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Kevin Moran
The University of Auckland, k.moran@auckland.ac.nz

Jonathon Webber
The University of Auckland

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RESEARCH

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Kevin Moran and Jonathon Webber

In an island nation such as New Zealand with easy access to surf beaches, surfing activities are very popular and, while generally perceived as a healthy form of outdoor recreation, they do have attendant risks. This study reports on nondrowning, surfing-related incidents that required medical first aid on beaches during five summer seasons from 2007–2012. Retrospective descriptive analysis of data from lifeguard first-aid reports found that 16% (n = 1,327) of injuries were the consequence of surfing activity. More males than females were treated for surfing injuries (68% male, 31% female). Lacerations (59%) and bruising (15%) accounted for most of the injuries. The head was the most common site of injury (32%), and most injuries were caused by contact with the victim's own board (50%). Ways of promoting surf safety via equipment modification, the use of protective head gear, the management of surfing activity by lifeguards, and public education are discussed.

Globally, surfing is a popular sport and recreational pastime, with an estimated 37 million participants, generating a surfing industry worth $6.24 billion in 2010 in the United States alone (Statistic Brain, 2012). With 14,000 kilometers of coastline extending over 10 degrees of latitude and fronting two major ocean masses, the Tasman Sea and the Pacific Ocean, it is hardly surprising that surfing activities are very popular in New Zealand. For some, surfing is an integral part of daily life, and a distinct surfing culture has evolved, especially in communities close to good surf beaches (Pearson, 1979). For others, surfing may be associated only with occasional summertime visits to the beach. The advent of fiberglass and polystyrene foam technology has meant that surf boards and body (Boogie) boards, the type often used by the occasional surfer, are cheap and readily available. While generally perceived as a healthy form of outdoor recreation, surfing has attendant risks. Of these risks, the most obvious risk for a water-based activity is the omnipresent threat of drowning. While the incidence of drowning during aquatic recreation including surfing has been well reported (for example, Morgan, Ozanne-Smith, & Triggs, 2008), other nondrowning related injuries associated with surfing activities have not been well reported.

Kevin Moran is with the Faculty of Education and Jonathon Webber is with the Department of Anaesthesiology at The University of Auckland, Auckland, New Zealand.

A national survey of sport and recreation suggested that 4.5% (n = 145,620) of the adult population of New Zealand over 16 years of age had surfed in the previous year, a proportion similar to that who had played rugby (5.7%), New Zealand's national game (Sport and Recreation New Zealand [SPARC], 2009). A national youth water safety survey conducted in New Zealand (Moran, 2003) reported that of the 2,202 high school respondents ages 16 or younger, two thirds (65%) had been surfing in the previous year, and, of these, one quarter (25%) regarded themselves as very frequent participants (weekly). Almost three fourths of students (74%) reported the availability of body boards, and one third (34%) reported ownership of or access to surfboards. In Australia, the 2006–07 Sweeney Sport Report, reported that 14% of the population were active surfers, and the sport's popularity exceeded that of other sports such as cricket, netball, and basketball (Surfing Australia, 2008). The Australian Sports Commission (2010) identified surf sports as one of the top ten nonorganized physical activities, with more than half (52%) of surfers never having been members of a board riding club.

Given the popularity of surfing in countries with access to surf beaches, the lack of information about the nature and extent of surfing injuries is surprising. Hartung and Goebert (1996) suggested one reason for this is the recreational nature of most surfing participation, where the activity is not organized and is undertaken by individuals rather than teams. In addition, a lack of consistency of what the term surfing (e.g., Surf board riding? Body surfing? Body boarding?) actually refers to has been identified as making comparison among studies difficult (Chalmers & Morrison, 2003). Some studies have reported on injuries sustained during competitive surfing (Lowdon, Pitman, & Pateman, 1987; Nathanson, Bird, Dao, & Tam Sing, 2007), but capturing information on recreational surfers is problematic. Several early studies in Hawaii (Allen, Eiseman, Straehley, & Orloff, 1977; Chang & McDanal, 1980; Hartung, Goebert, Taniguchi, & Okamoto, 1990) and Australia (Barry, Keinig, & Brophy, 1982; Draper, Thompson, & Fricker, 1987; Kennedy & Vanderfield, 1976; Lawless, Pountney, Porter, & Simpson, 1986; Lowdon, Pateman, & Pitman, 1983) used hospitalization data to describe surfing injuries. The reported incidence of injury ranges from 2.2 to 3.5 injuries per 1,000 hr of recreational surfing (Lowdon et al., 1983; Nathanson, Haynes & Galanis, 2002; Taylor, Bennett, Carter, Garewal, & Finch, 2004) and around 6.6 per 1,000 hrs for competitive surfing (Lowdon et al., 1987; Nathanson et al., 2007). More recent studies have again used hospitalization data to analyze surfing injuries. An analysis of New South Wales sport/leisure injuries requiring hospitalization (Mitchell, Boufois, & Finch, 2008) found that the rates of injury from surfing and body boarding in 2005 (OR = 4.1; 95% CI: 3.6, 4.25), were higher than other individual athletic activities such as jogging or triathlon (OR = 2.6; 95% CI: 2.2, 3.0), but not as high as team ball sports such as rugby football (OR = 23.2; 95% CI: 22.1, 24.4).

Another source of information available in New Zealand is that of injury claims paid under a national accident compensation scheme that compensates victims for costs such as medical expenses and loss of earnings. From 2007–2012, 16,592 new claims (M = 3,318 per year) for surfing-related injuries were registered, and these injuries resulted in payments of almost NZ$20 million (Accident Compensation Corporation, 2013). A study on adventure sports in New Zealand reported surfing as the fourth highest (behind horse riding, mountain biking, and tramping/hiking)

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for injury claims, with an injury rate of 11.1 per 1,000 participants (Bentley, Macky, & Edwards, 2006).

Unfortunately, studies that report on hospital admissions alone are likely to be biased since they include only the more severe injuries. Many outdoor recreational studies thus suffer from an under-reporting of minor injuries and injuries not requiring hospital treatment (Heggie, 2010). In an attempt to overcome this limitation, several studies have used self-reported retrospective analysis to report on surfing injuries (Meir, Zhou, Gilleard, & Coutts, 2011; Mitchell et al., 2008; Taylor et al., 2004). Using survey web site technology, Meir and colleagues surveyed 772 surfers online and found that 38% had sustained an injury in the previous year severe enough to keep them out of the water and, of these, injuries to the lower limb were most commonly reported (knee 16%, ankle and foot 15%). Taylor and colleagues (2004) surveyed 646 surfers onsite at eight Victorian beaches in Australia and reported an acute injury rate of 0.26 per surfer per year, (95% CI: 0.22, 0.30) or 2.2 injuries per 1,000 surfing days (95% CI: 1.9, 2.6). While self-complete surveys provided further evidence on the nature of surfing injuries, limitations regarding the validity of self-reported health behaviors previously reported (Mickalide, 1997; Nelson, 1996; Robertson, 1992) suggested that the results should be treated with some caution.

One source of surf injury information to date that has not been the subject of inquiry are data collected as a consequence of first-aid interventions at beaches patrolled by lifeguards. In the 5 year span of 2007–2012, New Zealand lifeguards provided first-aid treatment to almost 9,000 beachgoers, an average of 1,772 cases per annum—more than the average number of rescues (n = 1,343) performed each year (Surf Life Saving New Zealand [SLSNZ], 2012). A recent analysis of nondrowning, beach-related recreational injuries requiring first aid by the authors found that almost one sixth (16%) of all incidents were surfing-related (Moran & Webber, 2013).

It is the purpose of this study to describe the nature and extent of surfing injuries occurring at patrolled surf beaches in New Zealand via an analysis of data obtained from surf lifeguard incident report forms. Rather than being a purely descriptive study of surfing injury, an aetiological approach (that explores how and why injuries occur) is used to make recommendations about appropriate surf safety strategies. In doing so, it is hoped that the study will provide evidence-based recommendations for the promotion of public safety measures.

Method

This retrospective descriptive analysis of surfing injuries is a follow-up study that expands on the findings of a previous study of all beach-related injuries requiring first aid provided by surf lifeguards in New Zealand (Moran & Webber, 2013). Details of first-aid incidents are routinely recorded on Incident Report Forms by surf patrols and data are subsequently collated countrywide by the national organization (SLSNZ) for entry onto their patrol activity database. These data provide the evidence base from lifeguard activity and are reported in brief on the SLSNZ website and in an annual report (SLSNZ, 2012). Permission to access the national database was granted by SLSNZ, subject to the database being cleaned of any per-

sonal details of the patient to ensure confidentiality and anonymity. Ethics clearance for the study was obtained from the University of Auckland Human Participants Ethics Committee (19 October 2012).

For the purpose of this study, we adopted a slightly more expansive definition of surfing than that used in previous studies. In addition to the traditional description of surfing as surf board riding (using a short, long, stand-up paddle board, knee board, or kite board), all incidents before injury that involved riding waves were included as surfing-related, including body surfing (without a board, with/without fins) and body boarding (using a small body/Boogie board). Hang gliding (taking off from cliff sites adjacent to surf beaches and skim boarding (taking place in any shallow water) were excluded since they were not primarily surf-related.

Data Collection

The Incident Report Forms contained information on the injury occurrence (e.g., time, location) and the nature of the injury (e.g., laceration, marine sting). Demographic data collected included age, sex, and ethnicity as previously described (Moran & Webber, 2013). Separation of surfing activity from other forms of water-based recreation (such as swimming, boating, or sailing) was possible because the data were coded by 'activity before treatment.'

Two other sources of information, first-aid equipment usage and treatment outcome, were included in the data collection because they were considered indicative of the nature and extent of the surf-related injuries treated by lifeguards. The type of first-aid equipment involved was reported in six categories (e.g., oxygen therapy, first-aid supplies). The patient outcome also was reported in six categories (e.g., referred to doctor, left in stable condition).

The forms also included a section for attending lifeguards to provide written patient/incident notes where appropriate. These notes, where available, provided a rich source of additional data on why and how the injury occurred and are reported separately from the other data sources indicated above. Information was grouped, numerically coded, and tabulated according to injury site (e.g., an injury grouped under foot might include written comments such as heel, toe, and ankle). In some notes, further information was available on injury causes. This information was also coded into seven types (such as contact with own surfboard or contact with ocean floor/rocks) and tabulated. As was the case in the initial study of all beach-related first-aid injuries (Moran & Webber, 2013), where written notes were especially informative, some comments are reported verbatim as indicative of the etiology of surfing injuries.

Data Analysis

Nonleisure activities (such as vehicle-related injuries treated by lifeguards) and nonsurfing first-aid cases (such as land-based injuries) were removed from the original database because they were not pertinent to this study. The revised Excel spreadsheets were cleaned, recoded, and data then were entered into SPSS Version 19 for Windows. Descriptive analyses including frequency and percentages were used to describe all numerical variables. These included three independent variables (i.e., sex, age, and ethnicity) and four dependent variables related to the

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injury incident (i.e., activity before injury, type of injury, first-aid equipment used, and patient outcome). For ease of interpretation and to reflect the predominance of young people in the beach-going population, the original eight age groups were condensed and dichotomized to two broader age groups, children aged less than 16 years and youth/adults 16 years of age or older for use with the chi-square statistics. Cross tabulations providing chi-square statistics were conducted to determine significant bivariate relationships between the sociodemographic influences of age, sex, and ethnicity against the nature of injury.

Results

Of the 8,437 incidents requiring first-aid treatment by surf lifeguards throughout New Zealand from 2007 to 2012, 16% (n = 1,327) were reported as the consequence of surfing activity. Of these, significantly more males than females were treated for surfing injuries ($\chi^2(2) = 75.056$, $p = <.001$), with 68% of the patients being male and 31% female (sex not recorded in 1% of cases). Significantly more victims of surfing-related injuries were older than 16 years ($\chi^2(1) = 121.412$, $p = <.001$). Almost one half (43%) were between the ages of 16–30 years, with children ages 11–15 years accounting for one quarter (25%) of all surfing-related first-aid incidents. Of those engaged in surfing activity before receiving first-aid treatment, significantly more ($\chi^2(1) = 9.750$, $p = .002$) were European than non-European in ethnic origin (85% of sample compared with 62% of national population); all other minority groups were under-represented (15% of sample compared with 38% of national population). As a proportion of all first-aid incidents attended by lifeguards, surfing injuries did not vary significantly from year to year (M = 15.7%, range = 13.4–18.1%).

Surfing Injuries by Type

Table 1 shows, in descending order of frequency, the nature of the surfing injury treated by lifeguards over five years from 2007–2012.

Table 1 Surfing Injuries by Type, 2007–2012

Nature of Injury	*n*	%
Laceration/abrasion	768	59.2
Bruising	202	15.2
Marine sting/envenomation	94	7.1
Breathing difficulties	20	1.5
Cramp	11	0.8
Insect sting	6	0.1
Sunburn/burns	2	0.1
Other (feeling unwell)	47	3.5
Other (unspecified)	177	12.6
Total	1,327	100.0

Chi-square analyses were conducted to ascertain differences in surf-related injury types by sex, age, and ethnicity. Significant age differences were found in the reporting of marine stings with more victims younger than 16 years reporting stings (<16 years 68%, >16 years 32%), $\chi^2(1) = 32.799$, $p = <.001$. Significantly more males than females reporting bruising (male 56%, female 44%), $\chi^2(2) = 18.805$, $p = <.001$, and lacerations/abrasions (male 62%, female 55%), $\chi^2(2) = 6.593$, $p = .047$. Significant differences were also found when we analyzed lacerations/abrasions by age with twice as many victims over 16 years receiving first-aid treatment (<16 years 33%, >16 years 67%), $\chi^2(1) = 32.657$, $p = <.001$. No other significant sex, age, or ethnicity differences by injury type were found.

First-Aid Treatment and Patient Outcomes

Table 2 shows three fourths (75%) of injuries were minor, and patients left the scene in a stable condition after treatment, although some required assistance from the beach (5%). One fifth (20%) of cases required further medical intervention with lifeguards recommending that the patient seek medical advice (16%); some cases (4%) were deemed serious enough to warrant direct transport to hospital by ambulance/helicopter. No significant differences were found when patient outcomes were analyzed by age, sex, and ethnicity.

In terms of first-aid equipment used by lifeguards, almost three fourths of surf-related incidents (71%; $n = 945$) required the use of first-aid disposable supplies (such as wound dressings or saline solution). Almost one fourth (22%; $n = 296$) required no first-aid equipment, but more serious cases required oxygen therapy (3%; $n = 43$) or immobilization via neck brace (1.4%; $n = 18$) and/or stretcher (1.7%; $n = 23$).

Location of Surfing Injury via Written Incident Notes

In addition to the data on injury and incidents reported above, a more descriptive analysis of surfing injury site first-aid treatment was available from the written incident/patient notes for many of the incidents (60%; $n = 792$).

Table 3 shows that almost one third (32%) of injuries identified in the written notes were sustained to the head and neck, and, of these, peri-orbital lacerations and sand invasion were reported as eye injuries (2.5%; $n = 22$). Nosebleeds were

Table 2 Surfing First-Aid Treatment/Patient Outcome, 2007–2012

Posttreatment Outcome	*n*	%	Cumulative %
Left in stable condition	990	74.6	74.6
Referred to doctor	211	15.9	90.5
Transport to hospital	58	4.4	94.9
Assisted from beach	67	5.0	99.9
Deceased	1	0.1	100.0
Unknown/Not found	0	0.0	
Total	1,327	100.0	

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also specifically identified (4.2%; $n = 33$). The following extract from the written notes typified the nature and extent of head injuries:

> "Patient was surfing and went over the falls hitting his nose on the sand. He walked up to his car in the car park of his own accord . . . Two lifeguards went down and cleaned up his bloody nose as well as a minor abrasion on the bridge of his nose. After checking for c-spine injuries, he was released in a stable condition."

Injuries to the upper limb were commonly treated and, of those, injuries to the hands (e.g., fingers, wrists) were the most regularly identified injury site (9%; $n = 67$). A typical comment from the written notes included the following:

> "Cut to R finger from fin while surfing. Irrigated and applied Steri-Strips™ and plaster dressing. Patient fine, no referral required."

Almost half (42%) of all injuries occurred in the lower limbs and were variously reported as foot (19%; $n = 148$), ankle (4%; $n = 33$), and leg injuries (19%; $n = 147$). Of the latter, knee injuries were the most commonly treated (6%; $n = 50$). Foot/ankle injuries accounted for almost one quarter (23%) of surf injuries that required lifeguard first aid. Typical of the comments recorded for such foot injuries was the following:

> "Deep laceration on medial aspect of right foot, from surfboard fin. Deformity and loss of movement of the big toe. Washed with saline. Low level of consciousness, condition improved, and patient transferred to hospital."

Less frequently occurring injuries included those to anterior trunk (abdominal, pelvic and thoracic cavities; 3%; $n = 25$) and posterior trunk (spinal; 1%; $n = 11$) regions. Skin injuries reported in the written notes included marine (4%; $n = 33$)

Table 3 Location of Injury via Incident Notes, 2007–2012

Location of Injury	*n*	%
Head/neck/eyes	251	31.7
Upper limb—forearm, elbow, shoulder, hand, wrist	119	15.0
Trunk—abdomen/pelvis/thorax/spinal	36	4.5
Foot/toes/ankle	181	22.9
Lower limb—leg/thigh/calf/knee	147	18.6
Skin—marine and insect stings, rashes	47	5.9
Chronic conditions (e.g., asthma)	7	0.9
Other conditions (e.g., fatigue, nausea)	4	0.5
Total	792	100.0

and insect stings (<1%; $n = 2$) as well as chest rashes (2%; $n = 13$) from abrasive contact with the surf or body board.

Injury Causation via Written Notes

Table 4 shows that, of those incidents where written notes were recorded, being struck by their own surf board accounted for half (50%) of all surfing-related injuries. Typical of comments on injuries caused by contact with their own board is the following:

> "Patient hit by his own surfboard in face under left eye. Bruising, swelling, small cut, sand in eye. Eye was flushed with saline and eye wash to remove sand. Ice applied to swelling. Patient sent away with saline and ice pack and advised to seek further medical attention."

Collisions with other surfers resulting in injury were less likely than contact with the users' own board (50% vs. 6%), and a typical comment on such incidents was reported in the written notes as the following:

> "2 cm cut to head after being hit by fellow kneeboarder's board. Cleaned wound and stopped bleeding. Ice applied to reduce swelling. Mother picked patient up from surf club first-aid room, left in stable condition."

Contact with the ocean floor/rocks accounted for one fifth (21%) of surf injuries, and a typical comment on such incidents was the following:

> "Young girl body surfing dumped heavily on sandy bottom by big wave. Patient was upset and sand in hair and face. Taken to club house outdoor shower and washed down by mother removing sand from eyes, ears, nose, etc. Left with mother after assessment; patient was ok."

Table 4 Cause of Injury From Incident Notes, 2007–2012

Cause of Injury	*n*	%
Struck by own board	396	50.0
Struck by another board	46	5.8
Contact with ocean floor/rocks	168	21.2
Hydrostatic force of wipe-out (falling off)	34	4.3
Muscle—strain, cramp	6	0.7
Skin inflammation— marine and insect stings, rash	47	5.9
Other (e.g., asthma, fatigue)	11	1.4
Not described/insufficient information	84	10.6
Total	792	100.0

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Discussion

Analysis of first-aid cases suggested that surfing-related injuries, while mainly minor in severity, were commonplace among beachgoers at New Zealand beaches patrolled by surf lifeguards. Most patients (75%) left the scene in a stable condition after being treated, confirming a previous finding that most patients (90%) presenting at a hospital emergency department were likely to be discharged after initial treatment (Hay, Barton, & Sulkin, 2009). Males, those with ages of 16–30 years and of European ethnicity, were most frequently victims of surf-related incidents necessitating treatment. This confirmed previous findings that young adult men were most likely to incur a surfing-related injury (Hay et al., 2009; Taylor et al., 2004).

Almost three quarters (74%) of first-aid cases treated were soft tissue injuries resulting from lacerations or abrasions (59%), with bruising contributing a further 15%. Lacerations accounted for a slightly greater proportion of injuries than in previous studies by Hay and colleagues (2009) based on hospitalization data (38%) from the United Kingdom and cross-sectional surveys by Taylor and colleagues (2004) in Australia (46%) and Nathanson and colleagues (2002) in the United States (42%). The reasons for this disparity are not known, although the availability of on-site treatment is likely to have reduced the need for further medical treatment. It is also possible that victims are more inclined to seek first-aid assistance if such facilities are available at the beach.

The written notes also indicated that most acute surfing injuries were to the lower limbs (42%) and the head, neck, and eyes (32%); these are proportions similar to those found in studies from Australia (Taylor et al., 2004) and the United States (Nathanson et al., 2002). Some injuries (4%) were serious enough to warrant immobilization or stretcher use and immediate referral to hospital. Of the 58 cases transported to hospital from the beach, most (69%; $n = 40$) were for lacerations requiring surgical closure. The written notes also indicated that contact with a surfboard was the most frequent cause of surf-related injury, accounting for more than half (56%) of the incidents, consistent with the findings of previous studies (Allen, et al.,1977; Nathanson et al., 2002; Taylor et al., 2005). Our study further revealed that almost ten times as many victims were struck by their own board rather than another board (50% vs. 5.6%). The likely reason for this being the almost universal use of surf leashes that maintain close contact between the surfer and his own board in a "wipe out" (Lowdon et al., 1983). Incidents involving nonsurfers being struck by errant surfboards were uncommon, which is a likely consequence of the effectiveness of surf leashes and the lifeguard practice of separating surfing activity from swimming activity on patrolled beaches.

As indicated in the verbatim comments, lacerations were the most common outcome of collisions with surfboards; the written notes often cited sharp surfboard fins or noses as the culprit. While previous studies (Nathanson et al., 2002; Allen, et al., 1977; Lowdon et al., 1983) over the past three decades have identified this issue and recommended equipment modifications (such as blunt fin edges and protective guards on pointed surfboard noses), it would appear that the occurrence of such injuries has persisted, and further efforts to make manufacturers and users aware of the issue are recommended.

Contact with the sea floor accounted for one fifth (21%) of all injuries, a proportion similar to that reported by Nathanson and colleagues (2002) and Taylor and colleagues (2004) of 17% and 18%, respectively. The written notes indicated that spinal injuries were caused mostly by contact with the sea floor. While being less frequent than surfboard injuries, the sea floor contact incidents were likely to be more serious with 18 cases of neck/spinal injuries (31% of hospitalized cases over the 5-year period) requiring immediate on-site immobilization via neck brace and/or stretcher. Recent findings of an ongoing study on the head and spinal injuries of admissions to a New South Wales major spinal treatment center confirm that, for surfing spinal cord injuries, most acute spinal injuries involve the cervical spine and are due to contact with the sea floor (Dimmick, Sheehan, Brazier, & Anderson, 2013; Dimmick, Brazier, Wilson & Anderson, 2013). While protective headgear has been advocated as a possible solution to head lacerations (Nathanson et al., 2002; Taylor et al., 2005), helmets are unlikely to offer much protection to the spine from contact with the sea floor. With the exception of some reef breaks, their use on popular surf beaches in New Zealand has not been extensive, and evidence regarding their efficacy is lacking. Further research is required before recommendations for optional or mandatory helmet use when engaging in surfing activities are made.

Results from this study should be treated with some caution in light of several methodological limitations. First, the data included only surfing-related cases treated by surf lifeguards; it did not include cases treated by other agencies or bystanders and did not include injuries sustained at nonpatrolled beaches (unless requested to do so), nor did it include injuries sustained outside the summer patrol season (late October through late April). Second, not all cases included written notes to identify the nature and cause of injury. Third, given that the notes were written mostly by nonmedical personnel, the clinical accuracy of the information provided cannot be assured. Fourth, injury outcomes initially treated at the beach are not known; further follow-up study to relate on-site and subsequent medical treatment of surf injuries is recommended.

Conclusions

This investigation of surfing-related injuries requiring first aid has shed new light on the etiology of surf injuries and confirmed many of the previous findings of previous studies. While the risks associated with drowning when swimming in the surf are well documented and have been the subject of preventive strategies, strategies for the prevention of surfing injuries have not been as vigorously pursued or, where they do exist, the outcomes evaluated. Strategies for decreasing incidence are still necessary, despite the overall low incidence of injury during surfing. Changes to the equipment itself, the use of protective gear, especially in high risk areas (reefs and rocks), monitoring and managing of surfing activity by lifeguards, public education about risks, and risk management when surfing are all likely to reduce injury incidence. The challenge for those involved—surf board manufacturers, surf aficionados, water safety organizations, the beach-going public—is to use the evidence provided in this study to promote surf safety and ensure that a day surfing at the beach is pleasurable and injury-free.

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