Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Impact of COVID-19 on drowning patterns in the Great Lakes region of North America

Chris Houser\textsuperscript{a,b,*}, Brent Vlodarchyk\textsuperscript{a}

\textsuperscript{a} School of the Environment, University of Windsor, Windsor, Ontario, N9C 2J9, Canada
\textsuperscript{b} Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, N9C 2J9, Canada

ARTICLE INFO

Keywords:
Great Lakes
Drownings
COVID-19
Self-isolation

ABSTRACT

The COVID-19 pandemic significantly altered personal and group behaviors that may directly or indirectly affect other public health issues. This paper examines if and how COVID-19 indirectly influenced beach safety and drownings within the Great Lakes region using daily drowning data from 2020 in comparison to historical trends in drownings pre-COVID. Results suggest that the number of beach drownings in the Great Lakes region was significantly greater compared to the pre-COVID period of 2010–2019. Statistically significant increases in drownings were observed in Lake Michigan (+14), Lake Ontario (+11) and Lake Huron (+4), while no change and a slight decrease was observed in Lake Superior and Lake Erie respectively. Drownings were lower than the historical average early in the pandemic but began to increase as stay-at-home orders were lifted through June and July. It is argued that the increase in drowning is due to a combination of reduced local lifeguard resources, cancelled swimming lessons, large beach crowds, warm weather, high-water levels and self-isolation fatigue. Whether in the Great Lakes region or elsewhere around the world, beach safety cannot be sacrificed in a future public health emergency by budget cuts or by reducing the focus of lifeguards with enforcement of social distancing.

1. Introduction

Surf-related drownings due to strong waves and currents is a public health issue throughout most of the world (Sherker et al., 2008; Leavy et al., 2015; Brighton et al., 2013; Brewster et al., 2019; Brander and Houser, 2020), but it and many other public health issues were overshadowed by the COVID-19 pandemic. Google Trends data suggests that the number of searches for drowning in 2020 was only ~3% of total searches for COVID-19 in the United States, and only ~2% in Canada. Fewer searches for drowning-related articles and webpages were conducted in 2020 than in the previous 4 years, suggesting that it did garner the same level of public interest as in previous years (see Houser et al., 2019). Combined with the fatigue of self-isolation, the lack of public interest/ focus and changes in drowning hazard awareness campaigns, means that beaches users may not be aware of the surf hazard at a particular beach and appropriate swim-safe strategies as would be expected in previous years. This is not surprising given that the number of drownings and rescues appears to be dependent on the efficiency of national education programs (Brander and MacMahan, 2011) and public awareness and adherence to local warning systems (Caldwell et al., 2013; Brannstrom et al., 2014; 2015; Houser et al., 2017).

Anecdotal information from news headlines suggests that there was an increase in the number of emergencies and incidents as jurisdictions worldwide eased lock-down restrictions during the COVID-19 pandemic:

UK coronavirus live: Boris Johnson tells people to stop ‘taking too many liberties’ on lockdown easing – as it happened (Reuters, 2020b).

Rescue agencies say they’re ‘busier’, as COVID-19 sees more Albertans exploring their province (The Canadian Press, 2020)

Early in the pandemic, Houser and Brander (2020) argued that the easing of lock-down restrictions and cancelled summer travel plans had the potential to increase the number of visitors to local beaches. This argument was in part based on large beach crowds that made media headlines in Canada, the United States and Australia:

“Ontario Premier shocked by packed Toronto beaches, warns COVID-19 fight is not over” (CTV News, 2020)
“Thousands crowd British beaches, ignoring social distancing and risking COVID-19 exposure” (USA Today, 2020a)

“Huge crowds flocked to Sydney’s iconic Bondi Beach despite the coronavirus scare. So now it’s officially closing” (CNN, 2020)

“Beachgoers, park officials sound alarm for Lake Michigan safety” (Chicago Tribune, 2020)

Hundreds flock to Florida’s reopened beaches as state death toll hits 726 (The Guardian, 2020)

COVID-19 pandemic leads to spike in child drownings in Texas: Local authorities worry about the Memorial Day weekend as families flock to pools, lakes and beaches (KHOU, 2020)

Americans spend holiday at beaches and parks as virus death toll nears 100,000 (Reuters, 2020a)

Europeans hit the beach as Covid-19 lockdowns ease (France24, 2020)

Brazilian beaches packed over holidays even as COVID-19 death toll crosses 200,000 (USA Today, 2020b).

In a spotlight on Indiana Dunes National Park, National Geographic (2020) noted that “largely thanks to COVID-19, every day …. is like the Fourth of July …. Visitors are flocking to the Dunes in record numbers to combat cabin fever, despite summer’s aching heat and high humidity. Even mid-week, parking lots buzz by 10 a.m.”. Large beach crowds not only increase the potential for a local COVID-19 outbreak, but also increase the potential for drowning and rescue (Great Lakes Now, 2020) due to rip currents or rough surf. Unfortunately, however, COVID-related staff cuts, and furloughs meant that some beaches did not have lifeguards or the ability to establish swim zones or place flags to indicate swimming conditions (Holland Sentinel, 2020; milive, 2020). Throughout the region, beach lifeguards are hired directly by individual municipalities with public beaches, national and provincial/state parks or by private resorts.

Rescues and drownings are not strictly dependent on the presence of dangerous waves and currents; the hazard is also dependent on the spatial and temporal correspondence of beach users, and their personal and group behavior (Menard et al., 2018). Many drowning incidents show similar patterns in age, alcohol consumption and overconfidence in swimming ability, particularly amongst college-aged males who tend to engage in more risky behavior (Rolston and Scherman, 2003; Lapinski and Viken, 2014; Houser et al., 2016; Llopis et al., 2018; Sotes et al., 2018). When approaching a beach, most beach users end to trust their own instinct and experience and confirm their personal biases that a beach is safe based on the behavior of others on the beach and the mere presence of access points (Sherker et al., 2010; Barrett and Houser, 2012; Houser et al., 2015; Trimble and Houser, 2018; Llopis et al., 2018; Sotes et al., 2018). Recent evidence from Prince Edward Island suggests that awareness of warning flags and signs decreases as the number of beach users increase and people move away from access points and the designated swimming areas (Locknick and Houser, in review). The requirement for beach users to self-distance with COVID-19 combined with record high water levels on the Great Lake may have caused beach users being distributed over a greater distance alongshore.

The combination of a reduction in lifeguard resources, cancelled swimming lessons, large beach crowds, warm weather, high-water levels and self-isolation fatigue may have increased the number of rescues and drownings (Great Lakes Now, 2020). Estimates made by the GLSRP suggest that the number of drownings on Lake Michigan in 2020 beat the previous record set in 2012 (NYTimes, 2020a). This estimate, however, includes all drownings on Lake Michigan (including boating-related drownings, suicides, etc.) and it is not clear whether similar records were broken on the other Great Lakes. The current paper examines how COVID-19 indirectly influenced surf-related drownings within the Great Lakes region building on previous work by Vlodarchyk et al. (2019) who examined the spatial and temporal variability of surf-related drownings across the Great Lakes. Specifically, that study provides the base data to determine whether COVID-19 affected the number of drownings within the region relative to historical averages. The method used in this regional study can be used to estimate the impact of COVID-19 on drownings elsewhere in the world and to analyze how the number of drownings may change in a post-COVID world.

2. Study site

The Great Lakes are a collection of five water bodies that border the United States and Canada (Fig. 1) representing an area of around 245,000 km² and approximately 20% of the world’s fresh surface water. The lakes were formed by the advance and retreat of ice sheets through pre-existing river valleys during the Pleistocene glaciation event. The modern climate is characterized by cool-to-cold winters and warm-to-cool summers. Winds and waves on the Great Lakes tend to be associated with the passage of warm and cold fronts, with a distinct seasonality of strong winds during the winter caused by cold outbreaks from the polar front and episodic frontal winds during the summer. The Great Lakes are classified as a wave-dominated, microtidal environment, with the wave heights limited by the fetch. Energetic currents and waves are common during storms and are capable of causing localized storm surge and seiche, in addition to meteotsunamis that have been identified as a cause of rip currents (Linares et al., 2019).

There is an approximate population of 34,000,000 in the Province (Ontario) and States (Minnesota, Wisconsin, Illinois, Indiana Michigan, Ohio, Pennsylvania and New York) surrounding the Great Lakes. Most of this population is found within the six largest cities: Chicago, Toronto, Detroit, Buffalo, Cleveland, and Milwaukee directly on the lakes. Results of Vlodarchyk et al. (2019) suggest that a total of 391 drownings occurred on the Great Lakes between 2010 and 2017, with an additional 119 drownings occurred in 2018 (+49) and 2019 (+60). The per capita number of drownings in the Great Lakes region is comparable to drowning rates throughout the entire United States (Gensini and Ashley, 2010), Costa Rica (Arozarena et al., 2015; Llopis et al., 2018), and Australia (Brighton et al., 2013; Franklin et al., 2010).

There is considerable variability in the number of drownings among the lakes based on the size of the surrounding population, and variability from year to year in response to summer air and water temperatures. Between 2010 and 2017, the largest number of drownings occurred on Lake Michigan (n = 218; 52%), with most concentrated along the southern end of the lake, near large population centers. The number of drownings on the other lakes were: Superior (n = 30; 7%), Huron (n = 43, 10%), Erie (n = 77, 18%) and Ontario (n = 55, 13%). Across all of the lakes, most incidents during this period occurred in the summer months of June, July, and August, with a disproportionate number occurring on Sundays (n = 102; 26%). Most involved males between 10 and 30 years old (n = 167; 43%), with males between 15- and 20-years old accounting for the largest proportion of drownings (n = 69; 18%). The largest number of drownings during the study period was in 2012, which had relatively warm temperatures, fewer days of rain, and a minimum ice concentration. Most drownings occur during the summer when temperatures are between 10 °C and 33.5 °C, when waves were within ±22.5° of shore normal and average wind speed were ~5.1 m s⁻¹. Surf-related drownings in the region tend to be associated with rough surf and rip currents at headlands groins and jetties. While most rips in the region are structural (see Houser, 2020), there is evidence of bathymetrically controlled rips resulting from transverse bar and rip nearshore morphology on some beaches (Vlodarchyk et al., 2019).

3. Methods

Following Vlodarchyk et al. (2019), drowning counts were collected from the Great Lakes Surf Rescue Project (GLSRP), a non-profit organization and a chapter of the National Drowning Prevention Alliance. As
described on their Website (http://www.glsrp.org/), the aim of the GLSRP is “to be the leader of Great Lakes water safety and reduce the number of Great Lakes drownings through training, public preparedness, and public awareness”. Because the GLSRP is a non-governmental organization, they can only track drownings that are recorded as drowning and that have been publicly reported to local authorities and announced through articles, news reports, and reports by local authorities. Only drownings associated with beach activity were included in this study and those involving boating and suicides were not included. The decentralized nature of mortality records in both Canada and the United States makes it difficult to estimate the number of drownings from state/provincial or national databases. This makes GLSRP one of the most important resources for understanding the spatial and temporal distribution of drowning in the region, and the most effective means to differentiate between drownings associated with rip currents, structural currents and heavy surf (see Vlodarchyk et al., 2019).

Using a method similar to McKinney et al. (2011), changes in drowning due to COVID-19 were examined using the daily historical average of drownings from 2010 to 2019. The daily historical average of drownings and the cumulative sum of drownings was calculated for each lake individually and as an entire region. The potential impact of COVID-19 on the number of drownings is based on the difference between the number of drownings in 2020 versus the average of the previous year’s using a z-test:

$$z = \frac{\bar{x} - x_{2020}}{\sigma}$$

where \(\bar{x}\) is average between 2010 and 2019, \(x_{2020}\) is the number of drownings in 2020 and \(\sigma\) is the standard deviation between 2010 and 2019. Z values greater [1.96] suggest that the number of drownings in 2020 are statistically significant from the historical average. Changes in the number of drownings by age groups, lake and days of the week due to COVID-19 were examined using a Chi-square test.

4. Results

Using the predictive model developed by Vlodarchyk et al. (2019), ~51 ± 14 drownings were expected in 2020 based on the summer air temperature, precipitation, and ice coverage in the previous winter (a proxy for lake temperatures). To examine how this increase varied by lake, time series of the historical average drownings and the 2020 drownings are provided in Fig. 2. The number of Lake Michigan drownings in 2020 (37) is significantly greater than the historical average number of drownings (23) at the 95% confidence level ($z = 2.29, \rho < 0.01$). Statistically significant differences were also observed for Lake Ontario (+11, $z = 3.01, \rho < 0.01$) and Lake Huron (+4, $z = 2.89, \rho < 0.01$). No statistically significant differences from the historical average were observed for Lake Erie ($z = 0.53$) and Lake Superior ($z = 0.47$). Across all lakes, there were 24 more drownings in 2020 than the historical average number of drownings as of the end of September.

The time series of drownings on Lake Ontario in 2020 closely follows the reopening phases for the municipalities surrounding the lake. The first drownings occurred in mid-June on the same days that local public health units moved most regions in Ontario to Phase 2. A rapid increase in drownings also occurred as the health units moved most regions surrounding Lake Ontario to Phase 3 (Fig. 2f). The time series of Lake Huron did not exhibit a clear relationship to the early reopening phases in Ontario and Michigan but did begin to increase as Ontario at the historical rate (but below average) following the Ontario Phase 3 reopening. The increase in drownings increased rapidly towards the end of the summer in late August 2020, but there is no clear relationship with re-opening phases in Michigan and Ontario. The drownings, however, occurred at popular beaches within a short drive of Toronto, Ontario.

The drowning timeline for Lake Michigan also follows the reopening phases for the states of Michigan, Illinois and Indiana (Fig. 2b). Drownings were below the historical average while these states were in a lower phase and under stay-at-home orders (Michigan), but began to
increase as Michigan moved into Phase 4 (June 8) and the stay-at-home order expired (June 19). Over the same period Illinois moved into Phase 3 (May 29-June 3) and then into Phase 4 on June 26, while Indiana officially reopened on July 4th. With each state ‘re-opened’ the number of drownings on Lake Michigan increased rapidly and at a rate far greater than the historical average.

As noted, drownings in Lake Erie did not exhibit a statistically significant difference from the historical average drowning trend. The

Fig. 2. Time series of actual 2020 drownings and ensemble average of drownings between 2010 and 2019 for (a) all Great Lakes combined, (b) Lake Michigan, (c) Lake Superior, (d) Lake Huron, (e) Lake Erie and (f) Lake Ontario.

Fig. 3. Distribution of drownings by Province and State in 2020 and historically (2010–2019).

C. Houser and B. Vlodarchyk
The timing of the drownings or the fact that drownings are slightly below the historical average does not appear to be associated with re-opening phases in Ontario, Michigan, Ohio, Pennsylvania and New York. With the exception of Cleveland, Ohio and Erie Pennsylvania, there are no major cities along the Lake Erie shoreline with large public beaches. Similarly, Lake Superior has relatively few major cities and few public beaches that are within a short distance of large population centers.

More drownings in 2020 occurred in the Province of Ontario (35 versus 23%) and the State of Michigan (26 versus 21%) than expected based on the distribution between 2010 and 2019 (Fig. 3). The number of drownings in Illinois and Ohio were less than expected based on historical patterns. However, the change in the distribution of drownings by provinces and states is not statistically significant at the 95% confidence level ($\chi^2 = 11.17, \rho = 0.19$). This suggests that despite the statistically significant increase in drownings in Lake Ontario and Lake Michigan, the distribution by jurisdiction is consistent with historical averages. The distribution of drownings across the lakes in 2020 is not statistically different from the historical distribution ($\chi^2 = 7.3, \rho = 0.12$), despite a near doubling of drownings in Lake Ontario (+7 more than expected).

The distribution of drownings by age suggests that far fewer than expected drownings involved victims >50 years of age and less than 10 years (Fig. 4). Almost 45% of all drownings in 2020 involved victims between the ages of 10 and 20 years compared to only 25% of drownings between 2010 and 2019. The change in the age distribution of drowning victims in 2020 is statistically significant at the 95% confidence level ($\chi^2 = 16.22, \rho = 0.04$). There was no statistically significant difference in the proportion of male and female drowning victims in 2020 versus all previous years ($\chi^2 = 0.59, \rho = 0.44$). Consistent with previous years, the majority of drowning victims were male and there was a statistically significant increase in the number of drownings by young males (10-20 years of age) during 2020 compared to expected from the historical average ($\chi^2 = 7.5, \rho = 0.006$). Specifically, ~10 more young males drowned during 2020 than expected.

In 2020, almost 40% of all drownings occurred on Saturdays compared to only 15% of drownings occurring on that day between 2010 and 2019 (Fig. 5). The over-representation of drownings on Saturdays and to a lesser degree on Thursdays was balanced by lower-than-expected drownings on Wednesdays, Fridays and Sundays. The change in the distribution of drownings by day of the week in 2020 is statistically significant at the 95% confidence level ($\chi^2 = 21.72, \rho = 0.001$).

5. Discussion

This study estimates the impact of COVID-19 on the number of drownings in the Great Lakes region. It is estimated that there were ~24 more drownings than the historical average from 2010 to 2019. Statistically significant increases in the number of drownings were observed in Lakes Michigan, Ontario and Huron, with no statistically significant change observed for Lake Erie and Lake Huron. The distribution of drownings across provinces and states was not significantly different, because the majority of drownings were associated with the historical hotspots identified by Vlodarchyk et al. (2019). Most drownings in 2020 and historically are concentrated along the southern end of the lake and contained within area from Grand Rapids in the east to Milwaukee on the west side of the lake. In Lake Ontario most of the drownings were concentrated at the west end of the lake near the city of Toronto. The limited number of drownings on Lake Erie and Lake Superior may reflect the lack of public beaches within a short drive a large city, particularly at the start of the pandemic, when public mobility was at a minimum (Fig. 6). As the number of COVID-19 cases decreased, mobility increased and there was an associated increase in the rate of drowning. An increase in the drowning time series occurs as mobility begins to decrease at the end of August.

The timing of the drownings in Lake Michigan and Lake Ontario appears to be associated with the early reopening phases of Illinois, Indiana, Michigan and Ontario. Specifically, as stay-at-home orders were lifted, and residents were able to visit the beach, there was an increase in the number of drownings close to the main city centers. The significant increase in drownings on Saturdays suggests that there were more shorter visits to the local beach compared to longer distance visits as part of an extended holiday. The increased beach visits may have been driven by the closing of public pools and other facilities that residents would normally use for escaping the summer heat (NYTimes, 2020b). This means that a greater proportion of the beach users may not have had experience swimming in wave-dominated environments and may have over-estimated their ability to swim safely. In contrast to Lakes Michigan and Ontario, the increase in drownings for Lake Huron did not occur until later in the summer and followed the Ontario Phase 3 reopening and increase in mobility amongst Ontario resident and an increase in travel to ‘destination’ beaches several hours from the City of Toronto.

The rapid increase in drownings following the re-opening phases may have been driven by self-isolation fatigue and a psychological need to travel (Amagasa et al., 2020) and a decrease in adherence to social distancing measures (Zhao et al., 2020), which in turn resulted in an increase in COVID-19 infections (Xiong et al., 2020). A fatigue with restrictions may have altered the adherence of beach users to posted warning signs and flags, which have been shown to be overlooked and misunderstood in non-COVID years (Branstrom et al., 2014, 2015). The record high water levels in 2020 would have limited beach widths and resulted in a greater distribution of beach users alongshore, which may have limited their observance of signs and flags (Locknick and Houser, In Review). However, this would depend on the specific presence and distribution of flags and signs on a given beach and is not necessarily transferable to other sites around the world where popular beaches tend
to be wide and in marine-tidal environments. Unfortunately, COVID-related staff cuts, and furloughs meant that some beaches did not have lifeguards or the ability to establish swim zones or place flags to indicate swimming conditions (e.g., Holland Sentinel, 2020; mlive, 2020). The lack of warning flags and lifeguards at Holland State Park, Michigan was blamed for the drownings of a six-year-old and a 17-year-old on June 6. Where lifeguards were present, some were required to assume additional responsibilities to enforce social distancing requirements and beach capacity limits (WBUR, 2020; Boston 25 News, 2020; Insider, 2020; Virginian Pilot, 2020), which in turn refocuses lifeguard attention away from the water and puts them into difficult confrontational situations.

In the absence of lifeguards or at greater distance from designated swimming areas, the presence of other beach users will confirm pre-existing biases that the beach and conditions were safe (Menard et al., 2018). As argued by Trimble and Houser (2018) the mere presence of a public beach and a specific beach access point would further reinforce their assumptions that it was safe for swimming. The tendency for these biases to guide action at the beach is greatest amongst young males who appear more susceptible to group think and pleasure seeking at the expense of safety (see Rolison and Scherman, 2003; Lapinkski and Viken, 2014; Houser et al., 2016; Llopis et al., 2017; Menard et al., 2018; Sotes et al., 2018). During the pandemic, there was a statistically significant increase in the number of young males (<20 years of age) who drowned in the Great Lakes. Further study within the region and elsewhere around the world is required to determine whether self-isolation fatigue may have resulted in the increase of young male drownings and how this may be associated with non-compliance with public health measures (e.g. Nivette et al., 2020) and an increase in other public and mental health issues.

**Fig. 5.** Distribution of drownings by day of the week for 2020 and over the period 2010–2019.

**Fig. 6.** Comparison of total drownings in 2020 (solid line) against (a) COVID-19 case counts in Ontario (b) and relative mobility from Apple Mobility Trend data (https://covid19.apple.com/mobility) as a percentage of mobility on January 1st (100%).
Results of this study suggest that the COVID-19 pandemic indirectly increased the risk of drowning due to an increase in beach activity during reopening phases of the pandemic, changes in personal and group behavior and a reduction in lifeguards and swimming lessons in some jurisdictions. Understanding how the pandemic directly and indirectly affected beach drowning is an important lesson for beach management during a future public health emergency. Beach safety cannot be sacrificed by budget cuts or reduce the focus of lifeguards with the enforcement of social distancing or else the gains in reducing COVID-19 infections are lost at the beach. Restricting access to beaches to limit crowds and the potential for further waves of COVID-19 cases, will in turn limit the number of drownings as long as people heed those closures. But keeping the beaches open may be just as important as a trip to the beach may be important for the physical and mental health of those dealing with a global pandemic. The results of this study also raise the potential for an increase in drownings following widespread vaccination when people actively seek opportunities to travel and vacation. Using the methodology described in this study provides a means to quantify the impact of COVID-19 on drownings globally and the potential for increased drownings in a post-COVID world.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Funding was provided from the Natural Sciences and Engineering Research Council (NSERC) of Canada.

References

Amagasa, S., Kojin, H., Inoue, S., 2020. Mobility trends reports revealed ‘self-isolation fatigue’ in Japan: use of mobility data for coronavirus disease control. JMA J. 3 (3), 272–273.
Arozarena, I., Houser, C., Echeverria, A.G., Brannstrom, C., 2015. The rip current hazard in Costa Rica. Nat. Hazards. 75 (2), 753–768.
Brewster, B.C., Houser, R.E., Brander, R.W., 2019. Estimations of rip current rescues and

Guardian, The, 2020. 1000 drownings over the last 100 years: shocking new figures on how many people die in the UK oceans every year. https://www.theguardian.com/uk-news/2020/apr/18/1000-coronavirus-deaths-uk-oceans

CNN, 2020. Huge Crowds Flocked to Sydney’s Iconic Bondi Beach Despite the Coronavirus Scare. So now it’s Officially Closed. https://www.cnn.com/world/2020/03/21/australia-bondi-beach-closed-intl/index.h l

Brander, R.W., MacManan, J.H., 2011. In: Leatherman, S., Fletemeyer, J. (Eds.), Future Challenges for Rip Current Research and Outreach. Rip Currents, Beach Safety, Physical Oceanography and Wave Modeling. CRC Press, Boca Raton, FL, pp. 1–29.

Brannstrom, C., Trimble, S., Santos, A., Brown, H.L., Houser, C., 2014. Perception of the rip current hazard on Galveston Island and North Padre Island, Texas, USA. Nat. Hazards 72 (2), 1123–1138.

Brown, M., Vlodarchyk, C. Houser and B. Vlodarchyk

Brander, R., 2012. Identifying hotspots of rip current activity using wavelet analysis at Pemaccola Beach, Florida. Phys. Geogr. 33 (1), 32–49.

Brewster, B.C., Gouls, R., Brand, R., 2014. Perception of the rip current hazard on Galveston Island and North Padre Island, Texas, USA. Nat. Hazards 72 (2), 1123–1138.

CNN, 2020. Huge Crowds Flocked to Sydney’s Iconic Bondi Beach Despite the Coronavirus Scare. So now it’s Officially Closed. https://www.cnn.com/world/2020/03/21/australia-bondi-beach-closed-intl/index.html

Brander, R., 2012. Identifying hotspots of rip current activity using wavelet analysis at Pemaccola Beach, Florida. Phys. Geogr. 33 (1), 32–49.

Bostok, 2020. Swimming, swimmers, social distancing: challenges ahead for Cape Cod lifeguards. https://www.boston25news.com/news/health/swimmers-shocks-sociais-distancing-challenges-ahead-cape-cod-lifeguards-4TRD8USSVY5NEPPV

Lapinski, M., Vilen, G., 2014. Great Lakes Swim Safety Risk Communication for 18–24 year-old Males: Review of Key Literature and Results of a Focus Group Study Final Report. Michigan Sea Grant and the Michigan Department of Environmental Quality Coastal Management Program, Michigan State University Project.

Leavy, J.E., Crawford, G., Portsmouth, L., Jancey, J., Leveaucr, F., Nimmu, L., Hunt, K., 2015. Recreational drowning prevention interventions for adults, 1990–2012: a review. J. Community Health 40 (4), 725–735.

Linares, A., Wu, C.H., Bechel, A.J., Anderson, E.J., Kristovich, D.A., 2019. Unexpected rip current fundamentals induced by a meteotrust. Sci. Rep. 19 (1), 1–9.

Locknick, S., and Houser, C., In Review. Correspondence of Beach User Perception, Lifesaving Strategies and Rip Currents: Implications for Beach Management. McKenny, N., Houser, C., Meyer-Arendt, K., 2011. Direct and indirect mortality in Florida during the 2004 hurricane season. Int. J. Biometeorology 55 (4), 533–546.

Ménard, A.D., Houser, C., Brander, R.W., Trimble, S., Scaman, A., 2016. The psychology of beach users: importance of confirmation bias, action, and intention to improve beach safety. Nat. Hazards 64 (2), 953–977.

Milve, 2020. Could these Lives have been Saved by Lifeguards along Lake Michigan. https://www.mlive.com/music/muskegon/2020/10/could-these-lives-have-been-saved-by-lifeguards-along-lake-michigan.html.

National Geographic, 2020. This National Park draws Huge Crowds. The Pandemic may be Important for the Physical and Mental Health of those. https://www.nationalgeographic.com/travel/2020/07/indiana-dunes-national-park-first-year-open-coronavirus-crowds/#close.

New York Times, 2020a. Taking too Many Lives and Beaches as State Death Toll Hits 100 000: https://www.nytimes.com/2020/05/12/us/coronavirus-crowds-at-beaches-as-state-death-toll-nears-100000-idUS KBN2300L9

New York Times, 2020b. How to Save Summer 2020: a Balance can be Found to be Both Safe and Outdoors. https://www.nytimes.com/2020/04/25/opinion/summertime-safer-oceans.html

Nivette, A., Ribeau, D., Murray, A., Steinhoff, A., Bechtinger, L., Hep, U., Shanafan, L., Einhorn, M., 2021. Non-compliance with COVID-19 related public health measures among young adults in Switzerland: insights from a longitudinal cohort study. Soc. Sci. Med. 268, 113370.

Reuter, 2020a. Americans Spend Holiday at Beaches and Parks as Virus Death Toll Tops 100 000: https://www.nytimes.com/2020/07/09/us/coronavirus-beaches-and-parks-as-virus-death-toll-nears-100000-idUS

Riskin, M.R., Scherman, A., 2003. College student risk-taking from three perspectives. Experience 38 (152).

Sherker, S., Williamson, A., Hoffield, J., 2009. Why Australia needs an effective national campaign to reduce coastal drowning. J. Med. Sci. 11 (2), 81.

Sherker, S., Williamson, A., Hoffield, J., Brander, R., Hayen, A., 2010. Beachgoer beliefs and behaviours in relation to beach flags and current warnings. Accid. Anal. Prev. 42 (7), 1785–1804.
Sotes, I., Basterretxea-Iribar, I., Maruri, M.D.L.M., 2018. Are the Biscayne University students ready to go to the beach safely? Ocean Coast Manag. 151, 134–149.

The Canadian Press, 2020. Rescue Agencies Say they’re ‘busier’, as COVID-19 sees More Albertans Exploring their Province. https://globalnews.ca/news/7279781/alberta-rescue-agencies-increase-covid-19/.

Today, U.S.A., 2020a. Thousands Crowd British Beaches, Ignoring Social Distancing and Risking COVID-19 Exposure. https://www.usatoday.com/story/travel/news/2020/06/25/major-incident-u-k-thousands-crowd-beaches-amid-pandemic/3258949001/.

Today, U.S.A., 2020b. Brazilian Beaches Packed over Holidays Even as COVID-19 Death Toll Crosses 200,000. https://www.usatoday.com/story/travel/news/2021/01/08/brazilians-packed-beaches-over-holidays-covid-deaths-hit-200-000/6592970002/.

Trimble, S., Houser, C., 2018. Seawalls and signage: how beach access management affects rip-current safety. In: Beach Management Tools-Concepts, Methodologies and Case Studies. Springer, Cham, pp. 497–524.

Virginian Pilot, 2020. No-contact Rescues: how Lifeguards have Changed Their Ways. https://www.pilotonline.com/coronavirus/ns-nyt-lifeguards-changed-ways-cornavirus-20200817.dbvgphbho53vdjuc34vddbumn/story.html.

Vlodarchyk, B., Olivito, A., Houser, C., 2019. Spatial and temporal variation of surf drownings in the Great lakes: 2010–17. J. Coast Res. 35 (4), 794–804.

WBUR, 2020. As many Beaches Reopen, Lifeguards Tapped to Help Enforce Social Distancing Rules. https://www.wbur.org/hereandnow/2020/05/18/lifeguards-beaches-reopen.

Xiong, C., Hu, S., Yang, M., Luo, W., Zhang, L., 2020. Mobile device data reveal the dynamics in a positive relationship between human mobility and COVID-19 infections. Proc. Natl. Acad. Sci. Unit. States Am. 117 (44), 27087–27089.

Zhao, J., Lee, M., Ghader, S., Younes, H., Darzi, A., Xiong, C., Zhang, L., 2020. Quarantine Fatigue: First-Ever Decrease in Social Distancing Measures after the COVID-19 Pandemic Outbreak before Reopening United States arXiv preprint arXiv: 2006.03716.