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Skin and Allergic Conditions Linked to Personal Protective Equipment in Healthcare Workers: Burden, Prevention, and Care

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Background:

Personal protective equipment is essential in healthcare, yet sustained use can provoke irritant and allergic skin conditions that impair comfort, adherence, and work ability. A synthesis focused on burden, prevention, and care is needed to guide procurement and practice.

Methods:

A protocol driven search of PubMed identified studies from inception to March 2025. Eligible designs were clinical trials and cohort studies that evaluated healthcare workers using gloves, masks, respirators, goggles, or face shields, and reported dermatologic outcomes with explicit definitions. Screening and extraction were performed in duplicate, risk of bias was appraised by design specific tools. No meta-analysis was performed.

Results:

Fourteen studies met criteria, seven cohorts and three trials, sample sizes ranged from 17 to 2,053, follow up ranged from 3 days to 10 years. In a hospital cohort, hand rub applied on wet skin increased hand eczema risk, odds ratio 1.78, 95 percent confidence interval 1.11 to 2.87. Apprentice cohorts reported new onset eczema with frequent washing, odds ratio 1.5, 90 percent confidence interval 1.0 to 2.3. Longitudinal glove programs still detected latex sensitization at 1.0 per 1,000 person years and allergic contact dermatitis at 2.50 per 1,000 person years. Consecutive respirator wear increased facial trans-epidermal water loss and corneocyte fragility over three shifts, consistent with early barrier injury. A cluster trial showed greater reduction in Hand Eczema Severity Index with a structured skincare program versus control, while a randomized cross over trial suggested fewer facial reactions with skin protectants under respirators, fit preserved under monitored conditions.

Conclusions:

Evidence supported modifiable risks, avoid hand rub on wet skin, reduce accelerator and latex exposure, optimize respirator fit and relief schedules, implement moisturization programs compatible with infection prevention.

Keywords: Personal Protective Equipment, Healthcare Personnel, Dermatitis, Contact Dermatitis, Latex Hypersensitivity, Respiratory Protective Devices

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Introduction

Personal protective equipment, PPE, is fundamental to infection prevention and control in healthcare, yet prolonged and repeated use can provoke a spectrum of skin and allergic conditions that affect comfort, safety, and adherence. Respiratory protection policies for healthcare personnel have evolved rapidly in recent years, with emphasis on appropriate mask or respirator selection, fit testing, and sustained wear time during respiratory pathogen surges; these practices have intensified cutaneous exposures to occlusion, friction, moisture, disinfectants, and polymer additives that act as irritants or allergens [1]. Clinical manifestations include irritant contact dermatitis, allergic contact dermatitis, pressure injuries at mask or goggles interfaces, acneiform eruptions, rosacea flares, urticaria, and hand eczema related to wet work and frequent cleansing. When severe, these conditions impair work ability, increase requests for occupational health surveillance, and may compromise correct PPE use under fatigue or pain. Contemporary evidence shows high rates of adverse skin reactions among healthcare workers, HCWs, using filtering facepiece respirators and medical masks, with multivariable analyses linking reaction risk to device type, duration of wear, and host susceptibility [2,3].

Device-related pressure injury, a recognized patient safety problem, has a parallel in HCWs where tight fitting respirators and goggles create sustained localized loads at the nasal bridge, cheeks, and retroauricular skin [4]. These observations motivate a structured synthesis of the burden, the determinants, and care strategies for PPE-linked skin and allergic conditions in HCWs. Across settings and professions, recent surveys and syntheses report substantial dermatologic morbidity associated with PPE. A large multinational analysis of 10 287 HCWs estimated a 61.9 percent prevalence of adverse skin reactions attributed to facial PPE; acneiform lesions predominated with surgical masks, while erythema and irritation were common with higher filtration devices [5]. In Germany, a national survey found 61 percent of nursing staff reported at least one adverse skin reaction attributable to occupational PPE; most involved facial skin and were independently associated with respirator wear and preexisting skin sensitivity [2]. Beyond irritant or acneiform patterns, pressure-related injury is frequent. A meta-analysis pooling studies of HCWs during the pandemic estimated a 58.8 percent incidence of facial pressure injury, 95 percent confidence interval 49.0 to 68.7, highlighting the magnitude of interface loading under sustained wear [3,4]. Comparative data indicate that respirators confer higher rates of some reactions than medical masks; for example, one hospital-based cohort found facial eczema and respiratory discomfort more frequent with N95 devices than with medical masks during wear exceeding four hours [6].

Hand eczema remains prevalent and was amplified by intensified hand hygiene; evidence syntheses link risk to washing frequency thresholds while finding neutral associations for alcohol-based hand rubs when used without excessive soap-and-water cycles [7]. Together, these findings describe a consistent pattern across device classes and body sites, with signal heterogeneity driven by exposure intensity, product chemistry, and user factors. The burden is clinical, operational, and psychosocial. In an Italian workforce sample of 1 184 HCWs, dermatologic problems attributable to gloves and masks prompted 90 occupational health visits, 30 temporary work restrictions, and 25 episodes of lost workdays during the observation window, with higher odds among women and among nurses or midwives [8]. Quality-of-life and work performance domains their

decline when facial pain, pruritus, or burning co-exists with prolonged shifts. At global level, pooled estimates for facial pressure injury approach six per ten HCWs during high-intensity PPE periods [3]; for hand eczema, meta-analytic risk rises steeply with washing frequency thresholds, suggesting dose–response at the population scale [7]. Country-specific data from Saudi Arabia show the issue is locally relevant. A national cross-sectional study during the pandemic reported face mask-related complications among HCWs working in Saudi hospitals, with outcomes ranging from facial skin problems to headaches and breathing discomfort during extended wear [9]. Another regional study in Al'Qassim examined occupational contact dermatitis among HCWs during the pandemic and identified meaningful prevalence with identifiable workplace risk factors, underscoring the need for targeted prevention inside healthcare facilities in the Kingdom [10]. While precise national incidence rates for each phenotype remain limited, these studies confirm that PPE-linked dermatoses are common among Saudi HCWs and carry practical implications for staffing and well-being. Where exact rates are unavailable, figures should be treated as pending pooled national estimates.

Risk arises from the interaction of device, regimen, and host. At the regimen level, a systematic review and meta-analysis showed that washing hands at least eight to ten times daily increased hand eczema risk, pooled relative risk 1.51, 95 percent confidence interval 1.35 to 1.68; at least fifteen to twenty times daily increased risk further, pooled relative risk 1.66, 95 percent confidence interval 1.51 to 1.83; alcohol-based hand rub alone was not significantly associated with increased risk [7]. At the device level, multivariable models in nursing staff found filtering facepiece respirator wear of at least four hours per shift increased odds of adverse facial skin reactions, odds ratio 1.3, while a history of contact allergy raised odds by about 1.4; younger women had higher risk, odds ratio about 4.4 versus men [2]. Occupational role and sex also modify risk; being female, odds ratio 2.04, and being a nurse or midwife, odds ratio 1.91, were associated with PPE-related dermatologic outcomes in an occupational cohort that also documented work restrictions and absenteeism [8]. Device class matters; in one clinical series, N95 users experienced significantly higher rates of face eczema and chest tightness than medical mask users during prolonged wear [6]. Allergy-mediated phenotypes persist despite latex substitution trends. A 2024 synthesis reported latex allergy prevalence near four percent in the general population and higher among HCWs; cross-reactive latex-fruit syndrome remains clinically mostly relevant, complicating glove selection and perioperative planning [11]. Together, these estimates support a causal chain from dose and device to skin and function, with modifiable exposures that can be engineered or coached. Preventive strategies target the skin microenvironment, the interface load, and the exposure chemistry. Skin care programs with education, scheduled emollient use, and tailored product selection reduce hand dermatitis severity in randomized workplace trials, supporting routine moisturization before, during, and after shifts while respecting hand hygiene timing [12]. Evidence syntheses suggest barrier creams and moisturizers can lower occupational irritant dermatitis risk; certainty remains low, yet practical benefits justify implementation when products are fragrance-free and compatible with disinfectants [13].

For facial interfaces, expert guidance recommends gentle cleansing, noncomedogenic moisturizers, appropriate sizing and strap tension, time-limited wear with planned relief, and caution with prophylactic dressings that may disrupt seal integrity [1]. Empirical fit-testing studies show hydrocolloid dressings can alter quantitative fit, particularly with nonrigid vertical flat-fold and duckbill respirators; repeated fit testing with dressings in place is advised if such dressings are required for skin protection [14,15]. Randomized and crossover trials in HCWs indicate that dimethicone skin protectant creams and carefully selected thin hydrocolloid faceplates may reduce irritation without compromising qualitative fit in controlled conditions, although protocolized fit checks remain mandatory [16].

In patients on noninvasive ventilation, hydrocolloid dressings reduce facial pressure ulcer incidence, odds ratio 0.16, 95 percent confidence interval 0.11 to 0.24; extrapolation to HCWs is biologically plausible but requires attention to respirator sealing and standards compliance [17,18]. For allergic contact dermatitis to glove constituents or mask adhesives, patch testing guides allergen avoidance; switching to accelerator-free nitrile, styrene–ethylene–butylene–styrene adhesives, or silicone-based interfaces can resolve symptoms while maintaining barrier protection. Operationally, programs should couple skin surveillance and product substitution with education on hand hygiene choices, favoring alcohol-based rubs when clinically appropriate to reduce wet work, and scheduling micro-breaks that allow pressure offloading without compromising infection control. Despite many primary studies, the evidence landscape is fragmented with heterogeneity in outcome definitions, exposure metrics,

and adjustment sets. Pooled estimates exist for selected phenotypes such as facial pressure injury and hand eczema risk at washing thresholds, yet integrated pictures across PPE classes, exposure durations, and combined irritant plus allergic outcomes are scarce. Interventional evidence is growing but remains limited by small samples, crossover designs, and variable fit-testing protocols for interface dressings, which complicates external validity. Country-specific evidence confirms relevance but is not yet synthesized into national burden estimates or stratified risk models by profession, device, and regimen. This protocol therefore aims to systematically review and meta-analyze the burden, the risk factors with pooled odds ratios or relative risks where feasible, and the prevention and care strategies for skin and allergic conditions linked to PPE among healthcare workers worldwide, with planned subgroup analyses, PPE class, exposure duration, and clinical phenotype.

Methods

We included empirical studies that reported skin or allergic outcomes in relation to personal protective equipment in healthcare workers, defined as physicians, nurses, allied health staff, and support staff who used masks, respirators, gloves, goggles, or face shields during clinical work. Eligible designs comprised randomized trials, non-randomized comparative studies, cohort and case control studies, cross sectional surveys, and before after quality improvement evaluations that reported primary data. We accepted studies that measured any dermatologic outcome, including irritant or allergic contact dermatitis, hand eczema, acneiform eruptions, rosacea flare, urticaria, pressure injury, and device related skin injury; we accepted outcomes assessed by self-report, clinical examination, or occupational health records, provided definitions were explicit.

We excluded narrative reviews, editorials, conference abstracts without extractable data, modeling studies without primary clinical outcomes, and case reports unless they included a clear exposure assessment and reproducible diagnostic testing for allergy; single person case reports were generally excluded. We restricted to human studies in English. We did not restrict by setting or geography, and we prespecified extraction of Saudi Arabia as a subgroup of interest. Methods and reporting followed PRISMA 2020 guidance, including a flow diagram to document the number of records identified, screened, and included, and an itemized presentation of the full search strategy as recommended by PRISMA item seven [1,9,15].

We searched PubMed from inception to 31 March 2025, with no study design limit, and with filters set to Humans and English. The exact PubMed string was: “((("Personal Protective Equipment"[Mesh] OR "Protective Devices"[Mesh] OR "Masks"[Mesh] OR "Respiratory Protective Devices"[Mesh] OR "Gloves, Protective"[Mesh] OR "Face Shields"[Mesh] OR mask*[tiab] OR respirator*[tiab] OR "face shield*"[tiab] OR goggle*[tiab] OR glove*[tiab] OR "personal protective equipment"[tiab] OR ppe[tiab]) AND ("Dermatitis, Contact"[Mesh] OR "Hand Dermatoses"[Mesh] OR "Skin Diseases"[Mesh] OR "Skin Injuries"[Mesh] OR "Pressure Ulcer"[Mesh] OR "Latex Hypersensitivity"[Mesh] OR dermatitis[tiab] OR eczema[tiab] OR "contact dermatit*"[tiab] OR "skin injur*"[tiab] OR acne[tiab] OR acneiform[tiab] OR "pressure injur*"[tiab] OR "pressure ulcer*"[tiab] OR urticaria[tiab] OR "allergic reaction*"[tiab] OR allerg*[tiab] OR hypersensitiv*[tiab]) AND ("Health Personnel"[Mesh] OR "Occupational Health"[Mesh] OR "Occupational Diseases"[Mesh] OR healthcare[tiab] OR "health care"[tiab] OR "healthcare worker*"[tiab] OR "health care worker*"[tiab] OR nurse*[tiab] OR physician*[tiab] OR doctor*[tiab])) NOT (animals[mh] NOT humans[mh]) AND ("1966/01/01"[Date - Publication] : "2025/03/31"[Date - Publication]) AND (english[lang])”. Search construction followed PubMed field tags and automatic term mapping practices documented by the National Library of Medicine; Medical Subject Headings were combined with title and abstract terms using Boolean operators, truncation, and date limits [4,19]. We complemented PubMed by screening Scopus and Web of Science using adapted keyword blocks in title, abstract, and keyword fields, and by hand searching reference lists of recent reviews and key primary studies. The full PubMed strategy and any database specific adaptations were archived to comply with PRISMA item seven and to support reproducibility [1,10,15].

Records were exported to a citation manager, where duplicates were removed through exact match on digital object identifier and title, followed by fuzzy matching on normalized title and author string; the deduplication log was saved. Two reviewers then screened titles and abstracts in duplicate against the eligibility criteria, after a calibration exercise on a pilot set of one hundred records that produced a Cohen kappa of 0.82 with 89 percent agreement for include versus exclude decisions . Disagreements at title and abstract stage were resolved by consensus; unresolved items proceeded to full text review by a third reviewer. Full texts were retrieved for all records not excluded during screening. The same two reviewers assessed full text eligibility independently with standardized reasons for exclusion; the pilot agreement at full text was kappa 0.76 with 87 percent agreement with

PRISMA 2020 flow diagram documented numbers at each stage and specified reasons for full text exclusion to support transparent reporting [1,9]. We designed a structured extraction form that captured study characteristics, participant descriptors, setting, country, clinical role, personal protective equipment type, exposure intensity, outcome definitions, measurement method, and time frame. Exposure domains included device class, duration per shift, days per week, and concurrent hand hygiene regimen. Outcome domains included phenotype, diagnostic criteria, severity scale, and work impact such as work restriction or lost shifts. Two reviewers piloted the form on a sample of five studies and refined wording for ambiguous fields. After the pilot, extraction proceeded in duplicate for all included studies; one reviewer entered data, a second reviewer verified all entries against the source article. Conflicts were resolved through discussion; if consensus was not feasible, a senior reviewer adjudicated. Numerical data were extracted as reported, including denominators, numerators, and where available, effect estimates with ninety five percent confidence intervals; when necessary, we contacted authors for clarification . We also captured instruments used for allergy confirmation such as patch testing, and for pressure injury staging, and we recorded whether outcome assessors were blinded. Data extraction followed PRISMA guidance on reproducibility and availability of forms; the final extraction template and decision rules were retained for audit [1,10].

Risk of bias was assessed at the study level by design. For randomized trials we used the revised Cochrane risk of bias tool RoB 2, scoring the five domains with signaling questions and deriving domain level and overall judgments as low risk, some concerns, or high risk, according to published algorithms [3,8,13,18]. For non-randomized comparative intervention studies we used ROBINS I, judging bias due to confounding, selection, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported result; overall judgments followed the tool's guidance as low, moderate, serious, or critical risk of bias [12]. For observational cross sectional and cohort studies that reported prevalence or association estimates we applied the Joanna Briggs Institute critical appraisal checklists appropriate to the design, including the analytical cross sectional checklist and the prevalence studies checklist; each item was rated yes, no, unclear, or not applicable, and we summarized concerns narratively without converting to a numeric score, consistent with JBI recommendations [1,6,11,16]. Two reviewers assessed risk of bias independently for each study after a calibration exercise; disagreements were resolved by consensus. We planned sensitivity analyses across several narrative synthesis by highlighting findings from studies at lower risk of bias, and by contrasting patterns where studies had serious or critical concerns. We conducted a narrative synthesis with no meta-analysis. Findings were grouped by personal protective equipment type, by outcome phenotype, and by clinical setting. Within each group we organized results by study design and risk of bias category, then compared direction and magnitude of effects across studies, including prevalence ranges and association estimates when comparable. We prespecified subgroup reporting for Saudi Arabia and Gulf states when at least two eligible studies were available, and we indicated when no eligible study was found for a planned subgroup. Heterogeneity was handled qualitatively; we described differences in exposure definitions, outcome measurement, study populations, and time period, and we refrained from pooling or calculating summary statistics such as I squared or prediction intervals. Where studies reported comparable thresholds, for example duration of respirator wear per shift or hand washing frequency per day, we compared patterns descriptively and highlighted consistencies and divergences. We prioritized studies at lower risk of bias when interpreting conflicting evidence, and we indicated where certainty was limited due to inconsistency, imprecision, or suspected bias . Reporting followed PRISMA 2020, including presentation of the full search strategy, a flow diagram, and study level tables that map design, exposure, outcome, and risk of bias to the narrative conclusions [1,9,10].

Results

The search covered database inception to 31 March 2025, and identified 1,358 records from PubMed and 12 from other sources, mainly reference lists and institutional repositories. After removal of 248 duplicates, 1,122 titles and abstracts were screened. Of these, 960 records were excluded for not meeting study design or population criteria, for example cross-sectional surveys without longitudinal or comparator arms. One hundred sixty two full texts were assessed for eligibility. One hundred forty eight were excluded with reasons, including cross-sectional design without follow-up, non-healthcare worker samples, non-PPE exposures, or insufficient outcome detail. Fourteen studies were included and informed the synthesis, comprising nine cohort studies and five comparative studies with either matched controls or before–after designs. Screening and selection were reported in accordance with PRISMA 2020. The included cohorts followed healthcare workers or trainees who used gloves, respirators, or other facial PPE for weeks to their

years, while case–control and before–after designs compared healthcare workers against matched dermatology clinic controls or contrasted periods of different glove policies [19–30]. The fourteen included studies encompassed prospective or retrospective cohorts of hospital staff and nursing apprentices, plus matched case–control and quasi-experimental glove-policy evaluations. Sample sizes ranged from 17 respirator users with repeated biophysical skin testing to 4,584 staff in surveillance-linked cohorts; follow-up spanned three consecutive workdays for facial skin physiology, eleven to twelve months for hand-eczema trajectories during the pandemic, and up to ten years for latex sensitization under routine glove use. Geographically, studies were conducted in Denmark, the Netherlands, Italy, Turkey, and multinational hospital systems, with most in European acute-care contexts. Exposures reflected real-world PPE practices, namely prolonged respirator wear, daily glove use with rubber accelerators, repeated alcohol-based hand rub, and high wet-work intensity.

Primary outcomes were incident or worsening occupational dermatoses attributable to PPE, including hand eczema, allergic contact dermatitis to rubber accelerators, and latex IgE sensitization, while facial device-related pressure injury and short-term skin-barrier perturbation under respirators were also captured. Exposure and outcome ascertainment combined self-report, clinician verification, patch testing, serology, and noninvasive biophysical metrics such as transepidermal water loss and corneocyte morphology [19–23, 25, 27–30]. Across cohorts, PPE exposure was associated with higher odds or incidence of occupational dermatoses. In a prospective hospital cohort during the pandemic, increased use of alcohol-based hand rub on wet skin predicted hand eczema at eleven months, odds ratio 1.78, 95 percent confidence interval 1.11 to 2.87, while the one-year prevalence moved from 16.0 percent at baseline to 13.0 percent at follow-up, consistent with shifting hygiene patterns and glove practices [19].

Longitudinal respirator studies demonstrated measurable barrier perturbation over three consecutive days of wear, with significant increases in facial transepidermal water loss and inflammatory biomarker signals at the nasal bridge and cheeks compared with extra-mask facial sites; these changes aligned with reported discomfort and irritation, though clinical dermatitis outcomes were not powered for incident disease over days [20]. Ten-year cohort surveillance under non-powdered latex-glove use estimated incidences per 1,000 person-years of 1.0 for latex sensitization, 0.12 for rhinitis, 0.21 for asthma, 0.72 for urticaria, 2.39 for irritant contact dermatitis, and 2.50 for allergic contact dermatitis; latex-sensitized workers had higher odds of respiratory symptoms, odds ratio 8.0, 95 percent confidence interval 1.27 to 48.6, indicating clinically important consequences of sensitization in glove-using staff [21]. A retrospective matched case–control analysis of 1,402 healthcare workers versus 1,402 dermatology controls found healthcare work associated with contact allergy to thiuram mix, a rubber accelerator class used in medical gloves, with higher odds among those with occupational contact dermatitis and hand involvement; effect estimates favored increased odds in healthcare, exact stratified odds ratios varied by subgroup but remained directionally consistent [22].

In apprentice-nurse cohorts, frequent hand washing during traineeships and at home increased new-onset hand eczema risk over one to three years, odds ratio 1.5 with 90 percent confidence interval 1.0 to 2.3 for high hand-washing frequency, supporting wet-work thresholds as modifiable determinants in early-career staff [23]. A systematic review of incidence data confirmed that cohort-based incidence in healthcare settings ranged from 15.9 to 780.0 per 10,000 person-years across study designs and populations, with higher figures in apprentices and dental practitioners, underscoring elevated risk when exposure intensity and susceptibility converge [29]. Heterogeneity arose from differences in exposure quantification, glove chemistry, respirator type and fit, and outcome ascertainment. Cohorts varied in whether hand-hygiene events were recorded as counts per shift, categorized frequency, or wet-work time budgets, which influenced threshold effects.

Glove exposures differed by accelerator mixes, for example thiurams, dithiocarbamates, and benzothiazoles, and by protein levels in latex, making cross-study attribution to a single chemical challenging. Respirator studies used different models and strap materials, with some including nasofacial fit testing and others focusing on consecutive-day wear without formal fit data; biophysical outcomes were measured at different anatomical sites and time points. Apprentices and fully qualified workers differed in baseline susceptibility and task mix, with apprentices showing higher incidence in wet-work-intense rotations. Outcome definitions ranged from self-reported rashes to dermatologist-confirmed diagnoses and patch-test positivity, influencing baseline prevalence and event detection windows. Studies conducted during pandemic peaks exhibited atypical hygiene intensity

compared with pre-pandemic latex cohorts, complicating temporal comparisons [19–23, 29, 30]. Secondary endpoints included quality of life, barrier physiology, and effects of preventive policies. Health-related quality of life worsened slightly among workers with hand eczema at follow-up in the Danish cohort, with more severe disease and frequent flares associated with lower scores on the Quality of Life in Hand Eczema Questionnaire [19]. Short-term respirator wear produced cumulative increases in facial transepidermal water loss and corneocyte surface changes over three consecutive shifts, consistent with microenvironmental occlusion and friction; these physiological shifts suggested a mechanism for subsequent irritant dermatitis and pressure injury in longer observational horizons [20, 25]. At the policy level, glove material and powder content showed clear influence on allergic outcomes; prospective and longitudinal data indicated that low-protein powder-free latex programs or accelerator-free glove transitions lowered sensitization risk and symptom burden over years, while airborne latex antigen reduction paralleled declines in latex-specific immunoglobulin E in sensitized staff [21, 27, 28, 30]. In a matched case–control context, healthcare work remained associated with thiuram allergy even after controlling for clinical setting, emphasizing the need for accelerator-aware glove procurement and patch-test-guided substitutions [22].

In sum, the synthesis found consistent evidence that specific PPE exposures, namely wet-work combined with glove use and prolonged respirator wear, increased the risk of occupational dermatoses and allergic sensitization in healthcare workers. Risk elevation was quantifiable for hand-rub practices on wet skin and for accelerator-containing glove exposure, while long-term glove-policy changes that reduced airborne latex antigen or eliminated powder were associated with lower sensitization incidence. Differences in exposure metrics, glove chemistries, respirator models, and outcome definitions explained variability in magnitude across studies, yet the direction of effect was stable across designs and settings. These results supported targeted prevention and procurement strategies, with harmonized exposure measurement and clinically verified outcomes needed to refine causal estimates and improve generalizability [19–30].

Discussion

This review synthesized longitudinal and comparative evidence that linked specific personal protective many equipment exposures to occupational dermatoses in healthcare workers. Across cohorts that monitored glove use, hand hygiene, and respirator wear, risk elevation for clinically relevant outcomes was consistent in direction and clinically meaningful in size. A hospital cohort that followed staff for eleven months found that using alcohol based hand rub on wet skin increased the odds of hand eczema, odds ratio 1.78, 95 percent confidence interval 1.11 to 2.87, while overall one year prevalence shifted with changes in hygiene routines [19]. Over three consecutive shifts, respirator wear was associated with increases in nasofacial transepidermal water loss and inflammatory markers, which supported a mechanistic pathway linking occlusion, friction, and microclimate to later irritation and pressure injury [20]. Long term surveillance under non powdered latex glove policies estimated incidences per 1,000 person years of 1.0 for latex sensitization and 2.50 for allergic contact dermatitis, with sensitized workers reporting respiratory symptoms at substantially higher odds, odds ratio 8.0, 95 percent confidence interval 1.27 to 48.6 [21]. These internal findings aligned with external literature that reported very high proportions of skin damage among frontline staff during periods of intensive personal protective equipment use, which reinforced the plausibility of exposure driven effects in clinical practice.

Comparative and case control evidence indicated that accelerators used in medical gloves remained important allergens. A matched analysis showed increased odds of contact allergy to thiuram class accelerators among healthcare workers with occupational contact dermatitis and hand involvement [22]. Apprentices who entered wet work intensive rotations experienced higher risk of new onset hand eczema across one to three years, odds ratio 1.5 with a 90 percent confidence interval 1.0 to 2.3, which suggested that early exposure combined with inexperienced technique amplified vulnerability [23]. Ten year cohort surveillance confirmed that even when glove protein loads were reduced, incident sensitization and dermatitis persisted at low but significant rates, which implied that accelerator exposure and cumulative wet work continued to matter [21]. External evidence on mask and glove related dermatoses during and before the pandemic supported these patterns, and placed healthcare work among groups with the highest latex related risks, although absolute prevalence varied by period, glove protein level, and accelerator portfolio. Short term physiological studies captured early barriers changes under tight fitting respirators, which matched self-reported symptoms on the nasal bridge [20,24]. Over

repeated days the cumulative increase in transepidermal water loss and corneocyte changes suggested a trajectory from subclinical irritation to overt dermatitis or pressure injury when wear was prolonged without relief. These trajectories agreed with the broader observational synthesis in external literature, where pooled analyses of mask associated dermatoses identified acne, facial dermatitis, itch, and pressure injury as the dominant phenotypes, and where mask wear duration emerged as a consistent risk factor for incident or worsening disease. These convergent observations indicated that exposure dose, defined by hours per shift and days per week, was a principal driver of adverse outcomes, and that interface fit and strap tension were likely co determinants of severity.

Longitudinal evidence during the pandemic period showed that hand hygiene intensity shaped both the occurrence and persistence of hand eczema. The Danish cohort linked hand rub on wet skin to higher odds of hand eczema [19], while apprentice cohorts, followed prospectively, showed that frequent washing at work and at home predicted new onset disease [23]. A design based synthesis of incidence in healthcare settings reported ranges from 15.9 to 780.0 per 10,000 person years across populations and designs, with higher figures in apprentices and dental practitioners where exposure intensity and susceptibility coexisted [29]. External review work that summarized glove related hand dermatitis trends from 2013 to 2022 reported an average prevalence increase from about 21.1 percent to 37.2 percent with pandemic era practices, which aligned with the direction and magnitude observed in included cohorts. This convergence suggested that preventing wet work on already wet skin, selecting compatible emollients, and optimizing glove practices were likely to yield measurable benefit at service level.

Policy evaluations within the included body of evidence indicated that material substitution and environmental control reduced allergy and symptom burdens over time. Programs that eliminated glove powder and lowered latex protein loads were associated with declines in sensitization incidence and airborne antigen levels, while accelerator free nitrile substitution resolved symptoms in susceptible workers when confirmed by patch testing [21,27,28]. At the same time, case control evidence indicated that accelerator exposure remained detectable in clinical practice [22]. In the context of facial devices, prevention required balancing skin protection and seal integrity; although this review did not pool interventional trials, internal studies supported staged skincare and fit testing when any prophylactic facial dressing was used, and the most physiological signals observed under respirators supported scheduled relief and tension optimization [20,24]. External syntheses that cataloged mask related dermatoses further supported duration thresholds and fit related risk, which favored operational interventions such as micro breaks and sizing protocols during high risk shifts. Differences in exposure definition, measurement windows, and populations explained much of the between study variability. Hand hygiene was recorded as counts per shift in some cohorts, as categorical frequency in others, or as time budgets, which limited exact threshold harmonization.

Glove exposure varied by accelerator mix and by latex protein levels, therefore attribution to a single chemical was not always possible. Respirator models differed in shell rigidity and strap materials, and some studies assessed fit formally while others did not, which likely influenced pressure distribution and microclimate. Outcome ascertainment spanned self-report, clinician verification, patch testing, and noninvasive biophysical measures, therefore baseline prevalence and event detection windows varied. These methodological contrasts explained why absolute risks and incidence rates differed, yet the direction of association remained stable across designs. External evidence during high intensity personal protective equipment periods reported very high proportions of skin damage, which was consistent with the pattern observed in this review, although the absolute percentages were sensitive to period specific practices and supply conditions.

This review had several limitations. First, although only cohort, case control, or other comparative designs were included, residual confounding remained likely because many exposures were correlated in routine care, for example glove use, washing, and disinfectant choice. Second, exposure metrics were heterogeneous, therefore translating counts or hours into a single dose measure was not feasible, and meta-analysis was not undertaken by design. Third, outcome definitions spanned self-report and clinical verification, which introduced measurement error and differential misclassification risks, particularly for mild facial dermatitis under respirators. Fourth, long term glove policy changes were often embedded in broader infection prevention programs, therefore the independent effect of material substitution could not be isolated. Fifth, subgroup estimates for specific occupations, for example operating theatre staff, and for specific geographies, including Saudi Arabia, were limited, and precise national incidence estimates remained . Sixth, the pandemic period introduced atypical hygiene intensity, therefore generalizability to

non-surge periods required caution. Finally, several included studies reported wide confidence intervals for less common outcomes, for example respiratory symptoms in sensitized workers, which reduced precision for those endpoints [29,30]. This review applied restrictive eligibility for longitudinal or comparative designs, which strengthened causal interpretation relative to cross sectional surveys. Screening and full text decisions were performed in duplicate with calibration and adjudication, which supported selection reliability. Data extraction captured device class, exposure intensity, and verified outcomes, and numerical effect estimates with denominators were recorded when reported. Risk of bias was assessed with tools appropriate to design, and sensitivity inferences prioritized studies at lower risk. The synthesis integrated short term physiological evidence under respirators with longer term clinical outcomes under glove programs, which provided a coherent mechanistic narrative from exposure to phenotype. External literature from peer reviewed sources was used to contextualize magnitude and to assess transportability to different periods and settings, which enhanced relevance for policy and procurement decisions.

Taken together, longitudinal and comparative evidence indicated that healthcare workers exposed to wet work, accelerator containing gloves, and prolonged respirator wear experienced higher risks of occupational dermatoses and allergic sensitization. Risk estimates were consistent in direction across designs, with odds ratio 1.78, 95 percent confidence interval 1.11 to 2.87 for hand rub on wet skin [19], measurable nasofacial barrier perturbation over consecutive respirator shifts [20], and low but persistent incidences of latex sensitization and allergic contact dermatitis despite powder free policies [31-33]. Interventions that are biologically and operationally plausible, for example avoiding hand rub on wet skin, scheduling micro breaks for pressure offloading, optimizing strap tension and fit, and substituting accelerator free gloves when patch testing confirms allergy, were supported by the balance of evidence from included studies and by convergent external syntheses. Future research should standardize exposure metrics, use verified clinical outcomes, and evaluate pragmatic prevention bundles that integrate skin care, procurement, and work organization while preserving infection prevention efficacy.

Conclusions

This review showed that healthcare workers experienced a consistent excess of skin and allergic problems linked to personal protective equipment, with risk driven by wet work and frequent hand washing, prolonged mask or respirator wear, and glove chemistry, especially accelerators and residual latex proteins; effect sizes were clinically relevant, for example higher odds of hand eczema with improper hand rub timing and higher prevalence of facial dermatoses with longer mask use, while long term surveillance still detected latex sensitization despite powder free policies; prevention appeared feasible through bundled actions that included avoiding hand rub on wet skin, adopting accelerator free or low protein gloves after patch test guided assessment, optimizing fit and strap tension, scheduling short relief periods during extended wear, and embedding moisturizing regimens compatible with infection prevention; evidence certainty varied because exposure definitions and outcome assessments differed across cohorts and case control studies, yet the direction of association was stable across settings, including European hospitals and training programs, which supported near term procurement and policy changes while larger standardized prospective studies and pragmatic trials refined thresholds and quantified benefits at service level.

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Table 1. Characteristics of the studies included in the review on Skin and Allergic Conditions Linked to Personal Protective Equipment in Healthcare Workers

Study Reference	Study Design	Sample Size (n)	Population	Intervention / Exposure	Disease / Condition	Main Outcomes
[19] Yüksel 2022	Cross-sectional with registry linkage	795	Hospital staff, Denmark	Wet work, gloves, disinfectants	Hand eczema	Wet work >2 h/day, OR 1.78, 95% CI 1.21–2.63; reduced QoL.
[20] Abiakam 2023	Longitudinal cohort	17	Hospital HCWs, UK	Consecutive filtering facepiece respirator use	Facial barrier impairment	Transepidermal water loss rose 2.5–4.8 fold, hydration decreased.
[21] Larese Filon 2014	Prospective cohort	2,053	HCWs, Italy, 2000–2009	Latex glove policy change	Latex sensitization	Incidence declined 10.2 to 3.1 per 1000 person-years.
[22] Schwensen 2016	Matched case-control	1,402 cases, 1402 controls	National dermatitis registry, Denmark	HCW occupation, thiuram exposure	Allergic contact dermatitis	Higher odds of thiuram mix allergy in HCWs, exact OR .
[23] Visser 2014	Prospective cohort	721	Apprentice nurses, Netherlands	Frequent hand washing, wet work	Hand eczema	Frequent washing OR 1.5, 90% CI 1.0–2.3; atopy strong predictor.
[24] Évora 2023	Longitudinal cohort	17	Hospital HCWs, Portugal	Four consecutive respirator shifts	Facial skin function	Cumulative corneocyte fragility, progressive TEWL increase across shifts.
[25] Piapan 2023	Prospective cohort	242	Apprentice nurses during COVID-19, Italy	Prevention program, wet work	Hand eczema	Prevalence 17.9 to 21.5%; atopic history OR 2.61, 95% CI 1.18–5.80.
[26] Jiang 2020	Multicentre cross-sectional	4,306	PPE users, 161 hospitals, China	Level-3 PPE, long wear time	Device-related pressure injury	Prevalence 30.0%; sweating OR 43.99, 95% CI 34.46–56.17.
[27] Kelly 2011	Prospective before-after cohort	805	Hospital HCWs, USA	Switch to powder-free latex gloves	Latex sensitization	New sensitization fell 16-fold; 25% reverted to negative tests.
[28] Jones 2004	Longitudinal cohort	63	Dental students, UK	Powder-free latex glove exposure	Latex sensitization	No new sensitization over 5 years despite high atopy prevalence.
[12] Soltanipoor 2019	Cluster randomized trial	501	Hospital wards, Netherlands	Cream dispensers, monitoring, feedback	Hand dermatitis (HECSI)	HECSI −6.2 vs −4.2 at 12 months, relative improvement 56% vs 44%.

[16] Oblea 2024	Randomized cross-over	73	Military HCWs, USA	Hydrocolloid vs dimethicone under N95	Facial skin breakdown	Fewer reactions with protectants vs N95 alone; fit-test similar across arms.
[31] Hamnerius 2018	Large cross-sectional	9,051 HCWs (12,288 total)	Hospital employees, Sweden	Soap washing, glove time, hand rub	Hand eczema	One-year prevalence 21%; dose-response for soap washes and glove time.
[32] Huang 2020	Cross-sectional	521	Nurses and doctors, Guangzhou, China	Occupational hygiene, glove use	Hand eczema	Prevalence 9.6%; food allergy history OR 3.01, 95% CI 1.31–6.91.

Legend: HCW, healthcare worker; PPE, personal protective equipment; QoL, quality of life; HECSI, Hand Eczema Severity Index; TEWL, transepidermal water loss; OR, odds ratio; CI, confidence interval.

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