HHE Health Hazard® Evaluation Program

Evaluation of Blastomycosis Outbreak Among Workers at a Pulp and Paper Mill

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Authors: **Marcia L. Stanton, BS**
Allyson W. O'Connor, PhD, MPH
Ju-Hyeong Park, ScD, MPH, CIH
Xiaoming Liang, MS
Rachel L. Bailey, DO, MPH
R. Reid Harvey, DVM, MPH, DACVPM
Ryan LeBouf, PhD, CIH
Dallas Shi, MD, PhD
Perri C. Callaway, PhD
Jean M. Cox-Ganser, PhD
Stella E. Hines, MD, MSPH

Analytical Support: Xiaoming Liang, Brian Tift
Industrial Hygiene Field Assistance: Ju-Hyeong Park, Ryan LeBouf, Stephen Martin, Jr., Duane Hammond, Jean Cox-Ganser
Logistics: Michael Beaty, Melanie Street, Lisa Glisan, Travis Markle, Heather Rogers
Medical Field Assistance: Marcia Stanton, Allyson O'Connor, Perri Callaway, Anne Foreman, Suzanne Tomasi, NIOSH interviewers
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The 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].

Availability of Report

Copies of this report have been sent to the employer, employees, and unions at the plant. The state and local health departments and the Occupational Safety and Health Administration Regional Office have also received a copy.

Recommended Citation

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Introduction

Request

We received a management request for a health hazard evaluation at a pulp and paper mill. The request stated concerns about potential exposure to *Blastomyces* fungus resulting in an outbreak of blastomycosis among employees, contractors, and visitors. Blastomycosis is a potentially severe illness that can occur after breathing in fungal spores from the air. In response to this request, we conducted a medical survey, collected environmental samples, and performed a ventilation assessment.

Workplace

This pulp and paper mill produced paper for commercial printing and label applications. The mill is situated on approximately 2,000 acres along a river. At the time of our survey, the mill employed about 890 workers and contractors from several companies onsite for routine operations.

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

Our Approach

We conducted an initial site visit in March 2023 to learn about the paper mill's processes and procedures. During our visit on March 27 and 28, 2023, we did the following:

- Held opening and closing meetings with management and union and employee representatives to discuss the health hazard evaluation objectives.
- Toured all areas of the facility to learn about work processes, practices, and workplace conditions.
- Interviewed the health and safety director, the company occupational health physician and nurse, managers from multiple departments, and an industrial hygienist contracted by the company. Additionally, we spoke with some employees to discuss workplace health and safety concerns.

We returned in April and August 2023 to complete the following activities:

- Held a total of 10 one-hour informational sessions designed to allow all employees to ask questions about *Blastomyces* and blastomycosis.
- Performed a ventilation assessment involving a limited visual assessment of the air handling units and makeup air units that introduced outside air into occupied spaces of the mill.
- Collected a variety of environmental samples, both indoors and outdoors, including soil, organic material, surface dust, and filter materials from the heating, ventilation, and air-conditioning (HVAC) systems to analyze for the presence of *Blastomyces*.

- In August 2023, additional samples were collected during excavation along the river for construction of a new bridge and from additional areas on the mill property not previously sampled in April 2023.

- Conducted an offsite medical survey including an interviewer-administered work and health questionnaire and offered a urine antigen screening test for *Blastomyces*.

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

Our Key Findings

There were 162 of 645 workers who met the NIOSH case definition for blastomycosis.

- The NIOSH case definition required a person have either laboratory evidence for blastomycosis (including urine antigen tests below the limit of quantification but above the limit of detection) or self-report being diagnosed with blastomycosis and have worked at or visited the mill during October 1, 2022 – July 1, 2023.
- Among 603 NIOSH medical survey participants, there were 120 workers with blastomycosis. The blastomycosis case prevalence among the medical survey participants was 20% (n=120/603).
- There were 42 workers who received a diagnosis of blastomycosis reported to the state health department who did not participate in the NIOSH medical survey.

Workers in the E1 Paper Mill and Maintenance areas had a higher prevalence of blastomycosis compared to those not working in those areas.

- Workers in the E1 Paper Mill had a 40% higher prevalence of blastomycosis compared to workers who did not work in the E1 Paper Mill.
- Workers in the Maintenance areas had a 53% higher prevalence of blastomycosis compared to those who did not work in Maintenance areas.
- Working in both the E1 Paper Mill and Maintenance areas was associated with a two-fold increase (100% higher) in blastomycosis prevalence compared to not working in both areas.

Exposure to pooling water and visible mold indoors were identified as potential risk factors for blastomycosis.

- Daily exposure to indoor pooling water was associated with a nearly two-fold higher prevalence of blastomycosis.

- Daily exposure to indoor visible mold was associated with a 43% increase in prevalence of blastomycosis.
- These findings do not necessarily mean *Blastomyces* was growing indoors. It is more likely spores from the outdoor environment entered the mill, and the indoor conditions contributed to workers' exposure once the spores were present.

Environmental sampling did not identify *Blastomyces* on mill property

- Negative results from analysis of 533 samples do not necessarily indicate that *Blastomyces* was not present, given the limits of detection of our test methods and historical difficulties in identifying it in environmental samples.
- Presence of *Blastomyces* spores may have resolved by the time we collected the environmental samples.
- Although the original source of the fungus likely came from an outdoor area, it may have been possible that the spores got inside the mill and served as a secondary exposure source.

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

Our Recommendations

The Occupational Safety and Health Act requires employers to provide a safe workplace.

Potential Benefits of Improving Workplace Health and Safety:

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

The recommendations below are based on the findings of our evaluation. 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 groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or practical, administrative measures and personal protective equipment might be needed. Read more about the hierarchy of controls at https://www.cdc.gov/niosh/hierarchy-of-controls/about/.

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 *Recommended Practices for Safety and Health Programs* at https://www.osha.gov/shpguidelines/index.html.

Recommendation 1: Properly maintain all outdoor makeup air units and recirculating air handling units

Why? Ventilation systems impact how contaminants like dust, pollen, and mold are distributed and removed from spaces through filtration. The systems themselves can act as a source of contamination if they are not properly maintained. During our ventilation assessment, 59 of 67 units assessed were makeup air units that provided only outdoor air into the mill. There were no filters installed in the makeup air units although each had filter racks. The absence of filters allowed unfiltered, outdoor air into the mill. Many of these units were older with several nearing or exceeding their expected service life. Many of the coils inside the units were caked with dirt and debris. We also assessed eight recirculating air handling units serving office areas and process ventilation systems. These generally had filters installed.

In late April and early May 2023, the mill hired contractors to clean the heating, ventilation, and air-conditioning systems, including ductwork. After the systems were cleaned, filters in recirculating air handling units were upgraded. A process was also established to maintain filters used in all recirculating air handling units throughout the mill. Filters were installed in all makeup air units as well. During this period, many areas, including offices, control rooms, shops, and common areas were deep cleaned.

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

Follow the manufacturer's recommended maintenance schedule for all ventilation systems

- This includes replacing air filters, checking drip pans, ensuring thermostats are in working order, and checking and cleaning ventilation system dampers to ensure proper functioning. In addition, make sure water does not pool near the roof fresh air intakes.
- Continue to use filters with the highest Minimum Efficiency Reporting Value (MERV) rating possible inside the recirculating air handling units. Upgrading filtration from a MERV 8 to a MERV 13 provides over four times the capture efficiency of particles in the 1.0–3.0-micron size range which is relevant for *Blastomyces* spores.
- Ensure written preventive maintenance schedules include all regularly scheduled maintenance tasks (filter changes, checking drip pans, fan belt inspections, checking and cleaning ventilation system dampers, ensuring thermostats are in working order, etc.)

and who is responsible for conducting each task. Ensure all tasks are performed when scheduled.

Recommendation 2: Minimize pooling water and wet areas, and promptly remediate water incursion and visible mold in the mill

Why? Environmental conditions within the mill could impact the survival of *Blastomyces* indoors and the risk for exposure to spores and the subsequent risk for blastomycosis. Daily exposure to pooling water indoors was associated with almost double the prevalence of blastomycosis. Workers with blastomycosis reported greater daily exposure to standing pools of water indoors and visible mold on surfaces, walls or ceilings compared to workers without blastomycosis. Areas in the mill where more than five workers reported exposure to pooling water indoors included the E1 Paper Machine, E4 Paper Machine, E1 Coater, E3 Paper Machine, Woodroom Building, and E1 Maintenance areas.

Sampling done by an industrial hygienist hired by the mill in March 2023 identified areas of possible mold contamination and water incursion. The consultant recommended remediation in building 63 (room 63-144) and the cafeteria (including facility wide breakroom areas next to unoccupied union office). They also recommended addressing roof leaks in the small training room (room 52-171) and kitchen (room 52-182) in the administration building and reducing standing water in areas within Unit 1.

During March and April 2023, the mill completed mold remediation in multiple areas to address leaking water or pooling water, including room 63-144, the cafeteria and breakroom next to the unused union office, the kitchen, small training room, the men's locker room, and areas in E1 Paper Mill.

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

Routinely assess work areas for pooling water and dry areas when identified.

- Use squeegees, wet-dry vacuums, or other methods to remove water.
- Regularly check floor drains to ensure they are working properly and not clogged.

Routinely perform visual inspections for water leaks and damage and correct these when identified.

- Keep a record of when and where mold or water-damaged materials are discovered, and corrective actions performed to fix the underlying problems.
- Consider using the NIOSH Dampness and Mold Assessment Tool - General Buildings when inspecting buildings for dampness and mold, and keeping records.

Remove mold and moisture-damaged materials or clean with appropriate containment to minimize exposure to remediation workers, building occupants, and unaffected sections of the building.

- The following resources have information on the assessment and remediation of fungi in indoor environments as well as maintaining acceptable indoor environmental quality during construction and renovation projects.
    - New York City Department of Health and Mental Hygiene guidelines on assessment and remediation of fungi in indoor environments.
    - EPA guide on mold remediation and guidance on moisture control for building design, construction and maintenance.
    - NIOSH Workplace Solutions document on maintaining acceptable indoor environmental quality during construction and renovation.

Monitor repaired areas to ensure repairs and remedial actions are effective.

- The NIOSH Dampness and Mold Assessment Tool - General Buildings can also be used for this purpose.

Recommendation 3: Continue to educate your workforce on the signs and symptoms of blastomycosis

Why? In areas endemic for blastomycosis, and particularly when known blastomycosis cases have occurred, education on symptoms and early identification of blastomycosis are important for prompt care and treatment. Awareness of health symptoms associated with blastomycosis can lead to proper diagnosis and prompt treatment, potentially reducing the severity of the illness. People with certain medical conditions or who are taking medications that weaken the immune system may be more likely to develop severe blastomycosis than people who are otherwise healthy. Examples of conditions or medications that weaken the immune system include diabetes, kidney failure, HIV infection, autoimmune diseases, pregnancy, cancer, transplant recipients, immune deficiency, and those taking chemotherapeutics, corticosteroids, or other medications to suppress immune responses. Workers with these conditions who experience symptoms consistent with blastomycosis should seek timely care.

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

Make sure employees and contractors know the signs and symptoms of blastomycosis.

- Symptoms may include cough, fever, chills or night sweats, shortness of breath, poor appetite or weight loss, muscle pain, joint pain or bone pain, fatigue (extreme tiredness), or skin lesions. Blastomycosis is a treatable illness, and illness can be minimized when diagnosed and treated early.

Encourage employees to report new, worsening, or ongoing symptoms to their healthcare providers and to the mill nurse or physician

Recommendation 4: Educate workers about the potential for exposure, and continue to use a layered approach to reduce potential exposure to airborne *Blastomyces*

Why? The mill is located in an endemic region for *Blastomyces* with nearby environments like wooded areas and a riverway favorable for its growth. Therefore, mill workers should be educated about the potential exposure to *Blastomyces* within the mill properties and the associated risk of blastomycosis. Although we did not identify the exposure source through environmental sampling, *Blastomyces* potentially exists on mill property.

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

When moving chip or wood piles or during digging or excavation activities consider the following:

- Work upwind when possible.
- Use dust suppression techniques, such as spraying dirt with water to keep dust down.
- Use vehicles with enclosed cabs with filtration.
- Use fit tested NIOSH Approved® N95® respirators and other personal protective equipment.

Supporting Technical Information

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Section A: Workplace Information

Workplace

This paper mill produced pulp and paper used in commercial printing, media, and specialty paper for use as labels. The mill site, situated on forested land along a riverway, features a large complex of mill buildings, stacks of trees and wood chip piles for pulp processing, settling ponds for treating chemical effluent before it is released into the river, parking areas on either side of the river with footbridge access to the mill, and a network of unpaved roads. The mill property covers more than 2,000 acres, and most paper processing activities take place indoors after the wood is chipped. Pulp and paper production operations have taken place at this site since 1911.

Employee Information

At the time of our evaluation, there were about 890 employees and 40 contractors onsite. Employees were represented by three unions: United Steelworkers of America, International Brotherhood of Electrical Workers, and the International Brotherhood of Teamsters. Among participants of the health hazard evaluation, the mean age of employees was 45 years (range: 19 years–73 years). The mean job tenure for these employees was 12 years (range: 1 month–52 years). Production activities ran 24-hours a day with a variety of shifts with rotating start times.

History of Issue at Workplace

In late February 2023, a local health department was notified by healthcare providers of atypical pneumonia infections among workers at the mill. In early March 2023, the local health department officials, state health department epidemiology and laboratory personnel, and mill management began investigating the reported atypical pneumonia in workers. Clinical testing confirmed that the workers were infected with *Blastomyces*, a fungus that causes blastomycosis – a lung infection resulting from inhaling *Blastomyces* spores.

In late March, mill management submitted a health hazard evaluation request, and NIOSH was joined by subject matter experts from the Centers for Disease Control and Prevention's (CDC's) Mycotic Diseases Branch in responding.

Process Description

Raw Materials

Feedstock materials including lumber, sawmill chip residuals, biomass, and chemicals were received by truck and rail. Most lumber was locally sourced from woodland groups within a 90-mile radius of the mill.

Wood Processing

All wood materials including logs, chips and bark were stored within the wood yard at the 'backend' of the mill. In the wood room building, the logs were fed into a debarking process, and the bark was

removed. The bark was collected to use for fuel to generate steam for the paper machines and to generate electricity by the turbines. After the logs were de-barked, they were fed into a chipper where the wood chips were created. The chips then went through a screening process to remove irregularly sized chips. The chips were transported by conveyor and stored in piles according to wood type in the woodyard.

Pulp Production

The wood chips were moved by conveyor to be made into pulp by either chemical or mechanical processing. Wood type and finished product determined the choice of pulp processing.

Kraft Mill (chemical processing)

During chemical processing, the sorted chips were washed and sent to digesters. In the digesters, an acid solution known as white liquor was added to the chips and cooked at a specific temperature and pressure to dissolve the lignin and separate the fibers. The resulting pulp was called brown pulp because of the color. The liquid remaining at the end of this step was called black liquor. The pulp was then washed and screened before moving on to the bleach plant.

This process produced liquid waste that required additional processing in a recovery process. The black liquor was evaporated and burned in a recovery boiler to recover the chemicals in the form of green liquor. Lime was added to the green liquor so it could be turned back into white liquor for re-use in the pulping process. The recovery boiler used in this process generated steam which was fed to turbines to generate electricity used by the mill.

Mechanical Pulping (mechanical processing)

During mechanical processing, the sorted chips were washed and fed into a refiner machine where they were mechanically ground into smaller pieces and eventually into fibers. The last step in the mechanical process was bleaching the pulp.

Bleach Plant

The pulp from the Kraft Mill was transferred to the bleach plant where the brown pulp was changed to white pulp in chlorine dioxide and caustic washers.

Stock Prep

The bleached pulp then moved on to the stock prep area for further refining. Pulp was mixed with fillers (e.g., clay, calcium carbonate) to enhance the physical properties of the finished paper. The mixture of pulp and additives was blended for use in the paper forming machines.

Paper Machines

This mill had three paper machine lines (E1, E3, and E4 paper mills) where the prepared stock solution was converted into paper. Each machine had four main sections: the wet end, press section, dryer section, and calender section. At the first section, the prepared stock entered the 'wet end' of the process at the headbox where the stock was fed onto rotating wire mesh. At this stage, the mixture was ~ 99.5% water and 0.5% fiber. In the press section, the material was fed onto looped felt rollers where the water was squeezed out under pressure. The paper then moved to the dryer section where it passed through dryer cans where steam-heated rollers stretched the paper and removed remaining moisture. In

the calender section, the paper passed through heated rollers under pressure which resulted in the paper having a uniform thickness and smooth surface. The paper then passed through the coater. At this stage, starch, other binders, and color was applied to the surface of a roller and transferred to the paper. After each coating, the surface was dried. The coating process enhanced the strength of the paper and led to better printability. At the end of the machine, the paper passed through scanners to look for process defects and holes. The paper was wound onto a large spool, and it was now called a log.

Coating Kitchen

The final surface quality of the paper was controlled in the coating and finishing steps of the process. Coating compounds were mixed in the coating kitchen. Calcium carbonate was used to make the paper white. The coatings could also include clay and other binders. This coating created a smoother finish on the paper's surface. Both sides of the paper were coated and dried.

The paper then passed to the super calender which had a series of rollers that applied pressure and temperature. The logs were then transported to a winder where they were cut to specific sizes. Each section was then re-wound onto a core and sent to finishing.

Finishing and Shipping

In this area, each roll of paper was wrapped in kraft paper to protect it from damage during shipment. Rolls were loaded onto trucks or rail cars for shipment.

Boilers and Turbines

The mill had boilers and steam turbines. The steam boilers generated steam and power required during paper production. The steam generated was used by the turbines to produce electricity for the mill.

Water and Wastewater Treatment

The manufacture of pulp and paper required a lot of water. Water for mill activities was supplied from the Great Lakes. Water coming into the mill supported the pulp, stock prep, and paper machine processes, and water was re-circulated throughout these processes. The water was also part of the boiler and cooling water systems.

Wastewater produced during the paper production process contained solids and other compounds that had to be treated. In the wastewater treatment process, fluids went through a series of treatment steps, including primary and secondary clarifiers, activated sludge treatment, an aerated stabilization basin, settling basin, and tertiary clarifiers before being discharged upstream of the mill into the river adjacent to the mill.

Recovery and Utilities

Employees in the Recovery and Utilities Department were responsible for indoor and outdoor operations that supplied the mill with electricity, steam, compressed air, and water. This included operation of the boilers and turbines.

Employees in the wood waste and coal area fed one of the boilers bark, unused chips, and saw dust to be used as biofuel to generate electricity to power the mill.

Maintenance

All production activities were supported by the maintenance department. Some maintenance mechanics and electricians were assigned to specific areas of the mill including the paper machines, boilers, and pulp mills, but most were responsible for maintenance activities throughout all areas of the mill.

Administration

There were three individual buildings where most of the administrative employees worked. Many administrative employees spent time in various production areas in addition to their offices.

Contractors

Contractors were onsite daily to provide various services, including janitorial, security, waste removal, heating, ventilating and air conditioning (HVAC) maintenance, trucking, and chemical process support.

Employee Parking

Employees and contractors primarily parked in three areas. The first and largest parking area (Lot A) was located to the south across a river from the mill and employees crossed a footbridge to enter the mill. The second parking area (Lot B) was located onsite at the northwest end of the mill. During the winter months, Lot B was used by those working the night shifts to allow for snow removal in Lot A. Contractors parked in a designated area on the north side of the mill.

Personal Protective Equipment

All employees and contractors were required to wear hard hats, safety glasses, and hearing protection, that met standards set by the American National Standards Institute (ANSI), in all indoor and outdoor operating areas except for offices, control rooms, breakrooms, or restrooms. Open toe/heel shoes were not permitted on mill property. Safety shoes and boots were required for anyone performing work activities onsite. All employees and contractors were required to always carry a pair of gloves with them. Company-issued uniforms were not required, but shirts with sleeves covering the shoulders were required.

Personal gas monitors were required in some departments for chlorine dioxide, hydrogen sulfide, sulfur dioxide, and chlorine. Respirators were required in some areas and for specific tasks, including the woodyard, Kraft Mill, Lime Kiln, E1 Stock Prep, mowing, weed eating, garbage collection, air filter replacement, and excavation activities. Types of respirators ranged from NIOSH Approved® N95® filtering facepiece respirators to powered air purifying respirators and occasionally self-contained breathing apparatus (SCBA). The emergency response team members were required to use SCBAs during activities with potential airborne hazards. All employees required to wear respirators were included in the company's written respiratory protection program.

Section B: Methods, Results, and Discussion

Our evaluation included the activities listed below.

- Touring the mill's buildings and outdoor areas during our initial walkthrough site visit to learn about the pulp and paper production process.
- Establishing a data use agreement with the state health department to allow sharing of information when cases of blastomycosis were reported by healthcare providers and laboratories to the state's notifiable disease reporting system.
- Reviewing a consultant industrial hygiene report.
- Assessing a sample of ventilation systems.
- Collecting a variety of environmental samples both indoors and outdoors to be analyzed for *Blastomyces*.
- Offering a medical survey to employees and contractors including a work and health history questionnaire and urine antigen screening test for *Blastomyces*.
- Analyzing results of environmental samples, questionnaire responses, and urine antigen tests to understand whether there was a shared source of exposure.

Methods: Walkthrough site visit

NIOSH conducted a walkthrough site visit at the facility in March 2023 to learn about the mill's processes and procedures to assist with planning for future visits to investigate factors associated with blastomycosis infection among workers at the paper mill. The NIOSH field team included a health scientist, industrial hygienist, epidemiologist, laboratorian, and medical officer. NIOSH was accompanied by a fungal epidemiologist and fungal laboratorian from the Centers for Disease Control and Prevention's (CDC's) Mycotic Diseases Branch (MDB), and state and local health department officials.

Results: Walkthrough site visit

Mill management and employees provided a detailed guided tour of the facility including the woodyard, mills, finishing and shipping (PS&D) area, lagoons, and outlying areas to understand work processes, practices, and workplace conditions. We also spoke with the mill's Vice President of Operations, Health and Safety Director, occupational health physician and nurse, managers from multiple departments, and an industrial hygienist contracted by the company to assess potential *Blastomyces* exposures. Additionally, we spoke with some employees to discuss workplace health and safety concerns.

Methods: Public Health Data Review

Blastomycosis is a reportable disease in eight states including Michigan [CDC 2024a]. Cases were reported to the Michigan Disease Surveillance System by public health officials, healthcare providers and medical laboratories. Staff from the state and local health department then reviewed records and

contacted the reported cases to complete an interview to collect additional information including demographic information, diagnostic test details, symptom information, employment information including job title, exposures at work, and activities outside of work.
To aid in our health hazard evaluation, NIOSH and MDB completed a data use agreement with the state health department's Bureau of Infectious Disease Prevention to obtain a list of patients identified as having blastomycosis associated with the mill. Not all employees and contractors working at the mill participated in the NIOSH medical survey and sharing this data was necessary to help understand the scope of the outbreak and to help identify potential sources of exposure. Representatives from NIOSH, MDB, and the state and local health department met regularly between March 2023 and May 2024 to discuss the status of the outbreak.

Results: Public Data Review

The health department shared information for individuals with confirmed or probable blastomycosis (i.e., case-patients) meeting their case definition with illness onset between December 1, 2022 and July 1, 2023, who did not participate in the NIOSH medical survey through a data use agreement. Of the 124 case-patients in the health department list, 82 participated in the NIOSH medical survey. To explore contributing factors, NIOSH included data from the health department list for 42 case-patients affiliated with the mill who did not participate in the NIOSH survey. We reviewed information in the list (e.g., job information, medical history, non-work-related exposure information) and matched it with questions in the NIOSH medical survey questionnaire.

Methods: Company's industrial hygiene consultant report review

NIOSH reviewed the company's industrial hygiene consultant report from sampling completed in March 2023. The consultant's survey was not designed to detect *Blastomyces* specifically but to gain a better understanding of indoor fungal reservoirs and infiltration of outdoor fungi into the facility.

A total of 66 samples were collected including air samples to assess non-viable and viable mold spore concentrations (n=49), tape lift samples in areas with suspected mold growth (n=3), surface swab samples for potential mold or settled spores (n=5), bulk samples of materials (n=5), outdoor air control samples (n=2), and field blank samples (n=2). Areas sampled included: 1) wood waste and coal, 2) PS&D, 3) #45 winder, 4) cafeteria, 5) Unit #1 areas, and 6) wood tunnels.

Results: Company's industrial hygiene consultant report review

Sampling results indicated areas of possible mold contamination and water incursion.

- The report noted consistent findings of *Penicillium* and *Aspergillus* species and presence of *Mucor* or *Rhizopus* species in indoor spore trap or culture samples. However, these species were not in the outdoor control samples. This is consistent with the presence of indoor fungal reservoirs.
- Concentrations of hyphal fragments in the spore trap samples from the wood tunnel and wood waste and coal areas were found to be higher indoors than outdoors. Hyphae indicate mold growth.

Remediation of water damaged areas was recommended.

- Room 63-144 was identified as an area for further investigation and cleaning.
- The cafeteria area, including the large and small training room, kitchen, breakroom, and former union office, was identified as an area for remediation and roof repair.
- Areas within Unit #1 were identified as having regular standing water. Remediation of visible mold and instituting control measures or regular housekeeping to limit standing water were recommended.

During March and April 2023, mold remediation was completed by the company in multiple areas to address leaking water or pooling water, including room 63-144, small training room, men's locker room, kitchen, cafeteria and breakroom next to the unused union office, and areas in E1 Paper Mill.

NIOSH ventilation assessment, environmental sampling, and medical survey

On April 13, 2023, the mill idled routine production activities for three weeks to facilitate ventilation system assessments and ventilation ductwork cleaning followed by cleaning with high-efficiency particulate air (HEPA) filter vacuums and fungicidal chemicals. Idling the mill made it necessary for NIOSH to secure offsite locations in the community for informational meetings for employees and the medical survey. It also expedited our planned ventilation assessment and environmental sampling at the mill. The NIOSH team tried to stay ahead of the cleaning crews and collect samples prior to cleaning. However, there were a few HVAC systems that were cleaned prior to the NIOSH team arriving. In some cases, samples were still taken in an area that still had visible dust. In other cases, no samples were collected in those units.

Methods: Ventilation assessment

NIOSH performed a ventilation assessment at the workplace April 24–28, 2023. We focused on air handling units that provided some outdoor air in addition to recirculating filtered indoor air or makeup air units that only introduced 100% outside air into the occupied areas of the mill. We recorded the location of each unit, type of unit, make and model information, qualitative description of the unit's condition, type of filter and minimum efficiency reporting value (MERV) rating, type of supply or return ductwork associated with the unit, and zones or areas of the building the unit served.

Results: Ventilation assessment

There were over 400 HVAC systems with equipment from several manufacturers throughout the facility. We visually inspected 67 units throughout the mill, emphasizing air units that brought in outdoor air into the mill.

Makeup Air Units

We assessed 59 makeup air units that provided only outdoor air into the mill.

- The makeup air units were old, with many nearing or exceeding the end of their expected service life.

- There were no filters installed in any of these makeup air units even though the units had filter racks available.
- Coils inside the makeup air units were noticeably caked with dirt and debris (primarily leaves and bird feathers).

Recirculating air handling units

We assessed eight recirculating air handling units serving office areas.

- These units generally had MERV 8 or MERV 9 filters installed.

After ventilation assessment

Following the ventilation assessment, filters in the recirculating air handling units were upgraded to MERV 13 filters. MERV 13 filters were also installed in the makeup units.

We learned from the Operations Manager at the company that after changing the filters to MERV 13, some of the units experienced "freeze up" conditions. We recommended going back to the MERV 8 or 9 filters previously used to prevent the coils from freezing and damaging the systems. We encouraged doing research with different makes and models of filters when purchasing replacements because there should be MERV 11 or 13 filters available to improve filtration and keep the HVAC equipment operating without further issue.

Methods: Environmental samples

Sample collection

During April 24–28, 2023, NIOSH collected 477 environmental samples including soil, organic material, surface dust, and materials from the HVAC systems. We collected samples from various indoor and outdoor locations throughout the mill property. We selected the majority of indoor sampling locations based on the primary work areas where employees diagnosed with blastomycosis spent the majority of their time. However, additional indoor locations in areas with no reported cases were also sampled. The number of indoor samples (n=411) by work area and sample type are summarized in Table C1. We collected outdoor soil samples from banks (both sides) along the river by the mill facility and other land areas within the mill property. We also collected bulk material samples such as wood chips.

We collected surface dust samples by wiping accumulated dust on elevated indoors surfaces including the top of cabinets, desktops, machine surfaces, computer surfaces, HVAC surfaces, and the top of door frames. We wiped surfaces with an approximately 2-inch x 2-inch electrostatic cloth using a sterile technique to avoid cross-contamination among samples. We used new nitrile gloves for every sample. We placed cloth samples with collected dust into sterile 50 milliliter (mL) conical tubes with caps. Approximately 45 mL of soil and bulk material samples were collected into a 50 mL conical tube using a sterile spatula. We also collected used filters and duct liners available from HVAC systems.

From August 1–2, 2023, we collected 56 additional samples during excavation activities for construction of a bridge along the river and from additional areas on the mill property not previously sampled in April 2023. Locations of where the outdoor soil and bulk material samples were collected are mapped in Figure B1.

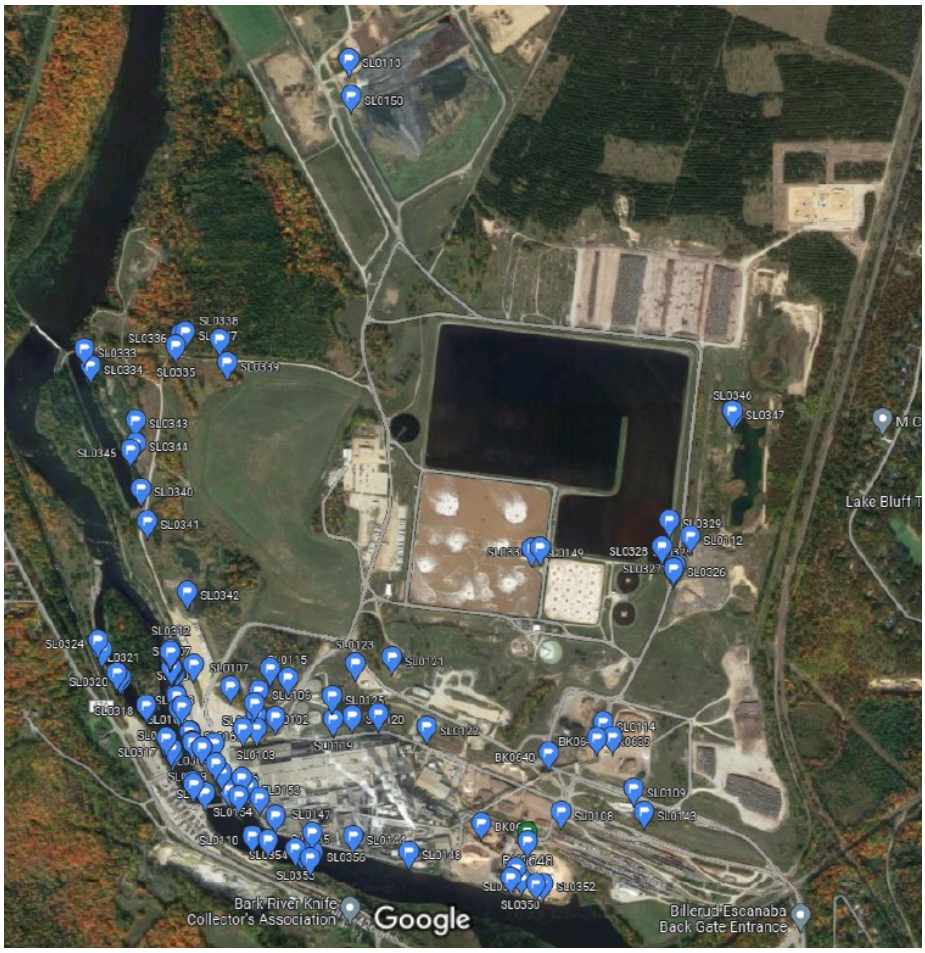


Figure B1. Outdoor sample locations for soil and bulk materials (N=122) collected during NIOSH environmental surveys in April 2023 and August 2023.

Sample analysis

There were no commercial laboratories offering analysis of environmental samples for *Blastomyces* which requires a biosafety level 3 (BSL-3) laboratory. In addition, there were no standardized analytical methods established for this testing. Scientists at the Marshfield Clinic Research Institute (MCRI) and the Wisconsin State Laboratory of Hygiene (WSLH) at the University of Wisconsin-Madison analyzed the samples for *Blastomyces*. We collaborated with these laboratories because of their proven track record and expertise in handling and analyzing environmental *Blastomyces* specimens.

We transported all environmental samples to MCRI in Marshfield, WI. The soil, water, and indoor surface dust collected with electrostatic cloth samples were stored in a -80 degrees Celsius (°C) freezer, and the air filter and duct liner samples were stored in a refrigerator until they were processed and analyzed. MCRI processed samples for the analysis of *Blastomyces* DNA and made aliquots for culturing *Blastomyces* in samples that were sent to the WSLH. Soil, electrostatic cloth, and filter samples were prepared and analyzed in parallel at both MCRI and WSLH.

Polymerase Chain Reaction (PCR)

At MCRI, DNA in the samples was extracted using extraction kits. DNA was amplified using polymerase chain reaction (PCR). PCR is a technique to rapidly amplify specific segments of DNA.

PCR targets included the *Blastomyces* adhesion-1 (BAD-1) gene which is specific for *Blastomyces* and the ITS3/4 gene found in all fungi, including *Blastomyces*. PCR products were analyzed by gel electrophoresis (a technique to separate mixtures of DNA by molecular size) and the presence of a visible band of the expected molecular size on the gel indicated the amplified genes were present in a sample [Anderson and Meece 2019; Meece et al. 2010].

Culture

All sample aliquots processed by MCRI were sent to WSLH for culture of yeast. An aliquot of 200 microliters (µL) from each sample suspension was added to four separate culture media including Sabouraud's dextrose agar (SAB), Brain Heart Infusion agar (BHI), BHI with chloramphenicol and gentamicin (BHI-A), BHI with chloramphenicol, gentamicin, and cyclohexamide (BHI-C). Antimicrobials were added to prevent growth of bacteria and environmental (non-*Blastomyces*) fungi. These cultures were incubated at 39°C for eight weeks with regular observation. The elevated temperature selects for yeast phase growth of *Blastomyces* and suppresses growth of environmental contaminates. Yeast-like growth (smooth creamy colonies) seen in these cultures was isolated by further sub-culture onto new media without antibiotics to obtain pure isolates. These isolates were then processed for identification by Matrix-assisted laser desorption time-of-flight mass spectrometry (MALDI-ToF) analysis and microscopy (wet mounts). Isolates that were unable to be identified by MALDI-ToF and visually resembled *Blastomyces*, big broad-based budding yeast, were submitted back to MCRI for *Blastomyces* identification by PCR. The MALDI-ToF does not have sufficient reference material in its library to identify *Blastomyces* but can successfully identify many types of bacteria and yeast to help reduce the number of isolates needing PCR level identification.

PCR Inhibition Assessment

To assess for PCR inhibition which could result in false negative PCR results, MCRI spiked 188 environmental samples' DNA extracts with bicoid DNA (genetic material containing instructions for producing the bicoid protein), provided by WSLH [Leach et al. 2018]. Scientists calculated the cycle at which the real-time PCR (RT-PCR) amplification curve crossed the threshold of detection (Ct, cycle threshold) for a control (water) compared to the environmental samples spiked with the bicoid DNA. An increase of 3 Cts or more (delay in amplification) in the environmental samples compared to the control was considered evidence of PCR inhibition in the environmental sample.

Culture and PCR Sensitivity Assessment

The limit of detection (LOD) was assessed for both the PCR and the culture methods. Two clinical isolates, one *B. dermatitidis* and one *B. gilchristii*, were cultured as a heavy lawn of yeast (2.0 McFarland) on potato dextrose agar (PDA). After 2 weeks at room temperature 200 µL of sterile phosphate buffer solution (PBS) was gently rubbed into the surface, releasing the spores from the hyphae. The supernatant was collected, and the purity and concentration were assessed by hemocytometer counts. Spore suspensions in 1x sterile PBS were prepared at 10-fold dilutions ranging from 10^5 down to 10^1 spores per 200µL.

To evaluate the sensitivity of PCR methods used for the environmental samples, 40 µL of $5x10^6$ spores per milliliter (spores/mL), 40 µL of $5x10^5$ spores/mL, 20 µL of $5x10^4$ spores/mL, 20 µL of $5x10^3$ spores/mL, and 20 µL of $5x10^2$ spores/mL were extracted with both Qiagen and Roche kits in

triplicate. Five µL of final concentrated extracts were tested using the same BAD-1 and ITS3/4 PCR assays used for the environmental samples. PCR products were analyzed by gel electrophoresis, and the presence of a visible band on the gels indicated the spores were detected at a specific concentration. The LOD was determined to be the concentration at which all three replicates were detected on the gel.

To evaluate the sensitivity of culture methods used for the environmental samples, 200 µL of the 10^3 and 10^2 suspensions were spread onto culture plates in triplicate. Culture media included all 4 solid media types used for the environmental samples (SAB, BHI, BHI-A, and BHI-C). Colony forming units (CFU) were counted after 8 weeks of incubation at 39°C. Sensitivity was calculated as the percent of CFUs counted compared to the number of spores added to the plates as determined by the hemocytometer counts.

Results: Environmental samples

Blastomyces was not detected in the 533 samples collected from various indoor and outdoor locations

We collected 533 samples at the outbreak location and sent them for laboratory analysis. The *Blastomyces* BAD-1 gene was not detected in any of the samples regardless of the preparation or extraction method. As a positive control, the internal transcribed spacer (ITS) region of fungal rRNA genes was also assessed in all samples using PCR. As expected, environmental fungi were reliably detected in many of these samples, most often in soil (100%) and less often in electrostatic cloth dust samples (62%) (Table C2).

All environmental samples were cultured in duplicate on multiple types of media. Environmental molds (mostly *Aspergillus* species) quickly grew on most of the plates, inhibiting detection of yeast-like growth. Yeast-like colonies were occasionally observed on all types of solid media. But the only media that restricted growth of these environmental molds sufficiently was BHI-C. Most yeast-like colonies were identified by MALDI-ToF as non-*Blastomyces* bacteria and yeast (*Pseudomonas*, *Candida*, and *Rhodotorula*). Overall, 22 isolates exhibited characteristics consistent with *Blastomyces*, displaying smooth, creamy colonies and budding yeast under microscopy. However, these isolates could not be identified by MALDI-ToF (Table C2) and were subsequently sent to MCRI for PCR analysis. All 22 isolates tested negative for *Blastomyces* using the BAD-1 PCR method, although they tested positive with the ITS3/4 PCR (Table C2).

Sensitivity

To evaluate the sensitivity of the methods used for PCR of the environmental samples, serial dilutions of spores from the two species of *Blastomyces* were assessed by PCR to determine the LOD. The LOD for the BAD-1 PCR was 1000 spores per PCR reaction for *B. dermatitidis* and 5000 spores per PCR reaction for *B. gilchristii* while the LOD for the ITS3/4 PCR was between 0.5 and 50 spores per PCR reaction, depending on the species and extraction kit (Table C3).

The sensitivity of the culture methods used on the environmental samples was evaluated. Recovery of spores cultured to solid media and grown in the yeast phase at 39°C varied by species and media type. Overall, 36% of *B. gilchristii* and 15% of *B. dermatitidis* spores counted by hemocytometer produced CFU on solid media. Recovery was similar between species on SAB (both ~30%), but *B. gilchristii* performed

better on the various BHI media types. Notably, *B. dermatitidis* was not recovered on the BHI-C plates, even when 1000 spores were added to the media.

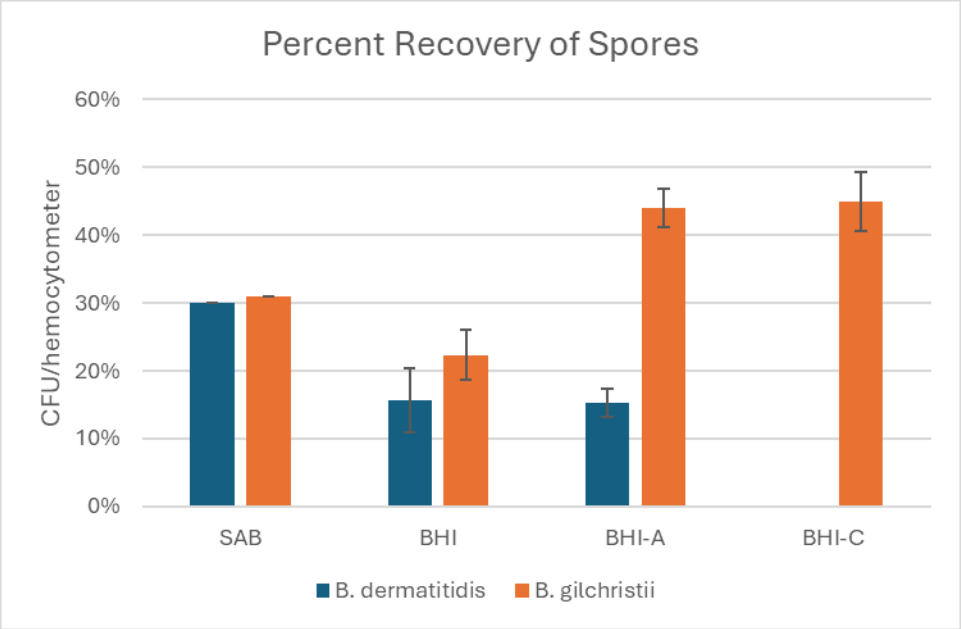


Figure B2. Percent detection of *Blastomyces* spores by species and media type using culture methods

PCR Inhibition Analysis

In total, we tested 188 DNA extracts using the bicoid PCR assay to evaluate potential inhibition in the analysis (Table C4). Of the 134 electrostatic samples tested, two returned negative PCR results (Ct > 29, i.e., positive for inhibition), while two others yielded undetermined results. The bicoid analysis conducted on direct soil samples (n=16) also yielded two negative results. In the soil slurry samples tested with spiked bicoid plasmid (n=22), there were again two negative results. However, the air filter samples (n=16) showed no evidence of PCR inhibition.

Methods: Medical survey

To prepare for the medical survey, the mill helped to coordinate scheduling appointment times for employees. When the mill announced they would be idling, NIOSH took over the scheduling activities and contacted employees by phone to assign appointment times. NIOSH prepared three informational handouts for distribution to employees and union representatives. The first handout provided general information about the health hazard evaluation and details about the medical survey. The second and third handouts provided information about blastomycosis and a urine antigen test. We also notified five contract companies with employees on the mill property for regularly contracted work to give them the opportunity to participate in the medical survey.

NIOSH held 10 one-hour informational sessions at the local United Steel Workers union hall April 20–21, 2023. NIOSH along with subject matter experts from the MDB and state and local health departments provided employees with information about *Blastomyces* and blastomycosis and the NIOSH medical survey.

Participants

During April 22–28, 2023, NIOSH conducted an offsite medical survey. All current employees and contractors were invited to complete a confidential, interviewer-administered work and health questionnaire and provide a urine sample for *Blastomyces* urine antigen screening test. Participation was voluntary; written informed consent was obtained from each participant before testing. All participants were given the option to provide written consent authorizing NIOSH to release their personally identifiable information associated with the health and work questionnaire or urine antigen test result to the state and local health departments.

Blastomyces urine antigen screening testing

We used a urine antigen test for *Blastomyces* to help identify possible infection or inhalation of a sufficient dose of *Blastomyces* spores to have a positive test. *Blastomyces* urine antigen testing has high sensitivity [Linder and Kauffman 2020]. Urine collection was non-invasive and logistically easier to collect and process than blood for serological testing. Participant consent for blood collection may have been lower than urine collection.

An antigen test detects the presence of antigens in a sample, like urine, collected from the body. Antigens are foreign substances produced by viruses, bacteria, or fungi like *Blastomyces*. The body's immune system recognizes antigens as part of an infection. This leads to activation of the immune system as it attempts to fight off infection. A positive test indicates the likely presence of antigens indicating possible exposure to *Blastomyces* fungus. *Blastomyces* antigen may remain detectable in urine for months after infection [Frost and Novicki 2015]. Typically, healthcare providers consider additional clinical and laboratory information when making a clinical blastomycosis diagnosis. A negative test result indicates that *Blastomyces* fungus was not detected in urine. It does not mean that a worker was never exposed to *Blastomyces*. Urine samples were refrigerated and shipped to MiraVista Laboratories, a Clinical Laboratory Improvement Amendments (CLIA)-certified commercial laboratory in Indianapolis, IN. MiraVista analyzed the samples using a *Blastomyces* quantitative enzyme immunoassay (EIA) test. The *Blastomyces* antigen was measured in nanograms per milliliter (ng/mL), and the quantifiable range for the urine test was 0.2 ng/mL to 14.7 ng/mL.

We notified workers with positive test results by phone and encouraged follow-up with their healthcare providers even if they did not have signs or symptoms of blastomycosis. We sent all participants individual result notification letters to the address they provided during the medical survey informed consent process and confidential interview. All urine antigen test results were provided for those participants who said 'Yes' to sharing their information during the informed consent process to the state health department for entry into the Michigan Disease Surveillance System.

Work and Health Questionnaire

The structured interview involved a NIOSH staff member administering a work and health questionnaire over the telephone. We collected work histories for all jobs held since October 1, 2022, and asked participants questions about work locations, work-related environmental conditions, respirator or facemask use, and non-mill-related activities. Health information was collected for self-reported symptoms and diagnoses, blastomycosis specific questions for those who self-reported being diagnosed with blastomycosis, and cigarette smoking or vaping history. The first known blastomycosis

illness onset date was January 1, 2023. The questionnaire collected self-reported information on health symptoms and medical findings since October 1, 2022, to capture a minimum exposure window of three months prior to illness onset.

We made a department list from the employee roster. Departments included Administrative Offices (Administration, Technical, Environmental, Safety, Human Resources, Mill Controller, Purchasing), Fiberline, Recovery & Utilization, Maintenance & Engineering, Paper Machine, PS&D Finishing and Shipping, and Wood & Coal Yard. We also included an 'Other' category to capture free text responses if a participant's department was not listed. We used facility maps provided by the company to create a numbered listing of 63 individual buildings or areas within the mill.

Work locations

Work location information was collected for up to three different jobs held at the mill from October 1, 2022 through April 30, 2023, including each worker's current or most recent job. **Primary work location** was defined as the primary area of the mill where a worker spent the most time for their current or most recent job. Each worker had one primary work location. We also assessed risk for blastomycosis based on **all reported work locations** during the same period. This included a primary work location, and if applicable, up to three secondary work locations for each job held during that period. Secondary locations included break rooms/lunchrooms/shacks and personal offices or desk locations. Most worked in several areas around the mill. Individual areas or buildings were grouped based on paper mill processes using a schematic map provided by the mill. Primary work locations and all working locations were analyzed by mill areas such as E1 Paper Mill or the Administrative offices (as opposed to specific locations, e.g., supercalender of E3 paper mill).

Environmental conditions at the mill

Exposure to environmental conditions at the mill could impact risk for exposure to *Blastomyces* spores and risk for blastomycosis. Participants were asked how often (i.e., never, rarely, some days, or every day) they were exposed to seven specific conditions around the mill since October 1, 2022. They were also asked to identify the primary location where they worked in the condition. Conditions included:

- Damp or wet mulch or pulp
- Dry mulch or saw dust
- Wet soil
- Standing pools of water outdoors on mill property
- Standing pools of water indoors on mill property
- Wind gusts indoors or blowing air while inside the mill
- Visible mold on surfaces, walls, or ceilings

We analyzed daily exposure (i.e., reporting every day) to each condition, as this was the most reliable measure for workers regularly exposed to each condition over the seven-month period.

Potential non-mill-related blastomycosis risk factors

We also asked participants about other paid jobs, activities, and exposures outside of their work at the mill since October 1, 2022, that might be risk factors for blastomycosis. Participation in the following activities were answered as "yes" or "no" and included:

- Chopping wood or building fires
- Gardening, mulching, composting, or lawn care
- Farming
- Construction work involving excavation work or digging or moving soil
- Hunting
- Hiking
- Fishing from shore not covered in ice

Defining blastomycosis Case Definition

NIOSH surveillance blastomycosis case definition

The NIOSH case definition for blastomycosis identified workers who may have been exposed to *Blastomyces* at or around the mill.

NIOSH case definition for blastomycosis: A case was defined as meeting AT LEAST ONE of the following conditions in a person who worked at or visited the paper mill between October 1, 2022, and July 1, 2023:

> **Condition 1:** Had confirmatory or presumptive laboratory evidence of blastomycosis (including urine antigen tests below the limit of quantification but above the limit of detection) regardless of clinical compatibility of health symptoms or medical findings.
>
> **Condition 2:** Self-reported diagnosis of blastomycosis from a healthcare provider on the NIOSH medical survey questionnaire.

Laboratory criteria

The Council of State and Territorial Epidemiologists (CSTE) defines laboratory evidence as confirmatory (e.g., a culture of *Blastomyces* spp. from a clinical specimen like lung tissue) or presumptive (e.g., detection in urine using a *Blastomyces* antigen test) for blastomycosis. Tests providing presumptive laboratory evidence, like an antigen test, have a reported 7%–24% probability of false positive results, and further testing may be required to make a clinical blastomycosis diagnosis. We used antigen testing as a screening tool rather than a diagnostic tool to identify workers who may have been exposed to *Blastomyces*. For antigen tests, the CSTE blastomycosis case definition requires antigen levels to be above the minimum level of quantification. However, no minimum level of quantification was required for antigen tests to meet the NIOSH laboratory criteria for case inclusion. Antigen only had to be detected by the test, including urine antigen tests below the limit of quantification but above the limit of detection (the lowest detectable concentration by the method).

Modified CSTE surveillance blastomycosis case definition

A modified CSTE surveillance definition was used in sensitivity analyses which assessed the strength and consistency of the findings using this blastomycosis definition compared to NIOSH's primary case definition.

Modified CSTE case definition for blastomycosis: Workers met the modified CSTE surveillance definition for blastomycosis if they a) met Conditions 1 or 2 above OR b) worked at or visited the mill between October 1, 2022, and July 1, 2023, and met the following condition:

Condition 3: Had health symptoms or medical findings since October 1, 2022, that met the NIOSH clinical compatibility criteria for blastomycosis regardless of laboratory evidence (as it aligned with the CSTE symptom/outbreak criteria).

For the modified CSTE case definition, NIOSH defined clinically compatible health symptoms and medical findings based on the CSTE Standardized Surveillance Case Definition for Blastomycosis criteria.

NIOSH defined clinical compatibility for blastomycosis as:

a) Reporting at least two clinically compatible health symptoms that started within two weeks of each other:

- Cough
- Fever or chills or night sweats
- Shortness of breath
- Poor appetite or weight loss
- Muscle aches or pain
- Joint pain or bone pain
- Fatigue or extreme tiredness

OR

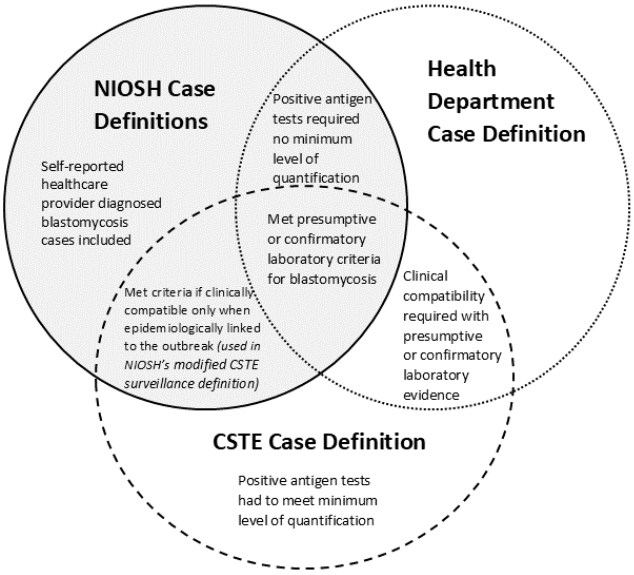
b) Reporting at least one clinically compatible medical finding:

- Abnormal lung findings on chest imaging
- Single or multiple skin lesions
- Inflammation of the brain
- Abscess, granuloma, or lesions other than on skin
- Bone or joint abnormality

To reduce misclassification of health symptoms potentially associated with blastomycosis, health symptoms and medical findings that started within ±2 weeks of the start of a self-reported coronavirus disease 2019 (COVID-19), influenza (flu), or a respiratory syncytial virus (RSV) illness were not considered clinically compatible for blastomycosis.

Comparison between NIOSH, Modified CSTE, and health department case definitions

We used a modified version of the CSTE definition because we used the urine antigen test as a non-invasive tool to assess exposure in this large workforce. To our knowledge, this was the first instance of active case finding using a urine antigen test that detects recent exposure. Passive surveillance for blastomycosis, such as reports to state or local health departments from healthcare providers and laboratories, who perform these tests to diagnose causes of symptoms and signs consistent with blastomycosis. Passive surveillance can underestimate the number of people with an illness if they do not seek care, if lab tests are not ordered, or notifiable diseases are not reported. In Figure B3, we compare criteria for the NIOSH, CSTE, modified CSTE, and health department blastomycosis case definitions.



Comparison of blastomycosis definitions

Criteria	CSTE standardized surveillance case definition for blastomycosis	NIOSH case definition for blastomycosis	NIOSH's modified CSTE surveillance definition for blastomycosis	Health department case definition for blastomycosis
Met presumptive or confirmatory laboratory criteria for blastomycosis	✓	✓	✓	✓
Positive antigen tests had to meet minimum level of quantification	✓			
Clinical compatibility for blastomycosis required with presumptive or confirmatory laboratory evidence*	✓			✓
Met case criteria if clinically compatible only when epidemiologically linked to the outbreak	✓		✓	
Self-reported healthcare provider diagnosed blastomycosis cases included		✓	✓	

* For a case to be considered probable for blastomycosis, clinical compatibility was not required when confirmatory laboratory criteria was available.

Figure B3. Comparison of blastomycosis case definitions

CSTE's standardized case definition defines a blastomycosis case as meeting one of the following conditions:

Confirmed:

a. A clinically compatible case that meets confirmatory laboratory criteria.

Probable:

b. A clinically compatible case that meets presumptive laboratory criteria, OR

c. A clinically compatible case that does not meet laboratory criteria but is epidemiologically linked (e.g., common environmental exposure which may be suspected among family members, coworkers, friends, etc.) to a confirmed case, OR

d. A case with confirmatory laboratory criteria but no clinical information available [CSTE 2019].

The NIOSH case definition was more inclusive than the CSTE and health department case definitions. The health department case definition identified people with confirmed or probable blastomycosis using conditions (a) and (b) in the CSTE definition above, except no minimum level of antigen quantification was required for antigen tests. The NIOSH case definition did not require clinical compatibility with laboratory evidence for blastomycosis or a minimum level of antigen quantification for antigen tests. This modification was made to include workers with likely exposure to *Blastomyces* in the case definition regardless of their health symptoms or medical findings. Both the NIOSH and health department definitions included cases based on confirmatory laboratory criteria alone or CSTE condition (d).

In NIOSH's modified CSTE surveillance definition, workers were identified as potentially having blastomycosis based on clinical compatibility as per CSTE condition (c). All workers/contractors/visitors had an epidemiologic link to the outbreak by working at or visiting the mill. Using CSTE condition (c), workers who were clinically compatible for blastomycosis, regardless of laboratory evidence, were identified. This included workers with potentially undiagnosed blastomycosis into modified CSTE surveillance definition. The health department did not consider cases based on CSTE condition (c).

We assessed health symptoms and potential locations of *Blastomyces* exposures during October 2022 – April 2023 with the offsite medical survey and as late as July 2023 for additional survey participants. This was a longer period than assessed by the health department. The health department case definition included people with a blastomycosis illness onset date of December 1, 2022, or later and collected symptom and exposure information 90 days prior to each individual's earliest illness onset date.

Data Analysis

Data sets and participants

NIOSH interviewer-administered questionnaire data was available for 603 of 608 employees, contractors, and visitors to the mill who participated in the NIOSH medical survey (i.e., NIOSH medical survey participants). We refer to employees, contractors, and visitors to the mill as workers in this report. Of the 608 participants, 578 underwent urine testing. Of the 578, we excluded the five records with missing or incomplete questionnaire data. Therefore, we had questionnaire data for 603 participants and both questionnaire and urine antigen data for 573 participants. Responses to the questionnaire were combined with the laboratory results of the *Blastomyces* urine antigen test.

Information from the health department list for the 42 case-patients, affiliated with the mill who did not participate in the NIOSH survey, was added to survey data for the 603 NIOSH medical survey participants to create the final analytic data set for 645 participants (i.e., all participants). This information and NIOSH medical survey data was stored on a password protected, encrypted CDC server. Individuals were identified by a unique number. The unique identification number was used in all analysis work; names were not included in the analysis datasets.

Facility location groupings

We collected information for work locations based on the schematic map provided by the mill. Individual areas or buildings were grouped based on paper mill processes. For example, areas within E1 Paper Mill were grouped together since it was an adjoining system. Maintenance areas were grouped based on where maintenance workers primarily worked despite those areas being spread across the mill. We analyzed facility locations/buildings individually and as grouped areas.

Statistical Methods

In this report, we describe the demographic characteristics, including age in years, sex (male versus female), race (non-White or more than one race versus White), and ethnicity (Hispanic, Latino, or of Spanish origin versus not). We also summarize job characteristics, such as work type, work locations, work shift [non-shift versus shift-based schedules for four crews (A, B, C, and D)], use of personal protective equipment (PPE), and health-related information. We calculated the percentages of these

characteristics for workers who did and did not meet the NIOSH blastomycosis case definition. Results were reported for all participants (n=645), when possible. When information was not available from the health department list for the 42 case-patients who did not participate in the NIOSH medical survey, analyses were reported for NIOSH medical survey participants (n=603).

We also assessed whether meeting the NIOSH blastomycosis case definition was associated with demographic and work characteristics, health outcomes and symptoms, PPE use, and work locations. We used t-tests and Wilcoxon rank-sum tests for continuous variables (e.g., age in years) and Pearson's chi-squared tests for binary (e.g., yes or no; male or female) and categorical (e.g., job department) variables. We used Fisher's exact tests for analyses with small counts instead of chi-squared tests. Statistical significance for associations between variables and having blastomycosis was noted in the tables at $0.05 \leq p < 0.10$ (marginally statistically significant), $p < 0.05$ (statistically significant), and $p < 0.001$ (highly statistically significant). Statistically significant p-values, i.e., lower than 0.05 ($p < 0.05$), suggested that differences in those who met the NIOSH blastomycosis case definition for the categories being analyzed (e.g., male versus female) were less likely due to chance (<5% of chance).

Blastomycosis illness onset was presented using an epidemic curve for all participants. Illness onset dates were self-reported in the NIOSH questionnaire. Blastomycosis onset among all participants was also presented by location at the mill.

The prevalence of blastomycosis was defined as the number of workers who met the NIOSH blastomycosis case definition divided by the number of workers in a group, such as being female, or who shared a common exposure, such as working in one area of the mill. For example, the prevalence of blastomycosis for E1 Paper Mill was calculated as:

$$\text{Prevalence} = \frac{Number\ of\ workers\ with\ blastomycosis\ who\ worked\ in\ E1\ mill}{Number\ of\ workers\ who\ worked\ in\ E1\ mill}$$

We mapped blastomycosis prevalence by a) workers' primary work location for their current or most recent job and b) for all locations workers reported working in (primary and secondary work locations, office location, and break room) since October 1, 2022. Those who worked in more than one area of the mill contributed to the case prevalence of each area where they worked.

Unadjusted prevalence ratios (PR) and 95% confidence intervals (CI) were used to report the ratio of the prevalence of blastomycosis among workers who worked in the location versus the prevalence of blastomycosis among workers who did not work in that location. For example, the PR of blastomycosis for E1 Paper mill was calculated as:

$$\text{Prevalence ratio (PR)} = \frac{Prevalence\ of\ blastomycosis\ among\ workers\ who\ worked\ in\ E1\ mill}{Prevalence\ of\ blastomycosis\ among\ workers\ who\ DID\ NOT\ work\ in\ E1\ mill}$$

PRs were estimated using a portion of the total mill workforce who participated in the survey, and CIs provided a statistical range within which the PR for the entire mill workforce likely lied. This is represented by upper and lower bounds for the PR estimate based on a margin of error. The narrower the range of the CI, the more precise the estimate is. PRs greater than one represent a higher prevalence of the outcome in one work location than in the rest of the mill locations. When the lower bound of the

CI is also greater than one, the PR is statistically significant, i.e., the prevalence of blastomycosis was greater for workers who worked in a location versus workers who did not work in that location beyond what would be expected by chance. PRs less than one represent a lower prevalence of the outcome in one work location than the rest of the mill locations and are statistically significant when the upper bound of the CI is less than one. When the 95% CI includes one, this indicates there may be a lesser likelihood of a true effect of an exposure on blastomycosis. But a 95% CI that does not include one suggests evidence that an effect of an exposure is more likely to exist [Savitz et al. 2024].

In the sensitivity analyses, all analyses were duplicated using NIOSH's modified CSTE surveillance definition which included more workers with possible blastomycosis than the primary case definition. Sensitivity analyses assess the strength and consistency of findings when a factor in the analysis is modified which in this situation was the blastomycosis outcome. The primary case definition relied on laboratory evidence to identify blastomycosis cases. The modified CSTE surveillance definition included additional cases based on health symptoms and medical findings that were compatible with blastomycosis. We compared changes in demographic or work characteristics, and the statistical significance of associations between these predictors and blastomycosis when using the modified CSTE surveillance definition to compare to the primary results. Tests for associations with health symptoms and medical findings were not run in sensitivity analyses since these symptoms/findings were integrated into the modified CSTE surveillance definition.

Additionally, we estimated blastomycosis risk among NIOSH medical survey participants using regression models. Regression models estimate relationships between exposures that potentially put workers at risk for blastomycosis and the health outcome, blastomycosis. Using data for the 603 NIOSH medical survey participants only, we used these models to investigate which individual or workplace characteristics were associated with an increased, decreased, or no change in risk of blastomycosis. Characteristics included work location or environmental conditions. We used Poisson regression with robust standard errors to model associations between work locations, environmental conditions, and blastomycosis. Estimates were calculated as PRs, or the ratio of the prevalence of blastomycosis among workers who reported an exposure to the prevalence of blastomycosis among workers who did not report that exposure.

Regression models for work location

Using regression models, we estimated unadjusted and adjusted PRs. Unadjusted PRs include simple associations between an exposure and blastomycosis but does not account for other factors that may influence the relationship, or so-called potential confounders. Adjusting for variables in the relationship between an exposure and blastomycosis accounts for potential confounders. Using causal hypotheses, we identified sex and tenure as potential confounders for the relationship between work location and blastomycosis. Associations with sex and blastomycosis have been reported [Williams et al. 2024], and tenure may determine the type of work processes and exposures that workers encounter. For relationships between environmental conditions and blastomycosis, work location was included in addition to sex and tenure in adjusted regression models. In the regression model results, we only report adjusted PRs.

For **primary work location**, we used effect coding for regression models to estimate associations between primary work location and blastomycosis. Estimates for each area were compared to the overall prevalence of blastomycosis at the mill. For example, the PR of blastomycosis for Administrative Offices was calculated as:

$$\text{PR} = \frac{\textit{Prevalence of blastomycosis for workers whose primary work location was the Admin Offices}}{\textit{Prevalence of blastomycosis among all workers at the mill}}$$

We also estimated PRs for each mill area based on **all reported work locations** between October 2022 through April 2023. For example, the PR of blastomycosis for E1 Paper Mill was calculated as:

$$\text{PR} = \frac{\textit{Prevalence of blastomycosis among workers who reported working in E1 mill}}{\textit{Prevalence of blastomycosis among workers who DID NOT report working in E1 mill}}$$

PRs and CIs were reported for estimates that were statistically significant at $p<0.05$ and marginally significant, at $p<0.10$. Estimates that are marginally significant can also offer useful information on trends of increasing or decreasing PRs, but several statistical factors, including small sample sizes in PR calculations, may affect why they did not meet the commonly used statistical significance threshold of $p<0.05$.

Regression models for environmental conditions

PRs for environmental conditions estimated the effect of daily exposure to environmental conditions on the prevalence of blastomycosis. For example, the PR of daily exposure to wet soil was calculated as:

$$\text{PR} = \frac{\textit{Prevalence of blastomycosis among workers who reported daily exposure to wet soil}}{\textit{Prevalence of blastomycosis among workers who DID NOT report daily exposure to wet soil}}$$

PRs were modeled for daily exposure to environmental conditions individually and in combination (e.g., daily exposure to pooling water indoors and pooling water outdoors), though exposure to each of these environmental conditions were not necessarily in the same area. Only select combinations are reported, though several combinations were explored.

Since pooling water indoors was identified as a blastomycosis risk factor, we also described the primary locations where workers reported daily exposure to pooling water indoors at the mill.

Environmental conditions and health symptoms not related to blastomycosis

We also assessed whether environmental conditions at the mill were associated with health symptoms reported by workers that could be caused by other exposures or illnesses not related to blastomycosis. We estimated associations between environmental conditions and non-respiratory illness-related health symptoms among all NIOSH medical survey participants and among subsets of participants who did not have blastomycosis (based on the NIOSH case definition for blastomycosis). Non-respiratory illness-related health symptoms included symptoms reported since October 1, 2022, which were not related to a known respiratory infection (i.e., blastomycosis, COVID-19, influenza (the flu), or respiratory syncytial virus (RSV)). Health symptoms were grouped into the following three outcomes:

- Respiratory symptoms

    - Cough
    - Shortness of breath, or working harder than normal to breathe
- Systemic symptoms
    - Fever or chills or night sweats
    - Poor appetite or unexpected weight loss
    - Muscle aches or pain
    - Joint or bone pain
    - Fatigue or extreme tiredness
- Any symptoms – any of the above symptoms

Statistical analyses were conducted using SAS software version 9.4 (SAS Institute, Cary, NC), ArcGIS Pro 3.2.0 (Esri, Inc., Redlands, CA), and JMP 16.1 (SAS Institute, Cary, NC).

Results: Medical survey

All tables described below can be found in Section C. We analyzed data for 645 workers, including 603 workers who participated in the medical survey and 42 additional workers who were case-patients on the state health department list when possible.

Urine antigen testing

Of the 573 workers with urine antigen test results included in these analyses, 521 workers (91%, n=521/573) had negative test results (i.e., *Blastomyces* antigen was not detected), and 52 workers (9%, n=52/573) had positive test results (i.e., *Blastomyces* antigen was detected). At the time of the NIOSH medical survey, 25 workers with positive urine antigen results (48%, n=25/52) were not included on the health department list. These workers were identified through the medical survey and may not have undergone clinical testing that resulted in a report of blastomycosis to the State's notifiable disease surveillance system or perhaps had negative tests in other settings.

Overall blastomycosis case prevalence

Among the 603 NIOSH medical survey participants, 120 workers met the NIOSH blastomycosis case definition (i.e., most likely had blastomycosis). This equates to a blastomycosis case prevalence of 20% (n=120/603). Note that we calculated case prevalence excluding the 42 case-patients with blastomycosis from the health department list.

Worker demographics

Table C5 reports the demographic characteristics for all participants (n=645) which includes information from the additional health department case-patients (n=42) and the NIOSH medical survey participants (n=603). Workers were predominantly male (83%, n=537), white (94%, n=596), non-Hispanic (98%, n=620), with an average age of 45 years (median age 46, range 19 years–73 years). For medical survey participants, most workers (98%, n=586) were residents of the Upper Peninsula of Michigan (mean residency: 37 years, range 0–73 years). Sex, ethnicity, and residency in the Upper Peninsula were similar between workers who did and did not meet the NIOSH case definition for blastomycosis. Workers who met the NIOSH case definition were younger (mean age 42 years) than workers who did not meet the case definition (mean age 46 years; p=0.003), and blastomycosis was more common among workers who were white (p=0.017). For tobacco use history, 66% (n=420) of

workers never smoked or vaped, 27% (n=173) formerly smoked or vaped, and 7% (n=45) currently smoked or vaped at the time of the survey. Smoking history and current smoking status were similar between workers who did and did not meet the NIOSH case definition for blastomycosis.

Job-related information

Work history characteristics are presented in Table C6. Most participants were company employees (94%, n=603) compared to contractors or visitors to the mill (6%, n=39), and blastomycosis was similar among employees and contractors/visitors. The average number of years working at the mill, or tenure, among all workers was 12 years, and workers who met the NIOSH case definition for blastomycosis worked at the mill for fewer years (mean tenure 10 years) than workers who did not meet the case definition (mean tenure 12 years). There were no significant differences in prevalence of blastomycosis by department. The percentage of workers who met the NIOSH case definition for blastomycosis in each department was the following: 27% (n=54/203) in the Paper Machine department, 27% (n=41/154) in Maintenance & Engineering, 21% (n=20/95) in the Administrative Offices, 28% (n=15/54) in PS&D Finishing and Shipping, 30% (n=14/46) in the Fiberline department, and 18% (n=6/34) in the Wood & Coal Yard. Thirty-nine workers worked in Recovery & Utilization, and 15 workers worked in other departments, but the number of workers in these departments who met the NIOSH case definition for blastomycosis was too small to report. There were also no significant differences in blastomycosis between those who did and did not work on a shift-based schedule or between the A, B, C, or D work crews.

During the NIOSH medical survey, almost half of participants (47%, n=281) reported using a respirator or facemask at any time during their work since October 1, 2022 (Table C7). Of those, 41% (n=246) used an N95 filtering facepiece respirator, 5% (n=29) used a self-contained breathing apparatus (SCBA), 5% (n=29) used full-face respirators, 4% (n=26) used half-face respirators, 1% (n=9) used a non-respirator facemask, and 1% (n=9) used another type of respirator/facemask.

Respirators were most often reportedly worn for dust exposure, including wood or soil dust exposure (18%, n=111) and other dust not related to wood or soil (22%, n=131). Respirators were also used to prevent infectious disease (12%, n=71), chemical exposure (10%, n=58), and for emergency response (4%, n=22).

For the 246 workers using N95 filtering facepiece respirators, 82% (n=201) reported voluntary use, 52% (n=127) used them some of the time or for some tasks, and most workers wore them rarely (42%, n=103). Most workers reported replacing their N95 filtering facepiece respirators once per day (58%, n=142) or multiple times per day (24%, n=59). Of workers who met the NIOSH case definition for blastomycosis and reported wearing N95 respirators, 35% (n=17/49) reported rarely wearing N95 respirators, 55% (n=27/49) reported wearing N95 respirators some of the time, and 10% (n=5/49) reported wearing them most or all of the time. There were no significant differences between workers who did and did not meet the NIOSH case definition for blastomycosis in how often they reported using N95 filtering facepiece respirators, whether their use was required or voluntary, or the frequency of their replacement.

Blastomycosis prevalence by work location

Blastomycosis occurrence or prevalence by location for all participants (n=645) is presented in Table C8. Forty percent (40%) of workers who worked in the Maintenance areas as their primary work location and 37% of workers who ever worked in the Maintenance areas met the NIOSH case definition for blastomycosis. Thirty-five percent (35%) of workers who worked in E1 Paper Mill as their primary work location and 31% of workers who ever worked in E1 Paper Mill met the NIOSH case definition for blastomycosis. All other areas of the mill and percentages of workers who met the NIOSH case definition for blastomycosis included Pulp Make Down (30%), PS&D Finishing and Shipping (29%), Administrative Offices (28%), Pulp Mill (22%), Mechanical Pulping (20%), Woodyard (20%), E4 Paper Mill (19%), Receiving and Storeroom (18%), E3 Paper Mill (17%), Outside Utilities (17%), Boilers (15%), and Engineering offices (12%).

The prevalence of blastomycosis using the NIOSH case definition since October 1, 2022 by primary work location is shown in Figure B4 below followed by the prevalence for having ever worked in a location (Figure B5).

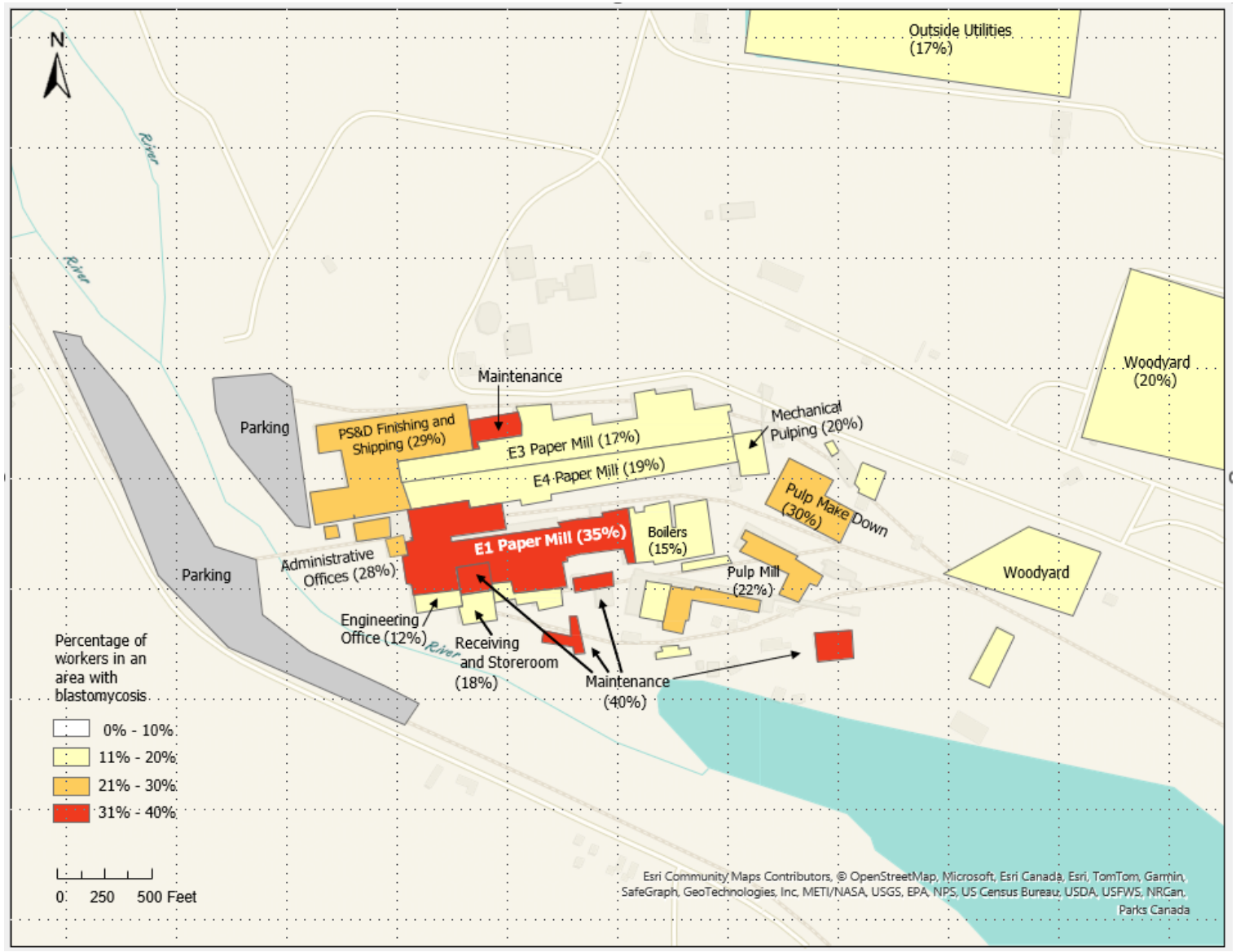


Figure B4. Prevalence of blastomycosis for each area by workers' reported primary work location for their current or most recent job for all participants (n=645)

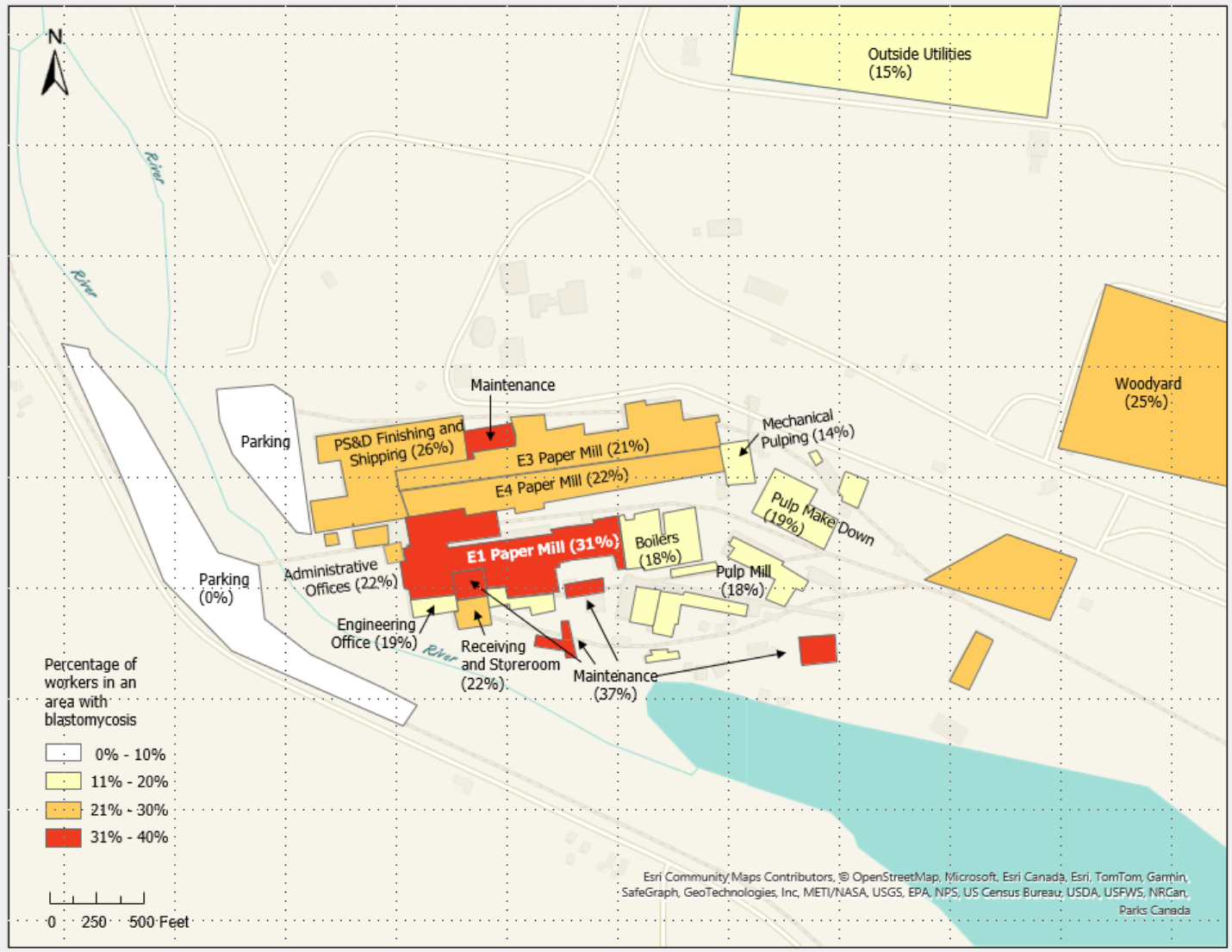


Figure B5. Prevalence of blastomycosis among workers in each area of the mill for all reported work locations, including primary and secondary work locations, office spaces, breakrooms/lunchrooms/shacks from October 1, 2022-Apirl 2023.

The mill maps (Figures B4 and B5) show the E1 Paper Mill and many of the Maintenance areas with the highest prevalence of blastomycosis were on the west side of the mill property, near the main entrance to the mill from the parking areas. The other areas with the highest prevalence (E4 Paper Mill, PS&D Finishing and Shipping, and the Administrative Offices) were also on the west side of the mill property.

The prevalence of blastomycosis was 72% greater among workers primarily working in Maintenance areas [PR=1.72 (1.21, 2.46)] compared to workers with all other primary work locations combined, and the prevalence was 64% greater for those who ever worked in Maintenance areas [PR=1.64 (1.21, 2.20)] compared to workers who did not work in Maintenance areas. The prevalence of blastomycosis was 56% greater among workers primarily working in the E1 Paper Mill [PR=1.56 (1.14, 2.12)] compared to workers with all other primary work locations combined, and the prevalence was 37% greater for those who ever worked in the E1 Paper Mill [PR=1.37 (1.04, 1.81)] compared to workers who did not work

Health outcomes and medical findings

For health symptoms reported since October 1, 2022 (Table C9 in Section C), every symptom was significantly more common among workers who met the NIOSH case definition for blastomycosis ($p<0.001$) compared to non-cases and among workers who had positive versus negative urine antigen test results ($p<0.01$). This is expected since meeting the health department case definition required clinical compatibility of health symptoms and medical findings with blastomycosis.

For the medical findings, 18% (n=118) of all participants reported abnormal lung findings on chest imaging from a radiograph or computed tomography (CT) scan. Abnormal lung findings were significantly higher among workers who met the NIOSH case definition for blastomycosis (63%, n=100) compared to workers who did not meet the case definition (4%, n=18; $p<0.001$). Some workers who did not meet the NIOSH case definition for blastomycosis had abnormal lung findings due to other reasons or were clinically evaluated and not diagnosed with blastomycosis. Of 162 workers who met the NIOSH case definition for blastomycosis, we had hospitalization information for 151 workers, and 12% (n=18) were hospitalized for the illness. There was one death among workers with blastomycosis.

We assessed self-reported respiratory illnesses other than blastomycosis since October 1, 2022. Among NIOSH medical survey participants (n=603):

- 56% (n=334) reported a cold
- 10% (n=61) reported COVID-19
- 7% (n=42) reported influenza
- 6% (n=35) reported pneumonia
- 2% (n=9) reported bronchitis

Among NIOSH medical survey participants who met the NIOSH case definition for blastomycosis:

- 48% (n=57) reported a cold
- 12% (n=14) reported COVID-19
- 5% (n=6) reported influenza
- 22% (n=26) reported pneumonia

Pneumonia was significantly higher among workers who met the NIOSH case definition for blastomycosis ($p<0.001$).

Four percent (n=7) of workers who met the NIOSH case definition for blastomycosis were asymptomatic at the time of survey completion, meaning they reported no clinical health symptoms or medical findings since October 1, 2022, that were not linked to COVID-19, RSV, or influenza (Table C9). This included 10% (n=5) of workers with positive urine antigen tests from the NIOSH medical survey who reported no symptoms (Table C10).

Reports of healthcare provider-diagnosed non-blastomycosis medical conditions were not common (Table C11) among NIOSH medical survey participants. During the medical survey, 11% (n=68) of workers self-reported a healthcare provider diagnosis of asthma, and 5% (n=29) of workers self-reported a healthcare provider diagnosis of diabetes.

Sensitivity analyses using the modified CSTE surveillance definition

In sensitivity analyses, we used the modified CSTE surveillance definition to identify 258 workers, or 43% of medical survey participants (n=258/603), who met this more inclusive definition for potential blastomycosis. This included 120 workers based on the primary NIOSH case definition and another 138 workers who met the modified CSTE surveillance definition based on clinical compatibility of health symptoms and medical findings alone.

Using the modified CSTE surveillance definition, differences in blastomycosis by sex (Table C5), smoking status (Table C5), tenure at the mill (Table C6), and use of a full-face respirator (Table C7) were no longer significant; younger age (Table C5) and self-reported pneumonia (Table C9) remained significantly associated with blastomycosis. Reports of health symptoms and medical findings were primarily attributed to workers who met the modified CSTE surveillance definition for blastomycosis, though 49% (n=169) who did not have blastomycosis using this definition had a cough. Surprisingly, use of a half-face respirator ($p=0.047$) and PPE for preventing infectious illness ($p=0.050$) were significantly higher among workers with blastomycosis who took part in the medical survey when using the modified CSTE surveillance definition. However, we do not have information on whether they used PPE before or after an illness or before or after knowledge of the blastomycosis outbreak. Also, we do not know if respirators were worn correctly (e.g., training, fit tested).

In Table C12, blastomycosis prevalence using the modified CSTE surveillance definition was greater for each area of the mill compared to using the NIOSH case definition. From the results by primary work location, the Pulp Make Down location had the highest blastomycosis prevalence estimate of 60%, and the E1 Paper Mill had a blastomycosis prevalence estimate of 57%. Also, the E1 Paper Mill had the only statistically significant elevated prevalence ratio [PR=1.28 (1.05, 1.56)], indicating that blastomycosis was 28% greater among workers in this location compared to workers with all other primary work locations.

Blastomycosis illness onset time

The epidemic curve of self-reported blastomycosis illness onset dates, by week, for 162 workers who met the NIOSH case definition for blastomycosis among all participants appears in Figure B6. Among all participants, the peak of the outbreak (i.e., when illness onset occurred among the most workers) was during the week of February 27, 2023. Illness onset dates ranged from November 1, 2022 to May 15,

2023, with an average illness onset date of March 4, 2023. The last case was reported in May 2023 and the outbreak was declared over by the state health department in July 2023.

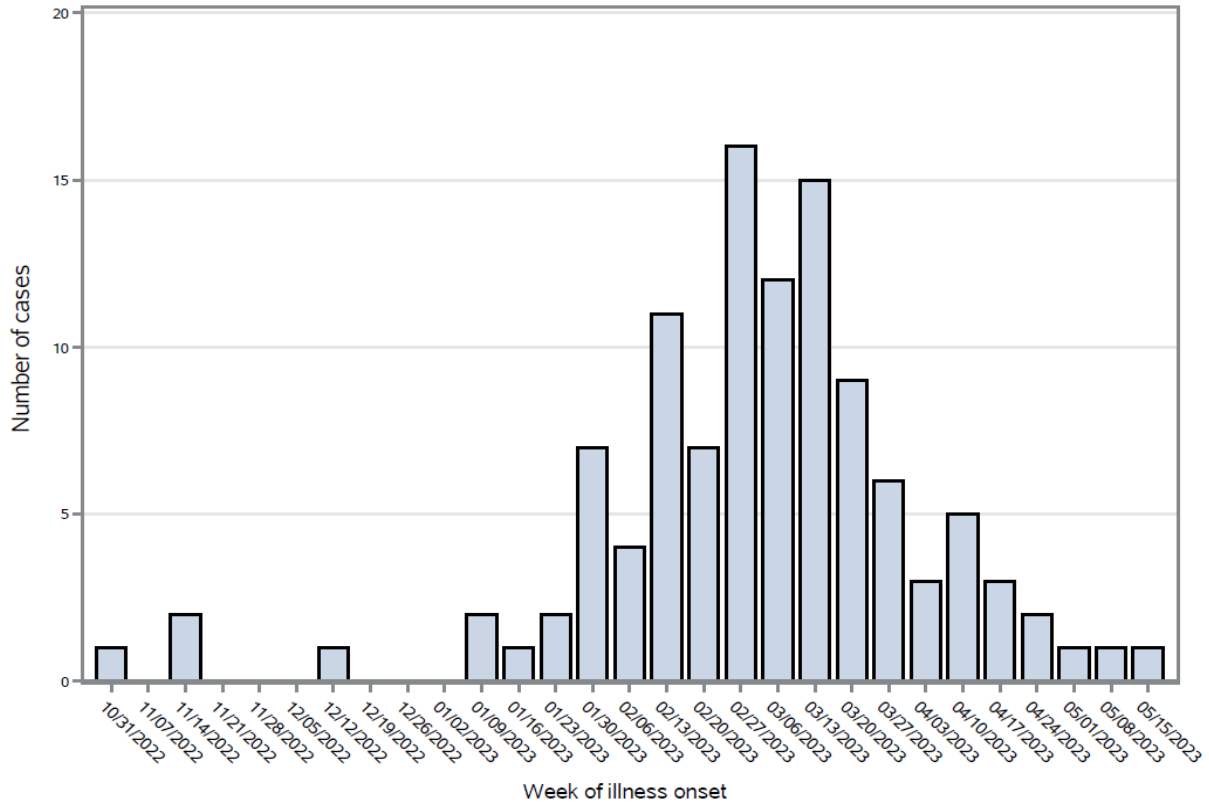


Figure B6. Number of workers with a case of blastomycosis by week of illness onset

Blastomycosis illness onset dates among all participants based on primary work location for current or most recent job are shown in Figure B7.

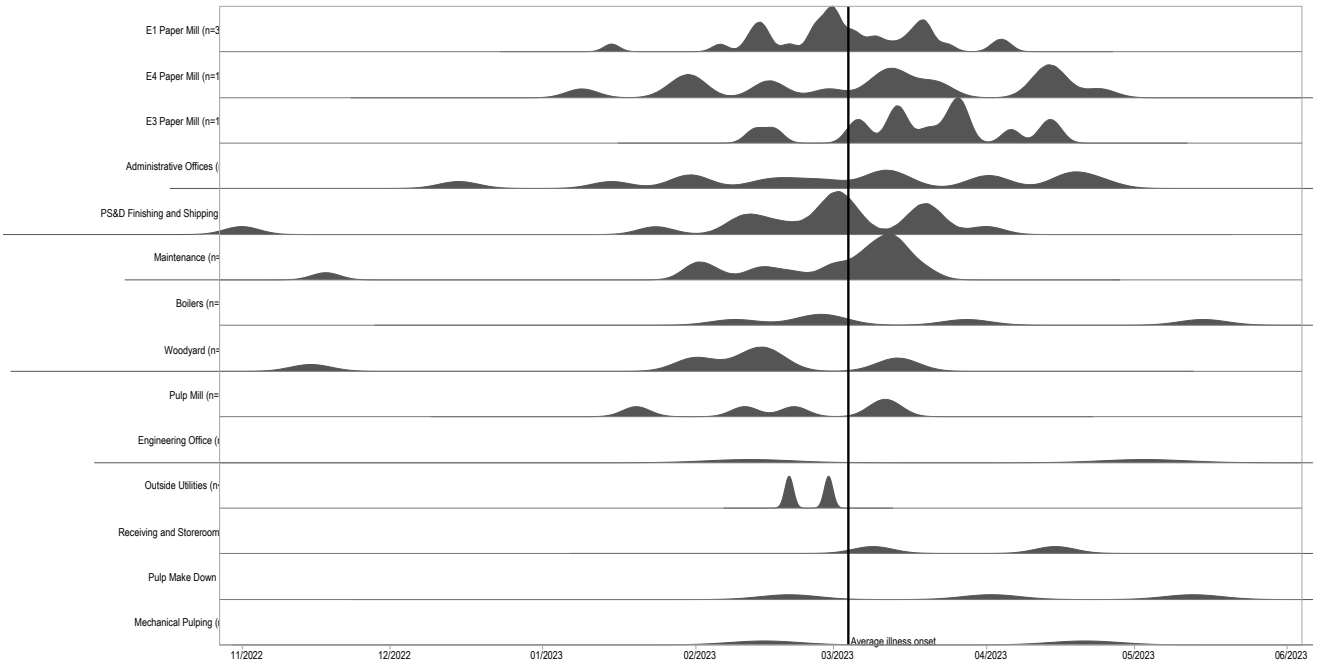


Figure B7. Illness onset date among all participants by primary work location

Early cases of blastomycosis occurred in workers who primarily worked in the Woodyard, PS&D Finishing and Shipping and in the Maintenance areas. Early onsets of illness in these areas were followed by periods of a month or more without another case. Illness onset periods varied by primary work location. For example, blastomycosis onset for Administrative Office workers spanned December 2022 through April 2023, but onset for Maintenance area workers spanned November2023 through March 2023. Blastomycosis cases occurred across the mill by early to mid-February 2023.

Minimum blastomycosis exposure window

The earliest possible exposure date we are aware of is December 20, 2022, when an individual who was later diagnosed with blastomycosis visited the mill site on only that date. The latest date we know of for a person who was at the mill for a single day and was later diagnosed with blastomycosis was January 26, 2023. Based on these individuals' days at the mill, we have evidence for a minimum five-week exposure window at the mill from at least December 20, 2022, through at least January 26, 2023. However, workers continued to become ill into early May 2023, so the exposure window was likely longer than January 26, 2023.

Blastomycosis risk using regression models

Regression models using data for the 603 NIOSH medical survey participants only were used to investigate whether individual or workplace characteristics were associated with risk of blastomycosis. Characteristics included work location or environmental conditions.

Primary work location

Based on **primary work location** (Table C13), after adjusting for tenure and sex, only the E1 Paper Mill was associated with an increased risk of blastomycosis. The prevalence of blastomycosis was marginally significantly higher, 47% (PR: 1.47; 95% CI: 0.99, 2.17, p=0.056) for those who primarily worked in the E1 Paper Mill compared to the overall prevalence of blastomycosis at the mill.

All work locations

Among **all reported work locations** between October 2022 through April 2023 (Table C14), the prevalence of blastomycosis was greater for those who reported working in the E1 Paper Mill or Maintenance areas. The prevalence of blastomycosis was 40% greater (PR: 1.40; 95% CI: 1.00, 1.95; p=0.048) among workers who reported working in the E1 Paper Mill compared to workers who did not report working there, and the prevalence of blastomycosis was 53% greater (PR: 1.53; 95% CI: 1.04, 2.25; p=0.031) among workers who reported working in the Maintenance areas compared to workers who did not report working there. Working in the E3 paper mill had a marginally significant 33% decreased prevalence of blastomycosis (PR: 0.67; 95% CI: 0.44, 1.03; p=0.069), compared to workers who did not report working there. Working in both the E1 Paper Mill and Maintenance areas was associated with a two-fold increase in the prevalence of blastomycosis (PR: 2.17; 95% CI: 1.35, 3.49) (Table C15).

Environmental conditions

Workers with blastomycosis per the NIOSH case definition reported greater daily exposure to standing pools of water indoors (27% vs. 15%; p=0.002), visible mold on surfaces, walls, or ceilings (28% vs. 20%; p=0.039), standing pools of water outdoors on mill property (12% vs. 7%; p=0.097), wind gusts indoors or blowing air while inside the mill (40% vs. 32%; p=0.089), and daily use of the turnstiles near

the front entrance of the mill (98% vs. 93%; p=0.031) compared to workers without blastomycosis (Table C16). Walking daily through the Administrative Offices (34% vs. 31%; p=0.640) and parking lot use (p=0.605) did not differ between workers with and without blastomycosis.

Daily exposure to pooling water indoors was a consistent predictor of increased blastomycosis risk. The prevalence of blastomycosis was 79% greater for workers who were exposed daily to pooling water indoors at the mill compared to those who were not exposed (Table C17; PR: 1.79; 95% CI: 1.25, 2.57; p=0.001). The specific areas of the mill where more than five workers reported primary exposure to pooling water indoors (Figure B8) included E1 Paper Machine (n=16), E4 Paper Machine (n=9), E1 Coater (n=7), E3 Paper Machine (n=7), Woodroom Building (n=7), and the E1 Maintenance areas in the basement (n=6).

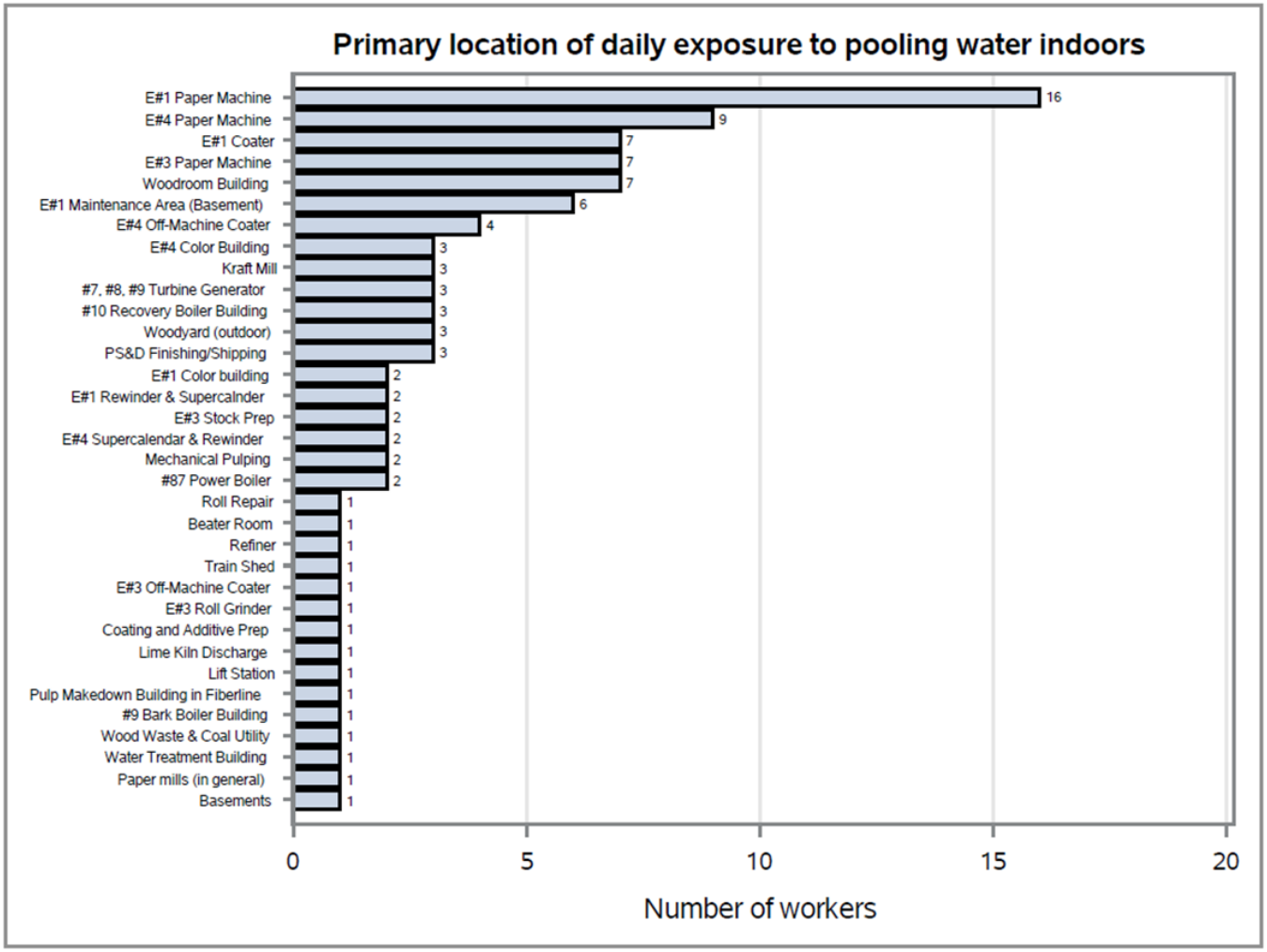


Figure B8. Number of workers reporting daily exposure to pooling water indoors by primary location of exposure at the mill

Daily exposure to pooling water outdoors was associated with an 82% (Table C17; PR: 1.82; 95% CI: 1.11, 2.98; p=0.018) increased prevalence of blastomycosis. However, pooling water outdoors was only significantly associated with blastomycosis when workers also reported daily exposure to pooling water indoors (Table C18; PR: 2.53; 95% CI: 1.42, 4.49; p=0.002). Daily exposure to pooling water outdoors,

but not also indoors, was not significantly associated with an increased risk of blastomycosis (PR: 1.46; 95% CI: 0.64, 3.29; p=0.368).

Daily exposure to visible mold was marginally associated with a 43% (Table C17; PR: 1.43; 95% CI: 0.99, 2.08; p=0.058) increased prevalence of blastomycosis. The specific areas where more than five workers reported daily exposure to visible mold (Figure B9) included the E1 paper machine, E1 rewinder and supercalender, E1 Maintenance area (basement), E4 supercalender and rewinder, E4 paper machine, Woodyard, and PS&D finishing and shipping.

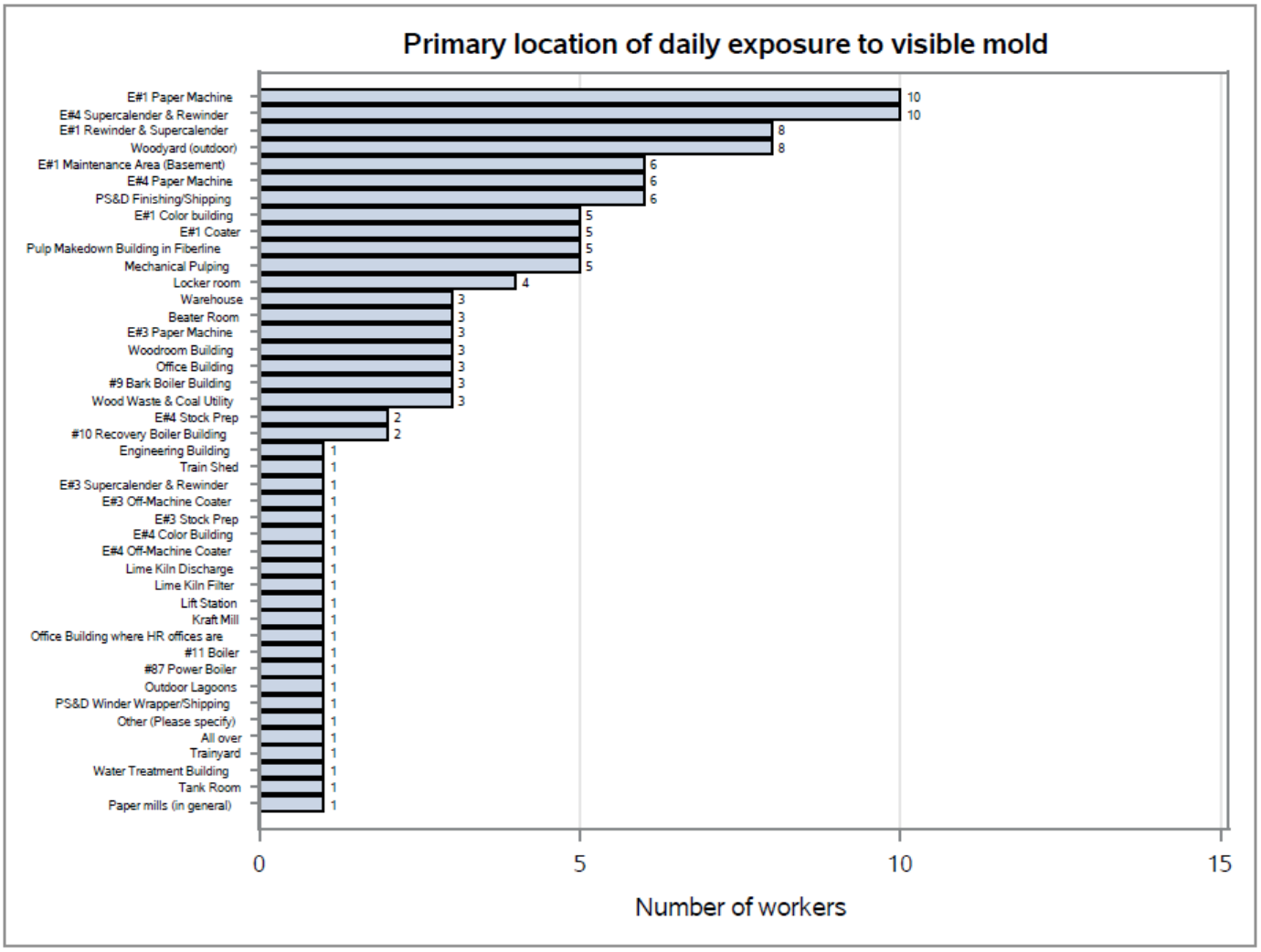


Figure B9. Number of workers reporting daily exposure to visible mold indoors by primary location of exposure at the mill

Non-mill-related activities

Participation in non-mill activities that have previously been associated with blastomycosis infection were reported more often by workers without blastomycosis than by workers with blastomycosis. Activities included gardening, mulching, composting, or lawn care, construction work, hunting, hiking, fishing from shore, camping or visiting a cabin, and chopping wood or building fires (Table C19). Living with dogs and farming were similar between workers with and without blastomycosis.

Environmental conditions and health symptoms not related to blastomycosis

Reported mill-related environmental conditions were associated with general health symptoms and blastomycosis; 30% of workers with blastomycosis were among the participants who reported respiratory symptoms not related to another illness. Daily exposure to pooling water indoors was significantly associated with respiratory health symptoms (Table C20; PR: 1.24; 95% CI: 1.03, 1.49; p=0.025) among all 603 NIOSH medical survey participants and marginally so among workers without blastomycosis (Table C21; PR: 1.20; 95% CI: 0.98, 1.46; p=0.071). Visible mold was also significantly associated with systemic health symptoms among all participants (Table C20; PR: 1.53; 95% CI: 1.21, 1.93; p<0.001) and workers without blastomycosis (Table C21; PR: 1.61; 95% CI: 1.25, 2.07; p<0.001). Wind gusts indoors were significantly associated with respiratory health symptoms among workers without blastomycosis (Table C21; PR: 1.21; 95% CI: 1.04, 1.42; p=0.017).

We observed additional associations between environmental conditions and non-respiratory illness-related health symptoms at the mill. For example, while damp or wet mulch or pulp was not associated with blastomycosis (Table C17), it was associated with respiratory symptoms among all medical survey participants (Table C20; PR=1.34; 95% CI: 1.13, 1.58; p<0.001) and those without blastomycosis (Table C21; PR=1.28; 95% CI: 1.08, 1.52; p=0.005).

Discussion

Blastomycosis is a rare disease caused by the fungus, *Blastomyces*, which occurs naturally in the region of the United States where the mill is located [Smith et al. 2022]. Only 26 cases were reported in Michigan in 2019, and 240 cases reported in the United States among the five states that voluntarily reported blastomycosis surveillance data to the National Notifiable Diseases Surveillance System in 2019 [Smith et al. 2022].

An incubation period is the time between exposure and when disease symptoms begin. There are many unknowns around the incubation period and exposure in blastomycosis [Schwartz and Kauffman 2020]. However, blastomycosis is thought to have an incubation period from two to three weeks up to three months with an average of four to six weeks [CDC 2024b; Klein et al.1986; Linder et al. 2023; Mazi et al. 2021]. To our knowledge, this is the largest outbreak of blastomycosis recorded worldwide. This outbreak marks the first recognized occurrence of blastomycosis in an indoor, industrial environment [Harvey et al. 2025]. Based on the NIOSH evaluation and the outbreak investigation by the state and local health departments, all cases in the outbreak occurred among workers, contractors, and visitors to the mill.

Estimate of blastomycosis in the mill workforce

This evaluation had strong participation by the mill workforce, suggesting our findings on prevalence and factors associated with infection approximate what would be seen in the workforce overall. Assuming about 1,000 workers were employed by the mill since October 1, 2022, then participation was approximately 64%. While all workers and contractors were invited to participate in the medical survey, the reasons why workers declined to participate could affect these results. For example, if workers who did not participate worked more often in one area of the mill (e.g., one of the paper mills) and were more or less likely to have developed blastomycosis, blastomycosis prevalence could be either underestimated or overestimated. The good response rate to the medical survey suggests participants

were representative of the mill workforce, but we cannot entirely rule out the possibility of some biased results due to non-participation.

The case prevalence for blastomycosis at the mill, or the percentage of workers who met the NIOSH case definition for blastomycosis among medical survey participants, was 20%. NIOSH and the state health department together identified 162 cases of blastomycosis in this outbreak using a broader, more inclusive NIOSH surveillance case definition. We included additional case-patients from the health department list, when possible, in our analyses to enhance the clinical information available on worker and workplace characteristics associated with blastomycosis. The NIOSH case definition identified workers with blastomycosis based on laboratory testing and self-reported healthcare provider diagnosis. Three quarters of workers with blastomycosis based on NIOSH's case definition were identified by the state health department as case-patients. Case-patients on the health department list had a stricter threshold for case identification since they had to meet clinical compatibility criteria in addition to having laboratory evidence of blastomycosis. Therefore, we are confident that workers who met the NIOSH case definition had blastomycosis.

It is possible that we did not capture all cases of the illness or all workers who were exposed to *Blastomyces* in these analyses. We relied on diagnoses of blastomycosis from state-based surveillance efforts and self-reporting of healthcare provider diagnoses by participants which may miss less severe cases of disease or people with blastomycosis who do not seek care. Asymptomatic individuals or those with mild symptoms early in the outbreak may not have been clinically tested for blastomycosis. Reasons for this include not visiting a healthcare provider to receive testing, not having sufficient symptoms to undergo blastomycosis testing through clinical services, having symptoms but a provider not suspecting blastomycosis, or being evaluated and testing negative for blastomycosis. Other workers with self-reported healthcare provider diagnosed blastomycosis were not reported to the state health department. Thus, NIOSH's case prevalence estimates are higher than what would be expected based on standard passive surveillance. However, based on good survey participation, we believe our findings are reasonable estimates for the entire mill workforce.

Case identification and the case prevalence may also be overestimated. The case prevalence could be high if there was higher participation in the medical survey from workers who were more ill, had reason to believe past illness may be related to blastomycosis or felt the urine antigen test would be positive than those who were less ill, had no reason to suspect blastomycosis, or felt their urine antigen test would be negative. Our findings are more likely to capture later infections due to increased awareness by the mill workforce and healthcare providers and because of the urine antigen testing administered by NIOSH during the medical survey.

Use of the urine antigen test for blastomycosis screening

Using urine antigen tests may affect the estimated case prevalence in both directions. Some workers with positive NIOSH urine antigen tests may never have been identified (or shown up in regular surveillance reported to the state health department) without screening in the medical survey. Urine antigen testing is non-invasive, has a rapid turnaround time for test results, and has high test sensitivity (76%–93%) in patients with blastomycosis [Mazi et al. 2021]. This means the test is able to accurately detect *Blastomyces* in most but not all of people who have been infected. How long *Blastomyces* antigen is

detectable in the body after inhalation or infection is not well characterized. Also, administering the urine antigen test only once and testing after the peak of the outbreak in early March 2023, may have limited our ability to identify everyone exposed to *Blastomyces*. However, false positive results are also possible. In one study, in patients with nonfungal infections and health subjects, the specify of Blastomyces antigen detection by quantitively enzyme immunoassay was 99%, but cross-reactions occurred in 95.6% of patients with histoplasmosis [Connolly et al. 2012]. In another study, specificity was 100% when patients with histoplasmosis were excluded [Bariola et al. 2011].

Some workers who tested positive on the NIOSH urine antigen test did not report symptoms. The NIOSH evaluation only identified 2% of workers who met the NIOSH case definition as asymptomatic, including 10% of workers with positive NIOSH urine antigen tests. This is surprising because previous studies reported rates of up to 50% of cases being asymptomatic [Klein 1986; Linder et al. 2023], though this estimate is based on very few studies.

Distribution of blastomycosis by worker characteristics and location

Mill workers in this evaluation were predominantly white, non-Hispanic males, and we observed that blastomycosis was greater among males, younger workers, and those with shorter tenures, or number of years worked. While blastomycosis was more common among white compared to non-white workers based on the NIOSH case definition, we did not see differences in blastomycosis by race when using the modified CSTE surveillance definition. Prior published surveillance data found that blastomycosis was more common among males than females [Egger et al. 2022; Smith et al. 2022].

While some workers had primary work locations in the mill, others, like maintenance workers, had no set work location and moved around the mill throughout their shift. Even those with fixed primary work locations often visited other parts of the mill. These factors made it challenging to capture every location where workers went in the mill over the seven-month period covered by the questionnaire (October 2022 through April 2023). Thus, we considered both primary locations and working in multiple locations in our analyses.

We found that workers with blastomycosis worked throughout the mill. However, workers in the Maintenance areas and the E1 Paper Mill had higher prevalences of blastomycosis compared to those who did not work in these areas. Our findings were consistent regardless of whether areas were primary work locations or secondary work locations, offices, or break areas. Sections of the Maintenance areas overlap with and are nearby E1 Paper Mill. There were Maintenance areas in the basement of E1 Paper Mill, and some of the small buildings used for maintenance lie between the river and E1 Paper Mill. Some of the Maintenance areas and the E1 Paper Mill were located on the west side of the mill nearest to the river. Moist soil and vegetation near riverbanks are associated with *Blastomyces* [Baumgardner et al. 2005; Klein 1987]. Our finding of the higher prevalence of blastomycosis in areas on the west side of the mill may also support that the original outdoor sources of *Blastomyces* are likely near the riverbanks or surrounding areas on the west side of the mill property. Also, there were several buildings between the E1 Paper Mill and the Woodyard, including the Pulp Mill and Boilers, which along with the Woodyard itself, did not have increased blastomycosis among workers.

Utility of the modified CSTE surveillance definition

We used the modified CSTE surveillance definition in sensitivity analyses to assess whether our primary findings remained consistent when workers with symptoms that were clinically compatible with blastomycosis were identified and added to the case count. Sensitivity analyses, like these, are helpful in assessing strength of associations, sources of bias, and confidence in results. Adding cases based on clinical compatibility for blastomycosis is consistent with methods used in blastomycosis surveillance [CSTE 2019]. Addition of cases based on clinical compatibility could include blastomycosis cases that were undiagnosed or unreported in the questionnaire. Using the modified CSTE surveillance definition, the percentage of all participants who met the case definition doubled from 20% to 43%. A 1986 blastomycosis outbreak in Wisconsin had a similar case prevalence. Of 95 children and adults (out of 98 people who were exposed) in a school group who were exposed to *Blastomyces* near a beaver pond, 51% screened positive for blastomycosis using symptom questionnaires, chest imaging, and laboratory testing [Klein et al. 1986].

The modified CSTE surveillance definition may have identified more workers than had blastomycosis, resulting in fewer or different associations between worker characteristics and blastomycosis. Misclassifying workers with other respiratory illnesses like a cold as having blastomycosis could overestimate blastomycosis among the mill population. Respiratory symptoms, such as cough and shortness of breath, and fever, were commonly reported by this mill workforce which might be attributed to higher rates of respiratory illnesses during the winter. Alternately, these symptoms may reflect contributions from wet environments, mold, and damp materials which are known predictors of respiratory symptoms and fever. Additionally, recall bias could over or underestimate the reporting of health symptoms potentially leading to misclassification of workers.

We did not identify new associations between worker characteristics with blastomycosis using the modified CSTE surveillance definition, except for factors related to PPE use. Rather, many associations between blastomycosis and worker characteristics were no longer significant, including sex, smoking status, tenure at the mill, history of diabetes, and working in the Maintenance areas. However, younger aged workers and workers working in E1 Paper Mill as their primary work location compared to all other places combined in the mill were still associated with a higher prevalence of blastomycosis.

Results using the modified CSTE surveillance definition are useful for testing associations based on a widely accepted blastomycosis case definition often used in surveillance; however, our conclusions rely primarily on results using the primary NIOSH case definition, as we know those workers were infected with *Blastomyces*. Use of the modified CSTE surveillance definition may have misclassified people as having blastomycosis when they did not. The window of symptom assessment (October 2022 to July 2023) was much longer in the medical survey than may be assessed for surveillance-identified cases of blastomycosis. Therefore, the modified CSTE surveillance definition was potentially oversensitive in including workers who were clinical compatibility for blastomycosis, but the consistency of higher prevalence of blastomycosis among younger aged workers and workers working in E1 Paper Mill is notable.

Timeline of exposure

Although exposures likely occurred over several weeks or months, some workers were on mill property for less than one day during the exposure window and developed blastomycosis. This suggests that short term or occasional exposure to areas with *Blastomyces* at the mill may have been sufficient to develop blastomycosis.

It can take weeks to months for blastomycosis symptoms to become apparent after exposure to the *Blastomyces* fungus. Identifying when someone was exposed to the fungus is difficult. Illness onset dates were reported from November 1, 2022 to May 15, 2023 among all participants and as early as December 14, 2022 to May 3, 2023 for case-patients on the health department list. We evaluated workers who spent limited time on site or who started work during the potential exposure window to help narrow the time when workers could have been exposed. Based on workers with limited visit dates to the mill, we believe the exposure window for blastomycosis was at least five weeks long, from December 20, 2022 to January 26, 2023. It is likely that workers were exposed before December 20, 2022 or after January 26, 2023. However, because of multiple exposure dates and the length of the incubation period from exposure to illness onset, it is difficult to conclude that the exposure window is larger using onsite dates from workers. The earliest cases in November 2022 may be outliers of early exposure, or they may indicate workers who experienced earlier exposures and/or shorter incubation periods between exposure and illness onset. Since blastomycosis illness onset dates were based on self-reported illness, response and recall bias were also possible.

We also estimated the exposure window using the epidemic curve (Figure B6) for all participants. The shape and time range of the epidemic curve suggests the likely period of *Blastomyces* exposure was mid-October to potentially mid-February. This assumes the incubation period ranged from 2 weeks to 3 months with an average of 6 weeks [Klein et al. 1986; Benedick et al. 1987; CDC 2024b]. This was a four-month period of exposure and was longer than the exposure window calculated for the health department case-patients which was a two-month window from early-December to early February. The length of the exposure window, and the symmetric shape of the epidemic curve, suggest there may have been continuous common sources of exposure at the mill. The *Blastomyces* exposure lasted over a longer period than would be expected in a point source outbreak with a short exposure like from a windstorm or soil disturbance that exposed workers to airborne *Blastomyces* spores. Since blastomycosis is not transmittable from person to person (except under very rare circumstances [CDC 2024b; López-Martínez and Méndéz-Tovar 2012], we did not expect to see an outbreak with waves of illness common to communicable disease outbreaks.

Exposure location and timing could vary between workers. We do not know if exposure was continuous over the potential exposure window or if there were intervals of increased exposure during the exposure window, or both. When comparing the illness onset dates by primary work location shown in Figure B7, some groups of workers may have had shorter exposure periods than others. For example, workers in Maintenance areas had a narrower onset window than workers in the Administrative Offices. It is possible that workers in the Administrative Offices had different routes of exposure to the *Blastomyces*, as opposed to a single mill-wide exposure source, and potentially a longer exposure window than workers in Maintenance areas. However, blastomycosis' potentially long incubation period makes

it difficult to say whether exposure was different for these groups or if the incubation period varied in these workers for unknown reasons.

Voluntary use of N95 filtering facepiece respirators

In March 2023, the mill began providing N95 respirators for voluntary use by workers to minimize potential exposure to *Blastomyces*. NIOSH questionnaire data showed there were cases of blastomycosis among workers who reported voluntary use of N95 respirators. However, most workers in the medical survey who reported wearing N95 respirators wore them rarely (42%) or some of the time (52%). Of the 49 workers who met the NIOSH case definition for blastomycosis and reported wearing N95 respirators, 35% reported rarely wearing N95 respirators, 55% reported wearing N95 respirators some of the time, and 10% reported wearing them most or all of the time. The epidemic curve suggests the likely period of *Blastomyces* exposure was mid-October 2022 to potentially mid-February 2023. If *Blastomyces* was present at this time, workers would have potentially been exposed before they began wearing N95 respirators. We do not have detailed information on when or where workers wore respirators or if N95 respirators were worn correctly with training or fit-testing.

Work location associated with blastomycosis

Using regression modeling we analyzed the risk of blastomycosis for all areas workers reported spending the most time from October 2022 through April 2023. Working in both the E1 Paper Mill and Maintenance areas had approximately double the risk of blastomycosis compared to working in all other parts of the mill combined. This suggests that people working in these locations may have had higher levels of exposure to the fungus at doses sufficient for causing infection.

The E1 Paper Mill was associated with increased blastomycosis risk. This area has both wet and dry paper making processes, where wet pulp is formed into dry paper. The E3 and E4 paper mills share similar papermaking processes like those in E1. However, working in the E3 and E4 paper mills was not associated with an increased risk of blastomycosis. In fact, working in the E3 Paper mill had a lower risk of blastomycosis than other areas of the mill. Maintenance areas were located throughout the mill, but some were in the basement of E1 Paper Mill. Exposure to pooling water indoors and visible mold was also noted in the E1 basement area. It is also worth noting that, compared to E3 and E4, the E1 paper mill is closer to the riverbanks, which could potentially be the original source of *Blastomyces*.

Environmental conditions associated with blastomycosis and other health symptoms

Reporting pooling water indoors at the mill was significantly associated with an increased risk of blastomycosis. We analyzed workers' daily exposure to the various environmental conditions from October 2022-April 2023. Analyzing daily exposure, unlike exposure on "some" days, helped to helped to verify that exposures happened consistently during the time that workers were on site. Daily exposure to pooling water indoors was associated with almost double the risk of blastomycosis. Water is integral to the paper making process and is found around the paper mill, particularly in the paper machine areas. Other environmental conditions at the mill were also associated with blastomycosis, including pooling water outdoors on mill property. However, when we assessed risk of blastomycosis for combinations of these exposures, pooling water indoors was the dominant risk factor for blastomycosis. This outweighed the effect of pooling water outdoors, as shown in Table C18.

Although pooling water indoors was associated with an increased risk of blastomycosis, it may or may not harbor *Blastomyces* fungus. Instead, it might indicate conditions that support growth of the fungus, like wet organic material, or encourage release of fungal spores. In outdoor settings, *Blastomyces* is thought to live in damp or decaying organic matter like leaves and wood [CDC 2024b; Klein et al. 1986,1987]. It is unknown whether it can live in liquid water in indoor environments [Jackson et al. 2021; Klein et al. 1987]. An experimental study examined characteristics of *Blastomyces* cultures grown in a laboratory. When they came in contact with water, spores were released. However, air currents did not release spores with light wind (0.82 meters/second) [McDonough 1979]. Conditions inside the mill, particularly where water pools indoors, may provide favorable conditions for fungal growth although more research is needed on this and whether wet wood, pulp, or other organic material indoors could foster *Blastomyces* growth.

Indoor dampness at work and exposure to mold are associated with adverse health outcomes; this includes asthma, rhinitis (i.e., nasal inflammation that can cause nasal congestion, sneezing, and an itchy, runny nose), respiratory infections, and eczema [NIOSH 2018]. Daily exposure to visible mold was marginally associated with blastomycosis, but we do not know if *Blastomyces* was in the visible mold reported by workers. It is not possible to identify specific fungal species, including *Blastomyces*, in visible mold without additional laboratory analyses. The mycelial or body form of *Blastomyces* grown in Sabouraud dextrose agar at 25°C in a laboratory appears white or tan with a cottony or wooly texture [University of Adelaide 2022]. However, unlike common molds that form visible colonies, *Blastomyces* does not typically grow in a way that makes it visible in nature. In addition, fungal spores released into the air by *Blastomyces*, which may cause respiratory infections, are too small to see without a microscope.

We initially considered that wood material delivered to the mill from regional sources may be associated with *Blastomyces* exposure. This is because decaying wood and organic matter are a known reservoir for the fungus. Few indoor areas of the mill dealt with non-chemically treated or superheated wood material, yet blastomycosis prevalence was highest among workers who worked primarily indoors. We did not observe associations between exposure to wood material (i.e., wet mulch or pulp; dry mulch or sawdust) and blastomycosis. While indoor environmental conditions may have contributed to increased blastomycosis risk at this mill, there is insufficient evidence that other specific paper milling processes like making pulp or processing wood into woodchips were responsible. However, pooling water indoors and visible mold were associated with respiratory health symptoms reported by workers who did not have blastomycosis, consistent with mold-related health symptoms observed in prior occupational literature.

We also observed associations between environmental conditions and non-respiratory illness-related health symptoms. Little is known about *Blastomyces* exposures in indoor environments. However, the same environmental conditions linked to health symptoms from general microbial exposures were also associated with cases of blastomycosis. This includes pooling water indoors and visible mold. In paper milling, respiratory symptoms are associated with paper dust exposure [Toren et al. 1994]. In this evaluation, associations between damp or wet mulch or pulp and respiratory symptoms not related to blastomycosis or another known illness indicates other possible occupational health issues at the paper mill. Addressing these indoor environmental quality conditions may help reduce blastomycosis risk

along with other adverse respiratory and systemic health symptoms associated with the mill environment.

Indoor exposure to and detection of *Blastomyces* at the mill

In this outbreak as defined by the local health department, blastomycosis occurred among mill workers, except for one local case in October 2022, suggesting an occupational exposure to *Blastomyces* at the mill. This was the largest known occupational outbreak of blastomycosis and only outbreak associated with a primarily indoor industrial setting. Most occupational cases of blastomycosis are associated with outdoor exposure to *Blastomyces*, so the potential for indoor exposure makes this outbreak unique. To our knowledge, there is no record of other large outbreaks at paper mills nor did other paper mills in the region see blastomycosis cases.

Although a total of 533 samples collected from both indoor and outdoor environments were analyzed using both culture-dependent methods (supplemented with MALDI-ToF) and culture-independent methods (PCR), environmental sampling did not identify *Blastomyces* anywhere on mill property. Therefore, we are unable to confirm the source of *Blastomyces,* or where it grew. We were also unable to confirm locations where exposures took place. However, negative results from the sample analysis do not rule out the presence of or exposure to *Blastomyces* in these environments, given the well-recognized historical difficulties of detecting the fungi in environmental samples [Anderson et al. 2019; Burgess et al. 2006; Jackson et al. 2021]. Although PCR-based methods have been recently developed and used, there is no standardized protocol, and the success rate of detection has varied widely but is generally very low [Anderson et al. 2019; Jackson et al. 2021].

To understand the limitations and capabilities of the assays used in this analysis, both PCR and culture methods were independently evaluated for their ability to detect *Blastomyces* spores. We employed the bicoid plasmid amplification PCR protocol to assess potential inhibitory factors in DNA extractions from environmental samples. Our results indicated that PCR inhibition did not significantly affect the detection of *Blastomyces* species or the ITS3/4 analysis in these samples. However, the LOD testing conducted during this investigation indicated that concentrations of 10^4 to 10^6 spores/mL would need to be present in a sample to detect this fungus. The PCR methods used have detected environmental *Blastomyces* at a low success rate in previous outbreak locations. Culture efficiency was approximately 25%, which was complicated by overgrowth from environmental molds. In view of the low sensitivities of the PCR and culture methods used in this investigation, it is possible that *Blastomyces* was present in some collected samples at levels below the LOD. Additionally, considering the 2-week to 3-month incubation period for blastomycosis after exposure, it is plausible that exposure to spores had already ceased by the time of the survey, meaning that the samples collected might not have contained *Blastomyces* spores. Additionally, *Blastomyces*-contaminated surfaces may have been overlooked because only a small portion of the mill's large surface area was covered by the surface samples. The very low success rate of environmental recovery of *Blastomyces*, both in this investigation and historically, suggests that there is still much we do not understand about the environmental sources of this pathogen.

The mill is in an endemic region for *Blastomyces* with nearby wooded areas and a riverway favorable for its growth. The original source of the *Blastomyces* is assumed to be from outside of the mill, such as the nearby riverbanks. Outbreaks of another fungal disease, coccidioidomycosis, occurred after fungal

spores were reportedly transported by wind causing outbreaks far from the original source [Flynn et al. 1979; Schneider et al. 1997]. If wind transport occurred in relation to the mill, it is likely that the source of *Blastomyces* was nearby the mill, most likely in the surrounding areas of the river on the west and southwest side. If the *Blastomyces* source was further away from the mill we would have expected to see others in the community be affected if it was a wind event. No cases of blastomycosis were reported for workers or patrons of the credit union adjacent to the mill. NIOSH is aware of a dog that was diagnosed with blastomycosis who had been in the county during the outbreak. Although not thought to transmit disease to humans, dogs are estimated to be infected with *Blastomyces* ten times more often than humans [Mazi et al. 2021].

If *Blastomyces* exposure only occurred outdoors, risk would likely be more evenly spread across the workforce or primarily concentrated among outdoor workers depending on where the exposures occured. We would not expect to see increased blastomycosis risk in certain areas of the mill or by indoor environmental conditions such as indoor pooling water. Outdoor exposure may also be more likely to result in community cases among non-mill workers. While our findings do not exclude potential outdoor exposure to *Blastomyces* at some point during the outbreak, our findings suggest there was possible indoor exposure either from spores entering from outside or *Blastomyces* surviving or growing inside the mill.

Blastomyces spores may have exposed workers in multiple places inside the mill. Assuming there was indoor exposure, where and how spores entered the mill to create an indoor source is unknown. Based on illness onset dates, *Blastomyces* exposure likely occurred from mid-October 2022 to potentially mid-February 2023. However, exposure may have persisted into May 2023 when the last blastomycosis cases were identified. Openings into the mill, unfiltered ventilation units, ventilation units with filtration levels inadequate for capturing fungal spores, and open doors and shipping bays could have been entry points for *Blastomyces*.

It is also difficult to pinpoint where exposure to *Blastomyces* occurred, particularly since it likely occurred over many months. *Blastomyces* creates an airborne respiratory hazard by releasing spores into the environment, so the original source(s) of *Blastomyces* spores may have been different from workers' locations. This is particularly true if spores were spread around the mill by air currents or wind indoors. Many workers traveled throughout the mill to perform their duties which increased potential for exposure.

In the medical survey questionnaire, we asked about non-mill-related exposures since outdoor activities and occupations, such as disturbing soil, pose a greater risk of blastomycosis in areas endemic for *Blastomyces* [McBride et al. 2017]. We observed outdoor activities were associated with reduced blastomycosis. This suggests outdoor activities, which are traditionally recognized as risk factors for blastomycosis, were protective against blastomycosis which is opposite of what would be predicted. We did not have information on other factors affecting relationships between non-mill-related exposures (e.g., self-reported health) and blastomycosis, so we did not explore these associations any further. Cases of blastomycosis during the outbreak were among mill workers (except for one non-mill related case in Fall 2022), suggesting that non-mill-related exposures were unlikely to have been related to the outbreak.

Interventions to decrease blastomycosis risk

Indoor exposure to *Blastomyces* is documented in other blastomycosis outbreaks [Hardin et al. 2003]; how long it can survive indoors is unknown. Therefore, we suggest continued vigilance in maintaining indoor environmental quality at the mill, educating the workforce about blastomycosis, and taking individual precautions, such as using respiratory protection, when necessary. Minimizing wet areas and pooling water, that foster microbial pathogens and mold growth, can reduce adverse health outcomes in indoor environments [McDonough et al. 1976; NIOSH 2012]. However, we recognize that water is integral to the paper making process, and eliminating wet areas may not be achievable in some areas.

Samples collected by the contracted industrial hygienist in March 2023 identified molds inside the mill and possible indoor fungal reservoirs. This implies conditions inside the mill might have been favorable for the survival or growth of fungi. The mill performed mold remediation and corrected water leaks after the contracted industrial hygienist's sampling was completed. Remediation was done in room 63-144 and the cafeteria area, including the breakroom next to the unused union office, during March and April 2023. In April 2023, multiple leak repairs were completed in the E1 area including the Coater area, Rack Room, and Maintenance Shop. Pooling water in the men's locker room was remediated by fixing a water heating unit that was leaking and repairing three leaking showers. In April and May 2023, water leaks were repaired in the administration building's small training room and kitchen.

Ventilation system maintenance is also important to filter outdoor air. Prior to April 2023, many of the makeup air ventilation units did not have filters installed, and recirculating air handling units were equipped with filters rated with a medium MERV rating of 8 or 9. Introducing unfiltered air could have increased the chances of *Blastomyces* spores entering the mill. Using MERV 8 or 9 filters in makeup air units would not have filtered out all small fungal spores. However, it could help keep the coils in the unit clean and improve conditioning of the air. *Blastomyces* spores are small, ranging from 2 to 10 micrometers [Al-Doory and DiSalvo 1992], so improved filtration in ventilation units may reduce spores from entering indoors. However, improved ventilation units would not prevent fungal spores from entering the mill through the shipping bay doors and other openings. During our walkthrough of the facility, we observed outdoor air being pulled or blown into the mill buildings through these openings. If exposure to *Blastomyces* occurred indoors at this mill, it may not have been entirely preventable.

In previous blastomycosis outbreaks, *Blastomyces* exposure commonly occurred outdoors. While we believe that *Blastomyces* exposure primarily occurred inside the mill during this outbreak, exposure outdoors on mill property is possible. Known pathways for infection include disturbing soil that contains *Blastomyces* [Mazi et al. 2021]. Although we did not identify outdoor sources through environmental sampling, *Blastomyces* potentially exists on mill property. The mill is located along a riverway, and there are wooded areas on the property, both are natural habitats for *Blastomyces*. Workers who perform activities that disturb soil or wood piles should be aware of the potential for *Blastomyces* exposure and take necessary precautions. This includes wearing appropriate respiratory protection. Workers with underlying medical conditions or taking medications that weaken the immune system may be at greater risk for developing severe blastomycosis.

In areas endemic for blastomycosis, and particularly when known blastomycosis cases occur, education on symptoms and early identification of blastomycosis are important for prompt care and treatment. Blastomycosis usually begins weeks or months after *Blastomyces* exposure which may delay recognizing and limiting exposure. Screening for *Blastomyces* exposure is not routine, so in this outbreak, surveillance and medical case finding identified that exposure occurred at the mill. A coordinated public health response with engagement from mill employees and managers, enhanced awareness of potential exposure to *Blastomyces* in endemic areas, awareness of blastomycosis health symptoms, and exposure controls likely reduced the number of cases and severity of blastomycosis in the workforce. Nevertheless, continued education of the workforce on blastomycosis is encouraged.

Conclusions

Although the mill is in an endemic region for *Blastomyces* exposure, this blastomycosis outbreak occurred among mill workers, suggesting an occupational exposure. While environmental sampling did not identify *Blastomyces* fungus on mill property, indoor mill working conditions were associated with increased blastomycosis risk. Workers with blastomycosis were identified throughout the mill, but more workers in the E1 Paper Mill and the Maintenance areas had blastomycosis compared to all other areas. This suggests that exposure to *Blastomyces* and risk of illness was greater in these areas. It is unclear if exposure occurred in one area or several areas. Exposure to indoor pooling water and visible mold at the mill, or the environment around these conditions, was also associated with increased risk of blastomycosis. The outbreak was considered over in July 2023. However, continuing blastomycosis prevention, including education on blastomycosis risk from potential exposure and symptoms, using PPE during high-risk activities, and improving indoor environmental quality at the mill through ventilation maintenance and housekeeping, is recommended. Some aspects of the mill potentially associated with *Blastomyces* exposure may not be modifiable, such as openings to the outdoors or using water in paper processing. Reducing damp and moldy indoor conditions may reduce blastomycosis risk and improve the general health of the workforce.

Attribution Statement

Section C: Tables

Table C1. Number of indoor samples by type and work areas collected during NIOSH environmental survey, April 2023.		
Sample type	Sampling location	Number of samples
Surface dust	Administration buildings	66
	Maintenance and shipping (basement)	28
	E1 Mill	52
	E3 Mill	45
	E4 Mill	46
	Fiberline	24
	Boiler/Turbine Maintenance	9
	Woodchip/Wood Waste & Coal	1
	HVAC system surfaces	73
Filter	HVAC system	66
Water	HVAC system	1
Total	–	411
Note: NIOSH=National Institute for Occupational Safety and Health; HVAC=heating, ventilation, and air conditioning.		

Table C2. Results of PCR and culturing for general fungi and *Blastomyces* for environmental samples.						
		PCR		Culture		PCR confirmation
Sample type	Number of samples analyzed	% positive for general fungi	% positive for *Blastomyces*	% positive for general fungal growth	Number of isolates sent back to MCRI for PCR confirmation	% positive for the isolates with PCR
Surface dust*	344	62	0	95	9	0
Soil/Bulk **	122	100	0	93	13†	0
Filter **	66	95	0	25	0	-
Water	1	100	0	0	0	-
Total	533	-	-	-	22	-

Note: PCR=polymerase chain reaction; MCRI=Marshfield Clinic Research Institute.
* Surface dust includes all samples from indoor and heating, ventilation, and air conditioning (HVAC) system surfaces.
** All samples were analyzed in duplicate.
† Of these, three isolates came from the same sample duplicate (two soil and one bulk material samples).

Table C3. Limit of detection of polymerase chain reaction (PCR)				
	BAD-1 LOD		ITS3/4 LOD	
Blastomyces species	spores/mL of sample	spores/PCR reaction	spores/mL of sample	spores/PCR reaction
B. dermatiditis				
Qiagen kit	$4x10^5$	1000	$2x10^3$	5
Roche kit	$4x10^5$	1000	$2x10^4$	50
B. gilchristii				
Qiagen kit	$2x10^6$	5000	$2x10^2$	0.5
Roche kit	$2x10^6$	5000	$2x10^4$	50
Note: mL=milliliter; BAD-1: *Blastomyces* adhesin-1; LOD: limit of detection; ITS3/4: internal transcribed spacer (ITS) primers.				

Table C4. Percent PCR inhibition by a subset of study samples by use of Bicoid plasmid.			
Sample Type	# of samples with Ct >29 or undetermined	Total Tested	% inhibited
Electrostatic Cloth	4	134	2.9
Direct Soil Analysis	2	16	12.5
Soil Slurries	2	22	9.1
Air Filters	0	16	0
Note: PCR=polymerase chain reaction; Ct = threshold of detection; %=percentage.			

Table C5. Demographic characteristics of participants.					
	All participants	Met the NIOSH case definition for blastomycosis		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 645††)	Yes (n = 162††)	No (n = 483††)	Yes (n = 300††)	No (n = 345††)
Age, years, mean (range)	45 (19–73)	42 (19–67)**	46 (19–73)**	44 (19–73)**	46 (20–69)**
Age, years, median	46	43	47	45	47
Sex, No. (Col. %)					
Male	537 (83)	142 (88)*	395 (82)*	251 (84)	286 (83)
Female	108 (17)	20 (12)*	88 (18)*	49 (16)	59 (17)
Race, No. (Col. %)					
Non-White or more than one race	38 (6)	‡	‡	13 (4)	25 (7)
White	596 (94)	‡	‡	277 (96)	319 (93)
Ethnicity, No. (Col. %)					
Hispanic, Latino, or of Spanish origin	10 (2)	‡	‡	‡	‡
Not Hispanic, Latino, or of Spanish origin	620 (98)	‡	‡	‡	‡
Smoking status, No. (Col. %)					
Never	420 (66)	94 (60)*	326 (68)*	188 (64)	232 (68)
Former	173 (27)	53 (34)*	120 (25)*	88 (30)	85 (25)
Current	45 (7)	10 (6)*	35 (7)*	19 (6)	26 (8)

Table C5 (continued). Demographic characteristics of participants.

	NIOSH medical survey participants§	Met the NIOSH case definition for blastomycosis$^{\pi}$		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 603††)	Yes (n = 120††)	No (n = 483††)	Yes (n = 258††)	No (n = 345††)
Residency in the Upper Peninsula of Michigan, No. (Col. %)					
Resident	586 (98)	‡	‡	‡	‡
Non-resident	12 (2)	‡	‡	‡	‡
Years of residency, mean (range)	37 (0–73)	36 (0–67)	37 (0–73)	37 (0–73)	37 (0–67)

πThe National Institute for Occupational Safety and Health (NIOSH) case definition required a person have either laboratory evidence for blastomycosis (including urine antigen tests below the limit of quantification but above the limit of detection) or self-report being diagnosed with blastomycosis and have worked at or visited the mill during October 1, 2022 – July 1, 2023.

†Workers met the modified Council of State and Territorial Epidemiologists (CSTE) surveillance definition for blastomycosis if they 1) met laboratory evidence for blastomycosis (including urine antigen tests below the limit of quantification but above the limit of detection), 2) self-report being diagnosed with blastomycosis, *or* 3) worked at or visited the mill between October 1, 2022, and July 1, 2023, *and* had health symptoms or medical findings since October 1, 2022, that met the NIOSH clinical compatibility criteria for blastomycosis regardless of laboratory evidence.

†† This is the maximum number of participants. Number of participants varies due to missing data.

‡ No. (%) omitted to avoid worker identification due to small numbers of responses (n<5).

§ Only NIOSH medical survey participants answered these questions (n=603). For case definition columns, percentages are out of 120 workers who met the case definition or 258 workers who met the modified CSTE surveillance definition. The 42 workers with blastomycosis from the state health department list of case-patients with blastomycosis were excluded.

*0.05≤p<0.1; **p<0.05; ***p<0.001 indicate level of statistical significance. T-tests were used for continuous variables, and Pearson's chi-squared tests were used for categorical variables to test differences by the case definition.

Table C6. Work characteristics of participants.					
	All participants	Met the NIOSH case definition for blastomycosis		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 645††)	Yes (n = 162††)	No (n = 483††)	Yes (n = 300††)	No (n = 345††)
Employment type across all jobs since Oct. 1, 2022, No. (Col. %)					
Ever an employee	603 (94)	147 (92)	456 (95)	278 (93)	325 (94)
Contractor/visitor only	39 (6)	13 (8)	26 (5)	20 (7)	19 (6)
Department for most recent job, No. (Row %)					
Administrative Offices (Administration, Technical, Environmental, Safety, Human Resources, Mill Controller, Purchasing)	95 (15)	20 (21)	75 (79)	42 (44)	53 (56)
Fiberline	46 (7)	14 (30)	32 (70)	26 (57)	20 (43)
Recovery & Utilization (R&U)	39 (6)	‡	‡	15 (38)	24 (62)
Maintenance & Engineering	154 (24)	41 (27)	113 (73)	74 (48)	80 (52)
Paper Machine	203 (32)	54 (27)	149 (73)	97 (48)	106 (52)
PS&D Finishing and Shipping	54 (8)	15 (28)	39 (72)	22 (41)	32 (59)
Wood & Coal Yard	34 (5)	6 (18)	28 (82)	13 (38)	21 (62)
Other	15 (2)	‡	‡	6 (40)	9 (60)

Table C6 (continued). Work characteristics of participants.					
	NIOSH medical survey participants§	Met the NIOSH case definition for blastomycosis		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 603††)	Yes (n = 120††)	No (n = 483††)	Yes (n = 258††)	No (n = 345††)
Crew for most recent job, No. (Col. %)					
A	74 (20)	18 (25)	56 (19)	37 (23)	37 (18)
B	63 (17)	10 (14)	53 (18)	30 (19)	33 (16)
C	64 (17)	10 (14)	54 (18)	20 (13)	44 (21)
D	75 (20)	13 (18)	62 (21)	31 (19)	44 (21)
Other	90 (25)	22 (30)	68 (23)	42 (26)	48 (23)
Years since starting work, mean (range)	12 (0-52)	10 (0-44)**	12 (0-52)**	12 (0-52)	12 (0-42)
Years since starting work, median	8	7 **	9 **	7	8

† The National Institute for Occupational Safety and Health (NIOSH) modified Council of State and Territorial Epidemiologists (CSTE) surveillance definition for blastomycosis included workers who had health symptoms and medical findings clinically compatible with blastomycosis. NIOSH modified the CSTE surveillance case definition by not requiring positive antigen tests to have a minimum level of quantification.
†† This is the maximum number of participants. Number of participants varies due to missing data.
‡ No. (%) omitted to avoid worker identification from the small numbers of responses (n<5).
§ Only NIOSH medical survey participants answered these questions (n=603). For case definition columns, percentages are out of 120 workers who met the case definition or 258 workers who met the modified CSTE surveillance definition. The 42 workers with blastomycosis from the state health department list of case-patients with blastomycosis were excluded.
* p<0.1; **p<0.05; ***p<0.001 indicate statistically significant values. T-tests and Wilcoxon rank-sum tests were used for continuous variables, and Pearson's chi-squared tests were used for categorical variables to test differences by the case definition.

Table C7. Personal protective equipment (PPE) use since October 1, 2022 among NIOSH medical survey participants (N=603).					
	NIOSH medical survey participants§	Met the NIOSH case definition for blastomycosis		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 603††)	Yes (n = 120††)	No (n = 483††)	Yes (n=258)	No (n = 345††)
Wore a respirator of facemask anytime during work at the mill, No. (%)	281 (47)	52 (44)	229 (48)	130 (51)	151 (44)
Type of facemask or respirator worn §§, No. (%)					
N95® filtering facepiece respirator	246 (41)	49 (41)	197 (41)	114 (44)	132 (38)
Half-face respirator	26 (4)	7 (6)	19 (4)	16 (6)**	10 (3)**
Full-face respirator	29 (5)	2 (2)*	27 (6)*	13 (5)	16 (5)
SCBA‡‡	29 (5)	5 (4)	24 (5)	14 (5)	15 (4)
Non-respirator facemask	9 (1)	2 (2)	7 (1)	4 (2)	5 (1)
Other	9 (1)	2 (2)	7 (1)	4 (2)	5 (1)
Primary reasons for PPE use, §§ No. (Col. %)					
Wood or soil dust exposure	111 (18)	22 (18)	89 (18)	54 (21)	57 (17)
Other dust exposure, not from wood and soil	131 (22)	26 (22)	105 (22)	62 (24)	69 (20)
Chemical exposure	58 (10)	9 (8)	49 (10)	27 (11)	31 (9)
Emergency response	22 (4)	5 (4)	17 (4)	10 (4)	12 (3)
Preventing infectious illnesses	71 (12)	15 (13)	56 (12)	38 (15)**	33 (10)**
Other	20 (3)	3 (3)	17 (4)	8 (3)	12 (3)
How often N95 was used,¶ No. (Col. %)					
Rarely	103 (42)	17 (35)	86 (44)	43 (38)	60 (45)
Some of the time	127 (52)	27 (55)	100 (51)	63 (55)	64 (49)
Most or all of the time	16 (7)	5 (10)	11 (6)	8 (7)	8 (6)

Table C7 (continued). Personal protective equipment (PPE) use since October 1, 2022 among NIOSH medical survey participants (N=603).

Reason for N95 use,¶ No. (Col. %)					
Required	16 (7)	2 (4)	14 (7)	5 (4)	11 (8)
Voluntary	201 (82)	41 (85)	160 (82)	92 (81)	109 (83)
Both	27 (11)	5 (10)	22 (11)	16 (14)	11 (8)
Frequency of N95¶ replacement, No. (Col. %)					
Never	8 (3)	0 (0)	8 (4)	2 (2)	6 (5)
After multiple days	36 (15)	7 (14)	29 (15)	15 (13)	21 (16)
Once per day	142 (58)	32 (65)	110 (56)	73 (65)	69 (52)
Multiple times per day	59 (24)	10 (20)	49 (25)	23 (20)	36 (27)

† The National Institute for Occupational Safety and Health (NIOSH) modified Council of State and Territorial Epidemiologists (CSTE) surveillance definition for blastomycosis included workers who had health symptoms and medical findings clinically compatible with blastomycosis. NIOSH modified the CSTE surveillance case definition by not requiring positive antigen tests to have a minimum level of quantification.
†† This is the maximum number of participants. Number of participants varies due to missing data.
‡ No. (%) omitted to avoid worker identification from the small numbers of responses (n<5).
§ Only NIOSH medical survey participants answered these questions (n=603). For case definition columns, percentages are out of 120 workers who met the case definition or 258 workers who met the modified CSTE surveillance definition. The 42 workers with blastomycosis from the state health department list of case-patients with blastomycosis were excluded.
*p<0.1; **p<0.05; ***p<0.001 indicate statistically significant values. T-tests were used for continuous variables, and Pearson's chi-squared tests were used for categorical variables to test differences by the case definition.
‡‡ SCBA = self-contained breathing apparatus.
§§ For type of facemask or respirator worn and primary reason PPE used, the participant could select more than one option.
¶The denominator for these rows comes from those who reported wearing an N95® filtering facepiece respirator (n=246).

Table C8. Prevalence and unadjusted prevalence ratios (PR) of blastomycosis by work location at the mill for all participants (n=645) using the NIOSH case definition for blastomycosis

	Primary work location of current or most recent job		Ever worked in location for all jobs since October 1, 2022†	
Mill Location	Prevalence of blastomycosis No. (%)‡	PR (95% CI)§	Prevalence of blastomycosis No. (%)‡	PR (95% CI)§
Maintenance	22 (40)	**1.72 (1.21, 2.46)**	38 (37)	**1.64 (1.21, 2.20)**
E1 Paper Mill	35 (35)	**1.56 (1.14, 2.12)**	55 (31)	**1.37 (1.04, 1.81)**
PS&D Finishing and Shipping	17 (29)	1.21 (0.79, 1.85)	25 (26)	1.04 (0.72, 1.51)
Administrative Offices	17 (28)	1.17 (0.76, 1.79)	22 (22)	0.85 (0.57, 1.27)
E4 Paper Mill	18 (19)	0.75 (0.48, 1.16)	36 (22)	0.84 (0.60, 1.16)
Pulp Mill	6 (22)	0.90 (0.44, 1.84)	12 (18)	0.72 (0.42, 1.22)
Woodyard	9 (20)	0.78 (0.43, 1.43)	23 (25)	1.00 (0.68, 1.47)
E3 Paper Mill	15 (17)	0.68 (0.42, 1.10)	35 (21)	0.82 (0.59, 1.14)
Boilers	7 (15)	0.59 (0.29, 1.18)	14 (18)	0.72 (0.44, 1.18)
Engineering Office	<5 (12)	0.46 (0.16, 1.34)	10 (19)	0.75 (0.42, 1.33)
Outside Utilities	<5 (17)	0.67	5 (15)	0.60 (0.27, 1.37)
Pulp Make Down	<5 (30)	1.22	5 (19)	0.74 (0.33, 1.66)
Mechanical Pulping	<5 (20)	0.81	<5 (14)	0.55 (0.22, 1.38)
Receiving and Storeroom	<5 (18)	0.73	<5 (22)	0.90
Parking	-	-	0 (0)	-

Note: CI= confidence interval; PR=prevalence ratio. Some locations do not have CIs since Pearson's chi-squared tests were unstable due to the small number of workers in that area. Bolded PR (CI) were statistically significant at $p<0.05$. No workers reported working in the parking areas for their primary work location.

† This included working in a location as a primary work location, secondary work location, office, or break room for any job at the mill since October 1, 2022.

‡ Four workers had missing work locations.

§ PRs are the ratio of the proportion of workers with blastomycosis among of workers who worked in the location versus the proportion of workers with blastomycosis among workers who did not work in that location.

Table C9. Health information for participants since October 1, 2022.					
	All participants	Met the NIOSH case definition for blastomycosis		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 645††)	Yes (n = 162††)	No (n = 483††)	Yes (n = 300††)	No (n = 345††)
Health symptoms and medical findings, No. (%)					
Cough	437 (68)	143 (90)***	294 (61)***	268 (90)	169 (49)
Fever or chills or night sweats	240 (37)	118 (73)***	122 (25)***	194 (65)	46 (13)
Shortness of breath, or working harder than normal to breathe	224 (35)	123 (76)***	101 (21)***	205 (69)	19 (6)
Poor appetite or unexpected weight loss	71 (11)	53 (35)***	18 (4)***	70 (24)	1 (0.3)
Muscle aches or pain	183 (29)	100 (64)***	83 (17)***	158 (54)	25 (7)
Fatigue or extreme tiredness	232 (36)	120 (76)***	112 (23)***	201 (68)	31 (9)
Abnormal lung findings on chest imaging, like on an x-ray or CT scan	118 (18)	100 (63)***	18 (4)***	116 (39)	2 (0.6)
Joint pain or bone pain	110 (18)	45 (38)***	65 (14)***	87 (34)	23 (7)
Skin lesions with no known cause, such as raised bumps, blisters, or ulcers	28 (5)	10 (8)**	18 (4)**	27 (11)	1 (0.3)
Had any health symptoms or medical findings potentially related to blastomycosis, No. (Col. %)					
Yes	461 (71)	155 (96)	306 (63)	293 (98)	168 (49)
No (i.e., asymptomatic)	184 (29)	7 (4)	177 (37)	7 (2)	177 (51)
Hospitalized for blastomycosis, No. (Col. %)					
Yes	18 (3)	18 (12)	0 (0)	18 (6)	0 (0)
No	611 (97)	133 (88)	478 (100)	270 (94)	341 (100)

Table C9 (continued). Health information for participants since October 1, 2022.

	NIOSH medical survey participants§	Met the NIOSH case definition for blastomycosis		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 603††)	Yes (n = 120††)	No (n = 483††)	Yes (n = 258††)	No (n = 345††)
Self-reported blastomycosis diagnosis, No. (Col. %)					
Yes	92 (15)	92 (77)	0 (0)	92 (36)	0 (0)
No	505 (85)	27 (23)	478 (100)	164 (64)	341 (100)
NIOSH medical survey urine antigen test result, No. (Col. %)					
Positive	52 (9)	52 (54)	0 (0)	52 (22)	0 (0)
Negative	521 (91)	45 (46)	476 (100)	181 (78)	340 (100)
Respiratory illness, No. (%)					
Cold	334 (56)	57 (48)*	277 (58)*	161 (63)	173 (50)
Influenza, or respiratory flu	42 (7)	6 (5)	36 (8)	19 (7)	23 (7)
COVID-19	61 (10)	14 (12)	47 (10)	27 (11)	34 (10)
Respiratory Syncytial Virus (RSV)	‡	‡	‡	‡	‡
Bronchitis	9 (2)	‡	‡	‡	‡
Pneumonia	35 (6)	26 (22)***	9 (2)***	35 (14)***	0 (0)***
Previous blastomycosis illness before October 1, 2022, No. (Col. %)					
Yes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
No	596 (100)	118 (100)	478 (100)	255 (100)	341 (100)

† The National Institute for Occupational Safety and Health (NIOSH) modified Council of State and Territorial Epidemiologists (CSTE) surveillance definition for blastomycosis included workers who had health symptoms and medical findings clinically compatible with blastomycosis. NIOSH modified the CSTE surveillance case definition by not requiring positive antigen tests to have a minimum level of quantification.

†† This is the maximum number of participants. Number of participants varies due to missing data.

‡ No. (%) omitted to avoid worker identification from the small numbers of responses (n<5).

§ Only NIOSH medical survey participants answered these questions (n=603). For case definition columns, percentages are out of 120 workers who met the case definition or 258 workers who met the modified CSTE surveillance definition. The 42 workers with blastomycosis from the state health department list of case-patients with blastomycosis were excluded.

*p<0.1; **p<0.05; ***p<0.001 indicate statistically significant values. T-tests were used for continuous variables, and Pearson's chi-squared tests were used for categorical variables to test differences by the case definition.

‡‡ NIOSH clinical compatibility criteria was defined as reporting at least two clinically compatible health symptoms that started within two weeks of each other, or one medical finding, since October 1, 2022.

§§ Medical findings also included inflammation of the brain, such as meningitis or encephalitis, or a focal brain lesion; abscess, granuloma, or lesions in other parts of your body besides your skin; and bone or joint abnormality, such as a bone infection or a pathologic fracture. Results were not reported for these findings due to small numbers of responses.

Table C10. Health symptoms for NIOSH medical survey participants who underwent urine antigen testing (n=573).		
	NIOSH urine antigen test result	
	Positive (n = 52†)	Negative (n = 521†)
Health symptoms, No. (%)		
Cough	40 (77)**	287 (55)**
Fever or chills or night sweats	33 (63)***	114 (22)***
Shortness of breath, or working harder than normal to breathe	30 (58)***	124 (24)***
Poor appetite or unexpected weight loss	13 (25)***	24 (5)***
Muscle aches or pain	24 (46)***	85(16)***
Joint pain or bone pain	19 (37)***	59 (11)***
Fatigue or extreme tiredness	29 (56)***	120 (23)***
Medical findings§, No. (%)		
Abnormal lung findings on chest imaging, like on an x-ray or CT scan	20 (38)***	48 (9)***
Skin lesions with no known cause, such as raised bumps, blisters, or ulcers	5 (10)*	18 (3)**
Self-reported blastomycosis diagnosis, No. (Col. %)		
Yes	26 (50)	44 (9)
No	26 (50)	472 (91)
Had any health symptoms or medical findings potentially related to blastomycosis, No. (Col. %)		
Yes	48 (92)	344 (66)
No (i.e., asymptomatic)	4 (8)	177 (34)
Number of health symptoms potentially related to blastomycosis, No. (Col. %)		
0	5 (10)	179 (34)
1	5 (10)	151 (29)
2 or more	42 (81)	189 (36)
Number of medical findings potentially related to blastomycosis, No. (Col. %)		
0	28 (54)	451 (87)
1 or more	24 (46)	68 (13)

† This is the maximum number of participants. Number of participants varies due to missing data.
§ Medical findings also included inflammation of the brain, such as meningitis or encephalitis, or a focal brain lesion; abscess, granuloma, or lesions in other parts of your body besides your skin; and bone or joint abnormality, such as a bone infection or a pathologic fracture. Results were not reported for these findings due to small numbers of responses. Symptoms and medical findings were reported since October 1, 2022, excluding those which occurred within two weeks of a self-reported COVID-19, influenza, or respiratory syncytial virus illness.
*p<0.1; **p<0.05; ***p<0.001 indicate statistically significant values. T-tests were used for continuous variables, and Pearson's chi-squared tests were used for categorical variables to test differences by the case definition.
‡‡ The National Institute for Occupational Safety and Health (NIOSH) clinical compatibility criteria was defined as reporting at least two health symptoms starting within two weeks of each other, or one medical finding, since October 1, 2022, that were clinically compatible with blastomycosis.

Table C11. Healthcare provider-diagnosed medical conditions for NIOSH medical survey participants.					
	NIOSH medical survey participants§	Met the NIOSH case definition for blastomycosis		Met the modified CSTE surveillance definition for blastomycosis†	
	(n = 603††)	Yes (n = 120††)	No (n = 483††)	Yes (n = 258††)	No (n = 345††)
Medical condition, No. (%)					
COPD (Chronic obstructive pulmonary disease), emphysema, or chronic bronchitis	‡	‡	‡	‡	‡
Asthma	68 (11)	13 (11)	55 (11)	30 (12)	38 (11)
Cardiovascular disease	26 (4)	7 (6)	19 (4)	13 (5)	13 (4)
Diabetes	29 (5)	8 (7)	21 (4)	13 (5)	16 (5)
Thyroid disease	20 (3)	‡	‡	5 (2)	15 (4)
Autoimmune disease like rheumatoid arthritis, lupus, or scleroderma	26 (4)	5 (4)	21 (4)	13 (5)	13 (4)
Taking oral steroids, chemotherapy, or other medications that weaken immune system	21 (4)	5 (4)	16 (3)	13 (5)	8 (2)
Organ transplant	‡	‡	‡	‡	‡

†The National Institute for Occupational Safety and Health (NIOSH) modified Council of State and Territorial Epidemiologists (CSTE) surveillance definition for blastomycosis included workers who had health symptoms and medical findings clinically compatible with blastomycosis. NIOSH modified the CSTE surveillance case definition by not requiring positive antigen tests to have a minimum level of quantification.
†† This is the maximum number of participants. Number of participants varies due to missing data.
‡ No. (%) omitted to avoid worker identification from the small numbers of responses (n<5).
§ Only NIOSH medical survey participants answered these questions (n=603). For case definition columns, percentages are out of 120 workers who met the case definition or 258 workers who met the modified CSTE surveillance definition. The 42 workers with blastomycosis from the state health department list of case-patients with blastomycosis were excluded.
*p<0.1; **p<0.05; ***p<0.001 indicate statistically significant values. T-tests were used for continuous variables, and Pearson's chi-squared tests were used for categorical variables to test differences by the case definition.

Table C12. Prevalence and unadjusted prevalence ratios (PR) of blastomycosis by work location at the mill for all participants (n=645) using the modified Council of State and Territorial Epidemiologists (CSTE) surveillance definition for blastomycosis.

	Primary work location of current or most recent job		Ever worked in location for all jobs since October 1, 2022†	
Mill Location	Prevalence of blastomycosis No. (%)‡	PR (95% CI)§	Prevalence of blastomycosis No. (%)‡	PR (95% CI)§
Maintenance	29 (53)	1.16 (0.89, 1.51)	53 (51)	1.13 (0.91, 1.39)
E1 Paper Mill	56 (57)	**1.28 (1.05, 1.56)**	92 (51)	1.16 (0.97, 1.38)
PS&D Finishing and Shipping	24 (41)	0.89 (0.65, 1.22)	44 (45)	0.97 (0.76, 1.23)
Administrative Offices	30 (50)	1.09 (0.84, 1.43)	47 (46)	1.00 (0.79, 1.25)
E4 Paper Mill	40 (43)	0.91 (0.71, 1.17)	74 (44)	0.95 (0.78, 1.15)
Pulp Mill	16 (59)	1.30 (0.94, 1.80)	30 (45)	0.98 (0.74, 1.30)
Woodyard	18 (39)	0.84 (0.58, 1.21)	43 (46)	1.00 (0.79, 1.27)
E3 Paper Mill	32 (37)	0.78 (0.59, 1.04)	67 (41)	0.84 (0.69, 1.04)
Boilers	23 (49)	1.06 (0.79, 1.44)	35 (46)	1.00 (0.77, 1.29)
Engineering Office	8 (31)	0.66 (0.37, 1.18)	23 (43)	0.93 (0.68, 1.29)
Outside Utilities	6 (50)	1.08 (0.61, 1.92)	17 (52)	1.12 (0.80, 1.58)
Pulp Make Down	6 (60)	1.31	12 (44)	0.96 (0.62, 1.48)
Mechanical Pulping	‡‡	0.65	10 (34)	0.74 (0.44, 1.23)
Receiving and Storeroom	5 (45)	0.98 (0.51, 1.89)	8 (44)	0.96 (0.57, 1.62)
Parking	0 (0)	-	‡‡	0.31

Note: CI=confidence interval; PR=prevalence ratio. Some locations do not have CIs since Pearson's chi-squared tests were unstable due to the small number of workers in that area. Bolded PR (CI) were statistically significant at $p<0.05$.

† This included working in a location as a primary work location, secondary work location, office, or break room for any job at the mill since October 1, 2022.

‡ Four workers had missing work locations.

§ PRs are the ratio of the proportion of workers with blastomycosis among of workers who worked in the location versus the proportion of workers with blastomycosis among workers who did not work in that location.

‡‡ No. (%) omitted to avoid worker identification from the small numbers of responses (n<5).

Table C13. Prevalence ratio (PR) and 95% confidence intervals (CI) for the associations between *primary* work location and blastomycosis at the mill from October 2022–April 2023*among NIOSH medical survey participants (n=603).

Primary work location for current or most recent job*	Unadjusted model		Adjusted model†	
	PR	95% CI	PR	95% CI
Administrative offices	1.38	(0.87, 2.20)	1.47	(0.91, 2.37)
Boilers	0.70	(0.33, 1.45)	0.69	(0.33, 1.41)
E1 Paper Mill	1.46	(0.99, 2.16)	1.47	(0.99, 2.17)
E3 paper mill	0.66	(0.37, 1.19)	0.65	(0.36, 1.18)
E4 paper mill	0.98	(0.62, 1.55)	0.99	(0.63, 1.57)
Engineering offices	0.62	(0.22, 1.70)	0.48	(0.14, 1.67)
Maintenance areas	1.34	(0.79, 2.27)	1.39	(0.81, 2.38)
Outside utilities	0.89	(0.27, 2.94)	0.88	(0.27, 2.85)
PSD Finishing and shipping	1.36	(0.85, 2.20)	1.39	(0.86, 2.27)
Pulp make down (pulp processing)	1.19	(0.38, 3.77)	1.25	(0.40, 3.92)
Pulp mill (chemical pulping)	1.03	(0.48, 2.21)	1.02	(0.47, 2.20)
Mechanical pulping	1.07	(0.33, 3.45)	1.04	(0.33, 3.32)
Receiving and storeroom	0.97	(0.30, 3.18)	1.15	(0.37, 3.60)
Woodyard	0.85	(0.44, 1.66)	0.85	(0.44, 1.64)

* Reference is the overall mean of blastomycosis for all areas of the mill.
† Adjusted for tenure and sex.
Note: The prevalence ratio (PR) is the ratio of the prevalence of blastomycosis among workers who worked in the location versus the prevalence of blastomycosis among all workers in the mill

Table C14. Prevalence ratios (PR) and 95% confidence intervals (CI) of blastomycosis for all reported work locations from October 2022–April 2023* among NIOSH meidcal survey participants (n=603)

Work location (worked in location versus did not work in location)	Unadjusted models		Adjusted models†	
	PR	95% CI	PR	95% CI
Administrative offices	0.96	(0.62, 1.49)	0.97	(0.62, 1.54)
Boilers	0.79	(0.46, 1.37)	0.78	(0.45, 1.34)
E1 Paper Mill	**1.41**	**(1.01, 1.96)**	**1.40**	**(1.00, 1.95)**
E3 paper mill	0.70	(0.46, 1.06)	0.67	(0.44, 1.03)
E4 paper mill	1.02	(0.71, 1.45)	0.97	(0.68, 1.40)
Engineering offices	0.94	(0.53, 1.69)	0.90	(0.48, 1.67)
Maintenance areas	**1.48**	**(1.01, 2.17)**	**1.53**	**(1.04, 2.25)**
Outside utilities	0.75	(0.33, 1.71)	0.72	(0.32, 1.62)
PSD Finishing and shipping	1.20	(0.80, 1.80)	1.19	(0.78, 1.80)
Pulp make down (pulp processing)	0.77	(0.31, 1.91)	0.81	(0.33, 2.03)
Pulp mill (chemical pulping)	0.77	(0.42, 1.39)	0.76	(0.42, 1.40)
Mechanical pulping	0.68	(0.27, 1.72)	0.73	(0.29, 1.83)
Receiving and storeroom	1.12	(0.47, 2.70)	1.24	(0.52, 2.97)
Woodyard	1.09	(0.70, 1.68)	1.08	(0.69, 1.68)

Note: Statistically significant prevalence ratios and confidence intervals are in bold.
* All reported work locations included a primary work location, up to three secondary work locations, a break room/lunchroom/shack location, and a personal office or desk location, if applicable, for each job held from October 2022 through April 2023.
† Adjusted for tenure and sex.

Table C15. Prevalence ratio (PR) and 95% confidence intervals (CI) of blastomycosis for ever working in E1 Paper Mill and/or the Maintenance areas during October 2022–April 2023 among NIOSH medical survey participants (n=603)

Conditions		**Unadjusted model**			**Adjusted model***	
Worked in E1 Paper Mill	**Worked in Maintenance areas**	n	PR	95% CI	PR	95% CI
+	**+**	38	**2.11**	**(1.32, 3.37)**	**2.17**	**(1.35, 3.49)**
+	**-**	129	1.24	(0.84, 1.84)	1.23	(0.83, 1.83)
-	**+**	53	1.19	(0.67, 2.10)	1.23	(0.69, 2.19)
-	**-**	383	Ref	Ref	Ref	Ref

Note: n=number of workers; * Adjusted for tenure and sex; "+" = reported working in location; "-" = did not report working in location; Ref = reference group.
Statistically significant prevalence ratios and confidence intervals are bolded.

Table C16. Environmental exposures since October 1, 2022, reported by NIOSH medical survey participants.					
	NIOSH medical survey participants	**Met the NIOSH case definition for blastomycosis**		**Met the modified CSTE surveillance definition for blastomycosis †**	
	n = 603††	Yes n = 120††	No n = 483††	Yes n = 258††	No n = 345††
Daily exposure to environmental conditions (Yes vs. no), No. (%)					
Damp or wet mulch or pulp	128 (21)	29 (24)	99 (21)	64 (25)*	64 (19)*
Dry mulch or sawdust	84 (14)	14 (12)	70 (15)	35 (14)	49 (14)
Wet soil	38 (6)	8 (7)	30 (6)	16 (6)	22 (6)
Standing pools of water outdoors on mill property	48 (8)	14 (12)*	34 (7)*	25 (10)	23 (7)
Standing pools of water indoors on mill property	102 (17)	32 (27)**	70 (15)**	59 (23)***	43 (13)***
Wind gusts indoors or blowing air while inside the mill	201 (33)	48 (40)*	153 (32)*	103 (40)**	98 (29)**
Visible mold on surfaces, walls, or ceilings	128 (21)	34 (28)**	94 (20)**	72 (28)***	56 (16)***
Passed through the front turnstile daily vs. not every day, No. (%)	564 (94)	117 (98)**	447 (93)**	245 (96)	319 (93)
Walked through administrative offices daily vs. not every day, No. (%)	190 (32)	40 (34)	150 (31)	86 (34)	104 (31)
Parking lot use, No. (%)					
Lot A and B	320 (54)	69 (58)	251 (53)	139 (54)	181 (53)
Always Lot A	243 (41)	44 (37)	199 (42)	99 (39)	144 (43)
Always Lot B	16 (3)	‡	‡	10 (4)	6 (2)
Contractor Lot	16 (3)	‡	‡	8 (3)	8 (2)

Table C16 (continued)**.** Environmental exposures since October 1, 2022, reported by NIOSH medical survey participants

† The modified CSTE surveillance definition for blastomycosis included workers who had health symptoms and medical findings that were clinically compatible with blastomycosis in addition to workers who met the NIOSH case definition criteria.

†† This is the maximum number of respondents. Number of respondents varies due to missing data.

‡ No. (%) omitted to avoid worker identification from the small numbers of responses (n<5).

* p<0.10; **p<0.05; ***p<0.001. Chi-square or Fisher's exact tests were used for categorical variables to test unadjusted differences by the case definition.

Table C17. Prevalence ratios (PR) and 95% confidence intervals (CI) of blastomycosis for daily exposure to environmental conditions among NIOSH medical survey participants (n=603).

Daily exposure to environmental conditions (exposed to condition versus not exposed)	**Unadjusted models**		**Adjusted model***	
	PR	95% CI	PR	95% CI
Standing pools of water indoors	**1.78**	**(1.26, 2.51)**	**1.79**	**(1.25, 2.57)**
Standing pools of water outdoors	1.52	(0.95, 2.44)	**1.82**	**(1.11, 2.98)**
Wind gusts indoors or blowing air inside	1.33	(0.96, 1.83)	1.29	(0.92, 1.80)
Visible mold on surfaces, walls, or ceilings	**1.45**	**(1.03, 2.05)**	1.43	(0.99, 2.08)
Damp or wet pulp or mulch	1.18	(0.81, 1.70)	1.24	(0.83, 1.85)
Dry mulch or saw dust	0.81	(0.49, 1.35)	0.80	(0.43, 1.47)
Wet soil	1.06	(0.56, 2.00)	1.12	(0.57, 2.19)

Note: Statistically significant prevalence ratios and confidence intervals are in bold.
* Adjusted for tenure, sex, and primary work location.

Table C18. Prevalence ratio (PR) and 95% confidence intervals (CI) of blastomycosis for daily exposure to pooling water indoors and pooling water outdoors among NIOSH medical survey participants (n=603).

Conditions			**Unadjusted model**		**Adjusted model***	
Pooling water indoors daily	**Pooling water outdoors daily**	n	PR	95% CI	PR	95% CI
+	**+**	25	**2.06**	**(1.18, 3.61)**	**2.53**	**(1.42, 4.49)**
+	**-**	77	**1.71**	**(1.16, 2.54)**	**1.66**	**(1.10, 2.51)**
-	**+**	23	1.25	(0.56, 2.77)	1.46	(0.64, 3.29)
-	**-**	476	Ref	Ref	Ref	Ref

Note: n=number of workers; "+" = exposed; "-" = not exposed; Ref = reference group. Statistically significant prevalence ratios and confidence intervals are bolded.
* Adjusted for tenure, sex, and primary work location.

Table C19. Non-mill-related exposures since October 1, 2022, reported by NIOSH medical survey participants.					
	NIOSH medical survey participants	**Met the NIOSH case definition for blastomycosis**		**Met the modified CSTE surveillance definition for blastomycosis†**	
	n = 603††	Yes n = 120††	No n = 483††	Yes n = 258††	No n = 345††
Non-mill-related exposures and activities, No. (%)					
Gardening, mulching, composting, or lawn care	311 (52)	53 (45)*	258 (54)*	120 (47)**	191 (56)**
Construction work vs. not	91 (15)	6 (5)***	85 (18)***	20 (8)***	71 (21)***
Hunting	307 (51)	51 (44)*	256 (53)*	125 (49)	182 (53)
Hiking	240 (40)	27 (23)***	213 (44)***	91 (36)*	149 (44)*
Fishing from shore	92 (15)	9 (8)**	83 (17)**	28 (11)**	64 (19)**
Camping or visiting a cabin	241 (40)	36 (31)**	205 (43)**	99 (39)	142 (42)
Lived with dogs	426 (71)	84 (71)	342 (71)	185 (72)	241 (71)
Lived with dogs diagnosed with blastomycosis	5 (1)	0 (0)	5 (1)	‡	‡
Chopped wood or built wood fires	343 (57)	50 (42)***	293 (61)***	127 (50)**	216 (63)**
Farming	51 (9)	7 (6)	44 (9)	14 (5)**	37 (11)**

† The modified CSTE surveillance definition for blastomycosis included workers who had health symptoms and medical findings that were clinically compatible with blastomycosis in addition to workers who met the NIOSH case definition criteria.

†† This is the maximum number of respondents. Number of respondents varies due to missing data.

‡ No. (%) omitted to avoid worker identification from the small numbers of responses (n<5).

* p<0.10; **p<0.05; ***p<0.001. Chi-square or Fisher's exact tests were used for categorical variables to test unadjusted differences by the case definition.

Table C20. Adjusted prevalence ratios (PR) and 95% confidence intervals (CI) for the associations between environmental conditions and health symptoms not related to blastomycosis, COVID-19, RSV, or flu reported since October 1, 2022, by NIOSH medical survey participants (n=603).

Daily exposure to environmental conditions (vs. not every day)	**Respiratory health symptoms** (Cough; Shortness of breath, or working harder than normal to breathe)		**Systemic health symptoms** (Fever or chills or night sweats; Poor appetite or unexpected weight loss; Muscle aches or pain; Joint or bone pain; Fatigue or extreme tiredness)		**Any health symptoms** (Respiratory or systemic)	
	PR	95% CI	PR	95% CI	PR	95% CI
Damp or wet mulch or pulp	**1.34**	**(1.13, 1.58)**	1.20	(0.93, 1.56)	**1.22**	**(1.06, 1.41)**
Dry mulch or sawdust	1.08	(0.87, 1.34)	1.18	(0.87, 1.59)	1.06	(0.88, 1.27)
Wet soil	0.93	(0.66, 1.32)	1.10	(0.71, 1.71)	1.02	(0.78, 1.34)
Standing pools of water outdoors on mill property	1.08	(0.82, 1.43)	1.13	(0.77, 1.66)	1.06	(0.84, 1.33)
Standing pools of water indoors on mill property	**1.24**	**(1.03, 1.49)**	1.11	(0.84, 1.49)	1.12	(0.95, 1.32)
Wind gusts indoors or blowing air while inside the mill	1.14	(0.97, 1.33)	1.22	(0.97, 1.53)	1.08	(0.95, 1.24)
Visible mold on surfaces, walls, or ceilings	1.15	(0.96, 1.37)	**1.53**	**(1.21, 1.93)**	**1.20**	**(1.04, 1.38)**

Note: Statistically significant prevalence ratios and confidence intervals are in bold.
* Poisson regression models adjusted for sex and age.

Table C21. Adjusted prevalence ratios (PR) and 95% confidence intervals (CI) for the associations between environmental conditions and health symptoms not related to COVID-19, RSV, or flu since October 1, 2022, reported by NIOSH medical survey participants who did not meet the NIOSH blastomycosis case definition (n=483).

	Respiratory health symptoms (Cough; Shortness of breath, or working harder than normal to breathe)		**Systemic health symptoms** (Fever or chills or night sweats; Poor appetite or unexpected weight loss; Muscle aches or pain; Joint or bone pain; Fatigue or extreme tiredness)		**Any health symptoms** (Respiratory or systemic)	
Daily exposure to environmental conditions (vs. not every day)	PR	95% CI	PR	95% CI	PR	95% CI
Damp or wet mulch or pulp	**1.28**	**(1.08, 1.52)**	1.16	(0.87, 1.56)	**1.21**	**(1.04, 1.40)**
Dry mulch or sawdust	1.07	(0.86, 1.33)	1.16	(0.83, 1.61)	1.10	(0.91, 1.32)
Wet soil	1.02	(0.73, 1.42)	1.06	(0.65, 1.74)	1.07	(0.82, 1.40)
Standing pools of water outdoors on mill property	1.26	(0.98, 1.62)	1.21	(0.79, 1.86)	**1.25**	**(1.02, 1.53)**
Standing pools of water indoors on mill property	1.20	(0.98, 1.46)	1.16	(0.83, 1.61)	1.10	(0.91, 1.32)
Wind gusts indoors or blowing air while inside the mill	**1.21**	**(1.04, 1.42)**	1.20	(0.93, 1.54)	1.12	(0.98, 1.29)
Visible mold on surfaces, walls, or ceilings	**1.21**	**(1.02, 1.44)**	**1.61**	**(1.25, 2.07)**	**1.24**	**(1.08, 1.43)**

Note: Statistically significant prevalence ratios and confidence intervals are in bold.
* Poisson regression models adjusted for sex and age.

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