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Awareness, Availability and Utilization of Smart and Functional Garments In Managing Diabetes Among Working-Class Women (Aged 30-60) In Enugu State: *Implications for Sustainable Family Development*

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Abstract

The study is a cross-sectional survey to determine the awareness, availability and utilization of smart and functional garments in managing diabetes among working class women (aged 30-60) in Enugu State: Implication for sustainable family development. Population for the study comprised 120 outpatient working class female diabetics (30--60 years) attending clinics at Teaching Hospitals in Enugu State. Instrument for data collection was a questionnaire while data were analyzed using descriptive statistics. Major findings include None of the smart garments; t-shirts, jackets, tops, skirts, pants, gowns, socks, shoes, bras were available or utilized as management support for the diabetics because diabetics were not aware of them and not available. The only functional garments mostly aware of custom-made body fit garments (85.0%) and old garments altered to fit (66.7%). They were also available (70.8%, 83.3%) and utilized (53.3% and 66.7% respectively). Only use of clean, soft bandages out of six diabetic hygiene and good grooming related management supports was aware of (75.8%), available (59.2%) and adopted (53.3%). The study concludes that working-class female diabetics in Enugu State lack adequate information on the role of smart garments, hygiene and good grooming for effective diabetic management for quality life. These could impact negatively not only on their health, psychosocial and mental well-being but on their productive and family lives. The study therefore recommends the need for effective health education and to put in place programs to promote greater awareness, availability and utilization of fashionable smart and functional garments at the local markets and hospitals for easy accessibility for the diabetics.

Keywords: Type 2 diabetes management, Smart and functional clothing, Hygiene, Working Class Females

Introduction

Diabetes mellitus is a significant global health concern, characterized by chronic hyperglycemia due to insufficient insulin production or ineffective use of insulin by the body. It is classified into three primary types: type 1 diabetes, type 2 diabetes, and gestational diabetes. Type 1 diabetes, previously known as insulin-dependent or childhood-onset diabetes, results from inadequate insulin production, necessitating daily insulin administration. Type 2 diabetes, once predominantly an adult condition, is increasingly affecting children and accounts for approximately 90-95% of diabetes cases (Alwan, 1994). This form of diabetes impairs the body's ability to use insulin, leading to elevated blood glucose levels.

Uncontrolled diabetes can result in serious complications, including nerve and blood vessel damage, cardiovascular disease, kidney failure, eye damage, hearing loss, sleep apnea, and cognitive decline (Mayo

Clinic, 2024). Mental health issues, such as depression, anxiety, and diabetes-related distress, are common among diabetics, particularly affecting working-class women who may perceive their diagnosis as a death sentence (Akhaury, 2022; CDC, 2023). This demographic—adult women, married or unmarried, working in various sectors—faces significant challenges in managing their health while maintaining an active lifestyle. Effective diabetes management is essential to alleviate symptoms, reduce morbidity and mortality, minimize economic burdens, and prevent complications. Basic management guidelines emphasize self-monitoring, access to essential resources, record-keeping, and regular follow-up (Alwan/WHO-EM/DIN6/E/G, 1993). Traditional interventions include dietary therapy, exercise, and insulin administration. Additionally, the adoption of smart or functional garments can enhance self-care, potentially improving self-esteem and psychological well-being.

Smart garments are designed with advanced fabrics that incorporate technology for increased functionality (Carrol & Kincade, 2014). These garments integrate micro-sensors that monitor physical signals, such as glucose levels via sweat, using innovative systems that generate energy from everyday movements (Watkins, 2011; Dejonge, 2013; Health Care Providers, 2023). For example, smart garments can measure blood glucose from microliters of sweat and transmit data to connected devices like smartphones or tablets, thus eliminating battery concerns and enhancing user experience. Smart fabrics also facilitate remote monitoring of chronic conditions, empowering patients to manage their health proactively (Atos, 2016). For instance, diabetic foot ulcers, a leading cause of non-traumatic amputations, have shown significantly reduced rates with the use of smart technologies like Siren Socks (Shih et al., 2024). These garments, equipped with strain sensors, enable real-time health monitoring and data sharing with caregivers, promoting independent living for patients while enhancing healthcare access (Labat & Sokoloski, 2012; Syduzzaman et al., 2015).

Statement of the Problem

The World Health Organization (2024) reports that approximately 422 million people worldwide have diabetes, with 90% of cases being type 2. In 2019, diabetes was responsible for 1.5 million deaths, with nearly half of these occurring before the age of 70. Additionally, diabetes contributes to around 20% of cardiovascular deaths and is linked to significant kidney disease mortality (Global Burden of Disease Collaborative Network, 2019). While smart and functional garments offer promising diagnostic, therapeutic, and monitoring capabilities for diabetic patients, research on their awareness, availability, and utilization remains insufficient, particularly in local contexts. This gap in diabetes management could predispose patients to chronic health complications or early mortality. Therefore, this study aims to explore and address these deficiencies.

Objectives of the Study

The general objective of this study was to determine the awareness, availability, and utilization of smart and functional garments as management support for working-class female diabetics (30--60 years) in teaching hospitals in Enugu state

The specific objectives of this study are to:

1. determine the awareness of smart and functional garments as a management support in diabetic condition by working class female diabetics attending teaching hospitals in Enugu state
2. determine the availability of smart and functional garments as a management support in diabetic condition by working class female diabetics in the study area
3. ascertain the utilization of smart and functional garments as a management support in diabetic condition by working class female diabetics in the study area.

Methodology

Study design: The study employed a cross-sectional survey to determine the awareness, availability and utilization of smart and functional garments by the female working class diabetics in the study area. The design was adopted because it seeks to discover the relative incidences, distribution and interrelations of sociological and psychological variables by studying small and large populations through selecting and studying sample chosen from the population (Olaitan et al., 2000).

Study area: The study was carried out in teaching hospitals in Enugu State. Three prominent Teaching Hospitals in the State include University of Nigeria Teaching Hospital Ikuku-Ozalla, National Orthopedic Hospital, Enugu, and Enugu State Teaching Hospital Park Lane. These hospitals are specialists in general medicine and working-class female diabetics in public service in the state attend these hospitals for treatment, management and health care.

Study Population: A total of 120 working class female diabetics (30-60 years) attending the general out-patient clinic in the hospitals at the time of the study participated in the study. They were chosen they were in their active working years, fashion conscious and are more likely to be negatively affected by their clothing and appearances in diabetic condition.

Instrument for Data Collection: A structured questionnaire was developed after an extensive review of the literature. The questionnaire was divided into five sections. Section A provided data on respondents' demographics. Sections B, C and D dealt with a checklist of information on the awareness, availability, and utilization of smart, functional garments and hygiene as management support for the working-class female diabetics

Validation of the Instrument: The instrument was face and content validated by experts in the field from the Department of Home Science and Management; and Nutrition and Dietetics, University of Nigeria, Nsukka. The questionnaire was subjected to a reliability test by administering it to 10 female working-class diabetics attending clinics at Bishop Shanaham Hospital in Nsukka L.G.A. using Cronbach alfa reliability co-efficient. A reliability coefficientmof 0.79 was obtained indicating relatively high reliability.

Methods of Data Collection

Data were collected on the spot by the researcher with a research assistant. A total of 125 copies of the questionnaire were distributed to the respondents on three visits to the hospitals. The extra five copies were included to make up for any loss. After health talks each clinic day, with the help of the Nurses on duty, the questionnaires were hand distributed to the respondents and collected on the spot after filling. A total of 120 copies of duly filled questionnaire representing 100 percent return rate was achieved.

Method of Data Analysis: Data were analyzed using descriptive statistics (frequencies, percentages) with Statistical Product and Service Solution (SPSS, version 22.0). Scores of 50% and above were regarded as positive responses whereas below 50% on any response was regarded as a negative response.

Results

Data on Table 1 on awareness, of smart and functional garments as management support in diabetic condition indicate that of the seven smart garments listed, majority of the respondents declared non awareness, of ambiotex smart shirts (71.7%), AIO smart sleeve (70.8%), battery less First-of-its-kind-smart glucose monitor (70.0%), Smart underwear for monitoring blood glucose (72.5%), hexoskin smart shirt (75.0%), Omsignal /Vitali Smart sports bra (64.2%) and siren diabetic socks (77.5%). This was shown in the very high scores of non-awareness of the items.

For the functional garments, greater majority (85.0%) of working-class female diabetics are aware of custom-made body fit garments as well as adjusted old garments' fit (66.7%). They indicated nonawareness of fashionable diabetic garments with special fastenings (68.3%).

The use of emery board or pumice stone

to gently remove accumulated dead skin, hammertoes splints and corrective shoes, bunion protector felt, or foam padded shoes and dry skin moisturizing soaps/lotions attracted very high scores of non-awareness They were aware of only clean, soft bandages as only clothing item used in managing diabetes as shown in Table 1

Table 1: Awareness of smart and functional garments in managing diabetes among working-class female diabetics in Teaching hospitals in Enugu state N = 120

S/N	Variable	Aw (%)	N Aw (%)
	Smart Garments		
1	Ambiotex smart shirts for fitness and stress level	34(28.3)	86(71.7)
2	AIO smart sleeve that monitors heart rate variability (HVR)	35(29.2)	85(70.8)
3	Batteryless First-of-its-kind-smart glucose monitor garment	36(30.0)	84(70.0)
4	Smart underwear for monitoring blood glucose	33(27.5)	87(72.5)
5	Hexoskin smart shirt for monitoring stress, sleep and heart rate	30(25.0)	90(75.0)
6	Omsignal /Vitali Smart sports bra	43(35.8)	77(64.2)
7	Siren diabetic socks	27(22.5)	93(77.5)
	Functional garments		
8	Custom made body fit garments	102(85.0)	18(15,0)
9	Adjusted/Altered old garments' fit	80(66.7)	40(33.3)
1 0	Fashionable diabetic garments with special fastenings; zipper at the laps, arm, tummy, buttons/ clearances,	38(31.7)	82(68.3)
	Hygiene and good grooming		
11	Use of emery board or pumice stone to gently remove accumulated dead skin	25(20.8)	95(79.2)
12	Use of hammertoes splints and corrective shoes	25(20.8)	95(20.8)
13	Use of bunion protector felt, or foam padded shoes	26(21.7)	94(78.3)
14	Use of shoe cushioned pads and insoles	32(26.7)	88(73.3)
15	Clean, soft bandages	91(75.8)	29(24.2)
16	Dry skin moisturizing soaps / lotions	32(26.7)	88(73.3)

Key: Aw= Aware, NAw= Not aware

Data in table 2 reveal very high percentage scores of none local availability of all the six smart garments listed. Custom made body fit garments and adjusted/altered old garments' to fit (70.8 and 66.7% respectively) but fashionable diabetic garments with special fastenings; zipper at the laps, arm, tummy, buttons/ clearances, were not available (93.3%).Only clean, soft bandages was hygiene and good grooming diabetes related item was available (59.2%).

Table 2: Availability of smart and functional garments in managing diabetes among working-class female diabetics in Teaching hospitals in Enugu state N = 120

S/N	Variable	Av (%)	NAv (%)
	Smart Garments		
1	Ambiotex smart shirts for fitness and stress level	0(0.0)	120(100.0)
2	AIO smart sleeve that monitors heart rate variability (HVR)	0(0.0)	120(100.0)
3	Batteryless First-of-its-kind-smart glucose monitor garment	0(0.0)	120(100.0)
4	Smart underwear for monitoring blood glucose	0(0.0)	120(100.0)
5	Hexoskin smart shirt for monitoring stress, sleep and heart rate	5(4.2)	115(95.8)
6	Omsignal /Vitali Smart sports bra	0(0.0)	120(100.0)
7	Siren diabetic socks	0(0.0)	120(100.0)
	Functional garments		
8	Custom made body fit garments	85(70.8)	35(29.2)
9	Adjusted/Altered old garments' fit	80(66.7)	40(33.3)
10	Fashionable diabetic garments with special fastenings; zipper at the laps, arm, tummy, buttons/ clearances,	8(6.7)	112(93.3)
	Hygiene and good grooming		
11	Use of emery board or pumice stone to gently remove accumulated dead skin	32(26.7)	88(73.3)
12	Use of hammertoes splints and corrective shoes	19(15.8)	101(84.2)
13	Use of bunion protector felt, or foam padded shoes	13(10.8)	107(89.2)
14	Use of shoe cushioned pads and insoles	5(4.2)	115(95.8)
15	Clean, soft bandages	71(59.2)	49(40.8)
16	Dry skin moisturizing soaps / lotions	4(3.3)	116(96.7)

Key: Av= Available, NAv= Not available,

Data in Table three reveals non utilization of all the identified smart garments as they attracted very high scores. Adjusted old garments to fit the current body size were adopted as the only diabetes management support (53.3%). Only the use of soft, clean bandages (53.3%). out of six hygiene and good grooming practices that facilitate diabetes healing was adopted

Table 3: Utilization of smart and functional garments in managing diabetes among working-class female diabetics in Teaching hospitals in Enugu state N = 120

S/N	Variable	U (%)	Nu (%)
	Smart Garments		
1	Ambiotex smart shirts for fitness and stress level	0(0.0)	120(100.0)
2	AIO smart sleeve that monitors heart rate variability (HVR)	0(0.0)	120(100.0)
3	Batteryless First-of-its-kind-smart glucose monitor garment	0(0.0)	120(100.0)
4	Smart underwear for monitoring blood glucose	0(0.0)	120(100.0)
5	Hexoskin smart shirt for monitoring stress, sleep and heart rate	4(3.3)	116(96.7)
6	Omsignal /Vitali Smart sports bra	0(0.0)	120(100.0)
7	Siren diabetic socks	0(0.0)	120(100.0)
	Functional garments		
8	Custom made body fit garments	100(83.3)	20(16.7)
9	Adjusted/Altered old garments' fit	64(53.3)	56(46.7)
10	Fashionable diabetic garments with special fastenings; zipper at the laps, arm, tummy, buttons/ clearances,	31(25.8)	89(74.2)
	Hygiene and good grooming		
11	Use of emery board or pumice stone to gently remove accumulated dead skin	6(5.0)	114(95.0)
12	Use of hammertoes splints and corrective shoes	19(15.8)	101(15.8)
13	Use of bunion protector felt, or foam padded shoes	6(5.0)	114(95.0)
14	Use of shoe cushioned pads and insoles	3(2.5)	117(97.5)
15	Clean, soft bandages	64(53.3)	56(46.7)
16	Dry skin moisturizing soaps / lotions	14(11.7)	106(88.3)

Key: Aw= Awareness, NAw= Not aware, Av= Available, NAv= Not available, U= Utilized, NU= Not utilized

Discussion

Findings in table 1 showed that majority of the diabetic patients were not aware of the smart garments. For instance, majority of the respondents declared none awareness of ambiotex smart shirts for fitness and stress level detection, AIO smart sleeve that monitors heart rate variability (HVR), battery less First-of-its-kind-smart glucose monitor garment, hexoskin smart shirt for monitoring stress, sleep and heart rate, omsignal /vitali smart sports bra and siren diabetic socks for foot ulcers. This was shown in the very high scores on the items. Siren diabetic socks attracted the least scores on awareness. These findings support those of Tsui, (2020) who in their study on GMI APC's wearable technology survey, found out that only 20% of respondents said they knew about smart clothing, indicating that consumers' perceptions of electronic textiles or smart clothing are not as high as other wearable products. The study finding also revealed unavailability (Table 2) and non utilization (Table 3) of the smart garments. Ju (2018) opined that unavailability and perceived risk of smart clothing was because of consumers' resistance of smart clothing when they think smart clothing is dangerous or cannot be used when they want to. The perceived danger in smart clothing has been fouled by Cientifica (2016), and Kim (2011) who reiterated that smart clothing has evolved from the initial form of attaching electronic devices to clothes to fourth-generation smart clothing, which is currently being developed to use devices that are not noticeable because they are as natural as possible. The non-awareness of the smart garments could also be a major factor for their non-availability and utilization locally. Scholten et al (2022), lamented that despite compelling evidence supporting the efficacy of smart socks and temperature sensing mats identifying pre-ulcer or diabetic foot ulcers weeks earlier than clinical exam and their cost effectiveness, these technologies have not been widely adopted. Diabetic foot ulcers are responsible for more admissions than any other diabetic complications and the leading cause of nontraumatic foot amputations in the US. Stressing further, Oliver and Motluoglu, (2023), emphasized that overall, about 5% of patients with diabetes mellitus develop foot ulcers and 1% end up with an amputation.

Female diabetics are only aware of, and utilize custom made, altered or adjusted regular garments to fit the current body size due to weight loss or gain (Tables 1, 2 and 3). The finding agreed with Ju, (2018) who found that, though, various smart garments for the diabetics have been introduced, consumers are yet to embrace them. Expectations are that products with improved performance and stability will be released soon to avert the resistance to smart clothing. In other words, consumers' fashion innovativeness plays a role in strengthening innovation resistance to affordable smart clothing, which can be inferred to be burdensome to purchase relatively expensive smart clothing as the trend changes (Ju, 2018). However, consumer technological innovativeness has not had any moderating effect on the relationship between smart clothing and innovation resistance. This is different from Ju & Lee (2020), who stated that consumer technological innovativeness affects the acceptance and purchase of smart clothing. Other functional and aesthetic garments with special features like fastening (zippers, button, and button clearance) pockets at the laps, arm, and tummy that facilitate easy and comfortable drug administration anywhere were not sufficiently known, available, or utilized by the diabetics. This finding has much implication for the diabetics their families, healthcare givers as well as the system.

The findings also revealed that soft bandages were the only measure they are aware of (75.8%, Table 1) , agreed locally available (59.2%, Table 2) and utilized (53.3% Table 3). Most of them are not mindful of the use of emery board or pumice stone to gently remove accumulated dead skin. Hammertoes splints and corrective shoes, bunion protector felt, or foam padded shoes and dry skin moisturizing soaps/lotions attracted very high scores of non-awareness, non-available and not utilized. The non-awareness and utilization of these hygienic measures by the diabetics as management support could be part of the reason for the open sores on the feet that are slow to heal

and pain in the leg. These measures have been suggested by McDemoth et al (2023), Scholten et al (2022), Oliver (2022), and the University of Michigan Health (2023). Neuropathy foot ulcers are the leading cause of nontraumatic foot amputations particularly diabetic patients. Shih et al (2024) lamented that traditional methods of monitoring and managing these patients are periodic in-person visits which are passive and may be insufficient for preventing neuropatic foot ulcers and amputations. Continuous remote temperature monitoring therefore has the potential to capture the critical period before the foot ulcers and other diabetes complications develop. It will also improve outcomes by providing real time data and early interventions. Ariyatum, Holland, Harrison and Kazi (2015) suggested that smart clothing should be positioned in the market just like functional clothing which would solve the incompatibility of fast fashion.

Conclusion and Recommendations

The study concludes that smart garments that help remote temperature and glucose monitoring of vital signs of the diabetics were neither locally available nor utilized in managing their diabetes as the working-class female diabetics in the study area lack information on their existence. Only regular traditional custom-made garments and adjusted old own garments to fit as well as the use of soft bandages were in practice. The study underscores the need for more local research activities into smart clothing and accessories for efficient management of diabetes individuals and family healthy living.

Based on the findings of the study, the following recommendations were made.

1. The Home Economics Extension agents in hospitals, schools, markets, churches, and any environment or space that offers an opportunity to do so should take the lead in sensitization and awareness of the importance of smart, functional garments and maintenance of good hygiene as management and emotional support in diabetic conditions.
2. There should be collaborative efforts between the textile industries, departments of universities that offer clothing and textile courses, and hospitals to produce smart and functional garments that will address local needs so that these garments will be locally available and more accessible.

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