Factors associated with shark attacks and deaths: a cross-sectional study

Fatores associados aos óbitos e ataques de tubarão: um estudo transversal
Factores asociados con las muertes y los ataques de tiburones: estudio transversal

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ABSTRACT
Objective: to evaluate the factors associated with shark attacks and deaths in Brazil. **Method:** this is a cross-sectional and quantitative study, carried out through virtual access to the *Global Shark Attack File* website. The analysis was performed in the R program, using descriptive statistics and the Pearson's chi-square and Fisher's exact tests. **Results:** there were 86 attacks, of which 26 (30.2%) resulted in deaths. An association was found between occurrence of the attacks and year, state, region, day of the week, shift and shark species, in addition to the victim's age group and gender and to the part of the body affected. No variable was associated with death as outcome. The state of Pernambuco accounted for the largest number of attacks (83.7%) and deaths (96.2%). **Conclusion:** shark attacks were associated with nine variables: three related to the victim's characterization and six to the profile of the accident. The deaths did not present a significant association. Pernambuco stood out as the state with the highest occurrence of attacks and deaths.
DESCRIPTORS: Sharks; Bites and Stings; Pre-Hospital Assistance; Death; Brazil.

RESUMO
Objetivo: avaliar os fatores associados aos óbitos e ataques de tubarão no Brasil. **Método:** trata-se de um estudo transversal, quantitativo, realizado mediante acesso virtual ao *website* do *Global Shark Attack File*. A análise foi realizada no programa R, a partir de estatística descritiva e dos testes de Qui-quadrado de Pearson e Teste Exato de Fisher. **Resultados:** ocorreram 86 ataques, dos quais 26 (30,2%) resultaram em óbito. Foi encontrada associação entre a ocorrência de ataque com o ano, estado, região, dia da semana, turno e espécie do tubarão, além da faixa etária, sexo da vítima e local do corpo acometido. Nenhuma variável apresentou associação com o óbito. O estado de Pernambuco computou o maior número de ataques (83,7%) e óbitos (96,2%). **Conclusão:** os ataques de tubarão estiveram associados com nove variáveis: três de caracterização da vítima e seis do perfil do acidente. Os óbitos não apresentaram associação significativa. Pernambuco sobressaiu como estado com maior ocorrência de ataque e óbitos.
DESCRITORES: Tubarões; Mordeduras e Picadas; Assistência Pré-Hospitalar; Morte; Brasil.

RESUMEN
Objetivo: evaluar los factores asociados con las muertes y los ataques de tiburones en Brasil. **Método:** se trata de un estudio transversal, cuantitativo, realizado a través del acceso virtual al sitio *web Global Shark Attack File*. El análisis se realizó mediante el programa R, utilizando estadística descriptiva y chi-cuadrado de Pearson y prueba exacta de Fisher. **Resultados:** hubo 86 ataques, de los cuales 26 (30,2%) resultaron en muerte. Se encontró que hay asociación entre el ataque y el año, estado, región, día de la semana, turno y especie de tiburón, además del rango etario, sexo de la víctima y parte del cuerpo afectada. Ninguna variable se asoció con la muerte. El estado de Pernambuco tuvo el mayor número de ataques (83,7%) y muertes (96,2%). **Conclusión:** los ataques de tiburones se asociaron con nueve variables: tres de la caracterización de la víctima y seis del perfil del accidente. Las muertes no mostraron una asociación significativa. Pernambuco se destacó como el estado con mayor número de ataques y muertes.
DESCRIPTORES: Tiburones; Mordeduras y Picaduras; Asistencia Prehospitalaria; Muerte; Brasil.

INTRODUCTION

Beaches are great attractions for people to visit in leisure activities, such as running, surfing and swimming, and directly influence the economy, mainly in countries with tropical climate[1]. However, activities at sea require attention, as they can be the scene of accidents and shark attacks, which more commonly occur in hot seasons, where the sea surface temperature favors the presence of animals, and because there is greater movement of people in aquatic recreation activities. Thus, shark attacks are a result of the human-animal interaction[2].

According to the International Shark Attack File (ISAF), 66 attacks were recorded worldwide in 2018, resulting in four deaths. In that year, Brazil was third in the ranking of countries, with three attacks and one death, only behind the United States of America (USA) and Australia[3].

Shark attacks are of concern due to the serious complications that can lead to death. In them, the victims present extensive tissue injuries, which require effective pre-hospital care and specialized surgical treatment to recover the affected region[4]. The emergency response team plays a fundamental role in the victim's clinical outcome, to recognize and treat the traumatic injuries that can quickly lead to death[5]. Fast resuscitation, bleeding control, stabilization of vital signs and also correct transfer to the surgical sector increase the chances of a positive prognosis and reduce the probability of death[5-6].

The professionals who make up Pre-Hospital Care and the urgency and emergency hospital services and work in coastal regions have a high probability of coming across shark attack victims. Therefore, they need to be equipped to deal with situations of this nature.

In this context, nurses stand out for performing actions that require clinical decision, communication skills, Nursing team leadership, service management, unit organization and provision of care. Thus, with the purpose of guiding decision-making in care and offering scientific data for training targeted at the reality experienced, the objective of the study was to assess the factors associated with shark attacks and deaths in Brazil.

METHOD

This is a descriptive and cross-sectional study with a quantitative approach, carried out through virtual access to the *Global Shark Attack File* (GSAF) website.

The GSAF is an online, public domain database that is continuously updated with worldwide shark incident reports[7]. The website is coordinated by the Shark Research Institute, a multidisciplinary and non-profit organization founded in 1991 at Princeton University, United States, by a team of physicians, surgeons and examiners, which represents the first organized shark conservation entity, with tracking projects, behavioral studies and production of scientific papers[8-9].

The population consisted of the victims of accidents with sharks who had their data attached to the GSAF. Data collection was carried out in December 2019, comprising a sample of 86 cases that met the inclusion criteria of being reports of shark accidents/attacks that occurred in the last 30 years (from January 1989 to

December 2019). The time limitation is justified by the lack of information in data filling-out in the years prior to this period. The exclusion criterion consisted in reports not available for online consultation.

For data collection, an instrument was designed specifically for this study, in Microsoft Excel, with the same variables available in the reports, referring to the characterization of the victims (age, gender, part of the body affected and whether death was the outcome at the location) and of the accidents (shift, day, month, year and season in which they occurred, geographic location/state and region of occurrence, and shark species involved in the attack). No information that could be related to the nurses' performance was collected, since the *Global Shark Attack File* database does not offer any other information, except for what was collected.

The data were analyzed in the R program, version 3.5.1. Descriptive statistics and the Pearson's Chi-square and Fisher's Exact tests were used to verify associations between the categorical variables. A 95% confidence interval and a significance level of 5% were considered for all the tests.

The study was funded by the researchers and waived submission to the Research Ethics Committee, since the data used were in the public domain.

RESULTS

The data collected revealed 86 accidents recorded from 1992 to 2019, of which 26 (30.2%) resulted in deaths. The year was statistically associated with the occurrence of shark attacks ($p = 0.011$), but was not associated with the deaths ($p = 0.929$). The years with the most victims were 1994, with 10 cases (11.6%) and 2002 and 2004, with seven cases (8.2%) each. Mortality presented a decreasing trend over the years, being more expressive in 2002, 2004 and 2006, with three (3.5%) deaths each year. Figure 1 presents the distribution of the shark attacks and deaths by year.
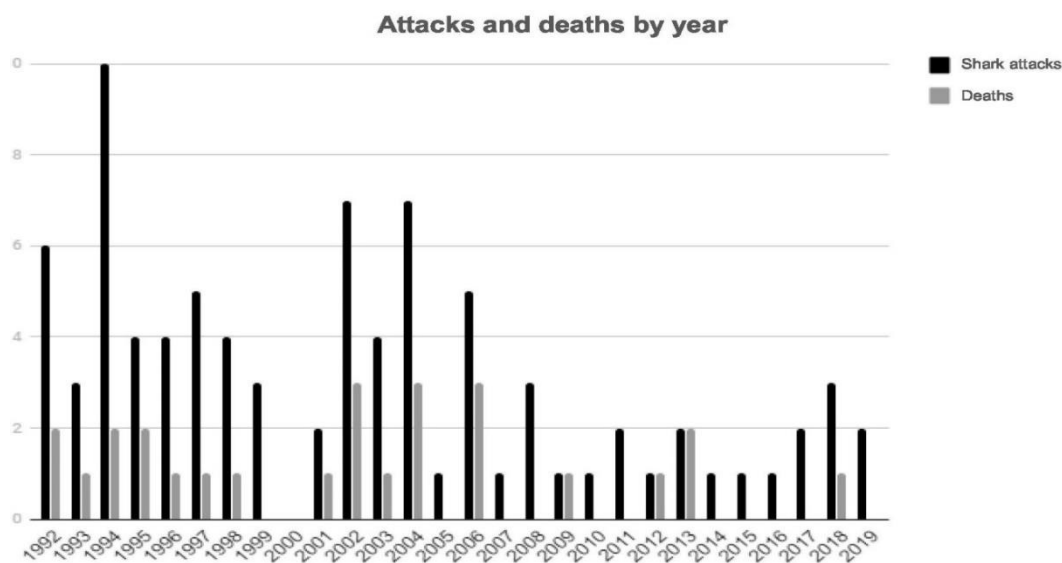

Figure 1 - Distribution of the shark attacks and deaths by year in Brazil (1992 – 2019). Pesqueira, PE, Brazil, 2020

Source: Prepared by the authors, 2020.

With regard to the geographic location, the data on the distribution of shark attacks and deaths by Brazilian states and regions are shown in Table 1.

Table 1 - Shark attacks and deaths by Brazilian states and regions (1992 – 2019). Pesqueira, PE, Brazil, 2019

State	Attacks n (%)	p*	Deaths n (%)	p**
Region		<0.001		0.461
Northeast	79 (91.9)		26 (100.0)	
Southeast	5 (5.9)		0 (0.0)	
South	2 (2.2)		0 (0.0)	
States		<0.001		0.667
Maranhão (MA)	4 (4.7)		1 (3.8)	
Rio Grande do Norte (RN)	1 (1.1)		0 (0.0)	
Pernambuco (PE)	72 (83.7)		25 (96.2)	
Bahia (BA)	2 (2.4)		0 (0.0)	
Rio de Janeiro (RJ)	5 (5.9)		0 (0.0)	
Rio Grande do Sul (RS)	1 (1.1)		0 (0.0)	
Santa Catarina (SC)	1 (1.1)		0 (0.0)	

* Pearson's Chi-square test. ** Fisher's Exact test.

Source: Prepared by the authors, 2020.

According to Table 1, the occurrence of shark attacks was associated with the geographic region (p < 0.001) and with the state (p < 0.001); however, there was no association with the deaths. Shark attacks were more prevalent in the Northeast region, with 79 cases (91.9%) and all with death as outcome. The state with the highest number of incidents was Pernambuco, with 72 attacks (83.7%) and 25 deaths (96.2%). Details of the variables that characterize the victims are shown in Table 2.

Table 2 - Victims' characterization variables, according to the occurrence of shark attacks and deaths in Brazil (1992 – 2019). Pesqueira, PE, Brazil, 2019

Variable	Attacks n (%)	p*	Deaths n (%)	p**
Gender		<0.001		0.307
Male	77 (89.5)		22 (84.6)	
Female	4 (4.7)		1 (3.9)	
Missing Information	5 (5.8)		3 (11.5)	
Age group		<0.001		0.799

0-11	1 (1.2)		0 (0.0)	
12-19	21 (24.4)		6 (23.1)	
20-30	19 (22.0)		7 (27.0)	
31-40	9 (10.5)		1 (3.8)	
41-50	3 (3.5)		1 (3.8)	
Missing Information	33 (38.4)		11 (42.3)	
Part of the body affected		<0.001		0.188
Upper Limbs	19 (22.0)		2 (7.7)	
Lower Limbs	41 (47.7)		2 (7.7)	
Head	1 (1.2)		0 (0.0)	
Hip	3 (3.5)		1 (3.8)	
Groin	1 (1.2)		0 (0.0)	
Missing Information	21 (24.4)		21 (80.8)	

* Pearson's Chi-square test. ** Fisher's Exact test.

Source: Prepared by the authors, 2020.

According to Table 2, all the variables that characterized the victims (age group, gender and part of the body affected) were associated with the occurrence of shark attacks (p < 0.001) and none of them was associated with death as outcome. There was predominance of attacks and deaths in males, due to the higher risk behaviors in which they incur. Among the age groups analyzed, that from 12 to 19 years old stood out; however, the highest mortality was found in the age group from 20 to 30 years old, with 19 cases (22.0%). The mean age of the victims affected by shark attacks was 23.2 years old and that of the victims who died was 22.8. The part of the body most frequently affected were the lower limbs. The data regarding the accidents' characterization variables are presented in Table 3.

Table 3 - Distribution of the characterization variables of the shark attacks and deaths in Brazil (1992 – 2019). Pesqueira, PE, Brazil, 2019

Variable	Attacks n (%)	p**	Death n (%)	p**
Period		<0.001		0.411
1990 – 1999	39 (45.3)		10 (38.5)	
2000 – 2009	31 (36.0)		12 (46.1)	
2010 – 2019	16 (18.7)		4 (15.4)	
Season		0.130		0.510
Spring	15 (17.4)		4 (15.4)	
Summer	19 (22.1)		4 (15.4)	
Autumn	27 (31.4)		7 (26.9)	

Winter	25 (29.1)		11 (42.3)	
Month		0.290		0.496
January	8 (9.3)		1 (3.8)	
February	4 (4.6)		1 (3.8)	
March	7 (8.1)		2 (7.7)	
April	8 (9.3)		1 (3.8)	
May	8 (9.3)		2 (7.7)	
June	11 (12.9)		5 (19.3)	
July	12 (14.0)		4 (15.5)	
August	3 (3.5)		1 (3.8)	
September	7 (8.1)		5 (19.3)	
October	8 (9.3)		1 (3.8)	
November	3 (3.5)		1 (3.8)	
December	7 (8.1)		2 (7.7)	
Day		0.007		0.719
Monday	16 (18.6)		5 (19.3)	
Tuesday	8 (9.3)		2 (7.7)	
Wednesday	12 (14)		2 (7.7)	
Thursday	5 (5.8)		3 (11.5)	
Friday	10 (11.6)		3 (11.5)	
Saturday	13 (15.1)		3 (11.5)	
Sunday	22 (25.6)		8 (30.8)	
Shift		<0.001		0.577
Morning	7 (8.1)		1 (3.8)	
Afternoon	27 (31.4)		10 (38.5)	
Evening	1 (1.2)		0 (0.0)	
Missing Information	51 (59.3)		15 (57.7)	
Shark species		0.004		0.938
White shark	3 (3.5)		1 (3.8)	
Bull shark	10 (11.6)		2 (7.7)	
Tiger shark	10 (11.6)		3 (11.5)	
Hammer shark	1 (1.2)		0 (0.0)	
Lemon shark	3 (3.5)		0 (0.0)	
Missing Information	59 (68.6)		20 (77.0)	

** Fisher's exact test

Source: Prepared by the authors, 2020.

As shown in Table 3, shark attacks were associated with the period (p < 0.001), day of the week (p = 0.007), shift (p < 0.001) and shark species involved in the attack (p = 0.004). None of the accidents' characterization variables were associated with

death as outcome. There was predominance of shark attacks between 1990 and 1999, in autumn, July, on Sundays, and during the afternoon. Regarding the shark species, Bull and Tiger stood out.

DISCUSSION

A reduction in the occurrence of shark attacks was observed over the decades, mainly in the state of Pernambuco. Several findings follow the global trend of reduction in the number of attacks, mainly in the United States, Australia, South Africa and New Zealand, with human behavioral change contributing positively to this[7]. In Brazil, this reduction can be justified by the interventions implemented, namely: campaigns, awareness raising by the media, signs and surfing prohibition in risk areas, and a number of decrees sanctioned in 1999 and 2014[4,10]. In this context, the nurses who hold management positions and other health managers must collaborate in an intersectoral manner, with increased signaling and inspection of coastlines.

With regard to the day and shift, an association was observed between the attacks and Sundays, during the afternoon. This fact can be justified by the fact that, in Brazil, such period corresponds to the favorable shift for leisure, since most of the population is not engaged in any work activity. Therefore, it is pertinent to invest in preventive and alert actions for the pre-hospital care teams, so that they can pay extra attention on that day/shift. It is noteworthy that the educational and training activities of the professionals involved in pre-hospital care should contemplate this reality, for the multiplication of the information provided to the professionals.

Regarding the geographic location, the region associated with the accidents and in which all deaths occurred was the Northeast. Such finding can be related to its hot climate and to the existence of a wide coastline, which makes the marine environment favorable for the encounter between sharks and bathers. This fact is ratified since the places where the most shark attacks occur in the world are California, Florida and Hawaii, which, in addition to a large coastal area, have one of the hottest climates in the country[4].

According to a study carried out in Germany on animal behavior, habitat configurations, as well as the characteristics and distribution of resources, exert an influence on their displacement pattern[11]. This reality is consistent with the coast of the Northeast region, in particular the state of Pernambuco, where the maritime geographic characteristics provide marine reliefs favorable to the search for the sharks' food supplies, close to the reefs, which contributes to the possibility of incidents[10]. It is believed that the large number of sharks in the coastal areas of the state can also be related to environmental, ecological and human action factors, which exert a direct impact on the naturalness of the habitat.

Thus, the increase in the number of shark attacks in this region may be favored by natural factors, by anthropogenic changes in the environment, and by the population increase related to the recreational use of beaches. According to the State Committee for Monitoring Incidents with Sharks in

Pernambuco[12], 65 shark attacks were recorded in six coastal municipalities and in the district of Fernando de Noronha between 1992 and June 2018. These incidents totaled 25 deaths, whose victims were bathers (21) and surfers (4). The main municipalities in which the attacks occurred are located in the Metropolitan Region of Recife, namely: Recife, Jaboatão dos Guararapes, Olinda and Cabo de Santo Agostinho.

When considering that training in health needs to be adapted to the regional demands, the pertinence of a differentiated approach to shark attacks is pointed out, in the courses offered in the Northeast region, mainly those in the state of Pernambuco, which should consider the high epidemiology of shark attacks to target the regional curricular training.

Regarding the victims' characteristics, an association was found between the attacks and gender, so that men were the most affected. This finding corroborates a study carried out in South Africa, in which a four times higher rate of drowning was observed in men[13]. These results point to the necessary reflection and intervention aimed at the male risk behaviors in the aquatic environment. Thus, the need to develop education strategies referring to the prevention of shark attacks aimed at the male population is highlighted.

Regarding the age group, the mean age, close to 23 years old, of the Brazilian victims is lower than the world mean, which is 26.1 years old[4]. Young individuals are expected to expose themselves to more risks, given the feeling of freedom and courage[14]. Therefore, it becomes necessary to prioritize and focus on young people, regarding the risk of shark attacks during aquatic recreational activities.

Regarding the part of the body affected, there was predominance of injuries in the lower limbs. These results are consistent with a study carried out in Pernambuco, in which it was observed that parts of the body such as calf, hand and forearm were the most affected in shark attacks[10]; as well as with a survey conducted in Spain, in which the limbs were the parts of the body parts most frequently affected in surfers[15].

Such findings can be related to the fact that the extremities are generally the first contact zone with the animal, as they tend to be submerged in the water, and because other injuries arise, as the victims move them in a natural attempt to defend from the attack. The severity of the injury caused by a shark bite depends on the species, on the size of the animal and on the nature of the event, since sharks do not have a chewing reflex due to the anatomical structure of their jaws[4].

It is pointed out that the involvement of the limbs, despite not directly affecting noble organs, can be serious. This fact is corroborated in a study from India, whose results show that lower limb injuries constitute nearly 20% of the deaths due to trauma, so that, over time, the chances of recovery decrease and can lead to amputation or even to death[16]. Thus, contents referring to extremity trauma and containment of limb bleeding should be included in the training of the professionals involved in pre- and intra-hospital care in coastal regions, mainly in northeastern Brazil.

Another factor that was associated with the occurrence of attacks was the shark species, among which Bull and Tiger stood out. A study that investigated worldwide shark attack data also found Tiger sharks as one of the five most frequently identified species in attacks[4].

The high rate of cases with these species can be related to the natural selection of the habitat. Due to the topographic characteristics of the environment and to the morphological characteristics of the animals, a limit of species present on the coast is established, so that the larger ones usually predominate over the smaller species[7]. Thus, larger species, such as Tiger and Bull, become resident in coastal areas, as there is less food in deep water, and other shark species are not part of the coastal population, but transitorily pass through it, causing sharks to be inhabitants present throughout the year[7] and, consequently, increasing the chance of attacks occurring with such species.

The limitations of the study are as follows: data collection from a single source and non-correlation with national information, due to absence of studies and data from national bodies available on the subject matter. In addition to that, the risk of underreporting, the existence of incomplete reports and the time lag for feeding the database researched are pointed out as a limiting factor. Another limitation is the fact that the study was conducted with data from Brazil, so that its findings may not correspond to those obtained in other countries, which makes the results not generalizable worldwide, presenting regional impacts.

CONCLUSION

It was observed that there was a statistical association between shark attacks and the accident-related variables: year, day, period/shift, region and state; as well as with the victim-related variables: age group, gender and part of the body affected. There was no association between any variable and death.

Of the 86 shark attacks investigated, there was predominance in 1994, 2002 and 2004, occurring on Sundays, during the afternoon, in the Northeast region, in the state of Pernambuco, with a majority of male victims, aged between 12 and 19 years old, with a mean age of 23.2 years old, the most affected body part being the lower limbs, and the species most frequently identified in the attacks being Bull and Tiger sharks.

The state of Pernambuco accounted for more than 95% of the 26 deaths found, most of which occurred in 2002, 2004 and 2006, with a reduction in the mortality rate over the years. There was predominance of deaths in the age group between 20 and 30 years old, with a mean of 22.8.

Considering that the sea is the sharks' natural habitat and that aquatic practices increase the possibility of encounters with human beings, it becomes relevant to expand knowledge about the favorable characteristics for the attacks, to encourage campaigns and raise awareness among bathers, as well as to signal risk areas, in order to reduce the number of new events. It is necessary to train the professionals in areas with a statistical predominance of cases, such as the Northeast region, in order to increase the victims' survival chances.

It is recommended that future studies consider the factors associated with hospital and post-discharge outcomes, in order to contribute to the state of the art on the theme.

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