Respiratory Protection in Low-resource Settings; A Post-Covid Review

Evaluating the Effectiveness of Informal Face Coverings and Practical Alternatives.

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Introduction

Workers in informal and low-resource occupational settings face persistent exposure to airborne hazards, including particulate matter, silica dust, chemical vapors, and infectious aerosols that contribute to chronic respiratory disease, acute infections, and long-term morbidity (Chakraborty & Sahu, 2025; Gidi et al., 2020). Despite the recognized importance of respiratory protection, access to certified protective devices remains limited for many workers globally (National Academies of Sciences, Engineering, and Medicine [NASEM], 2021).

In the absence of formal respiratory protection programs, workers frequently rely on improvised or informal face coverings—including cloth masks, scarves, and loosely fitted barrier coverings. These practices reflect both an awareness of airborne hazards and structural constraints, including cost barriers, inconsistent supply chains, and lack of employer-provided protections (Brosseau & Stull, 2022; Ebekozien et al., 2025). Although the COVID-19 pandemic generated extensive research on mask performance, much of this work focused on infection control rather than occupational exposure. As a result, there is a need to evaluate how these findings apply to informal workers who operate outside formal occupational safety systems.

This paper examines the effectiveness of informal face coverings as respiratory protection in occupational settings. The goal is not only to assess technical performance but also to identify practical, context-appropriate strategies that can improve

worker protection in environments where certified respirators are inaccessible or unaffordable.

Problem Statement

Across informal labor sectors including construction, agriculture, sanitation and street vending, workers are routinely exposed to airborne hazards without adequate respiratory protection. These exposures include fine particulate matter, silica dust, and infectious aerosols, each associated with significant health risks. Although personal protective equipment (PPE) is widely recognized as an effective method for reducing inhalation exposure, access to certified respirators remains limited in many low-resource settings.

In practice, workers often rely on informal face coverings that vary widely in effectiveness. Post-COVID research suggests that these alternatives can provide partial protection, but their performance is inconsistent and strongly influenced by material properties, fit, and user behavior (Tomkins et al., 2025). Importantly, barrier face coverings are not considered equivalent to certified respirators and are not recommended substitutes in high-exposure occupational environments (Brosseau & Stull, 2022). This gap between ideal occupational health standards and real-world conditions underscores the need for a pragmatic evaluation of informal protective strategies.

Worker Profile

This analysis focuses on workers operating within informal and low-resource occupational settings, including sanitation and waste workers, agricultural and food production workers, construction workers and artisans, and street vendors or other informal urban laborers. These groups represent a diverse but interconnected population that shares common vulnerabilities related to occupational health and safety.

Across these sectors, workers are frequently exposed to airborne hazards in environments lacking adequate engineering controls or ventilation. Many have limited or no access to certified PPE, and even when equipment is available, supply is inconsistent or quality is unreliable. Occupational health training is often minimal, leaving workers with limited knowledge of exposure risks or proper protective practices. Weak regulatory oversight further reduces accountability for employer-provided protections.

Informal workers typically operate outside formal occupational safety systems, meaning they lack access to structured respiratory protection programs, fit testing, and medical surveillance. As NASEM (2021) notes, many nontraditional workers are either not provided respiratory protection or receive equipment without adequate training or program support. Structural barriers, including cost, limited supply chains, and weak enforcement of occupational health regulations, further restrict access to effective protective measures (Ebekozien et al., 2025). As a result, workers often rely on improvised solutions, including cloth face coverings, even in settings with significant exposure risks.

Research Questions

1. How effective are informal face coverings at reducing inhalation exposure to airborne particles?
2. Which material characteristics influence filtration performance?
3. How does fit and leakage affect real-world protection?
4. What practical strategies can improve effectiveness in low-resource settings?
5. What alternative respiratory protection options are feasible?

Methods: Literature Selection

This review synthesizes peer-reviewed articles, systematic reviews, experimental studies, and gray literature to evaluate the effectiveness of informal face coverings as respiratory protection. The literature was selected to capture both technical performance data and real-world occupational contexts. Key areas of focus included filtration efficiency, occupational exposure patterns in informal settings, PPE use and compliance, and intervention studies evaluating mask effectiveness.

Sources were selected based on their relevance to occupational exposure and applicability to low-resource environments. Emphasis was placed on studies addressing informal workers, non-healthcare populations, or settings where access to certified respirators is limited. This approach ensures that findings are grounded in the realities faced by the populations of interest rather than idealized workplace conditions.

Inclusion Criteria

Studies were included if they met the following criteria:

- Examined mask or face covering performance through filtration testing, fit assessments, or observational evaluations.
- Evaluated occupational or real-world use rather than purely theoretical or laboratory scenarios.
- Focused on informal or non-healthcare populations where access to certified PPE is limited.
- Provided measurable data related to filtration, fit, or effectiveness.

This inclusion strategy ensured that the literature captured both the technical capabilities of face coverings and the contextual factors influencing their effectiveness in practice.

Analytical Approach

Rather than summarizing individual studies in isolation, this review uses a thematic analytical approach to organize the literature into four key categories: occupational exposure and vulnerability, filtration performance, fit and leakage, and real-world implementation. This approach allows for synthesis across studies, highlighting patterns, consistencies, and contradictions within the literature. By grouping studies based on shared themes, the analysis moves beyond simple description and instead evaluates how different types of evidence contribute to a broader understanding of respiratory protection in low-resource settings.

Literature Review and Analysis: Occupational Exposure and Vulnerability

Informal workers experience disproportionately high exposure to airborne hazards due to a convergence of environmental, structural, and socioeconomic factors. Many operate in settings with elevated concentrations of dust, particulate matter, bioaerosols, and chemical vapors, often without adequate ventilation or engineering controls. These exposures are strongly associated with increased risk of chronic respiratory disease, including asthma and chronic bronchitis (Chakraborty & Sahu, 2025). Street vendors, for example, work near traffic emissions, while sanitation workers encounter bioaerosols and decomposing waste. Agricultural and construction

workers face additional risks from dust and respirable crystalline silica, particularly where mechanization and protective infrastructure are limited (Sepadi & Nkosi, 2021).

Recent studies reinforce the breadth of these risks across informal labor sectors. Muruganantham et al. (2026) found that urban street vendors exposed to traffic-related pollution reported elevated respiratory symptoms linked to prolonged outdoor exposure. Maskay and Laguiwed (2026) documented respiratory and ergonomic challenges among coffee producers in the northern Philippines, attributing these outcomes to dust exposure and limited access to protective equipment. Karajgi (2026) similarly describes informal workers as consistently experiencing elevated airborne exposures due to inadequate workplace protections and weak occupational health oversight.

Structural vulnerabilities further exacerbate these risks. Low wages, job insecurity, and lack of employer accountability limit access to PPE and reduce the likelihood of consistent protective behaviors (Ebekozien et al., 2025). Even when workers recognize hazards, PPE use remains inconsistent due to discomfort, limited availability, and weak enforcement (Adu-Gyamfi, 2025). These intersecting environmental and structural factors create a context in which exposure is both high and poorly controlled, underscoring the need for accessible and effective respiratory protection strategies.

Filtration Performance of Informal Face Coverings

A substantial body of research evaluates the filtration performance of informal face coverings, offering insight into their potential as protective tools in low-resource occupational settings. Experimental studies consistently show that cloth masks filter a portion of airborne particles, typically achieving 40–60% filtration efficiency (Tomkins et al., 2025). Medical masks generally perform slightly better, while certified respirators like N95s exceed 95% filtration efficiency.

Material composition is a critical determinant of performance. Multi-layer fabrics, tightly woven textiles, and hybrid combinations of natural and synthetic fibers improve filtration relative to single-layer cloth masks (Brosseau & Stull, 2022). Laboratory studies demonstrate that certain fabric

combinations can filter ultrafine particles at substantially higher rates than single-layer materials (Mueller et al., 2020), and that tightly woven cotton and layered constructions enhance filtration (O'Kelly et al., 2020). Freeman et al. (2022) emphasize that mask effectiveness varies widely depending on fabric type, layering, and fit.

However, many informal face coverings were originally designed for source control rather than personal protection. Early public health messaging focused on preventing outward transmission rather than reducing inhalation exposure. Although subsequent research suggests that cloth masks can provide some degree of personal protection, performance remains inconsistent and highly dependent on user behavior and environmental conditions (Enright et al., 2024). Overall, informal face coverings can reduce exposure but offer limited and variable protection in high-exposure occupational environments.

Fit and Leakage

Fit is consistently identified as the most important factor influencing real-world mask effectiveness. Even when materials provide adequate filtration, poor fit allows air to leak around the edges of the mask, substantially reducing overall protection (Tomkins et al., 2025). Unlike certified respirators, which are designed to form a tight seal, informal face coverings rely on general fit and user adjustment, resulting in gaps around the nose, cheeks, and chin. As a result, effective protection may be far lower than material filtration efficiency alone would suggest.

Several strategies including double masking, adjustable straps, and mask braces can improve fit in controlled settings. Blachere et al. (2022) demonstrated that simple modifications like knotting ear loops or using mask braces significantly reduce edge leakage. However, these interventions may be impractical in occupational environments where workers face heat, physical exertion, or communication demands.

Comfort and breathability also shape real-world use. Masks that restrict airflow or cause discomfort are less likely to be worn consistently (Brosseau & Stull, 2022). Usability studies show that workers frequently report heat, breathing resistance, fogging of eyewear, and communication challenges during

prolonged mask use (Robertson & Kortum, 2021). These barriers are particularly relevant in informal labor settings where productivity and verbal interaction are essential.

Real-World Implementation

Real-world mask effectiveness is often lower than laboratory estimates due to behavioral, environmental, and organizational factors. Improper use, inconsistent wear, and challenging working conditions all contribute to reduced protection (Enright et al., 2024). Training can improve PPE compliance, Liow et al. (2022) found that structured programs increased correct PPE use among non-healthcare workers, but knowledge alone does not guarantee sustained behavior change. Shoaib et al. (2024) observed that improved awareness did not translate into significant improvements in observed mask-wearing practices.

Studies in non-healthcare occupational environments highlight the importance of integrating respiratory protection into broader workplace health systems. Letourneau et al. (2026) identified elevated airborne contaminants in Canadian hatching egg facilities and emphasized the need for consistent respiratory protection and ventilation improvements. Cole et al. (2026) found that tunneling workers in Australia recognized respirable crystalline silica as a major hazard but reported gaps in protective practices and workplace implementation.

These findings underscore that masks are most effective when combined with other interventions. Ventilation, physical distancing, and hygiene practices significantly reduce exposure and infection risk (Cooper et al., 2023). Effective respiratory protection therefore requires a systems-level approach rather than reliance on face coverings alone.

Comparative Effectiveness Across Mask Types and Contexts

Comparative studies reveal that the effectiveness of face coverings varies widely across exposure intensities and occupational conditions. While laboratory tests position cloth masks, surgical masks, and respirators along a gradient of increasing filtration efficiency, real-world performance is highly context dependent. Cloth masks may provide meaningful protection in low-

to moderate-exposure environments but are insufficient in high-exposure settings involving fine particulate matter or respirable crystalline silica (Brosseau & Stull, 2022).

Importantly, filtration efficiency does not translate linearly into exposure reduction. A mask with 50% filtration efficiency does not necessarily reduce exposure by 50% when fit-related leakage is present. Air bypassing the filter medium can dramatically reduce effective protection, particularly during prolonged exposure.

Hybrid or modified mask configurations can improve performance. For example, combining a surgical mask with a cloth overlay or using mask braces can increase effective filtration to levels approaching higher-grade equipment in controlled settings (Enright et al., 2024). However, feasibility in informal occupational environments remains uncertain due to heat, physical strain, and limited access to replacement materials.

Behavioral and Social Determinants of Mask Use

The effectiveness of face coverings is deeply shaped by behavioral and social factors. Perceived risk strongly influences mask use: workers who recognize airborne hazards are more likely to adopt protective behaviors. Yet awareness alone is insufficient. Competing priorities—such as productivity demands, comfort, and communication—often limit adherence (Shoaib et al., 2024). In informal labor settings, where income is tied to output, workers may prioritize efficiency over safety.

Trust in protective equipment and clarity of public messaging also affect behavior. Confusion about the effectiveness of fabric masks, fueled by inconsistent messaging, has reduced long-term compliance (Freeman et al., 2022). Social norms further shape use: in workplaces where mask use is uncommon or stigmatized, individuals may avoid wearing masks despite recognizing their benefits. Conversely, peer support and normalization increase compliance.

Gender and cultural factors also influence access and acceptance. Women may face barriers related to fit or availability, and cultural perceptions of face coverings may affect adoption in regions where masks are not traditionally used outside healthcare settings.

Limitations of Current Evidence

Despite substantial research, several limitations constrain understanding of informal face coverings in occupational settings. Much of the literature originates from the COVID-19 pandemic and focuses on infection control rather than occupational exposure to dust, silica, or chemical vapors. Few studies examine informal workers in low-resource settings directly, and many rely on laboratory simulations that do not reflect real-world variability in environmental conditions, work intensity, or resource constraints.

Measurement challenges further complicate assessment. Filtration efficiency is easily measured in controlled environments, but real-world exposure reduction is more difficult to quantify. Studies often rely on proxies or modeled estimates that may not capture actual exposure. Despite their importance, behavioral factors like compliance, comfort, and correct use are seldom measured in detail, limiting understanding of real-world mask performance.

Evaluation Criteria for Future Studies

Effective respiratory protection in occupational settings can be evaluated across several key criteria. These criteria help determine not only the technical performance of face coverings but also their practicality and sustainability in low-resource environments.

Filtration efficiency reflects the ability of a material to remove airborne particles. While cloth masks may provide moderate filtration, certified respirators consistently achieve higher performance levels. Fit and seal determine whether inhaled air passes through the filtering material or leaks around the mask's edges. Even high-quality materials offer limited protection when fit is poor.

Breathability influences whether a mask can be worn consistently, particularly in physically demanding environments. Workers in informal sectors often perform strenuous labor, making comfort a critical determinant of sustained use. Accessibility reflects whether workers can obtain, replace, and maintain protective equipment. Cloth masks are generally accessible and inexpensive, but their performance varies widely.

Usability encompasses ease of donning, doffing, cleaning, and maintaining face coverings. Masks that interfere with communication, visibility, or

physical movement may be less likely to be used consistently. In addition, durability is essential for reusable face coverings, as materials that degrade quickly may provide inconsistent protection over time.

Finally, cost-effectiveness and scalability are critical considerations in low-resource settings. Higher-performing equipment may not be financially accessible, and interventions must be feasible to implement at scale. These criteria highlight the need to evaluate face coverings not only based on technical performance but also on their practicality in real-world occupational contexts.

Recommendations

Short-Term (Harm Reduction)

Short-term strategies should focus on improving the effectiveness of existing informal face coverings. This includes promoting the use of multi-layer, high-density fabrics and encouraging simple fit improvements, examples being adjustable straps or layering techniques. Basic training on proper mask use i.e. how to wear, clean, and maintain face coverings can improve effectiveness.

Integrating masks with other exposure-reduction strategies, including improved ventilation and physical distancing, can significantly enhance overall protection. These combined approaches offer practical harm-reduction benefits in settings where resources are limited.

Medium-Term

Medium-term strategies should aim to improve access to higher-quality protective equipment. This includes developing low-cost, scalable respirator options appropriate for low-resource settings and strengthening supply chains to ensure consistent availability. Worker education programs should be expanded to increase awareness of exposure risks and protective practices.

Community-based distribution systems may also improve access to PPE, particularly in informal sectors where traditional workplace distribution mechanisms are absent.

Long-Term

Long-term solutions require structural changes to occupational health systems. Strengthening regulations to ensure worker protection, expanding access to certified respiratory protection, and integrating informal workers into occupational health frameworks are essential steps.

Investments in engineering controls in particular improved ventilation, dust suppression technologies, and process modifications are critical for reducing exposure at the source. Ultimately, improving respiratory protection will require both technical innovation and systemic policy change.

Additional Considerations

Several additional factors should be considered when implementing respiratory protection strategies. Cultural norms and perceptions may influence whether face coverings are accepted or consistently used. Climate conditions, particularly heat and humidity, can affect comfort and compliance. Gender disparities may influence access to protective equipment, particularly in informal labor sectors.

Sustainability is also an important consideration, as reusable face coverings may be more feasible in low-resource settings but require proper cleaning and maintenance. These factors highlight the need for context-specific solutions that account for social, environmental, and economic conditions.

Broader Implications for Occupational Health Equity

The findings of this review have broader implications for occupational health equity. The reliance on informal face coverings in many settings reflects deeper structural inequalities in access to health and safety resources. Workers in low-resource and informal sectors often bear a disproportionate burden of exposure to environmental hazards, while having limited access to protective measures.

Addressing these disparities requires a shift from reactive to proactive approaches in occupational health. Rather than focusing solely on mitigating exposure after it occurs, efforts should prioritize preventing exposure through improved working conditions, stronger regulatory frameworks, and equitable access to resources.

This also highlights the importance of integrating occupational health into broader public health and

development initiatives. Improving respiratory protection is not only a matter of individual behavior but also of infrastructure, policy, and social systems. Interventions that address these underlying determinants are more likely to achieve sustainable improvements in worker health.

Conclusion

Informal face coverings occupy a complex and often misunderstood position within the landscape of respiratory protection. While they provide measurable reductions in exposure to airborne particles, their effectiveness is limited by variability in material performance, poor fit, and inconsistent real-world use. As a result, they cannot be considered equivalent to certified respirators, particularly in high-exposure occupational settings.

However, dismissing informal face coverings entirely overlooks their practical importance in low-resource environments. For many workers, these coverings represent the only available form of protection. When used appropriately and in combination with other interventions, they can contribute to meaningful reductions in exposure and associated health risks.

The challenge, therefore, is not simply to evaluate whether informal face coverings are effective, but to understand how they can be improved and integrated into broader exposure control strategies. This requires a nuanced approach that considers technical performance, behavioral factors, and structural constraints.

Ultimately, improving respiratory protection for informal workers will require a combination of immediate harm reduction strategies, medium-term investments in accessibility and education, and long-term structural changes to occupational health systems. By addressing these multiple dimensions, it is possible to move toward more equitable and effective protection for workers across diverse settings.

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Appendix

Study	Objective	Methods/Materials	Key Findings	Relevance to Informal Workers
Tomkins et al. (2025)	Evaluate cloth mask filtration	Cloth, medical, N95	Cloth masks: 40-60% filtration	Establishes baseline performance of informal coverings
Enright et al. (2024)	Assess real-world mask use	Observational and lab	Fit dominates performance	Reinforced need for fit-focused interventions
Blachere et al. (2022)	Test fit modifications	Braces, knots, toggles	Braces greatly reduce leakage	Low-cost improvements feasible in informal settings
Freeman et al. (2022)	Compare fabric constructions	Cotton, synthetics, hybrids	Layering improves filtration	Supports hybrid fabric recommendations
Brosseau & Stull (2022)	Review cloth mask performance	Literature review	Cloth masks inconsistent	Highlights limitations in high-exposure settings
Cooper et al. (2023)	Evaluate combined controls	Ventilation and masks	Combined strategies reduce exposure	Supports layered protection approach
Robertson & Kortum (2021)	Study usability barriers	Surveys and interviews	Heat, fogging, discomfort reduce use	Critical for informal labor environments
Shoaib et al. (2024)	Examine training impacts	PPE training intervention	Knowledge increased but behavior remained unchanged	Shows limits of training alone
Liow et al. (2022)	Evaluate PPE training	Non-healthcare workers	Training improves correct use	Supports WHWB training programs
Murugananthan et al. (2026)	Street vendor exposures	Field measurements	High PM exposure; mask use inconsistent	Demonstrates occupational need
Maskay & Laguiwed (2026)	Agricultural dust exposure	Field study	Dust exposure + limited PPE	Reinforces vulnerability of informal workers

Karajgi (2026)	Informal worker exposures	Cross-sector review	High airborne contaminants	Supports need for accessible protection
Zangmeister et al. (2020)	Filtration of nanoscale aerosols	Cotton, synthetics	High-thread cotton performs well	Adds nuance to material selection
Pan et al. (2021)	Inward vs. outward protection	Cloth, surgical, N95	Cloth better for source control	Important distinction for occupational settings
Howard et. al (2021)	Global mask evidence review	Meta-analysis	Fit and comfort drive compliance	Supports behavioral section
Van der Westhuizen et al (2020)	Social perceptions of masks	Behavioral analysis	Social norms shape use	Relevant for informal labor uptake of mask interventions
Konda et al. (2020)	Filtration of common fabrics	Cotton, silk, chiffon	Hybrid fabrics highly effective	Supports hybrid fabric recommendations
Drewnick et al. (2021)	Household materials testing	> 20 materials	Leaks reduce efficiency by 60%	Reinforce importance of seal