

RESEARCH ARTICLES

Eighteen-Year Trends in Respirator Program Compliance: A Nationwide OSHA Enforcement Analysis

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Keywords: Respiratory protection, OSHA enforcement, Fit testing, 29 CFR 1910.134, Occupational Exposure, Filtering Facepiece Respirator
<https://doi.org/10.66828/001c.164538>

Journal of the International Society for Respiratory Protection

Vol. 43, 2026

Respiratory protection is a critical exposure control strategy in workplaces where airborne hazards are present. The U.S. Occupational Safety and Health Administration (OSHA) respiratory protection standard (29 CFR 1910.134) specifies requirements for respirator selection, medical evaluation, fit testing, training, maintenance, and program administration. During the COVID-19 pandemic, respiratory protection programs and fit testing in particular were widely discussed in the context of healthcare. National enforcement patterns across industries and over extended timeframes, however, have not been comprehensively characterized. This study analyzed U.S. OSHA enforcement records to examine the industry distribution, geographic pattern, and temporal trend of citations issued under the respiratory protection standard. Across complete reporting years 2008–2024 (with partial 2007 and 2025 data shown but excluded from analysis), 109,689 citations referencing 29 CFR 1910.134 were identified across 50,388 inspections (2.18 citations per inspection). Citations were most frequent in automotive body and paint repair (5,224), fire protection and emergency response (3,965), cut stone and abrasive product manufacturing (3,080), masonry contractors (3,021), and painting and wall covering contractors (2,208). When healthcare codes were aggregated (NAICS 621–623: ambulatory care, hospitals, and nursing and residential care), the sector accounted for 4,493 citations—about 4.1% of the national total—still a minority relative to the leading industrial sectors. Fit-testing citations [1910.134(f)] represented a persistent component of enforcement in every year (12–20% of annual respiratory protection citations); their share held near 14% before the pandemic and rose during 2020–2022, largely because a temporary, healthcare-concentrated surge of COVID-19–related fit-testing citations (23–27% of national fit-testing citations in 2020–2021) offset the pandemic decline in routine inspections. This surge had effectively ended by 2023 and represented only about 4% of respiratory protection citations even at its peak. Citations were geographically concentrated in populous states and in OSHA State Plan jurisdictions with independent enforcement programs. These findings indicate that respiratory protection program noncompliance is multi-sector and systemic, rather than concentrated primarily in healthcare.

Introduction

Respirators are used across a wide range of work environments to prevent inhalation of hazardous airborne materials, including silica dust, welding fume, solvent vapors, isocyanates, pesticides, and infectious aerosols (NIOSH-2018). Effective respirator use requires not only appropriate equipment but also a fully functional respiratory protection program. The OSHA respiratory protection standard (29 CFR 1910.134) mandates essential program elements, including written procedures, hazard assessment, respirator selection based on exposure risk, medical evaluation, initial and annual fit testing, user training, respirator maintenance, and periodic program evaluation (OSHA-2024). A deficiency in any single element can compromise worker protection (Coffey et al., 2004; Zhuang et al., 2005).

Respirator use is long-standing in industrial sectors such as automotive refinishing, abrasive blasting, structural steel fabrication, metal finishing, and construction. In these sectors, exposures often vary by task, respirator use may be intermittent rather than continuous, and work locations shift frequently (Cunningham et al., 2018). Workforces may include subcontracted labor, temporary workers, and small-team operations with limited administrative support. These structural conditions can challenge the implementation of routine fit testing, standardized training, and recordkeeping (Cunningham et al., 2018). The legal duty to provide a compliant respiratory protection program applies regardless of these conditions; in practice, however, many smaller employers fail to meet it, leaving workers inadequately protected.

Respirator use also expanded sharply in another setting during the COVID-19 pandemic. In healthcare and long-term care, N95 filtering facepiece respirators (FFRs) were widely implemented for both source control and worker protection, and fit-testing difficulties in hospitals were extensively documented. Respirator use and fit testing in clinical settings featured prominently in the respiratory protection literature published since 2020, with attention to supply shortages, emergency fit-testing protocols, and worker-protection concerns under extended-use and reuse conditions (Bartoszek et al., 2020; Degesys et al., 2020; Fakherpour et al., 2023; Haas et al., 2023; Sozkes & Sozkes, 2021; Toomey et al., 2021; Wang et al., 2024). Against this backdrop, respiratory protection program challenges have often been discussed as primarily a healthcare concern.

Healthcare, however, represents only one part of a broader population of respirator users. A national survey of private-sector employers found that required respirator use was concentrated in manufacturing, mining, construction, and agriculture rather than in healthcare, and that 91% of respirator-using establishments showed at least one indicator of a potentially inadequate respiratory protection program (Doney et al., 2005). Workers in these sectors frequently use half-mask a broad range of respirators that are more durable, and often more protective, than N95 FFRs—including full-facepiece elastomeric respirators, powered air-purifying respirators (PAPRs),

orand supplied-air systems rather than N95 FFRs. Enforcement. These reusable devices are suited to the continuous-duty exposures common in industry, in contrast to the intermittent, task-based N95 use more typical of healthcare, and their routine adoption reflects substantial sector familiarity with respiratory hazards and the available protective equipment. Even so, enforcement records in these sectors show recurring fit-testing and training deficiencies, yet these settings have received comparatively little attention in the recent literature.

Analysis of enforcement data allows a systematic evaluation of documented compliance deficiencies. Although enforcement does not sample all workplaces equally—inspections are targeted and resource-dependent—citation patterns spanning nearly two decades can reveal persistent program gaps, sector-specific challenges, and shifts in compliance activity over time. Because workplace inspections have measurable protective effects on injury outcomes (Levine et al., 2012), the distribution of enforcement activity is itself informative about where program deficiencies persist. This study addressed the need for a long-term, cross-industry examination of respiratory protection compliance using OSHA enforcement data. This study sought to characterize (1) the industry distribution of respiratory protection citations; (2) temporal trends, including pre-, intra-, and post-pandemic patterns; and (3) the prevalence and persistence of fit-testing citations.

Methods

Data source

OSHA violation and inspection datasets were obtained from the OSHA Enforcement Data program, publicly available through the U.S. Department of Labor Enforcement Data Catalog (OSHA-2025; https://enforcedata.dol.gov/views/data_catalogs.php; accessed 2025). The violation and inspection extracts were merged on the shared inspection identifier, `activity_nr`—the unique number OSHA assigns to each inspection activity, used here to link each cited violation to its parent inspection. To examine pandemic-era enforcement directly, a supplementary extract of OSHA enforcement actions identified as COVID-19–related (2020–2023) was also analyzed, and these COVID-19–related findings are presented separately below. Each such record retained the cited standards, issuance date, establishment name and location, and the initial penalty amount; citations of 29 CFR 1910.134 and of the fit-testing paragraph 1910.134(f) were identified within this extract using the same coding logic applied to the full dataset.

Case definition and coding

Citations issued under the respiratory protection standard were identified by selecting records encoded as 19100134, OSHA’s numeric representation of 29 CFR 1910.134. Sub-item letter codes were parsed to identify fit-testing citations (letter F, corresponding to paragraph 1910.134(f)). The unit of

analysis was the individual citation line item; counts therefore reflect distinct citations rather than inspections, and a single inspection could generate multiple citations. Records were de-duplicated on the combination of activity_nr and citation item before tabulation.

Industry and geographic classification

Establishment industry was classified using the North American Industry Classification System (NAICS) code recorded for each inspected establishment. NAICS is the standard system used by U.S. federal statistical agencies to classify business establishments by primary economic activity. Healthcare was defined as the aggregate of NAICS three-digit groups 621 (ambulatory health care services), 622 (hospitals), and 623 (nursing and residential care facilities) to capture the sector as a whole rather than any single establishment type. Geographic patterns were summarized by the establishment state field.

Analysis

Citations were aggregated by sector, state, and year. Annual citation counts for 2007 and 2025 were markedly lower than all intervening years; these reflect incomplete data capture at the boundaries of the extract (sparse early-period records in 2007 and an incomplete, lag-affected 2025 at the time of download) and were therefore retained for display but excluded from analysis. The complete-year window was 2008–2024 (eighteen calendar years 2007–2024, with 2007 noted as partial). One citation lacked a recorded issuance year and is therefore absent from the annual series ([Figure 1](#)) but is retained in the sector, state, and overall totals; the annual counts consequently sum to 109,688 rather than 109,689. Temporal trend in the fit-testing share was assessed with ordinary least-squares regression of the annual percentage on year, and the difference in fit-testing share across pre-pandemic (2008–2019), pandemic (2020–2021), and post-pandemic (2022–2024) periods was tested with a chi-square test of independence on citation counts. The pandemic period for this comparison was defined as 2020–2021, the interval of acute pandemic disruption to routine inspections; this is distinct from the 2020–2023 span of the separately analyzed COVID-19–related extract, which reflects the full period over which COVID-19–related citations were issued. Descriptive tabulation, statistical testing, and visualization were performed in Python (pandas, SciPy, and Matplotlib); no external statistical package beyond SciPy was used.

Results

Overall enforcement volume and temporal trend

A total of 109,689 respiratory protection citations were identified across 50,388 inspections, an average of 2.18 citations per inspection. Annual citation counts peaked at 7,904 in 2010, declined gradually through 2019, fell sharply in 2020 during pandemic-related reductions in OSHA field activity,

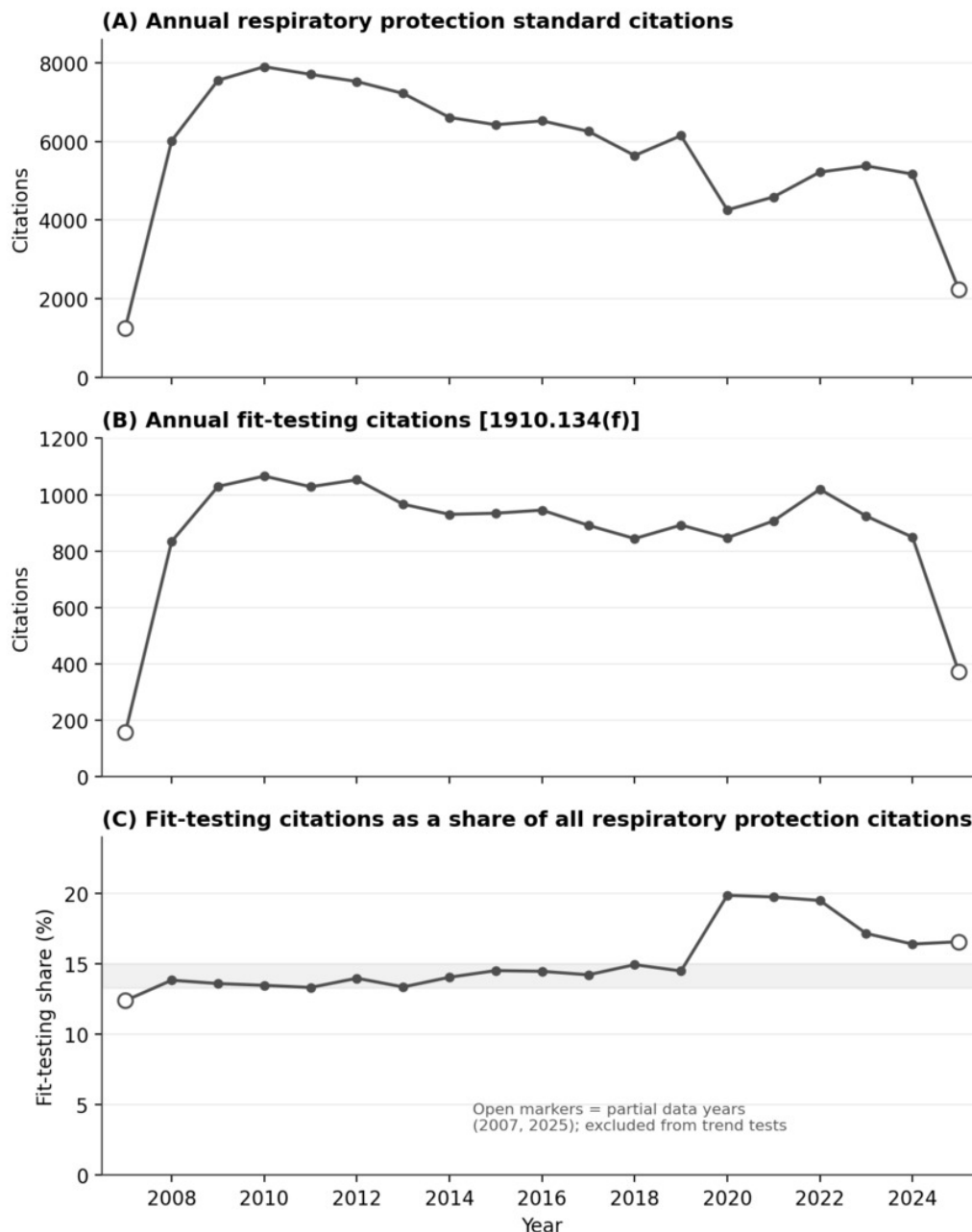


Figure 1. Annual respiratory protection standard enforcement, 2007–2025.

(A) Total citations issued under 29 CFR 1910.134 by year. (B) Annual fit-testing citations [1910.134(f)]. (C) Fit-testing citations as a percentage of all respiratory protection citations; the shaded band marks the pre-pandemic range (approximately 13–15%). Open markers denote partial-data years (2007, 2025), which were excluded from analysis.

and partially recovered to 5,172–5,381 in 2022–2024 ([Figure 1A](#)). Citation counts for the partial years 2007 and 2025 are shown as open markers and were excluded from analysis.

Industry distribution

Among individual NAICS codes, citations were most frequent in automotive body and paint repair (5,224), fire protection and emergency response organizations (3,965), cut stone and abrasive product manufacturing (3,080), masonry contractors (3,021), painting and wall

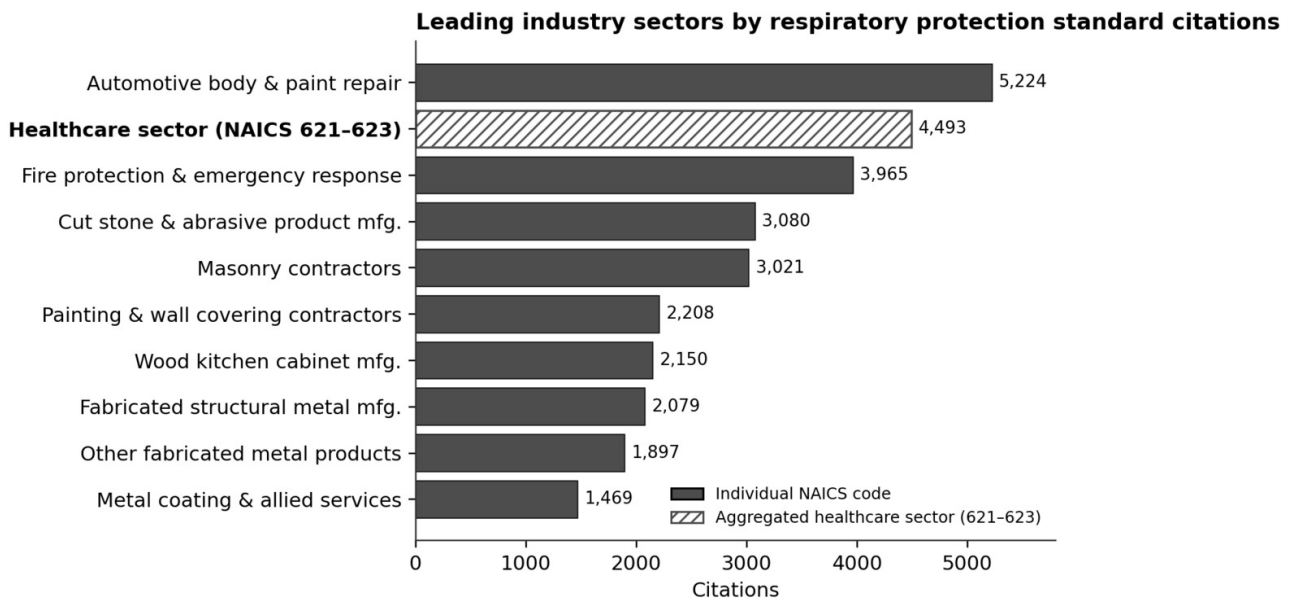


Figure 2. Leading industry sectors by respiratory protection standard citations (complete years 2008–2024).

Solid bars are the nine most-cited individual NAICS codes. The hatched bar is the aggregated healthcare sector (NAICS 621–623: ambulatory care, hospitals, and nursing and residential care), shown at the sector level for comparison; it is not an individual NAICS code. The nursing care facilities code (623110; 1,706 citations) is a 6-digit subset of the broader 623 group within this aggregate and is therefore not shown as a separate bar.

covering contractors (2,208), wood kitchen cabinet manufacturing (2,150), fabricated structural metal manufacturing (2,079), other fabricated metal products (1,897), nursing care facilities (NAICS 623110; 1,706), and metal coating and allied services (1,469). When the three healthcare NAICS groups were aggregated to the sector level, healthcare accounted for 4,493 citations—ambulatory care (621; 1,146), hospitals (622; 936), and nursing and residential care (623; 2,411)—or approximately 4.1% of the national total. The 6-digit nursing care facilities code (623110; 1,706) listed above is a subset of the broader 3-digit nursing and residential care group (623; 2,411), which also includes assisted-living and other residential-care establishments. Compared at the sector level ([Figure 2](#)), aggregated healthcare ranked second overall, behind automotive body and paint repair (5,224) and ahead of fire protection and emergency response (3,965), yet still represented a small fraction of all respiratory protection enforcement. Because the other bars in [Figure 2](#) are individual NAICS codes, the healthcare bar is shown at the sector level and identified accordingly; the nursing care facilities code (623110) is one component of this aggregate and is therefore not plotted separately.

Fit-testing citations

Fit testing citations represented a persistent component of enforcement in every year of the dataset, ranging from approximately 12% to 20% of annual respiratory protection citations ([Figure 1C](#)). In absolute terms, the annual fit-testing citation count rose to a peak of 1,066 in 2010 and then declined gradually to 892 by 2019—an approximately 16% decrease over

2010–2019 that paralleled the overall decline in enforcement volume—before a pandemic-era fluctuation (a 2020 dip followed by a rise to 1,019 in 2022; [Figure 1B](#)). As a share of all respiratory protection citations, fit testing held near 14.0% throughout the pre-pandemic period (2008–2019), rose to 19.8% during the pandemic (2020–2021), and settled at 17.7% post-pandemic (2022–2024). The difference across these three periods was statistically significant (chi-square test, $p < 0.0001$), and a regression of the annual share on year over 2008–2024 indicated a modest upward slope (approximately 0.35 percentage points per year; $p < 0.001$). This pattern is explained by the COVID-19–related enforcement data described below: the absolute fit-testing citation count held roughly flat during 2020–2022 while routine industrial inspections fell steeply, so the proportion of citations attributable to fit testing rose during the pandemic without a broad increase in fit-testing failures.

Geographic distribution

Citations were recorded across 57 state and territorial jurisdictions. The highest counts occurred in New York (7,941), Illinois (6,712), Tennessee (5,858), North Carolina (5,754), Oregon (5,694), Pennsylvania (5,173), Texas (4,818), Ohio (4,655), New Jersey (4,609), and Virginia (4,316) ([Figure 3](#)). These counts reflect a combination of establishment density, industrial mix, and enforcement activity; about half of U.S. states operate OSHA-approved State Plans that administer their own inspection programs, and both populous federal-OSHA states and State Plan states appear among the highest-count jurisdictions. State-level totals should therefore be read as descriptive of where citations were issued rather than as a direct measure of underlying noncompliance.

COVID-19–related enforcement, 2020–2023

A supplementary extract of OSHA enforcement actions identified as COVID-19 related contained 1,027 actions issued between 2020 and 2023, of which 799 cited the respiratory protection standard and 586 cited the fit-testing paragraph 1910.134(f). Approximately 58% of the respiratory protection actions, and 64% of the fit-testing actions, occurred at establishments whose names indicated healthcare delivery (for example, medical centers, hospices, senior living, and nursing facilities); this is a name-based approximation, as establishment NAICS codes were not available in this extract. COVID-19–related fit-testing citations accounted for 23%, 27%, and 14% of all national fit-testing citations in 2020, 2021, and 2022, respectively, and were effectively absent by 2023 ([Figure 4A](#)). This temporary, healthcare-concentrated surge of citations is what sustained the national fit-testing count while routine inspections fell, accounting for much of the elevated fit-testing share observed during the pandemic. Even at its peak, however, COVID-19–related enforcement represented only about 4% of all respiratory protection citations during 2020–2023, indicating that pandemic healthcare enforcement was a temporary overlay on a persistent industrial

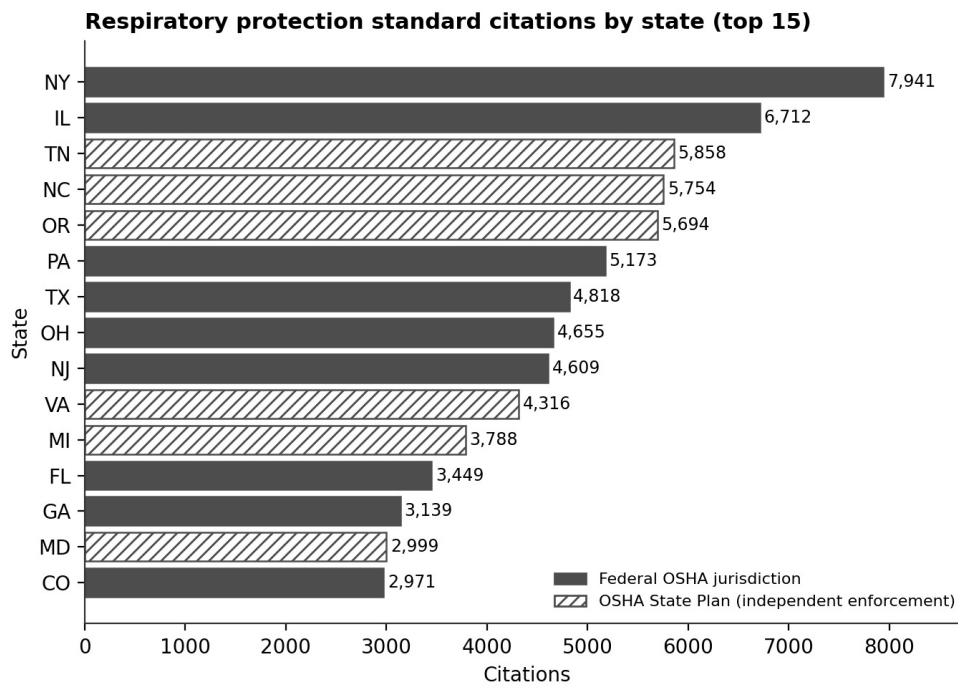


Figure 3. Respiratory protection standard citations by state (fifteen highest, complete years 2008–2024).

Hatched bars denote OSHA State Plan jurisdictions with independent enforcement programs; solid bars denote states under federal OSHA jurisdiction.

baseline rather than a reordering of where respiratory protection noncompliance occurs. The associated citations were substantive rather than nominal: among the 701 COVID-19–related respiratory protection citations carrying a penalty, the median initial penalty was \$13,494 (mean \$15,297; total \$10.7 million; [Figure 4B](#)).

Discussion

This analysis shows that respiratory protection program noncompliance, as captured by federal and state enforcement, is broadly distributed across industrial sectors and is not concentrated primarily in healthcare. The industries with the highest citation counts—automotive refinishing, abrasive and stone product manufacturing, masonry, painting, cabinet and metal fabrication, and construction trades—share organizational characteristics that complicate program administration: variable work locations, fluctuating and frequently subcontracted workforces, and limited dedicated safety staffing (Cunningham et al., 2018). These conditions can undermine the consistency of training, fit testing, and recordkeeping. The high citation volume among fire protection and emergency response organizations is also notable. Firefighters routinely use self-contained breathing apparatus (SCBA), and the respiratory protection standard requires that SCBA users—like all users of tight-fitting respirators—be medically evaluated, annually fit-tested, and covered by a written program (OSHA-2024; NFPA-2018). Operational familiarity with SCBA does not by itself satisfy these administrative

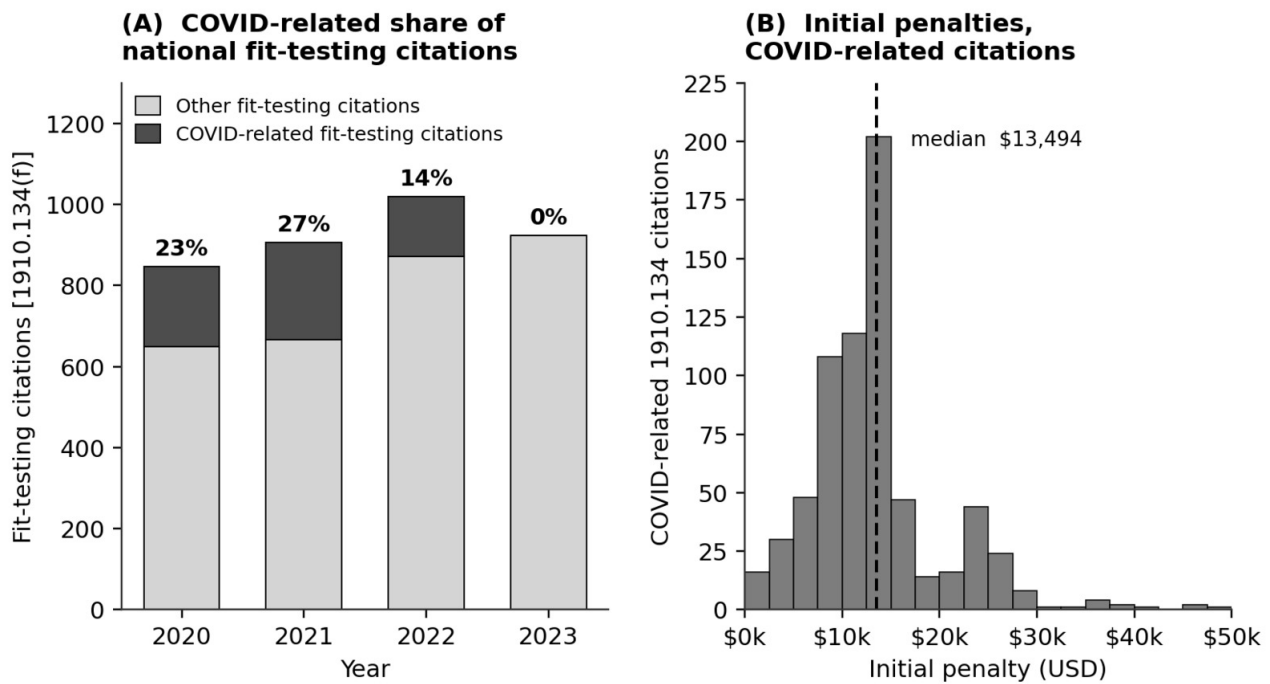


Figure 4. COVID-19–related respiratory protection enforcement, 2020–2023.

(A) National fit-testing citations [1910.134(f)] by year, with the COVID-19–related share highlighted; percentages denote the COVID-related fraction of national fit-testing citations in that year. (B) Distribution of initial penalties for COVID-19–related citations of the respiratory protection standard (citations with a nonzero penalty; dashed line marks the median).

requirements, which together with medical evaluation and written procedures are the elements that most often generate citations across all respirator types.

Healthcare has received considerable attention in the respiratory protection literature published since the pandemic (e.g., Bartoszko et al., 2020; Haas et al., 2023; Toomey et al., 2021; Wang et al., 2024), yet this attention is not matched by a proportionate share of documented enforcement. The citation data indicate that healthcare, even when all relevant NAICS groups are aggregated, accounts for roughly 4% of respiratory protection citations. Although this places healthcare second among individual sectors, the great majority of citations are distributed across numerous industrial and construction sectors rather than concentrated in any single one. This gap is consistent with the visibility of pandemic-era healthcare respirator use rather than a higher underlying rate of noncompliance, although, as noted below, a lower citation share may also partly reflect differences in how respiratory protection concerns are reported and channeled in healthcare settings. With that caveat, the pattern suggests that training, outreach, and resource-allocation strategies may warrant rebalancing toward industrial sectors where respirator use is routine but administrative oversight capacity is limited. Although the pandemic introduced new respiratory protection challenges in healthcare and underscored the need to ensure clinical workers have adequate protection, healthcare in aggregate incurred a citation volume comparable to that of single, long-established industrial sectors—reinforcing

that the larger and more persistent enforcement burden lies across general industry. It is worth noting that private-sector healthcare employers are subject to the respiratory protection standard as general-industry establishments under federal OSHA jurisdiction, while public-sector healthcare facilities fall under OSHA enforcement only in states operating approved State Plans; healthcare is therefore within the standard's enforcement scope, and its low citation share is not an artifact of being unregulated.

Fit-testing citations were a persistent feature of enforcement throughout the study period, present in every year and accounting for a stable pre-pandemic share (near 14%) of all respiratory protection citations even as their absolute count declined with overall enforcement volume during the 2010s. This persistence—rather than any single-year level—indicates an enduring, structural compliance gap rather than a transient or pandemic-specific phenomenon. Fit testing imposes recurring administrative demands: scheduling, equipment, trained evaluators, and repeat testing after respirator model or facial changes. These requirements create friction in workplaces without dedicated safety personnel (Coffey et al., 2004; Zhuang et al., 2005). The rise in the fit-testing share during 2020–2022 is explained by the COVID-19–related enforcement stream: routine industrial inspections contracted while a temporary, healthcare-concentrated surge of pandemic fit-testing citations sustained the absolute count, elevating the share. That this surge had effectively ended by 2023—while the underlying industrial baseline persisted—reinforces, rather than undercuts, the conclusion that fit-testing noncompliance is a durable, cross-sector problem. Practical responses follow directly from these patterns: shared or mobile fit-testing services, simplified recordkeeping tools, and targeted compliance assistance could reduce friction for small employers and emergency-response agencies that lack in-house safety infrastructure but bear the same legal obligations as large institutions.

Limitations

OSHA inspections are not random. Enforcement is influenced by injury patterns, complaints, programmed emphasis programs, and resource constraints, so citation counts cannot be interpreted as prevalence across the full workforce, and high-count sectors may partly reflect targeted inspection activity rather than higher underlying noncompliance rates. Because establishment-level inspection counts by sector were not analyzed here, citations could not be normalized to a per-inspection rate by industry; the cross-sector comparisons are therefore based on citation volume rather than per-inspection citation rates. Inspection-level records linking each inspection to an establishment NAICS code are publicly available through the same OSHA enforcement data system and would permit per-inspection normalization by industry in future work, distinguishing high citation volume that reflects intensive inspection targeting from higher citation intensity per inspection. Citation coding reflects noncompliance documented at the time of inspection and does not capture subsequent corrective action.

NAICS codes describe an establishment's primary business classification and may not match the specific task performed when a violation occurred. State-level comparisons are confounded by the differing enforcement intensity of federal versus State Plan jurisdictions.

The comparatively low healthcare citation share also has an important limitation: it may understate noncompliance rather than reflect genuinely better practice. Healthcare workers may be less familiar with OSHA reporting channels and their right to file complaints, and concerns about respiratory protection in clinical settings may be routed to other oversight bodies such as The Joint Commission or state health departments rather than to OSHA. In addition, pandemic-era enforcement in healthcare followed a distinct path: routine inspections were suppressed while a parallel stream of COVID-specific, complaint-driven inspections emerged, complicating direct comparison with industrial enforcement over the same period. Lower OSHA citation counts in healthcare should therefore not be read as evidence of fully adequate respiratory protection programs in that sector.

Conclusion

This eighteen-year analysis demonstrates that respiratory protection noncompliance, as documented through OSHA enforcement, is widespread across multiple industrial sectors and is not concentrated primarily in healthcare. Fit-testing citations were a persistent component of enforcement in every year, accounting for a stable pre-pandemic share of citations and indicating an enduring structural barrier to full program implementation rather than a pandemic-driven phenomenon. Training, enforcement, and resource-allocation efforts should give particular attention to industrial workplaces where respirator use is routine but administrative oversight capacity is limited—including construction trades, small manufacturing and metal-fabrication facilities, and emergency-response agencies—while recognizing that low citation counts in healthcare may reflect reporting and jurisdictional factors as much as program adequacy.

Submitted: October 30, 2025 CDT. Revised: June 12, 2026 CDT. Accepted: June 30, 2026 CDT. Published: July 13, 2026 CDT.



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Supplementary Materials

Supplement Dataset

Download: <https://jisrp.scholasticahq.com/article/164538-eighteen-year-trends-in-respirator-program-compliance-a-nationwide-osh-a-enforcement-analysis/attachment/352271.xlsx>
