



Paper Type: Original Article

## Evaluation and Ranking of Blood Sampling Gloves in Clinical Laboratory Environments Using a Hybrid MEREC–VIKOR Approach

Mohammad Javad Arab<sup>1</sup>, Saeid Mehrabian<sup>1</sup> , Pouria Solouki<sup>2</sup> , Narges Jafari Zareh<sup>3,\*</sup>

<sup>1</sup> Department of Mathematics, Faculty of Mathematical Sciences and Computer, Kharazmi University, Karaj, Iran; mohammadjavadarab@khu.ac.ir; saeid\_mehrabian@khu.ac.ir.

<sup>2</sup> Zanjan University of Medical Sciences, Zanjan, Iran; soloukipouria@gmail.com.

<sup>3</sup> Islamic Azad University, Sav.C., Saveh, Iran; zarehnarges27@gmail.com.

### Citation:

Received: 04 April 2025

Revised: 15 June 2025

Accepted: 04 August 2025

Arab, M. J., Mehrabian, S., Solouki, P., & Jafari Zareh, N. (2025). Evaluation and ranking of blood sampling gloves in clinical laboratory environments using a hybrid MEREC–VIKOR approach. *Annals of healthcare systems engineering*, 2(3), 174-185.

### Abstract

The optimal selection of blood sampling gloves in laboratory environments plays a vital role in ensuring personnel safety, preventing the transmission of infections, and maintaining the quality of clinical services. Despite the wide variety of available glove types and the numerous criteria influencing their selection, there is a clear need for an objective and comprehensive decision-making framework in this field. In this study, the Method based on the Removal Effects of Criteria (MEREC) method was employed for criteria weighting and the VIKOR method for ranking alternatives, in order to evaluate 20 commonly used blood sampling gloves based on 10 technical, safety, human, and economic criteria. The required data were collected through a 9-point Likert questionnaire with the participation of 30 experts in occupational health and safety. The results indicated that nitrile gloves with lotion, powder-free nitrile gloves, and blue nitrile gloves were identified as the best options, respectively. These findings emphasize that integrating performance characteristics (such as comfort and tactile sensitivity) with protective features (such as chemical and mechanical resistance) is essential in the selection of clinical gloves.

**Keywords:** Multi-criteria decision-making, Method based on the removal effects of criteria, VIKOR, Blood sampling gloves, Laboratory safety.

## 1 | Introduction

In recent years, the safety and quality of equipment used in clinical environments particularly blood collection gloves have become a major concern for healthcare managers and laboratory personnel [1]. Selecting appropriate gloves not only plays a crucial role in reducing occupational hazards associated with

 Corresponding Author: zarehnarges27@gmail.com

 <https://doi.org/10.22105/ahse.v2i3.47>



Licensee System Analytics. This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0>).

exposure to blood and biological fluids, but also has a direct impact on the accuracy of the sampling process, patient satisfaction, and the overall efficiency of laboratory systems [2]. Given the wide variety of gloves available on the market and the significant differences in their technical and safety characteristics, the establishment of a systematic framework for evaluating and ranking these products appears to be essential [3].

Gloves act as an effective barrier against pathogens only when they remain intact and undamaged. None of the commonly used types including latex or cut-resistant gloves provide complete protection against needle-stick injuries [4]. In high-risk situations, wearing double gloves or those with higher resistance, along with strictly observing hand hygiene, is essential since intact and healthy skin serves as the ultimate protective barrier against infections [5]. These findings highlight the importance of purposeful glove selection based on protective properties, durability, and clinical efficiency to ensure the simultaneous safety of both healthcare workers and patients [6]. A prospective study demonstrated that the puncture rate of examination gloves (latex and nitrile) in intensive care units is significantly associated with brand, duration of use, and type of activity (such as dressing change or patient washing). The integrity of gloves decreases considerably after 15 minutes of use. Given the increased risk of microbial leakage beyond this time frame, changing gloves every 15 minutes can create an appropriate balance between safety and practicality, and it is emphasized that gloves should never replace proper hand hygiene [7]. Another study found that Polyethylene (PE) gloves, due to their relatively high generation of negative electrostatic charge through contact and friction, can repel negatively charged viruses [8]. Therefore, selecting materials with a higher tendency to acquire a negative charge may enhance the protective efficiency of equipment against viral agents [9], [10].

Research has also warned that disposable laboratory gloves and some common reagents, such as Sodium Dodecyl Sulfate (SDS), may lead to false identification of PE in microplastic studies [11], [12]. This occurs because compounds such as stearates and fatty acids present in glove latex can be misinterpreted as PE when analyzed using standard techniques ( $\mu$ -Raman,  $\mu$ -FTIR, and pyr-GC/MS). These findings underscore the need for meticulous control of potential contamination sources and validation of analytical methods to distinguish real polymers from chemically similar compounds [4]. Current evaluations of medical gloves are inadequate regarding their impact on clinical performance, as mechanical properties such as friction and adhesion factors influencing tactile sensitivity, control, and precision in medical tasks have not been systematically considered. It has been emphasized that functional parameters should be integrated into testing standards to better understand and mitigate the negative effects of gloves on patient care and user safety. This approach requires linking material properties with manufacturing processes and real clinical use conditions [5]. Recently, through a multi-stage Delphi process, guidelines have been developed for the sustainable selection, use, and disposal of examination gloves in healthcare settings. These guidelines aim to support infection control and the safety of both patients and staff, while aligning with the Sustainable Development Goals (SDGs) and the one health principles. They emphasize using gloves appropriate to the clinical context (sterile for invasive procedures, non-sterile for body fluid contact), adherence to hand hygiene, avoidance of reuse, and proper training in donning and doffing techniques. Furthermore, it is recommended that glove disposal protocols comply with waste management regulations and, when feasible, employ biodegradable or recyclable materials to reduce environmental impact [6].

In this context, Multi-Criteria Decision-Making (MCDM) methods are recognized as effective tools for comparing and optimally selecting among different alternatives under multidimensional conditions. In this study, the Method based on the Removal Effects of Criteria (MERECE) method is employed to determine the weights of the criteria, while the VIKOR method is used to rank the alternatives. This integrated approach enables a comprehensive evaluation of blood collection gloves based on criteria such as chemical resistance, allergenic potential, user comfort, mechanical durability, and cost, thereby assisting clinical decision-makers in selecting the most suitable option with full awareness. The objective of this study is to propose a MCDM model for the optimal selection of blood collection gloves in laboratory environments. The main research question is as follows:

Which type of glove demonstrates the best performance based on technical, safety, human, and economic criteria, and how should the available options be ranked accordingly?

## 2 | Research Methodology

This research is applied in terms of purpose and descriptive–analytical in terms of data collection and analysis method, with a MCDM approach.

The statistical population consisted of 30 students majoring in occupational safety and health at the University of Zanjan, who provided the required data through a 9-point Likert-scale questionnaire (the reliability of the questionnaire was confirmed with a Cronbach's alpha coefficient of 0.81).

The MEREC method, introduced in 2021, determines the importance of a criterion based on the change in the overall performance of alternatives when that criterion is removed. The greater the reduction in the ability to distinguish between alternatives after removing a criterion, the more important that criterion is. In this method, the weights are derived directly from the decision matrix, eliminating the need for subjective inputs or prior assumptions about weight distribution. One of the main advantages of this method is the elimination of decision-maker bias [7].

### 2.1 | Procedural Steps of the Method based on the Removal Effects of Criteria Method

The steps of the MEREC method are as follows:

**Step 1 (Constructing the decision matrix).** A decision matrix is created in this step, which shows the score of each alternative with respect to each criterion.

**Step 2 (Normalizing the decision matrix).** Linear normalization is applied in this method to make the elements of the decision matrix dimensionless.

**Step 3 (Calculating the overall performance of each alternative).** In this step, a logarithmic measurement with equal criterion weights is applied to obtain the overall performance of the alternatives. The following equation is used for this calculation:

$$S_i = \ln \left( 1 + \left( \frac{1}{m} \sum_j |\ln r_{ij}| \right) \right) \quad (1)$$

**Step 4 (One-by-one elimination of criteria).** In this step, the performance of the alternatives is calculated by removing each criterion individually. At this stage, the logarithmic criterion similar to the previous step is used. The difference between this step and the previous one is that the performance of the alternatives is calculated separately based on the elimination of each criterion. Therefore, we obtain a set of performance values associated with the  $m$  criteria. The following relation is used to perform the calculations in this step:

$$S_{ij}^- = \ln \left( 1 + \left( \frac{1}{m} \sum_{j \neq k} |\ln r_{ij}| \right) \right). \quad (2)$$

**Step 5 (Calculation of the sum of absolute deviations).** In this step, the effect of removing criterion  $j$  is calculated based on the values obtained from *Step 3* and *Step 4*. Let  $E_j$  denote the effect of removing criterion  $j$ . Using the following formula, we can calculate the values of  $E_j$ .

$$E_j = \sum_j |S_i - S_{ij}^-|. \quad (3)$$

**Step 6 (Calculation of the final weights).** In this step, the final weights of the criteria are determined. The following formula is used to calculate the weights:

$$W_j = \frac{E_j}{\sum_j E_j}. \quad (4)$$

## 2.2 | Implementation Steps of the VIKOR Method

The VIKOR method is based on compromise programming in MCDM. It is used to evaluate problems involving incommensurable and conflicting criteria. In situations where the decision-maker is not able to identify and clearly express the preferences or priorities of a problem at the initial stage of its formulation and design, this method can be employed as an effective decision-making tool.

**Step 1 (Determination of the positive ideal and negative anti-ideal solutions).** In this step, the positive and negative ideal solutions must be identified. For benefit (positive) criteria, the positive ideal is equal to the maximum value in the criterion column, and the negative ideal is the minimum value in that column. For cost (negative) criteria, the opposite applies. Benefit criteria are those whose increase leads to greater utility, while cost criteria are those whose decrease leads to greater utility.

**Step 2 (Calculation of the utility measure (s) and regret measure for each criterion).** The utility measure  $S$  represents the relative distance of alternative  $i$  from the ideal solution, while the regret measure  $R$  represents the maximum dissatisfaction of alternative  $i$  due to its distance from the ideal solution. These values are obtained using the following relations.

$$S_i = \sum_{j=1}^n W_j \times \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}. \quad (5)$$

$$R_i = \max(S_i). \quad (6)$$

**Step 3 (Calculation of the VIKOR index (Q) for each alternative).** The VIKOR index for each alternative is calculated using the Eq. (7).

$$Q_i = v \left( \frac{S_i - S^*}{S^- - S^*} \right) + (1 - v) \left( \frac{R_i - R^*}{R^- - R^*} \right), \quad (7)$$

where,

$$S^* = \min S_i \quad S^- = \max S_i \quad R^* = \min R_i \quad R^- = \max R_i \quad . \quad (8)$$

**Step 4 (Ranking the alternatives based on S, Q, and R).** In the final step of the VIKOR technique, the alternatives are ranked in three groups according to the values of  $Q$ ,  $R$ , and  $S$ , from the smallest to the largest. The best alternative is the one that achieves the top rank in all three measures. Otherwise, the preferred alternative is the one with the smallest  $Q$  value.

## 2.3 | Research Criteria

The criteria of this study, based on previous research, are as follows:

- I. Permeability of materials into the glove (C1): to prevent the transmission of blood-borne infections to laboratory personnel, the use of appropriate gloves is essential.

- II. Resistance to chemical substances (C2): laboratory personnel are exposed to chemicals and disinfectants; therefore, the selected glove should not degrade rapidly and should not cause damage to the skin of the staff.
- III. Resistance to needle puncture (C3): given that blood sampling is performed using sharp needles, a suitable glove should have high resistance to puncture by needles.
- IV. Tactile sensitivity and hand dexterity (C4): due to the delicate nature of the blood sampling process and the sensitivity required when handling laboratory instruments, thick gloves reduce sensory feedback and cause interference.
- V. Comfort during long-term use (C5): laboratory personnel work for extended periods, and inappropriate gloves can cause fatigue, skin disorders, and consequently mental and cognitive discomfort.
- VI. Ease of donning and doffing (C6): proper and rapid donning and doffing of gloves is essential in glove selection; otherwise, it may lead to glove tearing and, consequently, the transmission of infection to the hands.
- VII. Cost (C7): considering financial constraints, selecting gloves with a reasonable price can be an important criterion in glove selection.
- VIII. Durability (C8): glove durability is an effective factor in glove selection and can play a significant role in reducing costs as well as decreasing waste rates.
- IX. Allergenic potential (C9): some materials used in gloves may cause skin sensitivity and allergic reactions, thereby endangering the physical health of personnel.
- X. Compliance with international standards (C10): compliance with international standards improves glove quality and safety and is an influential factor in optimal glove selection.
- XI. Positive criteria: criteria for which a higher value indicates a better option.
- XII. Negative criteria: criteria for which a lower value indicates a better option.

## 2.3 | Research Alternatives

Twenty commonly used types of blood-collection gloves were considered in this study, including latex, nitrile, vinyl, neoprene, chloroprene, PE, as well as specialized sterile and double-layer gloves (*Table 1*).

**Table 1. Research alternative.**

Powdered latex gloves (a <sub>1</sub> )	Powder-free latex gloves (a <sub>2</sub> )	Powdered Nitrile gloves (a <sub>3</sub> )	Powder-free Nitrile gloves (a <sub>4</sub> )	Powdered Vinyl gloves (a <sub>5</sub> )
Powder-free Vinyl gloves (a <sub>6</sub> )	Neoprene gloves (a <sub>7</sub> )	Chloroprene gloves (a <sub>8</sub> )	Textured Nitrile gloves (a <sub>9</sub> )	Textured latex gloves (a <sub>10</sub> )
Thick Nitrile gloves (a <sub>11</sub> )	Thick vinyl glove (a <sub>12</sub> )	Black Nitrile gloves (a <sub>13</sub> )	Blue Nitrile gloves (a <sub>14</sub> )	Sterile latex gloves (a <sub>15</sub> )
Sterile Nitrile gloves (a <sub>16</sub> )	PE gloves (a <sub>17</sub> )	Lotion-coated Nitrile gloves (a <sub>18</sub> )	Nitrile Surgical gloves (a <sub>19</sub> )	Double-layer Nitrile gloves (a <sub>20</sub> )

## 3 | Data Analysis

### 3.1 | Data Collection Instruments and Statistical Population

The following decision matrix was obtained from 30 students of the Occupational Health and Safety program at the University of Zanjan through a questionnaire with a Cronbach's alpha of 0.81. In this questionnaire, the students evaluated and rated the alternatives based on the criteria using a 9-point Likert scale. The decision matrix of this study is presented below:

**Table 2. Decision matrix.**

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Alternative										
A <sub>1</sub>	7	5	5	8	7	9	2	5	8	6
A <sub>2</sub>	8	5	6	8	7	7	3	6	7	7
A <sub>3</sub>	9	8	7	7	7	8	3	7	2	7
A <sub>4</sub>	9	8	8	7	8	6	4	8	1	8
A <sub>5</sub>	4	3	3	6	5	9	2	3	1	4
A <sub>6</sub>	4	3	3	5	4	6	2	3	1	4
A <sub>7</sub>	8	7	7	6	7	6	5	7	3	7
A <sub>8</sub>	8	7	7	6	7	6	5	7	3	7
A <sub>9</sub>	8	8	8	6	7	6	5	8	1	7
A <sub>10</sub>	7	5	6	7	6	7	3	6	8	6
A <sub>11</sub>	8	9	9	4	6	4	6	9	2	7
A <sub>12</sub>	5	4	5	4	5	4	3	5	1	4
A <sub>13</sub>	8	8	8	6	7	6	5	8	1	7
A <sub>14</sub>	9	8	8	7	8	6	4	8	1	8
A <sub>15</sub>	9	6	7	8	8	6	6	7	8	9
A <sub>16</sub>	9	9	8	7	8	6	7	8	1	9
A <sub>17</sub>	3	2	2	3	3	8	1	2	1	2
A <sub>18</sub>	9	8	8	8	9	9	5	7	1	7
A <sub>19</sub>	9	9	9	8	9	6	8	9	1	9
A <sub>20</sub>	9	9	9	5	7	3	7	9	2	8

### 3.2 | Calculation of Criteria Weights

The weights of criteria in MCDM problems are fundamental elements that can significantly influence the results. To minimize biases arising from human judgment, the MEREC method was employed in this study for weighting. First, the decision matrix is normalized (dimensionless). The normalized matrix is presented in *Table 3*.

**Table 3. Criteria weights.**

Option	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A <sub>1</sub>	0.778	0.556	0.556	1	0.778	1	0.2	1.8	0.125	0.667
A <sub>2</sub>	0.889	0.556	0.667	1	0.778	0.778	0.333	1.5	0.143	0.778
A <sub>3</sub>	1	0.889	0.778	0.875	0.778	0.889	0.333	1.286	0.5	0.778
A <sub>4</sub>	0.444	0.333	0.333	0.75	0.556	1	0.25	1.125	1	0.889
A <sub>5</sub>	0.444	0.333	0.333	0.75	0.556	1	0.5	3	1	0.444
A <sub>6</sub>	0.444	0.333	0.333	0.625	0.444	0.667	0.5	3	1	0.444
A <sub>7</sub>	0.889	0.778	0.778	0.75	0.778	0.667	0.2	1.286	0.333	0.778
A <sub>8</sub>	0.889	0.778	0.778	0.75	0.778	0.667	0.2	1.286	0.333	0.778
A <sub>9</sub>	0.889	0.889	0.889	0.75	0.778	0.667	0.2	1.125	1	0.778
A <sub>10</sub>	0.778	0.556	0.667	0.875	0.667	0.778	0.333	1.5	0.125	0.667
A <sub>11</sub>	0.889	1	1	0.5	0.667	0.444	0.167	1	0.5	0.778
A <sub>12</sub>	0.556	0.444	0.556	0.5	0.556	0.444	0.333	1.8	1	0.444
A <sub>13</sub>	0.889	0.889	0.889	0.75	0.778	0.667	0.2	1.125	1	0.778
A <sub>14</sub>	1	0.889	0.889	0.875	0.889	0.667	0.25	1.125	1	0.889
A <sub>15</sub>	1	0.667	0.778	1	0.889	0.667	0.167	1.286	0.125	1
A <sub>16</sub>	1	1	0.889	0.875	0.889	0.667	0.143	1.125	1	1
A <sub>17</sub>	0.333	0.222	0.222	0.375	0.333	0.889	1	4.5	1	0.222
A <sub>18</sub>	1	0.889	0.889	1	1	1	0.2	1.286	1	0.778
A <sub>19</sub>	1	1	1	1	1	0.667	0.125	1	1	1
A <sub>20</sub>	1	1	1	0.625	0.778	0.333	0.143	1	0.5	0.889

In this study, the overall performance table of the alternatives is presented in *Table 4*.

**Table 4. Alternative scores.**

Alternative	$S_i$
A <sub>1</sub>	0.276
A <sub>2</sub>	0.235
A <sub>3</sub>	0.146
A <sub>4</sub>	0.243
A <sub>5</sub>	0.280
A <sub>6</sub>	0.311
A <sub>7</sub>	0.214
A <sub>8</sub>	0.214
A <sub>9</sub>	0.151
A <sub>10</sub>	0.263
A <sub>11</sub>	0.213
A <sub>12</sub>	0.284
A <sub>13</sub>	0.151
A <sub>14</sub>	0.118
A <sub>15</sub>	0.235
A <sub>16</sub>	0.132
A <sub>17</sub>	0.382
A <sub>18</sub>	0.110
A <sub>19</sub>	0.117
A <sub>20</sub>	0.206

In this study, Step Four is presented as *Table 5*.

**Table 5. Ranking of alternative.**

Alternative	$S_1^-$	$S_2^-$	$S_3^-$	$S_4^-$	$S_5^-$	$S_6^-$	$S_7^-$	$S_8^-$	$S_9^-$	$S_{10}^-$
A <sub>1</sub>	0.266	0.253	0.253	0.276	0.266	0.276	0.213	0.253	0.193	0.260
A <sub>2</sub>	0.231	0.212	0.219	0.235	0.225	0.225	0.191	0.219	0.155	0.225
A <sub>3</sub>	0.146	0.141	0.136	0.141	0.136	0.141	0.098	0.136	0.116	0.136
A <sub>4</sub>	0.210	0.199	0.199	0.231	0.219	0.243	0.187	0.238	0.243	0.238
A <sub>5</sub>	0.249	0.238	0.238	0.269	0.258	0.280	0.254	0.238	0.280	0.249
A <sub>6</sub>	0.280	0.269	0.269	0.293	0.280	0.296	0.285	0.269	0.311	0.280
A <sub>7</sub>	0.209	0.203	0.203	0.202	0.203	0.197	0.146	0.203	0.168	0.203
A <sub>8</sub>	0.209	0.203	0.203	0.202	0.203	0.197	0.146	0.203	0.168	0.203
A <sub>9</sub>	0.146	0.146	0.146	0.139	0.140	0.134	0.080	0.146	0.151	0.140
A <sub>10</sub>	0.253	0.240	0.247	0.258	0.247	0.253	0.220	0.247	0.180	0.247
A <sub>11</sub>	0.208	0.213	0.213	0.185	0.197	0.180	0.138	0.213	0.185	0.203
A <sub>12</sub>	0.261	0.253	0.261	0.257	0.261	0.253	0.242	0.261	0.284	0.253
A <sub>13</sub>	0.146	0.146	0.146	0.139	0.140	0.134	0.080	0.146	0.151	0.140
A <sub>14</sub>	0.118	0.113	0.113	0.112	0.113	0.100	0.054	0.113	0.118	0.113
A <sub>15</sub>	0.235	0.219	0.225	0.235	0.230	0.219	0.161	0.225	0.149	0.235
A <sub>16</sub>	0.132	0.132	0.127	0.126	0.127	0.114	0.0436	0.127	0.132	0.132
A <sub>17</sub>	0.344	0.329	0.329	0.348	0.344	0.378	0.382	0.329	0.382	0.329
A <sub>18</sub>	0.110	0.105	0.105	0.110	0.110	0.110	0.0362	0.0996	0.110	0.099
A <sub>19</sub>	0.117	0.117	0.117	0.117	0.117	0.098	0.020	0.117	0.117	0.117
A <sub>20</sub>	0.206	0.206	0.206	0.186	0.195	0.160	0.123	0.206	0.177	0.201

$E_j$  score is presented as *Table 6*.

**Table 6. Ranking of alternative.**

$E_1$	$E_2$	$E_3$	$E_4$	$E_5$	$E_6$	$E_7$	$E_8$	$E_9$	$E_{10}$
0.202	3.947	3.965	4.070	4.022	3.997	3.106	3.998	3.780	4.0141

Finally, criteria weights is presented as *Table 7*.

**Table 7. Criteria weights.**

W1	W2	W3	W4	W5	W6	W7	W8	W9	W10
0.005	0.112	0.112	0.115	0.114	0.113	0.088	0.113	0.107	0.114

Table 7 presents the results of weighting ten evaluation criteria for blood-collection gloves using the MEREC method, yielding the following findings:

The criterion “permeability to material penetration” with a very low weight of 0.005, has the least importance in decision-making. This indicates that all examined glove types perform similarly and satisfactorily as barriers against the penetration of biological fluids; therefore, this characteristic functions as a necessary requirement rather than a differentiating criterion.

In contrast, six key criteria chemical resistance (0.115), allergy potential (0.114), compliance with international standards (0.114), needle-stick resistance (0.112), tactile sensitivity (0.112), and ease of donning/doffing (0.113) with weights close to 0.11, exhibit nearly equal and high importance in the final selection. This reflects a critical balance among protective dimensions (chemical and mechanical protection), long-term safety (reduced allergenicity), clinical efficiency (tactile sensitivity and ease of use), and quality assurance (international standards).

The cost criterion, with a moderate weight of 0.088, indicates that in decisions related to clinically sensitive protective equipment, safety and performance considerations take precedence over economic factors, although cost still plays a significant role.

Overall, this distribution of weights supports the validity of the study, as it aligns with the risk-management literature in clinical environments: criteria associated with irreversible risks (such as permanent allergies or chemical leakage) receive higher weights, whereas criteria that are manageable or uniform across all alternatives (such as permeability) exert less influence on the final decision.

### 3.3 | Ranking of the Alternatives

In the VIKOR method, the decision matrix is first normalized (made dimensionless). The normalized matrix in this study is as follows:

**Table 8. Normalized matrix.**

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Alternative										
A <sub>1</sub>	0.005	0.005	0.005	0.009	0.007	0.010	0.004	0.005	0.028	0.006
A <sub>2</sub>	0.006	0.005	0.006	0.009	0.007	0.008	0.006	0.006	0.024	0.007
A <sub>3</sub>	0.007	0.008	0.007	0.008	0.007	0.009	0.006	0.007	0.007	0.007
A <sub>4</sub>	0.007	0.008	0.008	0.008	0.008	0.006	0.009	0.008	0.003	0.008
A <sub>5</sub>	0.003	0.003	0.003	0.007	0.005	0.010	0.004	0.003	0.003	0.004
A <sub>6</sub>	0.0033	0.003	0.003	0.005	0.004	0.006	0.004	0.003	0.003	0.004
A <sub>7</sub>	0.006	0.007	0.007	0.007	0.007	0.006	0.011	0.007	0.010	0.007
A <sub>8</sub>	0.006	0.007	0.007	0.007	0.007	0.006	0.011	0.007	0.010	0.007
A <sub>9</sub>	0.006	0.008	0.0082	0.007	0.007	0.006	0.011	0.008	0.003	0.007
A <sub>10</sub>	0.005	0.005	0.006	0.008	0.006	0.008	0.006	0.006	0.028	0.006
A <sub>11</sub>	0.006	0.009	0.009	0.004	0.006	0.004	0.013	0.009	0.007	0.007
A <sub>12</sub>	0.004	0.004	0.005	0.004	0.005	0.004	0.006	0.005	0.003	0.004
A <sub>13</sub>	0.006	0.008	0.008	0.007	0.007	0.006	0.011	0.008	0.003	0.007
A <sub>14</sub>	0.007	0.008	0.008	0.008	0.008	0.006	0.009	0.008	0.003	0.008
A <sub>15</sub>	0.007	0.006	0.007	0.009	0.008	0.006	0.013	0.007	0.028	0.009
A <sub>16</sub>	0.007	0.009	0.00	0.008	0.008	0.006	0.015	0.008	0.0035	0.009
A <sub>17</sub>	0.002	0.002	0.002	0.003	0.003	0.009	0.002	0.002	0.003	0.002
A <sub>18</sub>	0.007	0.008	0.008	0.009	0.009	0.010	0.011	0.007	0.003	0.007
A <sub>19</sub>	0.007	0.009	0.009	0.009	0.009	0.006	0.018	0.009	0.003	0.009
A <sub>20</sub>	0.007	0.009	0.009	0.005	0.007	0.003	0.015	0.009	0.007	0.008

In the next step, the positive and negative ideals must be determined. For positive criteria, the positive ideal is equal to the largest value in the criterion column, and the negative ideal is the smallest value in that column. For negative criteria, the situation is reversed. Positive criteria are those whose increase leads to profit, while negative criteria are those whose decrease leads to profit.

**Table 9. Negative and positive criteria.**

$f_1^+$	$f_2^+$	$f_3^+$	$f_4^+$	$f_5^+$	$f_6^+$	$f_7^+$	$f_8^+$	$f_9^+$	$f_{10}^+$
0.007	0.009	0.009	0.009	0.009	0.010	0.002	0.009	0.003	0.009
$f_1^-$	$f_2^-$	$f_3^-$	$f_4^-$	$f_5^-$	$f_6^-$	$f_7^-$	$f_8^-$	$f_9^-$	$f_{10}^-$
0.002	0.002	0.002	0.003	0.003	0.003	0.018	0.002	0.028	0.002

The utility measure  $S$  represents the relative distance of the  $i$ th alternative from the ideal point, while the regret measure  $R$  represents the maximum dissatisfaction of the  $i$ th alternative due to its distance from the ideal point. The VIKOR index has been calculated and presented in *Table 10*.

**Table 10. VIKOR index.**

Alternative	$R_i$	$S_i$	$Q_i$
A <sub>1</sub>	0.107	0.403	0.035
A <sub>2</sub>	0.092	0.388	0.949
A <sub>3</sub>	0.038	0.234	0.009
A <sub>4</sub>	0.056	0.201	0.008
A <sub>5</sub>	0.176	4.957	1
A <sub>6</sub>	0.097	0.611	0.055
A <sub>7</sub>	0.056	0.353	0.023
A <sub>8</sub>	0.056	0.353	0.02
A <sub>9</sub>	0.056	0.274	0.015
A <sub>10</sub>	0.107	0.463	0.041
A <sub>11</sub>	0.166	0.575	0.060
A <sub>12</sub>	0.094	0.584	0.052
A <sub>13</sub>	0.696	0.152	0.184
A <sub>14</sub>	0.0569	0.201	0.008
A <sub>15</sub>	0.107	0.359	0.030
A <sub>16</sub>	0.696	0.974	0.165
A <sub>17</sub>	0.115	0.708	0.067
A <sub>18</sub>	0.050	0.147	0.001
A <sub>19</sub>	0.088	0.145	0.006
A <sub>20</sub>	0.113	0.329	0.028

*Table 10* presents the results of the three key indices of the VIKOR method for ranking 20 types of blood-collection gloves, each reflecting a distinct dimension of option performance. The  $S$  index (group utility) measures the weighted distance of each option from the ideal solution across all criteria, and lower values (such as 0.001 for option 18 and 0.006 for Option 19) indicate balanced performance and overall proximity to the ideal across the full set of criteria. The  $R$  index (maximum regret) reflects the greatest weighted deviation of an option from the ideal in its worst-performing criterion, and lower values (such as 0.145 for Option 19 and 0.147 for Option 18) emphasize that these options lack a critical weakness in any of the vital criteria (such as allergenicity or chemical resistance). The  $Q$  index (final priority) is a weighted combination of  $S$  and  $R$  with the parameter  $\nu$ , accounting for the trade-off between collective optimization and the minimization of maximum risk. The simultaneous analysis of these three indices provides several clinical insights:

- I. Nitrile gloves with lotion (Option 18), with the lowest values of  $S$  and  $R$ , demonstrate superiority in both overall performance and the absence of any critical weakness.
- II. Powdered latex gloves and powdered vinyl gloves exhibit the poorest performance in both  $S$  and  $R$ , indicating structural weaknesses across several key criteria, particularly allergenicity and chemical resistance.

III. The relative consistency between rankings based on S and Q confirms that, in the selection of clinical gloves, overall option performance (group utility) plays a more decisive role than the prevention of the worst-case scenario (maximum regret), a finding that is consistent with the risk-management literature in medical settings.

This analysis not only confirms the methodological validity of the proposed framework but also provides a clear roadmap for clinical decision-makers. Therefore, based on *Table 10*, the ranking of gloves is presented in *Table 11*.

**Table 11. Final alternatives ranking.**

$Q_i$	Alternative	Rank
0.001	A18	1
0.008	A4	2
0.008	A14	2
0.006	A3	3
0.009	A19	4
0.015	A9	5
0.023	A7	6
0.023	A8	7
0.028	A20	9
0.030	A15	8
0.035	A1	9
0.041	A10	10
0.052	A12	11
0.055	A6	12
0.060	A11	13
0.067	A17	14
0.165	A16	15
0.184	A13	16
0.949	A2	17
1	A5	18

In *Table 11*, the final ranking of alternatives using the VIKOR method based on the index has been carried out. This ranking provides several important insights for clinical decision-making and policy formulation. First, the top three alternatives show a significant gap compared with the other options and all belong to the nitrile family, which confirms the systematic superiority of this material in achieving an optimal combination of chemical resistance (weight = 0.115), low allergenic potential (weight = 0.114), and preservation of tactile sensitivity (weight = 0.112). Second, the performance gap between ranks 1–7 and the remaining alternatives indicates the existence of a “quality threshold,” above which options are recognized as acceptable solutions for high-risk laboratory environments, whereas options ranked 17 and 18 (powdered latex and powdered vinyl), due to poor performance in non-compensable criteria (such as allergenicity and permeability), are evaluated as completely unsuitable. Third, the consistency of the ranking with epidemiological literature, including [2] on glove durability in intensive care units and the evidence-based glove selection guidelines in [6], strengthens the validity of the proposed framework. Finally, this ranking not only provides a practical selection tool for laboratory managers but also, through the clear differentiation of “recommended,” “use with caution,” and “not recommended” options, lays the groundwork for the development of national standards for the selection of protective equipment.

## 4 | Conclusion

This study presents an objective and reproducible decision-making framework for the optimal selection of blood collection gloves in clinical laboratory environments, integrating the MEREK method for criteria weighting and the VIKOR method for option ranking. Unlike previous studies that have largely focused on one-dimensional evaluations, this research analyzes ten essential criteria in an integrated and objective manner across four dimensions: technical (chemical resistance, impermeability, needle-stick resistance), safety (allergenic potential, compliance with international standards), human factors (tactile sensitivity, comfort during prolonged use, ease of donning and doffing), and economic (cost, durability). The key findings indicate that lotion-coated nitrile gloves, powder-free nitrile gloves, and blue nitrile gloves were identified as the top three options. This superiority reflects nitrile's ability to achieve an optimal balance among chemical resistance (criterion weight: 0.115), low allergenic potential (weight: 0.114), preservation of tactile sensitivity (weight: 0.112), and compliance with international standards (weight: 0.114).

In contrast, powdered latex and powdered vinyl gloves were ranked lowest due to poor performance in non-compensatory criteria, particularly high allergenic potential and insufficient resistance to chemical agents. Analysis of *Table 7* further reveals the distribution of criteria weights: the criterion “permeability of substances into the glove”, with a very low weight (0.005), functions as a necessary condition rather than a discriminating criterion, whereas six key criteria with weights close to 0.11 play a dominant role in decision-making. This pattern reflects a prioritization of non-compensable risks (such as permanent allergy) over manageable criteria (such as cost, with a weight of 0.088). These findings are consistent with evidence from previous studies. Study [2] emphasizes the reduction in glove integrity after 15 minutes of use, while study [6] highlights, within its guidelines, the necessity of selecting gloves that achieve an optimal balance between protection and clinical performance. By eliminating the cognitive biases inherent in subjective methods such as AHP, the proposed framework ensures full transparency throughout the decision-making process.

Future research directions should focus on three main areas:

- I. Validation of the proposed framework in real clinical environments using measurable health outcomes (e.g., rates of bloodborne infections);
- II. Integration of Life Cycle Assessment (LCA) to evaluate the environmental sustainability of gloves and align selection strategies with SDGs;
- III. Development of dynamic models to optimize glove replacement strategies based on risk-oriented factors (such as the type of clinical activity and duration of use).

## References

- [1] Fay, M. F., Beck, W. C., Checchi, L., & Winkler, D. (1995). Gloves: New selection criteria. *Quintessence international*, 26(1), 25. <https://www.quintessence-publishing.com/deu/de/article/838308/quintessence-international/1995/01/gloves-new-selection-criteria>
- [2] Hübner, N. O., Goerdt, A. M., Mannerow, A., Pohrt, U., Heidecke, C. D., Kramer, A., & Partecke, L. I. (2013). The durability of examination gloves used on intensive care units. *BMC infectious diseases*, 13(1), 1-7. <https://doi.org/10.1186/1471-2334-13-226>
- [3] Ali, A. S., & Ali, W. Y. (2020). Proper material selection of medical gloves. *Journal of the egyptian society of tribology*, 17(4), 1–11. <https://doi.org/10.21608/jest.2020.116602>
- [4] Witzig, C. S., Foldi, C., Wörle, K., Habermehl, P., Pittroff, M., Müller, Y. K. (2020). When good intentions go bad—false positive microplastic detection caused by disposable gloves. *Environmental science & technology*, 54(19), 12164–12172. <https://doi.org/10.1021/acs.est.0c03742>
- [5] Preece, D., Lewis, R., & Carré, M. J. (2021). A critical review of the assessment of medical gloves. *Tribology - materials, surfaces & interfaces*, 15(1), 10–19. <https://doi.org/10.1080/17515831.2020.1730619>

- [6] Freitas, J., Lomba, A., Sousa, S., Gonçalves, V., Brois, P., Nunes, E., ... , & Alves, P. (2025). Consensus-based guidelines for best practices in the selection and use of examination gloves in healthcare settings. *Nursing reports (Pavia, Italy)*, 15(1), 1–13. <https://doi.org/10.3390/nursrep15010009>
- [7] Keshavarz-Ghorabae, M., Amiri, M., Zavadskas, E. K., Turskis, Z., & Antucheviciene, J. (2021). Determination of objective weights using a new method based on the removal effects of criteria (MERECE). *Symmetry*, 13(4), 525. <https://doi.org/10.3390/sym13040525>
- [8] Ghasemi, P., Ali, S. M., Abolghasemian, M., Malakoot, R. A., & Chobar, A. P. (2025). A stochastic sustainable Closed-Loop Supply Chain Networks for used solar photovoltaic systems: Meta-heuristic comparison and real case study. *Sustainable operations and computers*, 6, 15–33. <https://doi.org/10.1016/j.susoc.2024.11.001>
- [9] Abolghasemian, M., Bigdeli, H., & Shamami, N. (2024). Locating routing problem (LRP) of distribution of priority support items to ground forces in war conditions. *Engineering management and soft computing*, 10(1), 262–292. **(In Persian)**. <https://doi.org/10.22091/jemsc.2024.11320.1206>
- [10] Abolghasemian, M., Bigdeli, H., & Shamami, N. (2024). Modeling the positioning of support forces in future battles using data envelopment analysis and the principles of natural and managerial accessibility. *Defensive future studies*, 9(32), 65-98. **(In Persian)**. <https://doi.org/10.22034/dfs.2024.2007554.1720>
- [11] Sorourkhah, A., Azar, A., Babaie-Kafaki, S., Shafiei Nik Abadi, M., & Author, C. (2017). Using weighted-robustness analysis in strategy selection (case study: Saipa automotive research and innovation center). *Industrial management journal*, 9(4), 665–690. <https://doi.org/10.22059/imj.2018.247856.1007361>
- [12] Montazeri, F. Z., Sorourkhah, A., Marinković, D., & Lukovac, V. (2024). Robust-fuzzy-probabilistic optimization for a resilient, sustainable supply chain with an inventory management approach by the seller. *Big data and computing visions*, 4(2), 146–163. <https://doi.org/10.22105/bdcv.2024.481945.1208>