

## Comfort and functionality of workwear from the perspective of medical staff and patients

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### Original scientific paper\*\*

*The article examines the selection of fibers and fabrics used in the production of medical workwear, along with an assessment of its comfort and functionality from the perspective of both medical staff and patients. It presents the fundamental properties of three types of 100% cotton fabrics, originating from Israeli, Egyptian, and Greek cotton. These fabrics are used to produce men's and women's uniforms and surgical coats. A survey was conducted with 100 participants, comprising 50 healthcare workers and 50 patients. The respondents were divided into two groups, with equal representation of men and women across different age groups and educational backgrounds. Key findings from the survey include the following: a relationship was identified between the external appearance of healthcare workers and patients' perception of their professional competence (64%). Additionally, 84% of healthcare workers fully agreed that clothing plays a significant role in shaping their professional image. Regarding comfort, 45% of patients believe that the thermo-physiological properties of workwear are linked to the quality of services provided, a sentiment shared by 44% of healthcare workers. Moreover, all respondents (100%) acknowledged that uncomfortable clothing could negatively affect the performance of healthcare workers. Finally, every participant confirmed that fabric choice influences the thermo-physiological comfort of medical workwear.*

**Keywords:** cotton fabrics; medical clothing; a survey; medical staff; patients

### Izvorni znanstveni rad\*\*

U radu je istražen odabir vlakana i tkanina korištenih u proizvodnji medicinske radne odjeće, zajedno s procjenom njezine udobnosti i funkcionalnosti iz perspektive medicinskog osoblja i pacijenata. Predstavljene su temeljne karakteristike triju 100% pamučnih tkanina, proizvedenih od izraelskog, egipatskog i grčkog pamuka. Ove se tkanine koriste za izradu muških i ženskih uniformi i kirurških kuta. Provedeno je istraživanje na uzorku od 100 sudionika, od kojih je 50 zdravstvenih radnika i 50 pacijenata. Ispitanici su bili podijeljeni u dvije skupine, s jednakom zastupljenošću muškaraca i žena različitih dobnih skupina i obrazovnih razina. Ključni nalazi istraživanja uključuju sljedeće: utvrđena je povezanost između vanjskog izgleda zdravstvenih radnika i percepcije pacijenata o njihovoj profesionalnoj kompetenciji (64%). Nadalje, 84% zdravstvenih radnika u potpunosti se složilo da odjeća ima značajnu ulogu u oblikovanju njihovog profesionalnog imidža. Što se tiče udobnosti, 45% pacijenata smatra da su termo-fiziološka svojstva radne odjeće povezana s kvalitetom pruženih usluga, što dijeli i 44% zdravstvenih radnika. Osim toga, svi ispitanici (100%) priznali su da neudobna odjeća može negativno utjecati na rad zdravstvenih radnika. Na kraju, svaki sudionik istraživanja potvrdio je da izbor tkanine utječe na termo-fiziološku udobnost medicinske radne odjeće.

**Ključne riječi:** pamučne tkanine; medicinska odjeća; anketa; medicinsko osoblje; pacijenti

## 1. Introduction

Textile materials are increasingly used in all fields of medicine. In addition to being used for the production of protective clothing, textile materials in the form of fibers, fabrics, knits, and recently also non-woven textiles, can be used for the production of implants, blood filters or surgical bandages [1, 2].

Medical textiles or Medtech is one of the more important fields of technical textiles, representing structures designed and manufactured for medical applications. The number of applications is diverse, from thread for suturing wounds to complex composite structures such as bone replacement structures or artificial organs, e.g. skin, lungs, etc. [3, 4].

Medical textiles are among the fastest growing areas of textiles in the world, no other consumer goods are as widely distributed and widely used in hospitals as textiles [5, 6]. Medical protective clothing is adapted to the work environment and the environment in which the wearer moves. Usually such garments are comfortably tailored, with many pockets, flexible sleeves and a different way of dressing. People in work clothes are perceived differently than people in civilian clothes, which causes positive or negative emotions in the population [7-9].

The aim of this study is to select and propose a suitable fabric for the new protective workwear of the medical staff, which meets the requirements of the intended standard and is based, mainly, on the survey data and important properties of fibers and fabrics. The focus is on the selection of the most suitable fabrics and the analysis of models for medical staff clothing (uniforms), where, in addition to the fabric (raw material composition), the color and cut of the uniform are also important, all of which together contribute to the credibility of the health worker, and ultimately affect the opinion of patients about the professional skills of healthcare workers. A survey of medical protective clothing users and patients was conducted, and based on this, an analysis of the condition of the clothing used by medical personnel was performed.

## 2. Experimental

The research was organized in the textile factory Yumco in Vranje, Serbia, using the resources that this factory offers: fibers, yarns, fabrics, up to the final product – medical clothing. It started from 3 types of cotton fiber, Israeli, Egyptian and Greek origin.

The fiber characterization was performed according to the next standards:

SRPS F.S2.211:1963 - *Determination of length of textile fibres by measuring single fibers*;

SRPS F.S2.212:1963 - *Determination the linear density of textile fibres*;

SRPS F.A0.013:1977 - *Fibres and yarns - Terms and definitions*; and

SRPS F.S2.242:1984 - *Test method for breaking strength - Pressley apparatus*.

From these cotton fibers, single and double yarns are made, and from them woven fabrics were made in panama, plain and atlas weaves. Fabric I was made from Israeli, fabric II from Egyptian and fabric III from Greek cotton.

The fabric characterization was performed according to EN 12127:1997 - *Determination of mass per unit area using small samples*, ISO 7211-5:2020 - *Methods for analysis of woven fabrics construction*; and EN ISO 2060:1995 - *Determination of linear density by the skein method*.

The initial construction of the cuts was manually created in basic sizes, after which the cut parts were modeled and finalized. The basic cuts were then recorded using a digitizing board and transferred into the computer. Using the Gerber software package's computational system for construction preparation, the digitized cutting parts were modeled, refined, and graded.

In order to obtain data on the extent to which the current work uniform of healthcare workers satisfies functionality, protection, comfort, design and produces a positive opinion of patients, a survey was conducted, which made it possible to make the correct choice of the most suitable fabric, the most favorable color, the cut of the uniform, etc., based on the results obtained. The survey included 100 respondents, namely 50 healthcare workers and 50 patients, divided into two groups, both groups were equally represented by women and men, of different ages and educations.

## 3. Results and Discussion

The results of fiber measurements, conducted in accordance with the relevant standards, are provided in Table 1, while the results of fabric measurements are presented in Table 2.

From the results, the quality of cotton fibers can be recognized. Egyptian cotton has the longest fiber length (trading staple length), good Micronaire number (fineness) and the highest Pressley index (strength), compared to the other two tested cotton fiber samples.

The examined fibers meet the conditions that, with respect to the production process, good quality yarn can be obtained from them, and can be used for the production of medical clothing.

From the results of the woven fabric characteristics shown in Table 2 can be seen that only fabric III made of single yarn is the lightest. Fabrics I and II are much heavier, more robust, made of double yarns, mostly with a higher setting in the direction of the warp and weft (fabric II).

As the function of medical staff clothing depends on fabric properties, the analysis of the most important properties of these three cotton woven fabrics was performed. Results are presented in Table 3.

From the results in Table 3 can be seen that fabrics made from double yarns (I and II) have the highest numerical values for strength, and slightly lower

elongation compared to fabric III made from single yarns. Fabrics I and II shrink the most in the direction of the warp and the least in the direction of the weft. Fabric III is the most air-permeable and therefore the most porous.

To determine the comfort and functionality of such woven fabrics aimed for medical clothing, a survey was performed. It was conducted with 100 users of medical work clothing and patients, and based on it, an analysis of the condition of clothing in medical institutions was made (Tables 4-8). In order to facilitate the interpretation of the obtained results and the drawing of appropriate conclusions, the participants were divided into two groups; one consisting of health workers, doctors (44%) and nurses (56%), and patients aged 18 to 65+ (the highest percentage of patients is aged 25-54 years old, secondary education).

**Tab.1** Characteristics of cotton fibers

A type of cotton	Trading staple length (mm)	Middle staple length (mm)	% of fibers below 10 mm	Fiber thickness (Micronaire number)	Pressley index
Israeli	32.24	17.50	11.40	5.12	89000
Egyptian	33.31	17.62	11.80	5.00	90000
Greek	27.77	15.32	15.05	5.41	70000

**Tab.2** Characteristics of cotton woven fabrics

Fabric label	Weave	Mass per unit area (g·m <sup>-2</sup> )	Yarn setting (cm <sup>-1</sup> )		Yarn count (tex)	
			Warp	Weft	Warp	Weft
I	panama	210	38	25	16.7x 2	16.9x 2
II	atlas	189	45	28	9.7x2	16.9x2
III	plain	148	40	25	20.4	25.9

**Tab.3** The important properties of fabrics

Fabrics	Shrinkage (%)		Tear resistance (N)		Elongation at break (%)		Air permeability (m <sup>3</sup> ·m <sup>-2</sup> ·min)
	Warp	Weft	Warp	Weft	Warp	Weft	
I	-3.0	-0.8	1309	793	6.6	16.7	9.0
II	-3.0	-2.0	1050	1063	7.3	15.5	9.6
III	-2.9	-2.9	657	512	9.6	16.7	10.3

**Tab.4** Respondents' answers about the impact of healthcare workers' work clothes on the patients' opinion of their professional skills

Work clothes in the service of adequate health protection	Surveyed groups	
	Medical staff	Patients
Question/Answer	(%)	
<i>1. In your opinion, can the clothing of healthcare workers influence patients' perceptions of reliability, accessibility and care?</i>		
a) I do not agree	/	18
b) I have no opinion about it	16	18
c) I completely agree	84	64
<i>2. Do you think that the thermal comfort of the clothing of healthcare workers has anything to do with the quality of the services provided?</i>		
a) I do not agree	12	23
b) I have no opinion about it	44	32
c) I completely agree	44	45
<i>3. Do you think that uncomfortable work clothes can reduce the working ability of healthcare workers?</i>		
a) Yes	100	100
b) No	/	/

The respondents' answers about the impact of healthcare workers' work clothes on the patients' opinion of their professional skills are given in Table 4; and the answers about the choice of fabric and criteria important for the work uniform for medical staff in Table 5.

**Tab.5** Respondents' answers about the choice of fabric and criteria important for the work uniform for medical staff

Choice of fabric	Surveyed groups	
	Medical staff	Patients
<i>1. Choose the fabric that, in your opinion, is most suitable for work clothes for medical personnel?</i>	(%)	
a) Fabric I	34	/
b) Fabric II	26	/
c) Fabric III	40	/
<i>2. What criteria do you consider important for the fabric intended for the production of work clothes for medical personnel</i>		
a) To be easy to maintain	38	29
b) To be vapor permeable (absorbs sweat)	42	54
c) Not to crowd	20	17
d) To dry quickly	/	/

From the results of the respondents' survey shown in Table 4, the appropriate conclusions can be drawn based on the representation of the responses. The dress code in a healthcare institution can represent an important element of the image policy of both the healthcare institution itself and the group of medical workers. One of the many determinants that creates a professional image of medical workers is the so-called dress code, and therefore the style of professional clothing. The external appearance is directly related to the concept of comfort, health and safety at work, as well as the issue of identifying the medical staff of a given medical institution. External appearance also shapes a positive or negative image of the representatives of a given profession, thus influencing the professional prestige of the respective group of professionals [10-12].

The existence of a connection between the external appearance of healthcare workers at work and the perception of patients about their professional skills is confirmed by the results in which 64% of surveyed patients believe that the clothing of healthcare workers affects their opinion, and even 84% of surveyed healthcare workers fully agree with the statement that clothing it largely creates an image of their professional skills. According to the results from Table 4, it can be seen that 45% of the examined patients believe that the thermal comfort of the clothing has a connection

with the quality of the services provided. Medical staff also agree with this statement with 44% of respondents. 100% of respondents agree that uncomfortable clothing can reduce the working ability of healthcare workers.

When it comes to choosing the fabric as well as the criteria that should be met by the clothing of healthcare workers, the opinions of the medical staff were divided, 40% of the respondents declared that fabric III is the most suitable for their work clothes, 34% of the respondents opted for the fabric I, while 26% of respondents declared for fabric II. All of respondents (100%) answered affirmatively that the choice of fabric has an impact on the comfort of work clothes. These percentages are related to the lightness of the fabric, air permeability, etc. (fabric III), i.e. with some of its comfort properties. 42% of the surveyed health workers consider the ability to absorb sweat as an important criterion for their clothing, which is directly related to the comfort of wearing it, 54% of the surveyed patients consider this criterion the most important. Comfort must be ensured for both the static and active status of the garment. It is important that clothing for medical workers follows trends and broadly understands fashion, and above all, that it be practical, that it does not hinder movement, and that it ensures the safety of both patients and medical workers themselves [13, 14].

When asked to order the offered criteria for work clothes according to their priorities, the healthcare workers answered in the manner shown in Table 6. Adequate protection is considered to be the most important criterion, with 61%, bearing in mind that health workers are exposed to a high risk of infection during their work, followed by flexibility with 56%, which supports the fact that clothing should not restrict movement, that it must be, above all, practical. Color and aesthetic appearance are in fifth and fourth place when it comes to priorities, but that does not mean that they are less important. Work clothes, which can simultaneously fulfill all the mentioned criteria, including color and aesthetic appearance, are necessary for healthcare workers because they spend 6-8 hours a day in them.

**Tab.6** Presentation of answers to the question of criteria related to work clothes by priorities

Workwear criteria according to importance*	1	2	3	4	5
Thermal comfort	/	17	83	/	/
Adequate protection	61	27	11	/	/
Flexibility (freedom of movement)	39	56	6	/	/
The color	/	/	/	6	94
Aesthetic appearance	/	/	/	94	6

\*Grade 1 is the most important

Today, fashion trends have affected every aspect of business, including medicine, where the work clothes of healthcare workers should contribute to credibility, and good style certainly affects the self-confidence that is necessary for better performance in this sector. The results from Table 7 show that the largest percentage of respondents opted for grade 3 when it comes to durability, comfort and functionality of work clothes. The largest percentage of respondents rated their work uniform as 2, i.e. 33%, when it comes to aesthetic appearance.

**Tab.7** Presentation of the responses of healthcare workers regarding the aesthetics, comfort and functionality of work clothes

Assessment of work uniform	1	2	3	4	5
Durability	6	/	67	16	11
Aesthetic appearance	/	33	28	22	17
Functionality	/	11	39	28	22
Comfort	/	/	56	22	22

\*Grade 1 is the most important

How much the work clothes of health workers can influence the image of a health institution is shown by the data where 100% of the surveyed health workers and patients gave an affirmative answer, tab.8. White is the most traditional color when it comes to the clothing of healthcare workers, it is also the most common choice because it emphasizes cleanliness and as such represents an important element in assessing the professionalism of healthcare workers. That white color does not have to be and is not the only choice when it comes to the clothing of healthcare workers, is shown by the fact that 100% of the surveyed healthcare workers declared that they would like their employer to provide them with a choice of color.

Medical staff and patients agree that the choice of color would contribute to easier recognition of individual health care sectors.

The largest percentage of respondents in this study preferred the color white when it comes to the general medicine sector, the green color went to surgery, while the dark color is the most acceptable for pediatrics.

Work clothes, which can simultaneously fulfill all the mentioned criteria, including color and aesthetic appearance, are necessary for healthcare workers because they spend 6-8 hours a day in them. White is the most traditional color when it comes to the clothing of healthcare workers, it is also the most common choice because it emphasizes cleanliness and as such represents an important element in the assessment of the professionalism of healthcare workers, but it has also been shown that there is a connection between white uniforms and ease of identification. The largest percentage of respondents preferred the color white when it comes to general medicine, the color green went to surgery, and the largest percentage of respondents declared that dark color is the most acceptable for pediatrics.

Medical clothing and the choice of fabrics for it must meet high standards not only in terms of protection, comfort and functionality, but also aesthetic appearance and color as an important element of the recognizable style of a healthcare institution. Correctly selected fabric and model of medical clothing provides an effective way of protection for medical staff and patients, and at the same time creates pleasant working conditions and positive influence, both on staff and on patients.

#### 4. Conclusions

Medical workwear was produced using cotton fibers of different origins, all of which met satisfactory quality standards. These fibers fulfilled the requirements for producing high-quality yarns and fabrics.

**Tab.8** Display the answer to the color question

Choice of color	Surveyed groups					
	Medical staff			Patients		
<i>1. Do you think that every service in a health care facility should have its own color for easy identification?</i>	(%)					
a) Yes	100			100		
b) No	/			/		
<i>2. If you could choose which work clothes you would choose for the following health care sectors?</i>	White	Green	Navy blue	White	Green	Navy blue
a) Pediatrics	27	/	72	36	/	63
b) General medicine	67	17	17	59	18	23
c) Surgery	6	83	11	5	82	14

The resulting woven fabrics exhibited varied properties that directly impacted the quality, functionality, and comfort of the workwear. These findings were further supported by survey results, which highlighted a strong connection between the external appearance of medical workers and their professional image, as well as patients' perceptions of their competence and professionalism. Patients place significant importance on the external appearance of healthcare workers, as it influences their trust in the professionals' expertise.

Regarding fabric choice and the criteria for healthcare workwear, 40% of surveyed patients believed that a plain weave fabric made of 100% cotton was the most suitable, while 34% preferred a Panama weave and 26% favored an atlas weave. Although color and aesthetic appearance ranked fourth and fifth in terms of priorities, they remain important factors. Properly selected fabrics and designs for medical clothing not only provide effective protection for both medical staff and patients but also create comfortable working conditions and positively impact both groups.

Based on the surveys, it is evident that medical clothing and the fabrics used must adhere to high standards, encompassing protection, comfort, functionality, aesthetic appearance, and color. These elements collectively contribute to the professional image of healthcare institutions and play a vital role in shaping perceptions of quality and trust.

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