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# Optimal selection of respiratory mask for protection against volatile organic compounds with a multivariate decision-making approach

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**Abstract**

**Background:** Exposure to volatile organic compounds (VOCs) can impact health, affecting organs and causing various symptoms. Using a multivariate decision-making approach, this study focuses on the optimal selection of respiratory masks for protection against VOCs.

**Methods:** This research employed a multi-criteria decision-making approach to evaluate and select the optimal respiratory mask for protection against VOCs. The methodology will integrate two well-established techniques including the analytic hierarchy process (AHP) and the technique for order of preference by similarity to the ideal solution (TOPSIS). The key criteria for selecting a respiratory mask against VOCs are price, efficiency of volatile compound elimination, ease of use, and fit with the face to ensure a tight seal and prevent leakage. Based on the combined results, the respiratory mask with the highest overall score was identified.

**Results:** The highest weight (0.57) was assigned to price, followed by efficiency of VOCs elimination (0.23), ease of use (0.14), and fit with the face (0.04). Weights assigned to these criteria indicate their relative importance, with price being the most significant factor. The results highlight the prioritization of cost-effectiveness, efficiency, and user comfort in selecting the most suitable respiratory mask. The TOPSIS analysis, considering cost-effectiveness and other vital factors, identified respiratory mask number 3 as the optimal choice for workers based on the established criteria and expert opinions.

**Conclusion:** This study evaluated optimal respiratory masks to protect workers from VOCs, emphasizing a systematic, criteria-balanced personal protective equipment (PPE) selection approach for occupational needs.

**Keywords:** Respiratory masks, Personal protective equipment, Respiratory protective device, Volatile organic compounds, Multivariate decision-making

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## Introduction

Volatile organic compounds (VOCs) are a diverse group of chemicals that are emitted as gases from various sources such as paints, cleaning products, fuels, and building materials. While VOCs are present in indoor and outdoor environments, their impact on human health is a growing concern due to their potential adverse effects. Understanding the health effects of VOC exposure is essential for public health protection and effective risk management strategies (1-3). Exposure to VOCs can have a range of effects on human health, affecting different organ systems and leading to various symptoms and conditions. From respiratory irritation and headaches to neurological effects and long-term health risks, the consequences of VOC exposure are diverse and can pose significant challenges to individuals' well-being. Protecting workers from exposure to VOC vapors is crucial for ensuring their safety and well-being in various operational environments (4-6). To protect workers from respiratory exposure to harmful environmental factors including VOCs, personal protective equipment (PPE) is essential. PPE includes specialized clothing, gear, and devices designed to shield individuals from potential hazards in various work environments (7-9). A respiratory mask is a type of PPE that serves as a barrier to prevent harmful substances from entering the respiratory system, providing a crucial defense against toxic airborne pollutants. Respirators with absorbent cartridges can purify air and serve as a supplementary protective measure, especially when engineering controls are not viable. Individuals utilizing respiratory masks in contaminated environments must understand the level of protection provided by their PPE (10-12). Selecting the most suitable respirator that effectively mitigates the risks associated with VOC exposure is a complex decision-making process that requires careful consideration of multiple factors (13,14). In this context, the technique for order of preference by similarity to the ideal solution (TOPSIS) method emerges as a valuable tool for evaluating and ranking respirators based on their performance against VOC vapors. The TOPSIS approach offers a systematic framework for decision-making by considering both the benefits and drawbacks of each respirator option. By utilizing objective criteria and mathematical computations, the TOPSIS method enables workers to identify the optimal respirator that best meets their specific requirements in terms of VOC protection. TOPSIS is a robust and appropriate method for selecting the optimal mask in this study, as it effectively considers multiple criteria, assigns weights, identifies the ideal solution, and provides a clear ranking of alternatives (15-17). This research endeavors to apply the TOPSIS technique to compare and evaluate different respirators, aiming to determine the optimal choice for workers seeking protection against VOC vapors. This research can simplify the respirator selection process for workers in VOC-contaminated environments, ensuring improved safety and operational efficiency.

## Materials and Methods

This experimental study aimed to evaluate 10 different types of respiratory masks used by workers. These types of masks have been selected based on the most common use among the respiratory masks available in the Iranian market. Overall, the key selection criteria encompass market research to determine popular and available respirator models, identification of standards organizations-approved models, review of industry standards, and consultation with respiratory protection experts to identify the most suitable respirator types. The evaluation criteria included the effectiveness of respiratory masks, ease of use, fit with the face, and price of each respiratory mask. The key selection criteria for respirators include filtration efficiency, ease of use, fit, and cost. Effective filtration is paramount to protect workers from airborne contaminants. Respirators that are comfortable and simple to use are more likely to be worn properly. A tight facial seal is crucial to prevent bypass leakage. While price is a consideration, the health benefits of adequate protection should take priority. These criteria were considered according to the standards of respiratory masks as well as the opinions of experts and professors. Evaluating these factors can help identify respirators that are both effective and practical for workers. The study employed a structured approach combining multivariate decision-making techniques with the analytic hierarchy process (AHP) and TOPSIS. Data were analyzed using SPSS 19 software.

### *Evaluating the effectiveness of respiratory masks*

In the first phase of the study, the respirator cartridges used in different industries were identified and their specifications were obtained from their manufacturers and the relevant technical catalogs. In the following, a total of 10 respiratory masks commonly used for protection against VOCs were chosen and tested according to the EN 14387:2004 + A1:2008 standard (18). According to the standard, three samples of each type of cartridge were tested and their average transit time was reported as the transit time of that cartridge. The setup for evaluating and testing the performance of respiratory masks to remove VOCs was conducted according to the EN 14387:2004 + A1:2008 standard. Cyclohexane was used as a representative VOC, with a concentration of 1000 ppm and a flow rate of 15 liters per minute. The time taken for the downstream concentration to reach 10 ppm was considered the effectiveness of the respiratory mask (19,20). To determine the concentrations, a PhoCheck device was used. This device employs photoionization technology to identify a wide range of VOCs. The Tiger model detector is configured to detect total VOCs and is calibrated with isobutylene. All response variables of the device were adjusted accordingly. By selecting different gases from the device's internal list, the device can provide readings based on the desired gas parameters. All the used cartridges have a validity period without any preliminary process and in the immediate condition received the test. In Figure 1, the schematic diagram of the device for measuring the efficiency of the respiratory mask cartridge and its different parts is presented.

As can be seen in Figure 1, the air produced by the compressor first passed through particle filters and activated carbon filters to eliminate organic vapors, and after humidification by 70%, it entered the mixing chamber. The mixing chamber has three parts, the air first was monitored in terms of temperature and humidity using a temperature sensor and humidity controller, respectively. In the second part, cyclohexane was injected from a syringe pump (model HX-901A) with a specific injection rate on the heating part and was evaporated and mixed with the air entering from the first part, which is the

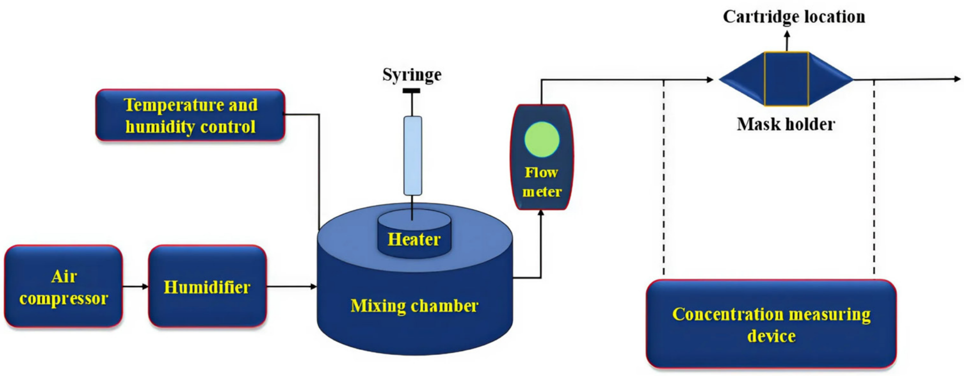


**Figure 1.** Schematic diagram of the setup designed to evaluate the effectiveness of respiratory masks

main chamber. The temperature of the heating part was set on the boiling point of the desired solvent (cyclohexane and was set at about 80 °C) and was controlled using a temperature sensor. After the air passed through the mixing chamber, it then proceeded through a flowmeter before entering the cartridge holder. To maintain a consistent airflow, a flow controller was installed at the outlet of the compressor. Additionally, the flow rate was calibrated using a wet gas meter device to ensure accuracy and precision in the measurement of airflow. This setup ensures that the air entering the cartridge holder is at a controlled and constant flow rate, allowing for reliable and reproducible results in the subsequent processes or experiments that require a specific airflow. The use of a flow controller and calibration with a wet gas meter device enhanced the reliability and accuracy of the experimental setup, providing a solid foundation for conducting further analyses or studies that depend on consistent airflow conditions.

### *Evaluating the ease of use*

Ease of use is a crucial factor in the effectiveness and user acceptance of respiratory protective equipment. The design, features, and intuitiveness of the respirator significantly impact the comfort, convenience, and ability of workers to properly don, wear, and maintain the device during work activities. Evaluating the ease of use is essential to ensure the selected respirators meet the practical needs and preferences of the employees who rely on them for respiratory protection (21,22). For this purpose, a detailed and comprehensive checklist was meticulously designed and thoroughly completed by the employees who utilized and interacted with the selected respirators regularly. The checklist was developed with input from experts in respiratory protection, ergonomics, and human factors. These experts provided valuable insights into the key factors contributing to ease of use. Additionally, a thorough review of existing literature on respirator design and user experience was conducted to identify relevant criteria for inclusion in the checklist. The feedback collected from pilot testing was carefully analyzed to identify areas where the checklist could be improved. Based on the analysis, the checklist was revised to address any identified shortcomings or inconsistencies. Observers also monitored participants to identify any issues or challenges they encountered. Finally, the process of completing the checklist was repeated three times, and the average points were considered to ensure comprehensive and reliable results. The checklist encompassed a wide range of factors, ensuring that the employees' experiences, feedback, and observations were comprehensively documented, enabling a thorough evaluation of the effectiveness and suitability of the chosen respirators in the workplace setting. Factors such as donning and doffing procedures, adjustability, and overall user-friendliness were considered to evaluate the ease of use of each respiratory mask.

### *Fit test*

Fit with the face is a critical aspect of respiratory protection. A proper, secure, and comfortable seal between the respirator and the user's face is essential to prevent unfiltered air from leaking in and ensure the intended protection level is achieved. Evaluating the fit characteristics, such as face piece size, shape, and adjustability, is necessary to confirm the respirators can be properly fitted to the diverse facial features of the workforce. In this regard, the researchers conducted a comprehensive fit test for the selected respiratory masks, ensuring a thorough evaluation of their performance and effectiveness. This rigorous assessment, which examined the fit and seal of the masks, was a critical step in the overall evaluation process. In this study, the fit test method used a qualitative saccharin-based approach, where the sweet taste of the artificial sweetener was the detection mechanism. The test procedure involves a specialized device that emits very small saccharin particles into the air. The test subject then dons the respiratory mask and performs a series of movements and activities, such as deep breathing, turning the head, bending, and talking. These simulated actions are intended to mimic the normal usage and movements a person would experience while wearing the mask (23,24). During these movements, the subject closely monitors whether they can detect the taste of the saccharin particles. If the saccharin taste is detected, it indicates that the mask is not forming a complete seal around the face and is allowing air leakage, which compromises the mask's protective capabilities and fit.

### *The price of each respiratory mask*

The price of each respiratory mask is a crucial factor to consider, as it can directly impact the organization's budget and purchasing decisions for respiratory protection equipment. While quality and performance should be the primary criteria, the per-unit cost also needs to be carefully weighed to ensure the selected respirators are affordable and sustainable within the available resources. Evaluating the sweet spot between the price points of the different respirator options is essential to achieving the best cost-benefit ratio, reconciling effective respiratory protection with the company's fiscal responsibility. For this purpose, a comprehensive price list of selected respiratory mask models was carefully curated and compiled. This detailed inventory covers a wide range of respiratory protection products, from budget-friendly options to premium high-performance units, ensuring that decision-makers have a thorough understanding of the market landscape and the associated cost implications. The compilation of this extensive price catalog can be a crucial step in the overall evaluation, as it equips the procurement team with the necessary data and insights to identify the most cost-effective respirator solutions that meet the organization's safety and functional requirements.

### *Selection of the optimal respiratory mask by AHP-TOPSIS*

The optimal respiratory mask can be effectively selected using the AHP-TOPSIS. This integrated approach enables a comprehensive evaluation of the available mask options by considering multiple criteria, such as filtration efficiency, comfort, durability, and cost, and then, ranking them based on their proximity to the ideal solution. In this study, to select the optimal respiratory mask based on the variables under study, the variables must be weighted first, and then, the best respiratory mask must be selected using the TOPSIS method. Therefore, the respiratory mask properties including the efficiency of removing volatile compounds, ease of use, fit with the face, and price of each respiratory mask were weighted according to the opinion of experts using AHP. This process was done by 13 experts who had the most knowledge and mastery of the subject. Then, the average table of all experts' opinions was calculated and the weight or importance factor of each respiratory mask feature was determined by the AHP method for the optimal respiratory mask. Then, the optimal respiratory mask for workers was selected using the TOPSIS method. Different steps of the AHP-TOPSIS approach are depicted in Figure 2 (25,26).

### *Formation of the decision matrix*

In the TOPSIS technique, N criteria (dependent variables) are used to evaluate M methods (independent variables). A score is assigned to each option based on each criterion. In this study, the scores are quantitative values obtained from experimental test results, forming an M × N decision matrix.

### *Normalizing the decision matrix*

The vector normalization method was used to normalize the values. This approach, unlike the simple linear normalization method, is based on the following equation: each row of the matrix is divided by the square root of the sum of the squares of the values in that row. This ensures that the normalized values maintain the original proportional relationships within the matrix.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

### *Forming the weighted normalized decision matrix*

The next step is to create a weighted normalized decision matrix based on the criteria weights. This is done by multiplying the normalized values in the decision matrix by the corresponding criteria weights obtained through other methods. The resulting weighted normalized matrix represents the final transformed data, incorporating both the original performance values and the relative importance of each criterion.

### *Calculation of positive and negative ideal solutions*

The criteria should be specified as either positive or negative. Positive criteria are those where higher values indicate better performance, such as product quality. For positive criteria, the ideal solution is the largest value in that column, and the anti-ideal is the smallest one.


**Figure 2.** Schematic representation of the various stages in the AHP-TOPSIS approach

Conversely, for negative criteria, where lower values are preferable, the ideal is the smallest value and the anti-ideal is the largest one.

### *Calculation of distances from positive and negative ideal solution*

In this step, the Euclidean distances of each option from the positive ideal solution (d+) and the negative ideal solution (d-) are calculated using the following equations. These distances represent how close each alternative is to the best and worst possible outcomes, respectively.

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2}$$

### *Calculation of similarity index and ranking of options*

The similarity index represents the relative score of each alternative and is calculated based on the following relationship, which considers the distances from both positive and negative ideal solutions. The alternatives can then be ranked in descending order of their similarity index values, with the highest value indicating the most preferred option.

$$CL_i^* = \frac{d_i^-}{d_i^- + d_i^+}$$

## Results

### *Evaluating respirator cartridge*

The test conditions for evaluating respirator cartridge performance, as specified in the EN 14387:2004+A1:2008 standard, are detailed in Table 1. The EN 14387:2004+A1:2008 standard is a technical standard developed by the European Committee for Standardization (CEN) that establishes the specifications and testing procedures for gas filters and combination filters used in respiratory protective equipment (18,27). This standard provides a comprehensive set of requirements and test methods to ensure the performance and safety of these filtration components, which are critical in protecting users from exposure to harmful gases, vapors, and particulates. It covers aspects such as filter classification, design, materials, resistance to airflow, and effectiveness in removing specific contaminants. The standard is widely referenced and applied across Europe to ensure the quality and reliability of respiratory protection devices used in industrial, occupational, and emergency response settings. It helps ensure a consistent level of protection and enables the evaluation and certification of filter products against established safety criteria. The efficiency evaluation results are summarized in Table 2. It is worth noting that the

cartridge names and models were withheld in this study, and each one was assigned a code for reporting the findings. To accurately determine the data, each mask code was evaluated with three repetitions, and the average was reported as the final efficiency.

### *Ease of use*

The designed checklist consisted of 29 questions; each assigned a point value. A perfect score of 29 points would be achieved if all questions were answered affirmatively. The questions on this list comprehensively assess three primary aspects of a mask: comfort, safety, and maintenance. Mask comfort is influenced by factors such as fit, materials, and weight, directly impacting user satisfaction. Mask safety is related to the quality of materials, filter efficiency, and adherence to standards. Maintenance includes proper washing, checking mask connections, and storage after use. Table 3 presents respiratory mask comfort checklist results with average scores out of 29 points for 10 different respiratory mask models. Overall, this datum provides a comparative assessment of the comfort and ease of use characteristics across the 10 different respiratory mask models, with mask number 1 being the most user-friendly option based on the criteria assessed. Mask number 1 has the highest average score of 25 out of 29, indicating it is the most comfortable and user-friendly respiratory mask. Also, masks number 5 and 6 have the lowest average scores of 15.5 and 15, respectively, indicating they are the least comfortable respiratory masks in this evaluation.

### *Fit test*

Fit test protocols are categorized into qualitative fit tests and quantitative fit tests. Quantitative fit tests employ instruments to measure the concentration of a test substance within and outside the respirator, offering a more quantitative evaluation of fit. While quantitative fit tests provide a more accurate assessment, they are often accompanied by limitations such as the need for specialized equipment, increased training requirements, and higher costs. Qualitative tests assess fit based on the taste or smell response to test agents during simulated test movements. Qualitative test results are binary-either pass (compliance factor of 100) or fail (compliance factor of 0). The compliance of mask respirators was evaluated using a qualitative method that relied on the taste of sodium saccharin. The qualitative compliance test results for the

**Table 1.** The test conditions for assessing respirator cartridge performance as per the EN 14387:2004+A1:2008 standard

| Minimum passing time under test conditions (min) | Airflow (L/min) | Input concentration (PPM) | Output concentration (PPM) | Relative humidity (%) | Temperature (°C) | Test agent |
|---|---|---|---|---|---|---|
| 70 | 15 | 1000 | 10 | 70 | 25 | Cyclohexane |

**Table 2.** The results of the performance evaluation of respiratory masks for VOCs

| Respiratory mask number | Time to pass (min) | |
|---|---|---|
| | Mean ± standard deviation | Standard |
| 1 | 129 ± 5 | 70 min |
| 2 | 110 ± 5.5 | 70 min |
| 3 | 81 ± 3.5 | 70 min |
| 4 | 90 ± 5.7 | 70 min |
| 5 | 105 ± 6.5 | 70 min |
| 6 | 71 ± 7 | 70 min |
| 7 | 109 ± 2.5 | 70 min |
| 8 | 91 ± 7 | 70 min |
| 9 | 102 ± 6 | 70 min |
| 10 | 70 ± 6 | 70 min |

**Table 3.** The results of the respiratory mask comfort assessment

| Respiratory mask comfort checklist (scores out of 29) | |
|---|---|
| Respiratory mask number | Average scores (scores out of 29) |
| 1 | 25 |
| 2 | 23 |
| 3 | 20.3 |
| 4 | 19.6 |
| 5 | 15.5 |
| 6 | 15 |
| 7 | 20 |
| 8 | 16.6 |
| 9 | 23 |
| 10 | 14 |

masks are presented in Table 4.

### *AHP-TOPSIS*

In Table 5, the weighting and importance of each studied feature, as determined by expert opinion, are presented. Price, efficiency of elimination of volatile compounds, ease of use, and fit with the face were considered of medium importance, with weights of 0.57, 0.23, 0.14, and 0.04, respectively. The assigned weights serve as a guideline for the subsequent evaluation and decision-making processes based on the specified criteria. The provided information presents the results of an analysis conducted to determine the optimal face mask for workers. The TOPSIS method was then employed to rank the available mask options based on these weighted criteria. Table 6 displays the final ranking of the optimal mask options as determined by the TOPSIS analysis. Based on the data presented in the table, the optimal mask for workers, as determined by the TOPSIS method, is the respiratory mask number 3, with a TOPSIS score of 0.8670289.

## Discussion

### *Performance of respirator cartridge*

The longest lifespan observed among the examined cartridges was 129 minutes, while the shortest one was 70 minutes. Across 10 different cartridge types analyzed, the operational lifetime of each one exceeded the minimum 70-min standard. Furthermore, a comparison of the average cartridge lifespan with the quantity of absorbent material they contained revealed a general trend - the more absorbent material present, the greater the time required for pollutants to pass through the cartridge. These results suggest that the tested cartridges perform well, exceeding the minimum lifespan requirement. Additionally, the amount of absorbent material seems to be a key factor in determining how long a cartridge lasts.

### *Comfort of respirator cartridge*

The checklist used in this study evaluated various aspects of comfort and user-friendliness, potentially including factors like breathability (How easily air can pass through the mask), weight and bulkiness (How comfortable the mask is to wear for extended periods), materials (How soft and irritation-free the mask materials are), ease of use (How easy it is to put on, take off, and adjust the mask) and so on. A total score of 29 points suggests a comprehensive checklist. A higher score indicates a mask that excels in most or all of these comfort and user-friendliness categories. The significant difference between mask number 1 (25 points) and mask number 5 and number 6 (15.5 and 15 points) suggests a substantial gap in comfort and user-friendliness. Mask number 1 performs well in most if not all, evaluated aspects. However, individual preferences may differ, for example, some people might prioritize breathability over a perfect fit.

### *Fit test*

The results showed that 4 out of 10 masks passed the qualitative fit test (masks 1, 3, 7, and 10). Also, 6 out of 10 masks failed the qualitative fit test (masks 2, 4, 5, 6, 8, and 9). The results suggest that a significant portion (60%) of the respiratory masks evaluated did not meet the required fit standards, which is an important factor in determining the level of protection they can provide to the user. Proper fit and sealing are critical for respirators to function as intended and filter out airborne contaminants effectively. The high failure rate (60%) in the qualitative fit test suggests significant room for improvement in the design, manufacturing, or user-fitting process of these respiratory masks to ensure they meet the necessary standards of protection.

### *AHP-TOPSIS*

Fit with the face, being the least weighted feature with a value of 0.04 was deemed of relatively lower importance compared to the other criteria. These weights reflect the expert consensus on the relative significance of each

**Table 4.** The results of the fit test of respiratory mask

| Respiratory mask number | Unacceptable | Acceptable |
|---|---|---|
| 1 | - | √ |
| 2 | √ | - |
| 3 | - | √ |
| 4 | √ | - |
| 5 | √ | - |
| 6 | √ | - |
| 7 | - | √ |
| 8 | √ | - |
| 9 | √ | - |
| 10 | - | √ |

**Table 5.** The weights and importance of each studied criteria

| Criteria | Price | Efficiency | Ease of use | Fit test | Weights |
|---|---|---|---|---|---|
| Price | 1 | 6.75 | 5.37 | 6.25 | 0.57 |
| Efficiency | 0.15 | 1 | 5 | 5.625 | 0.23 |
| Ease of use | 0.19 | 0.20 | 1 | 6.375 | 0.14 |
| Fit test | 0.16 | 0.18 | 0.16 | 1 | 0.04 |

feature in assessing and selecting the optimal respiratory mask for workers. The higher weights assigned to price (0.57) suggest that cost considerations play a significant role in the selection of the optimal respiratory mask. This indicates that cost-effectiveness and budget constraints are key factors influencing the decision-making process, as a higher weight implies a greater emphasis on this criterion. On the other hand, the efficiency of removal of volatile compounds, with a weight of 0.23, is also considered relatively important but to a lesser extent compared to price. This indicates that the effectiveness of the mask in removing volatile compounds is a key consideration, but it is not the sole determining factor in the decision-making process. Ease of use, with a weight of 0.14, is also deemed moderately important, highlighting the significance of user-friendliness and comfort in the selection of the respiratory mask. This factor acknowledges that the usability and convenience of the mask contribute to its overall effectiveness and user satisfaction. In contrast, fit with the face, with the lowest weight of 0.04, is considered of relatively lower importance compared to the other criteria. This suggests that while a proper fit is essential for ensuring the mask's effectiveness and comfort, it is not as critical as factors such as price, efficiency of removal, and ease of use in the decision-making process. Respiratory mask number 3 emerged as the optimal choice based on the TOPSIS method due to its superior performance in multiple key aspects, highlighting its suitability for providing effective protection against VOCs while meeting the needs and preferences of workers in such environments. The comprehensive evaluation and selection of the optimal respiratory mask using the multi-criteria decision-making

**Table 6.** Distances from ideal solutions and ranking of respiratory masks based on the evaluated criteria

| Respiratory mask number | Negative ideal (-d) | Positive ideal (+d) | TOPSIS score | Rank |
|---|---|---|---|---|
| 3 | 0.351 | 0.054 | 0.8670289 | 1 |
| 10 | 0.387 | 0.063 | 0.8602816 | 2 |
| 6 | 0.357 | 0.061 | 0.8544120 | 3 |
| 5 | 0.335 | 0.064 | 0.8398276 | 4 |
| 4 | 0.315 | 0.088 | 0.7822344 | 5 |
| 2 | 0.303 | 0.095 | 0.7603002 | 6 |
| 7 | 0.298 | 0.099 | 0.7506774 | 7 |
| 9 | 0.265 | 0.129 | 0.6733731 | 8 |
| 8 | 0.156 | 0.238 | 0.3958371 | 9 |
| 1 | 0.063 | 0.387 | 0.1397184 | 10 |

approach can significantly improve worker safety, reduce health risks, and promote effective protection against VOCs. This methodology and the resulting findings provide valuable insights for organizations and decision-makers in implementing effective VOC control measures and selecting appropriate PPE for their workforce.

## Conclusion

The optimal selection of a respiratory mask for protection against VOCs demands a thorough and systematic decision-making approach. By integrating a multivariate decision-making methodology, such as the AHP and TOPSIS, a comprehensive evaluation framework was established to prioritize key factors including price, efficiency of volatile compound removal, ease of use, and fit with the face. The AHP analysis identified price as the most critical factor in selecting respiratory masks, with a weight of 0.57, highlighting the importance of cost-effectiveness. This was followed by VOC elimination efficiency (0.23), ease of use (0.14), and fit with the face (0.04), emphasizing a balance between budget considerations and performance criteria in decision-making. The TOPSIS analysis reinforced these findings by ranking respirator mask number 3 as the optimal choice. This mask demonstrated a superior balance across all criteria, particularly excelling in cost-effectiveness and VOC elimination efficiency. The combined use of AHP and TOPSIS allowed for a comprehensive evaluation that not only highlighted the importance of price but also confirmed that high-performing respirators could still be cost-effective. Ultimately, the utilization of a multivariate decision-making approach enhances the decision-making process by providing a structured and objective method for selecting the most suitable respiratory mask. This methodology can serve as a valuable tool for health and safety professionals, enabling them to make informed decisions that prioritize both protection and user comfort in environments where exposure to VOCs is a concern. The study offers valuable insights but has limitations, including a focus on a limited range of respirator models in the Iranian market and reliance on expert judgments and subjective assessments for some criteria. Despite this, the findings are useful for organizations choosing respirators, and future research could refine the process by considering further criteria. Another point is that emerging materials and technologies are being explored to improve respiratory masks. Innovations include nanotechnology for enhanced filtration, smart cartridges with real-time monitoring sensors, antimicrobial coatings to inhibit bacterial growth, sustainable materials to reduce environmental impact, advanced filtration media for increased durability, and computational modeling to optimize design. Future studies are expected to further investigate these areas in depth.

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## Authors' contributions
**Conceptualization:** Vahid Jalili.
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**Writing–original draft:** Vahid Jalili.
**Writing–review & editing:** Somayeh Farhang Dehghan.

## Competing interests
The authors declare that they have no known competing financial interests or personal relationships.

## Ethical issues
The study was carried out in compliance with ethical guidelines (Ethical code: IR.BMSU.BAQ.REC.1402.120).

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