their
12
13 289 prognosis. Second, although medical providers in ski resort have collected
14
15 290 injury cases as through as possible, there were still patients who went to local
16
17 291 or superior hospitals directly, or did not receive any type of medical help for
18
19 292 mild injuries. In this case, the incidence of injury may be underestimated.
20
21
22 293 Currently, we are conducting a large-scale survey on the demography of
23
24 294 Chinese winter sports participants, and a prospective research of winter
25
26 295 sports injury in skiing population in China to fill the gap of epidemiological
27
28 296 study of winter sports injury in China. The effectiveness of hospital restructure
29
30 297 will be reported as well.
31
32
33
34
35
36

37 298 5. Patient and public involvement

38
39
40 299 It was not appropriate to involve patients or the public in the design, or
41
42 300 conduct, or reporting, or dissemination plans of our research.
43
44

45 301 6. Acknowledgement

46
47
48 302 The medical director of Wanlong Ski Resort, Zhang Jinwei, provided help in
49
50 303 the collection of injury data.
51
52

53 304 7. Funding

54
55
56 305 This work was supported by the National Key Research and Development
57
58 306 Program of China [2018YFF0301100].
59
60

1
2
3
4 307 8. Conflicts of interest

5
6 308 The author states no conflicts of interest.

7
8
9 309 9. Author Contributions

10
11 310 Chen Nayun carried out the data analysis and drafted the manuscript. Yang
12
13
14 311 Yuping carried out the design of patient information registration chart, and
15
16
17 312 helped to draft the manuscript. Ao Yingfang conceived of the study, and
18
19
20 313 participated in its design.

21
22 314 10. Data availability statement

23
24 315 The data in the present study is deidentified participant data which are
25
26
27 316 available upon reasonable request. Please contact the first author for
28
29
30 317 permission to reuse the original data. Email: albert_west@163.com

31
32 318 11. Reference

- 33
34
35 319 1. Ekeland A, Johnson RJ, Shealy J, Senner V, Dean SW. Skiing and
36
37 320 boarding injuries on Norwegian slopes during two winter seasons.
38
39
40 321 Journal of ASTM International. 2010;7(4).
- 41
42
43 322 2. Castellani C, Singer G, Eibisberger M, et al. An epidemiologic analysis
44
45 323 of winter sport accidents on ski slopes comparing two seasons. *J Sports*
46
47
48 324 *Med Phys Fitness*. 2019;59(4):648-654.
- 49
50
51 325 3. Ruedl G, Philippe M, Sommersacher R, Dunnwald T, Kopp M, Burtscher
52
53 326 M. [Current incidence of accidents on Austrian ski slopes]. *Sportverletz*
54
55 327 *Sportschaden*. 2014;28(4):183-187.
- 56
57
58 328 4. Haaland B, Steenstrup SE, Bere T, Bahr R, Nordsletten L. Injury rate
59
60

- 1
2
3
4 329 and injury patterns in FIS World Cup Alpine skiing (2006-2015): have the
5
6 330 new ski regulations made an impact? *Br J Sports Med.* 2016;50(1):32-
7
8
9 331 36.
10
11 332 5. Soligard T, Palmer D, Steffen K, et al. Sports injury and illness incidence
12
13 333 in the PyeongChang 2018 Olympic Winter Games: a prospective study
14
15 334 of 2914 athletes from 92 countries. *Br J Sports Med.* 2019;53(17):1085-
16
17 335 1092.
18
19 336 6. Asadollahi S, Bucknill A. Acute medial clavicle fracture in adults: a
20
21 337 systematic review of demographics, clinical features and treatment
22
23 338 outcomes in 220 patients. *J Orthop Traumatol.* 2019;20(1):24.
24
25 339 7. Kim S, Endres NK, Johnson RJ, Ettlinger CF, Shealy JE. Snowboarding
26
27 340 injuries: trends over time and comparisons with alpine skiing injuries. *Am*
28
29 341 *J Sports Med.* 2012;40(4):770-776.
30
31 342 8. Langran M, Selvaraj S. Snow sports injuries in Scotland: a case-control
32
33 343 study. *Br J Sports Med.* 2002;36(2):135-140.
34
35 344 9. Stenroos A, Handolin L. Incidence of Recreational Alpine Skiing and
36
37 345 Snowboarding Injuries: Six Years Experience in the Largest Ski Resort
38
39 346 in Finland. *Scand J Surg.* 2015;104(2):127-131.
40
41 347 10. Wasden CC, McIntosh SE, Keith DS, McCowan C. An analysis of skiing
42
43 348 and snowboarding injuries on Utah slopes. *J Trauma.* 2009;67(5):1022-
44
45 349 1026.
46
47 350 11. Provance AJ, Daoud AK, Tagawa A, Rhodes J. Pediatric and adolescent
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4 351 injury in skiing. *Res Sports Med.* 2018;26(sup1):150-165.
5
6 352 12. Ruedl G, Linortner I, Schranz A, et al. Distribution of injury mechanisms
7
8
9 353 and related factors in ACL-injured female carving skiers. *Knee Surg*
10
11 354 *Sports Traumatol Arthrosc.* 2009;17(11):1393-1398.
12
13
14 355 13. Girardi P, Braggion M, Sacco G, De Giorgi F, Corra S. Factors affecting
15
16
17 356 injury severity among recreational skiers and snowboarders: an
18
19 357 epidemiology study. *Knee Surg Sports Traumatol Arthrosc.*
20
21 358 2010;18(12):1804-1809.
22
23
24 359 14. Coury T, Napoli AM, Wilson M, Daniels J, Murray R, Milzman D. Injury
25
26
27 360 patterns in recreational alpine skiing and snowboarding at a
28
29 361 mountainside clinic. *Wilderness Environ Med.* 2013;24(4):417-421.
30
31
32 362 15. Maat SC, Luppino FS, Schipper IB, Krijnen P, Bartlema KA. Injury
33
34
35 363 patterns after skiing and snowboarding sports accidents. *J Sports Med*
36
37 364 *Phys Fitness.* 2020;60(1):119-124.
38
39
40 365 16. Ogawa H, Sumi H, Sumi Y, Shimizu K. Skill level-specific differences in
41
42
43 366 snowboarding-related injuries. *Am J Sports Med.* 2010;38(3):532-537.
44
45
46 367 17. Ruedl G, Kopp M, Burtscher M, Bauer R, Benedetto K. [Causes and
47
48 368 factors associated with collisions on ski slopes]. *Sportverletz*
49
50 369 *Sportschaden.* 2013;27(2):100-104.
51
52
53 370 18. Davey A, Endres NK, Johnson RJ, Shealy JE. Alpine Skiing Injuries.
54
55 371 *Sports Health.* 2019;11(1):18-26.
56
57
58 372
59
60

373

374 Tables and Figures

375

Table 1. Details of injured skiers and snowboarders

	Skiers (n=453)	Snowboarders (n=294)	P value
Sex, n (%)			
Male	281 (63.3%)	184 (62.6%)	0.846
Female	163 (36.7%)	110 (37.4%)	
Age, y	35.1±14.5	29.0±8.9	<0.01*
Skill level, n (%)			
Beginner	110 (29.5%)	101 (37.5%)	<0.01*
Medium	127 (34.0%)	118 (43.9%)	
Advanced	85 (22.8%)	37 (13.8%)	
Expert	51 (13.7%)	13 (4.8%)	

376

377

Table 2. Cause of injury and slope difficulty

	Injury not involving others (n=486)	Injury involving others (n=226)	P value
Beginner trail	93	18	<0.01*
Medium trail	103	87	
Advanced trail	292	121	

378

379

Table 3. injured body part in skiers and snowboarders

	Skiers (n=417)	Snowboarders (n=265)	P value
Head and cervical	57 (13.7%)	36 (13.6%)	<0.01*
Torso	83 (19.9%)	63 (23.8%)	
Upper extremity	79 (18.9%)	125 (47.2%)	
Lower extremity	222 (53.2%)	50 (18.9%)	
Multipart	22 (5.3%)	9 (3.4%)	

380

Table 4. The relationship between cause of injury and injured body part in skiers

382

	Injury not involving others (n=289)	Injury involving others (n=116)	P value
Head and cervical	21(7.3%)	31(26.7%)	<0.01
Torso	53(18.3%)	26(22.4%)	
Upper extremity	53(18.3%)	24(20.7%)	
Lower extremity	171(59.2%)	48(41.4%)	
Multipart injury	9(3.1%)	12(10.3%)	

383

384 Table 5. The relationship between cause of injury and injured body partin

385 snowboarders

	Injury not involving others (n=197)	Injury involving others (n=63)	P value
Head and cervical	17(8.6%)	19(30.1%)	<0.01
Torso	39(19.8%)	22(34.9%)	
Upper extremity	107(54.3%)	16(25.4%)	
Lower extremity	37(18.8%)	12(19.0%)	
Multipart injury	3(1.5%)	6(9.5%)	

386

387 Figure 1. The flow chart on how the injury occurred in the ski resort was

388 managed. If the patrol was called, the injured tourist will be sent to the resort

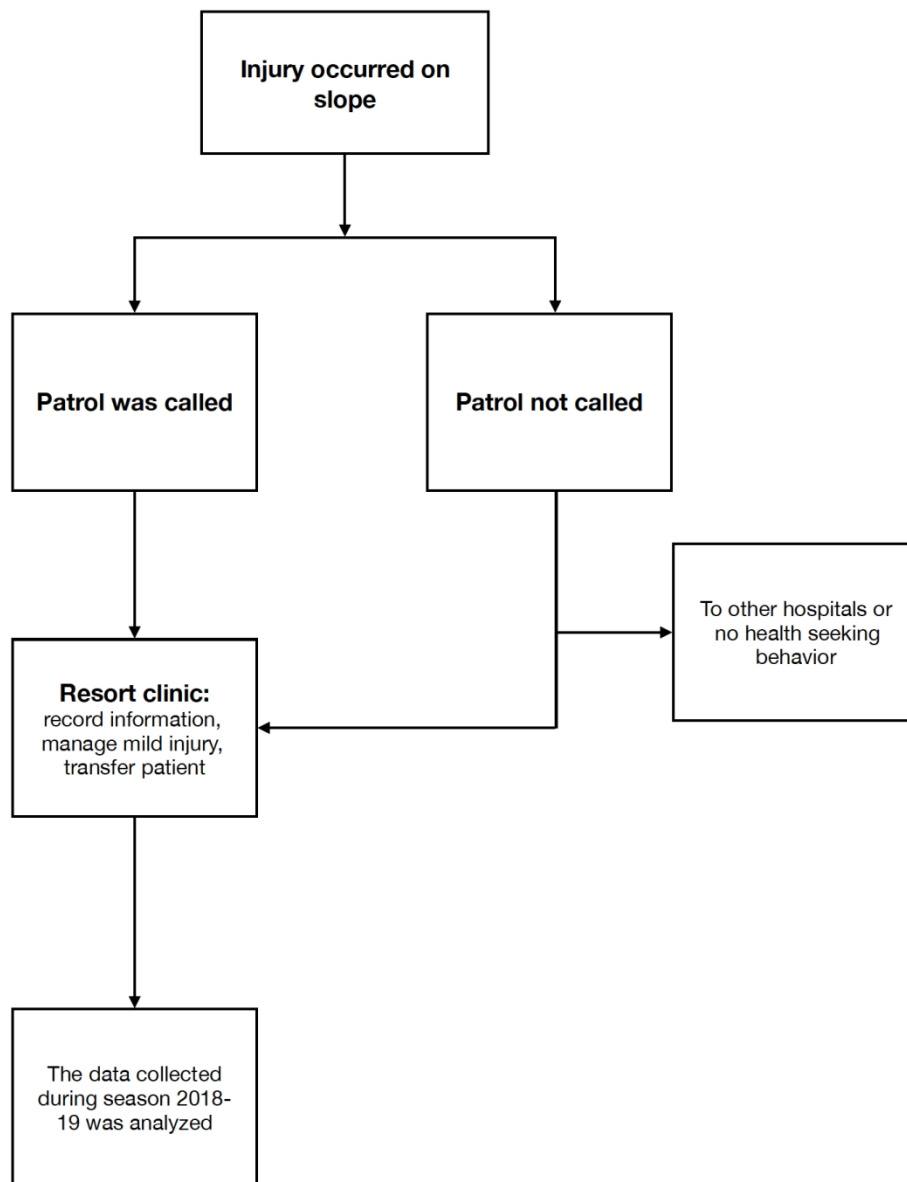
389 clinic where further management was performed. If the patrol was called, the

390 injured tourists may self-present to the resort clinic or go to other hospitals

391 without seeing the clinic staff first, or even have no health-seeking behavior.

392 The data in this study was collected during 2018-19 winter season.

393



45 The flow chart on how the injury occurred in the ski resort was managed. If the patrol was called, the
46 injured tourist will be sent to the resort clinic where further management was performed. If the patrol was
47 called, the injured tourists may self-present to the resort clinic or go to other hospitals without seeing the
48 clinic staff first, or even have no health-seeking behavior. The data in this study was collected during 2018-
49 19 winter season.

50 492x644mm (72 x 72 DPI)

Table 1. The relationship between sex and injured body part in skiers

	Male (n=260)	Female (n=158)	P value
Head and cervical	32(12.3%)	25(15.8%)	0.29
Torso	58(22.3%)	24(15.2%)	
Upper extremity	51(19.6%)	28(17.7%)	
Lower extremity	131(50.4%)	91(57.6%)	
Multipart injury	12(4.6%)	10(6.3%)	

Table 2. The relationship between sex and injured body part in snowboarders

	Male (n=158)	Female (n=107)	P value
Head and cervical	21(13.3%)	15(14.0%)	0.63
Torso	42(25.6%)	21(19.6%)	
Upper extremity	74(46.8%)	51(47.7%)	
Lower extremity	26(16.5%)	24(22.4%)	
Multipart injury	5(3.2%)	4(3.7%)	

Table 3. The relationship between age and injured body part in skiers

	Teenager (n=52)	Adult (n=329)	Elderly (n=22)	P value
Head and cervical	15(28.8%)	39(11.9%)	2(9.1%)	0.14
Torso	6(11.5%)	70(21.3%)	4(18.2%)	
Upper extremity	12(23.1%)	57(17.3%)	8(36.4%)	
Lower extremity	22(42.3%)	179(54.4%)	11(50%)	
Multipart injury	3(5.8%)	16(4.9%)	3(13.6%)	

Table 4. The relationship between age and injured body part in snowboarders

	Male (n=26)	Female (n=238)	Elderly (n=0)	P value
Head and cervical	6(23.1%)	30(12.6%)	0	0.21
Torso	4(15.4%)	59(25.2%)	0	
Upper extremity	15(57.7%)	109(45.8%)	0	
Lower extremity	2(7.7%)	48(20.2%)	0	
Multipart injury	1(3.8%)	8(3.4%)	0	

Table 5. The relationship between skill level and injured body part in skiers

	Beginner (n=106)	Medium (n=118)	Advanced (n=79)	Expert (n=49)	P value
Head and cervical	13(28.8%)	12(11.9%)	11(9.1%)	5(%)	0.19
Torso	18(11.5%)	27(21.3%)	16(18.2%)	10(%)	
Upper extremity	22(23.1%)	18(17.3%)	15(36.4%)	13(%)	
Lower extremity	54(42.3%)	164(54.4%)	48(50%)	24(%)	
Multipart injury	2(5.8%)	4(4.9%)	9(13.6%)	3(%)	

Table 6. The relationship between skill level and injured body part in snowboarders

	Beginner (n=93)	Medium (n=109)	Advance (n=36)	Expert (n=11)	P value
Head and cervical	15(23.1%)	11(12.6%)	5	1	0.32
Torso	20(15.4%)	27(25.2%)	10	2	
Upper extremity	46(57.7%)	51(45.8%)	14	7	
Lower extremity	14(7.7%)	26(20.2%)	8	8	

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
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
53
54
55
56
57
58
59
60

Multipart injury	2(3.8%)	6(3.4%)	1	0
------------------	---------	---------	---	---

For peer review only

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	6
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-8

1	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
2			(b) Report category boundaries when continuous variables were categorized	NA
3			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
4				
5				
6				
7				
8				
9	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
10				
11	Discussion			
12				
13	Key results	18	Summarise key results with reference to study objectives	9
14	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
15				
16	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
17				
18				
19	Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
20				
21	Other information			
22	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13
23				
24				

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.

BMJ Open

Injury patterns in a large-scale ski resort in the host city of 2022 Winter Olympic Games: a retrospective study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-037834.R2
Article Type:	Original research
Date Submitted by the Author:	29-Aug-2020
Complete List of Authors:	Chen, Nayun; Peking University Third Hospital, Institute of Sports Medicine Yang, Yuping; Peking University Third Hospital, Institute of Sports Medicine Ao, Yingfang; Peking University Third Hospital,
Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Public health
Keywords:	SPORTS MEDICINE, PUBLIC HEALTH, Orthopaedic sports trauma < ORTHOPAEDIC & TRAUMA SURGERY

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 Injury patterns in a large-scale ski resort in the host city of 2022 Winter

5
6
7 2 Olympic Games: a retrospective study

8
9 3 Chen Nayun^{1*}, Yang Yuping^{1*}, Ao Yingfang¹

10
11
12 4 1. Peking University Third Hospital, Peking University Institute of Sports

13
14 5 Medicine

15
16
17 6 * They contribute equally to this article.

18
19
20 7 Corresponding Author: Ao Yingfang

21
22 8 E-mail: aoyingfang@163.com

23
24
25 9 Running title: Injury pattern in Chinese ski resort

26
27
28 10 Word Count : 2848

1
2
3
4 23 Abstract

5
6 24 Objective: The aim of the study is to describe the injury patterns in
7
8
9 25 recreational skiers and snowboarders in China, and to provide the primitive
10
11 26 data to guide the restructure of regional health care facility to deal with the
12
13
14 27 increasing number of participants in snow sports. The secondary goal is to
15
16
17 28 compare injury patterns in different subgroups.

18
19 29 Design: Retrospective study

20
21
22 30 Methods: A retrospective study was performed in Wanlong Ski Resort in
23
24
25 31 Chongli. The data of all injured skiers and snowboarders treated in the resort
26
27 32 clinic during season 2018-2019 was collected. Patients information, including
28
29
30 33 sex, age, equipment, ski level, injured body part was analyzed.

31
32 34 Results: A total of 753 sports injuries were recorded. The estimated incidence
33
34
35 35 of injury was 1.98 per 1000 skier days. 453 cases (60.2%) were associated
36
37
38 36 with skiing. The mean age of skiers was older than snowboarders (35.1 ± 14.5
39
40 37 vs. 29.0 ± 8.9 , $p < 0.01$). Injury not involving others took up 67.9% of all injuries.
41
42
43 38 The most common injured body part in skiers was lower extremity injuries;
44
45
46 39 while in snowboarders, it was upper extremity injuries. Head and cervical
47
48 40 injury was identified in 13.7% of skiers and 13.6% of snowboarders.

49
50
51 41 Conclusion: The incidence of skiing/snowboarding injury in China is similar to
52
53 42 previous studies. The injury pattern differs according to different sports and
54
55
56 43 cause of injury.

57
58 44 Key words: Sports injury, Skiing, Snowboarding
59
60

1
2
3
4 45 Strength and limitations of this study:
5

6 46 1. Since Beijing was selected to host the 2022 Winter Olympics, skiing and
7
8
9 47 snowboarding population in China has risen rapidly. The present study is the
10
11
12 48 first epidemiological study investigating the injury patterns in Chinese ski
13
14 49 resort.
15

16
17 50 2. This study provided evidence for restructuring the local hospital in the host
18
19
20 51 city of 2022 Winter Olympic Games.
21

22 52 3. Several limitations exist in this study. The severity of injury and accurate
23
24
25 53 diagnosis were not recorded, patients were not followed up for their
26
27
28 54 prognosis. There were still patients who went to local or superior hospitals
29
30
31 55 directly, or did not receive any type of medical help for mild injuries. In this
32
33 56 case, the incidence of injury may be underestimated.
34

35 57

36
37 58

38
39
40 59

41
42 60

43
44
45 61

46
47 62

48
49
50 63

51
52 64

53
54
55 65

56
57 66

58
59
60

1. Introduction

Skiing and snowboarding are popular winter sports world-wide but carry a substantial risk of sports injuries, with reported incidence of 0.5-1.35 injuries per 1000 skier/snowboarder days in recreational skiers/snowboarders¹⁻³ and 6.9 injuries per 1000 runs (or 26.8 injuries per 100 athletes per season)⁴ in professional alpine skiers in recent years. In the latest Winter Olympic Games in PyeongChang, 12% of the athletes incurred at least one injury, equaling 12.6 injuries per 100 athletes over the 17-day period⁵.

Since Beijing was selected to host the 2022 Winter Olympics, skiing and snowboarding population in China has risen from 8 million in 2015 to 13.2 million in 2018 (industry annual report, 2019). The skiing population in China concentrates in developed areas; however, large-scale ski resorts in China are often located in areas remote from major cities. Undoubtedly, hospitals close to ski resorts have confronted an increasing number of injured skiers and snowboarders. It is important that regional facilities are equipped to ingest large number of patients and manage severe injuries.

The aim of the study is to describe the injury patterns in recreational skiers and snowboarders in China by investigating the largest ski resort in the host city of 2022 Winter Olympic Games, and to provide the primitive data to guide the restructure of the local hospital to deal with the increasing number of participants in snow sports. The secondary goal is to compare injury patterns in different subgroups.

89 2. Patients and Methods

90 The data of this retrospective study was collected from the resort clinic of
91 Wanlong Ski Resort in Chongli during ski season 2018-2019. Wanlong Ski
92 Resort is a destination ski resort in Northern China, which has various terrain
93 and the largest number of annual visits. The resort clinic is staffed by a
94 registered general practitioner and a nurse, and is responsible for the primary
95 care of all injured visitors, whether self-present or sent by patrols; it is also
96 responsible for treating mild injury, transferring patients to local hospital,
97 carrying out basic life support for life-threatening injuries. The season of 2018-
98 2019 in Wanlong Ski Resort lasted for 158 days, from 2018/11/1-2019/4/7. A
99 total of 388606 visits (379503 skier days) were recorded.

100 Besides patient's name, sex and age, we also recorded equipment, skill
101 level, the date and time of injury, the cause of injury, the slope difficulty and
102 the injured body part. Equipment was classified into skis and snowboards.
103 Special equipment, such as cross-country skis, skiboards, was rare in China
104 and not seen in recorded injured people. According to self-reported years of
105 participation in skiing and snowboarding, patients were classified as beginner
106 (first season), medium (1-5 years), advanced (5-10 years) and expert (≥ 10
107 years). The date of injury was divided into weekdays and weekends/holidays
108 according to the Chinese government holiday arrangement. The business
109 hour of Wanlong Ski Resort is 8:00-16:00, so we split the time of injury into 4
110 periods with 2 hours each, morning (first 2 hours of business), noon,

1
2
3
4 111 afternoon and late afternoon (last 2 hours of business). According to the
5
6 112 subjective description of injury scene, we summarized 2 types of causes of
7
8
9 113 injury: not involving others, defined as falling or crashing without any body
10
11
12 114 contact with others; and involving others, defined as crashing involving 2 or
13
14 115 more people. The slope difficulty was categorized into beginner trail, medium
15
16
17 116 trail and advanced trail according to the official data of slope inclination angle.
18
19 117 Injured body parts were categorized into the following 4 anatomical body
20
21
22 118 regions: (1) head/cervical, (2) torso, (3) upper extremity, and (4) lower
23
24
25 119 extremity. Acromioclavicular joint injuries were classified as upper limb injury,
26
27 120 while other clavicle injuries were classified as torso injuries.⁶ Injuries involving
28
29
30 121 gluteal region were classified as torso injury. Whether patients have multi-part
31
32
33 122 injuries was also recorded, while each injured body part was counted in one of
34
35
36 123 the above groups. The relationship between injured body part and sex, age,
37
38 124 equipment and cause of injury was further determined by subgroup analysis.

39
40 125 The present study is epidemiological and anonymous, therefore informed
41
42
43 126 consent was not applicable. This study was approved by Peking University
44
45
46 127 Third Hospital Medical Science Research Ethics Committee.

47 48 128 Statistical analysis

49
50 129 All statistical analysis was performed with SPSS (v 24.0; IBM Corp).
51
52
53 130 Continuous variables were presented as mean and standard deviations, while
54
55
56 131 categorical data were presented with frequency count and percentages. To do
57
58
59 132 comparison between subgroups, Chi-squared test was used for categorical
60

1
2
3
4 133 variables and student t test was used for continuous variables. When there is
5
6 134 missing data, the available case was analyzed to determine difference
7
8
9 135 between groups. $P < 0.05$ was considered to indicate statistical significance.
10

11 136 3. Results

12
13
14 137 During the study period, there were 388606 visits (379503 skier days) and
15
16
17 138 753 cases of injury recorded in Wanlong Ski Resort. The estimated incidence
18
19 139 of injury was 1.98 per 1000 skier days.
20

21 140 Features of injury

22
23
24 141 The mean age of injured visitors was 32.5 ± 12.9 years (range 3-73 years).
25
26
27 142 Pediatric patients under 15 years old took up 9.3%, while senior patients (over
28
29 143 the age of 60) took up 3.0% of all injured population. The number of males
30
31 144 was twice as females. Among these injuries, 453 cases (60.2%) were
32
33 145 associated with skiing. Table 1 shows more detailed demographic and sport-
34
35 146 related profiles of these injuries.
36
37
38
39

40 147 The season of 2018-2019 in Wanlong Ski Resort consisted of 107
41
42 148 weekdays and 51 weekends/holidays according to the Chinese government
43
44 149 arrangement. The average daily number of injuries was 3.38 on weekdays
45
46 150 and 7.65 on weekends/holidays. A peak of pediatric cases was noted in
47
48 151 January and February (Figure 1). Within a day, the percentage of injury
49
50 152 occurred in morning, noon, afternoon and late afternoon was 9.7%, 31.6%,
51
52 153 22.0% and 36.7% respectively.
53
54
55
56
57
58
59
60

1
2
3
4 154 Accidents not involving others took up 67.9% of all injuries. The most
5
6 155 common injured body parts were upper and lower limbs, which made up
7
8
9 156 28.4% and 37.6% of all injuries respectively. Head and cervical injuries also
10
11
12 157 took up a notable portion of injuries (13.1%).

13 14 158 Injury pattern in subgroups

15
16
17 159 The mean age of skiers was 35.1 ± 14.5 years, whereas the mean age of
18
19 160 snowboarders was 29.0 ± 8.9 years ($p < 0.01$). There was no significant
20
21
22 161 difference in the sex profile between skiers and snowboarders.

23
24 162 The injured body parts showed different patterns between skiers and
25
26
27 163 snowboarders. More than half of the patients injured while skiing sustained
28
29
30 164 lower extremity injuries, while the most common injury in snowboarders was
31
32
33 165 upper extremity injury. Head and cervical injury was identified in 13.7% of
34
35 166 skiers and 13.6% of snowboarders. Multipart injury took up 5.3% in skiers and
36
37
38 167 3.4% in snowboarders (Table 2). The cause of injury was also found to be
39
40
41 168 related with the injured body parts in both skiers and snowboarders. Head
42
43
44 169 injury took up a significantly more portion in accidents involving others. In
45
46
47 170 skiers, lower extremity injury had the highest rate in both accidents involving
48
49
50 171 others and accidents not involving others, while the rate was significantly
51
52
53 172 higher in accidents not involving others (Table 3). In snowboarders, head,
54
55
56 173 cervical and torso injury took up a greater portion in accidents involving others
57
58
59 174 (Table 4). The correlation between age, sex, skill level and injured body parts
60
175 was not significant. (Supplementary Tables 5-10)

1
2
3
4 176

5
6 177 4. Discussion

7
8
9 178 We found that the incidence of snow sports related injury of recreational
10
11 179 skiing and snowboarding population in China's largest ski resort was 1.98 per
12
13 180 1000 skier days, which was comparable to reported injury incidence of 0.5-3.7
14
15 181 per 1000 skier days in European and North American countries in recent
16
17 182 years.^{1,7-9} According to the government report, the total number of visits in ski
18
19 183 resorts in Chongli hit nearly 1 million in the 2018-19 ski season, which means
20
21 184 an estimated number of 2,000 sports injuries per season if such finding is
22
23 185 extrapolated to the whole region. Therefore, a better understanding of injury
24
25 186 pattern in Chinese population will guide the reform of local health care facility
26
27 187 and help dealing with the seasonal increase of sports injury.

28
29
30 188 The mean age of injured visitors was 32.5±12.9 years (range 3-73 years),
31
32 189 with 9.3% younger than 15 years old. In china, winter vacation for teenage
33
34 190 students lasts for about 4 weeks around Chinese New Year, which creates
35
36 191 a peak of teenage visitors to Chongli in January and February. We found
37
38 192 that sports injury in teenagers concentrated in January and February, and
39
40 193 took up nearly 15% of injuries occurred in these two months. The incidence
41
42 194 of ski injury was reported higher in teenagers than in adults.¹⁰ An increase
43
44 195 of pediatric patients of snow sports injury will be seen in the future, as more
45
46 196 young people participate in these activities.
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4 197 Previous studies found female skiers are more susceptible to lower
5
6 198 extremity injury, especially knee injuries, with nearly 50% of injured females
7
8
9 199 suffer from knee injury.¹¹ The present study found similar rate of females
10
11 200 suffering from lower extremity injuries in skiing population; however, there
12
13
14 201 was no significant difference in injured body parts between males and
15
16
17 202 females in both sports groups. Paolo G et al.¹² found that men experienced
18
19 203 more severe injuries than women, which may result from higher speed,
20
21
22 204 body weight and trail difficulty in men.

23
24 205 Snowboarding accounted for nearly 40% of the injured population in the
25
26
27 206 latest season. Based on the previously published data, an increase of the
28
29
30 207 percentage of snowboarders in total and injured winter sport population has
31
32
33 208 been noticed.^{7,13} Derived from skateboarding in 1970s, this young sport
34
35 209 appeals to more young people and at the same time, reshapes the injury
36
37
38 210 profile. In a study conducted in Big Sky area in United States, snowboarders
39
40
41 211 took up 42.8% of injured visitors in the 2009-2010 season, while between
42
43 212 1995 and 2000 only 23.0% of injured people were snowboarders.¹⁴ Many
44
45 213 studies reported that snowboarders had significantly more injuries to the
46
47
48 214 head, spine and upper extremity when compared with skiers, whereas skiers
49
50
51 215 sustained significantly more lower extremity injuries.^{7,14,15} The present study
52
53 216 revealed the same patterns, with higher rates of head, upper extremity injuries
54
55
56 217 in snowboarders, and lower rates of lower extremity injuries. In a study
57
58 218 comparing injury severity in different sports, the authors reported that the
59
60

1
2
3
4 219 percentage of mild, moderate and severe injuries in skiing were 41%, 44%
5
6 220 and 15% respectively, while the percentage in snowboarding were 34%, 53%
7
8
9 221 and 13%.⁹ Maat SC et al. ¹⁵reported that skiers were more seriously injured
10
11 222 with Injury Severity Scale (ISS) higher than 9.
12
13

14 223 Beginners and medium level skiers (63.5%) and snowboarders (81.4%)
15
16 224 made up the majority of injured visitors. In a study involving 19539 injured
17
18 225 snowboarders in Japan, proportions of the trunk and multiple injuries were
19
20 226 found to increase with higher skill level; the injury severity was also found to
21
22 227 increase with skill level.¹⁶ Another study found no relationship between skill
23
24 228 level and injury severity in skiing and snowboarding population once
25
26 229 unconscious patients (who cannot report their skill level) were ruled out.¹³
27
28
29

30 230 Over two thirds of the injuries did not involve others, which is lower than
31
32 231 the reported rate of self-inflicted injury on Austrian ski slopes.³ The
33
34 232 difference are likely attributed to the higher density of skiers/snowboarders
35
36 233 on the slope in China compared with other countries, which is implied by the
37
38 234 fact that the rate of crash accident was extremely high on medium trails.
39
40 235 (Supplementary Table11) Yet, no available studies provide conclusive
41
42 236 evidence of the influence factors of self-inflicted and crash injury rate.¹⁷ The
43
44 237 cause of injury was also found to be related with the injured body parts in
45
46 238 both skiers and snowboarders. Head injury took up a significantly more
47
48 239 portion in accidents involving others. Sport-specific injuries, such as
49
50 240 shoulder injury in snowboarding and knee injury in skiing,⁷ were more
51
52
53
54
55
56
57
58
59
60

1
2
3
4 241 frequent in accidents not involving others. These findings can be attributed
5
6 242 to different injury mechanism prevalent in various traumatic setting, with
7
8
9 243 non-contact injury often causing ligament and tendon sprains or tears,
10
11 244 contact injury causing bony injury and concussion.¹⁸
12
13

14 245 From an epidemiological view, the present study provides strategies that
15
16 246 can guide the restructure of local hospital and unload the burden in winter
17
18 247 season. First, establish pediatric orthopedic department to cope with the
19
20 248 pediatric patients who take up nearly 10% of the whole injury population,
21
22 249 especially the surge during winter vacation in China. Second, establish
23
24 250 department of neurosurgery and department of oral and maxillofacial surgery
25
26 251 in order to deal with the head and face injury, which took up to 13% of all
27
28 252 injuries. Third, rearrange the worktime schedule according to the time-related
29
30 253 “tide” of winter sports injury to increase effectiveness with limited manpower.
31
32 254 For example, change weekends into work days and set other rest days in
33
34 255 winter season to cope with the traumatic cases in weekend which are twice as
35
36 256 many as in weekdays. Fourth, intensive care unit is crucial to manage severe
37
38 257 injuries as the population of snowboarders, higher skill level and young
39
40 258 participant grow bigger, because these populations are at higher risk of
41
42 259 severe injuries according to previous studies. Fifth, build up communication
43
44 260 and cooperation network with nearby ski resorts to allow access to critical
45
46 261 patient’s information in advance and guide prehospital care. Although the
47
48 262 present study did not provide information about injury severity and number of
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4 263 patients who need transfer and further treatment, up to 60% of injured skiers
5
6 264 and snowboarders seen in resort clinic require transfer to hospital based on
7
8
9 265 existing literature.⁹ Up to now, the local hospital in Chongli has reinforced its
10
11 266 orthopedics and sports medicine department by seeking cooperation with
12
13
14 267 superior hospitals in Beijing. An evidence-based restructure of local hospital
15
16
17 268 may increase the accessibility to health care for injured skiers and
18
19 269 snowboarders in nearby ski resorts.

20
21
22 270 Several limitations exist in this study. First, the severity of injury and
23
24 271 accurate diagnosis were not recorded, patients were not followed up for their
25
26
27 272 prognosis. Second, although medical providers in ski resort have collected
28
29
30 273 injury cases as through as possible, there were still patients who went to local
31
32 274 or superior hospitals directly, or did not receive any type of medical help for
33
34
35 275 mild injuries. In this case, the incidence of injury may be underestimated.
36
37 276 Additionally, the injury severity and number of patients who needed transfer
38
39
40 277 was incomplete, so we were unable to estimate the burden of local hospital in
41
42
43 278 skiing season. Currently, we are conducting a large-scale survey on the
44
45
46 279 demography of Chinese winter sports participants, and a prospective research
47
48 280 of winter sports injury in skiing population in China to fill the gap. The
49
50 281 effectiveness of hospital restructure will be reported as well.

53 282 5. Patient and public involvement

54
55
56 283 It was not appropriate to involve patients or the public in the design, or
57
58 284 conduct, or reporting, or dissemination plans of our research.
59
60

1
2
3
4 285 6. Acknowledgement

5
6 286 The medical director of Wanlong Ski Resort, Zhang Jinwei, provided help in
7
8
9 287 the collection of injury data.

10
11 288 7. Funding

12
13
14 289 This work was supported by the National Key Research and Development
15
16
17 290 Program of China [2018YFF0301100].

18
19 291 8. Conflicts of interest

20
21
22 292 The author states no conflicts of interest.

23
24 293 9. Author Contributions

25
26
27 294 Chen Nayun carried out the data analysis and drafted the manuscript. Yang
28
29
30 295 Yuping carried out the design of patient information registration chart, and
31
32
33 296 helped to draft the manuscript. Ao Yingfang conceived of the study, and
34
35
36 297 participated in its design.

37
38 298 10. Data availability statement

39
40 299 The data in the present study is deidentified participant data which are
41
42
43 300 available upon reasonable request. Please contact the first author for
44
45
46 301 permission to reuse the original data. Email: albert_west@163.com

47
48 302 11. Reference

49
50
51 303 1. Ekeland A, Johnson RJ, Shealy J, Senner V, Dean SW. Skiing and
52
53 304 boarding injuries on Norwegian slopes during two winter seasons.
54
55
56 305 Journal of ASTM International. 2010;7(4).

57
58 306 2. Castellani C, Singer G, Eibisberger M, et al. An epidemiologic analysis
59
60

- 1
2
3
4 307 of winter sport accidents on ski slopes comparing two seasons. *J Sports*
5
6 308 *Med Phys Fitness*. 2019;59(4):648-654.
- 7
8
9 309 3. Ruedl G, Philippe M, Sommersacher R, Dunnwald T, Kopp M, Burtscher
10
11 310 M. [Current incidence of accidents on Austrian ski slopes]. *Sportverletz*
12
13 311 *Sportschaden*. 2014;28(4):183-187.
- 14
15
16
17 312 4. Haaland B, Steenstrup SE, Bere T, Bahr R, Nordsletten L. Injury rate
18
19 313 and injury patterns in FIS World Cup Alpine skiing (2006-2015): have the
20
21 314 new ski regulations made an impact? *Br J Sports Med*. 2016;50(1):32-
22
23 315 36.
- 24
25
26
27 316 5. Soligard T, Palmer D, Steffen K, et al. Sports injury and illness incidence
28
29 317 in the PyeongChang 2018 Olympic Winter Games: a prospective study
30
31 318 of 2914 athletes from 92 countries. *Br J Sports Med*. 2019;53(17):1085-
32
33 319 1092.
- 34
35
36
37 320 6. Asadollahi S, Bucknill A. Acute medial clavicle fracture in adults: a
38
39 321 systematic review of demographics, clinical features and treatment
40
41 322 outcomes in 220 patients. *J Orthop Traumatol*. 2019;20(1):24.
- 42
43
44
45 323 7. Kim S, Endres NK, Johnson RJ, Ettlinger CF, Shealy JE. Snowboarding
46
47 324 injuries: trends over time and comparisons with alpine skiing injuries. *Am*
48
49 325 *J Sports Med*. 2012;40(4):770-776.
- 50
51
52
53 326 8. Langran M, Selvaraj S. Snow sports injuries in Scotland: a case-control
54
55 327 study. *Br J Sports Med*. 2002;36(2):135-140.
- 56
57
58 328 9. Stenroos A, Handolin L. Incidence of Recreational Alpine Skiing and
59
60

- 1
2
3
4 329 Snowboarding Injuries: Six Years Experience in the Largest Ski Resort
5
6 330 in Finland. *Scand J Surg.* 2015;104(2):127-131.
7
8
9 331 10. Provance AJ, Daoud AK, Tagawa A, Rhodes J. Pediatric and adolescent
10
11 332 injury in skiing. *Res Sports Med.* 2018;26(sup1):150-165.
12
13
14 333 11. Ruedl G, Linortner I, Schranz A, et al. Distribution of injury mechanisms
15
16 334 and related factors in ACL-injured female carving skiers. *Knee Surg*
17
18 335 *Sports Traumatol Arthrosc.* 2009;17(11):1393-1398.
19
20
21
22 336 12. Girardi P, Braggion M, Sacco G, De Giorgi F, Corra S. Factors affecting
23
24 337 injury severity among recreational skiers and snowboarders: an
25
26 338 epidemiology study. *Knee Surg Sports Traumatol Arthrosc.*
27
28 339 2010;18(12):1804-1809.
29
30
31
32 340 13. Coury T, Napoli AM, Wilson M, Daniels J, Murray R, Milzman D. Injury
33
34 341 patterns in recreational alpine skiing and snowboarding at a
35
36 342 mountainside clinic. *Wilderness Environ Med.* 2013;24(4):417-421.
37
38
39
40 343 14. Wasden CC, McIntosh SE, Keith DS, McCowan C. An analysis of skiing
41
42 344 and snowboarding injuries on Utah slopes. *J Trauma.* 2009;67(5):1022-
43
44 345 1026.
45
46
47
48 346 15. Maat SC, Luppino FS, Schipper IB, Krijnen P, Bartlema KA. Injury
49
50 347 patterns after skiing and snowboarding sports accidents. *J Sports Med*
51
52 348 *Phys Fitness.* 2020;60(1):119-124.
53
54
55
56 349 16. Ogawa H, Sumi H, Sumi Y, Shimizu K. Skill level-specific differences in
57
58 350 snowboarding-related injuries. *Am J Sports Med.* 2010;38(3):532-537.
59
60

- 1
2
3
4 351 17. Ruedl G, Kopp M, Burtscher M, Bauer R, Benedetto K. [Causes and
5
6 352 factors associated with collisions on ski slopes]. *Sportverletz*
7
8
9 353 *Sportschaden*. 2013;27(2):100-104.
10
11 354 18. Davey A, Endres NK, Johnson RJ, Shealy JE. Alpine Skiing Injuries.
12
13
14 355 *Sports Health*. 2019;11(1):18-26.
15
16
17 356
18
19
20 357
21
22 358 Tables and Figures
23
24
25 359 Table 1. Demographic and sport-related information of injured population

	n (%)
Sex	
Male	475 (63.3%)
Female	278 (36.7%)
Age	
<15 years	68 (9.3%)
15-60 years	643 (87.7%)
>60 years	22 (3.0%)
Equipment	
Ski	453 (60.6%)
Snowboard	294 (39.4%)

Skill level	
Beginner	211 (29.5%)
Medium	246 (34.0%)
Advanced	122(22.8%)
Expert	64 (13.7%)
Slope difficulty	
Beginner trail	111(15.3%)
Medium trail	206 (26.5%)
Advanced trail	425 (58.1%)

360

361

Table 2. Details of injured skiers and snowboarders

	Skiers (n=453)	Snowboarders (n=294)	P value
Sex, n (%)			
Male	281 (63.3%)	184 (62.6%)	0.846
Female	163 (36.7%)	110 (37.4%)	
Age, n (%)			
<15 years	44 (10.3%)	22 (7.5%)	<0.01*
15-60 years	363 (84.6%)	270 (92.5%)	
>60 years	22 (5.1%)	0 (0%)	
Skill level, n (%)			

1				
2				
3				
4	Beginner	110 (29.5%)	101 (37.5%)	<0.01*
5				
6	Medium	127 (34.0%)	118 (43.9%)	
7				
8				
9	Advanced	85 (22.8%)	37 (13.8%)	
10				
11	Expert	51 (13.7%)	13 (4.8%)	
12				
13				
14	Date of Injury, n (%)			
15				
16	Weekdays	223 (50.2%)	134 (45.7%)	0.232
17				
18	Weekends/Holidays	221 (49.8%)	159 (54.3%)	
19				
20				
21				
22	Time of injury, n (%)			
23				
24	Morning	44 (10.1%)	28 (9.9%)	0.466
25				
26	Noon	137 (31.6%)	89 (31.3%)	
27				
28	Afternoon	86 (19.8%)	69 (24.3%)	
29				
30	Late afternoon	167 (38.5%)	98 (34.5%)	
31				
32				
33				
34				
35	Slope difficulty, n (%)			
36				
37	Beginner trail	67 (15.3%)	42 (14.4%)	0.868
38				
39	Medium trail	116 (26.5%)	82 (28.2%)	
40				
41	Advanced trail	254 (58.1%)	167 (57.4%)	
42				
43				
44				
45	Cause of injury, n (%)			
46				
47	Involving others	153 (32.5%)	97 (30.6%)	0.680
48				
49	Not involving others	291 (67.5%)	197 (69.4%)	
50				
51				
52				
53	Injured body part, n (%)			
54				
55	Head and cervical	57 (13.7%)	36 (13.6%)	<0.01*
56				
57	Torso	83 (19.9%)	63 (23.8%)	
58				
59				
60				

Upper extremity	79 (18.9%)	125 (47.2%)
Lower extremity	222 (53.2%)	50 (18.9%)
Multipart	22 (5.3%)	9 (3.4%)

362

363

364

365 Table 3. The relationship between cause of injury and injured body part in

366 skiers

	Injury not involving others (n=291)	Injury involving others (n=126)	P value
Head and cervical	21(7.2%)	36(28.6%)	<0.01
Torso	54(18.6%)	29(23.0%)	
Upper extremity	53(18.2%)	26(20.6%)	
Lower extremity	172(59.1%)	50(49.7%)	
Multipart injury	9(3.1%)	13(10.3%)	

367

368 Table 4. The relationship between cause of injury and injured body part in

369 snowboarders

	Injury not involving others (n=197)	Injury involving others (n=68)	P value

Head and cervical	17(8.6%)	19(27.9%)	<0.01
Torso	39(19.8%)	24(35.3%)	
Upper extremity	107(54.3%)	18(26.5%)	
Lower extremity	37(18.8%)	13(19.1%)	
Multipart injury	3(1.5%)	6(8.8%)	

370

371 Figure 1. Number of injury cases in differet age group during the season of

372 2018-2019.

373

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
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
53
54
55
56
57
58
59
60

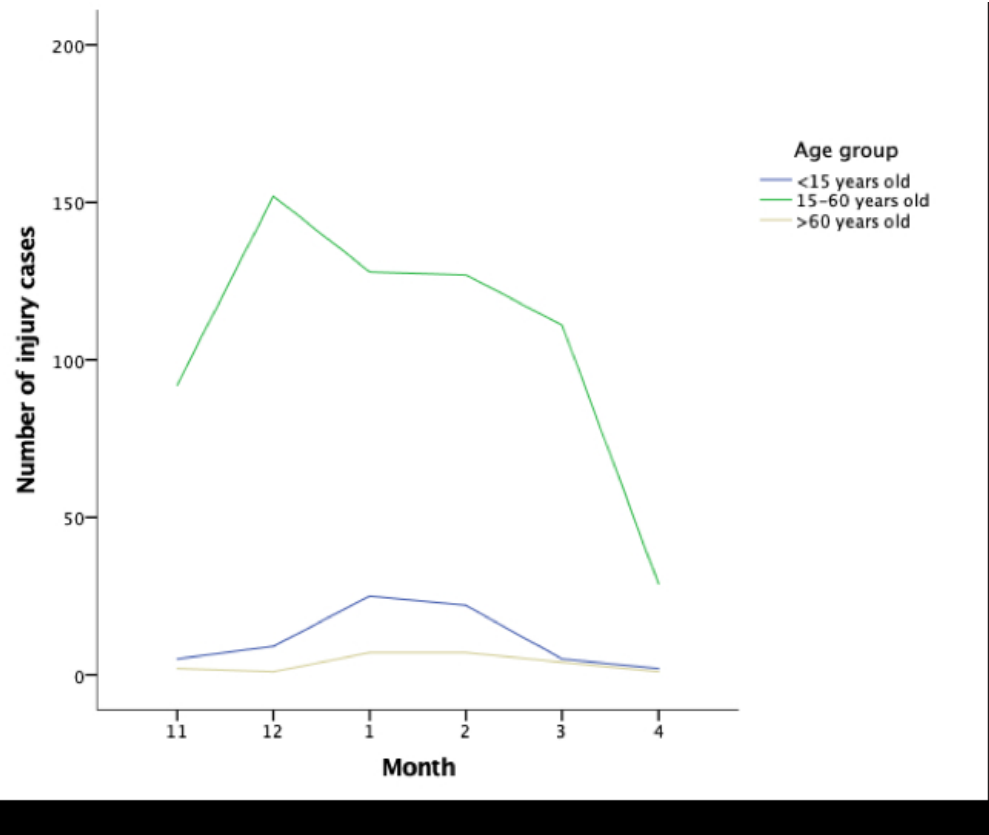


Figure 1. Number of injury cases in differet age group during the season of 2018-2019.

Table 5. The relationship between sex and injured body part in skiers

	Male (n=260)	Female (n=158)	P value
Head and cervical	32(12.3%)	25(15.8%)	0.29
Torso	58(22.3%)	24(15.2%)	
Upper extremity	51(19.6%)	28(17.7%)	
Lower extremity	131(50.4%)	91(57.6%)	
Multipart injury	12(4.6%)	10(6.3%)	

Table 6 The relationship between sex and injured body part in snowboarders

	Male (n=158)	Female (n=107)	P value
Head and cervical	21(13.3%)	15(14.0%)	0.63
Torso	42(25.6%)	21(19.6%)	
Upper extremity	74(46.8%)	51(47.7%)	
Lower extremity	26(16.5%)	24(22.4%)	
Multipart injury	5(3.2%)	4(3.7%)	

Table 7. The relationship between age and injured body part in skiers

	Teenager (n=52)	Adult (n=329)	Elderly (n=22)	P value
Head and cervical	15(28.8%)	39(11.9%)	2(9.1%)	0.14
Torso	6(11.5%)	70(21.3%)	4(18.2%)	
Upper extremity	12(23.1%)	57(17.3%)	8(36.4%)	
Lower extremity	22(42.3%)	179(54.4%)	11(50%)	
Multipart injury	3(5.8%)	16(4.9%)	3(13.6%)	

Table 8. The relationship between age and injured body part in snowboarders

	Teenager (n=26)	Adult (n=238)	Elderly (n=0)	P value
Head and cervical	6(23.1%)	30(12.6%)	0	0.21
Torso	4(15.4%)	59(25.2%)	0	
Upper extremity	15(57.7%)	109(45.8%)	0	
Lower extremity	2(7.7%)	48(20.2%)	0	
Multipart injury	1(3.8%)	8(3.4%)	0	

Table 9. The relationship between skill level and injured body part in skiers

	Beginner (n=106)	Medium (n=118)	Advanced (n=79)	Expert (n=49)	P value
Head and cervical	13(28.8%)	12(11.9%)	11(9.1%)	5(%)	0.19
Torso	18(11.5%)	27(21.3%)	16(18.2%)	10(%)	
Upper extremity	22(23.1%)	18(17.3%)	15(36.4%)	13(%)	
Lower extremity	54(42.3%)	164(54.4%)	48(50%)	24(%)	
Multipart injury	2(5.8%)	4(4.9%)	9(13.6%)	3(%)	

Table 10. The relationship between skill level and injured body part in snowboarders

	Beginner (n=93)	Medium (n=109)	Advance (n=36)	Expert (n=11)	P value
Head and cervical	15(23.1%)	11(12.6%)	5	1	0.32
Torso	20(15.4%)	27(25.2%)	10	2	
Upper extremity	46(57.7%)	51(45.8%)	14	7	
Lower extremity	14(7.7%)	26(20.2%)	8	8	

Multipart injury 2(3.8%) 6(3.4%) 1 0

Table 11. Cause of injury and slope difficulty

	Self-inflicted (n=486)	Crash (n=226)	P value
Beginner trail	93	18	<0.01*
Medium trail	103	87	
Advanced trail	292	121	

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	6
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-8

1	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
2			(b) Report category boundaries when continuous variables were categorized	NA
3			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
4				
5				
6				
7				
8				
9	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
10				
11	Discussion			
12				
13	Key results	18	Summarise key results with reference to study objectives	9
14	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
15				
16	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
17				
18				
19	Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
20				
21	Other information			
22	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13
23				
24				

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.

BMJ Open

Injury patterns in a large-scale ski resort in the host city of 2022 Winter Olympic Games: a retrospective cross-section study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-037834.R3
Article Type:	Original research
Date Submitted by the Author:	09-Oct-2020
Complete List of Authors:	Chen, Nayun; Peking University Third Hospital, Institute of Sports Medicine Yang, Yuping; Peking University Third Hospital, Institute of Sports Medicine Jiang, Yanfang Ao, Yingfang; Peking University Third Hospital,
Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Public health
Keywords:	SPORTS MEDICINE, PUBLIC HEALTH, Orthopaedic sports trauma < ORTHOPAEDIC & TRAUMA SURGERY

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3
4 1 Injury patterns in a large-scale ski resort in the host city of 2022 Winter

5
6
7 2 Olympic Games: a retrospective cross-section study

8
9 3 Chen Nayun^{1*}, Yang Yuping^{1*}, Jiang Yanfang¹, Ao Yingfang¹

10
11
12 4 1. Peking University Third Hospital, Peking University Institute of Sports

13
14 5 Medicine

15
16
17 6 * They contribute equally to this article.

18
19
20 7 Corresponding Author: Ao Yingfang

21
22 8 E-mail: aoyingfang@163.com

23
24
25 9 Running title: Injury pattern in Chinese ski resort

26
27
28 10 Word Count : 2428

1
2
3
4 23 Abstract

5
6 24 Objective: The aim of the study is to describe the injury patterns in
7
8
9 25 recreational skiers and snowboarders in China, and to provide primary data
10
11 26 for reconstruction of regional health care facility to deal with the increasing
12
13
14 27 number of participants in snow sports.

15
16
17 28 Design: Retrospective cross-section study

18
19 29 Methods: A retrospective study was performed in Wanlong Ski Resort in
20
21
22 30 Chongli, China. The data of all injured skiers and snowboarders treated in the
23
24
25 31 resort clinic during season 2018-2019 were collected. Patients information,
26
27 32 including sex, age, equipment, skill level, injured body part were analyzed.

28
29
30 33 Results: A total of 753 sports injuries were recorded. The estimated incidence
31
32
33 34 of injury was 1.98 per 1000 skier days. 453 cases (60.2%) were associated
34
35
36 35 with skiing. The mean age of skiers was older than snowboarders (35.1 ± 14.5
37
38 36 vs. 29.0 ± 8.9 , $p<0.01$). Injury not involving others took up 67.9% of all injuries.
39
40
41 37 The most common injured body part in skiers was lower extremity, contrary to
42
43 38 upper extremity in snowboarders. Head and cervical injury was identified in
44
45
46 39 13.7% of skiers and 13.6% of snowboarders.

47
48 40 Conclusion: The incidence of skiing/snowboarding injury in China was similar
49
50
51 41 to other countries. The injury pattern differed among different sports and
52
53 42 cause of injury.

54
55
56 43 Key words: Sports injury, Skiing, Snowboarding

57
58 44 Strength and limitations of this study:
59
60

- 1
2
3
4 45 1. The present study is the first epidemiological study investigating the injury
5
6 46 patterns in Chinese ski resort.
7
8
9 47 2. The severity of injury and accurate diagnosis were not recorded, and
10
11 48 patients were not followed up for their prognosis.
12
13
14 49 3. The incidence of injury may be underestimated, due to the fact that patients
15
16 50 might visit the local or tertiary hospital instead of the resort clinic, or did not
17
18 51 receive any medical help for mild injuries.
19
20
21
22 52
23
24 53
25
26 54
27
28 55
29
30 56
31
32 57
33
34 58
35
36 59
37
38 60
39
40 61
41
42 62
43
44 63
45
46 64
47
48 65
49
50 66
51
52
53
54
55
56
57
58
59
60

1. Introduction

Skiing and snowboarding are popular winter sports world-wide but carry a substantial risk of sports injuries, with reported incidence of 0.5-1.35 injuries per 1000 skier/snowboarder days in recreational skiers/snowboarders¹⁻³ and 6.9 injuries per 1000 runs (or 26.8 injuries per 100 athletes per season)⁴ in professional alpine skiers in recent years. In the latest Winter Olympic Games in PyeongChang, 12% of the athletes incurred at least one injury, equaling 12.6 injuries per 100 athletes over the 17-day period⁵.

Since Beijing was selected to host the 2022 Winter Olympics, skiing and snowboarding population in China has risen from 8 million in 2015 to 13.2 million in 2018 (industry annual report, 2019). Large-scale ski resorts in China are often located in areas remote from major cities where medical capacities for improvement to ingest large number of winter sports injuries and manage severe injuries.

The aim of the study is to describe the injury patterns in recreational skiers and snowboarders in China by investigating the largest ski resort in the host city of 2022 Winter Olympic Games, and to provide primary data to guide the reconstruction of the local hospital to deal with the increasing number of participants in snow sports.

2. Patients and Methods

The data of this retrospective study was collected from the resort clinic of Wanlong Ski Resort in Chongli during ski season 2018-2019. Wanlong Ski

1
2
3
4 89 Resort is a destination ski resort in Northern China, which has various terrain
5
6 90 and the largest number of annual visits. The resort clinic is staffed by a
7
8
9 91 registered general practitioner and a nurse, and is responsible for the primary
10
11 92 care of all injured visitors, whether self-present or sent by patrols; it is also
12
13
14 93 responsible for treating mild injury, transferring patients to local hospital,
15
16
17 94 carrying out basic life support for life-threatening injuries. The season of 2018-
18
19 95 2019 in Wanlong Ski Resort lasted for 158 days, from 2018/11/1-2019/4/7. A
20
21 96 total of 388606 visits (379503 skier days) were recorded.

22
23
24 97 Besides patient's information of sex and age, we also recorded equipment,
25
26
27 98 skill level, the date and time of injury, the cause of injury, the slope difficulty
28
29
30 99 and the injured body part. Equipment was classified into skis and
31
32
33 100 snowboards. Special equipment, such as cross-country skis, skiboards, was
34
35 101 rare in China and not seen in recorded injured people. According to self-
36
37
38 102 reported years of participation in skiing and snowboarding, patients were
39
40 103 classified as beginner (first season), medium (1-5 years), advanced (5-10
41
42 104 years) and expert (≥ 10 years). The date of injury was divided into weekdays
43
44 105 and weekends/holidays according to the Chinese government holiday
45
46
47 106 arrangement. The business hour of Wanlong Ski Resort is 8:00-16:00, so we
48
49 107 split the time of injury into 4 periods with 2 hours each, morning (first 2 hours
50
51 108 of business), noon, afternoon and late afternoon (last 2 hours of business).
52
53
54 109 According to the subjective description of injury scene, we summarized 2
55
56
57 110 types of causes of injury: not involving others, defined as falling or crashing
58
59
60

1
2
3
4 111 without any body contact with others; and involving others, defined as
5
6 112 crashing involving 2 or more people. The slope difficulty was categorized into
7
8
9 113 beginner trail, medium trail and advanced trail according to the official data of
10
11 114 slope inclination angle. Injured body parts were categorized into the following
12
13
14 115 4 anatomical body regions: (1) head/cervical, (2) torso, (3) upper extremity,
15
16
17 116 and (4) lower extremity. Acromioclavicular joint injuries were classified as
18
19 117 upper limb injury, while other clavicle injuries were classified as torso injuries.⁶
20
21
22 118 Injuries involving gluteal region were classified as torso injury. Whether
23
24 119 patients have multi-part injuries was also recorded, while each injured body
25
26
27 120 part was counted in one of the above groups. The relationship between
28
29
30 121 injured body part and sex, age, equipment and cause of injury was further
31
32
33 122 determined by subgroup analysis.

34
35 123 This study was approved by Peking University Third Hospital Medical
36
37 124 Science Research Ethics Committee. Informed consent was waived
38
39
40 125 considering that the study was epidemiological and anonymous.

41 42 43 126 Statistical analysis

44
45 127 All statistical analysis was performed with SPSS (v 24.0; IBM Corp).
46
47
48 128 Continuous variables were presented as mean and standard deviations, while
49
50
51 129 categorical data were presented with frequency count and percentages. To do
52
53
54 130 comparison between subgroups, Chi-squared test was used for categorical
55
56 131 variables and student t test was used for continuous variables. When there is
57
58
59
60

1
2
3
4 132 missing data, the available case was analyzed to determine difference
5
6 133 between groups. $P < 0.05$ was considered to indicate statistical significance.
7
8

9 134 3. Results

10
11 135 During the study period, there were 388, 606 visits (379, 503 skier days)
12
13
14 136 and 753 cases of injury recorded in Wanlong Ski Resort. The estimated
15
16
17 137 incidence of injury was 1.98 per 1000 skier days.
18

19 138 Features of injury

20
21
22 139 The mean age of injured visitors was 32.5 ± 12.9 years (range 3-73 years).
23
24 140 Pediatric patients under 15 years old took up 9.3%, while senior patients (over
25
26
27 141 the age of 60) took up 3.0% of all injured population. The number of males
28
29
30 142 was twice as females. Among these injuries, 453 cases (60.2%) were
31
32
33 143 associated with skiing. Table 1 shows more detailed demographic and sport-
34
35 144 related profiles of these injuries.
36

37
38 145 The season of 2018-2019 in Wanlong Ski Resort consisted of 107
39
40 146 weekdays and 51 weekends/holidays according to the Chinese government
41
42
43 147 arrangement. The average daily number of injuries was 3.38 on weekdays
44
45
46 148 and 7.65 on weekends/holidays. A peak of pediatric cases was noted in
47
48 149 January and February (Figure 1). Within a day, the percentage of injury
49
50
51 150 occurred in morning, noon, afternoon and late afternoon was 9.7%, 31.6%,
52
53 151 22.0% and 36.7% respectively.
54
55
56
57
58
59
60

1
2
3
4 152 Accidents not involving other skiers took up 67.9% of all injuries. The most
5
6 153 common injured body parts were upper (28.4%) and lower limbs (37.6%),
7
8
9 154 followed by head and cervical injuries (13.1%).
10

11 155 Injury pattern in subgroups

12
13
14 156 The mean age of skiers was 35.1 ± 14.5 years, whereas the mean age of
15
16
17 157 snowboarders was 29.0 ± 8.9 years ($p < 0.01$). There was no significant
18
19
20 158 difference in the sex profile between skiers and snowboarders.

21
22 159 The injured body parts showed different patterns between skiers and
23
24 160 snowboarders. More than half of the skier patients sustained lower extremity
25
26
27 161 injuries, while the most common injury in snowboarders was upper extremity
28
29
30 162 injury. Head and cervical injury was identified in 13.7% of skiers and 13.6% of
31
32
33 163 snowboarders. Multipart injury took up 5.3% in skiers and 3.4% in
34
35 164 snowboarders (Table 2). The cause of injury was also found to be related with
36
37
38 165 the injured body parts in both skiers and snowboarders. Head injury took up a
39
40
41 166 significantly higher rate in accidents involving others. In skiers, lower extremity
42
43
44 167 injury was most common no matter whether the accidents involved others or
45
46
47 168 not. However, the rate of lower extremity was significantly higher in accidents
48
49
50 169 not involving others (Table 3). In snowboarders, head, cervical and torso
51
52
53 170 injury took up a greater portion in accidents involving others (Table 4). The
54
55
56 171 correlation between age, sex, skill level and injured body parts was not
57
58
59 172 significant. (Supplementary Tables 1-6)
60

1
2
3
4 174 4. Discussion

5
6 175 We found that the incidence of sports injury of Chinese recreational skiing
7
8
9 176 and snowboarding population was 1.98 per 1000 skier days, which was
10
11 177 comparable to reported incidence of 0.5-3.7 per 1000 skier days in European
12
13
14 178 and North American countries in recent years.^{1,7-9} According to the
15
16
17 179 government report, the total number of visits in ski resorts in Chongli hit nearly
18
19
20 180 1 million in the 2018-19 ski season, which means an estimated number of
21
22 181 2,000 sports injuries in one season if such finding is extrapolated to the whole
23
24
25 182 region. Therefore, a better understanding of injury pattern in Chinese
26
27 183 population will guide the reform of local health care facility to deal with the
28
29
30 184 increasing number of participants in snow sports.

31
32 185 The mean age of injured visitors was 32.5±12.9 years (range 3-73 years).
33
34
35 186 9.3% of the injured population were younger than 15 years old. In china,
36
37
38 187 winter vacation for students last for about 4 weeks around Chinese New
39
40
41 188 Year. We found that sports injury in teenagers peaked in January and
42
43 189 February, and took up nearly 15% of all injuries occurred in these two
44
45
46 190 months. The incidence of ski injury was reported higher in teenagers than in
47
48
49 191 adults.¹⁰ As more young people participate in these activities, an increase of
50
51 192 pediatric patients of snow sports injury will be seen in the future.

52
53 193 Previous studies found female skiers are more susceptible to lower
54
55
56 194 extremity injury, especially knee injuries, with nearly 50% of injured females
57
58
59 195 suffer from knee injury.¹¹ The present study found lower extremity was the
60

1
2
3
4 196 most common injured body part in female skiers. However, there was no
5
6 197 significant difference in injured body parts between males and females in
7
8
9 198 both skiers and snowboarders. Paolo G et al.¹² found that men experienced
10
11 199 more severe injuries than women, which may result from higher speed,
12
13
14 200 body weight and trail difficulty in men.

17 201 Snowboarders accounted for nearly 40% of the injured population in the
18
19 202 latest season. Based on the previously published data, an increase of the
20
21 203 percentage of snowboarders in total and injured winter sport population has
22
23 204 been noticed.^{7,13} This young sport appeals to more young people and at the
24
25 205 same time, reshapes the injury profile. In a study conducted in Big Sky area in
26
27 206 United States, snowboarders took up 42.8% of injured visitors in the 2009-
28
29 207 2010 season, while between 1995 and 2000 only 23.0% of injured people
30
31 208 were snowboarders.¹⁴ Many studies reported that snowboarders had
32
33 209 significantly more injuries to the head, spine and upper extremity when
34
35 210 compared with skiers, whereas skiers sustained significantly more lower
36
37 211 extremity injuries.^{7,14,15} The present study revealed the same patterns, with
38
39 212 higher rates of head, upper extremity injuries in snowboarders, and lower
40
41 213 rates of lower extremity injuries. In a study comparing injury severity in
42
43 214 different sports, the authors reported that the percentage of mild, moderate
44
45 215 and severe injuries in skiing were 41%, 44% and 15% respectively, while the
46
47 216 percentage in snowboarding were 34%, 53% and 13%.⁹ Maat SC et al.

1
2
3
4 217 ¹⁵reported that skiers were more seriously injured with Injury Severity Scale
5
6 218 (ISS) higher than 9.
7
8

9 219 Beginners and medium level skiers (63.5%) and snowboarders (81.4%)
10
11 220 made up the majority of injured visitors. In a study involving 19, 539 injured
12
13 221 snowboarders in Japan, proportions of the trunk and multiple injuries were
14
15 222 found to increase with higher skill level; the injury severity was also found to
16
17 223 increase with skill level.¹⁶ Another study found no relationship between skill
18
19 224 level and injury severity in skiing and snowboarding population once
20
21 225 unconscious patients (who cannot report their skill level) were ruled out.¹³
22
23
24
25
26

27 226 In our study, the rate of injures not involving others was 67.9%, which is
28
29 227 lower than the reported rate on Austrian ski slopes.³ The difference are
30
31 228 likely attributed to the higher density of skiers/snowboarders on the slope in
32
33 229 China, which is implied by the fact that the rate of crash accident was
34
35 230 extremely high on medium trails (See Supplementary Table 7). Yet, no
36
37 231 available studies provide conclusive evidence of the influence factors of
38
39 232 self-inflicted and crash injury rate.¹⁷
40
41
42
43
44

45 233 The cause of injury was also found to be related with the injured body
46
47 234 parts in both skiers and snowboarders. Head injury took up a significantly
48
49 235 more portion in accidents involving others. Sport-specific injuries, such as
50
51 236 shoulder injury in snowboarding and knee injury in skiing,⁷ were more
52
53 237 frequent in accidents not involving others. These findings can be attributed
54
55
56
57
58
59
60

1
2
3
4 238 to different injury mechanism, with non-contact injury often causing ligament
5
6 239 and tendon tear, contact injury causing bony injury and concussion.¹⁸
7
8

9 240 From an epidemiological view, the present study provides strategies that
10
11 241 can guide the restructure of local hospital and unload the burden in winter
12
13 242 season. First, to establish pediatric orthopedic department to cope with the
14
15 243 pediatric patients who take up nearly 10% of the whole injury population,
16
17 244 especially the surge during winter vacation in China. Second, to establish
18
19 245 department of neurosurgery and department of oral and maxillofacial surgery
20
21 246 to deal with the head and face injury, which took up to 13% of all injuries.
22
23 247 Third, to rearrange the worktime schedule according to the time-related “tide”
24
25 248 of winter sports injury to increase effectiveness with limited manpower. For
26
27 249 example, change weekends into work days and set other rest days in winter
28
29 250 season to cope with the traumatic cases in weekend which are twice as many
30
31 251 as in weekdays. Fourth, intensive care unit is crucial to manage severe
32
33 252 injuries as the population at higher risk of severe injuries, including
34
35 253 snowboarders, higher skill level and young participant, are growing bigger.
36
37 254 Fifth, to build up communication and cooperation network with nearby ski
38
39 255 resorts to allow access to critical patient’s information in advance and guide
40
41 256 prehospital care. Although the present study did not provide information about
42
43 257 injury severity and number of patients who need transfer and further
44
45 258 treatment, up to 60% of injured skiers and snowboarders seen in resort clinic
46
47 259 require transfer to hospital based on existing literature.⁹ Up to now, the local
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4 260 hospital in Chongli has reinforced its orthopedics and sports medicine
5
6 261 department by seeking cooperation with superior hospitals in Beijing. An
7
8
9 262 evidence-based restructure of local hospital may increase the accessibility to
10
11 263 health care for injured skiers and snowboarders in nearby ski resorts.

12
13
14 264 Several limitations exist in this study. First, the severity of injury and
15
16 265 accurate diagnosis were not recorded, patients were not followed up for their
17
18 266 prognosis. Second, although medical providers in ski resort have collected
19
20 267 injury cases as through as possible, there were still patients who went to local
21
22 268 or superior hospitals directly, or did not receive any type of medical help for
23
24 269 mild injuries. In this case, the incidence of injury may be underestimated.
25
26 270 Additionally, the injury severity and number of patients who needed transfer
27
28 271 was incomplete, so we were unable to estimate the burden of local hospital in
29
30 272 skiing season. Currently, we are conducting a large-scale survey on the
31
32 273 demography of Chinese winter sports participants, and a prospective research
33
34 274 of winter sports injury in skiing population in China to fill the gap. The
35
36 275 effectiveness of hospital restructure will be reported as well.

37 276 5. Patient and public involvement

38
39 277 It was not appropriate to involve patients or the public in the design, or
40
41 278 conduct, or reporting, or dissemination plans of our research.

42 279 6. Acknowledgement

43
44 280 The medical director of Wanlong Ski Resort, Zhang Jinwei, provided help in
45
46 281 the collection of injury data.

1
2
3
4 282 7. Funding

5
6 283 This work was supported by the National Key Research and Development
7
8
9 284 Program of China [2018YFF0301100].

10
11 285 8. Conflicts of interest

12
13
14 286 The author states no conflicts of interest.

15
16
17 287 9. Author Contributions

18
19 288 Chen Nayun designed the study, carried out the data analysis and drafted
20
21
22 289 the manuscript. Yang Yuping carried out the design of patient information
23
24
25 290 registration chart, and helped to draft the manuscript. Jiang Yanfang helped to
26
27
28 291 connect with relevant staffs in Wanlong Ski Resort and revise the manuscript.
29
30 292 Ao Yingfang conceived of the study, and participated in its design.

31
32 293 10. Data availability statement

33
34
35 294 The data in the present study is deidentified participant data which are
36
37
38 295 available upon reasonable request. Please contact the first author for
39
40 296 permission to reuse the original data. Email: albert_west@163.com

41
42
43 297 11. Reference

- 44
45 298 1. Ekeland A, Johnson RJ, Shealy J, Senner V, Dean SW. Skiing and
46
47
48 299 boarding injuries on Norwegian slopes during two winter seasons.
49
50
51 300 Journal of ASTM International. 2010;7(4).
- 52
53 301 2. Castellani C, Singer G, Eibisberger M, et al. An epidemiologic analysis
54
55
56 302 of winter sport accidents on ski slopes comparing two seasons. *J Sports*
57
58 303 *Med Phys Fitness*. 2019;59(4):648-654.

- 1
2
3
4 304 3. Ruedl G, Philippe M, Sommersacher R, Dunnwald T, Kopp M, Burtscher
5
6 305 M. [Current incidence of accidents on Austrian ski slopes]. *Sportverletz*
7
8
9 306 *Sportschaden*. 2014;28(4):183-187.
- 10
11 307 4. Haaland B, Steenstrup SE, Bere T, Bahr R, Nordsletten L. Injury rate
12
13
14 308 and injury patterns in FIS World Cup Alpine skiing (2006-2015): have the
15
16
17 309 new ski regulations made an impact? *Br J Sports Med*. 2016;50(1):32-
18
19 310 36.
- 20
21
22 311 5. Soligard T, Palmer D, Steffen K, et al. Sports injury and illness incidence
23
24 312 in the PyeongChang 2018 Olympic Winter Games: a prospective study
25
26
27 313 of 2914 athletes from 92 countries. *Br J Sports Med*. 2019;53(17):1085-
28
29 314 1092.
- 30
31
32 315 6. Asadollahi S, Bucknill A. Acute medial clavicle fracture in adults: a
33
34
35 316 systematic review of demographics, clinical features and treatment
36
37 317 outcomes in 220 patients. *J Orthop Traumatol*. 2019;20(1):24.
- 38
39
40 318 7. Kim S, Endres NK, Johnson RJ, Ettlinger CF, Shealy JE. Snowboarding
41
42
43 319 injuries: trends over time and comparisons with alpine skiing injuries. *Am*
44
45 320 *J Sports Med*. 2012;40(4):770-776.
- 46
47
48 321 8. Langran M, Selvaraj S. Snow sports injuries in Scotland: a case-control
49
50 322 study. *Br J Sports Med*. 2002;36(2):135-140.
- 51
52
53 323 9. Stenroos A, Handolin L. Incidence of Recreational Alpine Skiing and
54
55
56 324 Snowboarding Injuries: Six Years Experience in the Largest Ski Resort
57
58 325 in Finland. *Scand J Surg*. 2015;104(2):127-131.
59
60

- 1
2
3
4 326 10. Provance AJ, Daoud AK, Tagawa A, Rhodes J. Pediatric and adolescent
5
6 327 injury in skiing. *Res Sports Med.* 2018;26(sup1):150-165.
7
8
9 328 11. Ruedl G, Linortner I, Schranz A, et al. Distribution of injury mechanisms
10
11 329 and related factors in ACL-injured female carving skiers. *Knee Surg*
12
13 330 *Sports Traumatol Arthrosc.* 2009;17(11):1393-1398.
14
15
16
17 331 12. Girardi P, Braggion M, Sacco G, De Giorgi F, Corra S. Factors affecting
18
19 332 injury severity among recreational skiers and snowboarders: an
20
21
22 333 epidemiology study. *Knee Surg Sports Traumatol Arthrosc.*
23
24 334 2010;18(12):1804-1809.
25
26
27 335 13. Coury T, Napoli AM, Wilson M, Daniels J, Murray R, Milzman D. Injury
28
29 336 patterns in recreational alpine skiing and snowboarding at a
30
31
32 337 mountainside clinic. *Wilderness Environ Med.* 2013;24(4):417-421.
33
34
35 338 14. Wasden CC, McIntosh SE, Keith DS, McCowan C. An analysis of skiing
36
37 339 and snowboarding injuries on Utah slopes. *J Trauma.* 2009;67(5):1022-
38
39 340 1026.
40
41
42
43 341 15. Maat SC, Luppino FS, Schipper IB, Krijnen P, Bartlema KA. Injury
44
45 342 patterns after skiing and snowboarding sports accidents. *J Sports Med*
46
47 343 *Phys Fitness.* 2020;60(1):119-124.
48
49
50 344 16. Ogawa H, Sumi H, Sumi Y, Shimizu K. Skill level-specific differences in
51
52 345 snowboarding-related injuries. *Am J Sports Med.* 2010;38(3):532-537.
53
54
55
56 346 17. Ruedl G, Kopp M, Burtscher M, Bauer R, Benedetto K. [Causes and
57
58 347 factors associated with collisions on ski slopes]. *Sportverletz*
59
60

348 *Sportschaden*. 2013;27(2):100-104.

349 18. Davey A, Endres NK, Johnson RJ, Shealy JE. Alpine Skiing Injuries.

350 *Sports Health*. 2019;11(1):18-26.

351

352

353 Tables and Figures

354 Table 1. Demographic and sport-related information of injured population

	n (%)
Sex	
Male	475 (63.3%)
Female	278 (36.7%)
Age	
<15 years	68 (9.3%)
15-60 years	643 (87.7%)
>60 years	22 (3.0%)
Equipment	
Ski	453 (60.6%)
Snowboard	294 (39.4%)
Skill level	
Beginner	211 (29.5%)

Medium	246 (34.0%)
Advanced	122(22.8%)
Expert	64 (13.7%)
Slope difficulty	
Beginner trail	111(15.3%)
Medium trail	206 (26.5%)
Advanced trail	425 (58.1%)

355

356

Table 2. Details of injured skiers and snowboarders

	Skiers (n=453)	Snowboarders (n=294)	P value
Sex, n (%)			
Male	281 (63.3%)	184 (62.6%)	0.846
Female	163` (36.7%)	110 (37.4%)	
Age, n (%)			
<15 years	44 (10.3%)	22 (7.5%)	<0.01*
15-60 years	363 (84.6%)	270 (92.5%)	
>60 years	22 (5.1%)	0 (0%)	
Skill level, n (%)			
Beginner	110 (29.5%)	101 (37.5%)	<0.01*
Medium	127 (34.0%)	118 (43.9%)	

Advanced	85 (22.8%)	37 (13.8%)	
Expert	51 (13.7%)	13 (4.8%)	
Date of Injury, n (%)			
Weekdays	223 (50.2%)	134 (45.7%)	0.232
Weekends/Holidays	221 (49.8%)	159 (54.3%)	
Time of injury, n (%)			
Morning	44 (10.1%)	28 (9.9%)	0.466
Noon	137 (31.6%)	89 (31.3%)	
Afternoon	86 (19.8%)	69 (24.3%)	
Late afternoon	167 (38.5%)	98 (34.5%)	
Slope difficulty, n (%)			
Beginner trail	67 (15.3%)	42 (14.4%)	0.868
Medium trail	116 (26.5%)	82 (28.2%)	
Advanced trail	254 (58.1%)	167 (57.4%)	
Cause of injury, n (%)			
Involving others	153 (32.5%)	97 (30.6%)	0.680
Not involving others	291 (67.5%)	197 (69.4%)	
Injured body part, n (%)			
Head and cervical	57 (13.7%)	36 (13.6%)	<0.01*
Torso	83 (19.9%)	63 (23.8%)	
Upper extremity	79 (18.9%)	125 (47.2%)	
Lower extremity	222 (53.2%)	50 (18.9%)	

	Multipart	22 (5.3%)	9 (3.4%)
--	-----------	-----------	----------

357

358

359

360 Table 3. The relationship between cause of injury and injured body part in

361 skiers

	Injury not involving others (n=291)	Injury involving others (n=126)	P value
Head and cervical	21(7.2%)	36(28.6%)	<0.01
Torso	54(18.6%)	29(23.0%)	
Upper extremity	53(18.2%)	26(20.6%)	
Lower extremity	172(59.1%)	50(49.7%)	
Multipart injury	9(3.1%)	13(10.3%)	

362

363 Table 4. The relationship between cause of injury and injured body part in

364 snowboarders

	Injury not involving others (n=197)	Injury involving others (n=68)	P value
Head and cervical	17(8.6%)	19(27.9%)	<0.01
Torso	39(19.8%)	24(35.3%)	

Upper extremity	107(54.3%)	18(26.5%)
Lower extremity	37(18.8%)	13(19.1%)
Multipart injury	3(1.5%)	6(8.8%)

365

366 Figure 1. Number of injury cases in different age group during the season of

367 2018-2019.

368

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
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
53
54
55
56
57
58
59
60

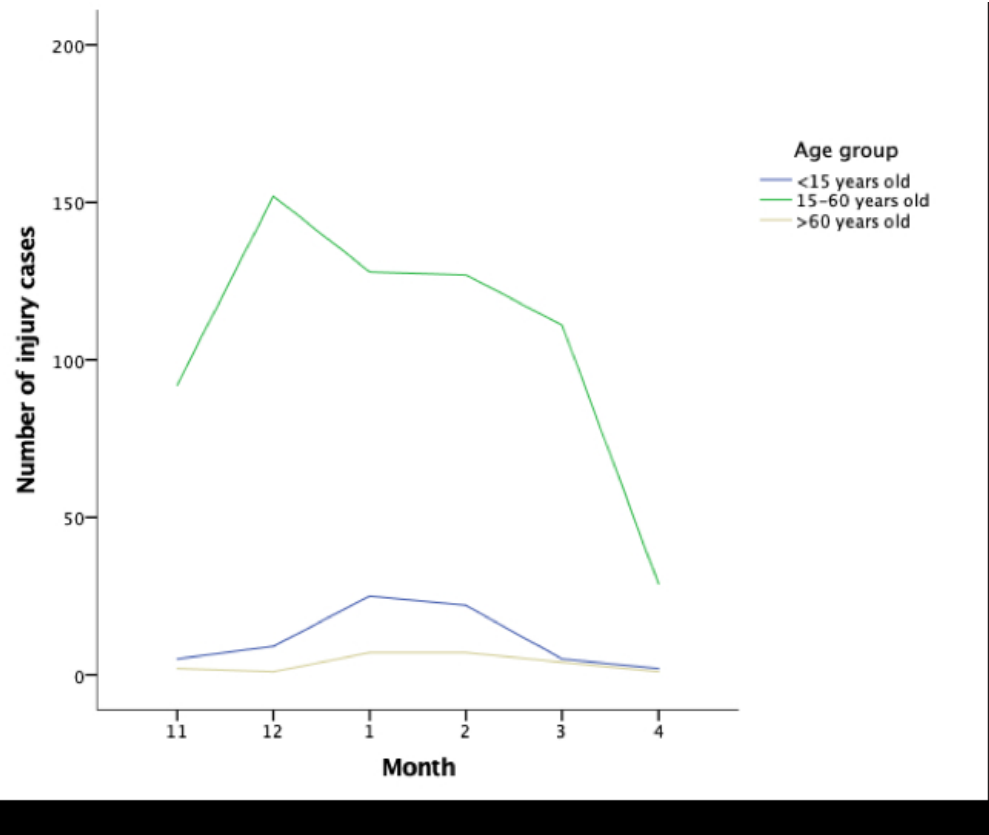


Figure 1. Number of injury cases in differet age group during the season of 2018-2019.

Table 1. The relationship between sex and injured body part in skiers

	Male (n=260)	Female (n=158)	P value
Head and cervical	32(12.3%)	25(15.8%)	0.29
Torso	58(22.3%)	24(15.2%)	
Upper extremity	51(19.6%)	28(17.7%)	
Lower extremity	131(50.4%)	91(57.6%)	
Multipart injury	12(4.6%)	10(6.3%)	

Table 2. The relationship between sex and injured body part in snowboarders

	Male (n=158)	Female (n=107)	P value
Head and cervical	21(13.3%)	15(14.0%)	0.63
Torso	42(25.6%)	21(19.6%)	
Upper extremity	74(46.8%)	51(47.7%)	
Lower extremity	26(16.5%)	24(22.4%)	
Multipart injury	5(3.2%)	4(3.7%)	

Table 3. The relationship between age and injured body part in skiers

	Teenager (n=52)	Adult (n=329)	Elderly (n=22)	P value
Head and cervical	15(28.8%)	39(11.9%)	2(9.1%)	0.14
Torso	6(11.5%)	70(21.3%)	4(18.2%)	
Upper extremity	12(23.1%)	57(17.3%)	8(36.4%)	
Lower extremity	22(42.3%)	179(54.4%)	11(50%)	
Multipart injury	3(5.8%)	16(4.9%)	3(13.6%)	

Table 4. The relationship between age and injured body part in snowboarders

	Teenager (n=26)	Adult (n=238)	Elderly (n=0)	P value
Head and cervical	6(23.1%)	30(12.6%)	0	0.21
Torso	4(15.4%)	59(25.2%)	0	
Upper extremity	15(57.7%)	109(45.8%)	0	
Lower extremity	2(7.7%)	48(20.2%)	0	
Multipart injury	1(3.8%)	8(3.4%)	0	

Table 5. The relationship between skill level and injured body part in skiers

	Beginner (n=106)	Medium (n=118)	Advanced (n=79)	Expert (n=49)	P value
Head and cervical	13(28.8%)	12(11.9%)	11(9.1%)	5(%)	0.19
Torso	18(11.5%)	27(21.3%)	16(18.2%)	10(%)	
Upper extremity	22(23.1%)	18(17.3%)	15(36.4%)	13(%)	
Lower extremity	54(42.3%)	164(54.4%)	48(50%)	24(%)	
Multipart injury	2(5.8%)	4(4.9%)	9(13.6%)	3(%)	

Table 6. The relationship between skill level and injured body part in snowboarders

	Beginner (n=93)	Medium (n=109)	Advance (n=36)	Expert (n=11)	P value
Head and cervical	15(23.1%)	11(12.6%)	5	1	0.32
Torso	20(15.4%)	27(25.2%)	10	2	
Upper extremity	46(57.7%)	51(45.8%)	14	7	
Lower extremity	14(7.7%)	26(20.2%)	8	8	

1
2
3
4 Multipart injury 2(3.8%) 6(3.4%) 1 0
5
6
7

8 Table 7. Cause of injury and slope difficulty
9

	Self-inflicted (n=486)	Crash (n=226)	P value
Beginner trail	93	18	<0.01*
Medium trail	103	87	
Advanced trail	292	121	

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	6
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-8

1	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8
2			(b) Report category boundaries when continuous variables were categorized	NA
3			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
4				
5				
6				
7				
8				
9	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
10				
11	Discussion			
12				
13	Key results	18	Summarise key results with reference to study objectives	9
14	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
15				
16	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
17				
18				
19	Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
20				
21	Other information			
22	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13
23				
24				

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.