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Original Article

A Community-Based Randomized Controlled Trial on Weekly Vitamin D_3 Supplementation for Prevention of Seasonal Respiratory Illness in Transit Workers

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ABSTRACT

Background: Seasonal respiratory illnesses contribute substantially to morbidity, absenteeism, and reduced productivity among transit workers because of their repeated exposure to commuters in crowded occupational environments. Vitamin D has immunomodulatory effects that may reduce respiratory infection susceptibility, but evidence from pragmatic high-exposure occupational settings remains limited. Objective: To evaluate the effect of weekly high-dose vitamin D_3 supplementation on the incidence, frequency, duration, and severity of seasonal respiratory illness among transit workers. Methods: A community-based randomized placebo-controlled trial was conducted over four months in Industrial and Urban Core Punjab. Seventy-two transit workers were randomized to weekly oral vitamin D_3 50,000 IU or matching placebo, and 68 completed follow-up. Baseline serum 25-hydroxyvitamin D was measured, and participants were followed weekly using symptom diaries and structured interviews. Respiratory illness incidence, number of episodes, illness duration, and WURSS-21 severity scores were compared between groups. Results: Respiratory illness occurred in 14/34 participants receiving vitamin D_3 and 25/34 receiving placebo (41.2% vs 73.5%; RR=0.56; 95% CI: 0.36–0.88; p=0.01). Vitamin D_3 also reduced mean episode frequency (0.62 ± 0.70 vs 1.18 ± 0.90; p=0.02), duration (3.4 ± 1.2 vs 5.1 ± 1.6 days; p<0.001), and WURSS-21 severity score (28.6 ± 8.9 vs 41.3 ± 10.5; p<0.001). Conclusion: Weekly vitamin D_3 supplementation significantly reduced respiratory illness burden among transit workers and may serve as a practical adjunctive preventive strategy in high-exposure occupational settings. Keywords: Cholecalciferol; Occupational Health; Respiratory Tract Infections; Supplementation; Transit Workers; Vitamin D Deficiency; Workplace Exposure.

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INTRODUCTION

Acute respiratory infections, including common cold and influenza-like illnesses, remain a major cause of preventable morbidity in working populations with frequent public interaction. Transit workers are particularly vulnerable because their duties require prolonged contact with large numbers of commuters, often in enclosed or crowded environments where respiratory pathogen exposure is repeated and difficult to avoid. This occupational risk contributes not only to individual illness but also to absenteeism, reduced productivity, and potential onward transmission within the community, making preventive strategies in this group a relevant occupational and public health priority (1,2).

Vitamin D has gained increasing attention as a potentially modifiable factor in respiratory infection prevention because of its established role in immune regulation. Beyond its skeletal effects, vitamin D

influences innate immunity by supporting antimicrobial peptide production, including cathelicidin and defensins, and contributes to balanced adaptive immune responses by limiting excessive inflammatory activity. These mechanisms provide biological plausibility for a protective role against respiratory infections, particularly among individuals with suboptimal vitamin D status (3,4).

Vitamin D insufficiency remains common even in regions with substantial sunlight exposure, partly due to indoor work patterns, air pollution, limited sun exposure, clothing practices, and prolonged occupational shifts. Transit workers may therefore represent a population in whom environmental exposure to infection overlaps with physiological susceptibility related to inadequate vitamin D status. Observational evidence has consistently linked low serum 25-hydroxyvitamin D concentrations with increased respiratory infection risk, but such findings are limited by confounding and cannot establish causality (5–7).

Randomized trials of vitamin D supplementation have produced mixed results, with variation in treatment effect likely explained by differences in baseline vitamin D status, dosing schedules, population risk profiles, adherence, and outcome definitions. Evidence suggests that individuals with deficiency and those exposed to higher infection risk may derive greater benefit, yet most trials have been conducted in clinical or general-population settings rather than occupational groups with repeated daily exposure. In addition, the practical value of intermittent high-dose weekly supplementation remains insufficiently studied in real-world community settings, despite its potential to improve adherence compared with daily regimens (8,9).

This study was therefore designed to address a specific evidence gap: whether weekly high-dose vitamin D_3 supplementation can reduce the incidence, duration, and severity of seasonal respiratory illness among transit workers in a pragmatic occupational setting. The study hypothesized that weekly oral vitamin D_3 supplementation would reduce the occurrence of respiratory illness episodes and lessen clinical burden, measured by illness duration and symptom severity, compared with placebo among high-exposure transit workers during the seasonal respiratory illness period (10).

MATERIALS AND METHODS

A community-based, parallel-group, randomized, placebo-controlled trial was conducted over four months in the Industrial and Urban Core region of Punjab, Pakistan, an area characterized by dense commuter movement and high daily occupational exposure among transit workers. The study population consisted of bus drivers, conductors, and ticketing staff working on major urban transit routes. The trial was designed to evaluate whether weekly oral vitamin D_3 supplementation reduced the incidence, duration, and severity of seasonal respiratory illness compared with placebo under real-world occupational conditions.

Eligible participants were men and women aged 20–60 years who had been employed full-time in transit-related work for at least six months and were willing to provide informed consent and complete weekly symptom monitoring. Individuals were excluded if they had chronic respiratory disease, current vitamin D supplementation exceeding 1,000 IU/day, known hypercalcemia, renal impairment, recent hospitalization for severe illness, or any clinical condition that could interfere with safe supplementation or interpretation of respiratory outcomes. Participants were recruited through workplace briefings, followed by eligibility screening and written informed consent before enrollment.

A total of 72 participants were enrolled to allow detection of a clinically meaningful difference in respiratory illness occurrence between groups while accounting for anticipated attrition in a community-based occupational cohort. Participants were randomly assigned in a 1:1 ratio to receive either weekly oral vitamin D_3 50,000 IU or a matching placebo for the study duration. Randomization was performed using a computer-generated sequence, and allocation concealment was maintained through sequentially numbered, sealed opaque envelopes. Participants and outcome assessors remained blinded to group

allocation, while supplementation compliance was monitored separately by an independent research assistant using capsule counts and adherence logs to reduce performance and assessment bias.

Baseline information was collected using a structured questionnaire covering age, sex, occupational role, daily working hours, smoking status, medical history, and relevant exposure characteristics. Serum 25-hydroxyvitamin D levels were measured at baseline using enzyme-linked immunosorbent assay to determine initial vitamin D status. The intervention group received oral cholecalciferol 50,000 IU once weekly, while the control group received an identical placebo capsule on the same schedule. Participants were followed weekly through structured telephone interviews and symptom diaries documenting cough, sore throat, nasal congestion, fever, illness onset, symptom duration, and work disruption.

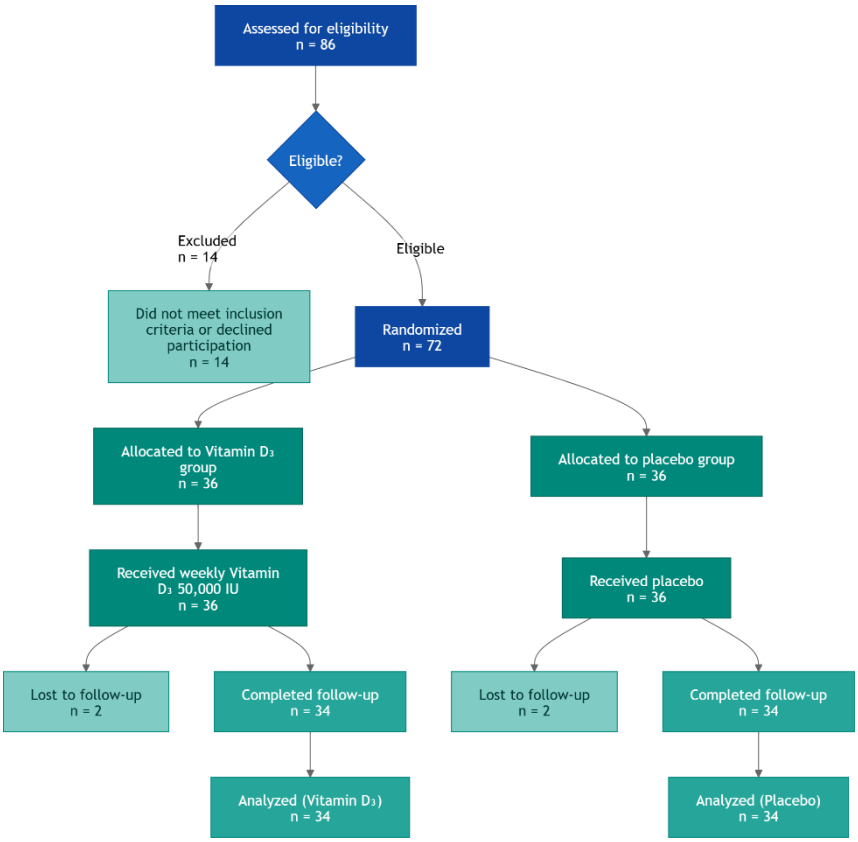

Figure 1 CONSORT Flowchart

The primary outcome was the incidence of respiratory illness, defined as the occurrence of at least one symptom-based respiratory illness episode during the follow-up period. Secondary outcomes were the mean number of illness episodes per participant, duration of illness in days, and symptom severity measured using the Wisconsin Upper Respiratory Symptom Survey-21. Severity scores were calculated during the acute phase of each reported episode to provide standardized comparison between groups. Baseline vitamin D level was also examined in relation to illness incidence and severity to evaluate whether lower baseline status was associated with greater respiratory illness burden.

To minimize bias, both participants and assessors were blinded, outcome definitions were standardized before data collection, and weekly follow-up was used to reduce recall error. Potential confounding was addressed by collecting baseline demographic, occupational, smoking, and vitamin D status variables and by comparing baseline characteristics between groups before outcome analysis. Participants lost to follow-up before completion were not included in the final comparative analysis, and the primary analysis was conducted on participants with complete outcome data. Compliance was summarized descriptively, and participants with incomplete weekly diaries were verified through structured follow-up calls where possible.

Data were analyzed using statistical software. Continuous variables were summarized as means and standard deviations, while categorical variables were reported as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Independent-samples t-tests were used to compare normally distributed continuous outcomes between groups, including illness duration and WURSS-21 severity scores. Chi-square tests were used to compare categorical outcomes, including the proportion of participants experiencing at least one respiratory illness episode. Correlation analysis was used to assess the association between baseline serum vitamin D level and respiratory illness outcomes. Statistical significance was set at $p<0.05$. The study was conducted after ethical approval, and all participants provided informed consent before enrollment. Data were anonymized during analysis, checked for completeness and consistency, and stored securely to maintain confidentiality and reproducibility.

RESULTS

A total of 86 transit workers were screened, 72 were randomized, and 68 completed follow-up, yielding a completion rate of 94.4%. The final analysis included 34 participants in each group. Baseline characteristics were broadly comparable, including mean serum 25-hydroxyvitamin D level, which was 19.8 ± 6.1 ng/mL overall, indicating insufficient vitamin D status in the cohort. Compliance with weekly supplementation exceeded 90% in the intervention group.

Table 1. Baseline Demographic and Clinical Characteristics of Participants

Variable	Category/Measure	Total Sample (N=68)
Age	Mean ± SD, years	38.6 ± 9.4
Gender	Male	54 (79.4%)
	Female	14 (20.6%)
Occupation	Driver	30 (44.1%)
	Conductor/Ticketing Staff	38 (55.9%)
Daily work hours	≤8 hours	23 (33.8%)
	>8 hours	45 (66.2%)
Baseline vitamin D	Mean ± SD, ng/mL	19.8 ± 6.1
Smoking status	Yes	21 (30.9%)
	No	47 (69.1%)

Respiratory illness incidence was significantly lower in the vitamin D_3 group than in the placebo group. Fourteen participants in the intervention group experienced at least one respiratory illness episode compared with 25 participants in the control group, corresponding to a relative risk of 0.56 and a 44.0% relative risk reduction. The absolute risk reduction was 32.4%, indicating a clinically meaningful reduction in illness occurrence.

Table 2. Incidence and Frequency of Respiratory Illness Episodes by Group

Outcome	Vitamin D_3 (n=34)	Placebo (n=34)	Effect Estimate	95% CI	p-value
Participants with ≥1 episode	14 (41.2%)	25 (73.5%)	RR = 0.56	0.36 to 0.88	0.01
Absolute risk reduction	—	—	32.4%	10.1% to 54.6%	—
Odds of illness	—	—	OR = 0.25	0.09 to 0.70	—
Mean episodes per participant	0.62 ± 0.70	1.18 ± 0.90	Mean difference = −0.56	−0.95 to −0.17	0.02
Standardized effect	—	—	Cohen's d = −0.69	—	—

Participants receiving vitamin D_3 also had shorter and less severe illness episodes. Mean illness duration was reduced by 1.7 days, while WURSS-21 severity scores were lower by 12.7 points compared with placebo. Both differences were statistically significant and clinically relevant.

Table 3. Duration and Severity of Respiratory Illness

Outcome	Vitamin D_3 (n=34)	Placebo (n=34)	Mean Difference	95% CI	Effect Size	p-value
Duration, days	3.4 ± 1.2	5.1 ± 1.6	−1.70	−2.39 to −1.01	Cohen's d = −1.20	<0.001
WURSS-21 score	28.6 ± 8.9	41.3 ± 10.5	−12.70	−17.42 to −7.98	Cohen's d = −1.30	<0.001

Baseline vitamin D level showed moderate inverse associations with respiratory illness outcomes. Higher baseline vitamin D concentration was associated with lower illness incidence and lower symptom

severity, supporting the biological plausibility that vitamin D status may influence both susceptibility and clinical burden.

Table 4. Correlation Between Baseline Vitamin D Level and Respiratory Illness Outcomes

Predictor	Outcome	Correlation Coefficient	95% CI	Variance Explained	p-value
Baseline vitamin D, ng/mL	Illness incidence	r = −0.42	−0.60 to −0.20	17.6%	0.003
Baseline vitamin D, ng/mL	Severity score	r = −0.47	−0.64 to −0.26	22.1%	0.001

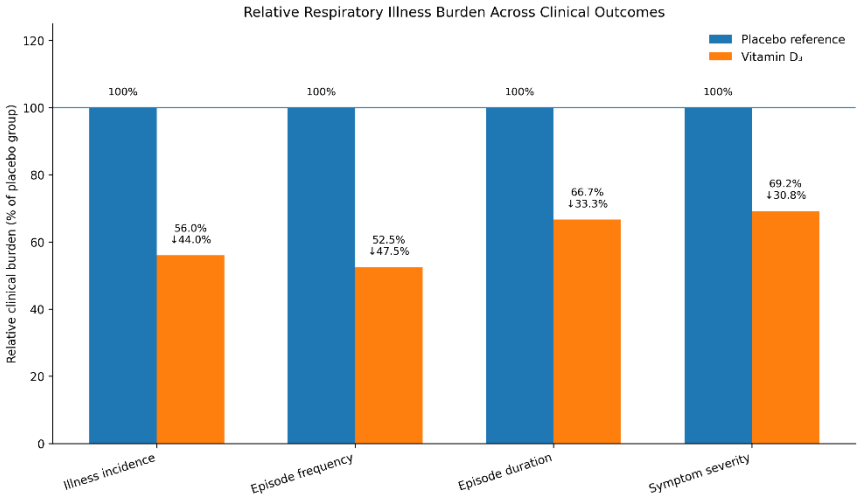

Figure 2 Relative Respiratory Illness Burden Across Clinical Outcomes

The figure demonstrates a consistent reduction in clinical burden across all evaluated respiratory outcomes in the vitamin D_3 group relative to placebo. Illness incidence was reduced to 56.0% of the placebo burden, equivalent to a 44.0% relative reduction. Episode frequency showed the largest proportional improvement, declining to 52.5% of placebo levels, while illness duration decreased to 66.7% and symptom severity to 69.2% of placebo values. This pattern indicates that weekly vitamin D_3 supplementation was associated not only with fewer respiratory illness events but also with a lower overall clinical burden when illness occurred.

DISCUSSION

The present community-based randomized controlled trial demonstrated that weekly oral vitamin D_3 supplementation was associated with significantly lower respiratory illness burden among transit workers. Participants receiving vitamin D_3 had a lower incidence of respiratory illness, fewer illness episodes, shorter illness duration, and lower WURSS-21 severity scores than those receiving placebo. The magnitude of effect was clinically meaningful, with a relative risk of 0.56 for illness occurrence and an absolute risk reduction of 32.4%, suggesting that supplementation may offer practical preventive value in occupational groups with repeated public exposure. These findings are consistent with previous evidence indicating that vitamin D may reduce susceptibility to acute respiratory infections, particularly in populations with low baseline vitamin D status or higher exposure risk (1,5).

The observed benefit is biologically plausible because vitamin D contributes to innate immune defense through regulation of antimicrobial peptides and modulation of inflammatory responses. Adequate vitamin D status may support epithelial barrier integrity and early immune responses to respiratory pathogens, while limiting excessive inflammatory activity that contributes to symptom burden. In this study, baseline serum 25-hydroxyvitamin D levels were generally insufficient, and higher baseline levels were moderately associated with lower illness incidence and lower symptom severity. This supports the interpretation that vitamin D status may influence both infection susceptibility and clinical expression of respiratory illness, although causality for the correlation analysis should be interpreted cautiously because it was observational within the trial dataset (3,4).

The reduction in illness duration and WURSS-21 severity scores is particularly important from an occupational health perspective. Transit workers operate in high-contact environments, and even short respiratory illnesses may affect attendance, work performance, and service continuity. The mean illness duration was 1.7 days shorter in the vitamin D_3 group, while severity scores were 12.7 points lower than placebo, indicating that supplementation was associated not only with prevention of illness episodes but also with attenuation of clinical burden among those who became symptomatic. These outcomes strengthen the practical relevance of the intervention beyond simple incidence reduction (2,8).

The results also help contextualize inconsistencies in previous vitamin D trials. Prior studies have reported variable effects, likely due to differences in baseline vitamin D status, participant risk profile, dosing frequency, adherence, follow-up duration, and outcome definitions. The present study focused on a high-exposure occupational population with insufficient baseline vitamin D levels and used a weekly high-dose regimen that may have improved adherence compared with daily dosing. These features may explain why a clearer benefit was observed in this cohort than in some broader population trials where baseline deficiency or occupational exposure risk may have been less pronounced (5,8).

Several strengths support the credibility of the findings. The randomized placebo-controlled design reduced selection bias, while blinding of participants and outcome assessors minimized performance and assessment bias. Weekly follow-up and symptom diaries reduced recall error, and the use of WURSS-21 provided a standardized measure of symptom severity. The inclusion of baseline serum 25-hydroxyvitamin D measurement also strengthened biological interpretation by allowing assessment of baseline status in relation to illness outcomes.

However, the findings should be interpreted within important limitations. The sample size was modest, and the trial was conducted within a single geographic and occupational context, which may limit generalizability to other populations, climates, and workplace settings. The study period covered one seasonal interval only, so long-term sustainability, safety monitoring beyond four months, and repeated-season effectiveness could not be assessed. Respiratory illness outcomes were symptom-based rather than laboratory-confirmed, which may have introduced misclassification between viral respiratory illness, allergic symptoms, or other upper respiratory conditions. Although weekly follow-up improved data quality, self-reported symptoms and adherence logs remain vulnerable to reporting bias.

Residual confounding also remains possible. Factors such as sunlight exposure, dietary intake, vaccination status, mask use, sleep quality, and household exposure were not fully controlled in the available dataset. Although randomization helps balance measured and unmeasured confounders, the small sample size may not ensure complete balance across all behavioral and environmental factors. Future studies should include larger multicenter samples, stratification by baseline vitamin D deficiency, laboratory confirmation of respiratory infections, and adjusted regression models incorporating relevant occupational and lifestyle variables.

Overall, the study provides supportive evidence that weekly vitamin D_3 supplementation may reduce respiratory illness burden among high-exposure transit workers with generally insufficient baseline vitamin D levels. The findings should not be interpreted as supporting vitamin D supplementation as a standalone substitute for vaccination, hygiene, ventilation, or occupational infection-control strategies. Rather, supplementation may be considered a low-cost adjunctive measure within a broader preventive framework, particularly for populations at risk of deficiency and repeated respiratory pathogen exposure.

CONCLUSION

Weekly high-dose vitamin D_3 supplementation was associated with a significantly reduced incidence, frequency, duration, and severity of seasonal respiratory illness among transit workers. The intervention showed clinically meaningful reductions in illness burden, including a 44.0% relative reduction in illness incidence and shorter symptomatic episodes compared with placebo. These findings suggest that

improving vitamin D status may be a practical adjunctive occupational health strategy in high-exposure worker populations, although larger multicenter trials with laboratory-confirmed outcomes, longer follow-up, and adjusted analyses are needed before broad implementation.

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