DEMOGRAPHIC DATA AND AUTOPSY FINDINGS OF REPORTED DROWNING DEATHS IN DURBAN, SOUTH AFRICA, FROM 2014 TO 2018

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Declaration

I, Dr Saxony Olivier, declare as follows:

1. That the work described in this dissertation has not been submitted to UKZN or any other institution for the purposes of an academic qualification, whether by myself or any other party.

2. That my contribution to the project is as follows: Conceptualisation of project; reading and compiling relevant literature; composing the research protocol and data collection tool; ethics application; data collection, entry, and cleaning; data analysis under the guidance of a statistician; interpretation of results; and composing of the dissertation.

3. That the contributions of others to the project are as follows: Dr Sipho Mfolozi provided guidance, edited, and contributed to the content of the final dissertation.

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CHAPTER 1

INTRODUCTION

1. Introduction

Drowning is defined by the World Health Organisation (WHO) as "the process of experiencing respiratory impairment from submersion or immersion in a liquid".[1] Drowning is a significant cause of preventable death worldwide, causing the loss of 372 000 lives annually.[2] Drowning is the third leading cause of unintentional death, and comprises 7% of all unintentional deaths across the globe.[3] More than 90% of these unintentional drowning deaths occur in low- to middle-income countries, a category into which South Africa falls.[2] Drowning death rates in Africa are reported to be 15 times higher than in Germany and 20 times higher than in the United Kingdom.[3]

Previously, drowning was subcategorised into multiple indistinct types, including wet, dry, active, passive, silent, secondary, and near drowning, causing confusion amongst clinicians and researchers and a lack of cohesion amongst epidemiological data. The WHO has simplified drowning outcomes into death, morbidity and no morbidity. This, along with simplification of the definition of drowning, has allowed for cohesive and uniform data collection in an international setting.[1] Drowning creates significant socio-political and -economic impacts in families, communities, countries and the world. It is known to affect primarily the poor and least educated members of society, and particularly affects those in low- to middle-income countries.[2] Sudden loss of a loved one to drowning causes significant grief amongst family units and immediate loss of a potentially income-generating family member.[4] The loss of parents to drowning increases the financial and care burden on other family members as children become orphaned, with the subsequent possibility of requiring social service intervention. Communities and countries experience this loss as an economic cost, as drowning victims are frequently within an economically-productive age group.[4] Survivors of drowning place significant strain on both their families and the health care system, as long-term neurological and cognitive deficits are a common outcome following survival of a drowning incident.[5, 6] The WHO has identified that inadequate healthcare services in low- to middle-income countries leads to a reduced survival time in victims following nonfatal drowning incidents.[2] Saunders et al. identified inequality, poverty, inadequate infrastructure and ineffective service delivery as drivers of South Africa's relatively high drowning rates.[7]

The drowning process has been succinctly summarised by Idris et al. as a continuum, beginning as the airways of the victim are submerged beneath the fluid surface, leading to

a period of voluntary breath-holding.[8] This is followed by hypercarbia and hypoxaemia as a result of a lack of gaseous exchange, with an eventual automatic respiratory drive causing active inhalation of the fluid following extensive swallowing of liquid. Aspiration of the fluid occurs, with the volume varying per individual, and death ensues due to asphyxia unless the victim is recovered and rapidly resuscitated.[8]

Durban is the third largest city in South Africa and is found on the Eastern coast of the country. Durban falls within the eThekwini Metropolitan District, one of eleven municipalities making up the KwaZulu-Natal province. eThekwini had a population of 3,442,361 at the national census in 2011, according to Statistics South Africa.[9]

The role of Forensic Pathology Services in the eThekwini district, as in the rest of the country, is to facilitate medicolegal death investigations by, amongst other functions, performing medicolegal autopsies on those who die of non-natural causes according to the Inquest Act 58 of 1959, with the primary purpose to ascertain their specific cause of death.[10] Other functions include investigation of the circumstances of death by a forensic pathologist attending the death scene. All cases of suspected drowning are therefore referred to Forensic Pathology Services by law as per the definition of a non-natural death, which is laid out in the Regulations Regarding the Rendering of Forensic Pathology Services of the National Health Act 61 of 2003.[11, 12]

Durban's warm, temperate climate, as a result of the warm Benguela current flowing from the equatorial Indian Ocean, lends itself to year-round water-related activities, with average maximum ambient temperatures ranging from 21.4°C to 27°C in the winter and summer months respectively, with high humidity levels nearing 80% in the warmer months, and an average ocean temperature of 23.2°C.[13] There are many fresh water sources within the eThekwini municipality, such as the large Inanda Dam on the uMngeni River. Public-access swimming pools are present throughout the city, and many homes in more affluent neighbourhoods have private swimming pools. These mild conditions and multiple water sources attract holidaymakers from across the country, with swimming and other water-related activities as a focus of their visits to the city.

Drowning risk has been found to be linked to the increasingly urgent problem of climate change. Two significant flooding events have occurred in Durban in the last five years, with significant loss of life and the declaration of a national State of Disaster.[14, 15] The construction of informal settlements on floodplains led to the loss of multiple lives and

homes, and has been previously identified as a concerning risk factor for drowning in low- to middle-income countries, particularly of migrants and other marginalised populations.[2, 15] These vulnerable communities have the fewest resources with which to handle such disaster situations and a lack of adequate systems for warning and evacuation of residents – an urgent area for improvement in drowning prevention measures.[2, 3, 15]

Although research has been done into the epidemiology and factors surrounding drowning in South Africa, there is a paucity of data from the province of KwaZulu-Natal - despite its coastal location, busy port, many rivers, and a significant number of drowning deaths being recorded in the Durban medicolegal mortuaries.[7, 16-22] This dissertation will therefore explore the factors surrounding drowning in Durban to allow for better understanding of the problem of drowning in this context.

2. Literature Review

A search of PubMed and Google Scholar databases was undertaken to identify the relevant recent extant literature from South Africa and worldwide. Cited references of selected papers were assessed and included in this study where appropriate.

2.1 Epidemiology

This dissertation focuses on death outcomes of drowning, as its other outcomes fall outside the scope of forensic pathology. There is a large variation in death rates from drowning in different countries worldwide. Lin et al performed an analysis of 60 countries in which the mortality rates ranged from a low 0.12 per 100 000 population in Turkey to 9.19 per 100 000 in Guyana. Within this analysis, South Africa and Colombia were noted to have high mortality among children under the age of four, but that older adults tended to have a lower mortality rate. South Africa was found to be 21st out of 60 countries in drowning all-age mortality.[23] The Global Burden of Disease data from 2016 indicated that the mortality rate for unintentional drowning in South Africa had decreased from 5.09 in 2000 to 3.95 per 100 000 in 2016.[24] The Global Burden of Disease data from

2017 confirmed that drowning mortality was highest in low to middle sociodemographic index countries, and that it was from these countries that important drowning outcomes data was lacking.[25, 26]

There are a handful of studies that outline drowning in a South African context, and different provinces within the country show differing drowning rates.[7, 17] Meel found the incidence of drowning in Mthatha to be 7.1 per 100 000 population between 1993 and 2004, which was noted to be five and seven times higher than that of the United States of America and Australia respectively.[19] In the Western Cape Province of South Africa, Simons et al. reported a drowning mortality rate of 3.8 per 100 000 population amongst children and Saunders et al. found an age-adjusted mortality rate of 3.2 per 100000 population in recent studies.[21, 22]

In their study of urban drowning in South Africa, Donson and Van Niekerk used the National Injury Mortality Surveillance System (NIMSS) to identify drowning cases in the early 2000s. They noted that the drowning rate in Durban during their study period was 2.0 per 100 000 population, and that the highest drowning incidence was found in coastal cities as opposed to inland urban areas. They acknowledged, however, that the NIMSS only carries data for 39 to 52% of all injury-related deaths, therefore the drowning incidence was likely to be higher than reported.[17] The NIMSS was also used in a study into injury-related deaths in children by Burrows et al., who found injury, drowning and burns to feature in the top three causes of death in all cities in South Africa except for Cape Town, in which firearm-related deaths were more common than drowning.[16]

2.2 Demographics

It is known that fatal drowning shows a strong male preponderance, with studies showing a male predominance of more than 70%. This has been attributed to many factors, including increased risk-taking behaviours and increased alcohol consumption in males. This male predominance is echoed in South African literature.[7, 19-22, 25, 27-37] It is also noted that young adult men have been identified as a high risk group in our country, with a mortality rate of 6.6 per 100 000 in males aged 25 to 29 in the Western Cape Province.[22]

Globally, drowning mortality is generally highest in children.[25] The mean age of drowning varies between countries, however, with some first world countries of Europe

and North America showing a higher mean ranging between approximately 43 and 53 years.[27, 28, 30, 35, 36] Truszkowsi et al. analysed drownings in Poland from 1998 to 2020, and found that most drownings occurred in those over 50 years, whilst the least drownings occurred in those under seven years.[32] Similarly in Canada, the highest drowning rates were found in those over 65 years, and the lowest in those under 14 years.[37] In contrast to this, studies out of South Africa show a preponderance for younger victims, with children and young adult men forming the bulk of the mortality in our setting.[7, 19-23, 38] Children under the age of 19 comprised 39.1% of the sample in a study of 1391 drowning deaths in the Western Cape Province by Saunders et al. More than half of the sample of Morris et al. in Pretoria were under the age of 18.[20] Meel demonstrated a decreasing drowning incidence with increasing age, with 30.3% of his sample under the age of 10 years in his study of the Mthatha area. A study by Tan in Singapore found the 20- to 29-year age group to have the highest drowning risk in the late 1990s.[39]

2.3 Manner of death

The manner of death in drownings is largely accidental worldwide, and many global statistics confine themselves to unintentional drowning deaths. However, suicide by drowning varies in frequency from country to country and is a significant cause for concern in some parts of the world. This has led to concern amongst some that overall drowning numbers are being underreported.[25] Reported suicidal drownings accounted for 16.6% in a study from the USA ranging to 31% in one in Sweden. [27, 30, 35, 36] The high drowning suicide rate of 32% at the River Torrens in Australia was accounted for by its easy availability as a means of suicide for a nearby urban population.[40] Donson and Van Niekerk reported the NIMSS data as showing a 1.2% suicidal drowning rate in the five major South African cities.[17]

In South Africa it is the role of the magistrate to rule on the manner of death, rather than the pathologist as is the common practice in many countries, therefore obtaining such information from mortuary data is a challenge.

2.4 Seasonal, day-to-day, and time-of-day variation

Studies across the globe show a predominance of drownings during the summer months, an understandable finding considering the increase in water-related activities in warmer weather.[27, 29, 34-37, 41] Similar proportions are seen in South Africa, with summer drownings in the region of 30 to 40% of the yearly totals.[7, 17, 20, 22] Donson and Van Niekerk's study based on NIMMS data showed that 19.2% of all drownings in Durban occurred in January.[17]

Similarly, drowning deaths occur most frequently on weekends, both locally and in the rest of the world.[17, 22, 32, 41] In the Western Cape Province, weekends accounted for 47.8% of all drowning incidents, and 7.7% occurred on public holidays.[22] 50.6% of drownings occurred on the weekend in Durban in the early 2000s.[17]

Few studies report on times of drownings. Recorded time of death can be misleading, as bodies retrieved from water may have their time of retrieval recorded as their time of death despite spending a prolonged period submerged. Studies in the USA and Australia found peak drowning times in the late afternoon and evening, with drownings in Arizona most frequent between 18h00 and 20h00, and those of children in Western Australia most frequent between 16h00 and 18h00.[42, 43] This was attributed to being both the peak time for swimming in pools and when adults were most likely to be distracted from supervision by preparation of meals.[43] Interestingly, Hansen and Thomsen found most of the drownings in Denmark to occur in the evening and at night, with almost 40% of drownings between 18h00 and 06h00.[30] In contrast, Tyler reported that 95% of drownings in low- to middle-income countries occurred during the day.[38] In the Western Cape Province, Saunders et al. found almost two-thirds of drownings to have occurred between 12h00 and 19h59.[22]

2.5 Body of water

The body of water in which drownings most frequently occur varies from place to place and depends largely on the major bodies of water associated with the studied area as well as the age of the population studied. In Canada, a study by Clemens et al. showed most drowning deaths to have occurred in natural bodies of water comprising mainly lakes and

flowing water sources, such as rivers (66%). Relatively few deaths were reported to have occurred in the ocean (9.6%), bathtubs (8.9%) and swimming pools (6.6%).[37] A recent Polish study showed similar results, with most drownings reported to have taken place in rivers (37%), and the least in the sea (5%).[32] In Denmark, 24.4% of drownings were found to have occurred at a dock, with a combined proportion of 48.2% of drowning deaths involving the sea (docks, beach and open sea).[36] In the coastal state of Connecticut, USA, 71% of drownings reportedly occurred in naturally-occurring fresh water sources such as rivers and lakes, whilst only 18% occurred in salt water.[27] Tyler's review of low- to middle-income countries found that small bodies of water such as wells, streams, ditches and ponds were more often the site of fatal drownings than larger ones.[38] Saunders showed that in the Western Cape Province, most drownings occurred in open bodies of water (77.8%), comprising oceans and lagoons (28.6%), ponds, dams and lakes (25.5%) and rivers and canals (23.7%), with swimming pools (12.5%), fresh water and storage tanks (6.0%) and bathtubs (3.7%) making up the remainder.[22] In contrast, 38% of drownings in Pretoria occurred in swimming pools, followed by rivers and dams (21% respectively) and bathtubs (5%).[20] Meel reported that most drownings in Mthatha occurred in natural collections of rainwater used for drinking and washing, but did not provide examples thereof.[19]

In the city of Durban, the following beaches are open to the public: Addington, Amanzimtoti, Anstey's, Battery, Bay of Plenty, Beachwood, Blue Lagoon, Bluff, Brighton, Bronze, Country Club, Dairy, Garvies, Glenashley, Isipingo, Laguna, La Lucia, North, Pipeline, Point, Reunion, Snake Park, South, Suncoast, Thekwini, Treasure, uMdloti, uMgababa, uMhlanga, uShaka, Virginia, Warner, Wedge, Westbrook and Winkelspruit. Lifesaving KwaZulu-Natal has a strong presence on beaches permitting swimming, with safe zones demarcated by flags However, lifeguards cannot be on duty at all hours and cannot monitor those accessing the water away from these zones.[44] Large rivers such as the uMngeni or oHlanga may act as channels by which bodies drowned upstream are washed downstream or into the ocean, particularly during floods. The possibility exists that, rather than having drowned via entering the ocean from the beach, bodies retrieved from the shoreline or shallow ocean were washed ashore after drowning in deeper ocean, as in the suspected 2018 case of an unregistered stowaway from a ship anchored off Durban's coast.[45] Local media reports have been released regarding

drowned bodies being recovered after washing ashore, the most recent of which was in September 2022.[46]

2.6 Alcohol and Drugs

Alcohol invokes both physical and mental effects which can expose an individual to an increased risk of death, particularly around bodies of water. Altered cognition and poor judgement can lead to increased risk-taking behaviours, while physical consequences of intoxication such as reduced swimming ability, vasodilation and hypothermia, disorientation and altered consciousness also play a role of survival of a person in water.[41, 47, 48] While the consumption of alcohol is prohibited on Durban beaches, it is nonetheless commonplace and its prohibition is poorly enforced by the city's metropolitan police. The bylaws prohibiting consumption extend to ban already-intoxicated persons from accessing the beach, however this is infrequently enforced.[49]

The 2004 review of Driscoll et al. estimated that alcohol was found in the blood of 30 to 70% of persons who drowned during recreational aquatic activities.[47] Pajunen et al. studied a large sample (N = 1697) of unintentional drowning victims and found 60.7% to have a positive blood alcohol concentration (BAC), with a 100% testing rate. Sixty-two point three (62.3%) of all victims had a BAC over 0.05g/100ml. The most frequent category into which measured concentrations fell in BAC-positive victims was 0.2 to 0.249g/100ml, and 10.7% had a BAC of over 0.3g/100ml.[48] Donson and Van Niekerk reported a lower testing rate (37.4%) and 40% of cases to have positive BAC in their South African study, of which 85% were at or above 0.05g/100ml.[17] Morris et al. found a 42% BAC-positive rate in Pretoria, 35% of which were measured to be over 0.05g/100ml.[20]

Male victims of drowning are more likely to have positive BAC than females, which was also found to be the case in the South African population, with men showing an elevenfold increase in likelihood when compared to females.[17, 27, 29, 35, 48]

Alcohol is known to be a risk factor in drowning mortality, however few studies exist in which this the risk has been attempted to be quantified.[47] It has been suggested that a BAC of 0.1g/100ml increases the risk of death associated with recreational boating tenfold, however has the potential to increase this risk even in small concentrations.[47]

Studies on persons with hangovers have shown that cognition and performance in driving is impaired when hung over, even when the BAC is zero.[50]

The role of other drugs in drowning has not been examined in depth in the literature. Twenty-six point seven (26.7%) of the unintentional drowning victims in the study by Pajunen et al. demonstrated the presence of at least one psychotropic drug, with some having up to seven drugs in their systems.[48] A study from the United States found drugs alone in 14.6%, and a combination of alcohol and other drugs in 36.8% of their studied drowning victims.[27] 14.86% of victims in a Hungarian study had positive toxicological investigations, while in Ohio, USA, only 3 out of 187 tested victims returned a positive test.[29, 51] A small study (N = 34) of drownings in an Australian river detected illicit substances in 18% (mainly 3,4-methylenedioxy-methamphetamine (MDMA) and tetrahydrocannabinol (THC)) and therapeutic drugs in 45%.[40] Forty percent (40%) of tested victims in a study by Ahlm et al. were positive for one or more psychoactive drugs, with a higher proportion in those ruled as suicides (69%). In the same study, illicit drugs were only detected in 10%.[35] In South Africa, drug toxicology testing is not routinely performed on suspected drowning deaths.

2.7 Autopsy Features

The diagnosis of drowning is a difficult one and is considered a diagnosis of exclusion due to its lack of specific pathognomonic autopsy features. Its diagnosis requires the consideration of multiple interconnected aspects, including a strong emphasis on the history of circumstances surrounding the death and a combination of suggestive postmortem findings.[52-56] These findings often occur more as a consequence of immersion than of drowning itself.[53] The features frequently described in the literature include: sand, silt or aquatic vegetation on the body, “washerwoman’s” changes of the hands and feet (pale prune-like wrinkling of the skin), cutis anserina, facial or subconjunctival petechial haemorrhages, a plume of froth at the mouth and nostrils that extends into the trachea, emphysema aquosum, increased lung weights, pulmonary oedema, pleural effusions, subpleural petechial haemorrhages, watery fluid in the stomach, fluid within the sphenoid sinus, intimal staining of the aortic root, cerebral oedema, and middle ear or mastoid bone haemorrhage.[30, 52-57] There is a large degree of overlap between these features and many other causes of death, which emphasises the lack of specificity of these findings.

Froth at the mouth and nose or in the airways is a commonly reported, however nonspecific, feature frequently found in drowned persons, and is thought to originate from the admixture of air, water, bronchial secretions and surfactant.[54] Twenty-five point two (25.2%) and 17% of cases in Denmark showed external and internal froth respectively.[36] Somers et al. found froth in 43% of studied drownings in children under the age of 17, and noted a significant decrease in its incidence as the postmortem interval lengthened.[58] Seventy-three percent (73%) of cases examined by Schneppe et al. demonstrated froth in the airways, and 31% by Morris et al. at the nostrils.[20, 30] It is important to remember, however, that the finding of airway froth is nonspecific and has even been found to arise as a postmortem immersion phenomenon.[59] Such a fragile feature as froth is easily washed away in water, lost during resuscitative efforts, and diminished with increasing postmortem interval, so it may have somewhat or entirely disappeared by the time of autopsy.[30, 54, 55, 58] Lunetta et al. found froth in the airways in a high percentage of cases (70.6%), but showed that the finding of froth in combination with overlap of the anterior lung margins was 100% specific for drowning when compared to controls. Those two features together, however, were only present in 11.1% of their cases.[60]

Emphysema aquosum, the term used for hyperinflated, waterlogged lungs with mediastinal overlap and rib indentations, is not uniformly used across all centres, with some authors frequently using this term (for example in 94.9% of cases in a German study) whilst others prefer to describe these pulmonary features separately, from “bulging lungs” (present in 24.4% of cases in a study from Denmark) to “pulmonary oedema” (61% in a study from the USA).[27, 30, 36] Morris et al. described the specific entity of emphysema aquosum in 33% of drowning cases in Pretoria.[20]

Increased lung weight arises from excess fluid within the lungs, comprising both aspirated drowning medium and intrinsic pulmonary fluids. Somers et al. found 80% of drowned children to demonstrate increased lung weights, and Bamber et al. found paediatric lung weights to be an average of 65% heavier than expected for age in drowning.[58, 61] A study of 578 subjects by Lunetta et al. demonstrated combined lung weights of at least 1000g in 90.3% of male and 51.5% of female drowning victims.[62] Girela-López et al. reported pulmonary oedema in 61% of their sample.[27]

Pleural effusions occur due to transudation of excess fluid from the parenchyma of the lung, and in contrast to froth in the airways, tend to increase in volume with a prolonged

postmortem submersion period as fluid leaks into the serous cavity.[52, 63] Somers et al. and Bamber et al. found pleural effusions in 36% and 18% of their respective paediatric samples.[58, 61] Hansen and Thomsen reported effusions in 44.4% of their 135 victims, with a wide range of volumes (mean 643.68ml SD 505.3ml).[36]

Localised intimal staining of the aortic root has been identified as a possible sign of drowning, although it is important to remember that the sign is nonspecific, particularly when generalised to all arteries, as commonly occurs in decomposition and other generalised pathologies that can cause haemolysis, such as sepsis and burns.[56, 64] It appears to occur only infrequently in cases of drowning.[30, 65]

Papadodima et al. suggest that a large volume of watery fluid found within the stomach at postmortem "strongly suggests immersion during life, but it does not confirm drowning", whilst others suggest that diluted intestinal contents occur frequently in drownings, such as in 49.7% of victims in a study by Schneppe et al.[30, 54]

Other less common features described with varying ranges of frequency include watery fluid within the sphenoid sinuses; facial, subconjunctival and subpleural petechial haemorrhages and haemorrhage into the middle ear or mastoid bone.[20, 30, 36, 61, 66]

The difficulty in diagnosing drowning is compounded by the frequent finding of decomposition in bodies retrieved from water, which can mask the commonly sought features through skin changes and organ autolysis and preclude what is already a challenging diagnosis.[27, 30, 56, 57] There is often a longer delay between death and the retrieval of a body than there would be on land, particularly in large bodies of water such as the sea, leading to relatively high rates of decomposition. Schneppe et al. noted that the findings of foam in the airways and emphysema aquosum declined with increasing degrees of decomposition, while there was a significant increase in cases with fluid within the sphenoid sinus. Features of decomposition were identified in 34% of their sample.[30] Ishigami et al. showed an increase in the incidence of pleural effusion and a decrease in lung weight as the post mortem interval increased.[63] Lunetta et al. reported 37.1% of drowning victims to have features of decomposition.[60] In contrast, Morris et al. found decomposition only 4% of cases in Pretoria, which may be related to Pretoria's inland location and bodies not being retrieved after hours to days from the ocean in coastal areas.[20]

2.8 Comorbidities, resuscitation, and hospitalisation

Comorbidities are a further confounding factor in the diagnosis of drowning, with features of natural disease found at autopsy not easily distinguishable as causes of death pre-immersion, causes of unconsciousness that could lead to subsequent drowning, or merely incidental findings. Common comorbidities adding particular difficulty to drowning diagnoses include seizure disorders and heart disease, including myocardial infarction, arrhythmias, and myocarditis.[35, 37, 54] Morris reported 12% of victims to have shown features of an underlying medical condition at autopsy, while Clemens et al. demonstrated that two thirds of drowned adults of the age of 65 or older in Canada had an accompanying chronic condition.[20, 37] Eight out of 28 paediatric drowning victims in a London study by Bamber et al. had significant comorbidities, from epilepsy to hypergammaglobinulaemia.[61] In Australia, Peden et al. studied drownings occurring in bathtubs, and deemed 19 out of 26 victims to have had a medical condition that contributed to their death.[67]

Morris et al. reported 61% of victims to have demised at the scene of drowning with no features of resuscitation having been attempted. Of those for whom resuscitation was attempted, 45% were found to be dead on arrival at a medical facility. Hospital admission of victims of drownings ranged widely from a matter of minutes to 45 days.[20] The range of admission duration was narrower in the smaller study of Bamber et al., where nine out of 28 children survived between 12 hours and four days in hospital.[61] Eighty-six point six percent (86.6%) of children in China died at the scene of drowning and 32.9% received some form of first aid.[34]

2.9 Histology and additional ancillary tests

Histological features are nonspecific, however can assist to supplement information gained at autopsy. Pulmonary features may include thin, compressed alveolar walls with dilated air spaces, fragmentation of elastic fibres and pneumocytes, vascular congestion, peribronchial or intraalveolar haemorrhage and a washout effect of alveolar macrophages. In the brain, cerebral oedema and hypoxic ischaemic encephalopathy may be identified.[52, 54, 55, 61, 66]

Additional special investigations used in other countries to aid in the diagnosis of drowning include diatom analysis, measurement of levels of blood electrolytes and trace minerals such as sodium, chloride, calcium, magnesium and strontium, and immunohistochemical identification of aquaporins. None of these tests are perfect markers of drowning, however, and some are contentious in their use. They may be helpful to assist in increasing the level of certainty of a diagnosis of drowning.[52, 54, 55, 66] Due to various factors including resource constraints, these investigations are not available in the laboratories in KwaZulu-Natal.

3. Conclusion and Research Question

Due to the paucity of data regarding drowning deaths in Durban and no previous local mortuary data being specifically studied, this study provided an opportunity to gain insight into drownings in this unique setting, both in terms of identification of at-risk groups based on demographic data, time and location, and assessment of autopsy data such as postmortem features and the role of alcohol in these deaths. It allows comparison with other locations, both within South Africa and internationally, and therefore draws on pre-existing preventative strategies to assess whether they can be applied to this setting or aid in the future strategies of others. In addition, the conclusions of this study aid in the guidance of focused preventative measures for this community by specifically answering the question: “What are the factors surrounding drowning deaths in Durban?”.

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CHAPTER 2

DEMOGRAPHIC DATA AND AUTOPSY FINDINGS OF REPORTED DROWNING DEATHS IN DURBAN, SOUTH AFRICA, FROM 2014 TO 2018

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Abstract

Drowning is a significant cause of preventable death worldwide, particularly in low- to middle-income countries. Durban is the second largest coastal city of South Africa, and no prior formal autopsy studies into drowning have been undertaken in this city, so little is known about the details of fatal drownings in this setting.

This study explored the factors surrounding drowning in Durban. A retrospective review of mortuary records of drowning deaths from 1 January 2014 to 31 December 2018 was undertaken, with a total sample size of 253.

Most drowning deaths occurred in males (85%, N = 215) and adults over the age of 18 years (75.5%, N = 191). Confirmed drownings occurred most frequently between 12h00 and 18h00 on weekend days in the summer months of the year. Forty-nine point seven percent (49.7%, N = 116) of drownings occurred in the ocean and 70.5% (N = 165) in naturally occurring bodies of water. Ninety point five percent (90.5%, N = 229) of victims died at the scene, with the remainder being transported to hospital, where 4% (N = 10) were found to be dead on arrival and 5.5% (N = 14)were hospitalised. The most frequent external autopsy findings were water or aquatic vegetation on the body, washerwoman's changes of the hands or feet and features of decomposition. The most frequent internal autopsy findings were pulmonary congestion and oedema, generalised visceral congestion and froth within the airways. Thirty-one point six percent (31.6%, N = 56) of tested victims had a positive blood alcohol test, and 69.6% (N = 39) of these had a blood alcohol concentration of more than 0.05g/100ml.

These results add to the knowledge base surrounding drowning in South Africa and contribute a clearer understanding of drowning deaths in this specific setting, while highlighting contribution of prior alcohol consumption and the particular need for increased awareness around beach safety and municipal by-law enforcement.

Keywords

Drowning
Durban
South Africa
Demographics
Autopsy features
Forensic pathology
Public health

1. Introduction

Drowning is defined by the World Health Organisation (WHO) as "the process of experiencing respiratory impairment from submersion or immersion in a liquid" and is a significant cause of preventable death, causing the loss of 372 000 lives annually.[1, 2] Drowning is the third leading cause of unintentional death, and comprises 7% of all unintentional deaths worldwide.[3]

More than 90% of these unintentional drowning deaths occur in low- to middle-income countries such as South Africa.[2] An analysis of 60 countries by Lin et al. found South Africa to be 21st out of 60 countries in drowning all-age mortality.[4] The Global Burden of Disease study noted the South African mortality rate for unintentional drowning to be 3.95 per 100 000 in 2016.[5]

Few studies have been undertaken within South Africa to examine the factors surrounding drowning deaths, and there is a paucity of data from the KwaZulu-Natal province despite its coastal location, busy port, many rivers, and a significant number of drowning deaths being recorded in its mortuaries.[6-13] In the early 2000s, Donson and Van Niekerk used the National Injury Mortality Surveillance System (NIMSS) to examine drowning deaths in the major South African cities, and found Durban to have a drowning mortality rate of 2.0 per 100 000 population, however they acknowledged that the NIMSS only carries data for 39 to 52% of all injury-related deaths, with the drowning incidence therefore likely to be higher than reported.[7] Meel found the incidence of drowning in Mthatha in the Eastern Cape Province of South Africa to be 7.1 per 100 000 population between 1993 and 2004, and Saunders et al. found an age-adjusted mortality rate of 3.2 per 100 000 population in the Western Cape Province.[9, 12]

Globally, drowning data show a male predominance as well as a predominance of young victims, with more than half of drowning deaths occurring in those younger than 25 years.[2] Both locally and worldwide, deaths tend to occur in the afternoons of warmer months of the year, and often on weekends, due to the increase in swimming activities.[7, 10, 12, 14-20] The body of water in which most victims drown varies widely depending on the geographic factors of the studied location (for example coastal location or proximity to water sources) and age of the population.

Drowning is a particularly challenging autopsy diagnosis, as it demonstrates no pathognomonic features at postmortem examination. The pathologist is often confronted with

only a limited constellation of nonspecific signs that must be used in combination with a suggestive history and the exclusion of other possible causes of death to conclude the diagnosis of drowning. Some of these features indicate only that the body has been immersed in water (for example, maceration of the skin of the hands and feet). Moreover, the frequent finding of changes of decomposition can mask these features and further complicate a firm diagnosis.[21-25] Furthermore, attempts to resuscitate the victim can intentionally or unintentionally remove some of the signs that may suggest drowning, such as the commonly-encountered plume of pink froth at the nose and mouth.[26] Resuscitation is known to cause additional perimortem injuries , such as rib fractures, facial and chest wall bruising and subarachnoid haemorrhage, many of which can mimic pathology of antemortem blunt force trauma and thus confound the diagnosis of drowning.[27]

The physical and mental effects of alcohol make its consumption a known risk factor for drowning.[2, 14, 28, 29] These effects include, amongst others, an increased risk of hypothermia, sensorimotor impairment, poor judgement and coordination.[14, 27] There is a paucity of data regarding the potential role therapeutic and recreational drugs play in drowning fatalities. However, a number of studies suggest that it may be underestimated.[15, 16, 29-31]

The purpose of this retrospective, descriptive study was therefore to examine the factors surrounding drowning in Durban, South Africa, in order to better understand the nature of these cases within this setting and to aid in informing preventative measures.

2. Methods

2.1 Design and setting

A retrospective record review was conducted of all bodies with a cause of death recorded as being consistent with drowning that underwent a medicolegal autopsy at two large medicolegal mortuaries (Gale Street and Phoenix) in the eThekwini Metropolitan Area of Durban, KwaZulu-Natal Province of South Africa from 1 January 2014 to 31 December 2018. In South Africa, the Inquest Act (Act 58 of 1959) requires all unnatural deaths to undergo medicolegal autopsies at the appropriate forensic mortuary in the province.[32, 33] During this five-year period, the two mortuaries performed a total of approximately 3 400 to 3 900 autopsies per year.

This study was approved by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (Reference BREC/94/2019). Permission to use data from Forensic Pathology Services was obtained before data collection began.

2.2 Data collection and analysis

Criteria for inclusion in the study included all bodies with a cause of death deemed to be fatal drowning that underwent medicolegal autopsy at one of the two mortuaries between 1 January 2014 and 31 December 2018. Exclusion criteria included bodies retrieved from water that had a confirmed cause of death other than drowning, as well as cases in which the cause of death was unclear or unapparent, or the postmortem report was incomplete. After cases were identified by paper and electronic databases, multiple variables were recorded into a Microsoft Excel spreadsheet for each victim. These included demographic details, location of the drowning incident, date and time of drowning or body recovery, possible pre-existing comorbidities, resuscitative efforts, "classic" pathology findings of drowning, antemortem pathology, postmortem pathology, decomposition, postmortem interval to autopsy, and results of ancillary tests such as blood testing for alcohol. Sources of data included autopsy reports, police summary documents (known as SAPS 180 forms), printed results of ancillary tests, and, infrequently, records of interviews held with family members of the deceased at the mortuary. Pre-existing medical records of the drowning victims were not available.

Descriptive statistics were used to summarise the data. Frequency and percent were reported for categorical data and frequency distributions of continuous data were examined for normality. Medians and interquartile ranges were reported for skewed data. Comparisons of categorical variables were performed using Chi square and Fishers exact tests.[34, 35] The Mann Whitney test was used to compare BAC medians in decomposed and non-decomposed bodies.[36] Statistical significance was set at $p < 0.05$. All data were analysed using IBM SPSS Statistics for Windows (v28.0 (2021) Armonk, New York, USA: IBM Corp).

3. Results

A total of 253 cases were included in the study, which comprised between 1.2 and 1.65% of the caseload for the two mortuaries over the five-year period (Figure 1). The cause of death in these cases was recorded as being consistent with drowning. Bodies retrieved from water with causes of death other than drowning were excluded from the study.

The median age of the victims was 28.5 years (range 0 – 91, IQR 18.0 – 37.75). Seventy-five point five percent (75.5%, N = 191) of the sample comprised adults of 18 years and older (Figure 2). Thirty point two percent (32.2%, N = 76) of the sample were between the ages of 26 and 35 years (Table 1). Eighty-five percent (85%, N = 215) of the sample was male, with a male to female ratio of 5.7:1. Although contentious in their use, the population groups "Black", "Asian", "Coloured" and "White" were included on the standard reporting form for police officers at the scene of death and used within postmortem reports. In this study the sample were reported to be 83% Black (N = 210), 10.3% Asian (N = 26), 5.5% White (N = 14) and 0.8% Coloured (N = 2) people (Table 1).

Most drowning deaths occurred in the month of December, followed by January and October (Figure 3). In the southern hemisphere, December and January are in summer, where temperatures can rise to as high as 35°C, whereas October is in spring. Saturday was the most frequent day of the week upon which victims drowned (18.2%, N = 46), followed by Sunday (15.8%, N = 40) and Friday (15.4%, N = 39) (Figure 4). Thirty-four percent (34%, N = 86) of all drownings occurred on weekends, and 5.1% occurred on public holidays (N = 13). Forty-five point seven percent (45.7%, N = 100) of drowning deaths were recorded to have occurred between 12:01 and 18:00 (Figure 5). Notably, however, the time of death and time of body retrieval from water may have been used interchangeably. The most common hours during which drownings were recorded to have occurred were from 15:00 to 16:00, 10:00 to 11:00 and 17:00 to 18:00. The average number of days between the recorded date of death and the performance of the autopsy was 3.2 (range 0 to 29).

The commonest body of water in which victims drowned was the ocean (49.6%, N = 116), followed by swimming pools (16.2%, N = 38) and rivers (15%, N = 35). Seventy point five percent (70.5%, N = 165) of drownings occurred in naturally occurring bodies of water, which included the ocean, rivers, lagoons, lakes, etc., while only 29.5% (N = 69) occurred in manmade bodies such as swimming pools, toilet holes, buckets of water, etc (Figure 6a). When comparing drowning fatalities in larger bodies of water such as the ocean, rivers and

dams, with drowning fatalities in smaller bodies such as swimming pools, baths, buckets of water and sewage pipes, a significant association ($p < 0.001$) was identified between the age category of the victim and the body of water (Figure 6b). Seventy-five percent (75%, N = 15) of children between the ages of one and five years drowned in swimming pools, with no cases of ocean drowning recorded in this age group. Fifty-seven point eight percent (57.8%, N = 104) of adults over the age of 18 years drowned in the ocean. There was a significant association between ocean drownings and the presence of decomposition features at autopsy (44% of ocean drownings, $p < 0.01$) (Table 2).

In cases where a specific beach was named, 20 drowning deaths occurred at North Beach (17.2% of recorded ocean drownings, N = 116) (Figure 6c). Similarly, where a specific river was named, most river drownings occurred in the uMlazi River (6 of N = 35 river drownings (17.1%)) (Figure 6d). Fifteen of 18 drownings recorded in dams (83.3%) occurred in the Inanda Dam.

Despite three major flooding events during the study period (July of 2016 and May and October of 2017), only two deaths were documented to have been a direct result of these floods, with one victim in July 2016 having been "swept into the ocean during heavy rainfall" and the other in October 2017 having been "caught in a flash flood whilst driving a motor vehicle". Ten (10) drowning deaths were reported to have occurred between 10 and 19 October 2017, which may have been related to floods which began on 9 October 2017, however this cannot be confirmed due to insufficient documentation of details.[37-39]

Details regarding the suspected manner of death were infrequently recorded. Two cases were reported as having been due to suicide. In one case, the victim allegedly intentionally jumped off a pier into the ocean, and in the other case the victim allegedly intentionally waded into the sea repeating the word "sorry" in the isiZulu language. In the few other cases for which information was provided, the manner of death appeared largely accidental. A suspected or known history of epilepsy was provided for six adult victims. In one case, an adult male with a history of nonspecific psychiatric symptoms allegedly drowned whilst undergoing an "exorcism" by a pastor in the ocean. The cause of all of the above deaths was categorised as consistent or compatible with drowning.

Seventy-nine point eight percent (79.8%, N = 202) of victims had no recorded features of resuscitation, with an additional 9.5% (N = 24) demonstrating only adhesive electrocardiogram electrodes on the chest. Ninety point five percent (90.5%, N = 229) of victims died on the scene, whilst 4% (N = 10) were reported to have been dead on arrival at hospital. Only 14 victims were hospitalised prior to death (5.5%). Of these, four had cardiopulmonary resuscitation initiated prior to arrival, which was continued in hospital until death was confirmed, while nine had spontaneous circulation upon arrival at the hospital but a Glasgow Coma Scale of less than four on admission. One case had no detail outlining the hospitalisation. The length of hospital stay ranged from 15 minutes to 16 days, with only five victims (aged 1 to 30 years) surviving beyond 24 hours.

The most commonly recorded postmortem pathology in this sample was pulmonary congestion (64.4%, N = 163), followed by pulmonary oedema (48.6%, N = 123). Sand or aquatic vegetation was noted on 37.5% (N = 95) of the victims, and 36% (N = 91) demonstrated skin maceration of the hands or feet, commonly referred to as "washerwoman's" changes . Thirty-four point eight percent (34.8%, N = 88) of victims showed generalised congestion involving multiple organs (Figures 7a and 7b). The records of thirty victims (11.9%) showed features of blunt force injury of varying severity, including scalp bruising, intracranial haemorrhage, fractures and skin lacerations. However, all of these cases were recorded as having a cause of death consistent with drowning.

In the 177 (70%) victims whose blood was tested for alcohol (BAC), fifty-two (29.4%) indicated a negative result, 56 (31.6%) indicated a positive result, and 69 (39%) had no result available in the file, or their blood samples were rejected by the laboratory for being of insufficient volume. No children under the age of 14 years had blood tested for BAC. The median BAC was 0.01g/100ml (IQR 0.00 – 0.13) with a maximum value of 0.39g/100ml (Figure 8). Thirty-nine victims (69.6% of those with a BAC test) had a BAC of more than 0.05g/100ml. Fifty-five point one percent (55.1%) of males and 27.3% (N = 3) of females tested positive for BA, with no statistically significant difference between the two groups.

There was a statistically significant difference ($p = 0.042$) between the BAC of bodies that demonstrated features of decomposition and those that did not. Amongst bodies that showed features of decomposition with a BAC of more than zero, the median BAC was 0.10g/100ml (IQR 0.02 – 0.17) whilst the median for non-decomposed bodies was 0.18g/100ml (IQR 0.06 – 0.24).

Toxicology analyses were undertaken on 12 victims (4.7%), using samples of blood, urine, bile, vitreous humour, and/or stomach contents. Of these, four (33.3%) were reported as having negative results and one case had its samples rejected by the laboratory for being of insufficient quantity. A single toxicological analysis indicated a positive result, having identified the drug ibuprofen, the concentration of which could not be quantified. Results were not available for the remaining six cases (50%).

Fourteen victims (5.5%) had tissue collected for histological investigation. Of these, only two had tissue examined, with relatively nonspecific features reported.

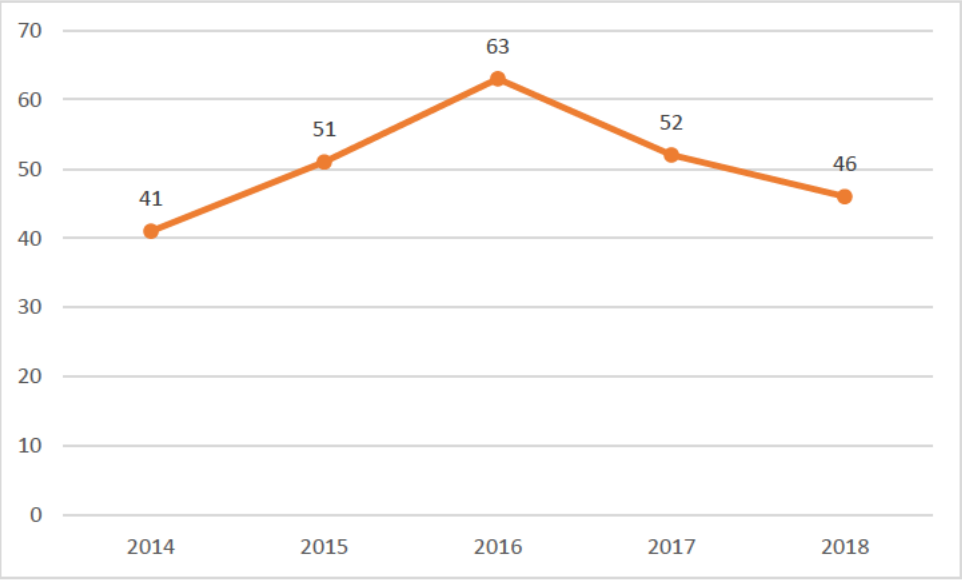

Figure 1: Number of drowning deaths by year (N = 253)

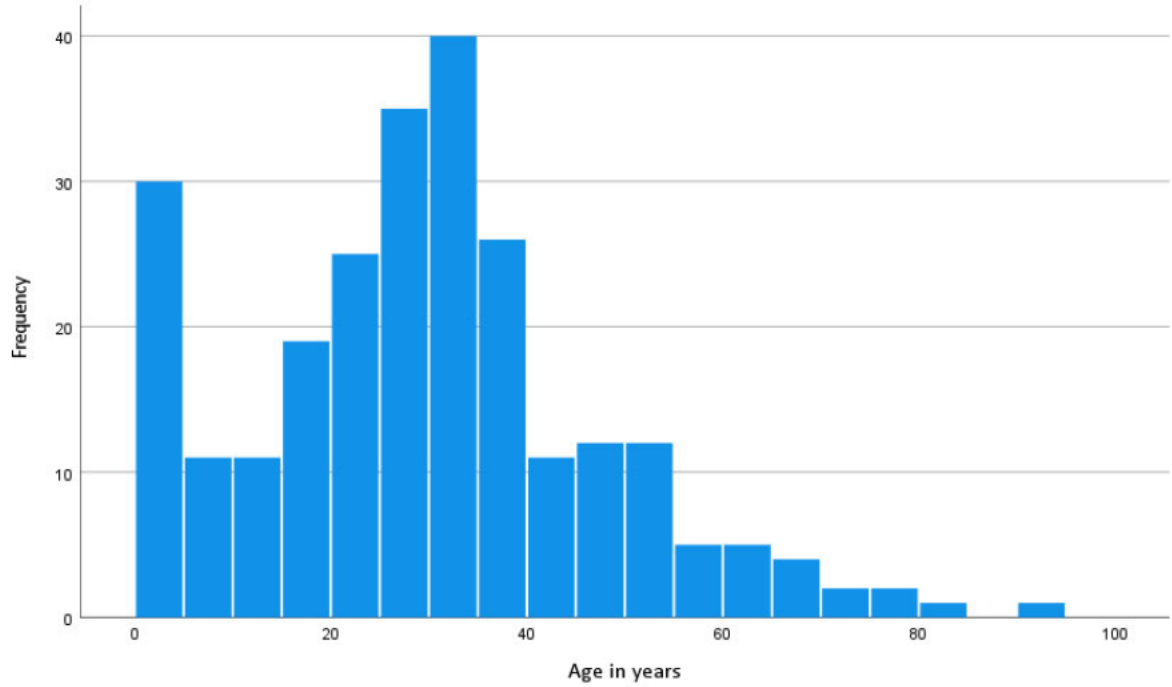

Figure 2. Histogram of age distribution of sample indicating a skewed distribution (N = 253).

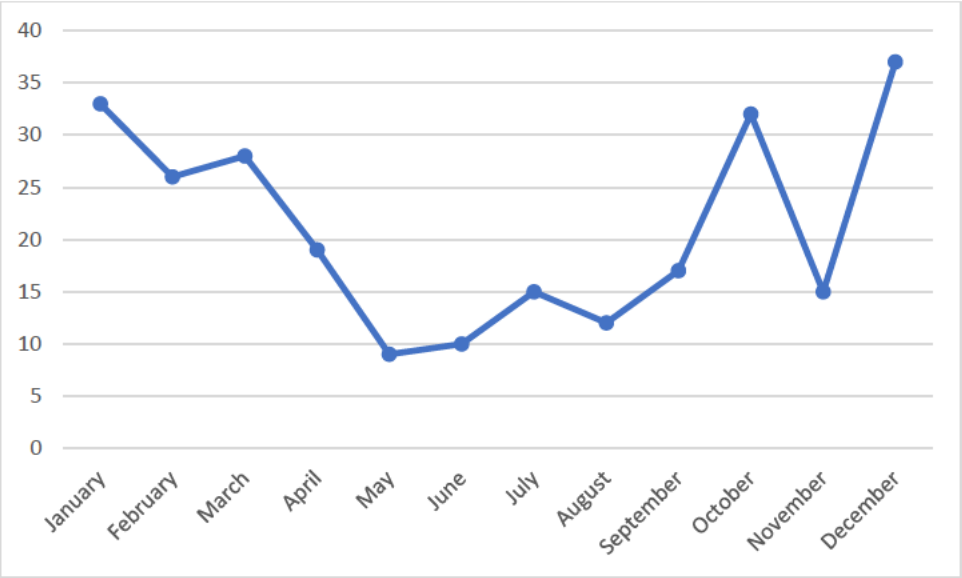

Figure 3. Number of drowning deaths by month (N = 253).

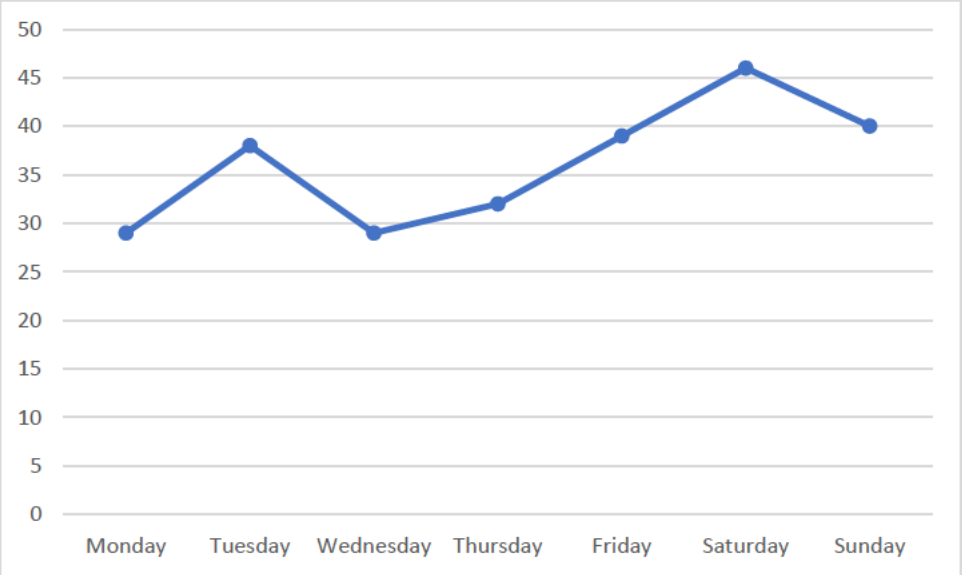

Figure 4. Number of drowning deaths by day of the week (N = 253).

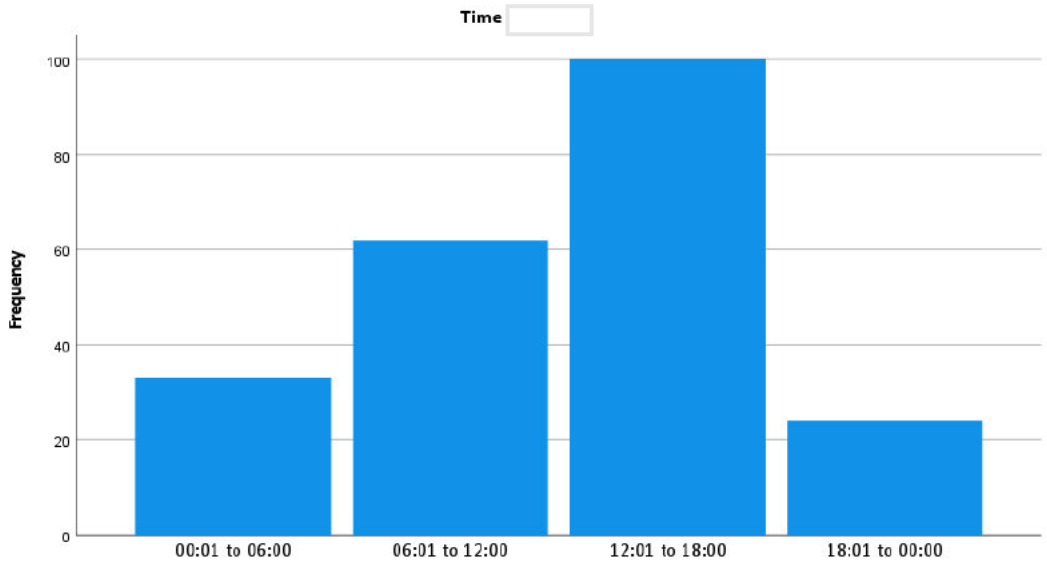

Figure 5. Drowning deaths by recorded time of day. It must be noted that the time of death and time of body recovery were frequently used interchangeably in police reports. 34 cases did not have time of death or recovery recorded. (N = 253)

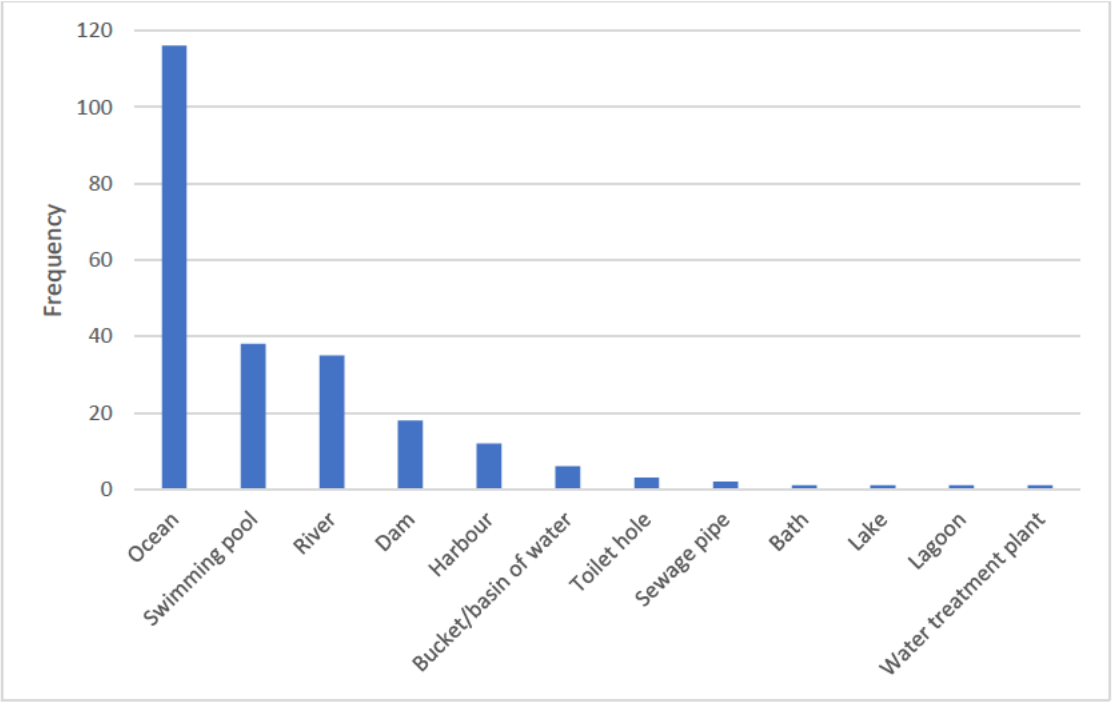

Figure 6a. Locations of drownings.

Note: 19 cases had no information regarding the body of water in which the victim drowned (N = 253).

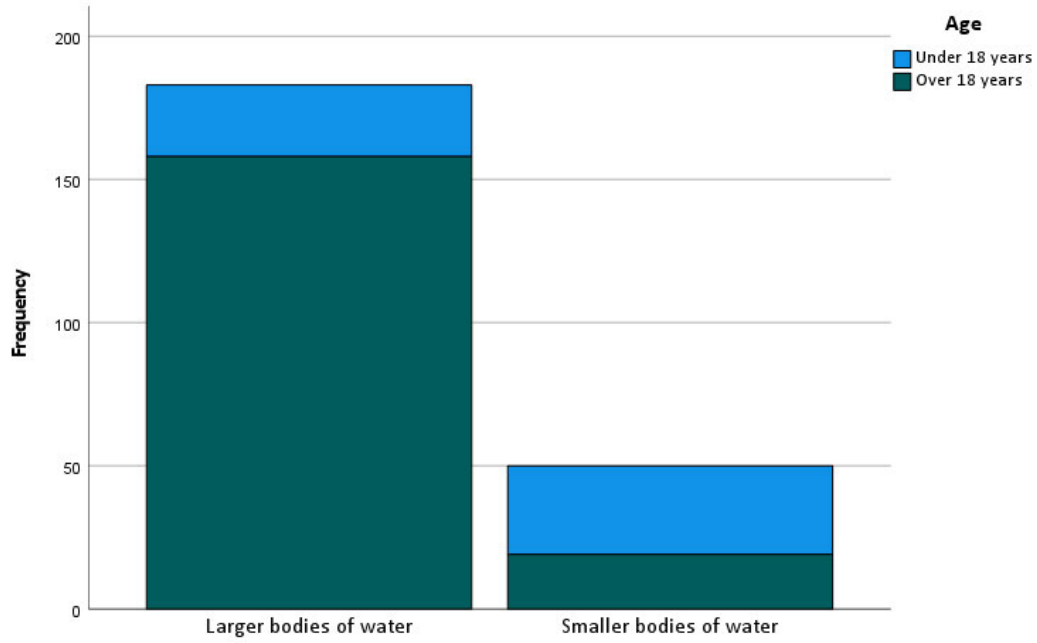

Figure 6b. Locations of drownings in those under and over 18 years of age (N = 253).

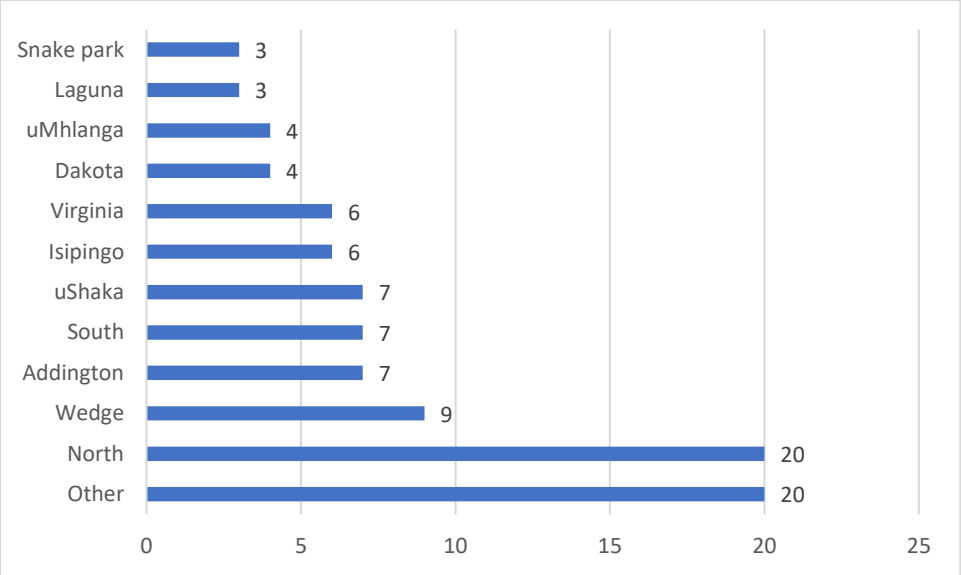

Figure 6c: Drownings at beaches in the Durban region specifically named in mortuary records. “Other” comprises Amanzimtoti, Ansteys, Bay of Plenty, Beachwood, Blue Lagoon, Bronze, Country Club, Cuttings, eThekwini, La Lucia, La Mercy, Tongaat, uMdloti and Westbrook beaches, at which two or less drowning deaths were documented at each beach. (N = 253)

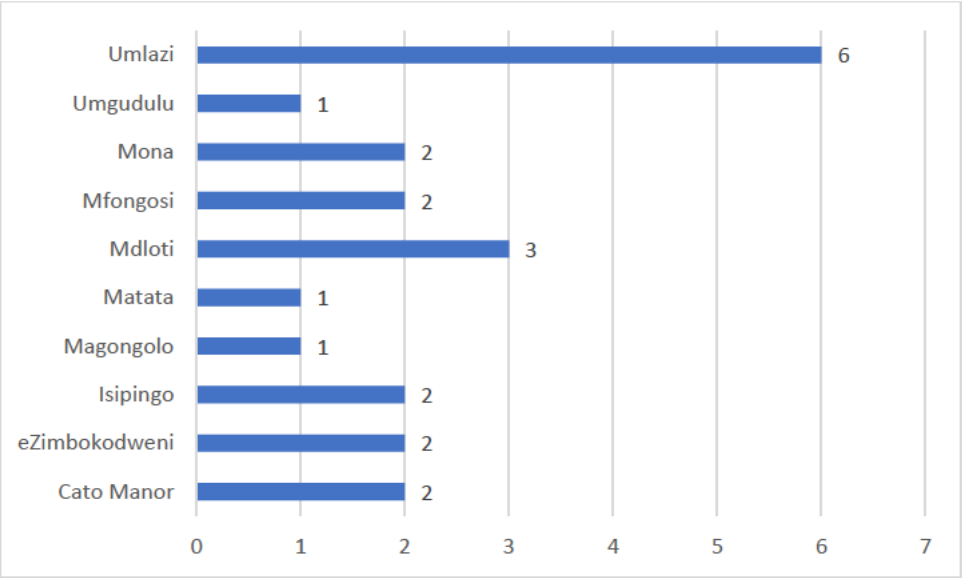

Figure 6d: Drownings at rivers in the Durban region specifically named in mortuary records. (N = 253)

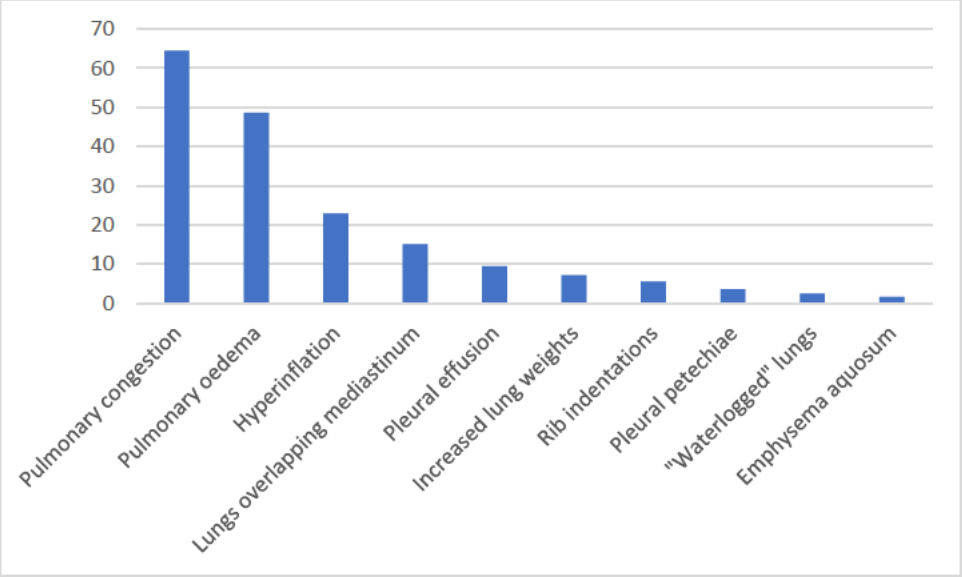

Figure 7a: Proportions (%) of cases displaying pulmonary features at postmortem (N = 253).

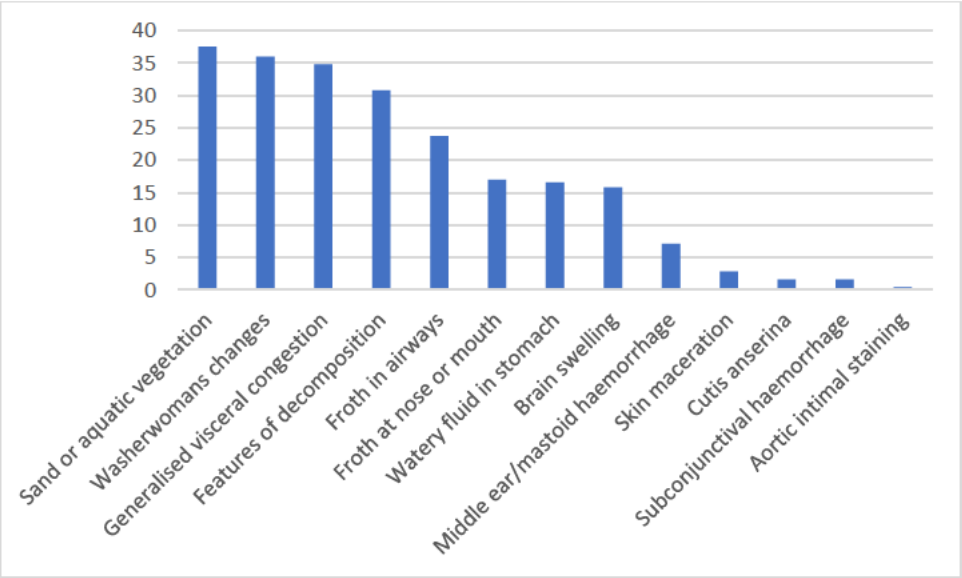

Figure 7b: Proportions (%) of cases displaying non-pulmonary features at postmortem (N = 253).

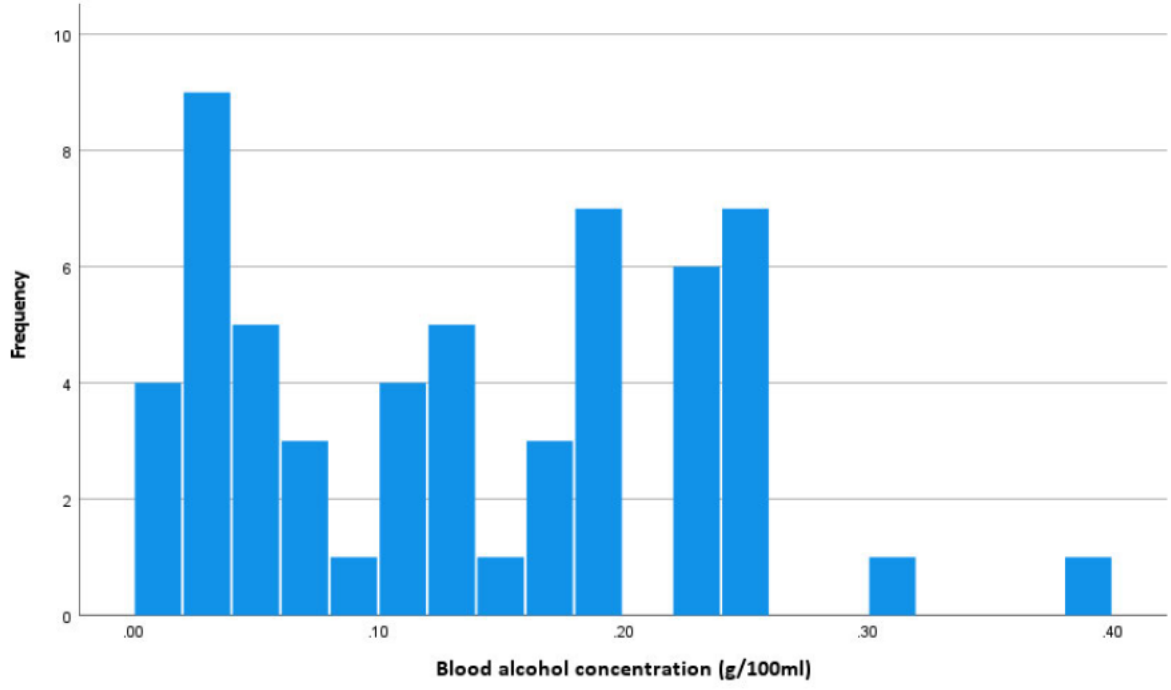

Figure 8. Histogram depicting BAC levels in victims with a positive BA test, indicating a non-normal distribution. Fifty-two victims had a BAC of 0.00g/100ml (N = 253).

Sex	N = 253(%)	
Male	215	(85%)
Female	38	(15%)
Population group*		
Black	210	(83%)
Asian	26	(10.3%)
Coloured	2	(0.8%)
White	14	(5.5%)
Age		
Less than 1 year	5	(2%)
1 to 5 years	25	(9.9%)
5 to 18 years	31	(12.3%)
18 years and older	191	(75.5%)
19 – 25	42	(16.7%)
26 – 35	76	(30.2%)
36 – 45	33	(13.1%)
46 – 55	18	(7.1%)
56 – 65	11	(4.4%)
66 and older	8	(3.2%)

Table 1. Demographic details (N = 253).

*One victim had no population group recorded and one had no age recorded

	Ocean	Harbour	River	Dam	Swimming pool	Bucket/ basin of water	Bath	Toilet hole/hole full of water	Other*
Less than 1 year	1 (20%)	0	0	0	1 (20%)	3 (60%)	0	0	0
1 to 5 years	0	0	0	0	15 (75%)	3 (15%)	0	2 (10%)	0
5 to 18 years	10 (35.7%)	0	8 (28.6%)	3 (10.7%)	5 (17.9%)	0	1 (3.6%)	1 (3.6%)	0
18 years and older	104 (57.8%)	12 (6.7%)	27 (15%)	15 (8.3%)	17 (9.4%)	0	0	0	5 (2.8%)
Total**	115 (49.4%)	12 (5 2%)	35 (15%)	18 (7.7%)	38 (16.3%)	6 (2.6%)	1 (0.4%)	3 (1.3%)	5 (2.1%)

Table 2. Number of drownings per age group in different bodies of water (%) (N = 253)

*In the 18 years and older category, one victim drowned in a lake, lagoon, and water treatment plant respectively, and two drowned in a sewage pipe

**Nineteen victims had no details recorded regarding the body of water in which they drowned, and one had no age recorded

4. Discussion

The aim of this study was to explore the factors surrounding drowning in Durban, a subtropical coastal city in South Africa, with regards demographic details, location of the drowning incident, date and time of drowning or body recovery, resuscitative efforts, "classic" pathology findings of drowning, antemortem pathology, postmortem pathology, decomposition, and results of ancillary tests such as blood testing for alcohol.

The mortuary case load in this study closely resembled that of Morris et al. who performed a similar study in Pretoria, an inland city of South Africa, who attributed 0.8 to 1.6% of their case load to drowning deaths, and the 2% of the San Diego County medical examiner's office in 2018.[10, 40] Few drowning studies report the proportion of overall mortuary caseload to which drowning can be attributed.

4.1 Age

The median age of victims in this study (28.5 years) was lower than that reported in similar studies from first world countries of Europe and North America, which showed mean ages ranging between approximately 43 and 53 years.[15, 19, 41-43] This may be attributable to South Africa's lower average age when compared to first world countries, or sociocultural differences in swimming and other water-related activities.[44] The median age in this study was also notably higher than that of the study by Morris et al. in Pretoria (16.3 years).[10] The current study showed a lower proportion of drownings in children (24.5% in those under 18 years) than expected from previous South African studies, which have consistently found high rates of drowning in children. The review of Saunders et al. reported an average of 43.2% of drownings documented in the NIMSS as occurring in children under 15 years.[13] Meel reported 54.6% of drowning cases in the city of Mthatha, Eastern Cape Province, South Africa, to be under the age of 20 years, while Morris et al. found that 55% of their sample was under the age of 18 years.[9, 10] In contrast to the inland cities of Pretoria and Mthatha, ocean bathing is very common in Durban and surrounding coastal towns and villages, with both locals and South Africans from inland areas visiting its beaches in great numbers, especially during the hot summer months. This may explain the somewhat older age of drowning victims in this setting. However, the seriousness that almost a quarter of drownings in Durban occurred in children should not be overlooked. A significant proportion of victims

under 18 years drowned in smaller bodies of water such as swimming pools, toilet holes, sewage pipes and buckets or basins of water when compared to adults. This corresponds to existing literature and highlights the need for an increased awareness of drowning risk around water sources and supervision of children in and around the home, and that barriers to access should actively be set in place.[2, 7, 10, 14] This study was unfortunately unable to ascertain detail of supervision prior to drowning deaths of children.

4.2 Body of water

The body of water in which drownings are most frequently reported varies by geography and depends greatly upon the major bodies of water in the studied area and their application. For example, approximately half of the sample in the current study drowned in the ocean, which is consistent with data from Denmark, whereas Clemens et al. in Canada reported the ocean as the site of death in only 9.6% of their study cohort, with lakes and rivers constituting around two thirds.[20, 43] Similarly, a recent study in Poland described the majority of drownings to occur in rivers (37%), with only a small proportion (5%) occurring at sea.[17] That more than two thirds of drownings in the current study occurred in larger open bodies of water is comparable with data from the Western Cape Province of South Africa, which contrasted findings from Pretoria where swimming pools were the major body of water in which victims drowned.[10, 12] This may be attributed to large natural open bodies of water being frequently used for bathing to cool off from Durban's hot and humid climate.[45] Only one out of the sample of 253 victims in the current study drowned in a bathtub. This emphasises the difference in bathing practices and access between Durban residents and those of first world countries, where bathtub drowning is of more significant incidence. This could be attributed to the frequent use of natural water sources and informal basins or buckets for bathing in place of regular bathtubs as a result of lower socioeconomic circumstances.[15, 20, 46, 47] These circumstances may also explain the deaths in this study attributed to drowning in toilet holes, as many residents do not have access to flushing toilets.

4.3 Sex

The marked male predominance in the current study's sample is consistent with both international and local data. This is attributed to many factors, including increased risk-taking behaviours, overestimation of ability to swim, and increased alcohol consumption in males.[7, 12, 14, 48].

4.4 Timing of drowning

According to the author's experience, the recorded times of death on the autopsy report can be misleading, as bodies retrieved from water may have their time of retrieval recorded as their time of death despite spending a prolonged period submerged. This detail is often not explicitly stated by officials at the scene of retrieval. In addition, postmortem intervals are infrequently estimated and documented, as bodies are generally removed from the scene of death and refrigerated prior to examination by the pathologist at autopsy, rendering death time estimation calculations such as the Henssge nomogram method highly inaccurate.[49]

The finding in the current study that drownings were reported to have occurred most frequently on weekends and in summer months is consistent with data from the rest of the country and the world.[7, 10, 12-20] That most drownings occurred in the afternoon between 12:00 and 18:00 corresponds with the findings in the Western Cape Province of South Africa and other low- to middle-income countries.[12, 48] An interesting contrast was made to the study of Hansen and Thomsen, which reported most of drownings in Denmark having occurred in the evening and at night, with almost 40% of drownings between 18:00 and 06:00.[43] The results from the current study should, however, be interpreted with caution because 13% of the sample had no time of death recorded.

4.5 Resuscitation and hospitalisation

A high percentage of victims in this study died at the scene of drowning, with a low rate of resuscitative efforts applied.[10, 18] This is comparable to the findings by Fang et al. in children in China, and is in contrast to findings by Morris et al. in Pretoria, South Africa. Notably, however, this study included only fatal drownings, and therefore excluded cases that were

resuscitated and survived, which are still classified as drowning cases according to the WHO definition.[1] The low rate of resuscitation likely reflects that many victims were dead long before they were retrieved from the body of water. The low rate may also speak to availability of witnesses trained or prepared to perform cardiopulmonary resuscitation. The reader is referred to statistics of non-fatal drowning based on media reports as recorded by Lifesaving South Africa, an organisation that provides ocean rescue services, whose detail therein is beyond the scope of the current study.[50] As in other data, the current study found a wide variation in duration of hospital admission in the small proportion of victims that were hospitalised prior to death.[10, 51]

A small percentage of cases in this study was found to have only adhesive electrocardiogram electrodes applied to the chest. This is unlikely to represent resuscitative measures having been applied, as it is a relatively common practice amongst paramedics used to confirm asystole in apparently dead victims.

4.6 Autopsy pathology

The postmortem diagnosis of drowning is a difficult one and constitutes a diagnosis of exclusion for many pathologists. It differs from the diagnosis of many other causes of death in that it has no pathognomonic features. The pathologist is expected to rely on a truthful circumstantial history, the exclusion of other causes of death, be they unnatural or natural, and the presence of a vague, nonspecific constellation of pathologies whose presence varies considerably according to a number of factors, including immersion time, decomposition, water temperature, postmortem predation by aquatic fauna, post-discovery resuscitation and interindividual variation.[21-25] The retrospective analysis of these features is further dependent on the consistency of which such features were recorded by the pathologist conducting the autopsy.[52]

Two of the most commonly reported pathologies associated with drowning recorded in the current study were pulmonary and generalised visceral congestion. While common and nonspecific, they were not frequently described in published studies of autopsy pathology of drowning deaths.

The finding of froth in the nose, mouth and airways is thought to be due to the admixture of air, water, bronchial secretions and surfactant. In this study, it was described as being present

at the nose and/or mouth in 17% of cases, and in the airways in 24%. These proportions were relatively comparable to findings described by Hansen et al. in Denmark, although notably less than those reported in other studies.[10, 23, 26, 42, 43, 52] This may be explained by the fragile nature of this pathology once it exists, as external froth can easily be washed away by water, may become lost during resuscitative efforts, or may disappear with increasing postmortem interval.[23, 24, 26, 42]

The prevalence of emphysema aquosum, a term used to describe hyperinflated, waterlogged lungs resulting in mediastinal overlap and rib indentations, is inconsistently reported in several drowning-related studies. Almost 95% and 33% of cases in studies from Germany and Pretoria, respectively, reported having this pathology. The current study found use of the term in only four cases (1.6%), whereas the above component parts of the entity were utilised in much higher frequencies. It is possible that pathologists prefer listing all the component features for clarity of reading by non-medical personnel, such as the magistrate holding the inquest into the death. It is equally plausible that this term was simply not familiar to the forensic pathologists who conducted autopsies on the bodies included in this study.

The infrequent finding (7.1%) of increased lung weights in the current study, in comparison to those of other countries, may be as a result of equipment failure in the current study and subsequent under-recording of lung weights.[26, 51, 52] In the author's experience, electronic scales for measuring organ masses were often unavailable or out of service during autopsies in the index mortuaries. However, the corresponding subjective macroscopic finding of pulmonary oedema was comparable to that of a study from the USA.[15]

Features of decomposition were recorded in 30.8% of cases – a figure comparable to that of the studies by Schneppe et al. and by Lunetta et al., but notably higher than in the Pretoria study of Morris et al. (4%).[10, 42, 52] This may be due to the differences in the intervals between death and body retrieval from water, which allow for more decomposition to occur. Retrieval of victims from the ocean may take longer than retrieval of victims from fresh water, an issue not experienced by inland cities. The presence of features of decomposition in bodies retrieved from the ocean was statistically significant in the current study (p <0.01). This finding is likely attributable to Durban's warm ocean temperatures and subtropical climate.[45]

4.7 Blood alcohol concentration

The 31.6% BAC positivity rate reported in the current study was at the lower end of the expected range, as most studies demonstrated positivity rates of between 30 and 70%.[7, 10, 15, 19, 20, 28, 29, 43, 53] When compared to results from South Africa, the proportion of victims with a BAC of more than 0.05g/100ml (69.6%) in this study fell between the 85% reported by Donson and Van Niekerk and the 35% reported by Morris et al.[7, 10] The testing rate was higher in the current study than that reported by Donson and Van Niekerk, however over two-thirds of results in the current study were unreported or blood samples had been rejected by the laboratory and were therefore unknown, which may be the source of significant sampling error.

The difference in BAC positivity between male and female victims was insignificant in comparison to the overwhelming majority of other studies. This may be accounted for by the small number of female victims in the present cohort, but also by indistinguishable alcohol-drinking habits and patterns between younger males and females observed in recent decades. Only three female cases indicated a positive BAC.[7, 15, 16, 19, 29]

The finding of a significantly higher median BAC in non-decomposed bodies than in bodies with features of decomposition was unexpected, as the literature suggests intrinsic alcohol production with putrefaction may increase BAC. Additional studies suggest, however, that postmortem blood dilution of immersed bodies may spuriously decrease the measured BAC.[54, 55] In addition, the possibility of sampling error is ever-present. The discussion of postmortem intrinsic ethanol production and degradation falls outside the scope of this study but may form the basis for future investigation.

4.8 Ancillary tests

The low rate of toxicological and histological investigation undertaken and reported in the current study may be accounted for by many interconnected factors, including but not limited to resource constraints, perceived helpfulness of testing by the attending pathologist, historical institutional practices, personal motivation of pathologists, and whether the deceased underwent a period of hospitalisation.

5. Limitations

Non-fatal drowning incidents were not included, as this study was mortuary-based. In addition, due to the nature of drowning deaths, it is possible that not all fatally drowned bodies were recovered, particularly from large bodies of water such as the ocean, and would have presumably decomposed entirely at sea. In addition, cases of drowning in which the body was too decomposed to comment on the cause of death may have been omitted from the sample. The studied numbers may therefore not truly reflect the magnitude of the drowning problem.

Insufficient information was a significant barrier in this study. In many cases there was insufficient information regarding the circumstances surrounding the deaths, including immersion time, the victims' ability to swim, the social context of immersion, eyewitness accounts, the use of safety devices such as lifejackets, the relation to torrential rains and flooding, and whether any adult supervision was present in the case of drowning of children.

The factors surrounding drowning deaths were not able to be fully explored in this study due to the lack of adequate circumstantial history and pre-existing medical records of victims, and inadequacy of appropriate ancillary investigations performed. This limited the in-depth examination to only that of demographic detail and macroscopic autopsy features. The incomplete nature of the postmortem investigation of these deaths attributed to drowning precludes a more definitive diagnosis for each victim, as the possible contributions of intoxication or an underlying medical disorder could not be excluded.

6. Recommendations

The finding that nearly half of victims drowned in the ocean in this sample highlights an urgent need for renewed focus on beach safety, with education and awareness as priorities. Particular attention should be paid to beaches in the city centre owing to their high rates of drowning (Figure 6c). Local by-laws regarding the use of designated safe swimming areas in fresh- and saltwater bodies of water at which trained lifeguards are on duty should be enforced. In addition, the use of life vests for watercraft passengers should be imposed.

Where local residents are unable to safely cross bodies of water without the risk of drowning, appropriately distributed infrastructure such as bridges should be constructed to allow safe passage.

Increased awareness of the dangers that smaller bodies of water, such as receptacles of water commonly found in and around the home, pose to drowning deaths is encouraged to reduce preventable drowning fatalities of children. The use of swimming pool nets and covers should be encouraged and enforced in private households.

More detailed information regarding drowning deaths across the country may identify or reiterate certain risk factors, allowing for targeted preventative measures to be set in place.

7. Conclusion

This study of the factors surrounding the drowning deaths of 253 people in Durban, South Africa, was able to find consistency with the majority of the extant literature, with some features setting it apart from studies elsewhere in the country, possibly due to its geographic and climatic differences.

The median age of drowning victims in this study was 28.5 years, with a 85% male predominance. Most drowning deaths occurred in 2016 (63 deaths). Drownings occurred most frequently on weekend days in the summer months of the year. The commonest body of water in which victims drowned was the ocean (49.6%), followed by swimming pools (16.2%) and rivers (15%). Two deaths in this study were reported as being due to suicide.

The most frequent external autopsy findings were water or aquatic vegetation on the body, washerwoman's changes of the hands or feet and features of decomposition. The most frequent internal autopsy findings were pulmonary congestion and oedema, generalised visceral congestion and froth within the airways. Thirty-one point six percent (31.6%, N = 56) of tested victims had a positive blood alcohol test, and 69.6% (N = 39) of these had a blood alcohol concentration of more than 0.05g/100ml. Toxicology and histology results proved non-contributory to the study

This study adds to the current knowledge base regarding drowning in South Africa and hopes to encourage further research in this area.

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CHAPTER 3
APPENDICES

Appendix A: Original Research Protocol

University of KwaZulu Natal
College of Health Sciences
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Factors surrounding drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, from 2014 to 2018

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Contents

Title of Study

Factors surrounding drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, over a ten year period from 2014 to 2018.

Aim of Study

To identify the factors associated with drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, over a ten year period from 2014 to 2018.

Objectives

1. To determine the demographics of people who die by drowning in the eThekwini district with regard to age, sex, race and location of drowning.
2. To identify any pattern in the timing of drownings with regard to seasonal, monthly or day-to-day variance, and survival period from the drowning incident.
3. To identify any risk factors for drowning (such as preexisting medical conditions, nutritional status, drug and/or alcohol use, additional contributing cause of death).
4. To ascertain what proportion of drowning deaths demonstrate 'classic' autopsy findings of drowning, and which the commonest of these are.
5. To ascertain the overall burden of drowning cases as a proportion of the total autopsies performed in the eThekwini district over the time period 2014 to 2018.

Background and Literature

Drowning is defined by the World Health Organization (WHO) as "the process of experiencing respiratory impairment from immersion/submersion in a liquid".[1]

Drowning is a significant cause of preventable deaths worldwide, causing the loss of 372,000 lives annually.[2] Drowning is the third leading cause of unintentional death, and comprises 7% of all unintentional deaths worldwide.[3] More than 90% of these unintentional drowning deaths occur in low- to middle-income countries, a category into which South Africa falls.[2] Drowning death rates in Africa are 15 times higher than in Germany and 20 times higher than in the United Kingdom. [3]

The eThekwini metropolitan district is one of eleven municipalities making up the KwaZulu-Natal province of South Africa and is the third largest municipality in South Africa. It is located on the east coast of the country; and includes the city of Durban and its surrounding areas. eThekwini had a population of 3,442,361 at the last national census in 2011, according to Statistics South Africa.[4]

The role of Forensic Pathology Services in the eThekwini district, as in the rest of the country, is to perform medicolegal autopsies on those who die of non-natural causes, to ascertain their specific cause of death. All cases of suspected drowning are therefore referred to Forensic Pathology Services by law.

Although research has been done into the epidemiology and factors surrounding drowning in South Africa, there is a paucity of data from our province - despite our coastal location, busy port, many rivers, and a significant number of drowning deaths being recorded in our mortuaries. Durban is included in studies very infrequently, the data collected is incomplete, and no studies on drowning deaths based on mortuary data have been undertaken. [5-10]

Burrows et al. found drowning to rank among the top three causes of fatal injury in all six of the major South African cities between 2001 and 2003. They noted that drowning was the top cause of death in both Tshwane (Pretoria) and Buffalo City (East London).[5] The study by Burrows et al. demonstrates data from more than fifteen years ago, and no study of its kind has been performed specifically in KwaZulu-Natal from mortuary data.

Donson and Van Niekerk reported an unintentional drowning rate of 2 per 100,000 in Durban between 2001 and 2005 based upon the South African National Injury Mortality Surveillance System (NIMSS), however conceded that the NIMSS captures only between 39 and 52% of the total number of fatalities in South Africa.[6] The proposed study aims to gather and analyse more complete data using medicolegal records, to demonstrate a clearer picture of the factors surrounding drowning deaths in the Ethekwini district. Meel recorded a mean drowning rate of 7.1 per 100,000 in the Mthatha area of the Eastern Cape, South Africa between 1993 and 2004, and Saunders et al. demonstrated a rate of 3.2 per 100,000 in the Western Cape between 2010 and 2016. [8, 10] Worldwide, however, the drowning death rates vary widely. Lin et al. recorded lowest rates in Turkey (0.12 per 100,000) and highest rates in Guyana (9.19 per 100,000).[11] Studies done in Canada and Singapore demonstrated far lower drowning rates, ranging from 0.57 to 1.74 per 100,000 and 0.88 to 1.72 per 100,000 respectively, while a study in the Philippines found a mortality rate of 3.5 per 100,000, comparable with that of Saunders in South Africa.[10, 12-14]

Morris et al. noted that 0.8 to 1.6% of the case load of the Pretoria Medicolegal Mortuary in Gauteng, South Africa, was drowning deaths.[9] The proposed study may demonstrate higher drowning rates due to the coastal location of the Ethekwini district, its many rivers, and warmer climate leading to increased water-related activities.

Donson and Van Niekerk noted that overall the highest drowning mortality rates in South Africa were noted in the 0-4 year age category (6.3/100,000), followed by the 5-14 year age category, which is in keeping with the global assessment of the WHO.[2, 6] Saunders et al. recorded a mortality rate of 4.8 per 100,000 in children under five years.[10] In high-income countries, the peak age of drowning tends to be older. [13, 15-18]

Fang et al. recorded significant differences between child drowning rates between rural (5.84 per 100,000) and urban (0.75 per 100,000) areas in Xiamen City, China.[19]

It has been globally documented that males significantly outnumber females in drowning deaths.[2, 13-16, 18-20] This has been attributed to many factors, including increased risk-taking behaviours and increased alcohol consumption in males. This male predominance is echoed in South African literature.[8-10] It is also noted that young adult men have been identified as a high risk group, with a mortality rate of 6.6 per 100,000 in males aged 25 to 29.[10]

In South Africa, it has been noted that drowning deaths tend to occur on Saturdays, Sundays and public holidays.[6, 10]

Drowning deaths tend to occur over the summer months, both in South Africa and worldwide, due to the increase in swimming and water-related activities.[6, 13, 16-19] Saunders et al. recorded a predominance of drowning deaths over the summer months of 42%. [10] Donson and Van Niekerk noted 15.8% of drowning deaths to have occurred in South Africa in December, followed by January (13.5%) and November (10.1%).[6] Morris et al. also recorded December as the commonest month for drowning deaths.[9] The proposed study may also confirm this trend due to increased aquatic related recreational activities in summer.

Drowning is a particularly challenging autopsy diagnosis, as it demonstrates no pathognomonic features at postmortem examination. The pathologist is confronted with only a limited constellation of nonspecific signs that must be used in combination with a suggestive history and the exclusion of other possible causes of death to conclude the diagnosis of drowning.

Autopsy features noted in the literature in drowning deaths include: sand, silt or aquatic vegetation on the skin; wrinkling of the skin of the hands and feet ("washerwoman's hands"); maceration of the skin; adipocere; emphysema aquosum; pleural effusions; pulmonary oedema; frothy fluid in the airways; increased lung weights; lungs overlapping the midline; rib indentations in lungs; subpleural petechiae; watery fluid in the stomach; a plume of froth at the nose and mouth; facial or subconjunctival haemorrhages; haemolytic staining of the aortic root intima; cutis anserina; middle ear and mastoid haemorrhages. [9, 17, 21-26] It is to be remembered, however, that many of these findings are non-specific to drowning, and some only features indicating immersion and not necessarily drowning itself.

The difficulty in diagnosing drowning is compounded by the frequent finding of decomposition in bodies retrieved from water, which can mask the commonly sought features through skin changes and organ autolysis, and preclude what is already a challenging diagnosis.[9, 17, 21, 24, 25, 27, 28]

Furthermore, attempts at resuscitation can intentionally or unintentionally remove some of the signs that may suggest drowning, such as the plume of froth at the nose and mouth.

Comorbidities are a further confounding factor, with features of natural disease found at autopsy not easily distinguishable as causes of death pre-immersion, causes of unconsciousness that could lead to subsequent drowning, or merely incidental findings. Common comorbidities adding particular difficulty to drowning diagnoses include seizure disorders and heart disease, including myocardial infarction, arrhythmias, and myocarditis. [13, 16, 28] Clemens et al. demonstrated that two thirds of drowned adults of the age of 65 or older in Canada had an accompanying chronic condition.[13]

The frothy exudate found in the airways and often at the nose and mouth is one of the more common characteristic findings at autopsy in drowning cases, however can be washed away with prolonged immersion and resuscitation, and is less likely to be found as the post mortem interval increases.[29]

Histological features are again nonspecific, however can assist to supplement the information gained at autopsy. Pulmonary features may include thin, compressed alveolar walls with dilated air spaces, fragmentation of elastic fibres and pneumocytes, vascular congestion, peribronchial or intraalveolar haemorrhage and a washout effect of alveolar macrophages. In the brain, cerebral oedema and hypoxic ischaemic encephalopathy may be identified. [24-26, 28]

Additional special investigations used in other countries to aid in the diagnosis of drowning include diatom analysis, measurement of levels of blood electrolytes and trace minerals such as sodium, chloride, calcium, magnesium and strontium, and immunohistochemical identification of aquaporins. None of these tests are perfect markers of drowning, however, and can only assist in increasing the level of certainty of a diagnosis of drowning. [24, 26, 28] Due to resource constraints, these investigations are not available in the laboratories in KwaZulu-Natal.

Studies from multiple centres worldwide have measured blood alcohol levels in drowning and have found a positive correlation. Alcohol increases the risk of drowning as it is associated with more high risk behaviours, as well as cognitive, neurological and physiological function.[30] Morris et al. in Pretoria demonstrated a 41% testing rate, with 42% of these testing positive for blood alcohol and 35% having a blood alcohol concentration of more than 0.05g per 100ml, the legal limit for driving in South Africa.[9] Donson & Van Niekerk found a positive blood alcohol result in South African drowning cases of 40%, and 85% at or above 0.05g per 100ml.[6] Positive blood alcohol results were found to be eleven times more frequent in males than females.[6] Pajunen et al. found a male to female ratio of positive results of 7.3, and 37.2% of tested individuals in Canada, 44% in Sweden, 47% in Maryland, 50% in New Zealand and 60.7% in Denmark had positive blood alcohol results. [15-17, 31, 32]

Drugs may be an under-investigated contributing factor in many cases of drowning. Pajunen et al. demonstrated a 26.7% drug positive rate in Helsinki, with some victims testing positive for up to seven different drugs, while Ahlm et al. found 40% of tested individuals positive for psychoactive substances. The commonest drugs found were benzodiazepines and antidepressants. 10% of individuals tested positive for illicit drugs.[15]

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Study Design

Quantitative, observational, descriptive, retrospective chart review.

Study Population

The study population comprises all people that have died due to drowning in the eThekwini district where a medicolegal autopsy has been performed in one of the three mortuaries in the eThekwini district between 2014 and 2018.

Sampling Strategy

The sampling strategy will be purposive – the sample will include all deceased individuals within the study population.

Paper and electronic databases of autopsies performed at the three medicolegal mortuaries will be used to identify potential eligible cases.

Statistical Planning

The variables that will be recorded are:

A. Demographics:
    a. Age in years
    b. Sex
    c. Race, categorized as per the SAPS 180 form into Black, Asian, Coloured or White
    d. Police station to which the case belongs
    e. Location at which the person was discovered
    f. Date and time of death (from which the day and season will be ascertained)
B. Comorbidity:
    a. Any known history of comorbidity
    b. Autopsy features of comorbidity
    c. Any known history of alcohol or drug use
    d. The nutritional status

C. Resuscitation/medical intervention
    a. Features of resuscitation found or reported
    b. Whether the person died at the scene, was declared dead on arrival at a health facility or was hospitalized
    c. If applicable, the length of hospital stay and any relevant details of the admission
D. Post mortem features of drowning or immersion
    a. Sand, silt or aquatic vegetation on the skin
    b. Maceration of the skin
    c. Washerwoman's hands or feet
    d. Cutis anserina
    e. Plume of froth at the nose and/or mouth
    f. Froth in the airways
    g. Emphysema aquosum
    h. Pleural effusion
    i. Pulmonary oedema
    j. Increased lung weights
    k. Lungs overlapping the midline
    l. Rib indentations in lungs
    m. Subpleural petechiae
    n. Watery fluid in the stomach
    o. Facial or subconjunctival haemorrhage
    p. Middle ear/mastoid haemorrhage
    q. Haemolytic staining of the aortic root intima
    r. Features of decomposition incl. adipocere
E. Laboratory investigations
    a. If blood alcohol levels were measured and the result
    b. If toxicological studies were done and the result
    c. If histological sections were taken and the result
F. The estimated post mortem interval (if stated)
G. The documented cause of death, and any underlying or contributory causes of death

Sample Size

The sample size is estimated to be between approximately 400 and 450 cases.

A sample size of 400 is required to estimate the proportion drownings by sex to within ± 7% with a baseline probability of 50% and probability of 95%. Data will be collected over a five-year period from the three medicolegal mortuaries in the Ethekwini district of KwaZulu-Natal, South Africa. An additional year may be included to reach the required sample size. Sample size was calculated using Stata V13.1.

Inclusion and Exclusion Criteria

Inclusion Criteria

All people that have died in Ethekwini due to drowning and where a medicolegal autopsy has been performed at one of the three medicolegal mortuaries within Ethekwini from 2014 to 2018.

Exclusion Criteria

Cases in which the autopsy report is incomplete or unavailable at time of data collection.
Cases retrieved from water but confirmed as having a cause of death other than drowning.
Cases where the circumstances of death are not clear or apparent.
Cases where important information is missing or unavailable.
Cases performed at eThekwini mortuaries done as referral cases from mortuaries outside the eThekwini catchment area.

Data Collection Methods and Tools

The method used will be chart review/case audit of all the cases of drowning that occurred in the eThekwini district over a five-year period where a medicolegal autopsy has been performed at a medicolegal mortuary in the Ethekwini district of KwaZulu-Natal, with collection of data with regards to different factors and characteristics of each case.

A data collection sheet will be used as a tool to capture the relevant variables. (See appendices) Data will be captured from the data collection sheets into a spreadsheet. The spreadsheet will comprise multiple categories based upon the documented variables from the data collection sheet, some of which will be continuous, some binary, some categorical and some descriptive.

Each drowning case will be considered an entity, which will contain various attributes (study number, age, sex, date of death, mortuary at which autopsy performed, comorbidities, etc) which may in some cases be broken down into further composite attributes (eg. day, month and year of death). These will be the fields comprising the spreadsheet. The spreadsheet will then be populated with the collected data and analysed from there.

Data Analysis and Statistical Techniques

Descriptive statistics will be used to summarize the data. Frequency and percent will be used for categorical data, such as sex and race. Frequency distributions of numeric data will be examined for normality and means or medians used as appropriate. Subgroup comparisons, for example between sex and race, will be done using Chi square statistics. Comparison of age by other demographic variables will be done using t-test or Mann Whitney as appropriate. The incidence of drowning deaths per year will be calculated and Poisson regression will be used to compare the incidence rate ratio (IRR). Data will be analysed in Stata V13. Data will be analysed and presented in tabular or graphical form where appropriate.

Study Location

Cases will be sourced from the three Forensic Pathology Services medicolegal mortuaries in the eThekwini district of KwaZulu-Natal, South Africa (Gale Street, Phoenix and Pinetown), and data will be collected and analysed at the Department of Forensic Medicine, Inkosi Albert Luthuli Central Hospital.

Study Period

The study will comprise all drowning cases from 1 January 2014 to 31 December 2018.

Limitations

Due to the nature of a retrospective descriptive study, this study will not be able to correlate variables with outcome, or determine cause and effect.

Often information provided from the South African Police Service when a body is brought to a medicolegal mortuary for autopsy is very scanty, therefore the exact circumstances and events surrounding drowning incidents are not often known. As these cases will have occurred some time in the past, limited opportunity will be available for questioning those with knowledge of these circumstances and events.

Although analysing the data from the eThekwini district will be able to provide an idea of the situation in other areas, the results from this study will only be able to be compared to other areas, and not generalised.

This study will rely on the accurate and thorough record-keeping of the doctors working in Forensic Pathology Services during the study period whose postmortem reports will be reviewed and from which data will be collected.

Special investigations to assist in drowning diagnosis such as diatom analysis and immunohistochemical staining are not available in South Africa, thus none of the studied cases will have the benefit of a positive result to aid in confirming their diagnosis. This should not affect this study, however, as these are uniformly unavailable in our setting, and found to be only assistive in the diagnosis of drowning, which is made largely based on macroscopic autopsy findings and suggestive circumstantial evidence.

Ethical Considerations

The main ethical consideration in this study will be the maintenance of confidentiality of the identities and details of the deceased individuals whose files and postmortem reports will be reviewed. No ethical issues with regards to confidentiality are anticipated.

As per Forensic Pathology Services protocol, all individuals admitted to a medicolegal mortuary are assigned an individual postmortem number, and in general the name of the deceased does not appear upon their postmortem report. The names, identification numbers and details of the deceased are found on the DHA 1663 Notification of Death form, identification forms and police documents, copies of which are kept in the file of the deceased. After review of the postmortem report and file of a deceased individual by the principal investigator only, relevant variables will be recorded onto a data sheet and a unique study number assigned. Thereafter the individual will be anonymized and identified only by their study number. Non-specific identifying information such as age, sex and physical identifying characteristics may be recorded.

The files and postmortem reports will be stored for the duration of the study in a lockable filing cabinet in a locked office at the Department of Forensic Medicine, Inkosi Albert Luthuli Hospital.

No consent is required from the studied individuals, only from the head of department who will allow access to the files of the deceased.

Another consideration is that of benefit to the community upon completion of the study. The study findings may highlight certain risk factors or areas where drowning prevention strategies can be implemented, thus bringing value to the population of eThekwini.

Appendices

Appendix A – Data collection sheet

Appendix B – Gatekeeper permission

Appendix B: Gatekeeper Permission Letter

UNIVERSITY OF KWAZULU-NATAL

health

Department:
Health
PROVINCE OF KWAZULU-NATAL

Dr SJ Ntsele

Head of Clinical Unit - Forensic Pathology Services

KwaZulu-Natal Department of Health

21 June 2019

RE: PERMISSION TO PERFORM RESEARCH AT GALE STREET, PHOENIX AND PINETOWN MORTUARIES, FORENSIC PATHOLOGY SERVICES, DURBAN.

Dear Dr Ntsele

I would like to request permission to perform research towards the MMed (Forensic Pathology) degree through the University of KwaZulu-Natal at the three mortuaries in the eThekwini district. Biomedical Research Ethics Committee (BREC) approval is pending, and a requirement is gatekeeper permission.

The research is titled '*Factors surrounding drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, from 2014 to 2018*,' and will be a descriptive, retrospective review of post-mortem reports from that period.

The post-mortem reports and files of all drowning deaths that have been autopsied at Gale Street, Phoenix and Pinetown Mortuaries from 1 January 2014 to 31 December 2018 will be reviewed. Permission is requested for release of the relevant post-mortem files to the principal investigator, for the study period.

Once these post-mortem files have been obtained, they will be temporarily stored in an office with lockable filing cabinets and a locked door for the duration of data collection. As soon as data collection is complete the files will be immediately returned to their respective archives.

The reports and files will be reviewed by the principal investigator only. A data collection sheet will be filled on review of a file, and a study number will be allocated in that order. Thus confidentiality will be maintained during processing of data, and any research output will not contain any identifiers maintaining confidentiality.

No ethical issues are anticipated.

Please see attached research protocol and data collection sheet.

Many thanks

[redacted]

Dr Saxony Olivier

Registrar, Forensic Pathology Services
HPCSA registration number: MP 0803111
University of KwaZulu-Natal student number: 218085976
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UNIVERSITY OF KWAZULU-NATAL

health

Department:
Health
PROVINCE OF KWAZULU-NATAL

GATEKEEPER PERMISSION TO PERFORM RESEARCH AT GALE STREET, PHOENIX AND PINETOWN MORTUARIES, FORENSIC PATHOLOGY SERVICES, DURBAN.

This is to confirm that Dr Saxony Olivier may proceed with the proposed research project entitled *'Factors surrounding drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, from 2014 to 2018'* for purposes of the MMed degree in Forensic Pathology through the University of KwaZulu-Natal.

Permission granted ✓	**Permission denied**

[redacted]

Dr SJ Ntsele

25/06/2019

Date

Appendix C: Data collection tool

Factors surrounding drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, from 2014 to 2018

Data Collection Sheet

Study number		Mortuary		PM number	

Demographic info

Age		Sex		Male		Female	
Race	Black		Asian		Coloured		White	
Police station		Place of death					
Date of death		Time of death					

Comorbidity

Known comorbidity	
Autopsy features of comorbidity	
Known alcohol/drug user	
Nutritional status	

Resuscitation/medical intervention

Features of resus					
Died on scene		Dead on arrival at hospital		Hospitalised	
Length of hospital stay		Detail			

PM Features

Sand/aquatic vegetation		Skin maceration		Washerwomans hands/feet	
Cutis anserina		Plume of froth at nose /mouth		Froth in airways	
Emphysema aquosum		Pleural effusion		Pulmonary oedema	
Increased lung weights		Lungs overlapping midline		Rib indentations	
Subpleural petechiae		Watery fluid in stomach		Facial/subconjunctival hge	
Middle ear/mastoid hge		Aortic intimal staining		Features of decomposition	

Laboratory Investigations

Blood alcohol tested		Result	
Toxicology done		Result	
Histo taken		Result	

PMI

Estimated PMI (if stated)	

Cause of death

Appendix D: BREC Approval Letter for Original Research Protocol

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

11 September 2019

Dr Saxony Olivier (218085976)
School of Lab Med & Medical Sc
Medical School

Dear Dr Saxony Olivier,

Protocol reference number: BREC/00000094/2019
Project title: Factors surrounding drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, from 2014 to 2018
Degree: MMed

Full Approval (Expedited Application)

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 28 June 2019.

Please ensure that outstanding site permissions are obtained and forwarded to BREC for approval before commencing research at a site.

This approval is valid for one year from **11 September 2019.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be **noted** by a full Committee at its next meeting taking place on **08 October 2019.**

[redacted]

Prof V Rambiritch
Chair: Biomedical Research Ethics Committee

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Appendix E: Approved Amendment to Original Research Protocol

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

12 August 2022

Dr Saxony Olivier (218085976)
School of Laboratory Medicine and Medical Science
Medical School

Dear Dr Olivier,

Protocol reference number: BREC/00000094/2019
Project title: Factors surrounding drowning deaths in the eThekwini district of KwaZulu-Natal, South Africa, from 2014 to 2018
Degree: MMed
New Title: Factors surrounding drowning deaths in Durban, South Africa, over a five-year period.

We wish to advise you that your application for amendments (listed below) received on 10 August 2022 for the above study has been **noted and approved** by a sub-committee of the Biomedical Research Ethics Committee.

Amendments noted and approved"

1. That records from only two mortuaries will be included, with a sample size of 253.
2. Change of title to the above new title.

The committee will be notified of the above approval at its next meeting to be held on 13 September 2022.

Yours sincerely

[redacted]

Ms A Marimuthu
(for) Prof D Wassenaar
Chair: Biomedical Research Ethics Committee