HHE Health Hazard® Evaluation Program

Evaluation of Potential Exposure to Cannabis Dust at a Cannabis Processing and Retail Facility

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Program Description

The National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 [29 USC 669a(6)]. The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations [42 CFR Part 85].

Disclaimer

This document is a NIOSH health hazard evaluation report prepared in response to a specific workplace or technical assistance request. The recommendations in this report are made on the basis of the findings at the workplace evaluated and may not be applicable to other workplaces. As such, this health hazard evaluation report is not intended as industrywide Centers for Disease Control and Prevention (CDC) or NIOSH guidelines or policy, and it does not establish new health standards, guidance, or regulatory requirements.

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Availability of Report

Copies of this report have been sent to the employer and employees at the facility. The state health department and the Occupational Safety and Health Administration Regional Office have also received a copy. This report is not copyrighted and may be freely reproduced.

Recommended Citation

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Introduction

Request

Management at a cannabis processing and retail facility requested a health hazard evaluation of potential exposure to cannabis dust during grinding and processing of ground cannabis. These concerns came from reports of workers in the cannabis production industry developing job-related asthma and allergic sensitization to cannabis.

Workplace

The facility was located on the first floor of a large, two-story building. A retail area was located immediately inside the entrance. A door in the retail area opened to the production area. The production area had a large room where grinding and pre-roll (pre-packaged cones filled with ground cannabis) production took place. It also had a separate decarboxylation room where essential oils were extracted from raw cannabis. Employees could access the break room through both the production and retail areas.

To learn more about the workplace, go to Section A in the Supporting Technical Information

Our Approach

The evaluation was designed to characterize potential exposures and health effects for employees grinding cannabis and processing the ground cannabis. We conducted an initial site visit in March 2024 to tour the facility, observe work practices and processes, interview employees, and gather information to prepare for a follow-up visit. We visited the facility a second time in September 2025 and completed the following activities:

- Observed work processes, work practices, and workplace conditions.
- Measured employee exposure to endotoxins (toxic parts of the cell wall of some bacteria that are released when the bacteria dies or divides) in air.
- Sampled surfaces using two methods for detecting cannabinoids, including delta-9 tetrahydrocannabinol (Δ9-THC), delta-9 tetrahydrocannabinol acid (Δ9-THCA), cannabidiol (CBD), and cannabinol (CBN).
- Measured particulates (mixture of solid particles and liquid droplets) in the air during grinding and pre-roll production.
- Administered baseline and end-of-shift questionnaires on work and demographic characteristics, personal protective equipment use, work-related symptoms, medical conditions, and perceptions about cannabis dust.

To learn more about our methods, go to Section B in the Supporting Technical Information

Our Key Findings

Employees were exposed to particulates and endotoxins in the air and cannabinoids on surfaces

- Particulate levels were higher at the grinding and pre-roll production workstation compared with other work areas.
- Cannabinoids were found on surfaces in production and nonproduction areas. When using the more sensitive Δ9-THC-only method, all surface wipe samples in both production and nonproduction areas had detectable levels of Δ9-THC.
- An employee's full-shift personal exposure to endotoxins was below occupational exposure limits; there were no applicable occupational exposure limits to compare the other exposures.

Some employees reported work-related symptoms associated with grinding and processing ground cannabis

- During our initial site visit, 3 of 7 (43%) interviewed employees reported symptoms they thought were work-related: one reported a scratchy throat and cough, another reported hives, and another reported a rash.
- Symptoms were associated with grinding and dry sifting/kiefing. These are tasks more likely to create cannabis dust. An employee reported the rash stopped after they started wearing Tyvek suits during the tasks.
- During the second site visit, 1 of 5 (20%) surveyed employees reported an irritated nose in the past 4 weeks they believed was work-related. No symptoms were reported on the day of our exposure assessment. That day, an employee was grinding cannabis and making pre-rolls but no dry sifting/kiefing happened.

To learn more about our results, go to Section B in the Supporting Technical Information

Our Recommendations

The potential benefits of improving workplace health and safety are:

↑ Improved worker health and well-being	↑ Enhanced image and reputation
↑ Better workplace morale	↑ Superior products, processes, and services
↑ Easier employee recruiting and retention	↑ Increased overall cost savings

The recommendations below are based on the findings of our evaluation. These recommendations are workplace-specific, based on the information available for the workplace evaluated, and are intended to improve this workplace's conditions. For each recommendation, we list a series of actions you can take to address the issue at your workplace. The actions at the beginning of each list are preferable to the ones listed later. The list order is based on a well-accepted approach called the "hierarchy of controls." The hierarchy of controls is a way of determining which actions will best control exposures. In most cases, the preferred approach is to eliminate hazards or to replace the hazard with something less hazardous (i.e., substitution). Installing engineering controls to isolate people from the hazard is the next step in the hierarchy. Until such controls are in place, or if they are not effective or practical, administrative controls and personal protective equipment might be needed. Read more about the hierarchy of controls on the NIOSH website.

We encourage the company to use a health and safety committee to discuss our recommendations and develop an action plan. Both employee representatives and management representatives should be included on the committee. Helpful guidance can be found in OSHA's Recommended Practices for Safety and Health Programs.

Recommendation 1: Reduce exposures to particulates when grinding and processing ground cannabis

Why? Particulates, especially cannabis plant material, can contain endotoxins and allergens. Exposure to these has been linked to breathing problems, including occupational asthma.

We observed an employee dry brushing equipment and sweeping floors in the production area after grinding cannabis and processing ground cannabis into pre-rolls. Company policy called for employees to wear face masks during grinding and processing tasks. However, face masks are not NIOSH Approved® respirators and are not designed to filter respirable particles. In addition, there was no respiratory protection policy for employees grinding and processing ground cannabis.

How? At your workplace, we recommend these specific actions:

Clean with wet methods or high-efficiency particulate air (HEPA) filter vacuums instead of dry sweeping or brushing.

- Train employees to use proper methods while cleaning. Dry sweeping or brushing dusty surfaces will release settled dust into the air. Wet methods (e.g., mops or surface wipes) or HEPA-filtered vacuums are better for cleaning material left on the floors and work surfaces in production areas.
- Consider respiratory protection for employees if using HEPA-filtered vacuums for tasks like emptying the dust cup or removing the bag, changing filters, or other activities that might put dust into the air.

If the workplace requires respiratory protection for employees, a respiratory protection program should be developed for the worksite.

- Prepare a written respiratory protection program that notes worksite-specific tasks that require respirator use. Also, assign a capable person to lead the program. The Occupational Safety and Health Administration (OSHA) specifies the requirements for your written program. This includes annual respirator fit testing, documented training, and medical clearance, among other things. Find that information here: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.134.
- OSHA has developed a Small Entity Compliance Guide for the Respiratory Protection Standard that you might find useful when developing your respiratory protection program.

Recommendation 2: Reduce exposures to cannabinoids in the workplace

Why? Employees can be exposed to cannabinoids by absorbing them through the skin or swallowing them. In this facility, we found cannabinoids on surfaces in both production and nonproduction areas, even though we did not expect to find them in nonproduction areas. Cannabinoids likely spread to other areas on employees' hands, gloves, clothing, and shoes. For example, we saw employees touch personal items like phones with contaminated gloves and leave production areas without removing their dirty gloves. The long-term health effects of exposures from these routes are unknown, making it important to use strict hand hygiene and cleaning practices to prevent unnecessary contact.

How? At your workplace, we recommend these specific actions:

Train employees about the importance of removing gloves and washing hands before going into nonproduction areas or using the restroom, eating, drinking, or smoking.

- Require employees to always remove their gloves and wash their hands with soap and water before leaving production areas.
- Instruct employees on proper handwashing techniques and when to wash their hands, for example, before going on break, at the end of the workday, and before using the restroom.

Clean high-touch surfaces like door handles as part of the regular cleaning schedule to reduce possible cannabinoid exposure.

- Use wet cleaning methods, like surface wipes with 70% alcohol, to clean high-touch surfaces at least once per shift. Include areas like door handles, microwave face, refrigerator handles, and other surfaces.

Recommendation 3: Encourage employees with work-related health concerns to talk to their supervisor or healthcare provider about their work exposures

Why? Finding symptoms early can make them less severe and help ensure proper management and treatment, if needed. It can also help the workplace take steps to prevent employees from developing conditions like work-related asthma or occupational allergies.

How? At your workplace, we recommend these specific actions:

Tell employees to report any symptoms they believe are work-related to their supervisor.

- Train employees to recognize signs and symptoms of work-related allergies and asthma.
- Make sure employees with these symptoms are seen promptly by a healthcare provider with the right expertise.
- Regularly review symptom reports to find patterns and take action if needed.

Encourage employees with work-related health concerns to tell their healthcare providers about their work.

- Employees can share a copy of this report with their healthcare provider.
- Employees can seek care for work-related medical concerns from a healthcare provider knowledgeable in occupational medicine, if needed. The American College of Occupational and Environmental Medicine and the Association of Occupational and Environmental Clinics maintain databases of providers to help locate someone nearby.

Consider setting up a medical surveillance program to find early signs and symptoms of work-related allergies and asthma.

- Include employees exposed to known allergens at work like cannabis in a written surveillance program that regularly assesses for signs and symptoms of allergy and asthma.
- Analyze the results to identify exposures and jobs with the highest risk for allergic sensitization and disease. Allergic sensitization is when the body's immune system develops a response to an allergen (like cannabis dust). After this happens, even small amounts of the allergen can trigger symptoms.
- Recognize that employees who have or develop work-related allergic sensitization may need to change to a job without allergen exposure. They might also be eligible for workers' compensation.

Recommendation 4: Address other health and safety issues we identified during our evaluation

Why? A workplace can have multiple health hazards that cause worker illness or injury. Beyond the hazards identified above, these can potentially cause serious health symptoms, lower morale and quality of life for your employees, and possibly increase business costs. Specifically, we saw a microwave used to heat high-percentage alcohol before it was used to clean equipment. Although not the focus of our evaluation, heating alcohol in the microwave creates a potential fire risk and explosion risk that should be addressed.

How? At your workplace, we recommend these specific actions:

Adjust the cleaning procedures and training for the production area.

- Do not heat alcohol in the microwave. It is better to use the alcohol at room temperature instead of heating it.
- Train employees who use high-percentage alcohol for cleaning how to properly handle flammable liquids. Training should cover potential fire hazards and the safe handling and storage of flammable liquids. Incorporate this training into new employee and annual refresher training.

Supporting Technical Information

Evaluation of Potential Exposure to Cannabis Dust at a Cannabis Processing and Retail Facility

HHE Report No. 2023-0102-3434

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Section A: Workplace Information

Building and Employee Information

The facility leased the bottom floor in a large, two-story building. This facility processed dried bulk cannabis material into products for sale in the retail area. Cannabis cultivation did not occur at this facility. Facility ventilation was provided by a general heating, ventilation, and air-conditioning (HVAC) system maintained by the building owner. The system discharged air to the outdoors at the side of the building, away from the roof air intake.

At the time of our follow-up visit, the facility employed eight employees. Most worked in the retail area, while one or two worked in the production area grinding or processing ground cannabis. Employees processed ground cannabis into pre-rolls or extracted essential oils from the material into cartridges for vape pens. Employees ground and processed ground cannabis approximately once per week. The amount of material processed varied depending on production demand. Employees worked overlapping shifts of various lengths seven days a week, with an hour break for lunch. There was no union.

Process Description

Employees used a tabletop machine to grind dried flower buds into the appropriate size for extraction or pre-rolls (Figure A1). The employee weighed the material before scooping it into the machine's hopper pan. The material was shredded by aluminum blades inside the machine. The machine could be equipped with three different screen sizes (4 millimeter [mm], 5.5 mm, and 6 mm). Employees used the smaller screen size to produce finer powder for extraction while the larger screen sizes were used to produce coarser powder for pre-roll production. The particulate was collected into a plastic tub that was attached to the machine by its lid. The employee occasionally shook the machine while it was operating to ensure all the material was processed. Once all the material was processed, the employee detached the plastic tub, dumped the material into a plastic bag, and then weighed the bag.

Figure A1. Grinding station showing the shredder and dried cannabis material. A DustTrak™, shown in the background on the left side of the work table, measured particulates generated during work tasks. Photo by NIOSH.

The employee used a shaker to make pre-rolls. The shaker was set up on the same table used to grind dried flower buds and was used to shake ground cannabis into paper cones that were loaded into a tray. The tray held up to 169 cones at a time. To start, the employee weighed out enough ground cannabis to fill each pre-roll with approximately 1 gram of material. The employee weighed ground cannabis in a plastic tub, then poured the weighed material into the open top of the shaker. While the shaker vibrated, the employee spread the ground cannabis into the cones by hand to make sure each cone was

filled evenly. The filled cones were set aside to be individually weighed and twisted. The employee wore nitrile gloves while grinding and making pre-rolls.

Employees also processed cannabis through dry sifting/kiefing and carbon dioxide (CO_2) extraction. At this facility, kiefing referred to using an enclosed tumbler to collect the trichomes, or kief, which contained the highest concentration of cannabinoids and terpenes in the cannabis plant. After collection, employees would scrape the kief out of the tumbler. Employees could then further refine the kief by dry sifting it through fine mesh screens. The employee heated the kief in a decarboxylation oven then used a press to extract hash oil.

Dry sifting/kiefing and pressing were done in a tent in a shared sallyport at the front of the lab where CO_2 extraction took place. Employees were required to wear gloves and a face mask, and Tyvek suits were provided for voluntary use during this process and during grinding. The decarboxylation oven exhausted air directly outdoors. These processes do not occur regularly at this facility and were not observed during our follow-up visit. In the lab, employees used an automated CO_2 extraction system to extract essential oils from ground cannabis; this process also did not occur during our follow-up visit.

Section B: Methods, Results, and Discussion

Methods: Observations of Work Processes, Practices, and Conditions

We collected information on the following during our site visit:

- Work processes
- Workplace conditions
- Personal protective equipment (PPE) usage during production tasks

Results: Observations of Work Processes, Practices, and Conditions

- Company policy called for employees to use face masks and nitrile gloves while grinding and making pre-rolls. During our visit, nitrile gloves were the only PPE worn during these tasks.
- Equipment and floors in the production area were cleaned with dry brushing and sweeping. The employee doing this cleaning was wearing nitrile gloves at the time.
- 91% isopropyl alcohol, used to clean grinding equipment, was heated in a microwave.

Methods: Exposure Assessment

Endotoxins

We collected a personal air sample on an employee who ground and packaged the ground cannabis during their shift. We used a three-piece, 37-mm diameter closed-face cassette with 0.4-micrometer (μm) pore size preloaded polycarbonate filters. The cassette was connected to a sampling pump that was calibrated at a flow rate of 2 liters of air per minute. The sample was analyzed for endotoxins using a recombinant Factor C assay method (HyGlos EndoZyme® rFC Assay) [Thorne et al. 2010]. The assay was a quantitative endpoint fluorescence test used to measure Gram-negative bacterial endotoxins. The sample was paused and the pump removed from the employee during breaks. For this analysis, the limit of detection was 0.02 endotoxin units (EU) per sample.

Cannabinoids

We collected surface wipe samples in production and nonproduction areas of the facility and analyzed for delta-9 tetrahydrocannabinol (Δ9-THC), delta-9 tetrahydrocannabinol acid (Δ9-THCA), cannabidiol (CBD), and cannabinol (CBN). Where possible, two samples were taken in each location, with the second taken directly adjacent to the first sample. The sampling area for all samples was outlined using a disposable 100-square-centimeter (cm^2) template. If it was not feasible to use the template (e.g., the surface was an irregular shape that did not lend itself to using the template), an estimated 100 cm^2 of surface was wiped for the sample.

Each pair of samples was analyzed using two methods, one for each sample. One sample was analyzed for Δ9-THC using the contract laboratory's internal method. The method used high performance liquid chromatography and tandem mass spectrometry with a limit of detection of 20 nanograms (ng) per sample. The second sample was analyzed for Δ9-THC, Δ9-THCA, CBD, and CBN using a modified

method [Ambach et al. 2014]. The modified method used high performance liquid chromatography with diode-array detection with a limit of detection of 2 micrograms (μg) per sample for each analyte.

Particulates

We measured particulates in the production area during a full shift using DustTrak™ DRX 8533 Aerosol Monitors (TSI, Inc.). One monitor was placed on the table where grinding and filling pre-rolls took place. Another monitor was placed approximately 20 feet away on another table sometimes used by employees to make pre-rolls, depending on production needs. A third monitor was placed in the retail area next to a cash register. All monitors were set to log particle concentrations every second in different size groups: particulate matter (PM) smaller than 1 μm (PM_1), PM smaller than 2.5 μm ($PM_{2.5}$), respirable (less than 4 μm), PM smaller than 10 μm (PM_{10}), and total PM (less than 100 μm). The data output was expressed as the mass concentration of particles per cubic meter (mg/m^3) of the sampled air. The lower instrument range was less than 0.001 mg/m^3.

Results: Exposure Assessment

Endotoxins

Employee exposure to endotoxins in air was below the American Conference of Governmental Industrial Hygienists (ACGIH®) threshold limit value (TLV®) of 90 endotoxin units per cubic meter of air (EU/m^3), as an average over an 8-hour work shift. ACGIH TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They are considered voluntary occupational exposure guidelines "to assist in the control of health hazards" [ACGIH 2026]. NIOSH has not established a recommended exposure limit (REL) for endotoxins. Likewise, OSHA does not have a permissible exposure limit (PEL) for endotoxins.

Cannabinoids

Surface wipe samples for cannabinoids were collected using two methods in nine locations throughout the facility (Table C1). One method analyzed samples for Δ9-THC only. The second method analyzed samples for multiple cannabinoids simultaneously (Δ9-THC, Δ9-THCA, CBD, and CBN).

For the Δ9-THC-only method, all samples had detectable levels of Δ9-THC. The surface wipe results ranged from 42–150 micrograms per 100 square centimeters ($\mu g/100\ cm^2$) in production areas and from 0.23–5.7 $\mu g/100\ cm^2$ in nonproduction areas.

For the method analyzing samples for multiple cannabinoids simultaneously, all surface wipe samples in production areas had detectable levels of Δ9-THC (range: 7–270 $\mu g/100\ cm^2$), as did two of four surface wipe samples in nonproduction areas (range: not detected–5.3 $\mu g/100\ cm^2$). Δ9-THCA was detected in all samples taken in production areas (range: 12–750 $\mu g/100\ cm^2$) and also in three of four samples taken in nonproduction areas (range: not detected–63 $\mu g/100\ cm^2$). CBD was detected in one of three samples in production areas (range: not detected–21 $\mu g/100\ cm^2$) but was not detected in nonproduction areas. All surface wipe samples in production areas had detectable levels of CBN (range: 22–89 $\mu g/100\ cm^2$) as did one of four samples in nonproduction areas (range: not detected–9.5 $\mu g/100\ cm^2$). Currently there are no occupational exposure limits (OELs) for these substances sampled in air or on surfaces.

Particulates

Table C2 summarizes particle concentrations, reported as mg/m^3, in different size groups during the sampling period. Respirable particle (less than 4 μm in diameter) concentrations ranged from 0.029 to 7.480 mg/m^3 on the table where processing activities took place, 0.012 to 0.491 mg/m^3 on a table 20 feet away from the processing activities, and 0.009 to 0.199 mg/m^3 in the retail area.

OSHA has a PEL for respirable dust of 5 mg/m^3, as an 8-hour time-weighted average (TWA). This limit is intended for nuisance dust that does not contain harmful components. Currently there are no OELs for cannabis dust. The area sample results cannot be compared to OELs directly because these limits are based on personal exposure levels.

Concentrations of airborne respirable particles increased while an employee ground cannabis and made pre-rolls, with higher concentrations occurring during grinding. Figure B1 shows the concentration of respirable particles at the table where grinding and filling pre-rolls took place. The highest peaks occurred during grinding.

The concentration of respirable particles increased in the production area around 9:30 a.m. when an employee began grinding cannabis to make pre-rolls. The employee was grinding for about 20 minutes. Within this period, short-duration higher peaks likely corresponded with dust generated as the employee scooped additional material into the grinder. Around 9:49 a.m., the employee turned off the grinder, took the top off, brushed the lid of the grinder off to remove residual powder. They then dumped the powder into a plastic bag around 9:50 a.m. We observed a peak in the concentration of respirable particles at this time. Shortly afterwards the concentration of respirable particles began to decrease.

For about 20 minutes, beginning at approximately 10:00 a.m., the employee hand-scooped powder from the bag to weigh the material before making pre-rolls. The employee then poured the powder into the shaker and ran the shaker for about 5 minutes. Afterwards, the employee brushed residual powder from the sides of the shaker and the inside of the plastic tub containing the shaker into the cones. Small peaks during this 20-minute period are likely related to these different activities. At around 10:19 a.m., the employee weighed the pre-rolls. This lasted for approximately 40 minutes, and the concentration of respirable particles decreased to background levels (i.e., ambient concentration) during this time.

From 11:22 a.m. to 11:44 a.m., the employee was grinding cannabis for extraction. During this period, the employee periodically scooped and added additional material to the grinder resulting in higher short-duration peaks. When grinding was completed at 11:44 a.m., the employee turned the grinder off, took the top off, and brushed the lid of the grinder off to remove residual powder. The employee then dumped the ground cannabis into a plastic bag.

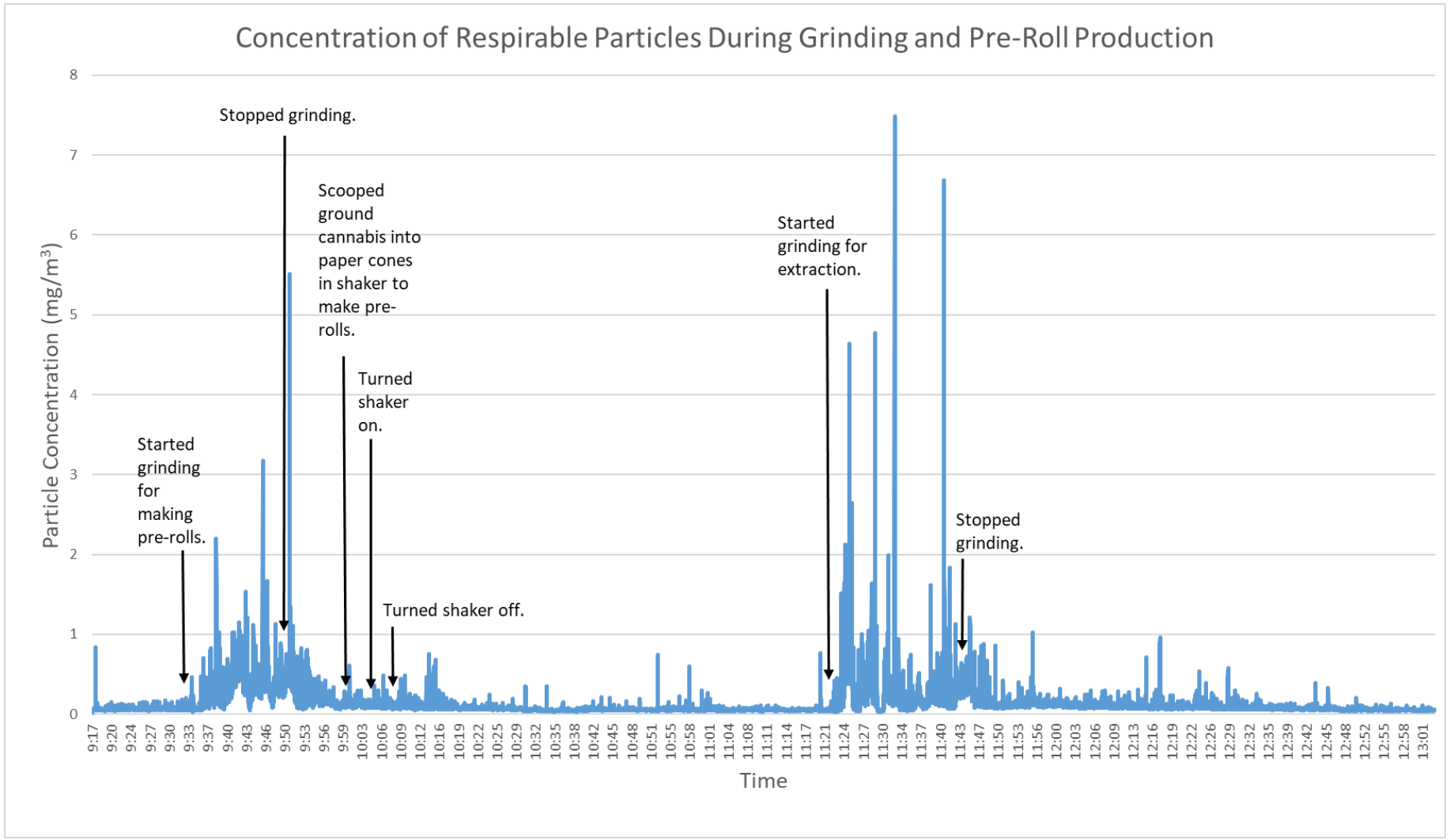

Figure B1. Concentration of respirable particles during grinding and pre-roll production. Figure by NIOSH.

Methods: Employee Interviews and Questionnaires

Confidential Interviews

We invited all employees available during the initial site visit to participate in confidential interviews. We described the interview to the employee and asked if they would like to voluntarily participate. Participating employees verbally consented. Most interviews took approximately 15 minutes.

Interviews were conducted in rooms that provided privacy. During the interview, we asked about work and demographic characteristics, perceptions about dustiness in the workplace, symptoms that the employee thought were related to working at this workplace, and workplace health or safety concerns.

We used R version 4.4.0 to perform statistical analysis. We calculated medians and ranges for continuous variables and counts and percentages for categorical variables. We used the information gathered from interviews to help design the questionnaires for the subsequent site visit.

Questionnaires

We invited all employees available during the follow-up site visit to participate in a baseline questionnaire and all employees working on the day of our exposure assessment to complete an end-of-shift questionnaire. We asked employees to read a cover sheet describing each questionnaire. Proceeding to fill out the questionnaires was considered to mean the employee had consented to participate. Each participant was assigned a unique identifier to write on each questionnaire they completed so we can link questionnaire responses; names were not recorded on the questionnaire forms.

Baseline Questionnaire

We invited all employees available during the site visit to complete a baseline questionnaire on their own. The baseline questionnaire took approximately 15–20 minutes to complete and asked about the following:

- Demographics, work history, and work tasks
- PPE use in the past 4 weeks
- Symptoms experienced in the past 4 weeks
- Medical history
- Perceptions about cannabis dust

We considered a symptom to be work-related if it was (1) better when away from work and (2) not related to seasonal allergies or an illness like a cold, the flu, or COVID-19.

We asked employees to respond to statements about cannabis dust using the following scale: 1 (strongly agree) to 7 (strongly disagree). We grouped responses of 1–3 as "agree," considered responses of 4 to be "neutral," and grouped responses of 5–7 as "disagree."

End-of-shift Questionnaire

We invited employees working on the day of our exposure assessment to complete a questionnaire at the end of their shift. We asked about that day's working hours, job tasks, PPE use, and any symptoms experienced at work. The end-of-shift questionnaire took approximately 5 minutes to complete.

Statistical Analysis

We used the unique identifier to link responses from baseline and end-of-shift questionnaires if an employee participated in both. We used R version 4.4.0 for descriptive statistics. We calculated medians and ranges for continuous variables and counts and percentages for categorical variables.

We did not attempt to combine interview and questionnaire responses because not all employees who participated in interviews during the initial visit were working at the facility when we returned for the site visit to administer questionnaires, and vice versa.

Results: Employee Interviews and Questionnaires

Confidential Interviews

Seven employees were available during the initial site visit; all participated in an interview. The median job tenure was 2 years (range: <1 to >5 years). Four employees reported working for a median of 17.5 hours per week (range: 6–25 hours). Most (86%, n = 6) were male. The median age was 32 years, ranging from the mid-20s to mid-50s.

By job title, three (43%) employees were categorized as working in selling, four (57%) in production, and three (43%) in management functions. Two (29%) employees reported only working in the retail area. Three (43%) employees reported working in the grinding room. All reported working with dry cannabis and almost all (86%, n = 6) reported working with ground cannabis.

When asked if the area where they worked was dusty, the most common response was "sometimes" (57%, n = 4). One (14%) employee each reported that their work area was "always," "rarely," and "never" dusty. However, it was not clear if employees were referring specifically to cannabis dust.

Of the seven employees interviewed, three (43%) reported symptoms they thought were related to their work at this facility. One (14%) employee each reported experiencing a scratchy throat and cough, hives, and rash. Employees reported that symptoms occurred during grinding and dry sifting/kiefing. The employee with a scratchy throat and cough associated it with grinding. The hives reported occurred on the entire body and was associated with grinding and dry sifting/kiefing. The rash was described as occurring on the exposed skin of the arms and neck and was associated with dry sifting/kiefing. The rash reportedly no longer occurred after Tyvek suits were added on a voluntary basis for the tasks.

In addition, gloves, which were required for dry sifting/kiefing, were taped to the Tyvek suit. Of these three employees with symptoms, one (33%) employee stated symptoms began shortly after they began working at the facility while two (67%) reported that they began approximately 1–2 years since starting to work at the facility.

Most (86%, n = 6) employees did not have any health or safety concerns about their workplace. All reported that they knew how to report concerns if they arose.

Questionnaires

Work and Demographic Characteristics

During the second site visit, five employees were available to participate in the baseline questionnaire; all participated. The three employees working on the day of the exposure assessment all participated in the end-of-shift questionnaire. Four employees participated in both interviews and questionnaires.

Of the five employees, the median job tenure was 4 years (range: 1–7 years). Four employees reported working for a median of 22 hours per week (range: 22–50 hours).

Three (60%) employees reported that they have worked in the cannabis industry before working at this facility or were currently working elsewhere in the cannabis industry. Among the five employees, the median total duration of cannabis industry work was 6 years, 8 months (range: 4 years–7 years, 2 months).

Of the five employees participating in the baseline questionnaire, four (80%) were male. The median age was 33 years (range: late 20s–mid 50s).

Work Tasks

Job tasks are presented in Table C3. The most commonly reported job task was selling products (budtending), reported by all five employees. Grinding cannabis and dry sifting/kiefing, which were the tasks that employees interviewed during the initial site visit associated with symptoms, were each reported by 2 (40%) employees.

PPE Use

All employees reported wearing gloves in the past 4 weeks. Face mask and Tyvek suit use was reported by one (20%) employee each. None reported using an N95® respirator in the past 4 weeks. Long pants and long sleeves were always worn at work by one (20%) employee, sometimes worn by three (60%) employees, and never worn by one (20%) employee during the past 4 weeks.

Table C4 shows the types of PPE used in the past 4 weeks by job task. While gloves were used for multiple job tasks, face mask use was only reported for grinding and dry sifting/kiefing, as required by the company, and Tyvek suit use was only reported for grinding.

Symptoms

One (20%) employee reported work-related nasal irritation during the past 4 weeks. No other work-related symptoms were reported.

In response to an open-ended question about any other workplace safety and health concerns, one employee described shortness of breath, wheezing, and throat irritation associated with a prior job at a cannabis facility. Symptoms began within 1 week of starting as a trimmer in a cannabis cultivation facility. This person necessitated reassignment to a different department, but symptoms were not completely resolved by the time of the questionnaire.

Medical History

The questionnaire asked employees whether they had ever been told by a doctor or other health professional that they had certain health conditions. Two (40%) employees reported that they had asthma diagnosed prior to starting to work in the cannabis industry. While they reported they still had asthma, neither reported that it had gotten worse while working in the cannabis industry. One (20%) employee reported a history of nasal or sinus allergies; none reported being diagnosed with eczema or any other skin or respiratory conditions.

Perceptions About Cannabis Dust

Figure B2 shows the distribution of employee responses to statements about cannabis; all employees reported currently using it for medical or recreational purposes. All employees who participated in the

questionnaire agreed that it is possible to protect yourself from exposure to cannabis dust (with 80% strongly agreeing) and the employer's attempts to protect workers from cannabis dust are effective. Employees agreed with or were neutral about the statement that the employer and management treats cannabis as a potentially harmful exposure.

Responses were more mixed to four statements about potential for exposure or health effects of cannabis dust, with some employees agreeing, disagreeing, or being neutral. All employees who participated in the questionnaire disagreed that the potential of being exposed to cannabis caused them anxiety, with 80% strongly disagreeing.

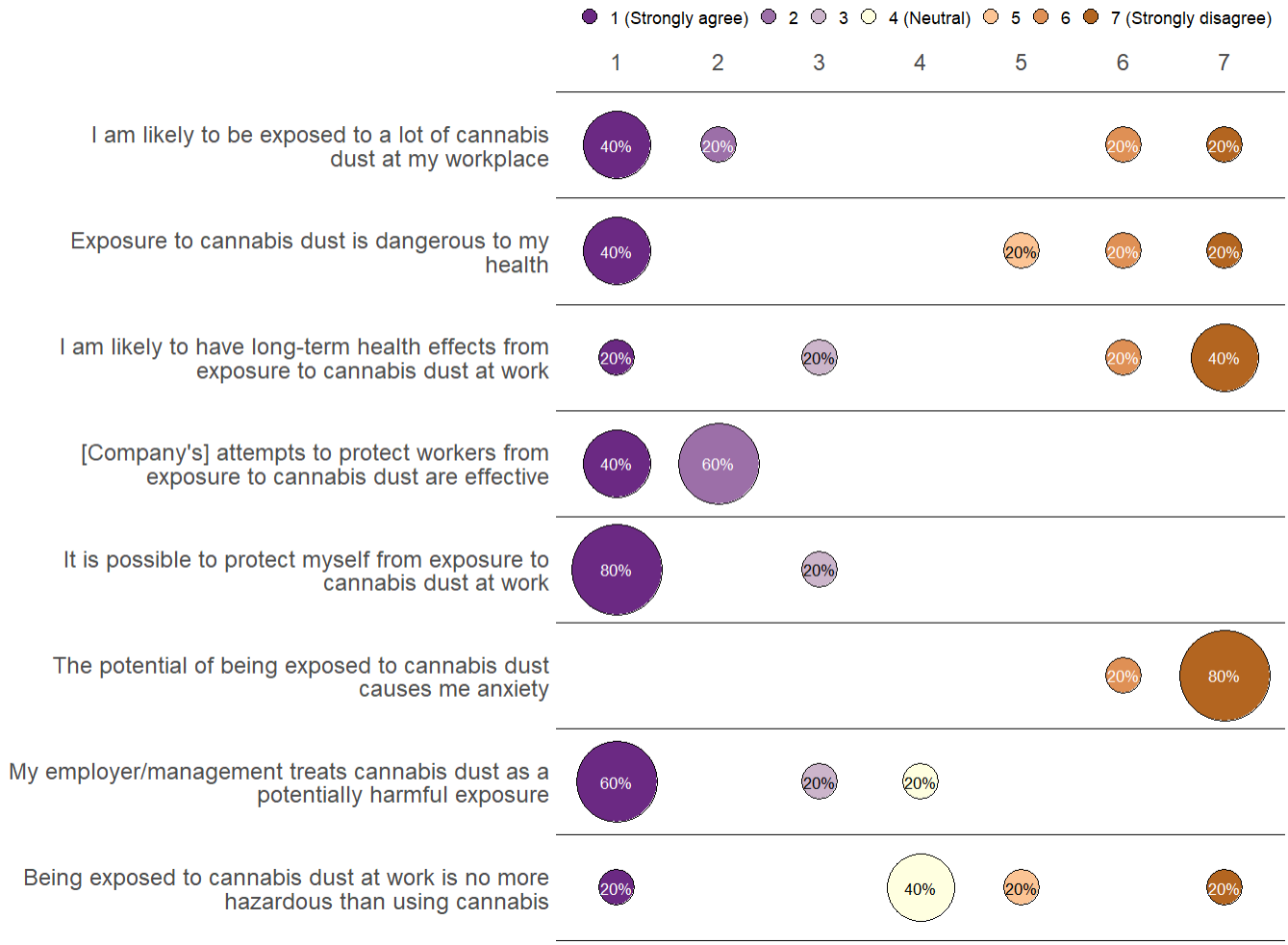

Figure B2. Responses to statements about cannabis dust on the baseline questionnaire (n = 5). Figure by NIOSH.

End-of-shift Questionnaire

Three employees were working on the day of our exposure assessment; all three completed an end-of-shift questionnaire. On that day, they reported working a median of 7.5 hours (range: 6–9 hours). Not all tasks reported on the baseline questionnaire were performed that day (Table C3). All three employees were selling products (budtending) for 3–6 hours.

Nitrile gloves were the only type of PPE used during the day. Gloves were used all the time during grinding (approximately 40 minutes) and making pre-rolls (approximately 10 minutes). Gloves were used some of the time during packaging and inventory tasks and by two of three employees while selling products (budtending).

None of the employees reported any symptoms during their shift.

Discussion

Exposures to endotoxins come from soil- and plant-disturbing activities. During our evaluation, we observed an employee grinding cannabis, making pre-rolls, as well as dry brushing and sweeping equipment and floors. These activities increased the opportunity for exposure to airborne endotoxins. The airborne endotoxin exposure we found was similar to what we detected on a production worker at another cannabis facility [NIOSH 2025a]. Personal airborne endotoxin levels found at previously evaluated facilities include an indoor cultivation and retail facility (range: 1.4–27.6 EU/m^3), outdoor cannabis farm (range: 3.0–37 EU/m^3), an indoor and outdoor cannabis cultivation facility (range: 1.0–85 EU/m^3), and an indoor cultivation facility (range: 6.0–980 EU/m^3) [NIOSH 2017, 2018, 2022, 2025a].

The concentrations found in this evaluation were much lower than those found in other kinds of agricultural settings, including two indoor herb processing plants (median endotoxin concentration: 3×10^5 EU/m^3); four peppermint and nine chamomile herb farm indoor processing operations (median endotoxin for peppermint farms: 1×10^6 EU/m^3; median endotoxin for chamomile farms: 1.8×10^4 EU/m^3); and an indoor hemp processing plant (mean endotoxin concentration: 1.9×10^4 EU/m^3) [Dutkiewicz et al. 2001; Fishwick et al. 2001; Skórska et al. 2005; Thilsing et al. 2015].

The main way cannabinoids are distinguished is by the degree of their psychoactivity, which indicates how a compound affects a person's nervous system. Δ9-THC is the psychoactive component of cannabis, whereas Δ9-THCA, CBD, and CBN are not psychoactive substances. It has not been determined whether occupational exposures to these cannabinoids causes long-term health effects. The differences between occupational exposures to psychoactive cannabinoids and non-psychoactive cannabinoids are also unknown.

We detected cannabinoids on both production and nonproduction surfaces. Production surfaces had higher concentrations compared with nonproduction surfaces. Cannabinoids are expected to be found in production areas. Detecting cannabinoids in nonproduction areas indicates that cleaning and hygiene could be improved to prevent contaminating nonproduction areas when leaving production areas. While collecting surface wipe samples, efforts were made to ensure that the majority of samples were adjacent. However, because of presumed unequal distribution of cannabinoids across surfaces, we cannot directly compare results between the two methods. Δ9-THCA concentrations were higher than Δ9-THC concentrations in all surface wipe samples. A previous NIOSH health hazard evaluation (HHE) report suggested that in cannabis cultivation workplaces, Δ9-THCA concentrations would be present in higher concentrations than Δ9-THC because the Δ9-THCA would not have been decarboxylated through heat or aging [NIOSH 2017]. The detected concentrations in this evaluation are consistent with those found in another evaluation in the production areas of an indoor cannabis cultivation facility [NIOSH 2025a].

Our results from particulate monitoring indicate that there are dust exposures during certain cannabis processing activities that disturb plant matter, such as grinding and making pre-rolls, but there are no specific OELs that can be used to evaluate these exposures. OELs exist for general dust, but those limits are intended for nuisance dust that is not known to contain harmful components. Additionally, area sample results cannot be compared to OELs since OELs are based on personal exposures. In this evaluation, we sampled areas where we expected work processes may produce particulates, and we were able to confirm that this was the case. The particulates produced during these tasks are likely a major mechanism by which endotoxins and cannabinoids are released when plant matter is disturbed.

Particles larger than 100 μm in diameter may be too big to enter the deepest areas of the lungs, but can enter the nose, mouth, and upper airways during breathing. Particles less than 4 μm in diameter are respirable and can penetrate deeply into the lower respiratory system [ACGIH 2026]. Fine particles (less than 2.5 μm in diameter) are primarily deposited in the small airways and alveoli [American Lung Association 2025]. Acute and chronic exposure to respirable particles have been linked with adverse health effects, including cardiovascular disease, respiratory disease, developmental and reproductive effects, and lung cancer [EPA 2026].

Symptoms reported by employees at this facility—nasal and throat irritation, cough, and skin symptoms—are consistent with those reported in the scientific literature addressing workers in similar workplaces. For example, an earlier HHE of employees at an indoor cannabis cultivation and retail facility found that 75% of interviewed employees reported eye, nose, or sinus symptoms [NIOSH 2025a]. In other earlier HHEs at cannabis facilities, interviewed employees also reported work-related eye, nose, and sinus symptoms [NIOSH 2018, 2022] and skin symptoms [NIOSH 2022]. Sack et al. [2020] also found that the odds of having similar work-related symptoms increased with more exposure to cannabis dust, but the results were not statistically significant. During a public health investigation after an employee fatality at a cannabis production facility, 4 of 10 coworkers reported work-related respiratory or skin signs and symptoms [Weaver et al. 2023].

While two employees reported being diagnosed with asthma, their conditions did not meet the definition of work-related asthma. Work-related asthma includes new-onset asthma or worsening of existing asthma triggered by exposures at work [NIOSH 2026]. However, another employee described shortness of breath, wheezing, and throat irritation that began after exposure to cannabis dust at a former job in cannabis cultivation. These symptoms are suggestive of work-related new-onset asthma at the prior job. A growing body of studies has linked employment in the cannabis industry with a spectrum of conditions that includes occupational asthma and allergy [Decuyper et al. 2020; Eidem et al. 2024; Pacheco et al. 2025; Reeb-Whitaker et al. 2022; Sack et al. 2023]. To date, two deaths among cannabis workers have been attributed to asthma exacerbations at work [Massachusetts FACE Program 2023; Pacheco et al. 2025; Weaver et al. 2023]. At least one of these deaths is thought to be consistent with asthma exacerbation triggered by cannabis allergy [Massachusetts FACE Program 2023; Weaver et al. 2023].

However, symptoms reported by employees in this evaluation were not as prevalent or severe as those noted in past evaluations. This might be due to multiple reasons, including differences in work characteristics, such as the volume of work and types of controls in place to prevent exposure. For example, cannabis was ground and processed approximately once per week at this facility and the grinding process was relatively enclosed. However, face masks, which the company required employees to use for grinding and dry sifting/kiefing, do not provide adequate respiratory protection because they

might not filter small particles. In addition, because a face mask is loose fitting, air might pass around it rather than be filtered by passing through it [NIOSH 2025b].

Differences in exposures could be another reason for the relatively low burden of symptoms observed in this evaluation. Potential hazards related to respiratory or allergic disease across the cannabis industry include allergens; organic dusts that can contain fungus, bacteria, and endotoxins; and volatile organic compounds [Couch et al. 2020; Decuyper et al. 2020; Eidem et al. 2024]. The extent and composition of hazards present can differ across various stages of the cannabis cultivation and manufacturing process [Eidem et al. 2024] and might vary by cannabis strain or batch [King et al. 2023].

Differences in individual susceptibility might also contribute to differences in health symptoms and conditions. For example, an allergy refers to an exaggerated immune system reaction to a specific substance (allergen) that does not bother most people. Thus, individual reactions to allergens can vary from none to severe, which makes it challenging to establish OELs. Even when OELs exist, such as for airborne respirable dust and endotoxins, levels below the limit do not exclude a sufficient level of allergen to trigger asthma or other allergic symptoms.

In addition, allergic reactions occur upon re-exposure after sensitization. Sensitization is the process by which the body develops antibodies or specific immune cells to a substance. Thus, there is often a delay, or latency, between exposure and symptom onset in an allergy-related response whereas other substances with irritant effects can lead to more immediate symptoms [Sack et al. 2023]. As a result, it might take time for health effects to develop, even though employees might have had prior occupational or nonoccupational exposure to cannabis. Early recognition of signs and symptoms for occupational allergy and work-related asthma are important to prevent adverse health outcomes [Dodd et al. 2026]. Training employees about workplace hazards, ways to minimize exposures, and how to recognize and report signs and symptoms of these conditions, along with prompt medical evaluation, are important for protecting cannabis industry workers [OSHA 2025; Weaver et al. 2023].

Questionnaire responses suggest that employees might be amenable to adopting measures to protect themselves from exposure to cannabis dust. All employees agreed that it was possible to do so and 80% agreed that management treats cannabis as a potentially harmful exposure. The latter finding is consistent with results of an online survey of cannabis industry workers in Colorado where participants perceived that their management valued safety [Walters et al. 2018]. Questionnaire responses were more mixed about the potential for exposure or health effects from cannabis dust. This might indicate a need for wider dissemination of emerging knowledge about the potential health effects of cannabis dust and relating it to occupational exposure. For example, 60% of employees disagreed with the statement that exposure to cannabis was dangerous to their health but only 20% (1 employee) agreed that being exposed to cannabis dust at work is no more hazardous than using cannabis. However, these findings might reflect the incomplete state of scientific knowledge about the health effects associated with cannabis dust.

Limitations

This evaluation is subject to several limitations. Industrial hygiene sampling can only document exposures and conditions in the locations evaluated on the days that the evaluation occurred. These results may not be representative of conditions during other days. It is important to note that some of the samples we collected were area samples where employees typically worked. Results from area samples cannot be directly compared with OELs, which are established for personal exposures.

Furthermore, there are no OELs for cannabis dust with which to compare personal sampling results. In addition, interviews and questionnaires were based on self-reported responses. Some questions asked about events up to 4 weeks ago, which leads to potential for decreased recall. Non-occupational exposure to cannabis, which was reported by all employees, might affect findings about the relationship between exposure and health effects. Finally, as this workplace had relatively few employees and not all were available to participate during our site visits, results might not be generalizable to other workplaces where cannabis processing takes place.

Conclusions

During cannabis grinding and pre-roll production, employees were exposed to particulates and endotoxins in air. Endotoxin exposures were below applicable OELs; there are no applicable OELs for comparison with our cannabis particulate sampling. Cannabinoids were detected on surfaces in production and nonproduction areas. Some employees reported work-related symptoms associated with tasks likely to generate cannabis dust. These results might be due to the relatively low volume of dust-generating tasks and controls in place and are not generalizable to other cannabis industry workplaces. As a best practice for occupational health, we recommended that the workplace further reduce exposures to endotoxins, cannabinoids, and particulates. We also recommended that they encourage employees with work-related health concerns to talk to their supervisor or healthcare provider about their exposures at work.

Attribution Statement

N95 and NIOSH Approved are certification marks of the U.S. Department of Health and Human Services (HHS) registered in the United States and several international jurisdictions.

Section C: Tables

Table C1. Surface wipe sampling for cannabis compounds in micrograms per 100 square centimeters (µg/100 cm^2)

	Δ9-THC-only method*	Cannabinoid method*			
Location	Δ9-THC	Δ9-THC	Δ9-THCA	CBD	CBN
Production					
Grinding table, before cleaning	[150]	[270]	750	[21]	89
Grinding table, after cleaning	42	[76]	220	ND	44
Door handle between production and break areas, production side†	NA	[7.0]	12	ND	[22]
Break area					
Door handle between production and break areas, break area side†	5.7	NA	NA	NA	NA
Fridge and freezer handles†	0.86	ND	ND	ND	ND
Microwave handle and buttons†	0.86	[5.3]	63	ND	[9.5]
Door handle between break room and retail area, break room side†	NA	ND	4.3	ND	ND
Retail area					
Door handle between break room and retail area, retail area side†	0.23	NA	NA	NA	NA
Cash register computer keyboard†	2.9	[2.0]	[5.2]	ND	ND

ND = not detected; NA = not applicable; did not sample because it would have been effectively "cleaned" by the other wipe sample; µg/100 cm^2 = micrograms per 100 square centimeters.

[ ] = values in brackets are between the limit of detection and limit of quantification. This means there is more uncertainty associated with these values.

* The limits of detection and quantitation for the Δ9-THC-only method were 0.02 and 0.07 µg/sample. The limit of detection for the cannabinoid method was 2 µg/sample and the limits of quantification for CBD, CBN, and Δ9-THCA ranged from 6.7 to 50 µg/sample. A limit of quantification could not be established for Δ9-THC using the cannabinoid method.

† The 100 cm^2 template could not be used so an estimated 100 cm^2 was sampled.

Table C2. Average particle concentrations in milligrams per cubic meter of air (mg/m^3) during the sampling day

	Production area: processing table Average (range)	Production area: 20 feet away Average (range)	Retail area Average (range)
PM_1	0.087 (0.025–7.340)	0.025 (0.012–0.481)	0.016 (0.008–0.197)
$PM_{2.5}$	0.088 (0.025–7.370)	0.026 (0.012–0.485)	0.017 (0.009–0.198)
Respirable	0.093 (0.029–7.480)	0.027 (0.012–0.491)	0.018 (0.009–0.199)
PM_{10}	0.124 (0.030–8.330)	0.033 (0.012–0.524)	0.024 (0.009–0.210)
Total	0.159 (0.030–12.400)	0.053 (0.014–0.629)	0.030 (0.010–0.246)

Range = minimum–maximum

Table C3. Job tasks, as reported on questionnaires

Job task	Baseline questionnaire (n = 5) No. (%)	End-of-shift questionnaire (n = 3) No. (%)
Selling products/budtending	5 (100%)	3 (100%)
Inventory	4 (80%)	3 (100%)
Packaging	3 (60%)	1 (33%)
Grinding cannabis	2 (40%)	1 (33%)
Making pre-rolls	2 (40%)	1 (33%)
Dry sifting/kiefing	2 (40%)	0
Extracting concentrates	2 (40%)	0
Administrative, management, or office work	2 (40%)	1 (33%)
Trimming	1 (20%)	0
Marketing	1 (20%)	0

Table C4. Personal protective equipment used during various job tasks in the past 4 weeks, as reported on the baseline questionnaire (n = 5)

Job task	Gloves	Face mask	N95 respirator	Tyvek suit
Trimming	✓			
Grinding cannabis	✓	✓		✓
Making pre-rolls	✓			
Dry sifting/kiefing	✓	✓		
Extracting concentrates	✓			
Packaging	✓			
Selling products/budtending	✓			
Inventory	✓			
Administration, management, or office work				
Marketing				

Section D: Occupational Exposure Limits

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects.

However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a preexisting medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a time-weighted average (TWA) exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limits (STEL) or ceiling values. Unless otherwise noted, the STEL is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- OSHA, an agency of the U.S. Department of Labor, publishes permissible exposure limits [29 CFR 1910 for general industry; 29 CFR 1926 for construction industry; and 29 CFR 1917 for maritime industry] called PELs. These legal limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970. The Occupational Safety and Health Act requires employers to provide a safe workplace.
- NIOSH recommended exposure limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the NIOSH Pocket Guide to Chemical Hazards [NIOSH 2007]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Another set of OELs commonly used and cited in the United States includes the threshold limit values or TLVs, which are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2026].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database contains international limits for more than 2,000 hazardous substances and is updated periodically.

OSHA (Public Law 91-596) requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions.

Endotoxins

Endotoxins are lipopolysaccharide complexes found in the outer cell wall of Gram-negative bacteria. Gram-negative bacteria are found throughout the environment. Endotoxins are released when bacteria are multiplying or die. Airborne endotoxin exposures between 45 and 400 EU/m^3 have been associated with symptoms of cough, wheeze, shortness of breath, chest tightness, and mucous membrane irritation, and signs of acute airflow obstruction [Farokhi et al. 2018; Thorne and Duchaine 2007]. Chronic health effects that have been associated with airborne endotoxin exposures include chronic bronchitis, bronchial hyperreactivity, chronic airways obstruction, hypersensitivity pneumonitis, and emphysema [Castellan 1995; Duquenne et al. 2013; Liebers et al. 2008; Liebers et al. 2020; Rylander 2006]. Some studies suggest that environmental and occupational endotoxin exposures may protect exposed individuals from developing atopic sensitization [Rylander 2006].

In 2024, ACGIH adopted a TWA of 90 EU/m^3 for an 8-hour working day based on pulmonary function and lower respiratory tract irritation [ACGIH 2026]. In the Netherlands, the Dutch Expert Committee on Occupational Standards has recommended a TWA of 90 EU/m^3 for an 8-hour working day. This exposure level is regarded as a no-observed-effect level based on epidemiologic studies showing evidence of respiratory health effects at concentrations near this level [DECOS 2010].

Δ9-THC

Δ9-THC is a cannabinoid that is the psychoactive component of cannabis. Occupational exposures to cannabinoids can occur through skin absorption, inhalation, and ingestion. The long-term health effects of these occupational exposure routes are presently unknown. There are no OELs for Δ9-THC. Most health effect research of Δ9-THC has focused on inhalation in nonoccupational settings. Short-term effects can include cannabis intoxication, which is characterized by symptoms such as impaired motor coordination, euphoria, anxiety, sensation of slowed time, impaired judgment, and social withdrawal. These symptoms occur during or within two hours of cannabis use [American Psychiatric Association 2013].

The National Institute on Drug Abuse [2024] listed mood changes, diminished memory, and disorientation as short-term health effects of an effective dose of cannabis. Other studies have associated chronic exposure to firsthand cannabis smoke with social anxiety disorder, depressive disorders, psychosis, and respiratory symptoms [National Academies of Sciences, Engineering, and Medicine 2017]. The adverse health effects associated with nonmedicinal, chronic consumption of Δ9-THC derived from *Cannabis sativa* and *Cannabis indica* have been extensively studied and reviewed [Chandy et al. 2024; Hall and Degenhardt 2014; Volkow et al. 2014]. Additional information on health effects can be found at Cannabis Health Effects | Cannabis and Public Health | CDC.

Δ9-THCA, CBD, and CBN

Δ9-THCA, CBD, and CBN are some of the 215 cannabinoids identified in cannabis [Radwan et al. 2021]. These are not psychoactive substances, meaning they do not change a person's mental state by affecting the way the brain and nervous system work. Unlike Δ9-THC, these cannabinoids do not cause intoxication or a "high." Currently, there are no OELs for Δ9-THCA, CBD, or CBN.

Hemp

Hemp, also derived from *Cannabis sativa*, is used for a variety of purposes including fiber, rope, paper composites, food, and oil and oil-based products [USDA 2000]. Occupational hemp exposure can result in a variety of clinical manifestations including sinusitis, byssinosis, and reductions in lung function [Zuskin et al. 1990; Zuskin et al. 1992; Zuskin et al. 1994]. Employees who directly handle the plant are particularly at risk [Barbero and Flores 1967; Valić et al. 1968; Zuskin et al. 1990; Zuskin et al. 1994]. There is no OEL for hemp.

Transdermal applications of medicinal cannabis demonstrate that occupational dermal absorption is a potential exposure route [Goldsmith et al. 2015]. Other studies have demonstrated dermal reactions such as urticarial rash (hives) in subjects who directly contact cannabis [Basharat et al. 2011; Ozyurt et al. 2014]. Urticaria has also occurred in forensic specialists and law enforcement officers following the handling of cannabis [Herzinger et al. 2011; Majmudar et al. 2006; Mayoral et al. 2008; Williams et al. 2008]. Several of these plant components have recently been shown to produce high molecular weight proteins that can result in allergic sensitization following personal exposure [Nayak et al. 2013].

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