

Risk factors and complications of nail-stick plantar injuries in Jamaican children

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DOAJ: [bea038ba6b61468993879a5c1ff2dab5](https://doi.org/10.2196/2023.1013)

DOI:

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Abstract

Objectives: To determine the prevalence of nail-stick foot injuries in children visiting the Bustamante Hospital for Children (BHC) in Jamaica, identify the time between injury and hospital presentation, identify the risk factors for injury and complications, identify the complications, and the association between time to presentation and complication rate.

Method: A retrospective cohort analysis of children between the ages of 0-12 years presenting to the BHC from July 1, 2015, to August 31, 2018, with nail-stick foot injuries was performed. Extracted data included demographics, date of injury and presentation, side injured, zone of injury, number of nail-sticks, footwear use during injury, treatment, date of hospital discharge and complications. Data were analysed to determine the factors associated with morbidity including complications.

Results: Two hundred and ten (210) children met the inclusion criteria. The prevalence rate was 6 patients per 1000 hospital admissions. The mean time to presentation was 2 days. Using Patzakis classification, 26, 76 and 66 persons had zone 1, 2 and 3 injuries respectively. The complication rate was 14.8%. Complications observed were abscesses (77.4%), retained foreign bodies (9.7%), osteomyelitis (6.5%), deep wound infection (3.2%) and cellulitis (3.2%). Children presenting after 2 days ($p < 0.0001$) and zone 1 injuries ($p = 0.030$) were more likely to have complications. Footwear was protective against complications ($p = 0.006$).

Conclusion: Nail-stick foot injuries are frequent presentations at the Bustamante Hospital for Children. Boys older than 9 years are the greatest at-risk group. The most common complication is abscess formation and delays in presentation greater than 2 days were more likely associated with complications.

Introduction

Penetrating plantar injuries are common occurrences in all age groups with associated frequent presentations to the Emergency Department.¹⁻⁵ Fitzgerald et al (1975) reported that approximate 1% of their emergency room visits were for children with penetrating plantar injuries.⁶ Children that sustain penetrating plantar injuries are usually secondary to nail-sticks into the sole of the foot.^{1,3,7,8} Complications from these injuries include persistent pain, retained foreign body, cellulitis, abscess formation, epidermal inclusion cyst, tendon laceration/dysfunction, nerve injury and osteomyelitis.⁸ Eidelman et al (2003) reviewed 80 children with complicated plantar punctures, fifty-nine (74%) had superficial cellulitis, eleven (14%) had retained foreign bodies, and ten (12%) patients had osteomyelitis and/or septic arthritis.⁹

The complication rates are associated with several risk factors including time to presentation after injury, location and depth of penetrating foreign object, type of penetrating foreign object, environment surrounding the injury, use of footwear, previous treatment, and the health status of the patient.^{2,10,11} This information must be obtained through a thorough assessment to ascertain an accurate diagnosis and implement appropriate management in an attempt to prevent a poor outcome.³ Understanding the epidemiology and pathogenesis may help to identify persons at higher risk for injury and complications. With public awareness and appropriate intervention and management, the frequency of these injuries and their complications can be reduced.

The Bustamante Hospital for children (BHC) is the only specialist paediatric hospital in the English-Speaking Caribbean and is located in Kingston, Jamaica.¹² It has a 283-bed capacity and cares for children from birth to 12 years old.¹² Although most patients presenting to the hospital live in the Kingston/St. Andrew and neighbouring parishes, the facility accepts referrals from other hospitals throughout the island. Therefore, the hospital's patient population represents a cross section of all children in Jamaica.

At BHC, children present frequently with nail-stick injuries to the plantar aspect of the foot. These children are routinely referred to the Orthopaedic team for further management. Despite the frequent occurrence of this injury, no published study was seen from Jamaica or the Caribbean looking at nail-stick foot injuries in children.

Upon recognising the frequent presentations and acknowledging the possible complications, this study was designed to evaluate the epidemiology, identify risk factors and complications, and determine the complication rate of nail-stick foot injuries at the BHC. Our objectives were to determine the prevalence of nail-stick foot injuries, identify the times between injury and presentation to the hospital, identify the complications associated with these injuries and respective rates, and to evaluate if there is an association between time to presentation and complication rates. With this information we attempted to quantify the problem and possibly suggest strategies for prevention.

Methods

This study was a retrospective cohort analysis of children presenting to the BHC from July 1, 2015, to August 31, 2018, with nail-stick foot injuries. Approvals for the research was obtained from the Ethics and Medico-legal Affairs Panel at the Ministry of Health, Jamaica and the Ethics Committee at the University of the West Indies, Mona, Jamaica. The study was conducted in accordance with both committees' guidelines for the Conduct of Research.

Routinely, all children presenting to the BHC with nail-stick foot injuries are referred to the Orthopaedic surgery service and admitted to the Orthopaedic ward. This study included children between the ages of 0 to 12 years that were admitted to the Orthopaedic ward with nail-stick foot injuries. Persons that were not referred to the Orthopaedic Surgery service (i.e., discharged home without Orthopaedic surgery consultation), were not admitted to the Orthopaedic ward (refused admission, admitted to other wards for other medical conditions), had multiple diagnoses on admission and irretrievable medical files were excluded. The hospital's coding system was used to identify all cases of non-specific foot injuries presenting to the BHC, as there was no specific code for penetrating foot injury. These cases were reviewed, and the study population was identified based on the inclusion and exclusion criteria.

Study participants were assigned identification numbers by the coordinator prior to data collection. This extracted data included demographic information, the place the injury occurred, date of injury, date of presentation, the side injured, zone of injury, number of nail-sticks, footwear use during injury, diagnosis, treatment, date of

hospital discharge and complications. The assessed risk factors for injury were age, gender, use of footwear, type of footwear and place of injury. Complications of the injury documented at initial presentation, during admission and at outpatient review were also recorded. The most serious of complications was documented per patient. As far as possible, the diagnoses did not overlap. Complications observed for were categorised as cellulitis, wound infection, abscess, retained foreign body, osteomyelitis, injury to tendon, nerve, blood vessels, and other. The anatomical zones of foot injury as described by Patzakis et al (Figure 1) were used to classify the injuries.¹¹

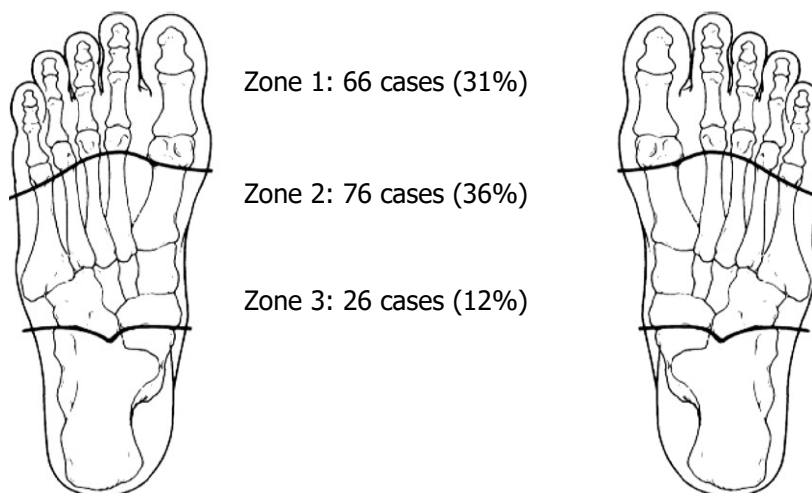
The data was collected using Epidata and exported to SPSS version 19.0 statistical software for analysis. Prevalence was calculated as per Orthopaedic ward admissions and hospital admissions. Age was categorised into 4 groups. Group 1 for ages 0 to 2.9 years, Group 2 for ages 3 to 5.9 years, Group 3 for ages 6 to 8.9 years and Groups 4 for patients 9 years and older. Time to presentation was calculated as the date of presentation minus the date of injury. Based on Racz et al and Chisholm et al, time to presentation was categorised into two days or less, and greater than two days.^{1, 2} Length of stay was the day of discharge minus the date of presentation. The outcome variable was complications. Pearson’s chi-square was used to identify significant variable associations and regression analysis was performed with statistical significance set at $p < 0.05$.

Results

Two hundred and seventy-two (272) children presenting to the BHC were identified with non-specific foot injuries, of which 210 case files were located for patients that qualified for the study. The excluded cases of nail-stick plantar injuries were 8 children that were not referred to the Orthopaedic service and 3 children that refused admission. For the 210 cases of nail-stick foot injuries observed between July 2015 to August 2018 (Table 1), the prevalence was 54 patients per 1000 admissions to the Orthopaedic ward and 6 patients per 1000 hospital admissions (Table 2). A progressive increase in the prevalence rate was noted between July 2015 and December 2017 for Orthopaedic ward admissions. This was as high as 64.1 patients per 1000. There were 141 males and 69 females with ages ranging from 1.1 to 11.8 years old. The mean age was 7.3 years old with a standard deviation (SD) of 2.8. Injuries were most common in the oldest age group, that is ages 9 years and older (Figure 2). The majority of patients lived in Kingston, Jamaica (81%), i.e., within the parish of the hospital’s location.

Time to presentation ranged from 0 to 31 days. The majority of cases (73.7%) presented within two days. The mean time to presentation was 2.4 days with a SD of 4.2. Approximately 93.3% of the patients sustained a single puncture injury, while 6.2 % of patients presented with two nail sticks. One child had three nail sticks

Figure 1. Study Population Distribution of Zones of Foot Injury



(Zones as postulated by Patzakis et al; reference 11)

Table 1. Distribution of Study Participants with or without Complications

Variables	Complications (n=31)	No Complications (n=179)	Total Admis- sion (n=210)
Gender			
Male	18 (13%)	123 (87%)	141
Female	13 (19%)	56 (81%)	69
Age			
Group 1 (0- 2.9)	0 (0)	16 (100%)	16
Group 2 (3 - 5.9)	5 (10%)	46 (90%)	51
Group 3 (6 - 8.9)	13 (19%)	57 (81%)	70
Group 4 (≥ 9 years)	13 (18%)	60 (82%)	73
Address			
Kingston	28 (16%)	142 (84%)	170
St. Andrew	2 (13%)	13 (87%)	15
St. Catherine	4 (17%)	20 (83%)	24
St. Thomas	0 (0)	1 (100%)	1
Time to Presentation			
≤ 2 days	10 (6%)	149 (94%)	159
> 2 days	20 (40%)	30 (60%)	50
Number of Sticks			
One	31 (16%)	165 (84%)	196
Two	1 (8%)	12 (92%)	13
Three	0 (0%)	1 (100%)	1
Zone of Injury			
Zone 1	14 (21%)	52 (79%)	66
Zone 2	6 (8%)	70 (92%)	76
Zone 3	9 (35%)	17 (65%)	26
Footwear			
Barefoot	10 (8%)	112 (92%)	122
	17 (23%)	56 (77%)	73
Length of Stay			
	2-27 days	0-13 days	0-27 days

Table 2. Admission and Prevalence Trends of Nail-stick Foot Injuries

Number of Admis- sions	July – December 2015	January– December 2016	January– December 2017	January – August 2018	Total (Average)
Nail-stick Injuries	28	64	66	52	210
Orthopaedic Ward	607	1246	1029	980	3862
Prevalence per 1000	46.1	51.4	64.1	53.1	(54.4)
Total Hospital Admis-	5157	10482	10958	6519	33116
Prevalence per 1000	5.4	6.1	6.0	8.0	(6.3)

Figure 2. Bar Chart showing Age Group Distribution

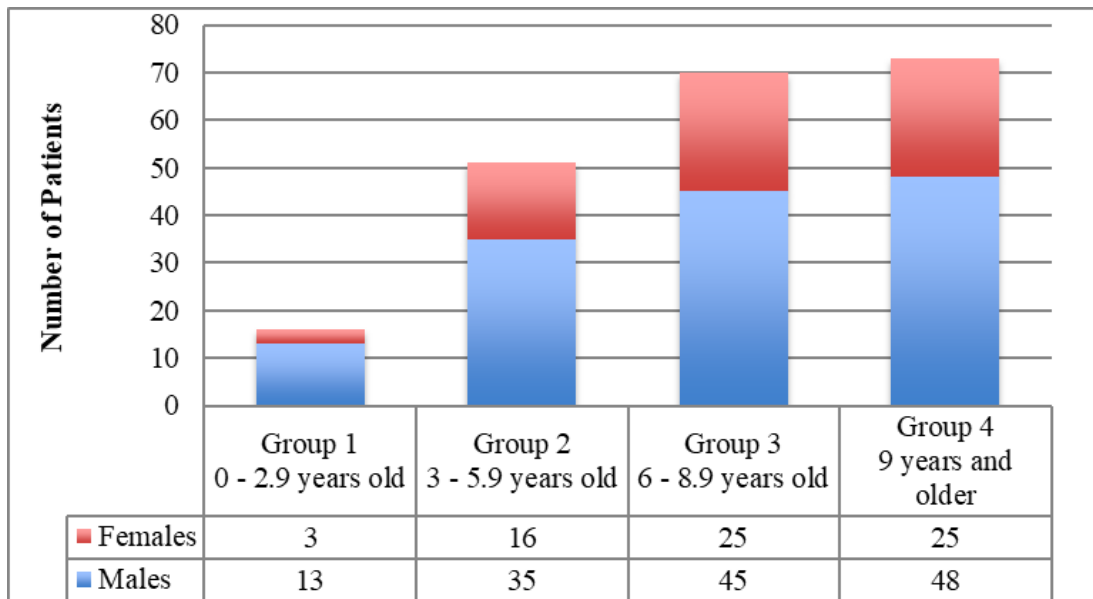


Table 3. Logistic Regression Analysis of Complications and Explanatory Variables

Complications	Odds Ratio	Standard Error	Z score	P-value	95% Confidence Interval
Female	4.78	3.22	2.32	0.020	1.28-17.88
No Footwear	4.29	2.76	2.26	0.024	1.22-15.14
Zone 2 Injury	0.23	0.18	-1.93	0.053	0.05-1.02
Zone 3 Injury	0.72	0.54	0.44	0.663	0.17-3.11
Time to Presentation >2 days	21.43	14.90	4.41	0.000	5.48-83.71

sustained at a single event. One hundred and twenty-two (58%) patients had been wearing footwear during injury, 35% were barefooted and in the remaining children, the use of footwear was not documented.

The zone of injury for our study was documented in 168 of the 210 cases. Seventy-six patients had zone 2 injuries. Sixty-six and 26 patients had zone 3 and zone 1 injuries respectively. One patient that sustained two nail sticks had a zone 2 and a zone 3 injury on the same foot. This case was classified as a zone 2 injury because of the close proximity of the proximal injury to the zone 2 area.

The majority of patients (95%) received antibiotic prophylaxis. Length of hospital stay ranged from 0 to 27 days with a mean stay of 4.2 days and a SD of 2.8. Complications were present in 14.8% of patients. Soft tissue abscesses accounted for 77.4% of complications.

Other complications observed were retained foreign bodies (9.7%), osteomyelitis (6.5%), deep wound infection (3.2%) and cellulitis (3.2%). The cases of osteomyelitis involved the calcaneus and the fifth metatarsal bone. No significant associations were noted between gender, age groups, and number of sticks and complications. Children presenting after 2 days were more likely to have complications ($p < 0.0001$). Children with zone 1 injuries were more likely to have complications ($p = 0.030$). Footwear was noted to be protective against complications ($p = 0.006$).

For time to presentation beyond two days, the odds ratio of having a complication was 21, [95% CI 5.5 to 83.7] ($p < 0.0001$). Girls were more likely to have complications compared to boys ($p = 0.02$). Footwear was protective, with barefooted children having more likelihood of developing complications ($p = 0.02$).

Discussion

Nail-stick injuries are common occurrences at the Bustamante Hospital for Children (BHC), accounting for at least 1 in every 18 admissions to the Orthopaedic ward. Our group of confirmed 210 cases over 38 months was larger than a group of 147 cases of penetrating plantar injuries reported from a Level-1 trauma centre in Texas, United States of America, over 52 months.¹³ The progressive increase in prevalence observed suggests either increased incidence of injuries or more persons are seeking hospital care for these injuries rather than using home remedies. This therefore more healthcare resources will be required to treat this increased patient load. This could be impacting the hospital's budget negatively and decreasing the resources available for other patients.

Boys had a higher frequency of injury compared to girls. Similar findings were noted by Laughlin et al (1997) with boys accounting for 84% of children admitted with infected penetrating foot injuries.¹⁴ In a study by Sharpe et al (2003) of 146 children with penetrating foot injuries, 76% (111) were boys.⁷ The tendency for boys to participate in more outdoor activities may be the reason behind these findings. Sharpe postulated that boys were more likely to go to unsafe, neglected areas where discarded nails could result in injury.⁷ Although some studies acknowledge the higher frequency in boys, there was no study seen that truly evaluated the possible reasons for this sex distribution.^{7, 9, 14}

Despite boys having a higher frequency of nail-stick foot injuries in our study, girls were more likely to get complications. Anatomically the feet of both sexes at this age are relatively the same. Hence, the increased frequency in girls may be related to factors other than gender. Other factors, such as footwear use during the injury and the type of footwear, may have resulted in the girls of this study being more likely to have complications. Girls more presumably wear poorly protective or non-protective footwear such as sandals and "flip-flops". The use of these types of poorly protective footwear could potentially increase the likelihood of greater contamination of the foot during the injury. Although the number of children wearing flip-flops and developing complications was equivalent for both sexes in the study, the number of girls wearing flip-flops was not sufficient to draw conclusions regarding causation.

Nail-stick plantar injuries occurred in higher frequency in the older age groups. It was highest in ages 9 years and above. Laughlin also noted a mean age of 9.0 ± 3.4 years in their study and Sharpe's study participants had a mean age of 9 years with injuries occurring mostly in 10-year-old children.^{7, 14} Younger children are less aware of dangers, which would inherently make them more likely to have these injuries. However, because of this decreased awareness, younger children are usually more supervised by adults. Older children are often allowed more autonomy of movement. Therefore, decreased adult supervision and increased activity levels with older children may be the reasons they are more at risk for these injuries and may therefore explain the increased frequency found in this study.

A survey of some of the study participants showed that many injuries occurred in and around the home. Unfortunately, this reflects the likelihood of lack of proper nail disposal, inadequate home safety measures and insufficient appropriate adult supervision. Public awareness and education measures could therefore be helpful in decreasing the frequencies of these injuries and hence the complications.

The majority of children in our study wore footwear at the time of injury, similar to Sharpe et al study.⁷ This was surprising as footwear is made to be protective against injury. However, this association with footwear and nail-stick injuries may also be the result of the poorly protective footwear being worn during the time of injury. Our study had a large number of participants that wore "flip-flops" at the time of injury. "Flip-flops" reportedly provide little to no protection to penetrating objects such as nails.¹⁰ In the study, footwear did not offer full protection against these injuries, but it was protective against complications ($p=0.006$). In contrast, some studies have however speculated that certain footwear use during penetrating foot injury can increase the risk of complications due to retained foreign body and inoculated flora, such as *Pseudomonas aeruginosa* from sneakers.^{2, 4, 10, 14, 15}

In our study population, there was equal distribution between the right and left foot. One patient even had bilateral foot injuries. With regards to the number of nail-sticks sustained, with only 6.7% of patients sustaining more than one nail-stick, we were unable to determine if increased number of sticks increased the risk for

complications. Patzakis et al (1989) formulated and published the zones of penetrating foot injury. The foot was divided into three zones where zone 1 is from the metatarsal neck to the end of the toes. Zone 2 is from the distal end of calcaneus to the metatarsal necks and zone 3 is the heel area. Zone 1 was the most injured zone in their study.¹¹ Our study revealed that zone 2 (36%) presumptively had the highest frequency of nail-stick foot injuries, followed by zone 1 injuries (31%). Increased zone 2 nail-stick injuries may be the result of patients running causing the midfoot to strike the ground first followed by the forefoot. This is because as speed increases from walking to running, initial ground contact changes from being hindfoot to midfoot to forefoot, with sprinters having increased forefoot initial ground contact.¹⁶

The complication rate in our study was 14.8%. This complication rate was higher than rates reported in the literature. This may be due to some persons only presenting after the complication ensued. Houston et al (1962) reported complication rates of 2% and 10.8% in patients initially presenting without complications and those presenting with complications respectively.¹⁷ Schwab and Powers (1995) reported that patients presenting to the emergency room had infection rates of 8% and a complication rate of 12%.¹⁸ Sharpe et al (2003) reported a 1.4% infection rate, and an 11% rate of a retained foreign body.⁷ We found that majority of persons with complications had these complications from initial presentation (94%). Only 1% of patients developed complications after initial presentation and this suggests the significant impact that early medical treatment has on the prevention of most complications.

Concerns of heightened or overestimated complication rates in some studies have been suggested as most patients presented only because they had complications. Weber (1996) did a survey of 200 ambulatory patients in the emergency room who had a previous history of plantar foot injuries. Forty-four percent of patients recalled having prior penetrating foot injuries of which only 50% of wounds were reported to a physician.¹⁹

Complications observed in this study were soft tissue abscesses, osteomyelitis, retained foreign body, cellulitis and a deep wound infection. Abscess development was far more common than the others at 77.4%. Abscess formations are the result of inoculation of infective

microorganisms into the soft tissues during the injury.⁷ The osteomyelitis rate for this study was 6.5%. In the Eidelman et al study (2003), abscesses/cellulitis were also the most common group of complications at 73.8%. They however had a higher rate of osteomyelitis (10%) than we observed.⁹ Patzakis et al (1989) reported an even higher rate of osteomyelitis (33%) in their study.¹¹

One objective of the study was to evaluate if the time to presentation was a significant prognostic factor in developing complications. According to Chisholm and Schlessler (1989) and Schwab and Powers (1995), increased time to presentation is predictive for complications.^{2,18} For delays greater than two (2) days, the study showed an increased likelihood to develop complications. This relationship between time to presentation and complication was a similar finding in studies done by Fitzgerald in 1975[6] and Eidelman et al in 2003.^{6,9} For the 80 children with secondary foot infections studied by Eidelman et al (64 were after nail-sticks injuries), they found an average delay of 4.1 days between injury and time to presentation.⁹ If some patients are only presenting because they have a complication and the likelihood of complications increase with longer time to presentation, the wide confidence interval (5.48 - 83.71) noted in the regression analysis between time to presentation and complications may be explained.

Patzakis et al (1989) evaluated 70 patients with penetrating foot injuries and found that 97.2% of the patients with complications had zone 1 injuries. Zone 1 injury was deemed to have the highest risk of complications, particularly osteomyelitis. The authors attributed an increased risk for complications in zone 1 and zone 3 areas because they are dominant weight bearing aspects of the foot. Zone 1 also has the least amount of soft tissue on the plantar surface when compared to zones 2 and 3, rendering it even more susceptible to deeper penetrating injuries. They recommended that in the absence of infection, zone 1 injuries should be considered for admission or very close monitoring.¹¹ Laughlin et al (1997) did not use the zones postulated by Patzakis in their study but they noted that all their cases of osteomyelitis occurred with injuries to the forefoot.¹⁴ We found that the zone of injury had associations with complications. Zone 1 had the highest risk for complications compared to zones 2 and 3 in Pearson's chi square tabulations. However, when other

variables such as age, sex, footwear, and time to presentation were taken into account, the difference in risk did not reach statistical significance but trended toward significance suggesting that in a larger population this would likely be significant.

Our study highlights the high prevalence of nail-stick plantar injuries and its complications in children presenting to the BHC. There is need for an educational program to highlight proper disposal of sharp objects, adequate supervision of young children and early presentation for medical treatment of all nail-stick plantar injuries. Being a retrospective study, missing data was a limitation that ultimately affected the power of the study. This missing data may have resulted in our inability to significantly prove certain associations, for example zone 1 injuries being a strong prognosticator for complications. In conclusion, nail-stick plantar injuries are frequent presentations at the BHC and children commonly present with complications. Boys older than 9 years are the greatest at-risk group. Complications are most common in those children presenting after 2 days and with zone 1 injuries. Prospective studies evaluating the demographics, treatment and clinical course of these injuries are needed to inform policy regarding resource allocation and treatment protocols.

ACKNOWLEDGEMENT: This research project was made possible with the guidance and assistance from our patients, families, colleagues and the staff at the Bustamante Hospital for Children. Thank you for all your input and efforts.

COMPETING INTERESTS: The authors have no competing interests.

ETHICS APPROVAL: Approvals for this study were obtained from the Ethics and Medico-legal Affairs Panel at the Ministry of Health, Jamaica and the Ethics Committee at the University of the West Indies, Mona, Jamaica. This study was conducted in accordance with both committees' guidelines for the Conduct of Research.

FUNDING: This is not applicable as no funding was sought for conduct of the research. The materiel and efforts given for the research were completely voluntary.

AUTHOR CONTRIBUTIONS: The names and contributions of each author are as follows:

- 1) Dr. Kijana Barrett - First author, research conceptualisation, chief investigator, literature review, research design, data collection, data entry, data analysis/interpretation and manuscript drafting
- 2) Dr. Dayanand Sawh - Second author, research conceptualisation, research design, data collection and manuscript editing/review
- 3) Dr. Wayne Palmer - Third author, research design, data analysis/interpretation, manuscript editing/review
- 4) Dr. Pierre Williams - Literature review, research design, data entry, data analysis and manuscript review
- 5) Dr. Charlene Chin See - Research design, data collection, data entry and manuscript review

References

1. Racz RS, Ramanujam CL, Zgonis T. Puncture Wounds of the Foot. *Clinics in Podiatric Medicine and Surgery*. 2010; 27 (4): 523-34.
2. Chisholm CD, Schlessler JF. Plantar puncture wounds: controversies and treatment recommendations. *Annals of Emergency Medicine*. 1989; 18(12): 1352-7.
3. Belin R, Carrington S. Management of Pedal Puncture Wounds. *Clinics in Podiatric Medicine and Surgery*. 2012; 29(3): 451-8.
4. Pennycook A, Makower R, O'Donnell AM. Puncture wounds of the foot: can infective complications be avoided? *Journal of the Royal Society of Medicine*. 1994; 87(10): 581.
5. Baldwin G, Colbourne M. Puncture wounds. *Pediatrics in Review*. 1999; 20(1): 21-3.
6. Fitzgerald RH Jr, Cowan JD. Puncture wounds of the foot. *The Orthopedic Clinics of North America*. 1975; 6(4): 965-72.
7. Sharpe KR, Lamb G, Bass A, Bruce CE. Prophylactic surgical debridement of foot punctures in 146 children. A year's practice with a review of the literature. *Foot and Ankle Surgery*. 2003; 9(2): 123 -7.
8. Haverstock BD. Puncture wounds of the foot. *Clinics in Podiatric Medicine and Surgery*. 2012; 29 (2): 311-22.
9. Eidelman M, Bialik V, Miller Y, Kassis I. Plantar puncture wounds in children: Analysis of 80

- hospitalized patients and late sequelae. *IMAJ-RAMAT GAN*. 2003; 5(4): 268-71.
10. Chong CH, Verhoeven W, Mun CW. Rubber foreign bodies in puncture wounds of the foot in patients wearing rubber-soled shoes. *Foot & Ankle International*. 2001; 22(5): 409-14.
 11. Patzakis MJ, Wilkins JE, Brien WW, Carter VS. Wound site as a predictor of complications following deep nail punctures to the foot. *Western Journal of Medicine* 1989; 150(5): 545.
 12. Southeast Regional Health Authority. Bustamante Hospital for Children. 2019 www.serha.gov.jm/bustamante-hospital-for-children (Accessed March 31, 2019)
 13. Volk A, Zebda M, Abdelgawad AA. Plantar and pedal puncture wounds in children: a case series study from a single level I trauma center. *Pediatric Emergency Care*. 2017; 33(11): 724-9.
 14. Laughlin TJ, Armstrong DG, Caporusso J, Lavery LA. Soft tissue and bone infections from puncture wounds in children. *Western Journal of Medicine*. 1997; 166(2): 126.
 15. Jacobs RF, McCarthy RE, Elser JM. Pseudomonas osteochondritis complicating puncture wounds of the foot in children: a 10-year evaluation. *Journal of Infectious Diseases*. 1989; 160(4): 657-61.
 16. Novacheck TF. The biomechanics of running. *Gait & posture*. 1998; 7(1): 77-95.
 17. Houston AN, Roy WA, Faust RA, Ewin DM. Tetanus prophylaxis in the treatment of puncture wounds of patients in the deep south. *Journal of Trauma and Acute Care Surgery*. 1962; 2(5): 439-50.
 18. Schwab RA, Powers RD. Conservative therapy of plantar puncture wounds. *Journal of Emergency Medicine*. 1995; 13(3): 291-5.
 19. Weber EJ. Plantar puncture wounds: a survey to determine the incidence of infection. *Emergency Medicine Journal*. 1996; 13(4): 274-7.