Smart Textiles in Medicals: A study of the level of acceptance and knowledge of the application of smart textiles in significant hospitals in Awka, Anambra State.

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Abstract

Clothing has always been viewed of as something we put on to cover ourselves, show off our personal style, and protect ourselves from the weather. But the emergence of smart textiles in the twenty-first century has fundamentally changed how people will wear clothing in the future. Smart textiles are materials that go beyond basic clothing to provide the wearer with further advantages. For instance, recognizing and reacting to wearer states such as change in body temperature, by regulating the body temperature. Monitoring of heart beat and lung functions and producing a feedback, as well fabric with antimicrobial properties that helps to reduce odour that results from perspirations. The study reviewed the several smart textiles items that have been created over time, with an emphasis on those that can be used in healthcare. The various contexts, in which they are utilized, including diabetic sock, smart newborn vests, smart clothes with built-in ECG among others, were examined. Information obtained from interviews conducted with 25 respondents in selected hospitals in Awka metropolis showed that most people are still unfamiliar with medical kits made with smart fabrics. Incorporating sensing and therapeutic capabilities into everyday textiles could be a powerful approach in the development of personalized healthcare. The research argued that if the smart textiles are compatible with other garment functions like comfort and

durability, and are affordable, consumers will readily adopt these smart textiles when awareness is raised. In conclusion smart textiles are described as an emerging sector and a big area for investment for Nigeria's textile industries that could assist in revitalizing the industry.

Keywords; Smart textiles, Monitor, Sensor, Patients, Healthcare

Introduction

For a very long time, the textile was crucial in providing man with clothing, but more lately, its importance appears to have gone beyond just that. New generation of textiles termed as "smart textiles" have been introduced as a result of current technology advancement. Fabric has been woven with gold and silver yarn made from metallic fibres for a very long time. But modern technology has enabled the creation of what has become known as smart textiles by incorporating electrical and other digital components into these yarns.

According to Thakkar (2022) a smart textile is a part of a system or a piece of fabric that can recognize and react to natural conditions or stimuli, such as those brought on by mechanical, thermal, chemical, electrical, magnetic, or other biological factors. Ariadna (2022) defines smart fabrics as intelligent systems that can recognize and process wearer states as well as observe or communicate ambient circumstances. The author notes that these materials can light up, change colour, regulate muscle movement, and even react to heat or sound.

Any time the term "smart textile" is thought about; "electronic textiles" immediately comes to mind. However, over the past ten years, "smart" textiles without electronics have begun to develop. There are now two types of smart textiles: electronic and non-electronic, which can be categorized based on their operating system. Electrical smart textiles, commonly referred to as e-textiles, are textiles that have been combined with electronic elements, allowing them to offer the wearer additional benefits beyond simple clothing. With non-electronic smart textiles, integration issues like soldering, poor washability, and shortened lifespan can be avoided. The non-electronic smart fabrics are more comfortable to wear because they do not contain heavy electronics (Ruckdashel et al. 2021).

Smart textiles, to put it simply, are fabrics that, because of the elements that make up its structure, are responsive to and sensitive to external stimuli. While some are woven using regular textile fibers that have electronic components like sensors implanted in them, others are woven using conductive or metallic threads, like silver or nickel thread that improve the fabric's conductivity. Sensors are electrical devices that are used to track environmental changes, including changes in temperature, pressure, sound, light, motion, and moisture, and transmit that information to other devices. The sensor in a microphone, which turns sound energy into an electrical signal that can be amplified, transferred, recorded, and repeated, is an excellent example of a sensor's responsiveness to changes in the environment.

Background

The idea and the fundamental components of e- textiles technological movement have been there for many years, but the movement has recently become more commercially focused. According to speculations, the phrase "smart material" was first used in Japan in 1989, and the first textile to bear the label "smart textile" was silk thread with a memory effect. Although it was commonly assumed that the development of shape-memory materials and polymeric gels in the 1960s and 1970s marked the beginning of smart materials, it was not until the late 1990s that intelligent textile materials were introduced to the market. Smart textiles materials are now being explored in variety of products including fashion, healthcare products such as diabetic sock, bandages, sports & fitness, military & space, home e-textiles such as interactive home furniture, and other industrial fabrics.

These intelligent textile materials grouped into electronic and non-electronic smart textiles have simple operating characteristics that can be described in terms of input, activity and output. The environment serves as the input for both types of systems, according to Ruckdashel et al. (2021). The activity of electronic smart textiles is defined by electrical circuitry, whereas the activity of non-electronic smart textiles is defined by material features. However, both systems' outputs are quantifiable changes (actuating). Smart textiles can also be categorized using a garment's aesthetic and performance attributes. In the fashion business, textiles with the ability to light up and change color, such as light-emitting clothes and vibrant dresses, are examples of aesthetic smart textile. Based on their performance, performance smart textiles can be further categorized into three: passive, active, and ultra / very smart (Hasan, 2021; Ariadna, 2022).

Among other things, conductive fibers and UV-protective garments are examples of passive textiles, which represent the first generation of smart textiles. Being only sensors, passive smart textiles depend on their structural integrity to function and are only able to recognize their immediate environment. Passive smart fabrics often do not alter in response to information they sense, according to Ariadna (2022). In other words, even if the surroundings change, the clothes stay the same. A cooling cloth, for instance, may help regulate body temperature but does not actively provide coolness. However, the fabric's structure helps to accelerate the evaporation of fluids.

Active smart textiles, on the other hand, adjust and change how they work in response to alterations in the outside environment or human input, such as movement, pressure or weather. They require electricity to power actuators and sensors. These materials are capable of changing their shape, storing and managing heat, among other things.

Similar to active smart textiles, but with a small variation, ultra smart textiles or very smart textiles perceive, respond to, and adapt to environmental situations. The term "ultra-smart textiles" refers to materials that are capable of detecting, reacting to, monitoring, and adapting to environmental stimuli such as thermal, mechanical, chemical, magnetic, or other sources. An ultra-smart fabric is composed of a component having cognitive, rational, and activation skills, similar to a brain (Ariadna, 2022).

In recent years, research and development in smart textiles has been extremely active which has led to its use in fashion, home furnishing, heath care, sports and militaryapplications to provide protection and enhance military performance. Textile world News (2018) reported that Siren's CEO and Co-founder Ran Ma, suggested that although their smart textiles branded as Neurofabric has endless applications across healthcare, Sports, military and fashion, but their Diabetic Sock and Foot Monitoring have made tremendous impact. This is because the sock wearer can continuously monitor their foot temperature to detect signs of inflammation which is a precursor to foot ulcers. And this has helped in reducing the incidence of foot amputation as a result of diabetic wound. Another example is Hexoskin Smart shirt that may be used to continuously monitor cardiac and respiratory functions

The Research Problem/ Objectives of the study

Despite advantages of these new innovations and development in smart textiles in the area of health care, consumer's awareness about smart textile and its use in hospitals is low in Anambra state and by extension Nigeria. In Nigeria, smart clothing, or clothing with sensors that track various aspects of your health and fitness, is still uncommon. Its commercial application has not been fully explored in Nigeria. The objectives of the study is to raise the awareness about smart textiles among textile manufacturers and textile design practitioners in Nigeria and the underlying financial prospects associated with the creation and use of smart textiles in various spheres of human endeavor; to find out the level of awareness of the use of smart textiles in Major Hospitals within Awka Metropolis and their willingness to accept smart textiles for use in monitoring health related issues.

Methodology

The study employed qualitative design, thus reviewed several smart textiles materials that have been created over time, with an emphasis on those that can be used in medicals and healthcare. Applications of smart textiles are discussed in the study. The various contexts, in which they are utilized, including diabetic sock, smart newborn vests, Smart shirts with built-in ECG among others, were examined. Purposive sampling technique was adopted in conducting interviews at Odumegwu Ojukwu University Teaching Hospital Awka, Clinix Diagnostics Hospital Awka, Apex Hospital Awka and Nnamdi Azikiwe Medical Centre in order to ascertain their level of awareness about the use of smart textile in monitoring and treating Patients. 25 respondents made up of 20 doctors, and 5 lab technologists were used to get response to the survey questions on smart textiles and its application for monitoring and treating patients. Their response to the survey questions were displayed in percentage.

Uses of Smart Textiles in Medical and Health care

The development of smart textiles is a recent technological development that has greatly benefited the medical industry. A key step in the advancement of customized healthcare is the incorporation of medicinal properties into common textiles. Over time, the health industry has witnessed changes

as a result of the use of smart textiles. A significant contribution to the development of the healthcare and wellness business is being made by the textile industry. This is demonstrated by the rapid expansion of market for sensors, which has seen a lot of businesses create smart textile goods for use in the medical and health sectors.

Smart textiles for healthcare can take many different forms, including textile sensors, actuators, and wearable electronics. These sensor-equipped smart fabrics enable wireless communication between the user and the operator, such as a patient and a medical team, as well as the recording and transmission of physiological data. Take a blood pressure cuff as an example, which measures blood pressure and shows the results on a different device so that medical staff may access the information. Another example is Smart vest that can be utilized used to track vital bodily processes including the heartbeat, breathing, and body temperature. As a result, it enables health care providers to detect heart and circulation disorders earlier.

A better level of psycho-physiological comfort is provided by such systems by ensuring patients' mobility, especially when long-term bio-monitoring is necessary (Mecnika, Hoerr, Krievins, and Schwarz, 2014). In another study, Nafe (2020) noted that the applications of smart textile sensors are very useful for the data collection. This makes treatment easier and more accurate.

Nafe further stated that a sensor might be fibre-based, textile-structured, textile-integrated, or textile-based. A sensor is said to be fibre-based if it only contains one fibre, and a sensor is said to be textile-structured if it contains textile materials in all of its transducer components. When textile acts as a carrier for textile-integrated sensors and when textile is a non-sensitive but inseparable component of a transducer, it is referred to as textile-based (Nafe, 2020).Some of the sensors used in healthcare are: Respiration rate sensors; Pulse oximetry sensor; Temperature sensors; Humidity sensors; pH sensor among others.

Smart Textile Kits for Health care

According to Textile World (2018), recent advancements in the healthcare system have been made possible by the availability of implantables and grafts, coatings and additives for wellness and bacterial prevention, or innovative uniform fabrics. However, sensor technology is one noteworthy field. Numerous textile businesses have created smart textile solutions that can be used in the medical and healthcare industries as a result of the sensor market's rapid growth. For instance, Textile world News reported that Siren, a San Francisco-based provider of health technology, unveiled Neurofabric TM, a diabetic sock and foot monitoring system with embedded microsensors. There are six sensors in this device; three on each side of the foot's ball, one in the arch, and one on the heel, which continuously monitor changes in the foot's temperature (see Plate 1).

According to the manufacturer, Siren Diabetic Socks' ability to measure foot temperature aids in the early detection of inflammation, which is a sign to diabetic foot ulcers. Additionally, clinical studies have shown that monitoring foot temperature is 87% more effective than routine diabetic foot care at preventing foot ulcers (Textile World, 2018).With the help of the app, the person wearing the socks may instantly see the temperature of their feet and compare day-to-day variations. Other exceptional qualities of Neurofabric ^{TM} include comfort fit, seamless fabrication

that prevents binding, machine washability without the need for charging, and moisture wicking, which draws moisture away from the foot area to support healthy skin. However, the lifespan of the inbuilt battery is six months.

Textile World (2018) reported another high-quality health accessory is that by Emglare, a San Francisco-based business. It is a pair of smart garments that have sensors built in to track heartbeat and cardiac electrical activity using electrocardiography (ECG) (see plate 2). All monitored health data are made available through a mobile phone application that may be contacted directly by Emglare's smart clothing. Using a wireless charger, the garment can be directly recharged. Undershirts and sports t-shirts for men, and sports bras and ordinary bras for women, were the original forms of the clothing. Because they were made to feel natural and comfortable even when worn all day, according to the manufacturer, these clothing are appropriate for everyday usage (Textile World, 2018)



Plate 1: Siren's Neurofabric ^{TM}, a diabetic sock and foot monitoring system, with sixmicrosensors. Source Textile world (2018)



Plate 2: Emglare's Smart clothing with integrated heart rate and ECG sensors

Source: (Textile world, 2018)

The creation of the Smart Baby Vest is one of the groundbreaking uses of smart textiles in the medical field. Hasan (2021) revealed that ITV Denkendorf researchers created a unique smart vest for infant that is fitted with microchips and sensor (See plate 3).This is used to keep an eye on key functions like the heart, lungs, and body temperature. As a result, it makes it possible for medical professionals to identify heart and circulatory diseases. Hasan remarks that this is already being used to prevent infant cot death. Additionally, it is applied to other adult patients who are in life-threatening circumstances in order to save lives. The sensors on the Smart Baby Vest are attached in a way as not to frighten the child. The smart vests are also designed to be lightweight so as not to disrupt the baby's normal response to the garment.



Plate 3: Smart Baby Vest equipped with microchips and sensors. Source: (Hasan, 2021)

Result and Discussion

Based on information gathered from the reviewed articles on smart textiles and their application for monitoring health related issues, an introduction of smart textiles as well as it use as input device for checking health status was made with each respondent before conducting the interviews. A total number of 25 respondents made up of 20 doctors, and 5 lab technologists were used to get response to the survey questions on smart textiles and its application for monitoring and treating patients. Result of their response to the interview questions indicated that 80% of the respondents did not have any knowledge of smart textile sensor that can be used for monitoring health status.

20% of the respondent indicated that they have seen it in the form of smart sock as well as smart vibrating knee pads used for physiotherapy that are privately owned by wealthy patients.

One of the doctors from Apex Hospital claimed that they advise patients to use smart diabetic socks and foot monitoring systems, but that they often order them from abroad because there is currently nowhere in Nigeria where they can be purchased. One of the responses from Clinix Diagnostic Center attested to the presence of a smart massaging chair in their Lagos location. Since we are now living in the digital age, 66.6% of the respondents said it is a great development that smart textiles are being used to monitor health status and that its benefits should be explored. However 33.3% of the respondents did not like the idea citing the adverse effect it might have on the patients and the cost implication. One of the respondents, a Cardiologist at Odumegwu Ojukwu University teaching hospital stated that he will prefer the students to monitor the pulse by having a physical touch with the patients than using any smart textile garget. 53% of the respondents indicated that the present day Nigeria is not yet ripe for that kind of technology because the government is yet to provide basic health infrastructure for the masses. But 46.6% of the respondents affirmed that smart textile technology can be adopted in Nigeria, but mainly in highbrow private hospitals for wealthy individuals.

Smart Textile, the Nigerian Situation:

The results of the interviews conducted and information gathered from the reviewed articles indicated that more of Nigeria's knowledge of smart textiles is based on theoretical academic research. For example, Yinka-Banjo and Salau (2017) conducted research on wearable technology with an emphasis on recent advancements in the realm of smart fabrics, materials, and production methods. In their study of the characterization and applications of smart textile technology, Okorun, Alade, and Uwaifo (2020) reviewed the electronic materials and textiles utilized in smart e-textiles. These scholarly efforts have not yet been applied in real-world industrial settings. The economic potential of smart textiles has not yet been fully realized by Nigerian textile factories. This, according to Agbaje (2022), is due to the absence of smart textile materials from Nigeria's textile sector.

However Agbaje (2022), reported on a Nigerian research team that made the first attempt to create smart nanotextiles using cotton and silk. Agbaje pointed out that the silver and silver-titanium oxide nanoparticles used in this experiment were made from wastewater from locust beans, which is typically not beneficial. Locust bean wastewater is a byproduct of processing locust bean tree seeds to create the local condiments known as okpei in Igbo, iru in Yoruba, and daadawa in Hausa. According to the author, before fabrics were dipped into the nanoparticle solution to create nanotextiles, some chemicals were reduced using the wastewater in the laboratory to form silver and silver-titanium nanoparticles. The author also mentioned that when integrated with electronics, nanotextile materials are frequently "smart" since they react differently to the outside environment. The testing results, according to the study, demonstrated that the nanotextiles developed stopped the growth of many dangerous bacteria and black mold, making them useful as antimicrobial

materials. Additionally, it was suggested that nanotextiles' outstanding antibacterial qualities could be used to create items like sportswear, nasal masks, and air filters. This experiment's findings have demonstrated that Nigeria can successfully develop smart textile materials. The researchers need to be supported in order for their findings to be applied in the Nigerian textile industries. They can be helped by giving them access to money that will allow them to turn their research findings into actual, marketable smart textile products.

With the ability to eliminate germs, it could be utilized to manufacture smart textiles materials for bandages, curtains, uniforms, and bed sheets. This would greatly aid in resolving healthcare issues and enable Nigerian textile mills to compete favorably with their international counterparts. But to fully take advantage of the prospects offered by smart textile innovation, interdisciplinary partnerships involving experts in a variety of fields including textile design, textile and polymer engineering, computer sciences, and microelectronics will be necessary.

Conclusion

A fascinating development in the realm of textile in the twenty-first century is the creation of smart textile. These fabrics may perceive and respond to natural conditions or stimuli, such as those caused by mechanical, thermal, chemical, electrical, magnetic, or other biological variables, in addition to their usual purpose of providing covering for the body as clothing. The use of smart fabrics has brought about dramatic advances in a variety of industries, including health care, fashion, home furnishings, military, and sports. The commercial potentials for smart textiles are still untapped in the Nigerian textile sector. The Nigerian textile industries have been negatively impacted by the current economic crisis.

However the textile industry in Nigeria has the potential to become more economically sustainable if the market for smart textiles is explored in the important sectors of healthcare. This is so that they can meet the fundamental requirements of man. Smart Textile materials can be exported to other African countries in addition to serving domestic consumers, if the textile industry in Nigeria taps into the opportunity created by the free trade agreement with the ECOWAS which would improve overall foreign revenues. This will boost and revitalize the Nigerian textile industry.

Additionally, as 80% of the respondents utilized for this study and consequently Nigeria are currently unaware of the products manufactured with smart textiles, it is also important to increase consumer awareness as this could help fuel future market growth. If smart textiles are to be quickly accepted by consumers, they must also be cost-effective and compatible with other garment attributes such as comfort and durability without having any negative side effects. For Nigeria's textile industries, the expanding market for "smart textiles" presents tremendous investment opportunities. However, in order to increase future sales, consumers must be educated about smart textiles.

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