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AN OBSERVATIONAL RETROSPECTIVE AUDIT OF PATIENTS PRESENTING TO A PRIVATE HOSPITAL GROUP DURING SPECIFIC TIMEFRAMES BEFORE, DURING AND AFTER THE COMRADES MARATHON OVER AN 8-YEAR PERIOD

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the degree of Master of Medicine in Emergency Medicine

Johannesburg, 11 June 2023

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

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Dedications

This work is dedicated to all the prehospital healthcare providers in the world of sport, that themselves dedicate their time and skills to allow our athletes to not only have fun and relax in a safe environment, but also to keep on pushing against boundaries set by ignorance, to improve on our understanding of human capabilities and to enhance the field of sports medicine. Keep up the excellent work.

Abstract

Introduction: This study examined the impact of the Comrades Marathon (CM) on the presentation of patients to the emergency departments (EDs) of a CM sponsoring private hospital group over an 8-year period.

Methodology: A retrospective, quantitative secondary database analysis of all patients presenting to the designated EDs during 3 defined timeframes: a 48-hour weekend one week before the CM; a 48-hour period spanning over the CM; and a 48-hour weekend one week after the CM.

Results: There was an increase in ED presentations during the CM timeframe compared to the weekends before and after the CM. There was a relatively greater increase in the CM female patient presentations (49.45%) compared to the registered number of female CM athletes (20%). All the EDs indicated an increased number of patient presentations during the CM “Up-run” years compared to the CM “Down-run” years (5 638 vs. 4 487, p-value 0.013). Musculoskeletal medical encounters appeared more common during the “Down-run” races (30.44% vs. 26.37%, p-value 0.318), with gastrointestinal (15.62% vs. 17.62%, p-value 0.043) and respiratory (11.99% vs. 13.25%, p-value 0.045) medical encounters more common during “Up-run” races. Fatigue (54.25% more common) and Electrolyte & Fluids (81.85% more common) medical encounters were common during the CM timeframe compared to both the Before and After timeframes.

Conclusion: Epidemiologically, the CM “Up-run” and “Down-run” may present with two distinct clinical profiles, due to the different elevation nature of the CM, and not as a single race. Limitations related to the retrospective nature of this study makes comparability with other studies difficult.

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Acknowledgements

This study could not have been done without the assistance of so many:

First and foremost, God our Saviour, for instilling in me the burning desire to take on this monumental task.

My phenomenal wife, who stood by my side through incredibly challenging times and provided an unquantifiable amount of support, and who rejoiced much louder than me when this study was completed.

My 2 dear children, who at the time did not understand why I couldn't play with them as often as a dad should, even when I was home.

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The private hospital group, and specifically the database manager, for allowing me to use data from their database, and with assisting me to extract data from the database.

Stuart Mann, creator of the website www.runningmann.co.za and multiple Comrades Marathon finisher, who helped me, a non-Comrades Marathon runner, to understand the intricacies of the 'Ultimate Human Race'.

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Abbreviations and Glossary

ACS – Acute Coronary Syndrome

ALS – Advanced Life Support

ASA – Athletics South Africa

BC – Before Christ

CM – Comrades Marathon

CNS – Central Nervous System

EAMC – Exercise Associated Muscle Cramps

ED – Emergency Department

EDs – Emergency Departments (plural)

EMS – Emergency Medical Services

ICU – Intensive Care Unit

KM – Kilometre

KZN – KwaZulu-Natal

RSV – Respiratory Syncytial Virus

WBGT – Wet Bulb Globe Temperature

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Chapter 1: Introduction and Literature Review

1.1 Introduction

This research report concerns itself with the patient presentation, to a group of private hospital emergency departments, during a fixed period, before, during and after the Comrades Marathon®. As will be shown, marathon events have a propensity to cause acute illnesses and injuries that results from the exercise undertaken during the event. Athletes who develop medically related issues during a marathon are treated either onsite where the medical event occurs, or at a medical post along the marathon route, at the end of the event medical tent or at the designated emergency departments in and around the marathon area.

This chapter, the literature review, intended to describe the current and relevant historical, English, published scientific and associated literature and media concerning the issue of acutely injured or ill athletes, or other persons related to the marathon, namely race staff, spectators, security personnel etc., presenting to the nearby EDs and thus potentially overwhelming such departments, during or immediately post the marathon. After a thorough search of the online English scientific literature, using Google, Google Scholar, PubMed, Ovid, Scientific Direct, Medline, and Scopus, only a single publication, namely "*Presentations of runners in Kong Kong [sic] Marathon to a local ED: a 10 years' glance*" published in the Hong Kong Journal of Emergency Medicine[1] was found. All other publications and media references concerning the acute medical management of athletes during marathon and ultra-marathon races, are directed to the logistics and operational aspects of onsite medical posts or tents. This scarcity of internationally published scientific publications regarding research into the effects of the acutely ill or injured marathon athlete on nearby emergency departments was sorely lacking, making a standard type of literature review impossible.

As a result of this paucity of medical literature, this literature review chapter include a detailed description and explanation concerning the following to deduce the possible impacts an ultra-marathon might have on emergency departments:

- The CM
    - Origin and historical perspective
- The Marathon and Ultra-marathon race
    - Characteristics and unique features
    - Participants: athletes and para-athletes
    - Medical logistics: onsite medical post and medical tent
    - Environmental conditions: altitude, humidity, temperature
    - Medical conditions: predicted and transpired. This section will be able to draw from the current medical literature of acute illness and injuries that have occurred during international marathons and ultra-marathons and treated mostly onsite.

1.2 Running: A Basic Human Function

Humans are the only primates capable of endurance running and can do so more efficiently than any other mammal due to several anatomical, physiological, and behavioural adaptations. There are several hypotheses regarding why humans developed the ability to run, but irrespective of the driving force behind this evolutionary change, at present, they mostly run for exercise and recreation[2]. There are still some present-day hunter-gatherer tribes that can perform up to 16 kilometres of running per day, with appropriate resting days after strenuous days[3]. The Tarahumara are a group of Native American people renowned for their exceptional endurance, with observational reports claiming they run distances of up to 170 miles (273 kilometres) without stopping and others claiming they run 65 miles (104 kilometres) without showing any signs of fatigue[4,5].

1.3 Pushing Boundaries: A Basic Human Need

For some, the boundaries of endurance running are meant to be explored and several different races have developed. At the most basic, races are classified according to distance. A marathon has a standardised distance of 42.195 kilometres (commonly abbreviated to 42.2 kilometres), the distance from the lawn in front of Windsor Castle, England to the royal box in White City Stadium, England, as was run in the London Olympic Games in 1908[6]. Any race with a distance more than 42.195 kilometres is classified as an ultramarathon. Such races commonly include 50

kilometres or 50-mile single day events, and longer distance single day or multi day events, with a 5 000 kilometres 52-day event currently being the longest ultramarathon in the world[7].

1.4 The Marathon

The concept of a competitive long-distance run is a relatively new idea and was not part of the Ancient Olympic Games. The only athletic event at that time was a 600-foot (182 metre) foot race[8]. The first competitive Marathon was run in 1896 during the first modern day Summer Olympic Games in Greece, an idea conceptualised by Michel Bréal, friend of Pierre de Coubertin, founder of the International Olympic Committee and father of the modern-day Olympic Games[9]. It is believed that the Marathon is named after the legendary run made by Pheidippides. Several versions to the legend exist based on different historical records. According to most records, he ran approximately 40 kilometres from the town Marathon to Athens to deliver news of Greece's victory over the Persians at the Battle of Marathon and/or to warn of a possible invasion by the Persians in 490 BC, and then died after delivering the message[6,9,10].

1.5 The Farther the Distance, the More Popular the Race

More people today are taking up the sport of running, although participation in marathon and sub-marathon distances peaked in 2016[11]. Ultramarathon participation has continued to increase every year[12]. The ability to run is part of human development and does not require special training or skill to perform, and is not limited to any gender, age group or a certain body habitus[3]. Running is convenient, as it can be performed almost anywhere: the road, sidewalk, a park, on the beach, hiking trails or even one's backyard and entry into the sport is at a low cost, as one only needs a pair of running shoes, although some argue that is optional[3,5,13]. With non-communicable disease on the rise, many people run to improve their health and wellbeing. Many people enjoy running as a social activity. South Africa is home to 6.7% of the world's ultramarathon athletes, ranking South Africa third behind France (12.4%) and the United States of America (12.1%)[12].

1.6 The Comrades Marathon®

The CM is one of the oldest and largest ultramarathons in the world and has been run yearly between Durban and Pietermaritzburg in South Africa's KwaZulu-Natal Province, since 1921[14,15]. The race is held during the months of May and June annually, with few exceptions, due to various external factors beyond the control of the race organisers. The CM did not take place for 5 years from 1941 until 1945 during the Second World War[16]. The race was cancelled in 2020 and 2021 due to the worldwide Covid-19 pandemic. As South Africa entered its first Covid-19 wave, the race organisers were reluctant to cancel the CM, but instead opted to postpone the race to a later date. This led to the CM not taking place for 2 years during the worldwide Covid-19 pandemic[17].

The date set for the CM has been changed over the years. The race was initially held on the 24th of May, which was celebrated as Empire Day, and later renamed Victoria Day when Union of South Africa was a British colony. In 1952, the race date was moved to fall on the Queen's birthday, the 14th of July. In 1962, after the Republic of South Africa came into existence as an independent country, the race day was moved to the 31st of May, the day of independence, named Republic Day[18,19].

After 1994, with the advent of the new Constitution in South African and abolishment of Apartheid, the CM was moved to the 16th of June, named Youth Day, because of the significance of that date historically, when the youth of Soweto began their active resistance against Apartheid policies. This lasted from 1995 until 2007[18,19]. Currently the CM is set to occur on a Sunday in May or June without it being associated or linked to any specific national holiday.

The race has certain specific entry requirements. Firstly, the athlete must participate in an Athletics South Africa, technically compliant, marathon or ultramarathon within a pre-set time, as published on the official CM website. This initial qualifying criterion changed to become more stringent for the 2019 CM, requiring athletes to finish within a shorter time limit to qualify for the CM. However, qualifying times for 89km and 100km events remained unchanged (Table 1). Any athlete that had completed a

recognised triathlon e.g., Ironman® triathlon (which consists of 3.8-kilometre swim, 180-kilometre cycle, and a 42.2-kilometre running components), would also qualify for the CM, irrespective of the finishing time[20].

Table 1 - Qualifying times for the CM according to qualifying race distance.

Race distance	Qualifying times pre-2019	Pre 2019 pace (min/km)	Qualifying times 2019 onwards	2019 onwards pace (min/km)
42,2km	05:00:00	00:07:07	04:49:59	00:06:52
48-50km*	06:00:00	00:07:30	05:49:59	00:07:17
52-54km*	06:30:00	00:07:30	06:24:59	00:07:24
56km	07:00:00	00:07:30	06:44:59	00:07:14
60km	07:40:00	00:07:40	07:19:59	00:07:20
64km	08:20:00	00:07:49	07:54:59	00:07:25
68km			08:29:59	00:07:30
80km	10:40:00	00:08:00	10:24:59	00:07:49
89km	12:00:00	00:08:05	11:59:59	00:08:05
100km	13:30:00	00:08:06	13:29:59	00:08:06

*The shorter distance was used for the calculation.

Data from the Comrades Marathon Rules and Information page[20].

Secondly, the athlete must be 20 years or older on CM race day[20]. Interestingly, this was not always an entry requirement, with the youngest winner of the CM being Phil Masterton-Smith who crossed the finishing line at 19 years of age in 1931. In recent times, the youngest participants are those celebrating their 20th birthday on race day[21].

1.7 CM Participant Limitations

CM participants include a range of athletes, who register for participation at the CM and who, as a result, may potentially experience a range of medical and health related issues.

These include:

- Adults with a minimum age of 20 years with no upper age limit, thereby including geriatric athletes.
- Pregnant athletes
- Para athletes using crutches or wheelchairs, visually impaired etc.

1.7.1 Age

There is currently no maximum age for participation in the CM[20]. The oldest athlete to complete the CM each year is rewarded by having their name added to the Founders' Trophy[22]. One of the oldest persons ever to complete the CM within the allotted time was Vernon Jones at the age of 80 years in 2016[23], a feat only done once before in 1989 by Wally Hayward[24]. This is 20 years younger than Fauja Singh, who, by the age of 100-years, stunned the world by shattering several records in multiple age brackets as a marathon runner. Singh has completed the London marathon six times after making his debut there in 2000 at the age of 89, and has since finished marathons in Toronto, New York, and more cities, the last one at the age of 100 years[25]. In a study by McKean, Manson and Stanish, to determine if injury patterns and risk factors for injury differ between Masters *(older than 40 years*) and younger runners, it was found that Masters runners were injured more than younger runners ($P<0.05$) and more Masters runners suffered multiple injuries than younger runners ($P<0.001$)[26]. Additionally, Masters athletes, unlike their younger counterparts, are more likely to present with chronic comorbid medical conditions such as hypertension, asthma, congestive heart failure and aortic stenosis[27].

1.7.2 Pregnancy

Pregnant women may also participate in the CM, with there being no medical pregnancy-related restrictions published on the official CM website[20]. Recommended medical guidelines suggest that pregnant women should aim to achieve at least 150 minutes of moderate-intensity exercise per week throughout their pregnancy[28].The guidelines do not mention any specific gestational age when these exercises should to be ceased, but rather list several medical contraindications to moderate exercise in general, some of which are related to the gestational age of the pregnancy or placenta praevia after 28 weeks of gestation[28]. Without any specific

contraindications, it appears acceptable to continue moderate exercise until the onset of labour[29]. The level of intensity of the exercise is based on heart rate of the person doing the exercise, and this will not be the same for every woman[28]. Very little has been published concerning exercising above these recommended levels, other than to consult an obstetric care provider. There are very few publications covering pregnancy in the elite athlete, most of which are limited to reviews and expert opinion[30–32], and most conclude that there is no firm evidence to suggest that participation in elite-level sport has led to adverse outcomes of pregnancy. Some studies found that strenuous exercise during the first trimester may increase the risk of miscarriage[33], while others did not show this correlation[32,34]. Most female long-distance athletes appear to reduce the intensity of their regular exercise during pregnancy, with a third (30.9%) continuing to run into their third trimester[35]. A factor that may impact in pregnancy in exercise is relaxation of ligaments and joints, especially in late pregnancy, after 28 weeks. Resultant instability may occur, which if not adequately adapted, have let to anecdotal incidents leading to serious injuries[36]. Additionally, few studies have identified a potential tendency for injury in elite athletes in the postpartum period, specifically a risk for stress fractures[37].

1.7.3 Para athletes

There is no mention of any requirement or CM rule prohibiting Para athletes from participation in the CM, except initial approval by the CM race organisers[38]. Para athletes are classified into sport-based categories based on their impairment as stipulated by the International Paralympic Committee[39]. The first Para athlete to successfully complete the CM wearing a leg prosthesis occurred 1996. In 2018 an amputee Para athlete successfully completed the CM with the assistance of crutches, with an approved "*5 hours earlier start handicap*" than the official race starts[40]. In 2016, two cerebral Para athletes, one diagnosed with cerebral palsy and the other diagnosed with spastic diplegia, participated in and successfully completed the CM. These Para athletes were "*assisted wheelchair*" athletes, which required them to be partnered with able-bodies athletes who would push their wheelchairs for the entire race[38]. The first self-propelled wheelchair Para athlete participated and successfully completed the CM in 2017[41]. Recently, Louzanne Coetzee took part in the Two Oceans Marathon 21.1km race on April 16, as a pacer for runners aiming to break two hours for the distance. Additionally, Coetzee, 28, won silver in the

women's 1500m T11 and bronze in the Marathon T12 at the Paralympic Games in Tokyo in 2021. Coetzee competes in the T11 category for athletes with the highest level of visual impairment[42,43]. No doubt she will be heading for the CM. The inclusion of Para athletes introduced a separate set of potential medical complications into the CM ultramarathon, like those evident in current international Para athletic sporting events[44,45].

1.8 The CM: part of South Africans' identity

Although the race is open to runners from all over the world, the CM is primarily a South African race. The number of international entries is capped, and most CM runners are South African citizens (19 817 of the 21 625 runners in 2019)[46,47]. The CM attracted between 19 545 and 24 594 entries per race over the last 10 years, with 80% of the athletes successfully finishing the race[16,48].

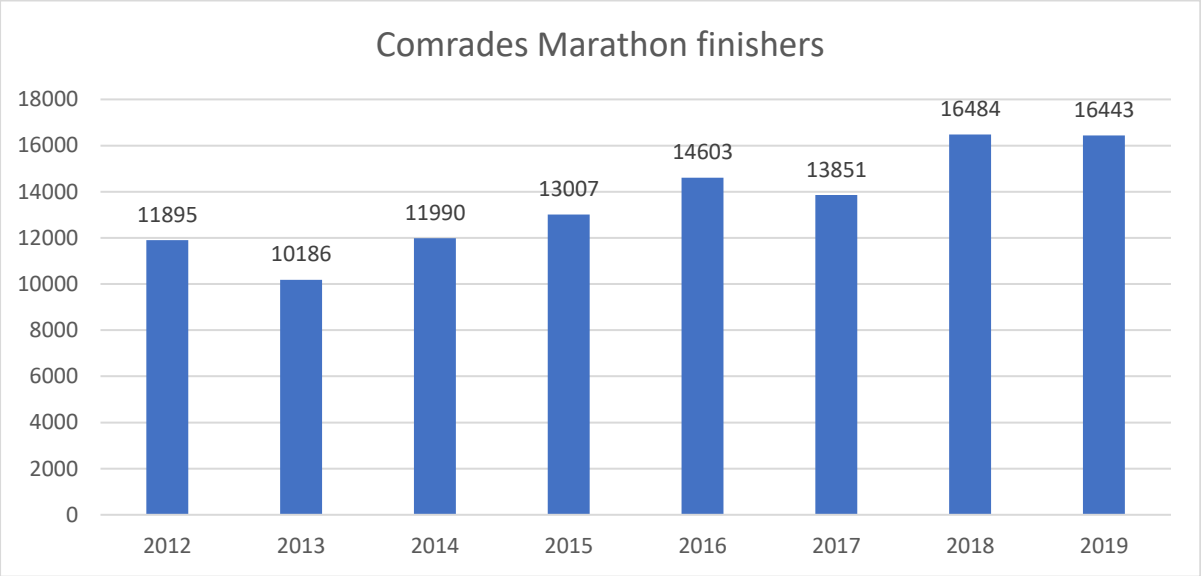


Figure 1: Total number of CM finishers during the study period[48].

To prepare adequately, athletes are required to run several hundred kilometres in preparation for the CM, with one coach recommending at least 850 kilometres of training to be able to finish the race[49].

1.9 Characteristics of the CM

The CM is unique in the sense that every year the route alternates between an “up” run from Durban that is approximately 87 kilometres and a “down” run from Pietermaritzburg that is approximately 90 kilometres[16].

The official start time of the CM is always at exactly 05h30 and is not dependent on the time that any athlete may initially cross the official start line. All athletes must cross the finish line by 17h30, 12 hours after the official starting time. Originally, the official race time was 12 hours from 1921 until 1927. The race time was reduced to 11 hours from 1928 until 2002, except for the 2000, which had a special 12-hour cut-off for the 75th anniversary of the CM. The 12-hour race time was increased back to the original 12 hours in 2003[16]. The increase in running time allows for a more inexperienced athletic field, with more athletes entering and attempting to complete the CM with the longer duration. Medically, the longer duration running times will also cause potentially more medical complications e.g., fatigue.

1.10 The “Up-run” – from Durban to Pietermaritzburg

The route starts outside the Durban City Hall, which has an altitude elevation of 23 metres above sea level and since 2017 terminates at the Scottsville Racecourse, Pietermaritzburg. Historically the termination point was at the Alexandra Parks Oval in Pietermaritzburg at an altitude elevation of 624 metres. There are slight variations

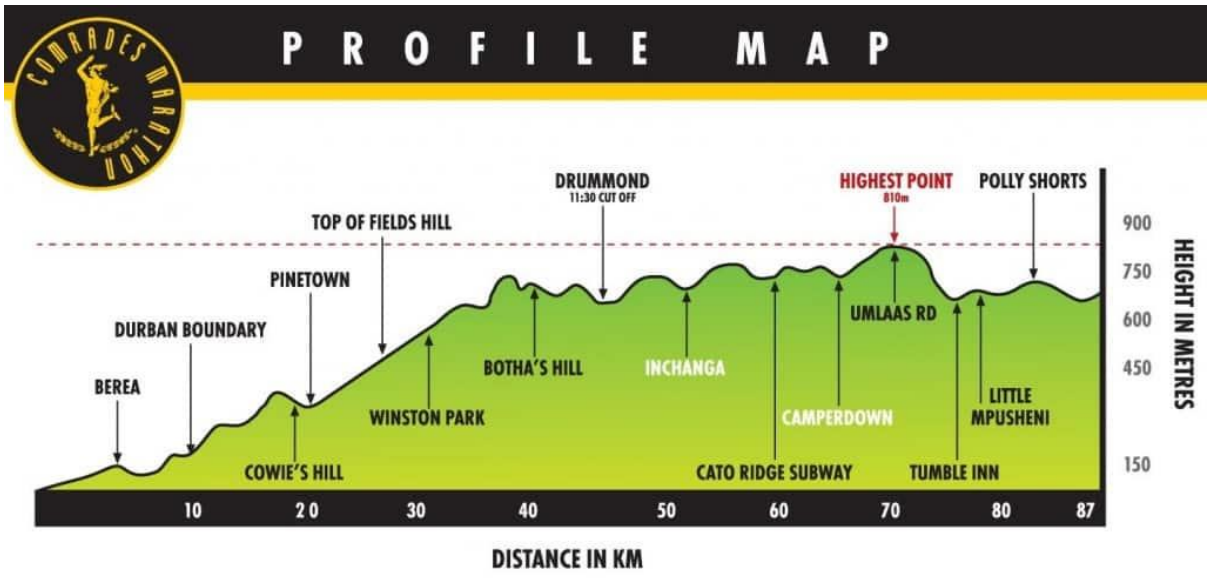


Figure 2: Elevation profile of the “Up-run” route[50].

in the route and the official distance varies from 86.863 to 87.720 kilometres. Total accumulated elevation gains during an “Up-run” averages 1950 metres[50].

1.11 The “Down-run” – from Pietermaritzburg to Durban

The route begins at the Pietermaritzburg City Hall and historically terminated at the Kingsmead Stadium, Durban. However, since 2018 the finish line was moved to the Moses Mabhida Stadium, Durban which has an elevation of 106 metres (348 ft).

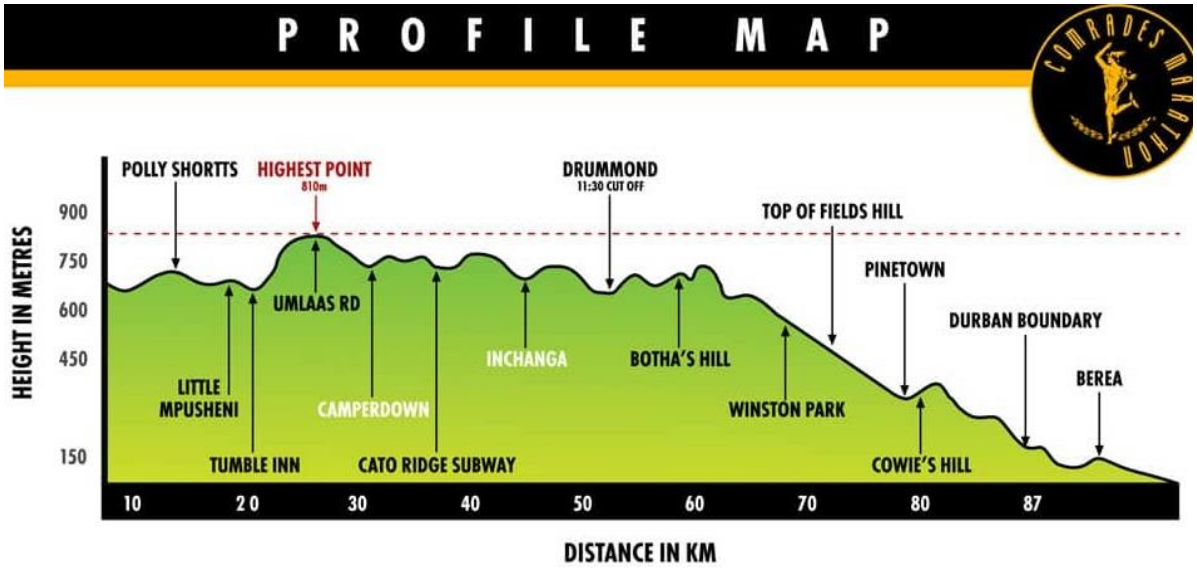


Figure 3: Elevation profile of the “Down-run” route[51].

There are slight variations in the route and the official distance varies from 89.208 to 90.184 kilometres. Total accumulated elevation gains during a “Down-run” averages 1300 metres[51].

1.12 The CM Is a Sport Mass Gathering Event

The World Health Organization (WHO) has defined a mass gathering event as a planned or spontaneous event where the number of people attending the event could strain the planning and response resources of the local community hosting the event[52]. The CM is an acknowledged sporting mass-gathering event where thousands of athletes, together with a multitude of roadside spectators, CM race officials, volunteers, media officials, emergency medical services, security, and traffic officers, etc., congregate for either participation in the event, observation in the event or management of the event. Many athletes travel to the Durban-Pietermaritzburg area with their families to make a holiday-type event out of the CM, as there are

many popular holiday destinations in the Durban and Pietermaritzburg environment. CM athletes, with their accompanying family or friends, usually start gathering in the

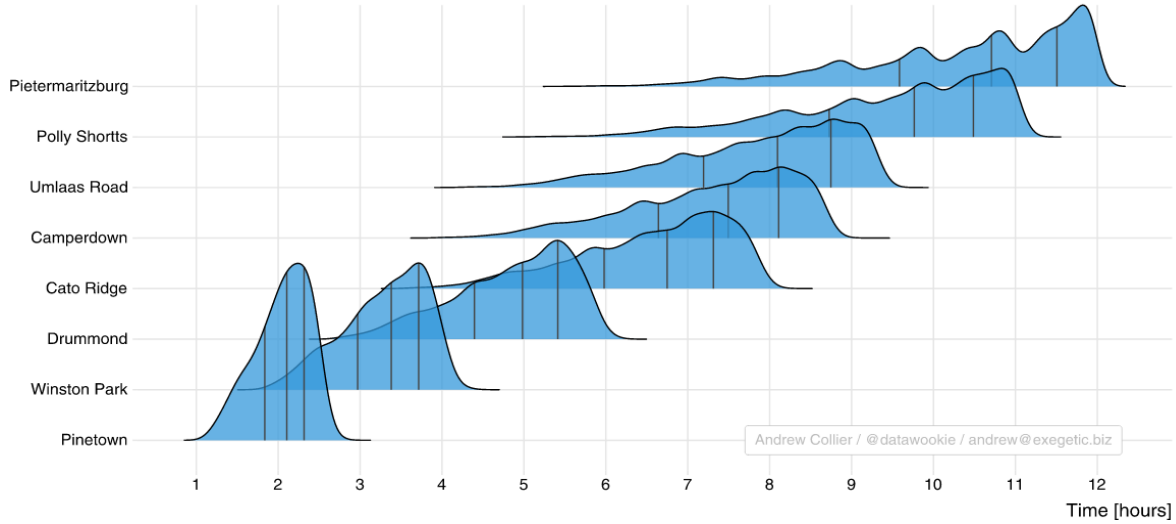


Figure 4: When the winner reaches the finish line, there are still a group of athletes that have not crossed the halfway mark at Drummond. The mass gathering has spread over more than 45 kilometres[53].

CM area before race day, for setting-up of the event, for race preparation, acclimatisation; whilst some remain in the area after race day for recovery or vacationing. Therefore, logistically, the CM is a large, popular sporting mass-gathering, bringing together thousands of people who need to be accommodated in the various Durban-Pietermaritzburg CM environment hotels and holiday homes over several days[53].

1.13 The Weather and Time of Year Considerations

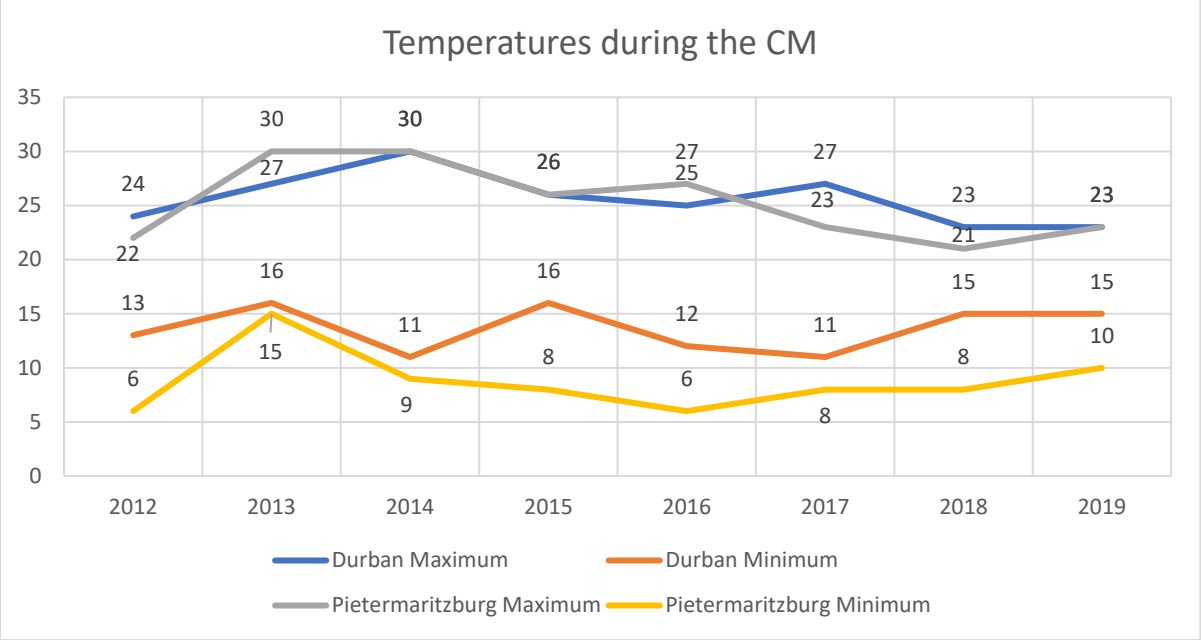


Figure 5: Minimum and Maximum temperatures at the start and finish lines during the study period[55-57].

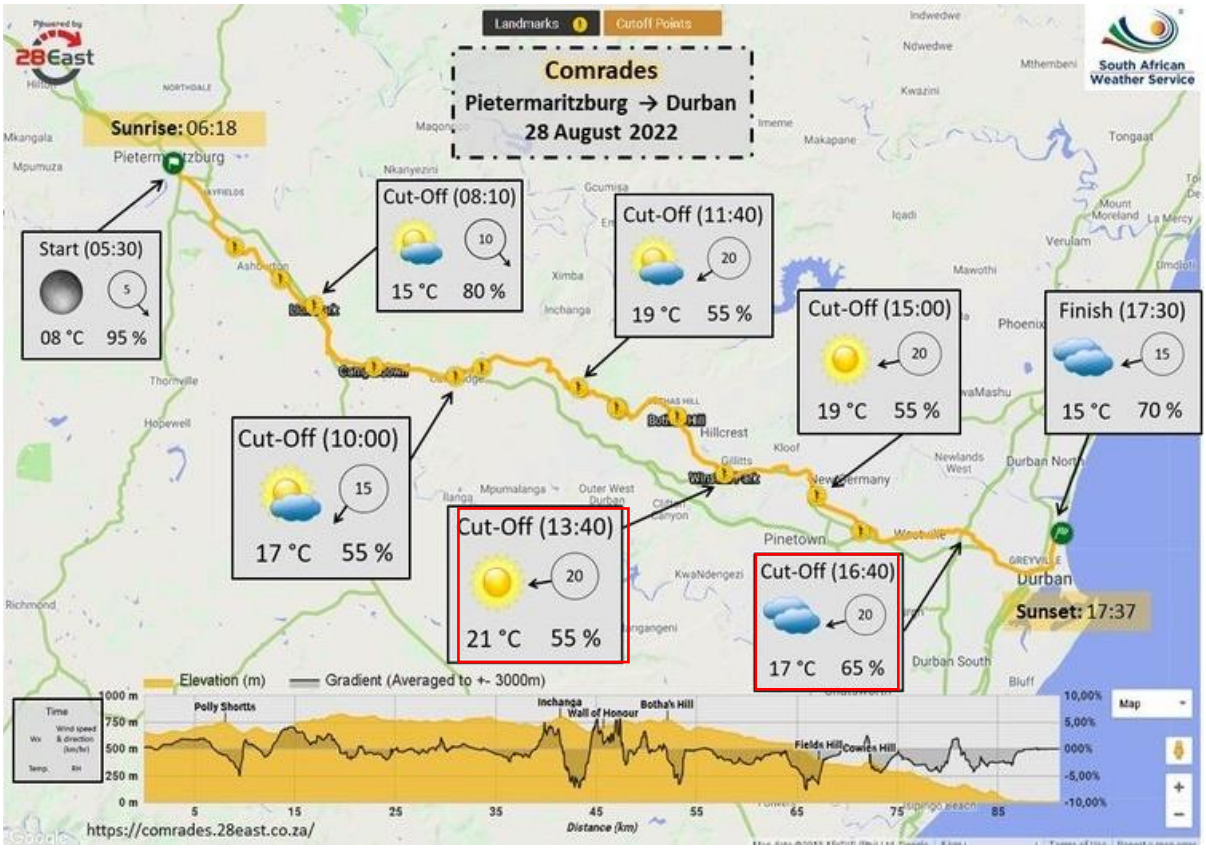


Figure 6: The temperature profile of the 2022 CM[58].

The CM is historically held around the start of austral winter in May or June[54]. During the study period, this ranged from the 21st to the 23rd week of the year. Temperature

recordings during the dates of the CM show similar maximum temperatures for Durban and Pietermaritzburg, while Pietermaritzburg has a lower minimum temperature. This will lead to a colder start for the “Down-run” years, while warm to hot days can be expected during either “Up-run” or “Down-run” years[55–57].[58]

Influenza (“flu”) is generally considered a disease of the colder months, although there are some variabilities every year as to when it starts. A study done by Motlogeloa et al showed that from 2015 to 2019, RSV season started around week 13 and finished around weeks 32-34, while the Flu season started around week 21 and ended around week 37[59].

The date the CM is held, is a challenging decision for race directors, since running in warmer weather places the athletes at risk of experiencing more medical encounters, while running in colder weather coincides with seasonal flu[54,60].

1.14 Elevation Considerations

The CM is unique and different from other marathons and ultramarathons because of the route change every year. The running inclination changes throughout the route and is not always positive (uphill) during an “Up-run” nor is it always negative (downhill) during a “Down-run”. The inclination is mostly positive during an “Up-run” and mostly negative during a “Down-run”. A review on the biomechanics and physiology of uphill and downhill running has found that during uphill running the lower limb muscles perform more mechanical work compared to level and downhill running which increases the energy cost of running, while downhill running at a gradient of at least -7% is associated with increased eccentric muscle load which increases the tibial shock and impact force which can lead to overuse injuries[61] as well as exertional rhabdomyolysis[62]. A retrospective study looking at a gorge type marathon with a continuous positive elevation change of 500m followed by a continuous negative elevation change of 500m showed an increase in musculoskeletal injuries amongst its participants compared to non-gorge type marathons[63]. The CM “Up-run” has a combined 1 950 metres elevation gain while still having a total of 1 300 metres elevation loss. The “Down-run” has a combined 1 300 metres elevation gain and 1 950 metres of elevation loss. With both the “Up-

run" and the "Down-run" having significant elevation gains and losses, it is not clear whether there is any difference in injury and illness patterns between the "Up-run" and the "Down-run". The second biggest ultramarathon in South Africa, the Two Oceans 56-kilometre ultramarathon in Cape Town, has an elevation gain of about 800 metres[64]. The Laingsburg Karoo 80 kilometres Ultramarathon has an elevation gain and loss of 772 metres[65]. A systematic review showed that ultramarathon athletes are injured more often than marathon athletes. The incidence of injury decreases with increasing age, running experience and number of ultramarathons completed[66,67]. Ultramarathons are generally undertaken by older and more experienced athletes, compared to shorter races. The average age of participants in ultramarathons are 44 years[68].

1.15 Medical Logistics of the CM

Mass-gathering events are known to place a strain on local emergency services[69]. The extensive planning and preparation for the yearly CM has taken this into consideration. The CM administration has therefore out-sourced the provision of emergency medical services (EMS) along the entire route to a private hospital group EMS, with a known national footprint, including paramedic, nursing and medical professionals, advanced life support (ALS) road and air ambulances, ALS medical motorcycles and quadbikes, and associated ancillary equipment, much of which are imported from outside the Durban-Pietermaritzburg locality. Logistically, during the recent CM 2022, there was eight paramedical / nursing stations along the CM road course, assisted and services by an aeromedical helicopter, four ALS rapid response motorcycles, five ALS rapid response motor vehicles and 16 advanced life support ambulances[70,71] to effect timeous resuscitation, stabilisation, and transport of acutely ill or injured patients, of whatever nature – athletes, staff, or spectators.

Additionally, in 2022, members of the University of KwaZulu Natal (UKZN) Division of Emergency Medicine provided acute emergency medical care at the CM end-of-race Medical Tent Field Hospital within the Moses Mabhida Stadium in Durban, where the CM officially ended. The Division also played host to visiting registrars from Wits University, Division of Emergency Medicine, and volunteer medical officers from various KZN hospitals. Dr Sharadh Garach, the Head of Emergency Medicine at the

University of KwaZulu-Natal said in an interview: '...*the medical tent utilised a rapid triage system to categorise unwell runners into treatment categories, ranging from basic wound care to ICU level heat stroke stabilisation*.' Of the more than 300 athletes that were treated in the 140-bed end-of-race Medical Tent Field Hospital, most of those in need of care arrived near the end of the race, about 80% of all athletes arrived within 2 hours of the final cut-off time[72]. Most were treated and safely discharged, with a small number being transferred to nearby designated emergency departments, mainly to those of the private hospital group, for further definitive treatment.

All these hospitals, each with an emergency department, were fully operational and capacitated to receive acute patients directly from the CM route via ambulance or from the Moses Mabhida Stadium medical tent field hospital. As stated in the Introduction, the medical encounters at marathon and ultramarathon medical tents are well documented[60], but there are scarce data available on patients presenting to hospital emergency departments from such events, and no such data exits for the CM, other than what can be found in the news media and related articles[71,73].

1.16 Medical Conditions During Running

Musculoskeletal injuries of the lower extremities from overuse are common during ultramarathons[74], with the ankle (34.5%) affected more commonly than the knee (28.1%)[75]. Most of these injuries involve connective tissues and the most prevalent injury is that of anterior compartment tendinopathy (19.4%) followed by Achilles tendinopathy (13.7%). Although uncommon, injury secondary to trauma can lead to acute ligamentous sprains or tears, tendon rupture, or meniscal tears. Overuse injuries to the muscular system are much less common, and mostly include calf or hamstring strains[75].Acute compartment syndrome is an extremely rare entity in endurance sport but can still occur when the circumstances are right[76]. Finally, bones can also sustain injuries, either from stress reactions (microfractures) or stress fractures[74,77]. Most athletes will develop pain during an ultramarathon[77], but this may be related to muscle soreness and fatigue. Dermatological injuries are quite common, with 40% of ultramarathon runners developing blisters and up to 70% of end-of-race medical tent field hospital visits being due to blistering. During two

161km ultramarathons, 5.8% of the athlete drop-outs were due to blistering. Other injuries include chafing and abrasions. Corns and calluses develop chronically but can form blisters underneath during a race. Subungual haematomas occur in 2.5% of marathon runners[74,77].

Acute illnesses due to an ultramarathon can be due to environmental factors or patient factors. The full range of heat-related illnesses occur during an ultramarathon, ranging from heat oedema to heat syncope to heat exhaustion or to an acute life-threatening exertional heat stroke, all with its associated complications[78]. These complications include multiorgan failure, rhabdomyolysis, and disseminated intravascular coagulation. Hypothermia is rare but can develop after completion of the race after running for many hours, more so if the weather is cool, rainy, or windy. Hydration related illnesses can range from simple dehydration to exercise associated hyponatraemia with or without encephalopathy. Patient factors include comorbid conditions such as exertional bronchospasm, asthma, atopic anaphylaxis, hypoglycaemia in the diabetic athlete or acute coronary syndrome[74,79,80]. Many acute medical conditions can be treated effectively onsite at the end-of-race medical tent field hospital facility. However, seriously ill patients may require further investigation and/or management in hospital.

Over a 4-year period at the Baltimore Marathon, 16 patients required transfer to hospital (0.47 per 1 000 athletes) for reasons including the gastrointestinal tract (diarrhoea and dehydration), neurological (seizures, focal neurological signs), environmental (hypothermia), cardiac (suspected ACS, syncope), respiratory (asthma) and trauma (pedestrian-vehicle accident)[81]. During the Two Oceans Marathon in Cape Town, from 2008-2011, the incidence of all medical complications was 5.14 per 1 000 for the 21km race starters and 12.98 per 1 000 for the 56km race starters, with serious life-threatening medical complications being 0.51 per 1 000 for the 21km race athletes and 0.65 per 1 000 for the 56km race athletes. These serious life-threatening medical complications included ischaemic heart disease (n=3), myocarditis (n=2), serious cardiac arrhythmias (n=2), symptomatic hyponatraemia (n=9), serious metabolic complications (n=5), hyperthermia (n=6), hypothermia (n=1), pulmonary oedema (n=2), hyperkalaemia (n=1), metabolic acidosis (n=1), significant dehydration (n=2), bronchospasm (n=2) and convulsions (n=1) between

the 2 races. The authors did not state in which of the two races these serious life-threatening medical complications occurred[82]. At the Gothenburg half marathon, there were 140 ambulance-required assistances (0.44 per 1 000 athletes) from 2010 until 2016, of which 80% were transported to hospital (0.35 per 1 000 athletes). Ambulance assistance was requested for collapse (n=104), anxiety, confusion or agitation (n=29), chest pain (n=5), cardiac arrest (n=4), vertigo (n=3), cramps (n=3), vomiting (n=3), sprain (n=2), tachycardia (n=1), dyspnoea (n=1), abdominal pain (n=1), allergic reaction (n=1) and for one runner that ran into a group of other runners[83].

A longitudinal study found that 4.9% of ultramarathon athletes underwent hospitalisation after a competitive event over the course of their ultramarathon career, with dehydration, electrolyte disturbances and heat exhaustion being the primary reason for more than half of all admissions (53%), followed by fractures and dislocations (20%). Skin injuries (blisters and wounds), concussions, soft tissue injuries and infections each formed 5% of admissions[66]. The authors did not elaborate on where these injuries and infections occurred.

Sewry et al. found in the landmark SAFER XVII study that both moderate medical encounters and serious or life-threatening medical encounters at the CM was higher compared to other races, with the total illness related medical encounters being 19.1 per 1 000 starters, and 1.8 serious or life-threatening medical encounters per 1 000 starters[60]. Although they did not report a transfer to hospital rate, as per the definition of the medical encounters, all serious or life-threatening medical encounters required hospital care, and some of the moderate severity medical encounters required hospital transfer. This means the transfer to hospital rate should lie somewhere between 1.8 and 19.1 per 1 000 starters, likely closer to the bottom.

The most common system affected during the Comrades Marathon from 2014-2019 was “multiple organs” which consisted of “fluid and electrolyte disorders” (8.8%), “heat illness” (0.3%) and “rhabdomyolysis” (0.02%), followed by “central nervous system” which consisted of “EAMC” (3.20%), “dizziness/nausea” (0.60%), “confusion” (0.10%) and “other CNS” (0.10%). There was an association with wet

bulb globe temperature and the number of medical encounters, with the rate highest of medical encounters when the WBGT was highest[60].

1.17 Summary

The available literature on medical conditions during running events provides clear evidence that as the length of a race increases, the number and severity of acute medical encounters also increase. This is particularly pronounced in ultramarathons, where the incidence of more severe medical encounters is higher than that observed in half and full marathons. Furthermore, the transfer rate to hospitals also increases from half to full marathons and is likely to be even higher during an ultramarathon. These findings indicate that ultramarathons impose a greater burden on local emergency departments compared to shorter distance races. Therefore, it can be definitively concluded that longer distance races, particularly ultramarathons, require greater medical support and preparedness to ensure the safety of participants.

Chapter 2: Methodology

2.1 Introduction

This chapter discusses the Methodology used to undertake this Research Report. It contains descriptions of the Aims and Objectives, Data Collection and Data Analysis processes. Costs incurred while performing the research and ethical considerations to do the research are also included.

Aim and Objectives

2.2 Aim

The aim of this study was to analyse and describe the effect of patients visiting the Emergency Departments of a private hospital group, during a fixed period before, during and after the Comrades Marathon event, either from injured or ill athletes participating in the marathon or from other non-athletes. The Aim is also to explore whether there were any factors that may contribute to differences in presentation numbers, pathologies, modes of transit to the emergency department or disposition from the Emergency Department.

2.3 Objectives

1. To describe the demographics of acutely ill and/or injured patients who presented to the Emergency Departments of the Comrades Marathon official sponsoring private hospital group, from midnight before the start of the race up until midnight the day after the end of the race (i.e., a total of 48 hours), over an 8-year period and compare this to the same timeframe (weekend) one week before and one week after the Comrades Marathon during the same period over 8 years.
2. To describe the diagnostic, transport, and disposition features of acutely ill and/or injured patients presenting to the Emergency Departments of the designated hospitals of the Comrades Marathon official sponsoring private hospital group, for the same timeframe as in Objective 1.
3. To compare the injury and illness incidence rates, Emergency Department presentation rates and hospital admission rates of patients presenting to the

Emergency Departments of the Comrades Marathon official sponsoring private hospital group, for the same timeframe as in Objective 1.

4. To compare various injury and illness incidence rates, Emergency Department presentation rates and Hospital admission rates of patients presenting to the Emergency Departments of the Comrades Marathon official private hospital group, for the same timeframe as in Objective 1, between “Up Comrades Marathons” to “Down Comrades Marathons”.

Methodology

2.4 Study Location

The data from the database was collected from five of the private hospital group’s Emergency Departments that were designated to receive patients from the Comrades Marathon over an 8-year period from 2012 – 2019.

Four of these hospitals are in Durban, within the eThekwini Metropolitan area, with one hospital located in Pietermaritzburg, within the Mduduzi Metropolitan area. Both cities are located within the Province of KwaZulu-Natal.

The “CM” timeframe consists of data from patients who presented to the designated Emergency Departments from midnight before the start of the Comrades Marathon race (Sunday 00:00) until midnight of the following day (Monday 23:59). The “Before” timeframe consists of data of patients that presented to the same designated Emergency Departments from Sunday 00:00 until Monday 23:59 one week before the race, and the “After” timeframe consists of data of patients that presented to the same designated Emergency Departments from Sunday 00:00 until Monday 23:59 one week after the race.

Sunday	Monday	T	W	T	F	S	Sunday	Monday	T	W	T	F	S	Sunday	Monday
Before timeframe							CM timeframe							After timeframe	

2.5 Study Design

This was a secondary, database analysis with a retrospective, descriptive and quantitative audit.

2.6 Study Population

The study population consisted of all patients that presented to the designated Emergency Departments of the Comrades Marathon private hospital group during the selected timeframes from patient data has been successfully captured into the private hospital database, and then successfully extracted.

2.7 Inclusion and Exclusion Criteria

All athletes that were acutely ill or injured during the Comrades Marathon were transported, if necessary, to the private hospital group designated Emergency Departments. These included patients that were or were not covered by private medical aid or insurance. Those that were not covered by private medical aid or insurance, were contractually covered for medical care for a 24-hour period from the beginning of the Comrades Marathon.

Inclusion criteria

- All patients that presented to the designated Emergency Departments of the Comrade Marathon private hospital group during the selected timeframes and from data that was successfully captured into the database, and successfully extracted onto a spreadsheet.
- All data, both complete, and incomplete were used.
- All patients that presented from the Comrades Marathon, as well as patients that presented from the community were included.
- Patients that presented via road ambulance, air ambulance, private vehicle, taxi or other public transport, police vehicle or by foot were included.

Exclusion criteria

- There were no specified a priori exclusion criteria.
- Patients that refused their data to be captured into the database at the time of hospital presentation could not be included.
- Patients that absconded or signed refusal of hospital care before their data could be captured could not be included.
- Patients that presented to the Emergency Department as a transfer from another hospital or Emergency Department.
- Data from any patient presenting to other Emergency Departments at other hospitals will not have been included in this Research Report.

2.8 Data Collection

Data was collected from the respective Emergency Departments at the time when the patients presented to the hospital. These data were stored in a database and was managed by a hospital group database manager. A request for data extraction was sent to the hospital group's operational research committee and after obtaining official permission the relevant data was extracted from the database with the assistance of the database manager. The primary investigator provided preselected variables for extraction. Some requested variables were not stored, and a revised set or variables was sent for extraction. Data was extracted onto a spreadsheet and stored on an encrypted memory drive for transportation and security.

2.9 Data Analysis

Microsoft Excel 365® and Statistica® v14.0.0.15 was used to process and analyse the data. Descriptive statistics was used. The categorical data were summarised and is presented as frequencies and percentages. The patients' ages are presented as mean, ranges, minimum and maximum.

2.10 Ethical Considerations

Permission to perform the study was obtained from the private hospital group's operational research committee (Approval number: UNIV-2021-0049). The Hospital Manager of each of the designated hospitals signed an acknowledgement form indicating that they are aware of the research taking place and allow their hospital to be involved. Ethics clearance was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (clearance number: M210852).

All data received from the private hospital groups' database was anonymised and contained no identifying parameters relating to any patient at all. The raw data was received from the Database manager and only the investigator and supervisor had access to this data.

2.11 Cost

Access to the data was provided by the private hospital group's operational research committee without cost.

Printing and stationary costs that were incurred by the investigator was covered by the investigator.

Other costs that were incurred includes transport costs and was also covered by the investigator.

No external funding was offered or received.

Chapter 3: Results

3.1 Introduction

In this chapter, the results obtained from analysis of the data obtained from the private hospital group's database, will be presented in text, table, and graphic forms. These data represent the findings from the 8-year period studied from 2012-2019.

The data presented span the timeframe from midnight (00:00) on the Sunday of the CM until the Monday midnight (23h59) after the CM, a period of 48 hours, for the weekend before (Before), the weekend of the CM (Comrades), and the weekend after the CM (After).

3.2 Gender

A total of 10 125 patients presented to the emergency departments (ED) during the study period, of which 5 116 (50.53%) were male and 5007 (49.45%) were female. Only 2 patient records indicated no gender assignment (0.02%).

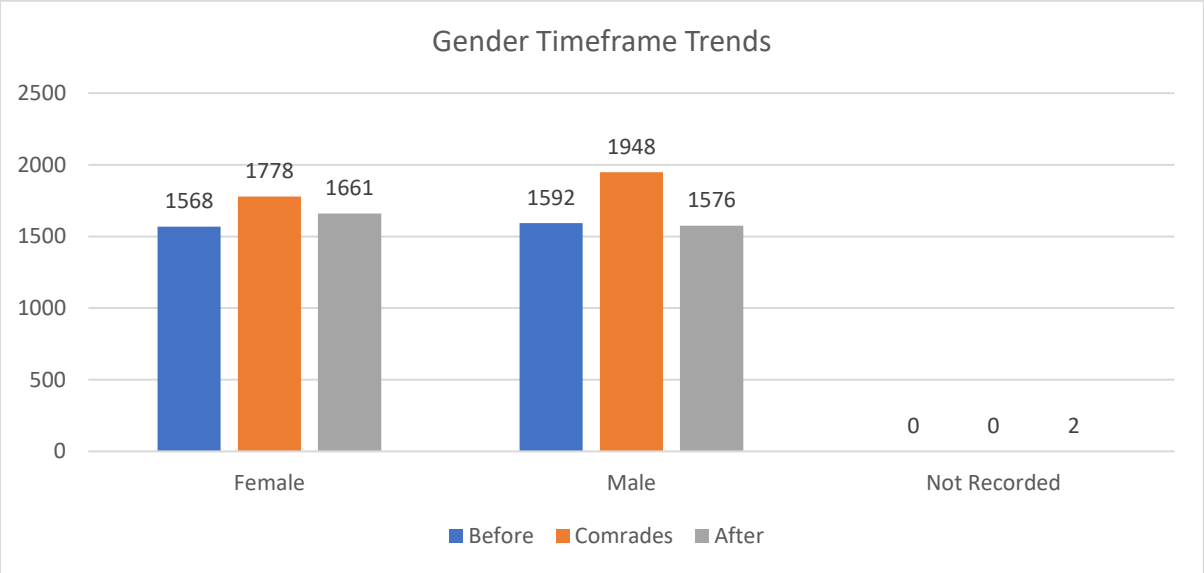


Figure 7: Total number of male, female, and unrecorded gender presentations across the 3 timeframes.

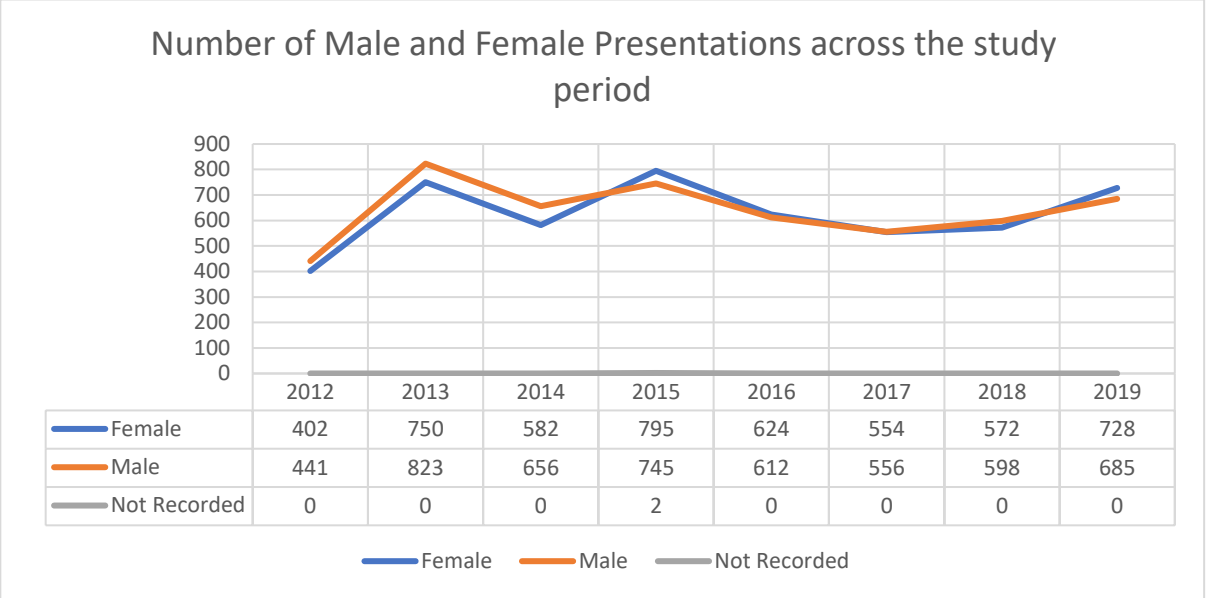


Figure 8: Graphical presentation of male, female, and unrecorded presentation across the study period.

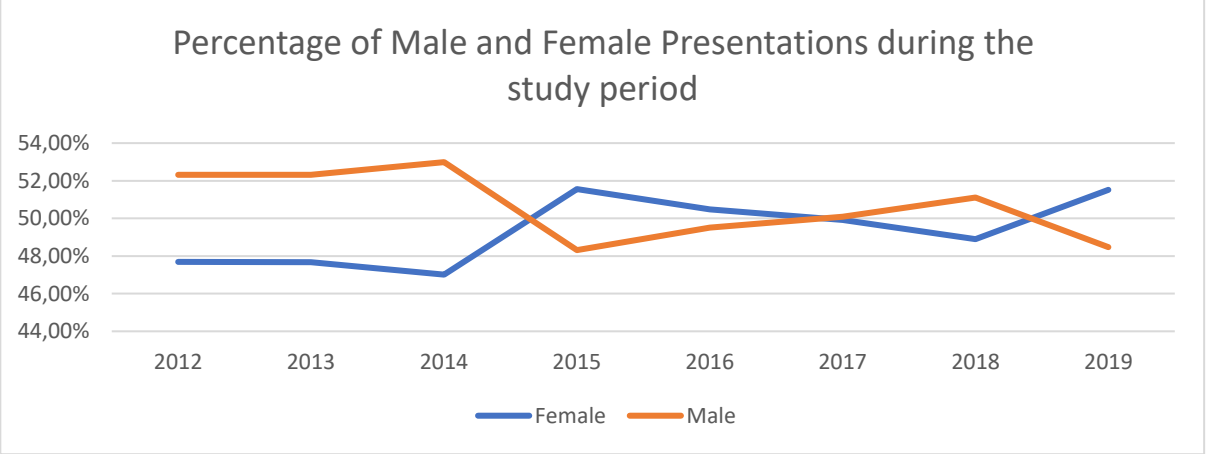


Figure 9: Differences between male and female presentations across the study period.

Table 2: Breakdown of presenting patients by genders across timeframes.

	Before	Comrades	After
Female	31.32%	35.51%	33.17%
Male	31.12%	38.08%	30.81%
Not recorded	0.00%	0.00%	100.00%

Table 3: Breakdown of timeframe presentations as per the recorded gender

	Female	Male	Not recorded
Before	49.62%	50.38%	0.00%
Comrades	47.72%	52.28%	0.00%
After	51.28%	48.66%	0.06%

3.3 Age

The mean age of patients presenting to the emergency departments during the study period was 34 years. The oldest patient was 101 years old. There was a non-symmetrical, bimodal distribution. The first peak with 650 (6.42%) infant presentations while the second peak occurred in 34-year-old patients (2.27%).

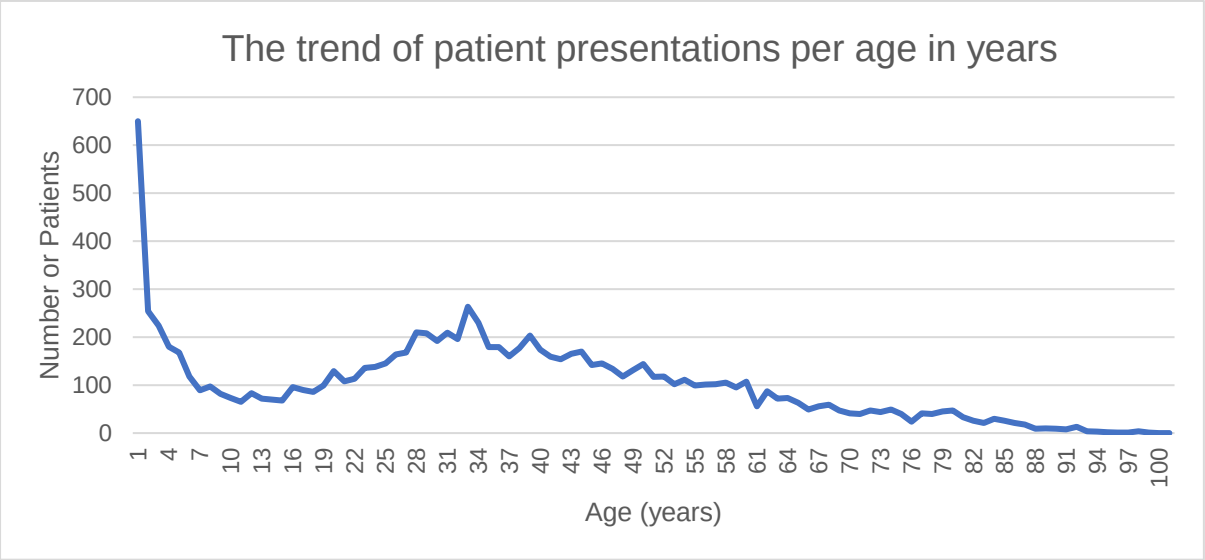


Figure 10: Number of patient presentations per age in years

Further age analysis was done after removing those patients not eligible or not likely to participate in the CM. Those under 20 years were removed since they were not old enough to participate in the CM, and those over 80 years old were removed since they weren't likely have to participated in the CM.

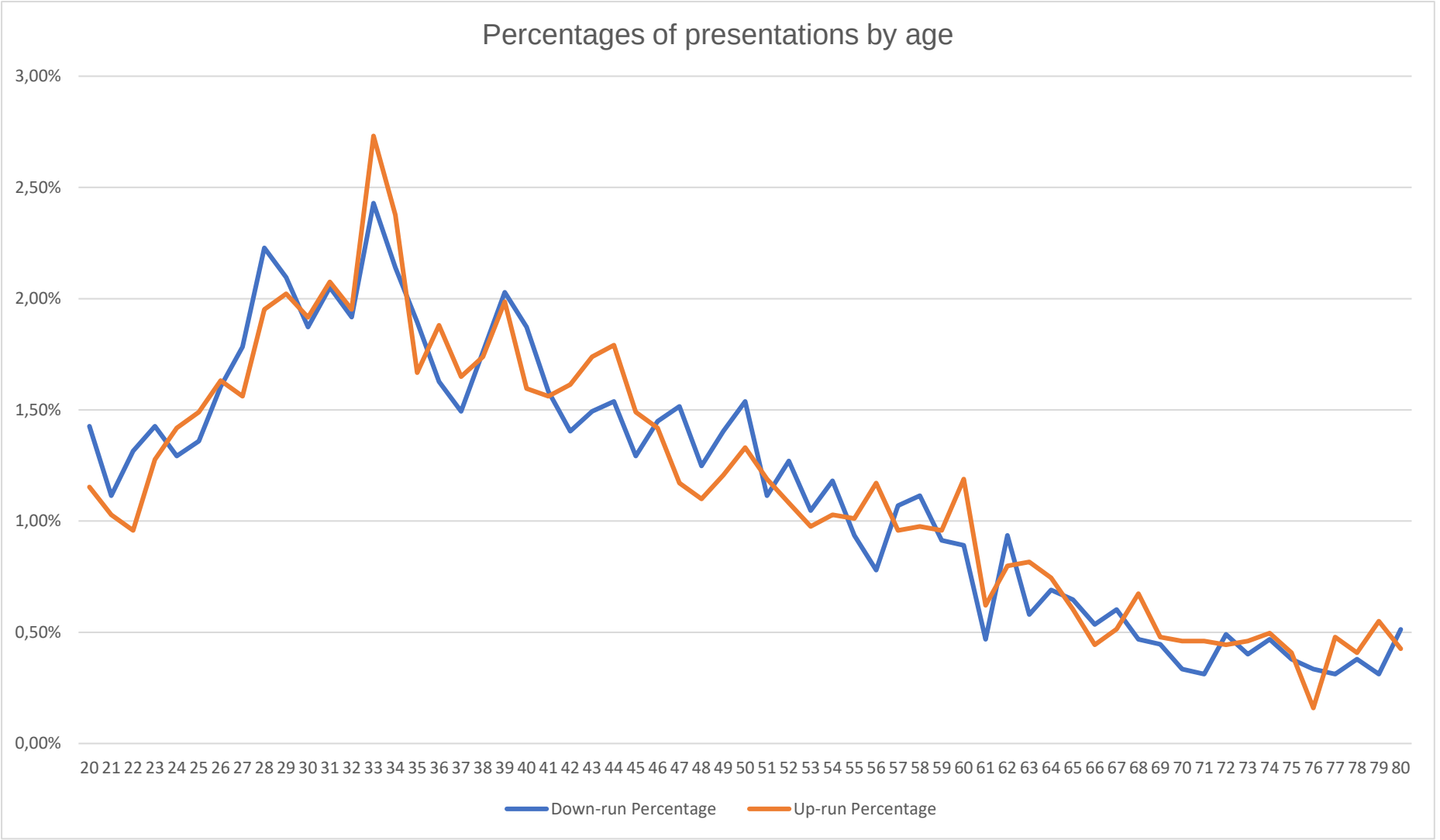


Figure 11: Percentages of patients presenting by age during the “Down-run” and “Up-run” years. Full table in Appendix 7.7

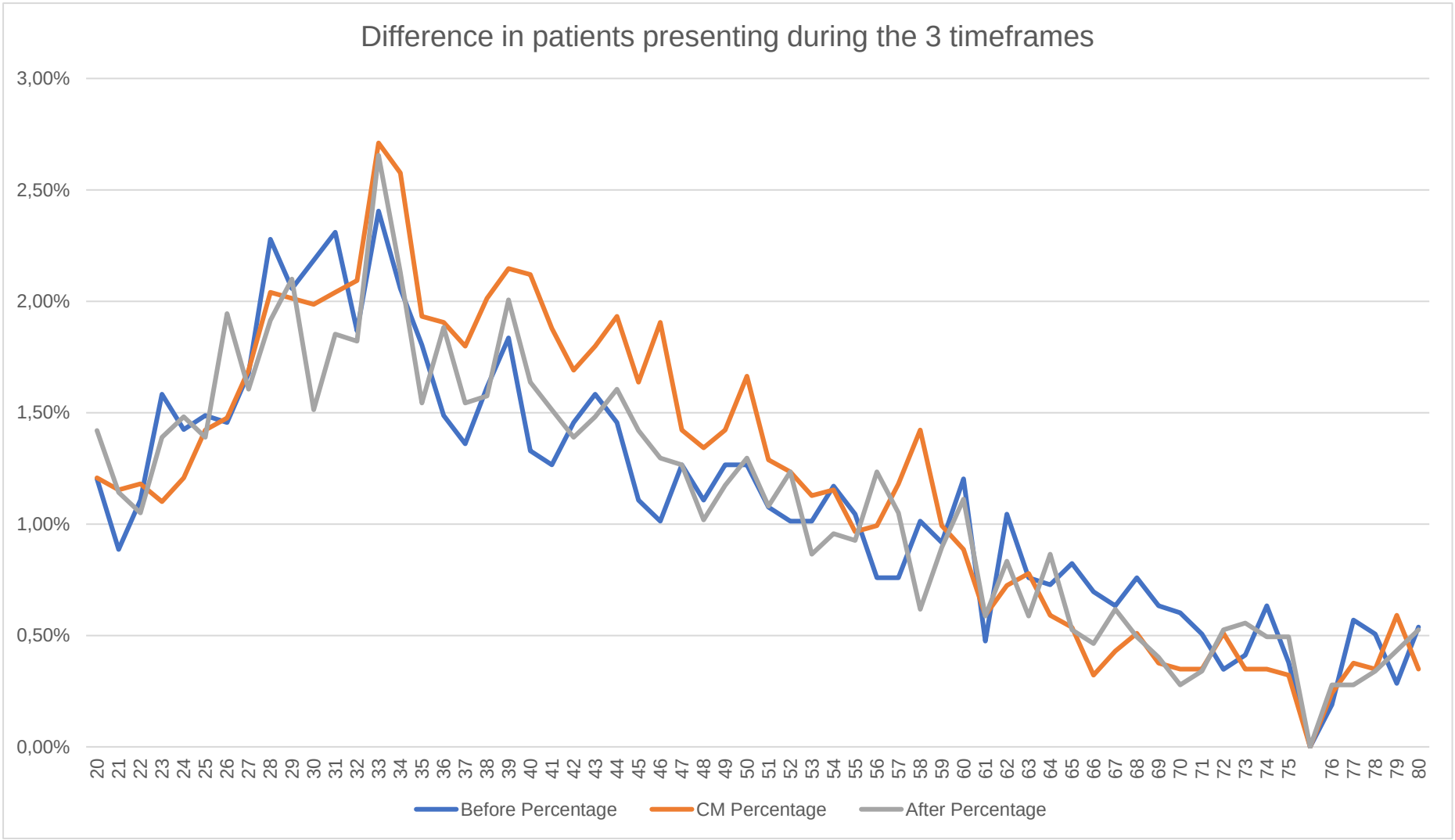


Figure 12 : Percentages of presentations across the 3 timeframes. Full table in Appendix 7.6

Table 4: Percentage differences between age-groups of patients presenting in “Down-run” and “Up-run” years.

Age Groups	Down-run	Down-run percentages	Up-run	Up-run percentages	Totals	Difference between Down-run and Up-run presentations
0-4	597	13.31%	711	12.61%	1 308	-5.22%
5-9	230	5.13%	324	5.75%	554	12.11%
10-14	169	3.77%	194	3.44%	363	-8.64%
15-19	213	4.75%	226	4.01%	439	-15.56%
20-29	702	15.65%	817	14.49%	1 519	-7.38%
30-34	467	10.41%	623	11.05%	1 090	6.17%
35-39	395	8.80%	503	8.92%	898	1.34%
40-49	664	14.80%	828	14.69%	1 492	-0.76%
50-59	492	10.97%	602	10.68%	1 094	-2.62%
60-69	281	6.26%	388	6.88%	669	9.89%
70-79	167	3.72%	244	4.33%	411	16.28%
80-89	92	2.05%	149	2.64%	241	28.89%
90-99	18	0.40%	28	0.50%	46	23.80%
100+	0	0.00%	1	0.02%	1	absolute
	4 487	100.00%	5 638	100.00%	10 125	

In Table 4, the ages have been combined in 5-year age groups, up until 20 years of age, then the Athletics South Africa’s official age group categories has been followed. The percentages of “Down-run” and “Up-run” presentations have been colour-coded on a spectrum from red to green. We can now appreciate a trimodal distribution of presentations: 0-4 years, 20-29 years, and 40-49 years. The difference between the “Down-run” and “Up-run” presentations has been colour-coded on a spectrum from red to blue. There were markedly increased numbers of presentations in geriatric patients over 80 years during the “Up-run” years, while 0-4-year-olds, teenagers (10–19-year-olds) and young adults (20-29-year-olds) presented more during the “Down-run” years.

Table 5: Percentage differences between the age-groups during the 3 timeframes

Age Groups	Before	Before Percentages	Difference from CM to Before	CM	Comrades Percentages	After	After Percentages	Difference from CM to After
0-4	414	13.10%	14.32%	427	11.46%	467	14.42%	25.81%
5-9	177	5.60%	21.34%	172	4.62%	205	6.33%	37.11%
10-14	140	4.43%	51.45%	109	2.93%	114	3.52%	20.31%
15-19	163	5.16%	31.64%	146	3.92%	130	4.01%	2.43%
20-29	479	15.16%	4.59%	540	14.49%	500	15.44%	6.51%
30-34	342	10.82%	-5.12%	425	11.41%	323	9.97%	-12.57%
35-39	256	8.10%	-17.30%	365	9.80%	277	8.55%	-12.70%
40-49	406	12.85%	-25.08%	639	17.15%	447	13.80%	-19.53%
50-59	317	10.03%	-16.57%	448	12.02%	329	10.16%	-15.52%
60-69	245	7.75%	34.99%	214	5.74%	210	6.48%	12.89%
70-79	140	4.43%	17.08%	141	3.78%	130	4.01%	6.06%
80-89	66	2.09%	-11.57%	88	2.36%	87	2.69%	13.73%
90-99	15	0.47%	47.39%	12	0.32%	19	0.59%	82.14%
100+	0	0.00%	0.00%	0	0.00%	1	0.03%	absolute
	3 160	100.00%		3 726	100.00%	3 239	100.00%	

In Table 5, the same age group categorisation has been used as in Table 4. The age groups have been compared between the 3 timeframes, Before, CM and After. The percentages were again colour-coded form red to green. The same trimodal distribution is noted during all 3 timeframes. Both the Before timeframe and the After timeframe have been compared to the Comrades timeframe, and colour-coded from red to blue. The blue cells indicate higher presentation rates during the Comrades timeframe for the 35-59-years compared to the Before timeframe, and 30-59 years compared to the After timeframe.

3.4 Emergency Department Presentations

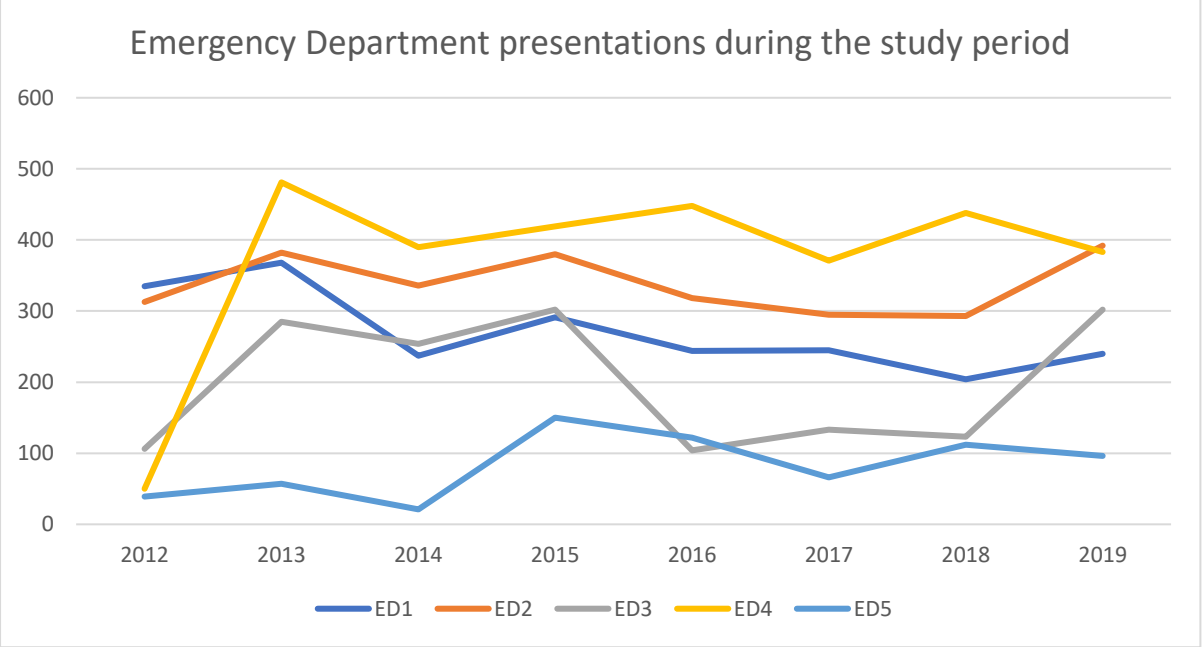


Figure 13: Trending the total number of presentations in the different EDs across the study period.

Table 6: ED presentations, split by timeframe and direction of race.

		Before	Comrades	After	Total
ED1	Down	333	341	346	1 020
	Up	318	503	323	1 144
Total		**651**	**844**	**669**	**2 164**
ED2	Down	402	457	401	1 260
	Up	487	479	483	1 449
Total		**889**	**936**	**884**	**2 709**
ED3	Down	180	186	221	587
	Up	318	360	344	1 022
Total		**498**	**546**	**565**	**1 609**
ED4	Down	393	562	371	1 326
	Up	561	617	476	1 654
Total		**954**	**1 179**	**847**	**2 980**
ED5	Down	79	88	127	294
	Up	89	133	147	369
Total		**168**	**221**	**274**	**663**
Column Total		**3 160**	**3 726**	**3 239**	**10 125**

Table 7: Differences in presentations to the 5 EDs between the 3 timeframes

	Before	Before Percentages	Change from CM to Before	CM	Comrades Percentages	After	After Percentages	Change from CM to After
ED1	651	20.60%	-9.05%	844	22.65%	669	20.65%	-8.82%
ED2	889	28.13%	11.99%	936	25.12%	884	27.29%	8.64%
ED3	498	15.76%	7.55%	546	14.65%	565	17.44%	19.04%
ED4	954	30.19%	-4.59%	1 179	31.64%	847	26.15%	-17.36%
ED5	168	5.32%	-10.37%	221	5.93%	274	8.46%	42.62%
	3 160			**3 726**		**3 239**		

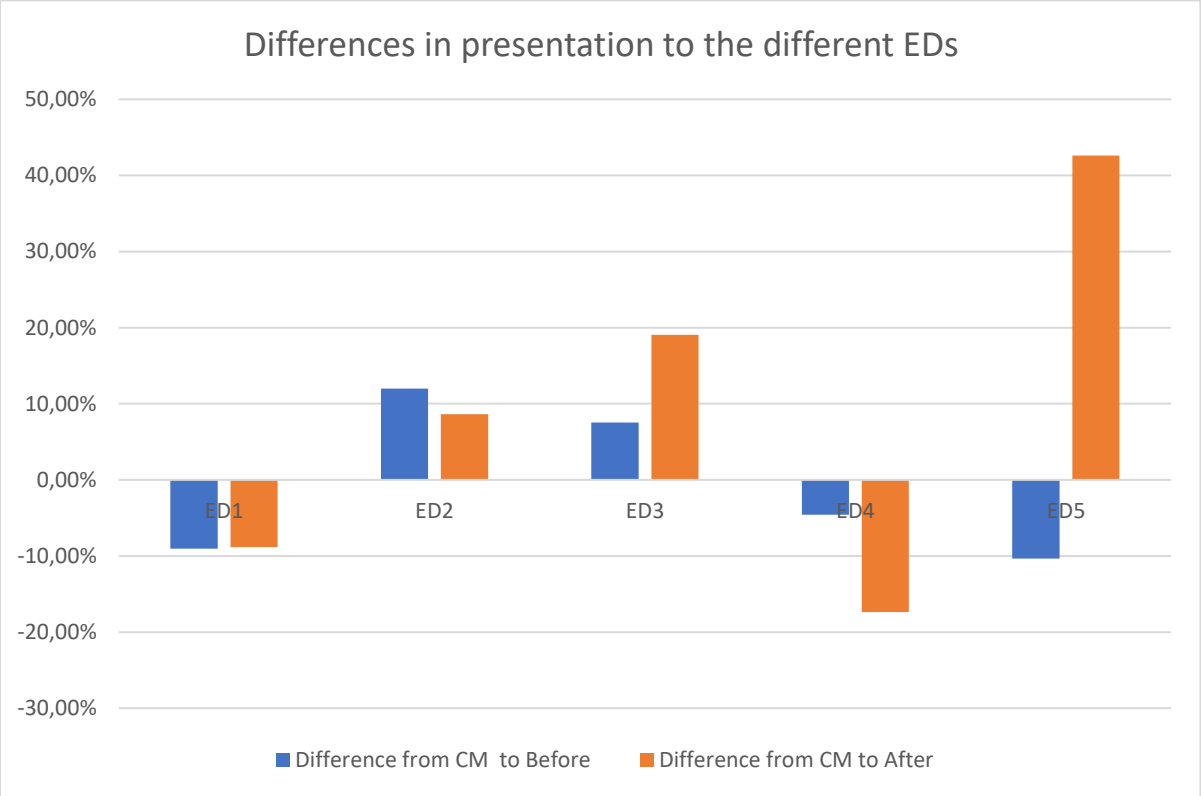


Figure 14: Percentage change in presentations to the 5 EDs from the CM timeframe to the Before and After timeframes

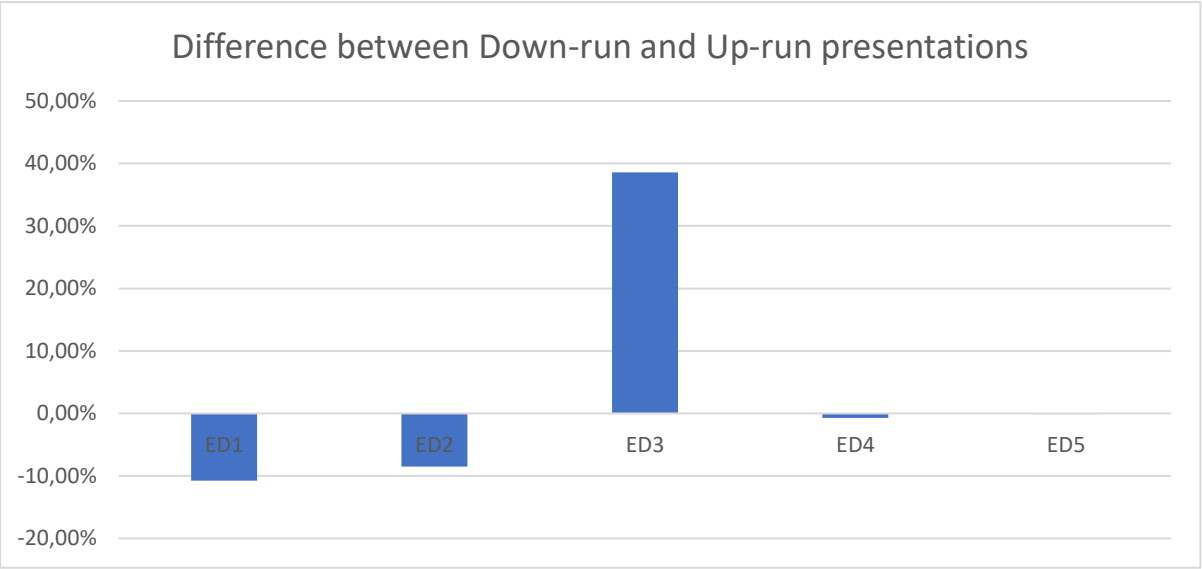


Figure 15: Percentage difference in the ED presentations between the “Down-run” and “Up-run” years

3.5 Medical encounters

Table 8: All medical encounters across the study period.

Medical Encounter	2012	2013	2014	2015	2016	2017	2018	2019	Totals
Musculoskeletal	204	395	413	393	404	326	345	373	2 853
Gastrointestinal	138	286	165	256	172	201	226	252	1 696
Respiratory	118	189	133	213	136	125	151	220	1 285
Neurological	57	118	90	144	81	108	116	118	832
Follow-up*	97	150	93	50	105	43	18	54	610
Cardiovascular	62	109	77	97	67	56	49	70	587
Dermatological	42	81	73	79	67	70	64	50	526
Temperature	21	70	40	77	63	35	47	98	451
Other	30	63	26	100	40	25	34	38	356
Gynaecological	9	19	24	22	13	22	18	31	158
Urological	18	10	20	19	12	12	19	14	124
Toxicology	18	11	17	14	14	17	19	13	123
Allergic	11	16	19	17	8	15	9	13	108
ENT	3	20	13	17	16	12	9	17	107
Metabolic	4	12	7	13	10	8	11	14	79
Fatigue	3	3	6	9	3	15	9	11	59
Ophthalmological	3	7	10	8	10	7	6	7	58
Psychiatric	4	4	1	8	11	9	7	11	55
Electrolyte, fluids	1	10	11	1	3	0	9	7	42
Renal	0	0	0	5	1	2	4	2	14
Environmental	0	0	0	0	0	2	0	0	2
All Groups	843	1 573	1 238	1 542	1236	1 110	1 170	1 413	10 125

*Follow-up included patients that returned due to the same problem, for review or for removal of sutures.

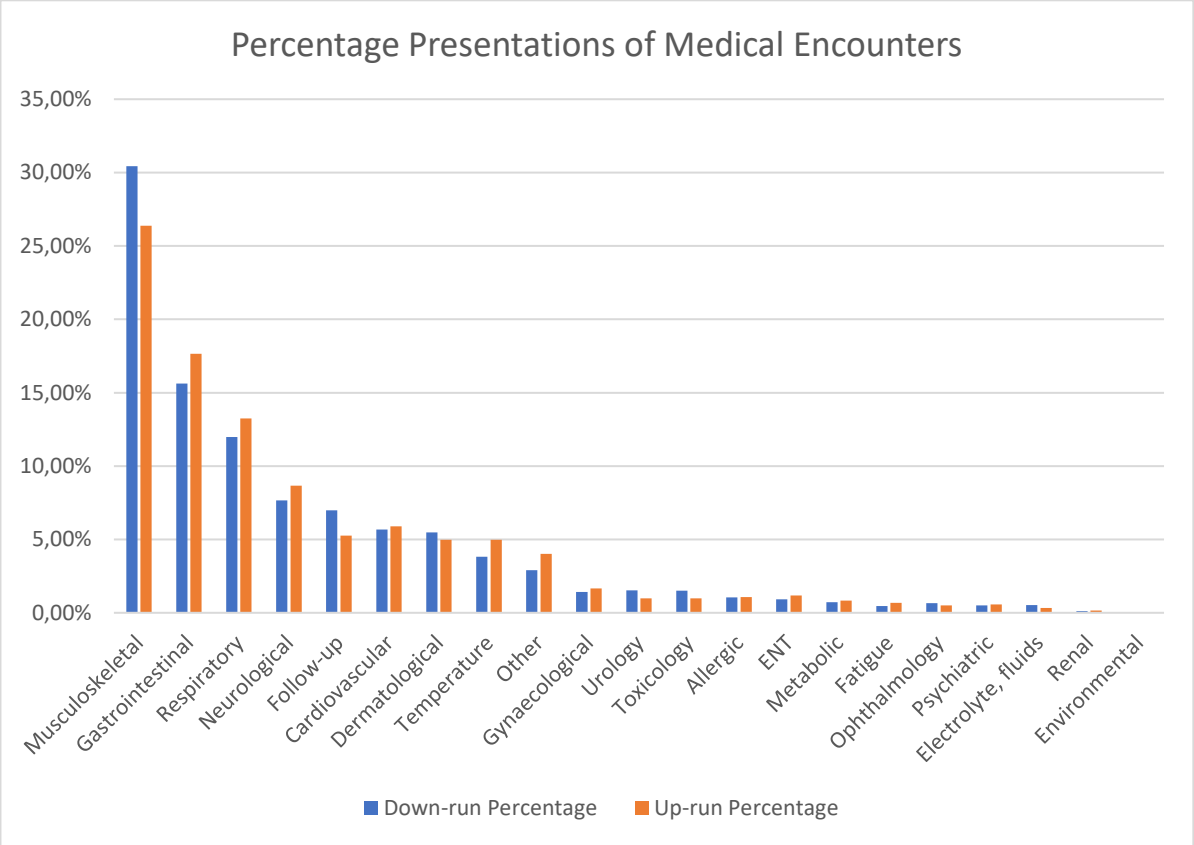


Figure 16: Breakdown of presentations by race direction.

Table 9: All medical encounters, split between the 3 timeframes and percentage difference to the CM timeframe.

	Before	Before Percentage	Difference to CM	CM	CM Percentage	After	After percentage	Difference to CM	Total	Difference between CM and non-CM
Musculoskeletal	945	29,91%	9,03%	1 022	27,43%	886	27,35%	-0,27%	2 853	4,38%
Gastrointestinal	450	14,24%	-24,42%	702	18,84%	544	16,80%	-10,86%	1 696	-17,64%
Respiratory	398	12,59%	6,17%	442	11,86%	445	13,74%	15,82%	1 285	10,99%
Neurological	273	8,64%	-7,77%	349	9,37%	210	6,48%	-30,78%	832	-19,27%
Cardiovascular	169	5,35%	-13,74%	231	6,20%	187	5,77%	-6,88%	587	-10,31%
Follow-up	216	6,84%	16,83%	218	5,85%	176	5,43%	-7,13%	610	4,85%
Dermatological	185	5,85%	41,65%	154	4,13%	187	5,77%	39,69%	526	40,67%
Temperature	131	4,15%	0,96%	153	4,11%	167	5,16%	25,56%	451	13,26%
Other	117	3,70%	6,94%	129	3,46%	110	3,40%	-1,91%	356	2,52%
Gynaecological	51	1,61%	20,27%	50	1,34%	57	1,76%	31,14%	158	25,71%
Urology	40	1,27%	0,35%	47	1,26%	37	1,14%	-9,44%	124	-4,55%
Fatigue	10	0,32%	-64,27%	33	0,89%	16	0,49%	-44,23%	59	-54,25%
Metabolic	26	0,82%	-4,20%	32	0,86%	21	0,65%	-24,51%	79	-14,35%
Electrolyte, fluids	4	0,13%	-85,26%	32	0,86%	6	0,19%	-78,43%	42	-81,85%
ENT	35	1,11%	33,13%	31	0,83%	41	1,27%	52,14%	107	42,63%
Allergic	36	1,14%	41,49%	30	0,81%	42	1,30%	61,05%	108	51,27%
Toxicology	38	1,20%	65,95%	27	0,72%	58	1,79%	147,11%	123	106,53%
Ophthalmology	18	0,57%	6,12%	20	0,54%	20	0,62%	15,04%	58	10,58%
Psychiatric	16	0,51%	10,98%	17	0,46%	22	0,68%	48,87%	55	29,92%
Renal	2	0,06%	-66,31%	7	0,19%	5	0,15%	-17,83%	14	-42,07%
Environmental	0	0,00%	0,00%	0	0,00%	2	0,06%	absolute	2	absolute
All Groups	3 160	100,00%		3 726	100,00%	3 239	100,00%		10 125	

In Table 9, the Difference to CM columns were colour-coded from red to green, with green indicating a higher prevalence outside of the Comrades timeframe, and red indicating a higher prevalence during the Comrades timeframe.

3.6 Summary

The results were presented in the categories Gender, Age, ED presentations and medical encounters, and then further subdivided by timeframe and direction of the race. Total numbers were presented per year where relevant. Colours were used to differentiate between “Up-run” and “Down-run” race data, and CM and non-CM data. Colour-scales were used to better distinguish the degree of differences in some of the larger tables better.

Chapter 4: Discussion

4.1 Introduction

In this chapter, the results of the Study will be discussed, namely the findings related to the different timeframes, as well as the “Down-run” and “Up-run” years and, where possible, to compare with these data with results published in peer-reviewed literature. No data could be found during an online literature review regarding ED presentations concerning “the week before” and “the week after” a similar type of event, and therefore no comparison was possible. Therefore, these data were compared internally with each other. Also, no other marathon or ultramarathon internationally or historically has an alternating change in course annually, run as an “Up” race and a “Down” race, and therefore, once again, these data could not be compared with other external published data. Of note, some, if not most, studies use race participants or race starters in their analysis. During this study, official race numbers of athletes completing the CM was used. This may skew the study findings, since some participants in the CM did not form part of official finisher numbers due to their medical encounter. This may have likewise affected comparability with other studies.

4.2 Gender

4.2.1 Numbers

Male (49.45%) and female (50.53%) emergency department presentations were similar throughout the study period, although there was some variation through the years (Figure 2). Males made up around 52% of presentations during the early years (2012 – 52.31%, 2013 – 51.32%, 2014 – 52.99%) but dropped to 48.31% in 2015. Male presentation percentages were similar in 2016 (49.51%), 2017 (50.09%) and 2018 (51.11%), and dropped again in 2019 (48.48%) (Figure 3). In the Chicago Marathon from 2015-2017, males made up of 53.4% and females of 46.6% the total participants while, of those that were transported to hospital, 47.2% were males and 52.8% were females[84]. Thus, while most participants were male, the majority of those requiring hospital care were females. Taljaard et al. found that gender distribution to an emergency department in a tertiary hospital in the Eastern Cape to be 44% female, 56% male and 0.1% unknown[85], while the Agency for Healthcare Research and Quality in the United States of America found that 55% of emergency

department visits were female, and 45% were male[86]. The gender disparity is much greater in the CM, compared to the Chicago Marathon. The genders of the CM finishers remained constant around 20% female and 80% male. This compares to the gender distribution at the Western States Endurance run, where males made up 80.7% of all starters from 2010-2013[87].

While the CM had a majority of male finishers in the field, the male and female presentations to the emergency departments were quite similar and no clear impact from the CM can be deduced. We know that a greater proportion of marathon and ultramarathon participants are male. From the Chicago Marathon it is evident that a greater proportion of females require transfer to hospital. It is not known how this translates to an ultramarathon distance event, and whether one should expect the same gender disparity, and to what extent that disparity should be found at the emergency departments. Further investigation and research are necessary regarding the gender disparity and requirements in health care in ultramarathon races.

4.2.2 Race Direction

Both males and females had an increase in presentations during the “Up-run” years (2013, 2015, 2019) compared to the previous “Down-run” year, except for 2017, where there was a decrease in presentations for both males and females (Figure 2).

The number of CM finishers showed a general increase from 2012 to 2019 but showed a decline from 2012-2013 and 2016-2017 (Figure 2). The male and female presentations in our study do not correlate with the CM male and female finishers during the study period. This might be because it is not only the athletes, normally measured by race starters, but also their families, spectators, and volunteers that present to the emergency departments.

4.2.3 Timeframe

Both males and females presented in increased numbers during the CM timeframe compared to the Before and After timeframes (Table 2). This may be due to the mass gathering nature of the CM, but further detailed research is required to prove this. Females had more presentations during the After timeframe compared to the Before timeframe, while Males had more presentations during the Before timeframe compared to the After timeframe. When comparing percentages, Female

presentations increased by 13.39% from the Before timeframe to the CM timeframe, then decreased 6.58% to the After timeframe. This means there was a 5.93% increase from the Before timeframe to the After timeframe. The reason for these increases and decreases requires further detailed research which is beyond the scope of this limited study.

Male presentations increased 22.36% from Before to the CM timeframe and decreased 19.10% to the After timeframe (Table 2). This means there was a 1.01% decrease from the Before to the After timeframe.

When comparing the gender distribution during the specific timeframes, males and females were similar during the Before timeframe (50.38% vs 49.62%), while male presentations was markedly higher during the CM timeframe (52.25% vs 47.72%), and female presentations was markedly higher during the After timeframe (48.66% vs 51.28%) (Table 3).

The increased number of presentations to the EDs during the CM weekend correlates with our expectations, with the CM being classified as a mass gathering sporting event. The increase in male presentations may be explained by the male-dominated gender distribution of the CM, and ultramarathons in general.

4.3 Age

4.3.1 Numbers

A review of the total ED presentations over the study period, demonstrates a bimodal distribution, with the first peak being evident amongst the infant group, and the second peak in mid-to-early 30's (Figure 4). When the ages are grouped together in 5-year periods up until 20 years of age when the ASA age group classification is used, a trimodal distribution is seen: under 5-year-olds, 20-29-year-olds, and 40-49-year-olds (Table 4).

The winter influenza (flu) season in South Africa usually begins around the 21st week of the year, while the Respiratory Syncytial Virus (RSV) annual season usually presents from the 13th until the 32nd or 34th week of the year[59]. During the study period, the CM was held five times in the 22nd week, twice during the 23rd week, and

once during the 21st week of the year. This might explain the increased number of presentations, especially in children under 5 years of age to the EDs.

The days of the Comrades Marathon did not correlate with the national school holiday calendar, thus the increased number of children presenting to hospital is not expected to be due to non-Comrades related families travelling to the coastal towns for holidaying.

The considerable number of children presenting to the EDs may be due to families traveling together to the CM as a family event, in many cases, but these presentations seem to decrease during the Comrades timeframe compared to the Before and After timeframes. Another speculative possibility could be that families only unite after the Comrades has finished. The increase in 0-9-year-olds from the Before to the After timeframes, might support this theory, however this is pure speculation. As stated previously, lack of any similar publications prevents external comparisons.

The 20-29-year-old age group contains a small number of CM athletes, 12.30% combined (Table 4). This alone cannot explain the second peak of ED presentations. Ultramarathons are generally run by the older athlete (average 43.2 years for men and 41.4 years for women participating in a 50-kilometre ultramarathon[88], and 44 years for all participants in a 161-kilometre ultramarathon), although the younger athletes have been shown to suffer more injury during participation[68].

The third peak coincided with the average age of ultramarathon runners, 44 years. The mean age at the CM was 41 years and 11 months. The demographics of patients presenting to EDs are highly variable and dependent or multiple factors, such as the demographics of the population that the private EDs are serving, services offered at the private hospital, whether it is a trauma centre or not, etc. A study done in India found a mean age of presentation to the ED to be 62.2 years[89], while Liston et al found the mean age to be 48.2 years at a hospital in the United Kingdom[90]. The mean age of presentations in this study was 34 years and 3 months, significantly lower.

It appears credible that the increased paediatric presentations could be due to the study period falling within the RSV and flu seasons of South Africa.

For further study age analysis, teenagers (all under 20 years) and geriatrics (all over 80 years) were removed (Figure 5, Figure 6).

The incidence of serious or life-threatening medical encounters at the Two Oceans Marathon was 0.65 per 1000 starters[82], while at the CM it was 1.8 per 1000 starters. These numbers do not translate to transfer to hospital numbers, as some moderate medical encounters were also transferred to hospital for further care. During their study period (2014-2019) they had 189 serious or life-threatening medical encounters[60]. Yet, the increase in numbers presenting during the Comrades timeframe is much higher than that, with close to 500 more presentations during the Comrades than either the Before (566 - 17.91% increase) or After (487 - 15.04% increase) timeframes (Table 5).

The increase in ED presentations during our study period could not have been athletes only, but also spectators, officials, and volunteers.

4.3.2 Race Direction

In the 20-29-year-old age group, there was a 7.38% decrease in presentations during the “Up-run” years. In the 30-34-year age group, there was a 6.17% increase in presentations during the “Up-run” years. The 35-59-year-old age groups remained similar in presentations between “Down-run” and “Up-run” years (35-39: +1.34%, 40-49: -0.76%, 50-59: -2.62%). In older patients, the presentations increased more during the “Up-run” years the older the patients were. There was a 9.89% increase in the 60-69-year age group and a 16.28% increase in the 70-79-year age group, compared to the “Down-run” years (Table 4).

4.3.3 Timeframe

A similar trimodal distribution is seen during the “Up-run” and “Down-run” as well as the Before, Comrades and After timeframes (Table 4, Table 5).

In all age groups from 0 to 29 years, there were more patients during both the Before and After timeframes, compared to the Comrades timeframe, but these were much

more significant in the under 20's. Age groups from 30-59 had a significantly higher presentation during the Comrades timeframe, with the peak in the 40-49-year-old age group (Table 5).

This increase correlates with the age of CM participants and could be due to athletes presenting to hospital.

Age groups from 60-79-years had a progressive decrease from Before to Comrades to After timeframes (Table 5).

4.4 Emergency Department Presentations

4.4.1 Numbers

Each ED received a similar number of patients through the years. ED4 received an abnormally small number of patients in 2012, 5.93%, while taking in between 27.11% and 36.25% during other years (Figure 7). The reason for this is not clear. ED4 is located near the finish line in Durban, and with 2012 being a "Down-run" year, higher presentation numbers are expected. The weather in 2012 was milder than other years and similar to 2018 and 2019, but the number of presentations does not correlate with either 2018 or 2019, therefor weather is not likely the causative factor to the low presentations. During an internet search, no logistical issues could be found regarding the hospital in 2012. One possibility to consider is that an issue occurred during data capturing, transferring, or storing.

4.4.2 Race Direction

Except for ED3 that showed a large discrepancy between "Up-run" and "Down-run" presentations, total ED presentations remained constant between "Up-run" and "Down-run" years (p-value 0.013), where ED1 and ED2 received more patients during the "Down-run" years, and ED4 and ED5 received similar amounts during "Up-run" and "Down-run" years (Table 6, Table 7, Figure 9).

ED1 is located near the start of the "Down-run" years. As most medical complications present nearer to the end of the race, it is unexpected to have this facility receive more patients during the "Down-run" years (Figure 9). When these presentations are further examined during the 3 timeframes (Table 6, Table 7), there is a large increase in presentations during Comrades timeframe during "Up-run" years, as expected. The

increase in “Down-run” years, especially in the After timeframe could indicate athletes and their families spending time in the area after the race. Further analysis is necessary, especially looking at the hourly breakdown of presentations.

ED2 is nearer to the “Down-run” finish line, and an increase in presentations to this facility during the “Down-run” years make geographically sense (Figure 9).

ED4 is the main receiving facility during “Down-run” years as it is nearest to the finishing line. There was a small difference in the presentations between “Up-run” and “Down-run” years. It is possible that patients from the route was transported back to this hospital to not overburden the main receiving emergency department during the “Up-run” years (Figure 9).

ED5 is geographically the furthest away from the CM route, and they received a similar proportion of patients during the “Up-run” and “Down-run” years (Table 5, Figure 9). It is possible that transport to this ED from the route was only for select patients which did not depend on factors like the location where the patient was picked up, or a logistical decision by the race medical director.

ED3 had a 38.56% increase in presentations during the “Up-run” years (Figure 9). This is an interesting finding, and unexpected, since ED3 is not the main receiving facility, and not geographically near the “Up-run” finish line. One possibility is that the main receiving facility during “Up-run” years “leap-frogged” stable patients to one of the smaller, quieter private hospital group EDs, such as ED3, to allow the “Up-run” designated hospital to focus on severely ill of injured patients, or to be able to receive more patients during the final stages of the race and from the end medical tent. Of note, the main receiving facility during the “Up-run” years is geographically distant from all other designated hospitals, and disaster planning and preparation may have played a bigger role compared to the “Down-run” years.

Other factors may also have played a role, factors that the investigator is not aware of. The ED3 hospital is located in a small coastal town and the possibility exists that other events may have coincided with the CM “Up-run” years, especially 2013, 2015 and 2019, when the presentations were the highest. The Royal Show is an annual

agricultural show held over 10 days around the end of May and the beginning of June and have in the past coincided with the CM weekend[91].

4.4.3 Timeframe

All emergency departments received more patients during the Comrades timeframe compared to the Before timeframe. When comparing percentages of presentations, ED2 and ED3 received more patients during the Before timeframe, compared to the Comrades timeframe. Both also received more patients during the After timeframe, with ED3 receiving almost 20% more than during the Comrades timeframe (Table 6, Table 7, Figure 8). ED2 and ED3 are each located in a small coastal holiday town, and the increase in presentations after the Comrades timeframe could possibly indicate athletes and their families vacationing in the areas after the CM race.

ED1 and ED4 both received more patients during the Comrades timeframe compared to both the Before and After timeframes (Table 6, Table 7, Figure 8). ED4 is one of the receiving hospitals nearest to the “Down-run” finish line and the large decrease in patients presenting to this ED during the After timeframe might be indicative of athletes and their families that have left the Durban area after the race.

ED5 received fewer patients during the Before timeframe compared to the Comrades timeframe. This can be explained by the geographical location of ED5 (Table 6, Table 7, Figure 8), which is the farthest away from the CM route and most people travelling to participate in the CM will try to stay nearer to the route of the race. There is a substantial increase of over 40% in presentations during the After timeframe compared to the Comrades timeframe. This, again, may be speculated to be due to the geographical location of ED5. It is located in a very popular coastal holiday town, and the increase in numbers could indicate holidaying in the town after the CM.

4.5 Medical Encounters

4.5.1 Numbers

Musculoskeletal related medical encounters remained the biggest cause for presentation through the study period, followed by gastrointestinal, respiratory, and neurological medical encounters. In all of these, in 2012, the numbers were much lower than any of the following years. (Table 8). The reason for this is not known.

4.5.2 Race Direction

The most common reason for ED presentation was musculoskeletal (30.44% “Down”, 26.37% “Up”, p-value 0.318) (Figure 10). Musculoskeletal complaints are common reasons for requiring medical assistance at marathon and ultramarathon races, but do not generally require hospital level of care[60]. At the Baltimore Marathon, none of their patients requiring hospital transfer had a musculoskeletal complaint[81]. In a questionnaire, 4.9% of ultramarathon athletes reported that musculoskeletal complaints (fractures and dislocations) to be 20% of their admissions[66]. Gastrointestinal complaints were the second most common reason for ED presentations, consisting of 15.62% of “Down-run” and 17.62% of “Up-run” presentations (p-value 0.043) (Figure 10). During a 161km mountainous ultramarathon, nausea and vomiting was the most common reason for medical encounters (24%). In the SAFER XVII study, 2.90% of medical encounters were gastrointestinal in nature[60]. The reason for this large discrepancy may be due to the advanced Point of Care diagnostic capabilities located at the CM field hospital. In this research study, some of the data consist of presenting complaints, and not always the final diagnoses. The third most common system affected in our study was respiratory, 11.99% of “Down-run” and 13.25% of “Up-run” presentations (p-value 0.045) (Figure 10). Respiratory related medical encounters are not common in ultramarathons and is usually related to athletes’ comorbid conditions like asthma[80]. At the Baltimore Marathon, asthma was a reason for hospital transfer of one patient[81] (6.25% of hospital transfers), while at the Two Oceans Marathon and Half Marathon, asthma (0.18 per 1 000 starters) and pulmonary oedema (0.03 per 1 000 starters) was reasons for hospital transfer[82]. Further analysis is required to see in what age groups the respiratory complaints were.

Musculoskeletal complaints were more common during the “Down-run” years. This is expected as the act of downhill running places an increased load on the lower limbs, including muscles, tendons, ligaments, and bones.

4.5.3 Timeframe

Musculoskeletal complaints were more prevalent during the Before timeframe, with Comrades and After timeframes being similar (Table 9). The increased number of musculoskeletal complaints before the race may be speculated to be an indication of possible last-minute training injuries, or those athletes with injuries trying to resolve these issues before the CM race day.

There was a 24.42% increase in gastrointestinal complaints during the Comrades timeframe compared to the Before timeframe, and 10.86% more compared to the After timeframe (Table 9). Gastrointestinal complaints are common in running and would account for the increased number of athletes presenting to the EDs[92]. However, it could also be due to spectators, families of the athletes or volunteers assisting in the race that suffer complications from a change in normal dietary practices like eating pre-prepared food from food stalls.

Respiratory complaints were increased during the Before and After timeframes, compared to the Comrades timeframe (Table 9). This correlates with the increased number of 0-19-year-old presentations and may be due to the seasonal flu[59].

The number of dermatological complaints did not correlate with expectations and what was found in other studies. The number of dermatological complaints decreased during the Comrades timeframe compared to the Before and After timeframes (Table 9), while in other studies, dermatological complaints are the biggest contributor to medical tent presentations. It could be that these problems, generally minor in nature, was managed by health care providers in the medical tents along the route and at the finish line. This supports the importance of having medical tents at sports events of this size.

Fatigue related complaints was 64.27% less during the Before timeframe, and 44.23% less during the After timeframe, compared to the Comrades timeframe (Table 9). This is consistent with expectations.

Electrolyte and fluid related complaints (including hypovolaemia, hyponatraemia, etc) was 85.26% and 78.43% more prevalent during the Comrades timeframe, compared to the Before and After timeframes, respectively (Table 9). This is consistent with expectations.

Toxicology (overdose) related complaints was low during the Comrades timeframe but increased 147.11% in the After timeframe and was 65.95% higher during the Before timeframe (Table 9).

Renal related complaints were low in general, with 14 in total, but half of those presented during the Comrades timeframe (Table 9). Renal failure has been described to occur in long distance running[93].

4.6 Summary

This Study found an increase in hospital presentations during the “Up-run” years, compared to the “Down-run” years of the CM. It also found that these increases occur during the CM timeframe, compared to the Before timeframe and the After timeframe. These increases do not occur in all age groups though, but mostly in the age groups of ultramarathon athletes. The study also found that the various clinical medical encounters during the CM timeframe are consistant with what was found in other studies.

This Study also seems to indicate that the CM may, in fact, present clinically as two separate medical events: a biennial “Down-run” ultramarathon from Pietermaritzburg to Durban, and a biennial “Up-run” ultramarathon from Durban to Pietermaritzburg. This proposition is somewhat loosely supported by the clinical and ED differences found not only in numbers of presentations to the EDs, but also in differences in age groups that presented, and in the affected systems of those medical encounters. This makes the CM not only unique in the alternating “Up-run” and “Down-run” routes annually, but also in the medical illnesses and injuries common to each of the respective runs. Further research is required to resolve this issue, particularly involving all the hospitals in the eThekwini and Mduduzi Metropolitan areas or a Study questionnaire involving the participants registered for the CM.

Chapter 5: Conclusion

This Study found that there was an increase in number of patients that presented to the CM sponsoring private hospital group's designated emergency departments during the CM. These increases may have been attributed to:

1. The Influenza and RSV seasonal effects causing a large proportion of paediatric (non-participant) emergency department visits,
2. Injuries resulting from the CM as the increase in numbers coincide with the participating age groups. The body systems affected appeared consistent with that found in other studies. The increased numbers of patients presenting to the designated EDs, and the various body systems affected on clinical presentation were different between the "Up-run" races and the "Down-run" races.

Despite the correlation between the CM and the increased numbers of patient presentations to the designated EDs, it is not possible, due to the limitations of this Study, to prove causality. However, this Study does suggest that such an association between the CM as a mass gathering event and increase in Emergency Department presentations may be present and future research regarding this is encouraged.

5.1 Strengths and Limitations

Various issues did arise during databank extraction from the private hospital group databank. At the first attempt of data extraction, the database manager could not find any parameters to indicate which patients originated from the CM race. Two separate datasets, one with patients from the CM, and one with patients from the community could not be created and analysed separately. Therefor one dataset with all patients during the three timeframes was collected.

Only studies published in English were reviewed during the writing of the literature review, and the possibility always exists that relevant articles in a different language were missed. However, during review of the general literature, no studies were found in other languages that were relevant to this Study.

Due to this Study being retrospective in design, from unaudited information captured from various individual emergency departments by different individuals, over the 8 years the data downloaded from the database may have been incomplete with data inconsistencies. Disposition contained several incomplete entries, but was considered high enough value to retain, and instead label the incomplete entries separately. The database contained three data fields (Presenting Complaint, ICD10 code, Final Diagnosis) that contributed to the final medical encounters data field. All Combined, the three fields contained enough information to not have any incomplete records, but inconsistencies in the record keeping were the biggest limitation. Of note, these inconsistencies do make medically sense. As an example: a patient could present with chest pain, and have a final diagnosis of Acute Coronary Syndrome, or Pneumonia. The final classification may then appear as medical encounter: Cardiovascular, sub-category ACS, or Respiratory, sub-category Infection. The inconsistencies arose due to incomplete Final Diagnosis and ICD10 data fields. They were categorised as Cardiovascular, sub-category Not Specified, taking into consideration that this might skew the analysed results.

There were some data entries that contained such similar information that the investigators were concerned it might be a double entry. There was always one data field different, (different gender, different emergency department, etc) that the decision was made to include all these as separate cases, as it was not possible to determine if it was a double entry or not.

This study was done in a single private hospital group's emergency department in the vicinity of the race and excluded patients that presented to any of the private hospital group's other emergency departments, other private hospital group emergency departments, public hospitals, clinics, general practitioners, pharmacies, or those that self-medicated at home. Therefore, this analysis may not be representative of the total actual impact of this event.

This study was done on a specific ultramarathon with several unique characteristics and is therefore not generalisable to other ultramarathons and shorter distance events, or events where the same route is repeated every year, events with a different elevation profile and events with a different population of participants.

The CM has been labelled the “Ultimate Human Race” in the media and other literature. It is renowned in South Africa and draws athletes that would not normally attempt any other ultramarathon. This might skew the results in favour of a higher number of injuries or illnesses suffered.

5.2 Future research

This is a field of study that requires further research.

First, causality between the CM and the increased presentations should be investigated to ascertain whether the CM does increase the numbers of presenting patients to the various emergency departments, and if so, the nature of these patients e.g., athletes, spectators, or volunteers. Additionally, the impact of the presence of an end-of-race medical tent field hospital on Emergency Department presentations can also be explored.

Second, while males form a large part of ultramarathon participants, emergency department presentations were similar between males and females. This finding needs further research in depth.

Third, a better analysis of the systems affected leading to the medical encounters should be undertaken not only to decrease the problems listed above, but also to provide more accurate data to analyse, and to be more comparable with other studies. An hourly analysis can also be made, to investigate the time-of-day certain pathologies presents.

The CM is a popular ultramarathon event in South Africa, with participants of different ages, genders, comorbid conditions, and motivation for participation. They should all be allowed to participate in an environment where their risk of injury or illness is minimised and where they will receive the best prehospital and if necessary, emergency department care when required. This can be assisted by ongoing research.

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Chapter 7: Appendix

7.1 HREC (Medical) Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Friedrich Johann Petrick

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M210852

NAME: (Principal Investigator)	Dr Friedrich Johann Petrick
DEPARTMENT:	Emergency Medicine
	[redacted]
PROJECT TITLE:	An Audit of Patients presenting to a Private Hospital Group for Comrades Marathon related Injuries and Illnesses for Emergency Department or Intra-Hospital Management
DATE CONSIDERED:	27/08/2021
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof E. Kramer
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	04/10/2021

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. I **agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **August** and will therefore be due in the month of **August** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature _____ Date _____

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

7.2 Change of Title Approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

08 February 2023
Person No: 2403063
TAA

Dr FJ Petrick
[redacted]
South Africa

Dear Dr Friedrich Petrick

Master of Medicine in Emergency Medicine: Change of title of research

I am pleased to inform you that the following change in the title of your Research Report for the degree of **Master of Medicine in Emergency Medicine** has been approved:

From:	**An Audit of Patients presenting to a Private Hospital Group for Comrades Marathon related Injuries and Illnesses for Emergency Department or Intra-Hospital Management.**
To:	**An observational retrospective audit of patients presenting to a Private Hospital Group during specific timeframes before, during and after the Comrades Marathon over an 8-year period**

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

7.3 Primary Investigator Request Letter

Dr Friedrich Petrick
Emergency Medicine Registrar - 2403063
The University of the Witwatersrand
Friedrich.petrick@wits.ac.za

[redacted]

Dear Recipient,

I am currently specialising in Emergency Medicine at Wits.

For my Master of Medicine, I would like to perform an audit of patients that presented to [redacted] Emergency Departments related to the Comrades Marathon from 2010 until 2019 (10-year period). This will include Comrades Marathon athletes, as well as officials, volunteers and spectators that required assessment and or admission from your Emergency Departments designated to treat patients coming from the Comrades Marathon.

I am in the process of applying for ethics clearance from the Human Research Ethics Committee (Medical) at Wits.

Professor E. Kramer will be supervising the study.

I hereby request permission to use the relevant data to perform this study. Can you please supply me with the necessary documentation to fill and sign to proceed with this matter?

Warm regards,

Dr Friedrich Petrick
Emergency Medicine Registrar

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

7.4 Private Hospital Group Approval

RESEARCH OPERATIONS COMMITTEE FINAL APPROVAL OF RESEARCH

Approval number: UNIV-2021-0049

Mr Friedrich Petrick

E mail: fpetrick@gmail.com

Dear Mr Petrick

RE: AN AUDIT OF PATIENTS PRESENTING TO A PRIVATE HOSPITAL GROUP FOR COMRADES MARATHON RELATED INJURIES AND ILLNESSES FOR EMERGENCY DEPARTMENT OR INTRA-HOSPITAL MANAGEMENT.

The above-mentioned research was reviewed by the Research Operations Committee's delegated members and it is with pleasure that we inform you that your application to conduct this research at private Hospitals, has been approved, subject to the following:

i) Research may now commence with this FINAL APPROVAL from the Committee.

ii) All information regarding the Company will be treated as legally privileged and confidential.

iii) The Company's name will not be mentioned without written consent from the Committee.

iv) All legal requirements regarding patient / participant's rights and confidentiality will be complied with.

v) All data extracted may only be used in an anonymised, aggregated format and for the purposes of this specific study as specified in the proposal. The data may under no circumstances be used for any other purpose whatsoever.

vi) The research will be conducted in compliance with the GUIDELINES FOR GOOD CLINICAL PRACTICE IN HUMAN PARTICIPANTS IN SOUTH AFRICA (2016).

vii) The Company must be furnished with a STATUS REPORT on the progress of the study at least annually on 30th September irrespective of the date of approval from the Committee as well as a FINAL REPORT with reference to intention to publish and probable journals for publication, on completion of the study.

viii) A copy of the research report will be provided to the Committee once it is finally approved by the relevant primary party or tertiary institution, or once complete or if discontinued for any reason whatsoever prior to the expected completion date.

ix) The Company has the right to implement any recommendations from the research.

x) The Company reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects/ Company or should the researcher not comply with the conditions of approval.

xi) APPROVAL IS VALID FOR A PERIOD OF 36 MONTHS FROM DATE OF THIS LETTER OR COMPLETION OR DISCONTINUATION OF THE TRIAL, WHICHEVER IS THE FIRST.

We wish you success in your research.

Yours faithfully

25/10/2021

Prof Dion du Plessis
Full member: Research Operations Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy

Dr Shannon Nell
Chairperson: Research Operations Committee
Date: 10/12/2021

This letter has been anonymised to ensure confidentiality in the research report. The original letter is available with author of research

7.5 Data Extraction Variables

A1	Dataset period	Before timeframe: 23-05-2010 00h00 until 24-05-2010 23h59 22-05-2011 00h00 until 23-05-2011 23h59 27-05-2012 00h00 until 28-05-2012 23h59 26-05-2013 00h00 until 27-05-2013 23h59 25-05-2014 00h00 until 26-05-2014 23h59 24-05-2015 00h00 until 25-05-2015 23h59 22-05-2016 00h00 until 23-05-2016 23h59 28-05-2017 00h00 until 29-05-2017 23h59 03-06-2018 00h00 until 04-06-2018 23h59 02-06-2019 00h00 until 03-06-2019 23h59 CM timeframe: 30-05-2010 00h00 until 31-05-2010 23h59 29-05-2011 00h00 until 30-05-2010 23h59 03-06-2012 00h00 until 04-06-2010 23h59 02-06-2013 00h00 until 03-06-2010 23h59 01-06-2014 00h00 until 02-06-2010 23h59 31-05-2015 00h00 until 01-06-2010 23h59 29-05-2016 00h00 until 30-05-2010 23h59 04-06-2017 00h00 until 05-06-2010 23h59 10-06-2018 00h00 until 11-06-2010 23h59 09-06-2019 00h00 until 10-06-2010 23h59 After timeframe: 06-06-2010 00h00 until 07-06-2010 23h59 05-06-2011 00h00 until 06-06-2011 23h59 10-06-2012 00h00 until 11-06-2012 23h59 09-06-2013 00h00 until 10-06-2013 23h59 08-06-2014 00h00 until 09-06-2014 23h59 07-06-2015 00h00 until 08-06-2015 23h59 05-06-2016 00h00 until 06-06-2016 23h59 11-06-2017 00h00 until 12-06-2017 23h59 17-06-2018 00h00 until 18-06-2018 23h59 16-06-2019 00h00 until 17-06-2019 23h59
A2	Location(s)	1. ED1 2. ED2 3. ED3 4. ED4 5. ED5

	Data Field(s)	Data Field Format	Description	Obtained
1	Age (years)	Number		Yes
2	Sex (male/female)	Text		Yes
3	Home City	Text	Patient's city of origin	No
4	Medical aid / Private funding	Text		Yes
5	Athlete / Non-athlete	Text		No
6	Year of Race	Number		Yes
7	ED Triage score	Number		No
8	Time period of hospital presentation (before, during, after race)	Time	Can be the time of triage – I will categorise	Yes
9	Means of Transfer (private vehicle/road ambulance/air ambulance)	Text		Yes
10	Pre-hospital treatment provided (First aid/BLS/ACLS/Other)	Text		No
11	Existing or new condition (Existing/New)	Text		No
12	Disposition (RHT, Absconded, Discharged, Admitted, Died)	Text		Yes
13	Duration of admission (time in hours/days)	Time	Can be the "discharge" time – I will calculate the duration	No
14	Diagnosis	Text		Yes
15	Treatment received in the Emergency Department (First aid/BLS/ACLS/Other)	Text		No
16	Treatment received in hospital (Medical/Surgical)	Text		No
17	Admission hospital (Hospital Name)	Text		Yes

7.6 Age in years in timeframe table

Age	Before	Before Percentages	Difference to Comrades	Comrades	Comrades Percentages	After	After Percentages	Difference to Comrades	Total	CM vs non-CM
1	216	6.84%	31.28%	194	5.21%	240	7.41%	42.31%	650	36.80%
2	89	2.82%	14.07%	92	2.47%	73	2.25%	-8.72%	254	2.67%
3	58	1.84%	-11.18%	77	2.07%	89	2.75%	32.96%	224	10.89%
4	51	1.61%	-6.04%	64	1.72%	65	2.01%	16.83%	180	5.40%
5	50	1.58%	22.82%	48	1.29%	70	2.16%	67.76%	168	45.29%
6	36	1.14%	14.72%	37	0.99%	45	1.39%	39.91%	118	27.32%
7	30	0.95%	47.39%	24	0.64%	35	1.08%	67.76%	89	57.57%
8	27	0.85%	-13.96%	37	0.99%	33	1.02%	2.60%	97	-5.68%
9	34	1.08%	54.19%	26	0.70%	22	0.68%	-2.66%	82	25.76%
10	33	1.04%	94.55%	20	0.54%	20	0.62%	15.04%	73	54.79%
11	22	0.70%	23.53%	21	0.56%	22	0.68%	20.51%	65	22.02%
12	25	0.79%	1.65%	29	0.78%	29	0.90%	15.04%	83	8.34%
13	30	0.95%	68.44%	21	0.56%	21	0.65%	15.04%	72	41.74%
14	30	0.95%	96.52%	18	0.48%	22	0.68%	40.60%	70	68.56%
15	19	0.60%	-19.99%	28	0.75%	21	0.65%	-13.72%	68	-16.86%
16	37	1.17%	32.20%	33	0.89%	26	0.80%	-9.37%	96	11.42%
17	33	1.04%	49.66%	26	0.70%	31	0.96%	37.16%	90	43.41%
18	32	1.01%	25.77%	30	0.81%	24	0.74%	-7.97%	86	8.90%
19	42	1.33%	70.77%	29	0.78%	28	0.86%	11.07%	99	40.92%
20	38	1.20%	-0.43%	45	1.21%	46	1.42%	17.59%	129	8.58%
21	28	0.89%	-23.22%	43	1.15%	37	1.14%	-1.02%	108	-12.12%
22	35	1.11%	-6.21%	44	1.18%	34	1.05%	-11.11%	113	-8.66%
23	50	1.58%	43.79%	41	1.10%	45	1.39%	26.26%	136	35.03%
24	45	1.42%	17.91%	45	1.21%	48	1.48%	22.70%	138	20.31%
25	47	1.49%	4.56%	53	1.42%	45	1.39%	-2.33%	145	1.12%
26	46	1.46%	-1.38%	55	1.48%	63	1.95%	31.77%	164	15.19%
27	53	1.68%	-0.80%	63	1.69%	52	1.61%	-5.05%	168	-2.93%
28	72	2.28%	11.71%	76	2.04%	62	1.91%	-6.16%	210	2.78%
29	65	2.06%	2.19%	75	2.01%	68	2.10%	4.30%	208	3.24%
30	69	2.18%	9.94%	74	1.99%	49	1.51%	-23.83%	192	-6.94%
31	73	2.31%	13.26%	76	2.04%	60	1.85%	-9.18%	209	2.04%
32	59	1.87%	-10.81%	78	2.09%	59	1.82%	-12.99%	196	-11.90%
33	76	2.41%	-11.27%	101	2.71%	86	2.66%	-2.05%	263	-6.66%
34	65	2.06%	-20.16%	96	2.58%	69	2.13%	-17.32%	230	-18.74%

Age	Before	Before Percentages	Difference to Comrades	Comrades	Comrades Percentages	After	After Percentages	Difference to Comrades	Total	CM vs non-CM
35	57	1.80%	-6.65%	72	1.93%	50	1.54%	-20.11%	179	-13.38%
36	47	1.49%	-21.95%	71	1.91%	61	1.88%	-1.17%	179	-11.56%
37	43	1.36%	-24.33%	67	1.80%	50	1.54%	-14.15%	160	-19.24%
38	51	1.61%	-19.82%	75	2.01%	51	1.57%	-21.78%	177	-20.80%
39	58	1.84%	-14.51%	80	2.15%	65	2.01%	-6.53%	203	-10.52%
40	42	1.33%	-37.31%	79	2.12%	53	1.64%	-22.82%	174	-30.07%
41	40	1.27%	-32.62%	70	1.88%	49	1.51%	-19.48%	159	-26.05%
42	46	1.46%	-13.91%	63	1.69%	45	1.39%	-17.83%	154	-15.87%
43	50	1.58%	-12.01%	67	1.80%	48	1.48%	-17.59%	165	-14.80%
44	46	1.46%	-24.67%	72	1.93%	52	1.61%	-16.92%	170	-20.79%
45	35	1.11%	-32.35%	61	1.64%	46	1.42%	-13.25%	142	-22.80%
46	32	1.01%	-46.86%	71	1.91%	42	1.30%	-31.95%	145	-39.40%
47	40	1.27%	-11.01%	53	1.42%	41	1.27%	-11.01%	134	-11.01%
48	35	1.11%	-17.46%	50	1.34%	33	1.02%	-24.08%	118	-20.77%
49	40	1.27%	-11.01%	53	1.42%	38	1.17%	-17.52%	131	-14.27%
50	40	1.27%	-23.93%	62	1.66%	42	1.30%	-22.07%	144	-23.00%
51	34	1.08%	-16.48%	48	1.29%	35	1.08%	-16.12%	117	-16.30%
52	32	1.01%	-17.97%	46	1.23%	40	1.23%	0.03%	118	-8.97%
53	32	1.01%	-10.16%	42	1.13%	28	0.86%	-23.31%	102	-16.74%
54	37	1.17%	1.46%	43	1.15%	31	0.96%	-17.07%	111	-7.80%
55	33	1.04%	8.09%	36	0.97%	30	0.93%	-4.14%	99	1.97%
56	24	0.76%	-23.52%	37	0.99%	40	1.23%	24.36%	101	0.42%
57	24	0.76%	-35.68%	44	1.18%	34	1.05%	-11.11%	102	-23.40%
58	32	1.01%	-28.81%	53	1.42%	20	0.62%	-56.59%	105	-42.70%
59	29	0.92%	-7.58%	37	0.99%	29	0.90%	-9.84%	95	-8.71%
60	38	1.20%	35.78%	33	0.89%	36	1.11%	25.49%	107	30.64%
61	15	0.47%	-19.61%	22	0.59%	19	0.59%	-0.65%	56	-10.13%
62	33	1.04%	44.11%	27	0.72%	27	0.83%	15.04%	87	29.57%
63	24	0.76%	-2.42%	29	0.78%	19	0.59%	-24.63%	72	-13.53%
64	23	0.73%	23.27%	22	0.59%	28	0.86%	46.41%	73	34.84%
65	26	0.82%	53.28%	20	0.54%	17	0.52%	-2.22%	63	25.53%
66	22	0.70%	116.17%	12	0.32%	15	0.46%	43.79%	49	79.98%
67	20	0.63%	47.39%	16	0.43%	20	0.62%	43.79%	56	45.59%
68	24	0.76%	48.94%	19	0.51%	16	0.49%	-3.13%	59	22.91%
69	20	0.63%	68.44%	14	0.38%	13	0.40%	6.82%	47	37.63%
70	19	0.60%	72.33%	13	0.35%	9	0.28%	-20.36%	41	25.99%

Age	Before	Before Percentages	Difference to Comrades	Comrades	Comrades Percentages	After	After Percentages	Difference to Comrades	Total	CM vs non-CM
71	16	0.51%	45.12%	13	0.35%	11	0.34%	-2.66%	40	21.23%
72	11	0.35%	-31.74%	19	0.51%	17	0.52%	2.93%	47	-14.40%
73	13	0.41%	17.91%	13	0.35%	18	0.56%	59.28%	44	38.60%
74	20	0.63%	81.40%	13	0.35%	16	0.49%	41.58%	49	61.49%
75	12	0.38%	17.91%	12	0.32%	16	0.49%	53.38%	40	35.65%
76	6	0.19%	-21.39%	9	0.24%	9	0.28%	15.04%	24	-3.18%
77	18	0.57%	51.60%	14	0.38%	9	0.28%	-26.05%	41	12.78%
78	16	0.51%	45.12%	13	0.35%	11	0.34%	-2.66%	40	21.23%
79	9	0.28%	-51.76%	22	0.59%	14	0.43%	-26.80%	45	-39.28%
80	17	0.54%	54.19%	13	0.35%	17	0.52%	50.43%	47	52.31%
81	10	0.32%	-1.74%	12	0.32%	11	0.34%	5.45%	33	1.85%
82	11	0.35%	62.13%	8	0.21%	7	0.22%	0.66%	26	31.39%
83	6	0.19%	1.07%	7	0.19%	8	0.25%	31.47%	21	16.27%
84	4	0.13%	-75.18%	19	0.51%	7	0.22%	-57.62%	30	-66.40%
85	5	0.16%	-15.78%	7	0.19%	14	0.43%	130.07%	26	57.15%
86	6	0.19%	1.07%	7	0.19%	8	0.25%	31.47%	21	16.27%
87	6	0.19%	41.49%	5	0.13%	7	0.22%	61.05%	18	51.27%
88	1	0.03%	-60.70%	3	0.08%	5	0.15%	91.73%	9	15.51%
89	0	0.00%	-100.00%	7	0.19%	3	0.09%	-50.70%	10	-75.35%
90	2	0.06%	-41.04%	4	0.11%	3	0.09%	-13.72%	9	-27.38%
91	4	0.13%	371.65%	1	0.03%	3	0.09%	245.11%	8	308.38%
92	3	0.09%	-29.25%	5	0.13%	5	0.15%	15.04%	13	-7.11%
93	3	0.09%	absolute	0	0.00%	1	0.03%	absolute	4	100.00%
94	0	0.00%	absolute	0	0.00%	3	0.09%	absolute	3	100.00%
95	0	0.00%	absolute	0	0.00%	2	0.06%	absolute	2	100.00%
96	1	0.03%	absolute	0	0.00%	0	0.00%	absolute	1	100.00%
97	0	0.00%	-100.00%	1	0.03%	0	0.00%	-100.00%	1	-100.00%
98	2	0.06%	135.82%	1	0.03%	1	0.03%	15.04%	4	75.43%
99	0	0.00%	absolute	0	0.00%	1	0.03%	absolute	1	100.00%
100	0	0.00%	absolute	0	0.00%	0	0.00%	absolute	0	0.00%
101	0	0.00%	absolute	0	0.00%	1	0.03%	absolute	1	100.00%
Total	**3 160**	**100.00%**		**3 726**	**100.00%**	**3 239**	**100.00%**		**10 125**	

7.7 Age in years in Down-run and Up-run table

Age (years)	Down-run Presentations	Down-run percentage	Up-run Presentations	Up-run percentage	Total	Total percentage	Difference from Down- to Up-run
1	306	6.82%	344	6.10%	650	6.42%	-10.53%
2	114	2.54%	140	2.48%	254	2.51%	-2.26%
3	94	2.09%	130	2.31%	224	2.21%	10.06%
4	83	1.85%	97	1.72%	180	1.78%	-6.99%
5	78	1.74%	90	1.60%	168	1.66%	-8.17%
6	51	1.14%	67	1.19%	118	1.17%	4.55%
7	37	0.82%	52	0.92%	89	0.88%	11.85%
8	35	0.78%	62	1.10%	97	0.96%	40.98%
9	29	0.65%	53	0.94%	82	0.81%	45.45%
10	39	0.87%	34	0.60%	73	0.72%	-30.62%
11	31	0.69%	34	0.60%	65	0.64%	-12.71%
12	30	0.67%	53	0.94%	83	0.82%	40.60%
13	36	0.80%	36	0.64%	72	0.71%	-20.42%
14	33	0.74%	37	0.66%	70	0.69%	-10.77%
15	26	0.58%	42	0.74%	68	0.67%	28.56%
16	50	1.11%	46	0.82%	96	0.95%	-26.78%
17	47	1.05%	43	0.76%	90	0.89%	-27.19%
18	39	0.87%	47	0.83%	86	0.85%	-4.09%
19	51	1.14%	48	0.85%	99	0.98%	-25.10%
20	64	1.43%	65	1.15%	129	1.27%	-19.17%
21	50	1.11%	58	1.03%	108	1.07%	-7.68%
22	59	1.31%	54	0.96%	113	1.12%	-27.16%
23	64	1.43%	72	1.28%	136	1.34%	-10.47%
24	58	1.29%	80	1.42%	138	1.36%	9.77%
25	61	1.36%	84	1.49%	145	1.43%	9.59%
26	72	1.60%	92	1.63%	164	1.62%	1.69%
27	80	1.78%	88	1.56%	168	1.66%	-12.46%
28	100	2.23%	110	1.95%	210	2.07%	-12.46%
29	94	2.09%	114	2.02%	208	2.05%	-3.48%
30	84	1.87%	108	1.92%	192	1.90%	2.32%
31	92	2.05%	117	2.08%	209	2.06%	1.21%
32	86	1.92%	110	1.95%	196	1.94%	1.79%
33	109	2.43%	154	2.73%	263	2.60%	12.44%

Age (years)	Down-run Presentations	Down-run percentage	Up-run Presentations	Up-run percentage	Total	Total percentage	Difference from Down- to Up-run
34	96	2.14%	134	2.38%	230	2.27%	11.09%
35	85	1.89%	94	1.67%	179	1.77%	-11.99%
36	73	1.63%	106	1.88%	179	1.77%	15.56%
37	67	1.49%	93	1.65%	160	1.58%	10.47%
38	79	1.76%	98	1.74%	177	1.75%	-1.27%
39	91	2.03%	112	1.99%	203	2.00%	-2.05%
40	84	1.87%	90	1.60%	174	1.72%	-14.73%
41	71	1.58%	88	1.56%	159	1.57%	-1.36%
42	63	1.40%	91	1.61%	154	1.52%	14.96%
43	67	1.49%	98	1.74%	165	1.63%	16.41%
44	69	1.54%	101	1.79%	170	1.68%	16.49%
45	58	1.29%	84	1.49%	142	1.40%	15.26%
46	65	1.45%	80	1.42%	145	1.43%	-2.05%
47	68	1.52%	66	1.17%	134	1.32%	-22.76%
48	56	1.25%	62	1.10%	118	1.17%	-11.89%
49	63	1.40%	68	1.21%	131	1.29%	-14.10%
50	69	1.54%	75	1.33%	144	1.42%	-13.49%
51	50	1.11%	67	1.19%	117	1.16%	6.64%
52	57	1.27%	61	1.08%	118	1.17%	-14.83%
53	47	1.05%	55	0.98%	102	1.01%	-6.87%
54	53	1.18%	58	1.03%	111	1.10%	-12.91%
55	42	0.94%	57	1.01%	99	0.98%	8.01%
56	35	0.78%	66	1.17%	101	1.00%	50.07%
57	48	1.07%	54	0.96%	102	1.01%	-10.47%
58	50	1.11%	55	0.98%	105	1.04%	-12.46%
59	41	0.91%	54	0.96%	95	0.94%	4.82%
60	40	0.89%	67	1.19%	107	1.06%	33.30%
61	21	0.47%	35	0.62%	56	0.55%	32.64%
62	42	0.94%	45	0.80%	87	0.86%	-14.73%
63	26	0.58%	46	0.82%	72	0.71%	40.80%
64	31	0.69%	42	0.74%	73	0.72%	7.82%
65	29	0.65%	34	0.60%	63	0.62%	-6.69%
66	24	0.53%	25	0.44%	49	0.48%	-17.10%
67	27	0.60%	29	0.51%	56	0.55%	-14.52%
68	21	0.47%	38	0.67%	59	0.58%	44.01%

Age (years)	Down-run Presentations	Down-run percentage	Up-run Presentations	Up-run percentage	Total	Total percentage	Difference from Down- to Up-run
69	20	0.45%	27	0.48%	47	0.46%	7.44%
70	15	0.33%	26	0.46%	41	0.40%	37.95%
71	14	0.31%	26	0.46%	40	0.40%	47.80%
72	22	0.49%	25	0.44%	47	0.46%	-9.56%
73	18	0.40%	26	0.46%	44	0.43%	14.96%
74	21	0.47%	28	0.50%	49	0.48%	6.11%
75	17	0.38%	23	0.41%	40	0.40%	7.67%
76	15	0.33%	9	0.16%	24	0.24%	-52.25%
77	14	0.31%	27	0.48%	41	0.40%	53.49%
78	17	0.38%	23	0.41%	40	0.40%	7.67%
79	14	0.31%	31	0.55%	45	0.44%	76.22%
80	23	0.51%	24	0.43%	47	0.46%	-16.95%
81	9	0.20%	24	0.43%	33	0.33%	112.23%
82	9	0.20%	17	0.30%	26	0.26%	50.33%
83	10	0.22%	11	0.20%	21	0.21%	-12.46%
84	8	0.18%	22	0.39%	30	0.30%	118.86%
85	10	0.22%	16	0.28%	26	0.26%	27.34%
86	13	0.29%	8	0.14%	21	0.21%	-51.02%
87	3	0.07%	15	0.27%	18	0.18%	297.92%
88	5	0.11%	4	0.07%	9	0.09%	-36.33%
89	2	0.04%	8	0.14%	10	0.10%	218.34%
90	5	0.11%	4	0.07%	9	0.09%	-36.33%
91	2	0.04%	6	0.11%	8	0.08%	138.75%
92	4	0.09%	9	0.16%	13	0.13%	79.07%
93	1	0.02%	3	0.05%	4	0.04%	138.75%
94	0	0.00%	3	0.05%	3	0.03%	absolute
95	2	0.04%	0	0.00%	2	0.02%	-100.00%
96	1	0.02%	0	0.00%	1	0.01%	-100.00%
97	0	0.00%	1	0.02%	1	0.01%	absolute
98	3	0.07%	1	0.02%	4	0.04%	-73.47%
99	0	0.00%	1	0.02%	1	0.01%	absolute
100	0	0.00%	0	0.00%	0	0.00%	absolute
101	0	0.00%	1	0.02%	1	0.01%	absolute
Total	**4 487**		**5 638**		**10 125**		

End.