



Research article

Nurses' experience with chronic foot pain and their job-the national science foundation foot health survey

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ABSTRACT

Background: Chronic foot pain (CFP) impacts nurses' ability to provide care at the bedside. Treatment options for CFP were insufficient to address foot pain for nurses who stand or walk for prolonged periods while providing care to patients.

Aims: This study aimed to explore nurses' experience with CFP, current treatment options for foot pain, and the impact of foot pain on nurses' job performance.

Methods: This is secondary data from Individual interviews ($n = 122$) involving open-ended questions. Data were collected between April 2019–September 2020 while attending the National Science Foundation (NSF) I-Corps program comprising faculty and students among others in the United States. Multiple linear regression and multinomial/binary logistic regressions were conducted to assess what factors were associated with the pain and pain relief solutions.

Results: Nurses who worked at the bedside predominantly switched jobs and reported higher levels of foot pain than those who did not switch jobs ($\beta = 0.19, p = .044$). Longer working hours ($\beta = 0.35, p < .001$) were associated with higher levels of pain. Nurses who worked longer time were more likely to purchase new work shoes and socks ($OR = 1.177, p = .025$) to alleviate foot pain than changing shoes only.

Conclusions: Most nurses expressed interest in new products to relieve their CFP. Innovations are urgently needed to address CFP. Future longitudinal studies are required to further elucidate appropriate preventative strategies to prevent and treat CFP in nurses.

1. Introduction

Nurses are the largest number of healthcare workers in the United States with approximately 4.2 registered nurses (RN) [1]. Approximately 84.5% of individuals in the United States are employed nursing [1]. About 59% of healthcare professionals globally are nurses with a global workforce of around 28 million [2]. As the federal government projects more than 203,000 new RN positions will be created each year from 2021 to 2031 [1] in the United States, questions remain if nurses are positioned to experience longevity and job satisfaction in their various positions. In addition, whether nurses are satisfied with the conditions of their job, especially bedside nurses. What are the implications of spending most working days and hours while standing on your feet? Studies have not been able to elucidate factors affecting nurses' turnover or those nurses who constantly switched jobs and if chronic foot pain (CFP) plays a role in nurses' turnover.

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The national average for nursing turnover rates in the United States is between 8.8% and 37%, depending on the geographic location and nursing specialty [3]. According to the 2021 Nursing Solutions, Inc. National Health Care Retention and RN Staffing report, the average cost of nurse turnover for a bedside RN is between \$28,400 to \$51,700 resulting in an average loss of \$3.6 to \$6.5 million per year by hospitals. In 2020, nurses and midwives account for approximately 50% of the global health workforce while acknowledging a shortage of 5.9 million nurses globally [2]. High nursing turnover and shortages have been attributed to an aging workforce and nursing burnout among others [4,5]. There has been limited information on the impact of CFP on nurses' ability to provide care to patients at the bedside, and the implications on high nurse turnover as well as nurses' satisfaction with their various nursing positions.

Nurses are at risk of developing CFP due to the physical demand of their job [6]. Prior studies associated the high prevalence of CFP among nurses with the physical demand of the nursing profession such as prolonged standing, lifting, and pulling patients at work [4, 7]. On average, nurses spend between 8 and 12 h on a normal daily work schedule. Activities of nurses especially those at the bedside involve prolonged standing, walking, and pulling patients among others [4,6]. The main objectives of the study are 1) to explore nurses' experience with CFP, current treatment options for foot pain, and the impact of foot pain on nurses' job performance and 2) to explore future inventions to address foot pain among nurses and perhaps other professionals that stand for prolonged periods on their feet. Accurately estimating the burden of CFP on nurses, especially those that stand for prolonged hours at work will provide the basis for embarking on clinical and cost-effective solutions to alleviate foot pain not just among nurses, but the general population. More than 77% of Americans experience foot pain. CFP can profoundly impact the quality of life [8]. In addition, foot pain has been identified as an independent risk factor to increase the risk of falls and reduce the quality of life [9].

To understand the daily experiences of nurses with CFP and the effectiveness of current solutions to foot pain, our team embarked on a National Science Foundation (NSF) I-Corps program in the United States between 2019 and 2020 [10]. The NSF I-Corps program supports teams of faculty and graduate students from all over the world as they explore the commercialization of early-stage ideas and products that are beneficial to society. In this study, we explored the current state of CFP, foot solutions, and treatment options for CFP among nurses from within and outside the United States. Consequently, we will develop inventions to address CFP among nurses and other professionals that stand for prolonged periods on their feet not just in the United States, but globally.

2. Methods

This is a secondary data analysis of data collected during the NSF I-Corps program in the United States between 2019 and 2020. The original study examined the current state of CFP, foot solutions, treatment options, and opportunities for inventions for CFP for professions that stand for prolonged periods on their feet. A detailed description of the original study protocol and the primary outcome results were published elsewhere [6]. As part of the parent study, personal interviews involving open-ended questions to elicit meaningful information from nurses from within and outside the United States about the current state of CFP, solutions, and potential innovations to address CFP were conducted. Before stakeholders' interviews, each team of NSF participants was required to come up with sets of hypotheses to be tested with potential stakeholders. We conducted predominantly a face-to-face interview and Zoom since COVID-19 on nurses who work in bedside, ambulatory, and other administrative positions in various health, business, and community institutions.

The NSF launched the I-Corps program in 2011 to foster entrepreneurship and facilitate the commercialization of NSF-funded technologies [10]. The program supports teams of faculty and graduate students as they explore the commercialization of early-stage ideas. I-Corps instructors coach teams to identify product opportunities through their research. In addition, it assists innovators in creating devices specific to their participants' needs. Each of the I-Corps programs comprises 7 weeks of intense face-to-face interviews with stakeholders, among other activities [6,10].

2.1. Participants

Potential participants were contacted before interviews by Zoom, LinkedIn, WhatsApp, Facebook, email, and phone calls. To accommodate the participants' schedules, interviews were conducted at the participants' chosen times and days for the interview. Participants were randomly selected from different cities within and outside the United States. In addition, we visited hospitals, universities, athletic centers, restaurants, and nursing organization websites sites to locate potential individuals. All interviews lasted for approximately 20–30 min.

Adults who were aged 18 years or older, able to give oral consent to participate in the interviews and had lived experiences of foot or leg pain were included in the study. Participants (nurses), who had not been diagnosed with foot or leg pain were considered. Nurses with a job that required prolonged standing, walking, and lifting were all included in the interview. Those not able to consent to participate in the interview, not having a job that required prolonged standing, walking, and not being willing to be interviewed for at least 20 min were excluded. Ethical approval was obtained from the Woman's Institutional Review Board. Data were collected, de-identified, and stored in a secure password-protected personal computer.

2.2. Data collection

Data were gathered using open-ended questions during the individual interviews. Before nurses' interviews, each team of NSF participants was required to establish sets of hypotheses to be tested as well as sets of interview questions to prove or disprove the hypotheses with potential stakeholders. In addition, demographic information was collected that asked about experience with pain,

current solutions, and current treatments for foot pain. Our teams' hypotheses included: i) prolonged standing, walking >8 h a day, and lifting patients cause pain in the feet and legs of nurses; ii) successful management of CFP will increase productivity and improve quality of life, and iii) current foot pain solutions and treatments are not sufficient for those with pain greater than five on a scale of zero to 10. There were limited predetermined interview questions written by the team ahead of scheduled individual interview sessions. Participants were given opportunities to share experiences and provide specific situations and treatments for managing chronic foot pain. Follow-up and most subsequent questions were directed based on participants' responses to the initial questions. The study questions included: i) How many hours do you spend each day at your job?; ii) How many hours do you spend standing, walking, or lifting objects at your job?; iii) On a scale of zero to 10, how would you rate foot, leg or any pain while performing your duties at your job?; iv) While on your feet or legs, do you experience the worst pain at work or home?; v) What are your experiences about prolonged standing or walking at your job or home?; vi) How long before you start feeling foot pain while standing or walking on your feet?; and vii) What treatment helps with your pain? All data were de-identified immediately after collection and entered on the Excel sheet.

2.3. Statistical analysis

Descriptive statistics were first used to report sample characteristics. Frequencies and percentages were used to describe categorical variables and means, and standard deviations were used to describe continuous variables. Next, a multiple linear regression was conducted to assess what factors were associated with pain severity. The omnibus F test and adjusted R^2 were reported on the overall model significance and effect size. If the overall model was significant, each predictor's significance was assessed while controlling for the other covariates. A multinomial logistic regression was then used to examine the relationships between demographics and the pain category, and a binary logistic regression was conducted to assess the relationships between the demographics and the solution. The chi-square test and Nagelkerke R^2 were used to indicate the model significance and effect size. The odds ratio (OR) was reported to predict the likelihood of a predictor influencing the outcomes. Cross tabulations using Fisher's exact, or chi-square tests were also used to examine the relationships between every two categorical variables. All analyses were conducted in IBM SPSS v25. Alpha levels for all analyses were 0.05.

3. Results

3.1. Sample characteristics

A total of 122 participants were included in the study, most of whom worked inpatient (90.2%) as an RN (77.9%), a few licensed practical nurses (LPNs) (4.9%) and nurse practitioners (NPs) (17.2%). As seen in [Table 1a](#), nearly half were African American (40.2%), followed by Caucasians (27.9%), Asians (26.2%), and Hispanics (5.7%). The study comprised mostly female nurses (83.6%) and a few male nurses (16.4%). Over half of the sample reported high pain levels (59.2%), and most pains occurred with standing (93.4%). On average, nurses worked for 7 h at a time before they experienced foot pain. A majority of the sample reported foot pain only (73.0%). The most common solution to relieve/prevent the pain was to change the shoes only (74.4%), but only 49.2% of participants reported

Table 1a
Frequencies and percentages on participants' characteristics.

Demographic Characteristics	<i>n</i>	%
Gender		
Female	102	83.6
Male	20	16.4
Nurse type		
Licensed vocational nurses	6	4.9
Nurse Practitioner	21	17.2
Registered nurses	95	77.9
Race/Ethnicity		
African American	49	40.2
Asian	32	26.2
Caucasian	34	27.9
Hispanics	7	5.7
Age		
20-30	14	11.6
30-40	32	26.4
40-50	33	27.3
50-60	27	22.3
60-70	15	12.4
Switch jobs		
No	44	36.1
Yes	78	63.9
Worked inpatient		
No	12	9.8
Yes	110	90.2

Note. *n* not summing up to 122 indicates missing values.

that the solution was effective. A more detailed sample description can be found in Tables 1a and 1b.

3.2. The relationships between demographics and pain levels

Multiple linear regression was first performed to predict pain severity from demographics. The overall model was significant, $F(8, 108) = 4.87, p < .001$, and accounted for 21.0% of the variance (adjusted $R^2 = 0.210$). As shown in Table 2a, older participants reported higher pain levels ($\beta = 0.19, p = .036$). Participants who switched jobs reported higher levels of pain than those who did not switch jobs ($\beta = 0.19, p = .044$). Longer working hours were also associated with higher levels of pain ($\beta = 0.35, p < .001$). Moreover, Hispanic participants reported higher pain than African Americans ($\beta = 0.25, p = .006$).

When the pain scale was categorized into three severity levels, the results from a multinomial regression showed that the overall model was significant, $\chi^2(10) = 43.88, p < .001$, Nagelkerke $R^2 = 0.370$. The low pain (1–5 on a scale of 0–10) levels and high pain levels (greater than 5 on a scale of 0–10) were compared with minimal pain (0) in this model. Specifically, in Table 2b, older participants were more likely to report low levels of pain and high levels of pain than minimal pain ($p < .05$). Likewise, participants who worked longer hours were more likely to report low or high levels of the foot compared than not reporting any foot pain ($p < .01$). It was not surprising to find that higher ratios of high levels of pain over no pain and low levels of pain over no pain were reported in RNs when comparing with the other types of nurses ($ps < .05$), indicating that RNs were more likely to have pain than the other types of nurses. Ethnicity was not included in this model because there was no sufficient sample size at each level.

3.3. The relationships between demographics and pain solutions

Participants reported several ways to manage their pain by changing either shoe and socks intermittently and sometimes both shoes and socks simultaneously. Due to the small proportions of the sample changing socks only, pain solutions were dichotomized into changing shoes only as compared to changing socks and/or shoes. The results, in Table 3, suggest that the overall model was significant, $\chi^2(5) = 11.09, p = .05$, Nagelkerke $R^2 = 0.134$. Participants who switched jobs reported being more likely to change shoes only than changing both shoes and socks ($OR = 0.303, p = .021$). Those who worked longer time were more likely to choose to change

Table 1b
Descriptive statistics on pain, regions, and solutions.

Demographic Characteristics	n	%
Most pain with standing		
No	8	6.6
Yes	114	93.4
Most pain with sitting		
No	115	94.3
Yes	7	5.7
Pain category		
Minimal pain	16	13.3
Low pain level	33	27.5
High pain level	71	59.2
Region		
Arch	2	1.8
Foot	81	73.0
Foot/Ankle	2	1.8
Foot/Arch	3	2.7
Foot/Heel	5	4.5
Foot/Leg	12	10.8
Heel	1	.9
Heel/Arch	3	2.7
Leg	2	1.8
Solution		
Shoes	90	74.4
Socks	5	4.1
Shoes/Socks	26	21.5
Shoe change		
No	14	11.6
Yes	107	88.4
Socks change		
No	67	55.4
Yes	54	44.6
Effectiveness		
No	62	50.8
Yes	60	49.2
	n	Mean (SD)
Hours worked before the pain	117	7.0 (3.2)
Pain scale	120	4.9 (2.8)

Note. n not summing up to 122 indicates missing values.

Table 2a
The relationships between demographics and pain scale using multiple linear regression.

Outcomes	Unstandardized β	SE	Standardized β	p	95% CI for OR	
					LL	UL
Males ^a	-.801	.63	-.11	.208	-2.054	.452
Another nurse type	-.365	.66	-.05	.579	-1.665	.935
Switch jobs	1.098	.54	.19	.044	.033	2.164
Age	.430	.20	.19	.036	.028	.832
Hours worked before the pain	.305	.07	.35	<.001	.160	.451
Asian ^d	.338	.64	.05	.595	-.920	1.597
Caucasian	.964	.62	.16	.122	-.262	2.190
Hispanics	2.978	1.06	.25	.006	.884	5.071

Note. $F(8, 108) = 4.87, p < .001, \text{Adj. } R^2 = 0.210$. ^aCompared with females; ^bCompared with RN; ^cCompared with not switching jobs; ^dCompared with African Americans. LL, lower limits; UL, upper limits.

Table 2b
The relationships between demographics and pain categories using multinomial regression.

Outcomes	B	SE	Wald	OR	p	95% CI for OR	
						LL	UL
Low pain levels*							
M0ales ^a	-.562	1.03	.30	.570	.586	.075	4.312
Other nurse type ^b	-2.637	1.18	5.00	.072	.025	.007	.722
Switch jobs	.896	.93	.93	2.450	.336	.395	15.197
Age	.987	.45	4.75	2.683	.029	1.104	6.517
Hours worked before pain	.422	.15	7.86	1.525	.005	1.135	2.048
High pain levels*							
Males ^a	-1.624	1.04	2.44	.197	.118	.026	1.514
Other nurse type ^b	-2.647	1.14	5.40	.071	.020	.008	.660
Switch jobs	.893	.91	.97	2.442	.326	.412	14.475
Age	1.143	.45	6.53	3.135	.011	1.305	7.533
Hours worked before pain	.572	.15	14.49	1.772	<.001	1.320	2.378

Note. $\chi^2(10) = 43.88, p < .001, \text{Nagelkerke } R^2 = 0.370$. *Compared with minimal pain. ^aCompared with females; ^bCompared with RN; ^cCompared with not switching jobs. OR, odds ratio; LL, lower limits; UL, upper limits.

Table 3
The relationships between demographics and solutions using logistic regression.

Demographics	B	SE	Wald	OR	P	95% CI for OR	
						LL	UL
Males ^a	-.308	.65	.22	.735	.637	.204	2.648
Other nurse type ^b	.786	.60	1.69	2.194	.194	.671	7.172
Switch jobs	-1.194	.52	5.33	.303	.021	.110	.835
Age	-.129	.20	.42	.879	.517	.595	1.299
Hours worked before pain	.163	.07	5.03	1.177	.025	1.021	1.357

Note. Shoes and/or socks change was compared with shoe change (as a reference) in outcome measures. $\chi^2(5) = 11.09, p = .05, \text{Nagelkerke } R^2 = 0.134$. ^aCompared with females; ^bCompared with RN; ^cCompared with not switching jobs. OR, odds ratio; LL, lower limits; UL, upper limits.

socks and/or shoes than change shoes only ($OR = 1.177, p = .025$). However, gender, nurse type, and age did not appear to be related to the pain solution strategies.

3.4. The relationships of pain levels with regions, pain solutions, and effectiveness

To further identify if the pain was related to pain regions (e.g., arch, ankle, heel, leg, and knee), pain solutions, and effectiveness, crosstabulations were performed, as shown in Table 4. Participants who reported minimal pain were asked to provide opinions on strategies and effectiveness in pain prevention although their pain level was minimal. The pain levels were significantly associated with the shoe change strategy, $\chi^2 = 7.49, p = .015, \text{Cramer's } V = 0.259$. A greater proportion of participants with high pain levels (94.4%) reported that they changed shoes to alleviate the pain than those who had low pain levels (75.0%). In addition, a greater proportion of participants with minimal pain (81.3%) reported that using pain solutions to prevent the pain was effective as compared to the participants with high levels of pain (43.7%), $\chi^2 = 7.42, p = .024, \text{Cramer's } V = 0.249$.

Table 4
Relationships of regions, solution, and effectiveness with pain levels.

Variable	Minimal Pain		Low Pain Level		High Pain Level		Fisher's Exact	p	Cramer's V
	N	%	N	%	N	%			
Region							.97	.989	.098
Foot only	5	100.0 ^a	24	72.7 ^a	50	70.4 a			
Foot/leg	0	0.0 ^a	4	12.1 ^a	10	14.1 a			
Other regions	0	0.0 ^a	5	15.2 ^a	11	15.5 a			
Solution							5.51*	.064	.215
Shoes only	14	87.5 ^a	19	59.4 ^a	55	77.5 a			
Shoe and/or sock	2	12.5 ^a	13	40.6 ^a	16	22.5 a			
Shoe change							7.49	.015	.259
No	2	12.5 ^{ab}	8	25.0 ^b	4	5.6 a			
Yes	14	87.5 ^{ab}	24	75.0 ^b	67	94.4 a			
Sock change							2.13*	.344	.134
No	9	56.3 ^a	14	43.8 ^a	42	59.2 a			
Yes	7	43.8 ^a	18	56.3 ^a	29	40.8 a			
Effectiveness							7.42*	.024	.249
No	3	18.8 ^a	17	51.5 ^{ab}	40	56.3 b			
Yes	13	81.3 ^a	16	48.5 ^{ab}	31	43.7 b			

Note. For each row category, the proportions with different superscripts differed significantly, $p < .05$. * chi-square test.

3.5. The relationships of regions with pain solutions and effectiveness

Finally, we found that the pain regions were significantly associated with the solution nurses selected and the effectiveness. In Table 5, the results demonstrated that a greater proportion of nurses who had pain in other regions (e.g., arch, ankle, heel, leg, etc.) chose to change shoes as well as socks (75.0%) than the nurse with foot pain only (21.3%), Fisher's exact = 23.18, $p < .001$, Cramer's V = 0.482. It is worth noting that all participants with foot and leg pain chose to change shoes only. Nevertheless, the results also showed that less proportion of nurses who had pain in other regions reported that the solutions were more effective (6.3%) than the nurses with foot pain only (49.4%) and foot/leg pain (64.3%), Fisher's exact = 13.48, $p = .001$, Cramer's V = 0.335.

4. Discussion

Based on the findings of this study, most nurses had worked at the bedside predominantly in hospital settings. In addition, most indicated they left bedside nursing to pursue other opportunities in administrative positions. Reasons for leaving bedside included a more conducive work environment and musculoskeletal discomforts such as foot and ankle pain, among others. Many nurses experienced chronic foot pain that resulted in other musculoskeletal conditions such as knee and back pain. Notable causes of CFP for nurses were walking and standing for prolonged periods on their feet. On a standard basis, nurses who work in hospital settings are working 12-h shifts, and from those interviewed, 80–90% of those 12 h are spent on their feet. We realized during our study that most nurses who provided bedside care experienced other lower extremity musculoskeletal discomfort (MSD) such as knee pain. However, the literature is sparse on the nurses who provide bedside care and lower extremity MSD, as well as reasons for abandoning bedside care. The framework for studying risk factors for lower extremity musculoskeletal discomfort in nurses especially nurses at the bedside should include lower extremity musculoskeletal discomfort (MSD) which is prevalent and yet understudied in nurses [11].

In addition, this study explored the causes of CFP and the relationship to changing jobs in nurses. The results showed that those who switched jobs (63.9%) and worked with inpatients had higher levels of foot pain than people who did not switch jobs (36.1%) and

Table 5
Relationships of solution and effectiveness with regions.

Variable	Foot Only		Foot/Leg		Other Regions		Fisher's Exact	Cramer's	
	n	%	n	%	n	%		p	V
Solution							23.18	<.001	.482
Shoes only	63	78.8 ^a	14	100.0 ^a	4	25.0 ^b			
Shoe and/or sock	17	21.3 ^a	0	0.0 ^a	12	75.0 ^b			
Shoe change							2.38	.351	.169
No	12	15.0 ^a	0	0.0 ^a	1	6.3 ^a			
Yes	68	85.0 ^a	14	100.0 ^a	15	93.8 ^a			
Sock change							4.11*	.137	.193
No	47	58.8 ^a	8	57.1 ^a	5	31.3 ^a			
Yes	33	41.3 ^a	6	42.9 ^a	11	68.8 ^a			
Effectiveness							13.48	.001	.335
No	41	50.6 ^a	5	35.7 ^a	15	93.8 ^b			
Yes	40	49.4 ^a	9	64.3 ^a	1	6.3 ^b			

Note. For each row category, the proportions with different superscripts differed significantly, $p < .05$. * chi-square test.

worked in inpatient settings. Also, increased working hours were significantly related to higher levels of foot pain. People working long hours were more likely to report experiencing higher pain levels than those not working long hours at work. A factor that stood out was the fact that many of the nurses who switched jobs mostly worked by the bedside and worked long hours at work (approximately working 12 h/day). There were limited studies on nurses who provided bedside care and the incidence of foot pain. However, an exploratory survey to determine the incidence of work-related foot pain/discomfort among RNs showed a high incidence of foot pain in nurses who worked at the bedside compared to nurses in administrative positions [12]. Other studies have identified different causes of foot pain that included nursing activities during patient care, age, floor surfaces, weight, heavy workload, and certain aspects of shoes among others [6,7,11–15]. The possible explanation for varied reasons for foot pain in all the studies could be related to differences in scope of practice, socio-cultural environments, healthcare systems, and working hours. For example, our study comprised licensed vocational nurses (LVN) 4.9%, RNs 77.9%, and nurse practitioners (NPs) 17.2% who worked in varied areas in a hospital and outpatient settings. While in Getie et al. (2021), nurses worked nightshifts in a hospital setting in Ethiopia. There was limited information on the different levels of nurses in the various studies. And studies are lacking if there are differences in lower extremity MSD-related reasons for various nurses (i.e., LVN, RNs, and NPs) reasons for abandoning bedside care.

There was a correlation between age and foot pain in nurses as seen in our study. Older nurses reported higher levels of foot pain than younger nurses. Similarly, a study done in Uganda in East Africa showed nurses aged 40 years and older were 7.66 times more likely to develop ankle/foot pain [7]. As well as the study conducted in Japan showed nurses over the age of 50 years old were more likely to experience ankle-foot pain [16]. In the general population, foot/ankle pain is the most reported joint pain among adults older than 55 compared to other musculoskeletal symptoms such as knee and hand/wrist [17,18].

We inquired how long participants stand, walk, or sit before experiencing foot pain at work. On average, nurses worked for 7 h at a time before they experienced foot pain. To our knowledge, no study has elucidated the correlation between foot pain and a specific time frame before one starts to experience foot pain either at work or at home. Previous studies showed that nurses walk an estimated distance of 4–5 miles in a 12-h shift [19–21], but we lack information about how long it takes for one who is standing or walking for longer periods to start experiencing foot pain. Research is needed to further evaluate this finding. By knowing exactly when nurses or others standing or walking for prolonged periods start to experience pain, then, we should be able to adequately target interventions for CFP.

We also explored if there were differences in race and ethnicity regarding nurses experiencing CFP. When we included all demographics in the same multiple linear regression model, the results indicated that when controlling for the other covariates, Hispanics though not many in the study reported higher levels of pain than African Americans. A review of the pain experience of Hispanic Americans noted that racial/ethnic minorities report more pain and have a higher prevalence of pain conditions compared to non-Hispanic Whites [21]. As noted in the review, the differences in the pain experience could be related to differences among groups regarding pain processing, pain coping, and cultural factors [6,21,22].

Most of the nurses in our study noted a lack of sustainable and cost-effective products to manage chronic foot pain as a major reason for leaving bedside care. On average, many of the nurses were spending \$170/per pair of shoes and \$500/per year on shoes. While most nurses indicated spending on average \$15–\$45 on compression socks to manage foot pain. Most nurses changed their shoes more often than any other treatment options such as splints or inserts and non-steroidal anti-inflammatory drugs (NSAIDs). While most nurses spent a significant amount of money on shoes and sometimes compression socks, most expressed less relief and expressed “willingness to pay anything for pain.” Proper footwear is essential for nurses to improve overall health and reduce high rates of prevalence of musculoskeletal disorders. The impact of improper footwear and nurses’ health has been examined in previous studies. A study by Refs. [18,23] noted that nurses have many foot problems that affect their workability. Inadequate shoes can produce an increased risk for foot disorders in healthcare workers [23,24] and nurses should pay attention to comfortable footwear [7].

However, there was no census among nurses regarding the best treatment options for chronic foot pain. Current treatment options for foot pain which are largely non-operative [25], included NSAIDs, custom-made orthotics, splints, and surgery in severe cases. Most nurses used nonprescription formulary drugs such as NSAIDs which is controversial as many feet pain is not an inflammatory process [6,26]. Some nurses indicated using localized injections and other topical corticosteroids for short-term use which has been shown in some literature can have effects on fat pads leading to atrophy and plantar fascia rupture [25]. Others indicated going through foot surgeries which often did not take care of the CFP.

Surprisingly, most nurses interviewed expressed a lack of knowledge of different ways to take care of their feet. As noted in previous studies, maintaining good foot health will require regular individual attention as well as organizational involvement in an institution. Nurses need to be educated on how to take care of their feet [12,18]. Foot care should be an important aspect of nurses’ and other healthcare workers’ efforts to improve the knowledge and practice of foot care. Targeted education programs regarding the prevention, self-management and treatment strategies for foot pain are needed for nurses and other healthcare workers that stand for prolonged periods [4,27].

4.1. Strengths, limitations, and implications for clinical practice

To our knowledge, this is the first investigation into the experiences of nurses who experience chronic foot pain during an NSF I-Corps program. An important objective of our study was to obtain information that will be useful in the design of products to manage CFP in nurses and other professionals that stand and walk for prolonged periods. Completing this important project has led to the development of a prototype in the early stages to address CFP in nurses and other professions that stand for prolonged periods. Our team comprising engineers among others is working together to develop our prototype, currently in the early stages of design.

This study has some limitations that warrant further attention. Participants were from limited regions within and outside of the

United States; therefore, data may not have been representative of the general population from other cities, states, and countries. Nevertheless, this study provides a solid foundation from which researchers and clinicians can begin to understand the daily experiences of CFP in nurses, especially those that provide care at the bedside. Future studies should focus on collaboration with other clinics or institutions, and recruitment by social media to identify a more accurate representation of nurses with CFP.

Administrators need to encourage preventative activities for nurses in the job area. Workplace interventions for nurses should include measures to reduce musculoskeletal pain. In addition, other activities should include the importance of foot health. Employee in-service programs should include the selection of appropriate footwear as well as regular foot assessments and treatments. Foot self-care should include the importance of proper footwear with arch support, the use of compression socks, and activities such as leg elevation, and foot exercises among others during break time at work. Nurses should be encouraged to pay attention to comfortable footwear as well as their foot health.

5. Conclusions

The overall findings of this study indicated that CFP can be significantly disabling, especially among nurses at the bedside. Nurses stand or walk for long periods at work, thus increasing the risk of foot pain. Nurses have many foot problems that negatively affect their nursing care practice and work performance. Nurses are aware of the impact of foot pain on work productivity and quality of life. Some of the hindering factors could be overcome with nurses' awareness and foot self-care education. Worsening foot pain led most nurses to change their areas of work and interest in working in the inpatient units. Worsening and debilitating foot pain is integral to general well-being and longevity at nurses' jobs. Nurses identified several factors promoting and hindering foot health at work. Due to the widespread nature of CFP among nurses and their various contributing factors, the issue of devastating foot pain should be addressed globally. Work environments for nurses that encourage exercise, weight loss, and foot self-care should be encouraged.

Declarations

Author contribution statement

All the authors contributed the following.

- 1-Conceived and designed the experiments (NDM)
- 2-Performed the experiments (NDM)
- 3-Analyzed and interpreted the data (NDM, WW)
- 4-Contributed reagents, materials, analysis tools or data (NDM, WW)
- 5-Wrote the paper (NDM, WW).

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

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