

ERGONOMICS OF PRESCHOOL CLOTHING: AN ANALYSIS OF STAKEHOLDER CONCERNS AND DEMAND FOR WEARABLE TECHNOLOGY

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Keywords	Abstract
<i>Preschool clothing</i> <i>Ergonomics</i> <i>Functional</i> <i>Wearable</i> <i>technology</i>	<p>This study aims to identify ergonomic functional incompatibilities and safety vulnerabilities in children's clothing within preschool educational settings and to determine stakeholder (parents and educational staff) demand for wearable technology solutions that could address these problems. An exploratory sequential mixed-methods design was employed. In the first phase, themes were identified through a case study; in the second phase, these themes were tested via a survey administered to 126 parents and 22 educational staff members. Data were analyzed using the Mann–Whitney U test, Kruskal–Wallis H test, and Chi-square test.</p> <p>The findings indicate that educational staff reported significantly higher levels of concern than parents regarding ergonomic and safety-related issues requiring immediate intervention, such as “bedwetting,” “falling,” and “fever.” Consistent with these elevated concerns, both groups demonstrated a high level of acceptance toward a technology-supported clothing solution (88% of parents and 82% of staff), revealing a strong shared demand.</p> <p>In conclusion, stakeholders emphasized that existing clothing solutions are inadequate for the dynamic conditions of preschool environments and highlighted a clear need—particularly among educational staff—for proactive monitoring systems designed to reduce workload and enhance child safety.</p>

OKUL ÖNCESİ GİYİM ERGONOMİSİ: PAYDAŞ ENDİŞELERİ VE GİYİLEBİLİR TEKNOLOJİYE YÖNELİK TALEP ANALİZİ

Anahtar Kelimeler Öz

<i>Okul öncesi giyim</i> <i>Ergonomi</i> <i>Fonksiyonel</i> <i>Giyilebilir teknoloji</i>	<p>Bu çalışma, okul öncesi eğitim ortamlarında çocuk giysilerindeki ergonomik açıdan fonksiyonel uyumsuzlukları, güvenlik açıklarını tespit etmeyi ve bu problemlere çözüm olabilecek giyilebilir teknoloji ürünlerine yönelik paydaş (ebeveyn ve eğitim personeli) talebini ortaya koymayı amaçlamaktadır. Araştırmada, keşfedici ardışık karma yöntem deseni kullanılmış; ilk aşamada bir vaka çalışmasıyla keşfedilen temalar, ikinci aşamada 126 ebeveyn ve 22 eğitim personeline uygulanan anket ile test edilmiştir. Veri analizinde Mann-Whitney U, Kruskal-Wallis H ve Ki-Kare testleri kullanılmıştır.</p> <p>Araştırma bulguları, eğitim personelinin “alt ıslatma”, “düşme”, “ateşlenme” gibi anlık müdahale gerektiren ergonomik ve güvenliğe yönelik endişelerinin, istatistiksel olarak ebeveynlerden anlamlı derecede daha yüksek olduğunu göstermektedir. Bu yüksek endişeye paralel olarak, teknoloji destekli bir giysi çözümüne her iki grubun da yüksek oranda (%88 ebeveyn, %82 personel) olumlu yaklaştığı ve bu konuda güçlü bir ortak talep olduğu saptanmıştır.</p> <p>Sonuç olarak, paydaşlar mevcut giysilerin okul ortamının dinamik koşullarında yetersiz kaldığını ve özellikle eğitim personelinin iş yükünü hafifletecek proaktif takip sistemlerine belirgin bir ihtiyaç duyduğunu belirtmektedir.</p>
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1. Introduction

Early childhood is recognized a unique phase in the human life cycle where the most rapid developmental changes occur, laying the foundation for an individual's future cognitive, social, emotional, and physical competencies. High-quality education and care services provided during this period not only maximize children's learning potential but also play a key role in building a more equitable and sustainable society (OECD, 2021; UNICEF, 2019). With an awareness of this strategic importance, early childhood education (preschool) services in Türkiye have been structured under the responsibility of two ministries in accordance with children's age groups and developmental needs. The Ministry of Family and Social Services of the Republic of Türkiye (ASHB) provide services for children aged 0–66 months through crèches and day care centers, primarily delivering basic care, a safe environment, and exposure to early stimulation. In addition, it functions as a social infrastructure that supports working parents' participation in the labor force (ASHB, 2016). Conversely, the Ministry of National Education of the Republic of Türkiye (MEB) conducts a structured, program-based educational process with defined academic objectives for children aged 36–68 months through kindergartens and preschool classes, preparing them for primary education (MEB, 2023). This institutional framework aims to operationalize the principle of acting in the best interests of the child by providing a continuous support mechanism from birth until the commencement of compulsory education.

The preschool period is a critical stage of development during which children rapidly develop their physical, cognitive, and social skills, learning about the world through play and discovery. During this time, elements of the immediate environment, such as the clothing and furniture with which children interact daily, are fundamental ergonomic factors that influence their development beyond mere coverings or tools. Designs that do not adapt to children's constantly changing anthropometric structures and active nature pose significant problems (Bülbul et al., 2018). For example, improperly designed clothing can hinder the development of motor skills by restricting movement, impede self-care skills due to its difficult-to-wear-and-remove structure, and endanger physical health due to safety hazards. Similarly, inappropriate designs can negatively affect posture and the musculoskeletal system, paving the way for long-term health problems, as seen with the misuse of digital devices (Iqbal et al., 2021). Therefore, a product's ability to adjust and adapt to a child's developmental needs is a fundamental principle of ergonomic design (Thorat and More, 2019). Furthermore, fabric, pattern, sewing, and

embellishment features that determine clothing comfort are important parameters that reinforce this principle (Vural et al., 2006). In this context, designing children's clothing ergonomically is a priority issue.

Preschool educators are responsible for monitoring each child's physical and emotional well-being, in addition to planning and implementing pedagogically supportive activities within an institutional framework. However, completely fulfilling this responsibility in a dynamic classroom environment with an average of 20 children presents significant challenges. In large groups, instantly identifying each child's individual needs (e.g., sudden fever, falls, excessive sweating, toileting needs, or peer bullying) and intervening in a timely manner increases teachers' workload and stress levels. Indeed, systematic reviews on teacher well-being show that an increase in "non-teaching duties" and "high job demands" are among the most important determinants of burnout (Ng et al., 2023; Wahab et al., 2024). This situation highlights the cognitive and emotional strain educators experience when they are constantly alert in a school environment that exceeds the limits of human attention and capacity. Supported by observations and interviews, this situation increases educators' cognitive load, causing them to work in constant crisis management mode. This reduces the efficiency and quality of planned pedagogical activities. Failing to detect a health problem in time or neglecting a self-care need can have serious physical consequences for the child and pave the way for traumatic social experiences that negatively affect the child's attitude toward school and learning. Parents also share these concerns.

In recent years, rapid developments in the Internet of Things (IoT) and wearable technologies have led to revolutionary changes in sectors such as health, sports, elderly care, and industrial safety (Lu et al., 2020). Smart textiles have the capacity to continuously and passively collect users' physiological data and environmental interactions through miniature sensors (e.g., temperature, humidity, accelerometer, and GPS) integrated into the fabric structure (Juttila et al., 2015; Haar et al., 2013). This data can be transmitted to a central system or smart device via wireless communication protocols for analysis. Alerts can be sent to relevant individuals when an abnormal situation is detected. These technologies have a wide range of applications, from systems that detect falls in elderly individuals to smart shirts that analyze athletes' performance data. They present a significant opportunity to solve monitoring problems in preschool education (Saeedbakhsh et al., 2025; López Valencia, 2025). Technology-supported clothing that can instantly monitor children's body temperature, activity level, location, and wetness

status can assist educators by enabling proactive intervention. This increases child safety and reduces staff stress, allowing them to focus on educational quality (Jutila et al., 2015; Haar et al., 2013).

With the development of wearable technologies, the potential to proactively monitor children's health and safety has emerged. These products, known as "smart clothing," promise to provide parents and educators significant reassurance by tracking critical data such as fever, falls, and location. However, it is critically important that these technological innovations be designed with fundamental ergonomic needs in mind (Koca and Ok Zöhra, 2023). Technology should not overshadow a child's comfort, play, or freedom of movement. Therefore, innovative clothing solutions developed for preschoolers must be based primarily on real ergonomic issues and user concerns. Furthermore, the success of a technological product targeting a sensitive user group, such as children, depends not only on its technical capabilities. Parents and educational staff play an active role in product selection and purchasing decisions, so acceptance and adoption of a technological product depends on how well it aligns with their expectations, needs, and concerns. A solution under development may be rejected due to practical usage difficulties, such as short battery life or challenging maintenance processes, comfort issues, such as rigid sensors or skin-irritating materials, or aesthetic concerns. More importantly, any technological innovation must not compromise the fundamental safety standards established through years of experience in children's clothing. Standards such as TS EN 14682, which addresses the risk of strangulation from cords and drawstrings, and the TS EN 17394 series, which addresses the danger of swallowing small parts, are also necessary for technology-integrated clothing (Dirgar and Oral, 2020). Therefore, every step in this area should center on user-centered design principles, blending the possibilities offered by technology with the developmental needs of children, the practical expectations of stakeholders, and unwavering safety rules.

This research aims to identify ergonomic problems, safety hazards, and functional incompatibilities in children's clothing in preschool settings, as well as expectations regarding clothing from the perspectives of two key stakeholders: parents and educators. Additionally, the study aims to provide a valuable roadmap for academic literature and the sector by presenting data that establishes the need for user-centered and ergonomic designs in preschool children's clothing. The study also explores stakeholder approaches to technology-supported clothing that could provide solutions to these problems. In line with the study's general objective, the following questions were addressed.

1. What are the general views and preferences of parents and educational staff regarding the ergonomics of children's clothing in preschool settings?

2. What problems do staff and parents encounter in preschool education institutions regarding the monitoring of children's education and care activities, and which activities would they like to see monitored?

3. What are the views of preschool education staff and parents regarding technological clothing designed to monitor children?

2. Scientific Literature Review

In its most general definition, ergonomics is a scientific discipline that studies human interaction with the environment. It aims to increase human well-being and system performance by optimizing this interaction (Rice, 2008; Deng and Yang, 2012). Clothing that causes discomfort, restricts movement, or creates obstacles is one of the primary causes arising from poor body-garment fit (Koca et al., 2008). As an interdisciplinary field concerned with aligning products, systems, and environments with the needs, capabilities, and limitations of human users, the application of ergonomic principles is critically important when designing for children, particularly in supporting their physical, cognitive, and emotional development (Rice, 2008). Clothing ergonomics is a specialized subfield that extends these principles beyond aesthetics, aiming to maximize clothing's dynamic fit with the human body, functionality, and psychophysiological comfort (Koca and Kaya, 2016). It considers clothing on a living body that moves, changes, and performs different functions, not just on a static mannequin (Vural et al., 2006). Thus, clothing ergonomics involves the scientific combination of patterns, fabrics, and design details to protect the user's physical health, provide freedom of movement, and ensure comfort (Koca and Baran, 2018; Çağdaş and Bor, 2010).

Children cannot be considered "miniature adults"; they have unique anthropometric measurements, constantly changing physical abilities, and different cognitive perceptions. Consequently, products designed for children must address their specific needs and promote healthy development (Deng & Yang, 2012). Studies on preschool furniture have shown that poorly designed desks and chairs can lead to poor posture and hinder children's learning processes (Paschoarelli and da Silva, 2000; Wise and Wise, 1991). Ergonomic principles are equally important, if not more so, for clothing, an indispensable part of children's daily lives. Designing functional children's clothing requires a multifaceted approach that considers comfort, safety, health, cognitive development, and aesthetics (Santiago et

al., 2024). Therefore, achieving a balance between functionality and aesthetics is crucial in the design process of children's clothing (Koca and Koç, 2008).

However, existing literature points to common ergonomic problems in preschool clothing. Chief among these are the frequent anthropometric mismatches between clothing and standard sizing systems due to children's rapid growth and constant changes in body proportions (Bezerra et al., 2017). Tight patterns, inappropriate sleeve and leg lengths, and inflexible fabrics can restrict active play, during which children demonstrate basic motor skills such as running, jumping, and climbing. This not only causes physical discomfort, but it can also negatively affect children's freedom of movement and motor skill development (Park & Nam, 2009; Santiago et al., 2024). In addition to restricting movement, certain clothing design details can pose serious safety problems. In play areas of preschool settings, for example, drawstrings on jackets, large buttons, and loose accessories can get caught on play equipment and pose a strangulation hazard (Brickman, 2001). Incorrect material selection or stiff labels can also irritate and cause allergic reactions on children's sensitive skin (Dogbey et al., 2015). Beyond physical safety and comfort, clothing functionality also plays a critical role in children's development. Difficulties putting on and taking off clothing can hinder the development of self-care skills, such as dressing and undressing independently, during the preschool years. Complex zippers, small buttons, and tight necklines can impede children's progress in becoming independent and cause frustration (Bhandari, 2021; Bezerra et al., 2017). This is especially true for children with sensory sensitivities or motor skill difficulties, such as those with autism spectrum disorder (ASD). This highlights the need for adaptive clothing designed specifically for this group (Baizhanova and Madiyeva, 2024).

In response to the multifaceted ergonomic and safety challenges posed by traditional clothing, wearable technologies developed in recent years offer innovative solutions. The Internet of Things (IoT) and wearable technologies provide revolutionary opportunities to monitor children's safety and health (Saeedbakhsh et al., 2025). Wearable sensors can monitor children's physical activity, location, posture, and vital signs (Jutilla et al., 2015; Haar et al., 2013). For instance, smart clothing has been developed to reduce the risk of sudden infant death syndrome (SIDS) by tracking infants' body positions, and the effectiveness of these technologies has been demonstrated (Greenspan et al., 2021). Similarly, applications of wearable technology designed to track children's motor development, measure their temperature, or ensure their safety in school environments are becoming increasingly attractive to researchers and parents alike (López Valencia,

2025; Kara and Cagiltay, 2023). These technologies emphasize clothing's potential to evolve beyond its traditional protective and covering functions, becoming proactive safety and health monitoring tools.

Current literature details the ergonomic and safety problems of children's clothing, such as incompatibility, restricted movement, and hazardous design elements. It also demonstrates the potential of wearable technologies to monitor children's safety and health. However, there is a clear gap in studies combining these two areas: systematically identifying ergonomic problems arising from clothing and directly assessing demand from stakeholders, such as parents and educators, for wearable technology solutions to these problems. Existing studies generally define the problem or offer a technological solution but do not directly analyze the need for the solution or user expectations. This study aims to fill this gap precisely. First, the research aims to reveal ergonomic problems, safety issues, and functional incompatibilities arising from children's clothing in preschool environments using an exploratory approach. Second, it aims to quantitatively analyze the concerns and demands of key stakeholders, such as parents and educational staff, regarding wearable technology concepts that could solve these identified problems. These findings will establish a user-centered, needs-based knowledge base to guide future design processes.

3. Clothing Ergonomics in the Preschool Period

The preschool period, which spans from approximately age two to six, is considered a critical stage of development when the brain grows fast and fundamental skills are acquired. Development during this period is examined in three main interacting areas: physical-motor, cognitive, and socio-emotional development. Physical motor development includes gross motor skills, such as running and jumping, as well as fine motor skills, such as buttoning a shirt and holding a pencil. These skills form the basis for exploring the environment and gaining independence. Cognitive development includes problem-solving, language acquisition, memory, and symbolic thinking. During this period, children begin to make sense of the world and establish logical connections. Socioemotional development involves recognizing and managing emotions, developing empathy, forming relationships with peers, and learning social rules.

According to Erikson (1963), the "initiative versus guilt" stage plays a critical role in the development of a child's autonomy and self-confidence during this period. However, ergonomic principles developed for adults cannot be directly applied to children due to their constantly changing anthropometric

measurements, motor skills, and cognitive perceptions (Koca, 2007).

Child ergonomics focuses on adapting product, environmental, and system designs to children's developmental characteristics, needs, and abilities (Rice, 2008; Paschoarelli and da Silva, 2000; Deng and Yang, 2012). In this context, children's clothing is the environment with which they interact most throughout the day. The ergonomic design of clothing encompasses three components: physical, cognitive, and organizational ergonomics.

Physical ergonomics: The clothing must fit the child's body measurements (anthropometry) without restricting movement (biomechanics) and ensure physiological comfort (e.g., sweating and balanced heat). A fundamental requirement of physical ergonomics is allowing the child complete freedom of movement during typical preschool activities, such as running, jumping, and climbing. Preschool children have faster metabolisms than adults, a higher body surface area-to-volume ratio, and thermoregulation systems that are not yet fully developed. Therefore, they sweat and lose heat more easily (Yuan and Ryu, 2022). This necessitates that their clothing be made from breathable fabrics that wick moisture away from the body and provide seasonally appropriate insulation. These properties determine the clothing's thermophysiological comfort level. Furthermore, for a rapidly growing and constantly moving child, clothing must be flexible and unrestrictive to ensure healthy gross motor skill development and proper body-to-clothing fit.

Cognitive Ergonomics: Clothing must be designed so that children can easily put them on and take them off by themselves. Details such as button size and zipper ease must be compatible with the child's mental development and motor skills. This compatibility directly affects the child's sense of autonomy and achievement. Design features such as elastic waistbands, large buttons, and Velcro fasteners allow children to develop their fine motor skills and gain self-confidence by experiencing the feeling of "I can do it myself." Complex clothing that requires assistance, on the other hand, can lead to frustration and dependence on adults.

Organizational Ergonomics: This concept refers to the clothing's interactions within the "system" in which it is used. In the context of preschool education, this system includes children, parents, educational staff, and the policies, processes, and cultures with which they interact (Rice, 2008; Koca and Kaya, 2016; Santiago et al., 2024). In a school setting, this means that the clothing must be compatible with home processes (ease of care by parents) and school processes (practical use by educational staff). Examples include stain-resistant,

quick-drying fabric and an easily visible name tag area. Thus, the organizational ergonomics of a clothing concern not only the child's physical comfort, but also its effect on the roles, workloads, and communication of other stakeholders in the system, such as parents and educators.

Due to their curious nature and underdeveloped perception of risk, children require products that meet the highest safety standards. Cords, buttons, accessories, and other small components in children's clothing can pose life-threatening risks, such as strangulation, entanglement, and ingestion (Dirgar and Oral, 2020). Standards have been developed at the national and international levels to minimize these risks. The TS EN 14682 standard, which has been adopted in Turkey, aims to prevent entanglement and strangulation risks by imposing strict rules on the use, length, and design of cords and drawstrings in children's clothing, differentiated by age group and body area. The TS EN 17394 standard series, currently in effect, aims to prevent swallowing and strangulation hazard by defining the minimum resistance that small clothing components, such as buttons, snaps, and sequins, must exhibit against detachment and by establishing test methods for this. Any innovative clothing technology must prioritize these basic mechanical safety standards.

In Turkey, the activities of preschool institutions are regulated by the ASHB's "Regulation on Private Nurseries and Day Care Centers" or the MEB's "Regulation on Preschool Education and Primary Education Institutions," depending on their purpose of establishment. Both regulations set standards covering a wide range of areas, including the institutions' physical conditions, staff qualifications, education programs, and child safety. This legal framework imposes a duty of supervision on administrators and staff to protect children from dangers while they are at the institution. This obligation includes taking precautions against physical dangers and monitoring children's health and general well-being. Therefore, tools and technologies that facilitate monitoring children in educational institutions and help staff fulfill this legal responsibility are not only practical necessities, but also institutional responsibilities.

Wearable technologies are electronic devices that can be worn on the body or attached as an accessory. They typically have the ability to collect, process, and transmit data via sensors (Ismar et al., 2020; Haar et al., 2013). Wearable electronics developed for children usually focus on functions such as health monitoring (temperature and heart rate), safety (GPS location tracking and fall detection), and activity tracking. However, a technology's success depends not only on its technical capabilities, but also on its acceptance by end users. According to the Technology Acceptance Model (TAM), acceptance of

technology fundamentally depends on "perceived usefulness" and "perceived ease of use" (Davis, 1989). This research focuses on the "perceived usefulness" of wearable technology for parents and educational staff. This usefulness is directly related to the extent to which technology provides solutions to existing ergonomic problems and safety concerns. "Perceived ease of use," on the other hand, is shaped by practical expectations, such as the product's battery life, durability, and ease of maintenance. Therefore, understanding the current concerns and practical expectations of stakeholders is a prerequisite for designing an acceptable and successful smart clothing. This study aims to provide a user-centered understanding of wearable technology solutions for the preschool period by exploring these two fundamental factors.

4. Method and Study Group

In this study, an exploratory sequential design—one of the mixed-methods research approaches—was employed to gain an in-depth understanding of the ergonomic problems and safety vulnerabilities arising from the clothing of children attending preschool education, as well as the concerns of stakeholders (parents and educational staff), and to assess the demand for wearable technology solutions aimed at addressing these issues (Figure 1).

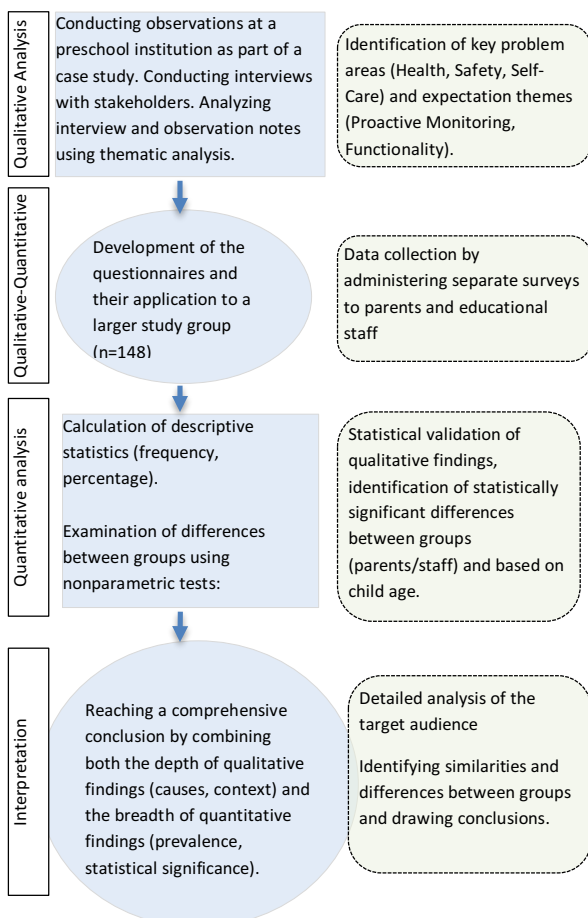


Figure 1. Adapted from Creswell and Plano Clark (2018).

This design, as defined by Creswell and Plano Clark (2018), provides an ideal framework for investigating topics for which sufficient theory or measurement tools do not yet exist. The exploratory sequential design employs a sequential timing approach, giving priority to qualitative data collection and analysis in the initial phase. It involves an initial phase of qualitative data collection and analysis, followed by the development and implementation of a quantitative instrument based on these findings, and finally, the interpretation of results from both phases. The design follows a two-stage structure: it begins with the collection and analysis of qualitative data, which then informs the creation of a quantitative data collection tool that is applied to a larger sample.

The first, qualitative phase of the study was conducted specifically as a case study based on a holistic single-case design (Yin, 2018). This approach focuses on "how?" and "why?" questions, aiming to gain an in-depth understanding of a phenomenon within its real-life context. Accordingly, a specific preschool institution is treated as a holistic "case" within its own context. The main reason for selecting a case study design at this stage was to "explore" the research problem in its natural setting from a comprehensive perspective—using multiple data sources such as observations and interviews—and to develop hypotheses and measurement variables for the subsequent quantitative phase.

In the second, quantitative phase of the study, a survey developed based on the qualitative findings was administered to a larger sample of 148 participants using a descriptive and relational screening model. This approach allows the newly developed measurement instrument to be tested quantitatively on a broader sample, and for the quantitative results to be interpreted in relation to the initial qualitative findings. Because the quantitative results are grounded in participants' original qualitative perspectives, this structure provides a clearer understanding of the phenomena (Creswell & Plano Clark, 2018). Thus, the prevalence of themes identified through the case study can be measured, and differences between groups are statistically tested.

Following the administration of the survey to the 148-participant study group, the collected quantitative data were analyzed using descriptive and comparative statistical tests, including the Mann-Whitney U, Kruskal-Wallis H, and Chi-square tests (Büyüköztürk, 2024). In the final stage, findings from both methods were integrated to reach the overall interpretations. This integrated structure combines the contextual depth provided by

qualitative data with the statistical generalizability offered by quantitative data, enabling a comprehensive understanding of the research problem.

The study group consisted of parents and educational staff from a private preschool in the Merzifon district center in Amasya, Turkey. The study group was determined using the purposive sampling method, which is frequently used in qualitative research designs. Considering the exploratory nature of the research and practical limitations, the researchers opted for convenience sampling, which involves collecting data from easily accessible units (Yağar and Dökme, 2018). [AP12.1] This method enables researchers to include participants with extensive knowledge of the phenomenon under investigation who are accessible and willing to participate in the study. A total of 148 people participated in the quantitative phase of the study, which was completed in 2024. This included 126 parents and all 22 educational staff members working at the institution. In line with the research design, the data collection process was carried out in two stages, allowing for comprehensive data collection from both quantitative and qualitative sources.

Qualitative Data Collection: In the first stage, an unstructured interview form and observation technique were used to collect exploratory data. The interview form, developed by the researchers, included open-ended questions for parents (40) and educational staff (22), such as "difficulties experienced with children's clothing at school," "expectations of ideal preschool clothing," and "approach to technological solutions." Observations were conducted to identify clothing use and clothing-related problems during playtime, mealtimes, and classroom activities in the children's natural environment.

Quantitative Data Collection: In the second phase, a questionnaire was developed based on themes that emerged from the qualitative analysis (e.g., health monitoring, safety, practicality, and comfort). The questionnaire included demographic information, clothing preferences, and 5-point Likert-type items measuring anxiety levels (1 = I am not anxious at all, 5 = I am very anxious). It also included multiple-choice questions to determine opinions on technological features. The survey form was submitted to field experts for review to ensure content validity, and it was tested for comprehensibility by applying it to a pilot group. The survey was administered online to parents and in person to educational staff through the school administration to collect data. We analyzed the collected qualitative and quantitative data using different statistical techniques.

For the qualitative data analysis, observation notes and interviews were analyzed using thematic analysis. First, the data were coded. Then, these codes were grouped together to form categories and main themes (problems and concerns). To ensure the reliability of the research, a different researcher reviewed the coding to assess inter-coder agreement. The quantitative data, collected through the questionnaire, were analyzed using the SPSS (Statistical Package for the Social Sciences) 26.0 program. Since the data did not show normal distribution, nonparametric tests were used for the analyses.

- The Mann-Whitney U Test was used to compare the ordered data of two independent groups (parents and educational staff), such as anxiety levels measured on a 5-point Likert scale. This test evaluates whether the distribution of scores between the two groups is statistically different by comparing their mean ranks.
- To compare the ordinal data of more than two independent groups, such as the 3-4-year-old, 4-5-year-old, and 5-6-year-old groups, the Kruskal-Wallis H Test was applied. This test examines whether the distribution of at least one group differs from the others; when a significant difference is found, the results of pairwise comparisons with Bonferroni correction are examined to determine between which groups this difference exists.
- To determine whether there is a significant relationship between the proportions of "Yes/No" responses given to categorical variables such as groups' clothing preferences, the Chi-Square (Chi-Square) Independence Test was used. This test analyzes whether there is a significant difference between observed frequencies and expected frequencies. When the assumptions of the Chi-Square test were not met (more than 20% of the cells in the table had an expected value less than 5), the results of Fisher's Exact Test, which provides more reliable results, were interpreted. To examine the effect of the "Group" and "Age" variables on each other, the analyses were repeated separately for each subgroup.

5. Results

During the initial qualitative phase of the study, observations made at preschool and unstructured interviews with stakeholders (parents and educational staff) revealed key problem areas related to children's clothing. These areas could serve as the basis for solutions to the problems. The data obtained through content analysis were grouped under three main themes and corresponding expectations, as summarized in Table 1.

These qualitative findings demonstrate that child monitoring problems are multidimensional,

presenting significant challenges for children and educational staff. The data obtained from the content

analysis are grouped under three main problem themes and three corresponding expectations.

Table 1. Thematic Analysis of Observation and Interview Findings

<i>Raw Statement from Observation/Interview (Ok Zöhra, 2025)</i>	<i>Interpretation</i>	<i>Emerging Problem / Expectation</i>
1. <i>Challenges in Health Monitoring: "There are 20 children in the classroom, and it's impossible to attend to all of them at once. Noticing a child with a fever before it's too late is difficult, and it increases my anxiety level."</i>	<i>Monitoring physical health indicators in crowded classrooms is entirely dependent on the staff's immediate attention. This situation carries the risk of overlooking issues and delays in intervention.</i>	<i>Problem: Delays in detecting physiological changes (body temperature, sudden drops) that require immediate intervention. Expectation: Proactive wearable technology that instantly and objectively alerts responsible personnel to critical changes in the child's health.</i>
2. <i>Self-Care and Hygiene Issues: "When a child who is engrossed in play wets themselves, delayed detection of this situation can lead to the child catching a cold and becoming the subject of ridicule among their peers."</i>	<i>The time difference between wetting and intervention creates both physical (illness) and social/emotional (shame, exclusion) risks for the child.</i>	<i>Problem: Failure to detect bedwetting in a timely manner. Expectation: A system that instantly detects wetness and sends a discreet alert to responsible personnel.</i>
3. <i>Staff Workload and Education Quality: "Attempting to find immediate solutions to each child's individual problems can disrupt and fragment planned educational activities."</i>	<i>The cognitive load of educational staff is constantly divided between group education and individual needs. This situation reduces the effectiveness of education.</i>	<i>Problem: Situations requiring individual monitoring reduce the integrity and quality of education. Expectation: A tool that automates monitoring tasks, allowing staff to focus their energy on providing quality education.</i>
4. <i>Functionality of Clothing and Independence: "Children are expected to use the toilet independently and dress and undress themselves, but some clothing is not suitable for this."</i>	<i>When current clothing designs are not compatible with the child's motor skills, they hinder self-sufficiency and the feeling of independence.</i>	<i>Problem: Clothing that does not support the child's development of autonomy. Expectation: Functional clothing designs that the child can easily use and that support their independence.</i>
5. <i>Physical Ergonomics and Comfort: "A sweating child should be noticed immediately, and clothing should be designed to prevent sweating. Children should be able to move comfortably."</i>	<i>Thermal comfort (chill/sweat) is a critical factor for both the child's health and motivation to participate in activities.</i>	<i>Problem: Clothing disrupting the child's body temperature balance and this not being noticed in time. Expectation: Clothing made from highly breathable, flexible fabrics that do not restrict movement.</i>
6. <i>Safety and Location Tracking: "Our greatest fear is losing sight of a child due to distraction for even a moment while in the garden or on an outing."</i>	<i>It is difficult to know where all children are at any given moment in crowded and open areas. These checks are time-consuming and prone to error.</i>	<i>Problem: The risk of the child leaving the designated safe area or getting lost in a crowd. Expectation: A tracking system that indicates the child's location within the school boundaries and alerts when they leave the area.</i>

Key Problem Areas:

- Health and Physiological problems: Participants indicated that significant problems include children "sweating and getting cold" or "running a fever" during the day without being noticed immediately.
- Safety problems: Safety problems, such as children frequently falling in the dynamic school environment and wandering off by disappearing from sight in playgrounds or at school entrances and exits, were highlighted as major concerns.
- Self-Care and Implementation Difficulties: The management of self-care-related accidents, such as bedwetting, especially in younger age groups, as well as the inability to easily put on and take off clothing, which hinders a child's independence, were expressed as implementation difficulties by both parents and educators.

Key Expectation Areas:

- Proactive Health Monitoring: Stakeholders indicated a need for clothing solutions that can instantly detect and alert them to physiological changes, such as fever or sweating. This would enable proactive measures against illness.
- Enhanced location and movement safety: There is a strong demand for technologies that report a child's location within school boundaries, detect sudden movements such as falls, and provide alerts in cases of prolonged immobility.
- Functionality and Supporting Independence: There is a common expectation that any clothing developed will have basic ergonomic features, such as flexibility and easy-to-open fasteners, to support the child's comfort, freedom of movement, and ability to dress and undress independently.

Qualitative findings show that parents and educational staff have multifaceted concerns about children's clothing, including comfort, aesthetics, health, safety, and the efficiency of educational

processes. These themes reveal that clothing is perceived as more than just a product; it is an ergonomic element that directly affects the functioning of the school ecosystem. The exploratory findings formed the basis for shaping the questions and hypotheses of the quantitative survey, which was the second phase of the research. Focusing on areas of concern from the qualitative findings allowed us to statistically examine the reflections of these concerns in a broader sample and the differences in opinion among stakeholder groups. This formed the basis for shaping the questions and hypotheses of the quantitative survey, which was the second phase of the research.

The demographic characteristics of the participants are important for interpreting the research findings. Examining the age distribution of the parent participants reveals that the majority (52.4%) are in the 26-33 age range, followed by 34-41 (38.9%). In terms of educational level, 67% of parents are college graduates, indicating a high overall educational level of the sample. Regarding family structure, 61.1% of parents reported having two children, and 93.7% had a child enrolled in preschool. Furthermore, the gender distribution of the children included in the study is balanced, with 50% girls and 50% boys, which reduces the likelihood that the findings are influenced by gender.

The demographic profile of the educational staff is similar to that of the parents in many respects. Half of the staff (50%) are aged 26–33, followed by those aged 34–41 (36.4%). Half of the participants are classroom teachers, and the other half are support staff. Examining the staff's professional experience, the majority have 0-3 years (31.8%) or 10+ years (27.3%) of experience, reflecting the perspectives of new and experienced staff in the research data. Regarding working conditions, it was found that all staff worked more than six hours per day, and the majority of the classes they were responsible for had between 16 and 20 students (72.7%), while 27% had 21 or more students. These results demonstrate that staff members are in close contact with children throughout the day and that their observations are based on substantial experience. Of the 148 study participants, 126 (85.1%) were parents, and 22 (14.9%) were educational staff. The balanced distribution of participants according to the age groups of the children they are responsible for provides a suitable basis for comparing expectations for different age groups: 3-4 years old (28.4%), 4-5 years old (35.8%), and 5-6 years old (35.8%). Table 2 shows the distribution of participants according to the age groups of the children for whom they are responsible.

Table 2. Distribution of Children for Whom Participants Are Responsible by Age Group

Age group	Parent (n=126)	Education personnel (n=22)	Total (n=148)
	Number (n)	Number (n)	Percent (%)
Ages 3-4	36	6	28.6
Ages 4-5	45	8	35.7
Ages 5-6	45	8	35.7
Total	126	22	100.0

When examining the types of clothing that participants prefer for children in a school environment, "comfortable sportswear" stood out as the preferred clothing type for both parents (96%) and staff (100%). When asked to rank their priorities regarding clothing features, the top three priorities remained unchanged for both groups. The participants' preferences for types of clothing for children in the school environment were analyzed using the chi-square test, and the results are presented in Table 3.

Table 3. Comparison of Parents' and Educators' Clothing Type Preferences

Clothing type	Parent (%)	Education professional (%)	X ² value	Significance (p)
	Casual-sportswear	96.0	100.0	0.904
Everyday clothing	36.5	9.1	6.425	.011
Special clothing	6.3	0.0	1.477	.224

Note: Participants were allowed to select more than one option. The Chi-Square test was used for significance (p < .05).

According to Table 3, "casual sportswear" is the preferred clothing type for the vast majority of both groups, and there is no statistically significant difference between the groups in this regard (p = .342). However, a significant difference was found between the groups regarding "everyday clothing" (p = .011). While 36.5% of parents indicated a preference for everyday clothing, only 9.1% of education staff did so. This suggests that educators view casual sportswear as a uniform, while parents expect clothing to be worn not only at school, but also for daily activities, such as going home or visiting the park. Educators, on the other hand, focus more on the practical needs of the school environment. "Special clothing" is the least preferred option for both groups.

The prevalence of the main areas of concern identified in the qualitative analysis among the parent and education staff groups, as well as how these concerns differ according to age group, were examined. Differences in levels of concern between the two groups were analyzed using the Mann-Whitney U test, both generally and for each age group specifically. The results of the general comparison are presented in Table 4.

The findings in Table 4 show that the anxiety levels of educational staff are systematically higher than

those of parents. This difference is statistically significant, particularly in areas requiring immediate intervention, such as “bedwetting,” “falls,” “fever,” and “dropping out of school.”

Table 4. General Comparison of Parents' and Educators' Levels of Anxiety

Matter of anxiety	Parent avg. rank	Education personnel avg. rank	Significance (p)
Bedwetting	68.74	107.50	<.001*
Falls	71.02	94.41	.015*
Fever	70.94	94.86	.012*
Entering leaving school (departure)	70.91	95.05	.010*
Prolonged immobility	71.82	89.86	.057
Sweating and catching a cold	74.21	76.14	.841
Irritability, excessive stress, etc.	73.54	80.02	.500

Note: The Mann-Whitney U test was used for significance ($p < .05$).

Interaction analyses conducted to examine how these differences vary across age groups provide more detailed results. In the 3-4 age group: The educational staff's anxiety is significantly higher than that of parents regarding “fever” ($p = .003$) and “dropping out of school” ($p = .042$).

- In the 4-5 age group: Differentiation focuses on “bedwetting” ($p = .008$), ‘fever’ ($p < .001$), and “falls” ($p = .047$).

- In the 5-6 age group: Staff concern is significantly higher regarding “fever” ($p < .001$), “bedwetting” ($p = .006$), ‘falls’ ($p = .018$), and “prolonged immobility” ($p = .025$).

This interaction analysis shows that the concerns of educational staff differ according to age group. For example, while the concern about “dropping out of school” is a critical issue for staff in the youngest age group, this difference disappears as age increases. Conversely, the concern about “prolonged inactivity” emerges as a significant difference in the oldest age group.

When all participants' responses were evaluated together, the Kruskal-Wallis H Test was used to examine whether there was a general difference in concerns between age groups. The results showed significant differences between age groups in the areas of “child sweating and getting cold” ($p = .039$) and “dropping out of school” ($p = .026$). Paired comparison analyses revealed that the anxiety about “sweating and catching a cold” was significantly higher in the 4-5 age group compared to the 3-4 age group ($p = .037$). The “school avoidance” anxiety was found to be significantly higher in the 5-6 age group compared to the 3-4 age group ($p = .045$).

To measure the acceptability of a technological solution for these identified areas of concern, participants were asked, “Would you like to see the design of clothing that would enable those responsible to sense and intervene when situations that cause you concern arise?” The distribution of responses to this question is presented in Figure 2.

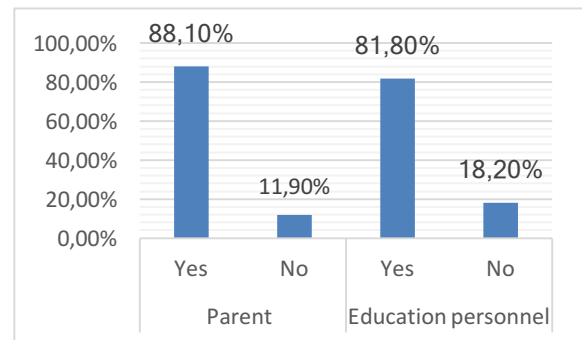


Figure 2. Rates of Technology-Supported Clothing Demand Among Parents and Education Personnel

As shown in Figure 2, most parents (88.1%) and educational staff (81.8%) have a positive attitude toward technology-supported clothing solutions. A Chi-Square test showed that there was no statistically significant difference in the high acceptance rates of technological solutions between the two groups ($\chi^2 = 0.660$, $p = .417$). This quantitative finding confirms the strength of the need identified in the qualitative analysis and the strong, shared demand for technological solutions to the identified ergonomic problems.

6. Discussion and Conclusion

This case study highlights ergonomic problems and safety issues arising from children's clothing in preschool settings, as well as the demand among stakeholders for wearable technology products that could solve these problems. The main findings show that parents and educational staff have common and divergent concerns stemming from their different roles.

First, both stakeholder groups prioritize ergonomic concerns in children's clothing. Participants ranked “comfort,” “independent dressing,” and “safety” features as the most important, emphasizing the role of clothing as a tool for play and learning in child development. These findings align with fundamental principles in child ergonomics literature stating that clothing should support children's motor skills (physical ergonomics) and sense of autonomy (cognitive ergonomics) (Santiago et al., 2024; Rice, 2008).

One of the most striking findings is the difference in the intensity and nature of concerns about monitoring children between parents and educational staff. As shown in Table 4, educational

staff are statistically significantly more concerned about issues requiring immediate intervention, such as "wetting," "falling," "fever," and "leaving school." This reflects the fact that they directly face problems and bear responsibility during the day. This finding demonstrates that clothing ergonomics affects not only the child, but also the caregiver (i.e., the educator). The high level of concern experienced by staff can be interpreted as an ergonomic mismatch that increases the workload and renders traditional monitoring methods inadequate. Furthermore, considering the age factor, it appears that staff perceive "the child's problem of going outside of school" as more critical at younger ages; this is evidenced by a significant difference in anxiety levels in the youngest age group (3-4 years). These findings highlight the potential of wearable technologies to serve as an early warning system, detecting not only obvious events (e.g., falls), but also abnormal changes in activity levels (Jutilla et al., 2015; Haar et al., 2013).

The third key finding of the study is the high demand among stakeholders for a technology-supported clothing solution to address the identified ergonomic problems. Most participants (88% of parents and 82% of staff) responded positively to this idea, indicating a clear need for innovative solutions. However, this acceptance is not unconditional. Considering the participants' concerns, the solution must pose no risk to safety. Therefore, the basic mechanical safety rules for children's clothing (e.g., cord safety and small parts risk) cannot be compromised for technological benefits. Full compliance with existing international standards, such as the TS EN 14682 and TS EN 17394 series, is a prerequisite for market acceptance of every product developed (Dirgar and Oral, 2020).

In conclusion, the physiological and positional monitoring of children in preschool education has been revealed to be a significant concern for parents and educational staff. Existing clothing is insufficient in addressing these concerns. Stakeholders are highly interested in wearable technology solutions that proactively monitor children's health and safety, reduce potential ergonomic problems, lighten staff's operational load, and provide parents with reassurance. This study shows that the smart clothing market for preschoolers is an important opportunity area that responds to deep social and ergonomic needs, as well as an area of technological innovation.

7. Suggestions

Based on the results obtained, the following recommendations have been developed for researchers and industry professionals:

- For textile and technology companies: When developing smart clothing products for preschool

children, place user concerns and ergonomic requirements (safety, comfort, practicality, and independence) at the center of the design process.

- For product development processes: Prototype testing and usability studies should be conducted in collaboration with parents and educational staff to measure product performance in real-life scenarios.

- This research is limited to a single case. The generalizability of the findings can be increased by conducting similar studies in public and private schools at different socioeconomic levels.

- Ergonomics studies designed within ethical guidelines can examine children's opinions, reactions, and perceptions of comfort regarding technology-assisted clothing.

- Special case studies can be designed to investigate the potential of wearable technologies for monitoring children with special needs, such as autism spectrum disorder or diabetes.

Conflict of Interest

No conflict of interest was declared by the authors.

Ethics

Ethical approval for this research was obtained from the Ankara Hacı Bayram Veli University Ethics Commission (Date:16.02.2023, Decision No:165138)

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