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PII: S0048-9697(18)34019-1  
Reference: STOTEN 29040  
To appear in: Science of the Total Environment  
Received date: 31 July 2018  
Revised date: 10 October 2018  
Accepted date: 10 October 2018

Please cite this article as: Marnie L. Campbell, Linda Peters, Cameron McMains, Mariana Cruz Rodrigues de Campos, Rebecca Sargisson, Boyd Blackwell, Chad L. Hewitt, Are our beaches safe? Quantifying the human health impact of anthropogenic beach litter on people in New Zealand. Stoten (2018), doi:10.1016/j.scitotenv.2018.10.137

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.
Are our beaches safe? Quantifying the human health impact of anthropogenic beach litter on people in New Zealand.

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Abstract

The environmental, social and cultural importance of beaches permeates human society, yet the risk of human injury associated with increasing exposure to anthropogenic beach litter remains an unknown. While the impact of marine debris and beach litter on marine and coastal fauna and flora is a widely reported global issue, we investigate the impact on human health in New Zealand. Anthropogenic beach litter is ubiquitous, few beaches remain pristine, which consequently influences tourist choices and potentially negatively interacts with humans. Human impacts are not well-investigated, with no quantitative studies of impact but many studies qualitatively inferring impact. New Zealand has a socialised medical system allowing a quantitative, decadal assessment of medical insurance claims to determine patterns and trends across ecosystems and causes. We demonstrate for the first time that anthropogenic beach litter poses a common and pervasive exposure hazard to all ages, with specific risk posed to young children. The New Zealand system allows these hazards to be investigated to determine the true effects and costs across a nation, providing an evidence base for decision-makers to address this ubiquitous environmental issue.

Keywords

beach management; environmental values; human health; marine debris; pollution; water quality
1. Introduction

Urbanisation and associated anthropogenic pressures placed upon coastal areas has resulted in numerous threats and impacts to the environment, citizens, cultures, and economies of countries (e.g., Silva et al., 2011). Yet, globally, beaches are recognised as important contemporary tourist destinations that provide numerous natural capital assets (Roca et al., 2009; Brenner et al., 2010; Ariza et al., 2012; Semeoshenkova et al., 2017), with socio-economic values that span across commercial use, such as seine netting and bait gathering, to recreational use, to the more abstract, like scenic quality, comfort, and safety (e.g., Pena-Alonso, et al. 2018). Coastal areas, especially beaches, are iconic places for New Zealanders that also annually attract more than 800,000 international tourists (Statistics NZ, 2016), but are they safe? Beaches are actively managed to minimise hazards, to provide public playgrounds (e.g., James, 2000; Klein and Dodds, 2017) and enhance value (Blackwell, 2007) both of which attract visitors (Blackwell et al., 2013; McLachlan et al., 2013; Lucrezi and van der Walt, 2016; Williams et al., 2016) thus providing, a natural resource that enhances the New Zealand economy. Much of this management focus is oriented towards water based activities (e.g., surfing, swimming, and fishing) and improving the amenity value of beaches through maintenance of a clean environment.

Unfortunately, clean beaches are a thing of the past (Moore, 2008); over six-million items enter the seas each day, much of which ends up on beaches (Williams et al., 2013). Beach litter accumulation, either from marine debris or visitor littering behaviours, is perceived as causing a significant loss of amenity value (Ballance et al., 2000; Tudor and Williams, 2003; Blackwell, 2007; Blackwell and Tisdell, 2010). Additionally, beach users are significantly concerned with beach cleanliness and safety; tourists are unhappy with “dirty” beaches (Ballance et al., 2000; Santos et al., 2005; Roca and Villares, 2008; McKenna et al., 2011); and both children (e.g., Hartley et al 2015) and local residents are concerned about cleanliness, litter and its impacts (e.g., García-Morales et al., 2018; Keissling et al., 2017). We consider that appropriate and cost effective beach management should also consider and rely on the degree to which perception of cleanliness correlates with the
evidence of litter-related injuries. An initial understanding of the prevalence and type of litter on beaches that relate to acquired injuries is the first step in moving towards evidence-based management.

Our current understanding of how beach litter affects our health is poor. Ivar do Sul and Costa (2007) have suggested that we have underestimated the human health impact from beach litter for many decades, despite clear, quantified evidence that beach litter and marine debris affect animals (e.g., Verlis et al., 2013, 2014; Vegter et al., 2014; Hardesty et al., 2015; Wright et al., 2015). The impact to humans has been discussed in the literature but remains, for the most part, unquantified (e.g., Thompson et al., 2009; Keswani et al., 2016; Miranda and de Carvalho-Souza, 2016; Kiessling et al., 2017), with the exception of a single study in Australia (Campbell et al., 2016). In Australia, approximately 21% of users of “clean” beaches are injured in some manner by beach litter, yet few people (12.9%) consider that their health is at risk from beach litter (Campbell et al., 2016). No additional publications were found that document and quantify the impact that marine debris and beach litter has on human health.

Conversely, water-based risks in coastal areas have been widely acknowledged: beach injuries and tourist deaths are commonly associated with drowning (Aldraldes and Perez-Gomez, 2009; Avramidis et al., 2009), interactions with wildlife (stings, bites) (Haddad et al., 2002; Taylor et al., 2002; Pommier et al., 2005; Gershwin et al., 2009), and water sports (Taylor et al., 2004; Staines et al., 2005). Research on human health impacts of beaches are often focussed on contaminated water (e.g., Ashbolt et al., 2010; Soller et al., 2010; Keswani et al., 2016) and beach-safety. Beach-safety initiatives tend to be holistic in their outlook, however there is an inherent bias towards water safety (Surf Life Saving New Zealand, 2009) as opposed to beach safety (Hegie, 2013).

We propose that marine debris and beach litter (collectively Anthropogenic Beach Litter; ABL) is an unrecognised, but pervasive, hazard to humans that has rarely been explored globally and never in New Zealand. This paper focusses on determining the extent and type of ABL injuries that have been reported in New Zealand. Ideally, we would have also investigated the demographic factors
that influence ABL injuries, which an understanding of could lead to improved beach management strategies. However, due to human research ethics limitations, the dataset we have used is not linked to individuals’ demographics, but provides a 10-year overview of the human health impacts associated with marine debris and beach litter on beaches in New Zealand. We do not link ABL injuries to the prevalence of material on beaches (e.g., Slavin et al., 2012), as this is part of a larger study that is currently underway. This study lays the groundwork to understand the true costs of ABL impacts to human health in New Zealand. As such, we set the foundations for a nationwide analysis of the implications of ABL impacts upon humans. Although New Zealand is the focus, the outcomes of this study have broader, global implications.

2. Material and Methods

2.1 Human health impacts

Our exploration of human health impacts covered all of New Zealand (all islands and territories) with the scale of resolution maintained at a Territorial Authority (Regional Council level). To understand the types and extent of beach injuries that occur in New Zealand that are related to ABL we requested and received a 10-year (2007-2016) dataset from the ACC (Accident Compensation Corporation; https://www.acc.co.nz/; ACC ethics approval #337). The ACC maintain a database that provides insight into injuries that have occurred in NZ and have been lodged for a government insurance claim, and may include international visitors. Due to confidentiality, individual claims were not linked to domestic residents or international visitors.

ACC insurance claims cover all visitors to NZ and residents. The information on the database is, for the most part, drawn from the information claimants have provided to the ACC. A number of caveats exist on use of the ACC data: i) information is reliant upon information that the claimants and treating physicians provide the ACC (e.g., age, ethnicity, gender, cause of injury); ii) there is large variability in the nature and quality of the descriptions claimants provide; iii) confidentiality of the data is maintained and hence data are aggregated when required and linkages between
demographics and injury types are lost; and iv) not all injuries or causes of injuries are reported. Thus, the data are not a definitive measure of the claims ACC received but are indicative. Similarly, the ability to link demographics with injury types, causes of injuries, and locations of injuries is not feasible as confidentiality of the data needs to be maintained.

To facilitate the ACC database enquiry we provided a list of search terms to interrogate the database. Our search terms focussed upon:

- Cause of anthropogenic beach litter (ABL) beach injury;
- Injury medical diagnosis;
- Generic demographic influences (age, gender, ethnicity, and injury locality); and
- Cost to NZ taxpayers.

The data received from the ACC were aggregated to Regional Council scale to ensure confidentiality of claimants. When fewer than three occurrences of an injury type or diagnoses occurred the information was categorised as the number “3”. Similarly, if a claim was less than $100 in cost, the cost was categorised as “$100”. We report the information as total numbers or averages. Ages are classified into four categories based upon the Canadian Statistics Standards (http://www.statcan.gc.ca/eng/concepts/definitions/age2): children 0-14; youth 15-24; adults 25-64; and seniors 65+. Thus, the data have limitations that ensure the confidentiality of all claimants is maintained.

2.2 Statistical analyses

Due to the limitations of the ACC dataset, the injury ACC data were examined using linear models, ANOVA, and descriptive statistics to identify patterns between: new and active claims; causes and diagnoses of injuries; the influence of time of day upon when injuries occur; the influence of age, gender, ethnicity, location; and the cost of active claims at NZ beaches. For cross-comparison, we used data from the 2013 New Zealand Census at the level of Territorial Authority
Regional Council). Statistical analyses were undertaken using Sigmaplot with significance determined at $p < 0.05$.

3. Results

3.1 ACC data outcomes: beach injuries in New Zealand

During the 10-year period, 78,370 new beach injury claims were lodged and 82,891 active beach injury claims were accepted and managed. New and active claim data are examined separately because they are auto-correlated (lack independence) but do not necessarily fully overlap. For example, not all new claims become ongoing active claims. Of the new claims lodged in this period, 4,024 were due to injuries caused by ABL, with a further 3,726 active ABL injury-related claims being already managed. Thus, on average, in NZ each year there are 7,837 new human health insurance claims lodged and 8,289 accepted and managed claims relating to injuries that occur at beaches. On an average daily basis, this represents ~21.5 new claims each day, with a further 23 active claims continuing. Of the new claims, 5% (~402 claims or 1.1 new claims per day) relate to ABL.

To place this into context the average annual NZ population during the same 10-years was 4.48 million with an average of 49,348 injuries per year. If we extrapolate these data against the NZ population (noteing that this will result in an over-estimate, as the ACC injury data extends to NZ residents and tourists, with no demarcation between these groupings), it suggests that on average ~1.1% of the population is injured per year, with ~0.18% of the population affected by beach related injuries each year (noting that this potentially includes international tourist numbers). Of course, not all of the NZ population visits the beach, yet 64% of the NZ population live within 5km of the coast (NZ Treasury, 2016, 2017).

The number of claims (both new and active) lodged are increasing linearly through time (Fig. 1). In 2012, a general downward trend in the total number of beach injuries ended. There was a significant increase in injuries in 2013 over 2012, and the increase has been variable, but consistent since. All injury claims are increasing by 1.8% per year, however reporting of beach litter related
injuries are increasing at a faster rate by 4.99% per year ($R^2 = 0.75$) and other beach injuries are increasing by 4.92% per year ($R^2 = 0.72$) with an accelerated increase since 2011 (Fig. 1). Similarly, the proportion of claims with an accident description (noting that not all claims have a description) is relatively high (average 92.97%) and has increased linearly through time ($R^2 = 0.89$).

[insert Fig. 1]

3.1.1 Stated injury causes and diagnoses

The ACC data set recorded 31 different causes of injury due to ABL during the 10-year dataset (Fig. 2), with the top-five most common injury claims making up 74% of new claims, being:

1) Punctures (27% new claims y$^{-1}$; 26% active claims y$^{-1}$); 
2) Loss of balance or personal control (24% new claims y$^{-1}$; 24% active claims y$^{-1}$); 
3) Collision or knocked over by an object (9% new claims y$^{-1}$; 9% active claims y$^{-1}$); 
4) Tripping or stumbling (8% new claims y$^{-1}$; 9% active claims y$^{-1}$); and 
5) “Other” or unclear cause (7% new claims y$^{-1}$; 7% active claims y$^{-1}$).

[insert Fig. 2]

These ABL/human interactions resulted in 13 different injury diagnoses (Fig. 3). ABL/human interactions predominantly cause lacerations, puncture wounds, or ‘stings’. A significant portion (97%) of harm to claimants came from:

1) Infected/ non-infected laceration, puncture wound, “sting” (59% new claims y$^{-1}$; 55.1% active claims y$^{-1}$); 
2) Soft tissue injury (contusion, internal organ, strain) (23% new claims y$^{-1}$; 26.2% active claims y$^{-1}$); 
3) Foreign body in orifice/eye (8% new claims y$^{-1}$; 7.9% active claims y$^{-1}$); 
4) “Other” (4% new claims y$^{-1}$; 2.7% claims per year); and 
5) Fracture/dislocation (3% new claims y$^{-1}$; 2.9% active claims y$^{-1}$).
When averaged between the years of measurement, the number of active claims for injuries sustained during each hour peaks (Fig. 4) during the typically warmest hours of the day (mid-morning to mid-afternoon). The highest number of claimed injuries occurs between 2pm to 4pm. There is a separate, much smaller peak in the middle of the night between 1am and 3am indicating that injuries occur over the 24 hr time period (Fig. 4). This reflects a distinct bell-shaped curve is observed for the time of day when injuries occur, over a 24 hour time period.

Fewer beach injury claims (new or active) are made by adults, with children and youth having a disproportional representation in new and active ABL-associated injury claims relative to the 2013 census and for children relative to all beach injuries (Fig. 5). Half of new ABL related injury claims came from people aged 20 to 65 years, with 42% of new ABL-related claims associated with children (aged 0-19 years). The number of new versus active claims did not differ statistically between age categories (children, youth, adults and seniors) ($t_{(6)} = 2.45$, $p = 0.675$), however, the statistical power of this observation was low (power = 0.105), most likely due to the variability in the data set. Hence, the inference regarding age categories is provided with caution. More than 30% of all injury claims (4,077) made between 2007-2016 for children (0-14) were associated with new ABL-related injuries (1,242), whereas ABL-related injuries for youth (15-24) and adults (25-64) were a lower percentage of all injury claims made between 2007-2016 (Fig. 5).
Males have more new (57%) and active (55%) beach injury claims with the ACC compared to females. The rate of new claim submissions are increasing linearly for both males ($R^2 = 0.66$) and females ($R^2 = 0.84$).

The average number of claims associated with ABL injuries based on a claimant’s self-stated ethnicity was representative of the NZ 2013 census data, with a few exceptions (Fig. 6). The Asian population is slightly over-represented in the average number of ABL claims 2.7% greater than population representation for all of New Zealand. Pacific Peoples have 5.7% fewer claims than population representation, and Other Ethnicity have 4.2% fewer claims. Note that Residual Categories represent unstated ethnicity.

[insert Fig. 6]

### 3.1.5 Influence of locality

There are 16 NZ Regional Councils, with 76.6% of the NZ population located on the North Island in nine of the Regional Council jurisdictions. The number of new claims lodged relating to ABL-related beach injuries was somewhat representative of the 2013 NZ population census data, with a slight over-representation of North Island (83% of new claims) and subsequent under representation of the South Island (16% of new claims).

The distributional spread across regions for ABL-related new ACC claims was statistically similar to the NZ population spread (Fig. 7; $U = 120.0$, $P = 0.777$), with some general exceptions that were not statistically significant. For example, both Canterbury and Wellington had significantly fewer new claims lodged compared to their population size (Canterbury: 6.9%; Wellington: 2.9%). Alternatively, eight jurisdictions had more new claims compared to their population size (Fig. 7). The population of the West Coast region sustains a proportionally higher amount of ABL injuries than any other in New Zealand. Those with a proportion of new claims that exceeded the proportion of their population tended by be associated with tourist hubs (e.g., Bay of Plenty: 5.9%; Northland: 5.1%; Gisborne: 2.5%).
3.1.6 Cost of active claims

The vast majority (86%) of ABL claim costs involve medical treatment (41%), weekly compensation (31%), and hospital treatment (15%). Death-related costs are less than 2% of active claims. Loss of balance or personal control, punctures, tripping or stumbling, twisting movement and collision or being knocked over by an object are the top five causes of ABL injuries. These causes are responsible for 72% of all active ACC claim costs for the period examined, with loss of balance comprising a third of all ABL-related injury costs. Just three diagnoses make up 82% of active claims: soft tissue injury; infected and non-infected lacerations, punctures, and wounds; and fractures and dislocations. As to be expected, the time of day when the costs of injuries peaked, matched when the majority of injuries are reported (between 2 and 4pm).

The average annual cost of active claims attributed against children (0-14 year olds) is less, than claims made by seniors, adults and youth (Fig. 8a). This is in contrast to the number of active claims, where children and youth dominate the number of claims made (Fig. 5). There is a moderate ($R^2=0.52$), positive relationship between age and cost of active injury claims however, the annual average cost per claim is lowest for children (0-14) and seniors (65+) is also low (Fig. 8b). This pattern is likely a consequence of no salary compensation being included in the claim (Fig. 5b).

The majority (60.5%) of injury costs are associated with males. This is proportionally higher than the number of active claims by gender, where men comprise 55% of active claims. Thus, on average, male claims result in greater costs than females suggesting either that the injuries are more severe, or that more is spent on male claims as a consequence of differential employment rates and salary scales.
In general, NZ Europeans/Pakeha are the most common ethnic group in NZ and the average costs of ABL injuries are commonly represented by Europeans (Fig. 6). The Asian population is slightly over-represented relative to census data in the costs of active claims (0.8%) but 1.9% lower in the average costs of claims relative to number of claims. Pacific Peoples and Maori claims costs were underrepresented (7.2% and 3.3% respectively) relative to census and 1.5% and 1.3% lower than the average number of claims (Fig. 9). Other Ethnicity and Residual Categories average claims are higher than expected based on number of claims (1.8% and 3.3%, respectively). The average costs of injuries based on a claimant’s self-stated ethnicity was representative of the NZ 2013 census data, with a few exceptions. The average claim was NZ$450, however average claim sizes varied between ethnicities, noting that Residual Category included both the greatest average cost and the greatest variability (Fig. 9).

[insert Fig. 9]

4. Discussion

Human use of marine environments is annually increasing, with specific growth of recreational and tourism activities focused on beaches (e.g., Aguilo et al., 2005; Toimil et al., 2018). In New Zealand, more than 800,000 international tourists visit New Zealand beaches annually (Statistics NZ, 2016). Unfortunately, this increasing utilisation is coupled with an increase in Anthropogenic Beach Litter (ABL) that can cause a loss of amenity value, decreases tourism, and potentially enhances risk of personal injury (e.g., Phillips and House, 2009). We found that over a 10-year period both new and active beach injury claims to the responsible government agency (ACC) increased through time, resulting in 161,261 total claims over the 10-year period, and averaging 7,837 new and 8,289 active claims per year (averaging 0.75% of all NZ injury claims per year). ABL related injuries are shown to disproportionately result in puncture injuries, affect children (0-14), and occur in tourism hubs. These findings demonstrate that ABL is a pervasive and growing hazard to human health in the context of New Zealand.
Despite numerous passing claims of potential human health impacts of ABL in the literature (e.g., Mobilik et al., 2014; Rangel-Buitrago et al., 2017), few explicit assessments have been published (but see Ivar do Sol and Costa, 2007; Campbell et al., 2016; Carbery et al., 2018). Many of these claims appear to be based on impacts of marine debris and beach litter on animals; animal impacts are primarily entanglement and ingestions, but also include toxic exposure and puncture following entanglement (e.g., Derraik, 2002; Fossi et al., 2018).

The interactions of animals with marine debris and beach litter are naïve behaviours – mistaking an item as a food object or being attracted to colour or smell (e.g., Derraik, 2002; Fossi et al., 2018; Kershaw and Rochman, 2016). Many incidental human interactions with ABL appear to also exhibit similar naïve behaviours. Ivar do Sol (2005) reported an indirect human health exposure to the liquid contents of washed up lightsticks at Costa dos Coqueiros beaches in Brazil. At this location local beach users inappropriately used the lightsticks chemicals for topical application (e.g., sun protection, massage oil, etc; Ivar do Sol, 2005). Ivar do Sol and colleagues (2005, 2006) undertook further investigations of the potential harm using animal models and found skin irritations including erythema (redness), oedema (swelling), and rash resulted from exposure.

ABL injuries represented an average of 1.6% of all claims across New Zealand during the period 2007-2016. No claim of human mortality associated with ABL was reported during this 10-year window, however 31 different causes of injury were reported. The primary injury claim was punctures associated with stepping on or falling on ABL (27% of new claims per year and 26% of active claims per year; Fig. 2), an over-representation by >360% of all injuries in New Zealand for the same period (average of 6.7% of all claims per year). The next suite of injuries caused by ABL related to slips, trips and falls (loss of balance or personal control, collision or knocked over by object, and tripping or stumbling) that collectively comprise more than 41% of all new and active claims per year (Fig. 2) compare favourably with all claims for the whole of New Zealand (an average of 43.1% of all claims per year). This over-representation of puncture wounds highlights that ABL at beaches increases individual exposure to serious injury.
We noted that children (0-14) had a disproportionately high representation of ABL-injury claims (30.8% of new claims; 28.3% of active claims) relative to the population representation in the 2013 census (20.4% of population), and consistent with the proportion of all injury claims in New Zealand (30.5% of all claims for 0-14 age group). This signifies a high risk exposure to this vulnerable element of society, noting that the average annual expenditure is much less than other age groups. Young children exhibit naïve behaviours when interacting in the environment, and in similar vein to animal interactions with ABL, young children would mistakenly ingest items, be attracted to colour, and not read warning labels leading to exposure.

We noted that the geographic distribution of ABL-associated claims was largely in keeping with population size, however those few locations where new ABL-associated claims exceeded the proportion of NZ population were associated with tourist hubs (e.g., Bay of Plenty: 5.9%; Northland: 5.1%; Gisborne: 2.5%) (Fig. 7). This increase in claims may have been due to injuries sustained by international tourists, or by domestic visitation to “high value” beaches. The Bay of Plenty, Northland, and Gisborne regions are renowned for their “pristine” beaches and actively market these as tourist destinations. Recent bucket list destinations for “NZ best beaches” highlight these regions with 30% to 50% of top beach destinations for New Zealand from these three regions (33% CNN Travel (2018); 33% Lonely Planet (2018); 50% Trip Advisor (2018)).

While bucket-list tourism is on the rise, repeat visits by both international and domestic tourists have been demonstrated to provide high returns to the economy (Krelling et al., 2017) and provide primary motivation for local government beach cleaning (Newman et al., 2015). Previous economic analyses have considered the potential impacts on tourism associated with the presence of ABL (Ofiara et al., 1999; Jang et al., 2014) and more importantly the perception of uncleanliness (Krelling et al., 2017) with estimated overseas tourism impacts of ABL between US$29million (Jang et al., 2014) to US1.1billion (Ofiara et al., 1999). These calculations have assessed impact to the user experience (Krelling et al., 2017), including destination choice based on perception (Ofiara et al., 1999; Jang et al., 2014), or willingness to travel to another destination (Krelling et al., 2017). To our
knowledge there are no similar assessments of the ABL related economic impacts on tourism in New Zealand.

While assessments consider various aspects of travel risk that influences tourism choices (e.g., Krelling et al., 2017; Osland et al., 2017), the risk of personal injury is typically focused on the tourism activity (tour bus, diving, mountain climbing) or travel (terrorism, automobile accidents, disease) and not on the risk of casual injury, such as we have demonstrated here. We have demonstrated that Anthropogenic Beach Litter (marine debris and beach litter) form a pervasive hazard to personal injury at beaches. The extent to which these risks are manifest across the continuum of clean to “dirty” beaches remains to be seen but is likely to significantly influence risk perception (see Campbell et al., 2016).
Acknowledgements

We thank the New Zealand Accident Compensation Corporation (ACC), for providing the data of all ACC claims that refer to injuries sustained from beach litter (2011-2015). Prior to access to the ACC data human research ethics approval was obtained from the University of Waikato, Faculty of Science and Engineering, Human Research Ethics Committee (application numbers FSEN-2015-8 and FSEN-2016-08). Ethics approval was also obtained from the ACC (Ethics Approval #337).

Funding

MLC, LP, RS received partial funding from the University of Waikato Strategic Investment Fund to undertake this research. No further funding was received to undertake this research.

Authors’ contributions

MLC conceived the ideas and designed the data collection and analysis. MLC and LP secured ACC data and human research ethics approval from both the ACC and the University of Waikato. MLC, CMcM and CLH analysed and interpreted the data, and wrote the manuscript text. All authors contributed critically to the drafts and provided editorial input. All authors gave final approval for publication.

Conflict of interest

None of the authors has competing or conflicting interests in relation to the issues addressed in this paper.

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Figure Captions

Fig. 1. Total number of beach injury claims lodged with the New Zealand ACC per year.

Fig. 2. The top five types of self-reported causes of beach-based ABL injury claims within the New Zealand ACC dataset averaged across 2007 to 2016 (inclusive). Each box accounts for one reported injury from the average data per category.

Fig. 3. The top five diagnoses for self-reported ABL associated injuries within the New Zealand ACC dataset averaged across 2007 to 2016 (inclusive). Each box accounts for one reported injury from the average data per injury type.

Fig. 4. The average ABL related injury active claims per year over the course of a day (24 hours) based upon the New Zealand ACC dataset from 2007 to 2016 (inclusive).

Fig. 5. Total percentage of injury claims lodged with the New Zealand ACC between 2007-2016, based upon age categories of children (0-14), youth (15-24), adults (25-64), and seniors (65+). Grey bars denote new ABL claims, black bars denote active ABL claims, white bars denote all claims in New Zealand, and red bars denote population representation in the 2013 Census.

Fig. 6. Percentage of the NZ population by ethnicity (2013 NZ census – red bars) and the average annual percentage (±SE) of active ACC claims (black bars) and costs (grey bars) related to ABL injuries. Note that the NZ Census does not have “Residual Categories”.

Fig. 7. Geographic distribution of ABL related incidents per 10,000 residents by Territorial Authority (based on 2016 NZ Census).

Fig. 8. Costs (NZ$) of ABL injuries by age category: A) average annual cost of active ACC claims; and B) average annual cost per claim.

Fig. 9. Average claim cost (NZ$ ± SE) of active ACC claims related to ABL injuries by self-stated ethnicity.
Highlights

- Anthropogenic beach litter (ABL) is a global issue that impacts multiple ecospheres
- ABL effects on human health have been inferred but rarely quantified
- We assessed human ABL impacts using a national dataset of medical insurance claims
- The number of ABL claims increased significantly between 2007 and 2016
- Gender, age, ethnicity and region influenced incidences of ABL related injury
Figure 2
Figure 5

The bar chart shows the percent of claims for different age groups:

- **Seniors**
  - White bar: 5%
  - Red bar: 15%

- **Adults**
  - Black bar: 45%
  - Gray bar: 35%

- **Youth**
  - White bar: 10%
  - Red bar: 20%

- **Children**
  - Black bar: 25%
  - Gray bar: 30%

The chart indicates that adults have the highest percent of claims, followed by children, seniors, and youth.
Figure 8

A) Average Annual Cost of Claims

- Seniors
- Adults
- Youth
- Children

B) Average Annual Cost per Claim

- Seniors
- Adults
- Youth
- Children
Figure 9