Journal of Arts and Social Sciences
https://ojs.jass.pk

Designing Functional and Aesthetic Home Textiles for Mosquito Control in the Indoor Built Environment: A Review of Needs Assessment and Opportunities in Punjab

Amna Khalid[*], Mumtaz Hasan Malik[**], Sadia Farooq[***], Shahzad Maqsood Khan[****]

[*] *Assistant Professor, School of Design and Textiles, University of Management and Technology, Lahore, Pakistan*
[**] *Professor, School of Design and Textiles, University of Management and Technology, Lahore, Pakistan.*
[***] *Assistant Professor,University of Home Economics, Lahore, Pakistan*
*****Professor,Institute of Polymer & Textile Engineering, University of the Punjab, Pakistan*

ARTICLE INFO

Article history:
Submitted 10.01.2024
Accepted 18.06.2024
Published 30.06.2024

Volume No. 11
Issue No. I
ISSN (Online) 2414-8512
ISSN (Print) 2311-293X
DOI:

Keywords: Functional Textiles, Mosquito Control, Vector Protection, Sustainability, Interior Textiles

ABSTRACT

Recently, there has been a lot of innovation in the design and craft of decorative interior textiles. With the advent of advanced technologies and sustainability concerns all over the world, there has been phenomenal progress in the usage of functional applications in the field of interior textile design. These functional applications offer multiple solutions to impart in interior textiles that not only provide an aesthetic appeal in the indoor environment but also furnish the need for health and vector protection. Considering the present environmental conditions and prevalence of vector-borne diseases in the indoor environment in Pakistan, this review study was conducted to assess the user acceptance, and feasibility of manufacturing such products in the mainstream of Punjab textile industry. By employing the design thinking methodology, the study sorted out the technologically feasible and economically viable. Desirability, feasibility and viability. The home textile product that can function as a mosquito repellent in the indoor space after applying a vector protective finish can offer significant benefits to the users. The products may also cater to multiple functions along with their aesthetic appeal. The research presents the needs analysis and recommendations for utilizing functional applications in home textile products.

Introduction

Interior textiles include a diverse variety of materials and textiles that are utilized in the planning and embellishment of interior spaces. These fabrics improve a room's style, comfort, and ambiance in addition to serving aesthetic and practical functions. Furniture like chairs, couches, and benches are covered with upholstery textiles. They are selected according to their comfort, strength, and aesthetic appeal. Faux leather and leather, along with woven materials like linen, cotton, and polyester mixes, are popular upholstery materials (Mondal, 2008). For window treatments, drapery and curtain textiles are used to provide light control, decoration, and seclusion. These textiles range in weight from sheers that are lightweight to heavier ones like silk, velvet, or jacquard. They are available in a range of hues, designs, and textures to go with the decor of the space. Bed sheets, duvet covers, pillowcases, and bedspreads are all examples of bedding textiles. These materials are picked for their plushness, ventilation, and simplicity of maintenance. Cotton, satin, linen, and silk are typical sleeping fabrics. Carpets and rugs provide texture, floor warmth, and aesthetic appeal. They provide the area definition and comfort underfoot. Wool, sisal, nylon, and synthetic fibers are among the materials used to make rugs and carpets (Mondal, 2008). They are available in a variety of styles, prints, and pile heights. Wallpaper, cloth wall panels, and tapestries are all examples of wall

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

coverings. These fabrics provide color, pattern, and texture to walls, enhancing their visual appeal. Wallpaper is available in a broad variety of patterns and can be made of paper or cloth. Tapestries and fabric wall panels add an opulent and beautiful touch. Cushions and pillows both have practical and aesthetic usage. They certainly provide chances for pattern and color coordination while also improving the coziness of beds and sitting spaces. Different materials, such as linen, cotton, velvet, and beautiful textiles with decorations, can be utilized to make cushions and pillows. Napkins, tablecloths, and placemats are a few instances of table linens. They are used to guard the tabletop and make eating extra welcoming. Tablecloths can be decorated with needlework and designs and are accessible in a variety of materials, including linen, polyester, cotton, and mixes. Absorption of sound and superior acoustics are the paramount aims when creating acoustic fabrics. They are employed in places where silence is desired, such as theatres, conference rooms, and recording studios. Such materials possess a stylish appearance and are made to be sound-absorbing.

Research Significance

The study advances the understanding and feasibility of textile technology incorporated into design. The knowledge and exploration of functional/vector control materials, their characteristics, and their potential for use in home textiles might result in the creation of unique textile products that can enhance interior spaces' utility, comfort, and long-term viability along with the aesthetics.

The user experience in indoor environments may be improved through the use of functional materials in interior textiles. The study investigates how these developments might enhance inhabitants' convenience, comfort, and general well-being in interior environments. Recommendations have been made to utilize functional/vector control elements to be used into indoor textiles without detracting from the aesthetic value and architectural coherence.

Functional Textiles and their Applications

The term "technical textiles," also sometimes recognized as "engineered textiles" or "functional textiles," denotes fabrics that are manufactured and designed for explicit functional properties rather than aesthetic appeal. The above-mentioned textiles were developed to satisfy particular performance specifications and were designed to be used in a variety of fields and applications. They frequently have specialized qualities like exceptional endurance, tolerance to harsh environments, or state-of-the-art capabilities like flame retardancy or moisture-wicking (Gehrke et al, 2019).

Protective Textiles: They are made to offer defense against potential chemical, physical, or biological threats. They are used in a multitude of fields, involving the military, law enforcement, responding to emergencies, and industrial settings, as well as in healthcare. Examples include hospital gowns, clothes made to withstand chemicals, bulletproof vests, and fabrics made to withstand heat (Maity, Singha & Pandit, 2023).

Technical textiles are used in a wide range of areas and industries, providing modern alternatives and enhanced performance. As new technologies and materials are created, these textiles continue to advance, pushing the limits of what is practical in terms of usefulness, sustainability, and efficiency.

Table 1. Technical textiles - Types and applications

Polymers	Breathable textiles, Flame retardant, Antistatic, Hydrophobic, Antimicrobial, Repellent, Hydrophilic
Specialty Polymers	EMI shielding, UV protective, Heat reflective, Wound dressings
Smart Polymers	Intelligent smart textiles, Biomedical uses, Camouflage, Self-healing

Literature Review

Many vector-borne illnesses, which are spread to people by the bites of infected insects, particularly mosquitoes, are believed to be indigenous to the South Asian region (Kumar et al, 2012). Within South Asia's many nations and regions, there may be differences in the incidence of certain diseases. Following are some of the main vector-borne illnesses that affect South Asia with special reference to Pakistan and Punjab region.

Malaria: In South Asia, malaria is a major threat to public health. It is brought on by Plasmodium parasites that the Anopheles mosquito spreads. Malaria is most prevalent in nations like Bangladesh, India, and Myanmar. The deterrence of malarial vectors is a main concern, as are early discovery and quick cure (Kumar et al, 2018).

Dengue Fever: The Aedes mosquito, which also carries the dengue virus, is the primary carrier of dengue sickness. Dengue epidemics sometimes happen in South Asia, which includes Pakistan, Bangladesh,

Correspondence concerning this article should be addressed to Amna Khalid, amnakhalid.dr@gmail.com

Sri Lanka, and India. The public's knowledge, early case detection, and the reduction of vectors are the main goals of dengue prevention initiatives.

Chikungunya: The chikungunya virus, which is spread by Aedes mosquitoes, causes it. Chikungunya cases have been reported in South Asia, specifically in Sri Lanka, Bangladesh, and India. Examples of preventive strategies include personal insect repellent and vector control.

Japanese Encephalitis: Infected mosquitoes, particularly those of the Culex genus, transmit the Japanese encephalitis virus, which causes the illness (Gopalakrishnan, Baruah & Veer, 2014). The disease is endemic in several nations in South Asia, including Bangladesh, Nepal, and India. Campaigns for immunization and efforts to eradicate mosquito populations can prevent Japanese encephalitis.

Filariasis: The parasitic worms that cause lymphatic filariasis, commonly referred to as elephantiasis, are spread by mosquitoes of the Culex, Aedes, and Anopheles species. There are continuing programs to eradicate filariasis in South Asian nations, including Sri Lanka, India, and Bangladesh. These programs entail the delivery of widespread drugs and vector control methods (Gopalakrishnan, Baruah & Veer, 2014).

Zika Virus: Similar to dengue and chikungunya, the Aedes mosquito is the main vector of the Zika virus. Although South Asia has a comparatively low frequency of the Zika virus in comparison to other areas, occasional instances have been observed in nations like India and Bangladesh. To stop the Zika virus from spreading, vector control and surveillance measures are taken.

It is crucial to remember that vector-borne illness frequency and effects might differ across and within South Asian nations. Public health initiatives, vector control strategies, and greater availability of healthcare facilities for diagnosis and treatment are all used in the fight against these illnesses.

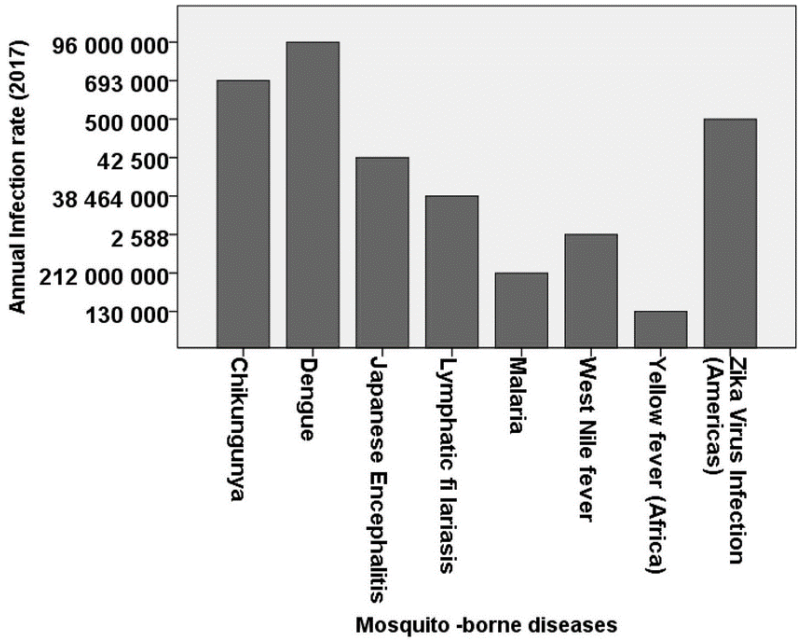

Figure 1. Mosquito-borne diseases in the south Asian regions in 2017 (Source World Health Organization)

According to the WHO, mosquito-borne diseases are a major public health problem. The figure 1 shows the number of people infected with mosquito-borne diseases in 2017 within South Asian regions. The most common disease is dengue, with 212 million cases. Malaria is the second most common disease, with 207 million cases. Chikungunya, Japanese encephalitis, lymphatic filariasis, West Nile fever, yellow fever, and Zika virus infection are also shown on the figure. In 2017, there were an estimated 229 million cases of mosquito-borne diseases in this region.

Types of Mosquitos in the Indoor Premises

Numerous mosquito species can be found indoors, subject to the area and factors affecting the environment. Anopheles, Culex, Aedes, Mansonia, and Culiseta are a few common mosquito species that may wreak havoc in enclosed spaces. Aedes mosquitoes are voracious biters and are believed to transmit diseases including dengue fever, the Zika virus, and chikungunya. Even though many species are active during the daytime, certain species are capable of biting at nightfall. Aedes mosquitoes have black and white stripes on their body and legs. The Culex species of mosquito is located inside as well as outside (Webber, 2015). They have a history of dispersing diseases like filariasis and the West Nile virus. Culex mosquitoes

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

are most prevalent in the late afternoon and sometimes in the early evening, and they are attracted to areas with stagnant water. Their small size and lengthy, thin legs can be used to identify them.

Malaria is supposed to be the basic illness that Anopheles mosquitoes spread. They like moist areas like ponds, swamps, and lakes. Most of the time they are active late at night. Anopheles, a tall, slender mosquito, flies and makes a distinctive buzzing noise (Webber, 2015). Mansonia mosquitoes are often witnessed in tropical settings. They breed in moist places with slow-moving rivers, marshes, and bogs. Mansonia mosquitoes are infamous for dispersing diseases like filariasis and the Ross River virus owing to their vicious biting behaviors. In colder areas, Culiseta mosquitoes are habitually encountered. They can infect animals with diseases, although they are less likely to bite humans. Numerous locations, including marshes, tree holes, and both natural and man-made containers, are used by the Culiseta mosquito to spawn (Webber, 2015).

It is vital to remember that different mosquito species and populations may exist based on a particular area and environmental factors. Eliminating mosquito breeding grounds, utilizing insecticide-treated bed nets, and employing mosquito repellents are all effective ways to lower mosquito populations indoors and the risk of contracting illnesses carried by them.

Conventional Methods of Mosquito Eradication in the Indoor Environment

The necessity to reduce mosquito populations and stop the transmission of illnesses carried by mosquitoes has led to the evolution of mosquito elimination techniques over time. The first strategy is source reduction, which entails removing or changing mosquito breeding grounds to halt the spread of populations of mosquitoes (Floore, 2006). This strategy, which has been used for millennia, calls for actions like draining stagnant water, filling in puddles and ditches, and removing vegetation that serves as a breeding ground for mosquitoes. Biological control techniques come in second. To reduce the population of mosquitoes, it makes use of natural predators and viruses. Adding predatory fish, like Gambusia affinis (mosquitofish), to bodies of water so they may eat mosquito larvae is one approach (Karunaratne & Surendran, 2022). Similar to this, it has been frequently used microorganisms like Bacillus thuringiensis israelensis (Bti), which generate toxins detrimental to mosquito larvae. Next are insecticides. In the middle of the 20th century, insecticides were widely used to manage mosquito populations. At first, DDT (dichloro-diphenyl-trichloroethane) and other pesticides were often employed to control mosquitoes (Benelli, Jeffries & Walker, 2016). Yet, the use of DDT and other persistent insecticides has been limited owing to health and safety issues. Insecticides are now used more sparingly and often in conjunction with other types of pest management.

Larvicides and adulticides come in fourth. While adulticides are used to manage adult mosquito populations, larvicides are substances that are exclusively aimed at mosquito larvae. To stop the growth of larvae, larvicides are administered to breeding areas, like stagnant water bodies. Adulticides, which are meant to eradicate adult mosquitoes, are frequently sprayed or fogged in outdoor areas (Kamaraj & Rahuman, 2010). Genetic control is the fifth. By releasing genetically engineered mosquitoes or changing mosquito genetics, genetic control techniques seek to reduce the population of mosquitoes. One illustration is the dispersal of male mosquitoes with a sterilizing gene, which hinders female mosquitoes' capacity for efficient reproduction. This strategy is currently being developed and tested. Integrated pest management (IPM) comes in sixth. IPM combines a variety of pest management techniques, such as source reduction, biological control, targeted pesticide usage, and community outreach (Flint & Van den Bosch, 2012). The main goals of IPM techniques are to reduce the usage of chemical pesticides and find long-term sustainable alternatives.

Mechanism and Classification of Mosquito Repellents

To operate, repellents used for mosquito control must either stop mosquitoes from landing or approaching the skin (Dickens & Bohbot, 2013), or they must kill them immediately on contact. Based on how they work, they may be divided into two primary groups: repellents that work in the olfactory and tactile modes.

Olfactory Mode Repellents: They operate by obstructing the mosquito's use of its sense of smell to find and locate a suitable host. They produce an unpleasant or perplexing odor that deters insects. Olfactory mode repellents include picaridin, DEET, and essential oils as some popular examples. One of the most popular insect repellents is DEET. It conceals the human aroma that mosquitoes find attractive, making it challenging for them to find and settle on the skin. Another powerful insect repellent that makes it difficult for mosquitoes to recognize humans is picaridin, which interferes with their olfactory receptors. Eucalyptus, citronella, lemon, and lavender oil are some instances of essential oils that have repelling characteristics. They emit odors that repel mosquitoes and aid in preventing their approach.

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

*Tactile Mode Repellents***:** To keep mosquitoes from landing on the skin, tactile mode repellents build a

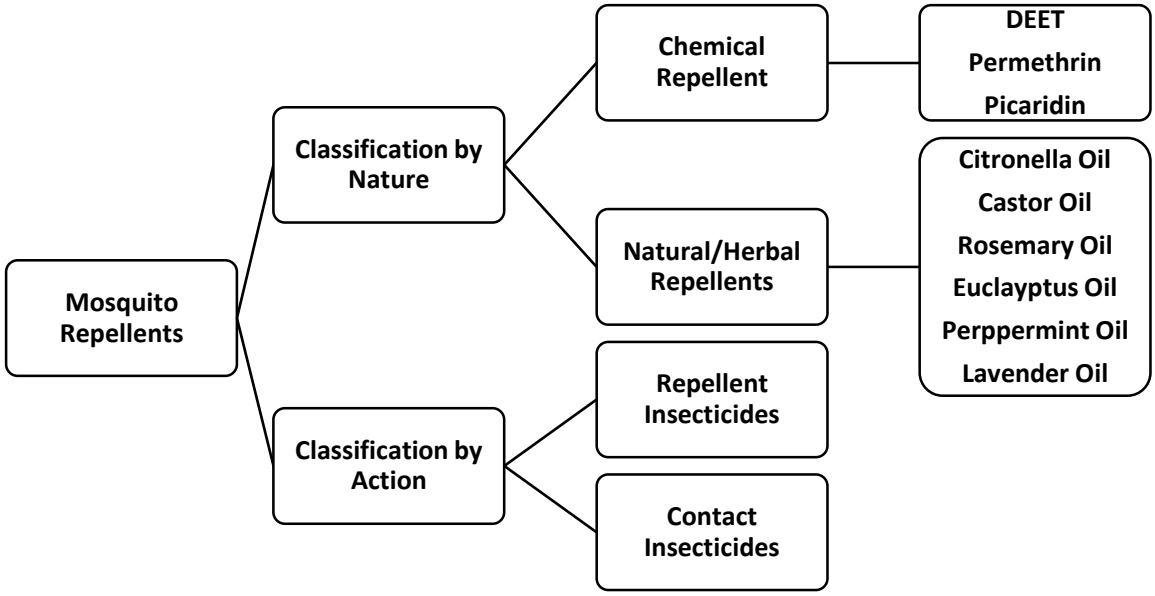

Figure 2. Classification of mosquito repellents by nature and action properties

tactile or physical barrier. They reduce the skin's attractiveness to mosquitoes or make it challenging for them to settle and bite. Insecticide-treated clothing, mosquito nets, and physical barriers are a few instances of tactile mode repellents (Gupta & Gupta, 2019). The physical barrier created by long trousers, long sleeves, socks, and shoes keeps mosquitoes from directly touching the skin. Insecticide-treated mosquito nets in particular establish a physical barrier surrounding sleeping spaces so that people are protected from bites by mosquitoes. A tactile mode repellent effect is produced when clothing is treated with insecticides like permethrin. When mosquitoes touch the treated cloth, they are either killed or repelled.

Insecticide-Infused Textiles for Protection against Mosquitos

By integrating insecticides straight into the fabric, textiles that have been treated with insecticides are intended to offer greater defense against mosquitoes. When exposure to mosquitoes is an issue indoors or outdoors, these fabrics are frequently used for clothes, sleeping nets, and other items. When fabrics have been treated with insecticides, mosquitoes are either repelled or killed on contact. Pyrethroids, such as deltamethrin or permethrin, which are efficient against mosquitoes but have minimal toxicity to humans, are among the most widely used insecticides (Raja et al, 2015). In the instance of the repellent impact, textiles treated with pesticide stop mosquitoes from landing on or biting through the fabric by displacing them. Insecticides reduce the danger of infections spread by mosquitoes by putting up a barrier between the wearer and the insects. The insecticides included in these fabrics may also have insecticidal action, which translates to the ability to instantly kill mosquitoes. The insecticide damages mosquitoes' nerve systems when they come into touch with the medicated cloth, which can result in death or paralysis (Goel & Aggarwal, 2007).

In terms of long-lasting defense, fabrics impregnated with insecticides are made to do so. Because the insecticide is bonded to the fibers of the cloth, it keeps working even after several washings or extended use. Clothing, caps, socks, bed nets, and curtains are just a few items that may be made from fabrics that have been treated with insecticides. These can be especially helpful while camping, hiking, or gardening outside or in places where mosquitoes are a problem. When applied as instructed, insecticides present in these fabrics are usually regarded as secure for human consumption. To ensure correct usage and maintenance, it is crucial to adhere to the manufacturer's instructions and recommendations. Preventing direct personal contact with the treated regions, ensuring sufficient ventilation while the fabric is being treated, and keeping pets and kids away from the fabric are all examples of protection (Faulde, 2018). Textiles with insecticide infusions provide an extra barrier of defense against mosquitoes and can support existing mosquito prevention strategies. They are a useful tool in regions with large populations of mosquitoes or the prevalence of diseases since they are successful in lowering mosquito bites and the risk of mosquito-borne infections.

Theoretical Framework for Designing Aesthetic and Functional Home Textiles Products

In order to ascertain the needs analysis and opportunities for integrating functional/vector control applications onto the conventional home textile products, a theoretical framework has been developed that

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

aligns with the objectives of this study by focusing on theories from user experience design, material science and design innovations (Cherenack, K., & Van Pieterson, L. 2012). The theoretical framework illustrates the study, shapes the study interrogative questions and facilitate in the analysis of collected data. The diffusion and adoption of functional/vector control applications on interior textiles follow pattern in line with diffusion of innovation theory, developing from the early adopters to mainstream users. User feedback and engagement play an important role in shaping the functionality and design of interior textiles with integrated functional/vector control materials. The involvement of these materials can result in the transformation of the interior design tactile experience, influencing visual appeal, entire consumer satisfaction and aesthetics. By embracing this theoretical framework, the study will contribute to an in-depth understanding of the relationship between aesthetics considerations, innovation diffusion and user-centered design in terms of the innovation in functional/vector control materials in interior textile. This theoretical framework will regulate collection of data, analysis and interpretation, permitting to uncover understandings that deepen and improves the fields of interior design and material innovation.

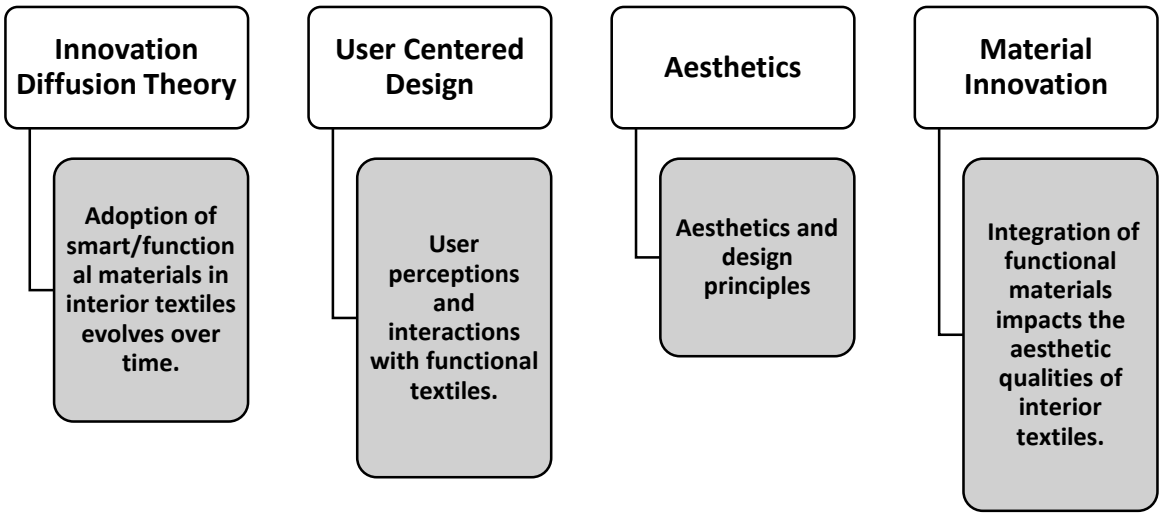

Figure 3. Theoretical Framework for designing Home Textiles Products with enhanced functionalities

Need Analysis of Mosquito Repellent Home Textile Products

Products made of home textiles that are mosquito-repellent play a significant role in providing shields from mosquitoes in enclosed spaces. Mosquitoes may transmit illnesses including West Nile virus, Zika virus, chikungunya, dengue fever, and malaria. These illnesses have the potential to be fatal and can have major health effects. Products made of home textiles that repel mosquitoes assist in provide an obstacle between people and the insects, lowering the danger of mosquito bites and the spread of infectious illnesses (Raja et al, 2015). Mosquitoes may get inside buildings through doors, open windows, or tiny cracks in screens. Once they are inside, they may bother people and make disturbances, particularly at night while people are asleep. Bed linens, curtains, and mosquito nets that are insect repellent can act as an obstacle, keeping insects out of sleeping spaces and fostering a more tranquil and pleasant environment.

Table 2. Need Assessment of Mosquito Repellent Home Textile Products

Need	Description	Home Textiles
Protection from mosquito-borne diseases	Mosquitoes can transmit a variety of serious diseases, including malaria, dengue fever, chikungunya, and Zika virus. Mosquito-repellent home textile products can help protect people from these diseases by repelling mosquitoes.	Mosquito repellent curtains, mosquito repellent bedding, mosquito repellent blankets

Reduced use of chemical repellents	Traditional mosquito repellents often contain DEET, a chemical that can be harmful to humans and the environment. Mosquito repellent home textile products can provide an alternative to chemical repellents, which can help to reduce the exposure of people and the environment to these chemicals.	Mosquito repellent pajamas, mosquito repellent mosquito nets, mosquito repellent hammocks
Improved comfort and sleep quality	Mosquito bites can be itchy and uncomfortable, and they can also disrupt sleep. Mosquito repellent home textile products can help to improve comfort and sleep quality by eliminating mosquito bites.	Mosquito repellent curtains and bed sheets, mosquito repellent pillows, mosquito repellent towels
Aesthetic appeal	Mosquito repellent home textile products can be stylish and decorative, so they can also be used to improve the appearance of a home.	Mosquito-repellent curtains in different colors and patterns, mosquito repellent bedding with attractive designs, mosquito repellent hammocks in different sizes and styles

Mosquito bites can result in itchiness, pain, and skin rashes, which can disrupt sleep and create general discomfort. Textiles treated to repel mosquitoes provide people comfort and peace of mind by ensuring that they won't get bitten when lounging or sleeping at home. It improves people's overall health and quality of life. Home textiles that repel mosquitoes can be a more environmentally friendly option than repellents that use chemicals (Katz, Miller, & Hebert, 2008). They eliminate the requirement for using topical repellents on the skin, which may include chemicals, by embedding mosquito-repellent qualities straight into the fabric. People with sensitive skin or those who prefer natural or non-toxic options may find this to be very helpful. Home textiles that repel mosquitoes are simple to use and require little work. They are simple to work into routines and already-existing home design. For instance, you may cover windows with mosquito-repellent drapes and cover mattresses or other pieces of furniture with mosquito nets. With the help of this convenience, people may safeguard their families and themselves without having to make any big lifestyle adjustments.

Table 3. Target market for mosquito repellent home textile products – online survey March 2023

Target Market Group	**Description**
People who live in areas with high mosquito populations	People who live in areas with high mosquito populations are more likely to be interested in mosquito repellent home textile products because they are at a higher risk of being bitten by mosquitoes and contracting mosquito-borne diseases.
People who travel to areas with high mosquito populations	People who travel to areas with high mosquito populations are also at a higher risk of being bitten by mosquitoes and contracting mosquito-borne diseases. Mosquito repellent home textile products can provide them with additional protection while they are traveling.
People who are at high risk for mosquito-borne diseases	People who are at high risk for mosquito-borne diseases, such as pregnant women, young children, and people with weakened immune systems, are particularly interested in mosquito-repellent home textile products because they can help to protect them from these diseases.
People who are concerned about the health and environmental risks of chemical repellents	People who are concerned about the health and environmental risks of chemical repellents may be interested in mosquito-repellent home textile products as an alternative. Mosquito repellent home textile products can provide effective protection from mosquitoes without the use of harmful chemicals.
People who want to improve their comfort and sleep quality	Mosquito bites can be itchy and uncomfortable, and they can also disrupt sleep. Mosquito repellent home textile products can help to improve comfort and sleep quality by reducing the number of mosquito bites.

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

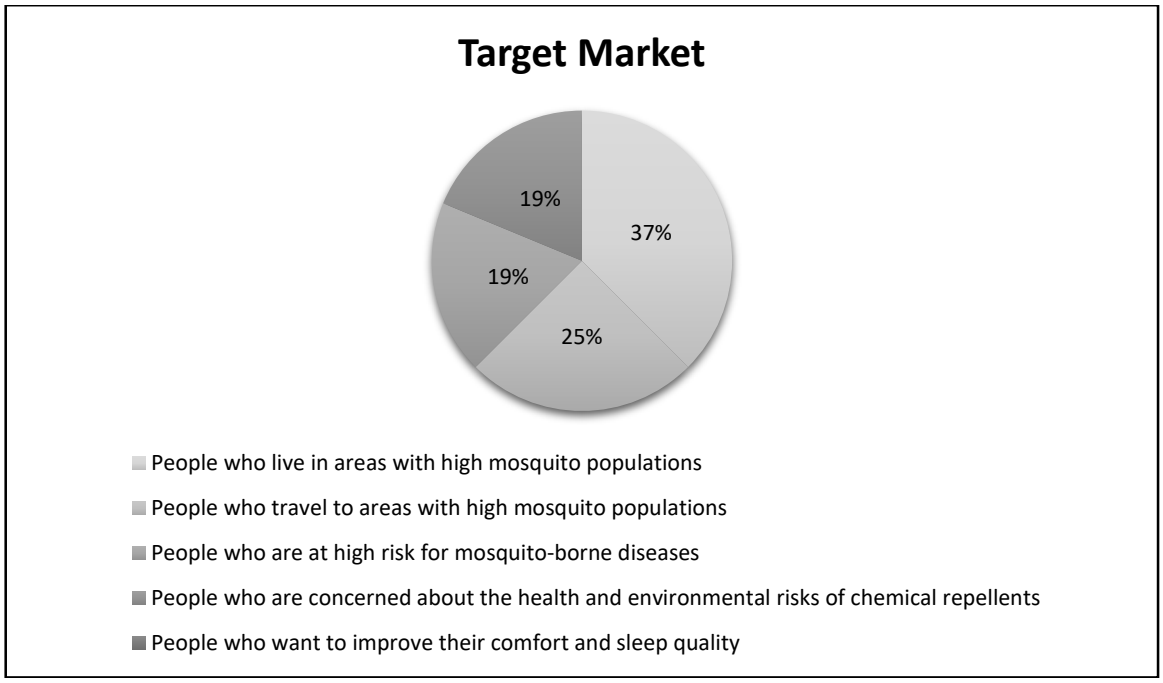

Figure 4. Pie-Chart Showing Target Market Segmentation for Mosquito Repellent Home Textile Products (online survey March 2023)

Mosquito Repellent Functional Application on Home Textiles (Window Fabrics)

Mosquitoes can enter inside rooms from windows, but applying repellent to window materials can assist in establishing an obstruction. Conventionally, to efficiently apply insect repellent to window materials, a few measures must be taken. The first step is to choose a mosquito repellent that can be applied to fabrics. Seek for repellents made especially for use on fabrics, since they are developed to bind on the fabric and offer durable protection. The second step is to carefully read and adhere to the manufacturer's directions on the mosquito repellent product. Pay heed to any particular instructions or safety considerations relating to the application of cloth. Third, make sure the window materials are dry and clean before putting the repellent on them. By vacuuming or lightly brushing the cloth surface, remove any dust, grime, or debris. The repellent is then applied to the entire fabric surface in the fourth phase, and it is tested in a small, discrete area to make sure it is compatible and to look for any discoloration or negative responses (Melby & Cathcart, 2002). Use the insect repellent on the window fabrics in the fifth step, following the directions. To do this, apply the repellent solution to the cloth by brushing, spraying, or soaking it. Be careful to uniformly coat the whole cloth area, giving special attention to any seams or corners where mosquitoes may hide. In the sixth step, allow the window materials to completely dry after applying the repellent. This can take a few hours or whatever duration the manufacturer specifies. To prevent spreading the repellent to other surfaces or skin, wait until the sprayed cloth is dry before handling it or folding it. When exposed to weather or regular washing, insect repellent on window materials may lose some of its efficacy over time (Debboun & Strickman, 2013). To preserve ongoing protection, adhere to the manufacturer's advised reapplication intervals. Avoid direct inhalation or contact with the insect repellent solution when applying it, and make sure there is enough ventilation. When applying a spray, cover nearby surfaces or items with a cover sheet or piece of plastic to prevent overspray.

However, several advanced methods are now being introduced to apply functional finishes on the textile materials that are far more efficient and long lasting. Highly durable functional textiles can be produced through microencapsulation of vector control substances, for example, organic citronella or moringa oil are few of the methods that can be used on the home textile products for increased efficacy in the vector control within the interior premises (Aldalbahi et al, 2021).

Prospects of Converting a Decorative Interior Textile into a Functional/Protective Home Textile Product

There are several opportunities and benefits associated with transforming a beautiful interior textile into a protective/functional home textile product. A beautiful interior textile can perform a dual duty by adding preventive or practical qualities. For instance, adding light-blocking capabilities may turn a beautiful curtain into a blackout curtain, increasing seclusion and regulating lighting. This transformation makes the cloth more useful and valuable to the user by enabling it to provide utilitarian advantages beyond its aesthetic appeal (Cherenack & Van Pieterson, 2012). The usability and usefulness of a decorative textile are increased

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

when it is made into a functional/protective home textile product. It makes it possible for the textile to answer certain demands or difficulties in the home setting. As an example, a beautiful tablecloth can become more useful and long-lasting by being made water- or stain-resistant, shielding the underlying surface from stains or spills.

Enhancing safety and protection within the house is possible by turning a beautiful textile into a protective home textile product. For instance, adding fire-resistant qualities to ornamental curtains or upholstery materials can lower the likelihood of fire dangers and give inhabitants a more secure atmosphere. Without sacrificing the textile's visual appeal, this transformation gives an extra layer of protection. It is possible to turn a decorative textile into a practical/protective home textile product when demands and situations change (Fung, 2002). The converted textile may be altered or redesigned to meet changing demands as the needs of the users change. The textile will always be useful and relevant thanks to its versatility.

A brand or product line may stand out in the market by offering protective or practical home textile goods that are developed from ornamental textiles. Customers that value both beauty and utility are catered to, broadening the target market and maybe growing market share. Sustainable design principles may be enhanced by transforming a beautiful textile into a practical/protective home textile product. Repurposing current ornamental textiles results in less waste and increases the lifespan of the items than developing wholly new ones. Sustainability and responsible consumerism are compatible with this.

Table 4. Common Textiles and Suitable Functional Applications

Type	Most Suitable Application
Cotton	Cotton is versatile and can be used for a wide range of functional finishes, including dyeing, printing, and flame retardant treatments (Riello, 2013)
Polyester	Polyester is often chosen for moisture-wicking and quick-drying finishes, making it suitable for sportswear and outdoor apparel.
Nylon	Nylon is known for its durability and is often used for coatings that enhance water resistance, making it ideal for rainwear and outdoor gear.
Wool	Wool can be treated for warmth, fire resistance, and moisture management, making it suitable for cold-weather clothing and protective gear.
Silk	Silk is a luxurious fabric that can be treated for antimicrobial and UV-resistant finishes, making it suitable for undergarments and outdoor clothing.
Synthetic Blends	Fabrics made from blends of synthetic and natural fibers offer a combination of properties, such as comfort, durability, and moisture management, making them suitable for various applications.
Technical Fabrics	High-performance technical fabrics like Gore-Tex or Dri-FIT are engineered with specific functions in mind, such as waterproofing or moisture control, and are used in specialized apparel and gear.
Denim	Denim can be treated with various finishes for added durability, color retention, and style, making it suitable for jeans and casual wear.

Results and Discussion

There are many chances and advantages in creating new interior textiles, particularly window materials, with practical uses for both aesthetics and vector control in the indoor built environment. The creation of window textiles that are aesthetically pleasing and add to the entire aesthetics of interior spaces ought to be the main goal of the new product development. Enhancing the fabric's attractiveness and harmonizing it with the interior design concept may be accomplished by using appealing patterns, colors, and textures. The problem of mosquito or insect infestation in interior spaces can be addressed by incorporating vector control technologies into window textiles (Baldwin & Clark, 2000). This can be done by adding explicitly mosquito-repellent characteristics into the fabric or by structuring the fabric in a way that keeps ventilation and natural light while preventing insects from entering via windows. Beyond their visual appeal, the new window textiles ought to deliver functional performance. To improve comfort and efficiency of energy in the interior environment, they ought to provide good privacy, light control, and thermal insulation qualities. The selection of materials for the window coverings ought to be done with great care. They ought to be long-lasting, simple to maintain, and immune to fading or damage brought on by exposure to sunlight) (Fang et al, 2021). The ethics of responsible design may also be supported by the selection of sustainable and eco-friendly materials.

The usefulness of window materials may be improved even more by incorporating technology. For

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

example, including intelligent elements like light sensors or motorized controls can enable automatic modifications to confidentiality and light levels, offering convenience and customization possibilities for users. The creation of a product can benefit greatly from working with textile engineering, vector control, and interior design professionals. Research and input from prospective users can be used to pinpoint particular requirements, preferences, and difficulties relating to aesthetics and vector control in the interior built environment. It is essential to guarantee the new product's effectiveness and safety. It is crucial to test the window textiles for vector control efficiency, sturdiness, and compliance with pertinent norms or laws. Having certifications or endorsements from recognized organizations can increase the product's credibility among customers. A compelling marketing plan that positions the new window fabric goods as creative, useful, and appealing can aid in developing a distinct selling offer. Pointing out the advantages of aesthetics and vector control in the interior built environment helps draw in the target market and set the product apart from competitors.

In short, striking a careful balance between practicality, aesthetics, and efficacy is necessary when creating innovative window fabric products with practical uses for aesthetics and vector control in the interior built environment. It is feasible to develop novel and appealing items that improve the aesthetic appeal of interior spaces while tackling vector control issues by taking into account the variables described above and using cooperation, research, and technology.

Table 5. Design Process for Home Textile Product Development using Functional Finishes

Research and Concept creation	Determine current industry trends, user requirements, and cutting-edge technology for functional textile finishes. Performing a study on the components, methods, and uses of smart/functional finishes. Creating design ideas and concepts in accordance with the determined market requirements and technology potential.
Tests and Material Selection	Consider and choose the best textile materials that can support sophisticated or practical finishes. Check to see if the chosen materials are compatible with the functional qualities as desired, such as conductivity, water resistance, or UV protection. When choosing materials, take into account elements like durability, comfort, and environmental sustainability.
Cooperation and Knowledge	Work together with specialists in textile engineering, material science, and smart technology to make sure the smart/functional finishes are feasible and to maximize their performance. To comprehend the technological needs and potential, consult manufacturers, suppliers, and academics who focus on smart fabrics.
Prototype Development	Create textile product prototypes with the smart/functional finishes. To include the intelligent/functional aspects of the textile material, use the proper production processes, such as knitting, weaving, or coating. To confirm the necessary functional characteristics and gauge performance, thoroughly test and evaluate the prototypes.
Performance Validation and Testing	Run thorough tests to determine how well the smart/functional finishes operate in various environments, including those with varying temperatures, humidity levels, and wear-and-tear. Evaluate the product's compliance with any applicable industry standards, laws, and safety requirements. To evaluate the efficacy and attractiveness of the smart/functional finishes, conduct user trials or obtain feedback from potential users.
Modification and Iteration	To pinpoint areas that want improvement, examine the test results and user input. Improve the product's usefulness, appearance, and performance by modifying the design, the materials, or the production methods. Develop and test prototypes iteratively as required to get the results you want.
Manufacturing and Production	Based on the completed design and improved prototype, determine the manufacturing procedures and production volume. Form alliances or relationships with producers or suppliers that can create textile products with smart/functional finishes. To guarantee consistent performance and functioning, make sure quality control procedures are in place throughout the production process.
Market Launch and Evaluation	Create a marketing and PR plan to attract the target market to the functional textile product. Assess the product's success in satisfying customer wants and market expectations while keeping an eye on the market's reaction and gathering consumer feedback. Keep the product under constant review and revision based on consumer input, technical developments, and market trends.

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com

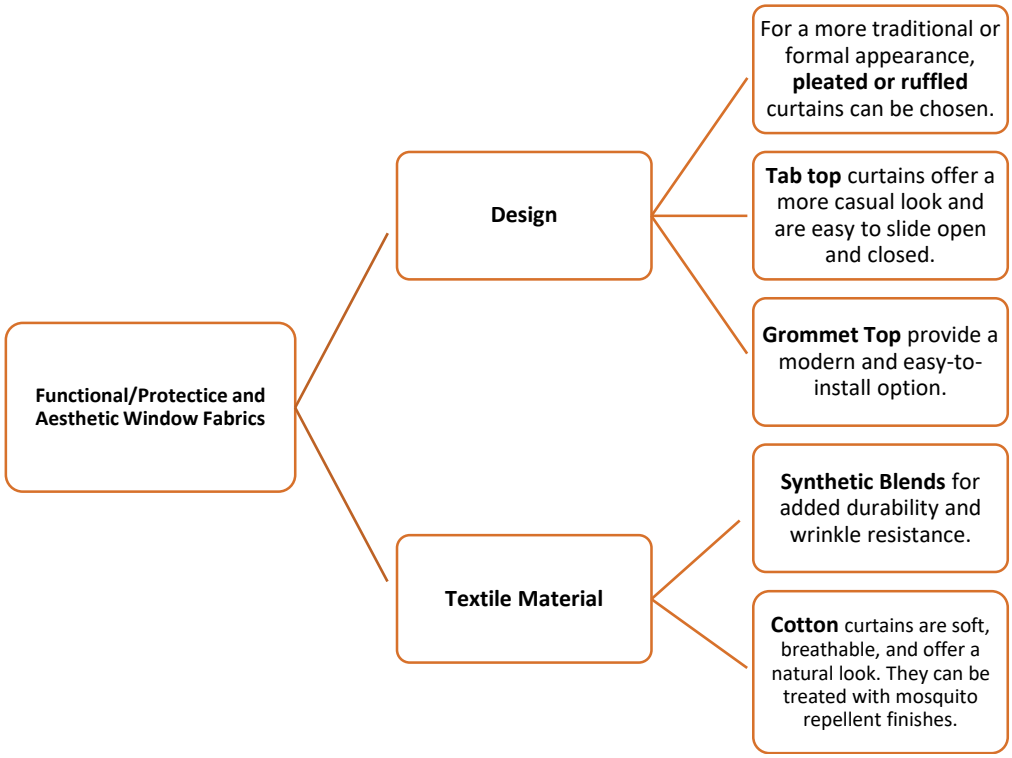

Figure 5. Most Suitable Textile Materials and Design for Development of Mosquito Repellent Window Fabrics

Conclusion

Designing a functional and aesthetic textile product for interior design will be based on accessibility. Various retail stores, home décor stores, and internet marketplaces in this region provide a large variety of alternatives for conventional window textiles, making them readily available on the market. They are widely utilized and available to customers. When compared to standard textiles, functional window fabrics, especially those with extra qualities like thermal insulation, UV protection, or sound absorption, may be more difficult to find. They can need specialized producers, merchants, or suppliers who specialize in functional or technical fabrics. Traditional window textiles frequently place a high value on aesthetic appeal, design variation, and trends to make themselves appealing to a broad spectrum of consumers. Desirability is frequently determined by visual elements including color, pattern, and texture. Consumers looking for advantages beyond appearances may find functional window textiles appealing. Practical textiles are desirable because of things like energy efficiency, privacy, light management, or certain practical qualities such as moisture resistance, and fire resistance. The cost of manufacturing is another factor. Utilizing easily available materials and regular textile production technologies are typical strategies for making standard window fabrics. The price of manufacturing may vary based on the level of design intricacy, the volume of the production, and the overall quality of the fabric. To manufacture useful window fabrics, extra stages, specialized materials, or technologies could be required. It might lead to higher manufacturing expenses than with conventional textiles. The expense may be affected by the complexity of incorporating functioning components as well as the availability of certain materials or technologies. Available materials and technology determine the usage of functional materials on conventional fabric. Classic window textiles are typically made using classic textile materials including cotton, polyester, silk, or blends of these fibers. They rely on conventional weaving, knitting, dyeing, or printing techniques. Functional window textiles can be made using technical fibers such as high-performance synthetics and microfibers and cutting-edge coatings or treatments. Innovative techniques, such as nanotechnology or smart textiles, can be used to provide certain functional properties.

It is important to keep in mind that the specific functional features included in the window textiles may have an impact on the materials and technologies' accessibility, appeal, cost, and availability. Manufacturers and providers of functional textiles could have additional options and expertise in these areas. Expanding accessibility and reducing production costs could potentially be aided by upcoming technical advancements and growing customer demand for practical textiles.

References

A. Aldalbahi, M. E. El-Naggar, M. H. El-Newehy, M. Rahaman, M. R. Hatshan, and T. A. Khattab, "Effects of technical textiles and synthetic nanofibers on environmental pollution," "Polymers," vol. 13, no. 1,

p. 155, 2021.
A. Angelucci, M. Cavicchioli, I. A. Cintorrino, G. Lauricella, C. Rossi, S. Strati, and A. Aliverti, "Smart textiles and sensorized garments for physiological monitoring: A review of available solutions and techniques," "Sensors," vol. 21, no. 3, p. 814, 2021.
B. D. Coleman, "Historic arts & crafts homes of Great Britain," Gibbs Smith, 2005.
C. Y. Baldwin and K. B. Clark, "Design rules: The power of modularity," vol. 1, MIT Press, 2000.
Ching and C. Binggeli, "Interior design illustrated," John Wiley & Sons, 2018.
E. Classen, "Comfort testing of textiles," "In Advanced characterization and testing of textiles," pp. 59-69, Woodhead Publishing, 2018.
G. Benelli, C. L. Jeffries, and T. Walker, "Biological control of mosquito vectors: past, present, and future," "Insects," vol. 7, no. 4, p. 52, 2016.
G. S. Aldrete, S. M. Bartell, and A. Aldrete, "Reconstructing Ancient Linen Body Armor: Unraveling the Linothorax Mystery," JHU Press, 2013.
H. Conway and R. Roenisch, "Understanding architecture: an introduction to architecture and architectural history," Psychology Press, 2005.
H. Z. Özek, "Development of waterproof breathable coatings and laminates," In "Waterproof and water repellent textiles and clothing," pp. 25-72, Woodhead Publishing, 2018.
I. Locher and A. G. Sefar, "Joining technologies for smart textiles," "Multidisciplinary know-how for smart-textiles developers," pp. 285-305, 2013.
J. Bennett, O. Rokas, and L. Chen, "Healthcare in the smart home: A study of past, present and future," "Sustainability," vol. 9, no. 5, p. 840, 2017.
J. F. Pile, "A history of interior design," Laurence King Publishing, 2005.
J. Gehrke, V. Tenner, V. Lutz, D. Schmelzeisen, and T. Gries, "Smart textiles production: Overview of materials, sensor and production technologies for industrial smart textiles," "MDPI Books," p. 204, 2019.
K. Cherenack and L. Van Pieterson, "Smart textiles: Challenges and opportunities," "Journal of Applied Physics," vol. 112, no. 9, p. 091301, 2012.
K. Ching and C. Binggeli, "Interior design illustrated," John Wiley & Sons, 2018.
K. L. Fischer, "Compliance with pollution prevention and spill reporting requirements: A study of small businesses in Maine," Diss. University of Maine, 2001.
L. Berglin, "Smart textiles and wearable technology," Högskolan i Borås, 2013.
L. Van Langenhove, "Smart textiles for medicine and healthcare: materials, systems and applications," Elsevier, 2007.
M. Afshari, D. J. Sikkema, K. Lee, and M. Bogle, "High-performance fibers based on rigid and flexible polymers," "Polymer Reviews," vol. 48, no. 2, pp. 230-274, 2008.
M. Bussagli and M. Reiche, "Baroque & Rococo," Sterling Publishing Company, Inc., 2009.
M. Debboun and D. Strickman, "Insect repellents and associated personal protection for a reduction in human disease," "Medical and Veterinary Entomology," vol. 27, no. 1, pp. 1-9, 2013.
N. Nielson, "Interior textiles: Fabrics, application, and historic style," John Wiley & Sons, 2007.
P. Pandian and K. M. Ashifa, "Analysis and design of fire resistance cloth in fire works industries," "Materials Today: Proceedings," vol. 33, pp. 1032-1037, 2020.
R. A. Angelova, "Non-woven textiles in the indoor environment," InTech, Croatia, http://doi.org/10.5772/61324, 2016.
R. Bogue, "Smart materials: a review of capabilities and applications," "Assembly Automation," vol. 34, no. 1, pp. 16-22, 2014.
R. Riello, "Cotton: the fabric that made the modern world," Cambridge University Press, 2013.
S. M. Brzostowski, "Identification and characterization of a negative regulator of the cell cycle in Saccharomyces cerevisiae," Diss. University of Colorado at Boulder, 2002.
S. Mondal, "Introduction to smart textiles and their applications," In "Smart textiles and their applications," pp. 1-8, Woodhead Publishing, 2016.
S. Mondal, "Phase change materials for smart textiles–An overview," "Applied thermal engineering," vol.
S. Pandian and K. M. Ashifa, "Analysis and design of fire resistance cloth in fireworks industries," "Materials Today: Proceedings," vol. 33, pp. 1032-1037, 2020.
T. Altenburg, X. Chen, W. Lütkenhorst, C. Staritz, and L. Whitfield, "Exporting out of China or out of Africa? Automation versus relocation in the global clothing industry," "Discussion Paper," no. 1/2020.
T. Bucher,"Neither black nor box: Ways of knowing algorithms," "Innovative methods in media and communication research," pp. 81-98.

Correspondence concerning this article should be addressed to Amna Khalid, amnakhalid.dr@gmail.com

T. Das, A. Das, and R. Alagirusamy, "Testing and evaluation of functional textiles," In "Functional and Technical Textiles," pp. 757-778, 2023.
T. P. Campbell, "Tapestry in the Renaissance: art and magnificence," Metropolitan Museum of Art, 2002.
V. Koncar, "Introduction to smart textiles and their applications," In "Smart textiles and their applications," pp. 1-8, Woodhead Publishing, 2016.
Y. Adanur, "Handbook of weaving," CRC Press, 2020.
Y. Adanur, "Wellington Sears handbook of industrial textiles," Routledge, 2017.
Y. Fang, G. Chen, M. Bick, and J. Chen, "Smart textiles for personalized thermoregulation," in "Chemical Society Reviews," vol. 50, no. 17, pp. 9357-9374, 2021.

Correspondence concerning this article should be addressed to Amna Khalid, amnakhald.dr@gmail.com