Occupational Electronic Health Records

Recommendations for the Design and Implementation of Information Systems in Occupational and Environmental Medicine Practice—ACOEM Guidance Statement

Louis E. Fazen, MD, PhD, Bill E. Martin, IV, MD, MBA, MPH, MMCi, Marcia Isakari, MD, MPH, Michele Kowalski-McGraw, MD, MPH, Robert K. McLellan, MD, MPH, Raj Ahsan, MD, MPH, and Manijeh Berenji, MD, MPH

Objective: Occupational and environmental medicine (OEM) clinicians require specialized electronic health records (EHRs) to address the privacy, data governance, interoperability, and medical surveillance concerns that are specific to occupational health. **Methods:** The American College of Occupational and Environmental Medicine (ACOEM) Section of Health Informatics evaluated clinical workflow concerns, assessed health information requirements, and developed informatics recommendations through iterative consultation with ACOEM members. **Results:** The ACOEM presents 10 recommendations that specialized occupational EHR systems (OEHRs) should meet to serve the information needs and practice requirements of OEM clinicians. Common challenges in OEM practice and potential informatics solutions are used to illustrate each recommendation. **Conclusions:** The recommendations serve as a framework for occupational health clinicians to consider in their adoption of OEHRs and provide software engineers a set of requirements to facilitate the development and improvement of OEHRs.

Keywords: occupational and environmental medicine, electronic health records, clinical informatics, data privacy, clinical decision support, interoperability, health information exchange

From the American College of Occupational and Environmental Medicine, Elk Grove Village, IL.

This guidance paper was developed by ACOEM Work Group on Electronic Health Records and Occupational Data under the auspices of the Council on Government Affairs. It was approved by the ACOEM Board of Directors on August 25, 2024. ACOEM requires all substantive contributors to its documents to disclose any potential competing interests, which are carefully considered. ACOEM emphasizes that the judgments expressed herein represent the best available evidence at the time of publication and shall be considered the position of ACOEM and not the individual opinions of contributing authors.

The authors report no conflicts of interest.

Supplemental digital contents are available for this article. Direct URL citation appears in the printed text and is provided in the HTML and PDF versions of this article on the journal's Web site (www.joem.org).

Address correspondence to: Julie Ording, MPH, ACOEM, 25 Northwest Point Blvd, Suite 700, Elk Grove Village, IL 60007 (jording@acoem.org).

DOI: 10.1097/JOM.0000000000003236

Occupational and environmental medicine (OEM) is a board-certified specialty under the American Board of Preventive Medicine that focuses on the prevention and management of work-related injuries and illnesses.[1] The practice of OEM is multifaceted, comprising both clinical medicine and population health in a range of practice settings. In addition to serving as the treating provider for individual patients in the context of a work-related injury or illness, OEM clinicians often conduct a variety of medical evaluations as an agent of an employer, agency, or legal body. To perform these tasks efficiently and promote the health of workers, OEM clinicians require robust and interoperable electronic health record (EHR) systems that support clinical decision making at the point of care while meeting all local employer policies as well as state, federal, and international regulatory requirements for data privacy and security.

The American College of Occupational and Environmental Medicine (ACOEM), the largest professional organization representing OEM specialists, has recently proposed minimum criteria that all EHRs should meet to improve medical service delivery to current and former American workers.[2] In the current paper, the ACOEM presents 10 recommendations that specialized Occupational Electronic Health Record (OEHR) systems should meet to serve the information needs and requirements commonly encountered across diverse OEM practices. The recommendations provide a framework for occupational health clinicians to consider in their adoption of OEHRs and lay out goalposts for software developers seeking to improve the practice of OEM.

TEN RECOMMENDATIONS FOR OEHRs

1. ***Health Data Governance and Stewardship***: OEHRs facilitate health data governance and stewardship through controls that are transparent and accessible at the point of care.
2. ***Privacy and Security***: OEHRs ensure the privacy of employee health and exposure information and maintain EHR industry standards for security.
3. ***User Access Controls and Permissions Management***: OEHRs utilize access controls and permissions management to facilitate access to occupational health data.
4. ***Interoperability***: OEHRs support interoperability and exchange of electronic personal health information (PHI) through application programming interface (APIs) and current data standards.
5. ***Documentation and Data Entry***: OEHRs facilitate structured documentation of occupational exposures and hazards to improve quality and outcomes in occupational health.
6. ***Clinical Decision Support***: OEHRs implement clinical decision support (CDS) systems to improve decision making at the point of care.
7. ***Reporting and Medical Surveillance***: OEHRs enable real-time reporting, epidemiology, and medical surveillance to identify sentinel events and prevent occupational injuries and illnesses.
8. ***Patient Education Materials***: OEHRs improve access to easy-to-read, multilingual patient education materials relevant to the employee diagnosis and context.
9. ***Employee Health Portal***: OEHRs connect employees to an occupational health portal that fosters worker participation and engagement in occupational health.
10. ***Workflow Customization***: OEHRs allow sufficient flexibility to enable OEM providers to customize OEHR processes to existing clinic workflows.

BACKGROUND

Historically, OEHRs have arisen from home-grown databases serving a particular industry or occupational niche; have been carved out from general purpose EHRs designed for office-based practices or healthcare systems; or have been affixed on top of customer relations management software. Although such systems may have addressed the immediate needs of OEM clinicians, such information systems are typically not scalable across an organization's workforce and are frequently unable to meet the increasingly complex legal and policy requirements for data security and the protected disclosure of health information. A well-designed OEHR can ensure compliance with all relevant health record governance and privacy laws; facilitate data sharing and interoperability with other information systems; facilitate communication with patients and workplaces; and improve the workflows and efficiency of an OEM clinical practice (Fig. 1).

Extensive guidance is already available to assist clinicians adopting general purpose EHRs, including evidence-based resources from the American Medical Association (AMA),[3] The Office of the National Coordinator for Health Information Technology (ONC),[4] and the Agency for Healthcare Research and Quality (AHRQ).[5] The available guidance has largely focused on the adoption of ONC-certified EHRs to meet the meaningful use and Merit-Based Incentive Payment System (MIPS) criteria that is required for Medicare reimbursement. Most occupational health clinics, however, are exempt from the MIPS requirements, and have greater flexibility in EHR implementation. The existing resources also do not address the privacy, data governance, interoperability, and medical surveillance concerns that are specific to occupational health.

USE CASES AND OPTIMIZATION OF OEHRs

The following sections present a use case scenario to highlight common information management challenges that OEM clinicians routinely face and how each proposed recommendation may operate to improve care. Although each recommendation is consistent with current standards and best practices in implementing general-purpose EHRs, the informatics requirements of OEM providers are often unique. The subsequent discussion section describes the underlying informatics requirements for each recommendation in more detail and the mechanisms by which OEHR implementations can improve the quality and efficiency of clinical OEM practices (Table 1).

1. Recommendation for Health Data Governance and Stewardship

OEHRs facilitate health data governance and stewardship through controls that are transparent and accessible at the point of care.

Clinical Case

Current Challenges

A new physician assistant uses an EHR template to interview his first patient, a 24-year-old woman with dyspnea that has progressively worsened over the past several months during her work at a distribution center. Guided by the primary care note template, he learns that the patient is pregnant with her first child and the dyspnea is present during any type of physical activity and is not work-related. He provides reassurance that dyspnea is a common physiological response in the context of increased oxygen demand

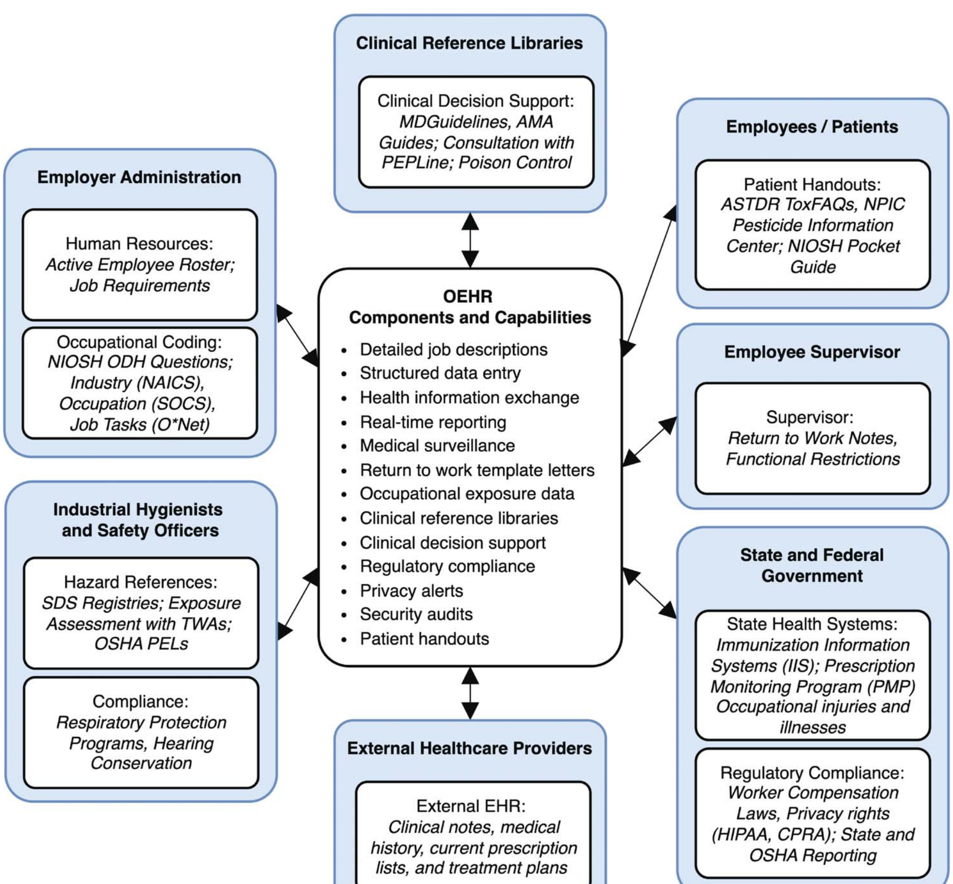

FIGURE 1. OEHR information flows and functionality.

TABLE 1. Occupational Electronic Health Record Functions

OEHR Component	Clinical Utility	Implementation Example
Health data governance and stewardship	Foster best practices in health data governance and stewardship through transparent and accessible controls.	A preplacement note template alerts clinicians about GINA before allowing data entry in a family history field.
Privacy and security	Ensure the privacy and security of employee health records and occupational exposure information.	Label encounters to differentiate the privacy laws governing administrative exams from those as treating provider.
User access controls and permissions management	Control access to PHI and ensure only the minimum necessary data is shared in accordance with HIPAA.	Export only the subset of medical history that is relevant to a particular workers' compensation claim.
Interoperability	Exchange personal health information across health information systems, providers, and personal devices.	Retrieve data from audiometry equipment, digital spirometers and continuous positive airway pressure machines using a FHIR API.
Documentation and data entry	Ensure consistency in the documentation through reference to standardized terminologies.	Document occupation and industry using NAICS and SOCS codes with the NIOSH ODH standard.
Clinical decision support	Assist clinicians in clinical exposure assessment and promote adherence to clinical guidelines.	Present links to relevant AMA Guides®, MDGuidelines®, Poison Help, or the PEPline following entry of a diagnosis.
Reporting and medical surveillance	Facilitate epidemiology, reporting and surveillance to identify sentinel events and prevent occupational injuries.	Present real-time reports to improve compliance with respiratory protection and hearing conservation.
Patient education materials	Provide easy-to-read, multilingual handouts to patients and supervisors regarding work-related health hazards.	Link to ASTDR Toxic Substances Portal, ToxFacts, National Pesticide Information Center (NPIC), International Agency for Research on Cancer.
Employee health portal	Foster worker participation and engagement in occupational health through access to a health portal.	Allow employees to submit symptom screening questions online and prompt at-risk workers to schedule spirometry.
Workflow customization	Allow clinicians to customize OEHR processes to improve preexisting clinical workflows.	Use OEHR data to auto-populate and transmit restricted duty forms or return-to-work letters to supervisors.

AMA, American Medical Association; API, application programming interface; FHIR, Fast Healthcare Interoperability Resources; GINA, Genetic Information Nondiscrimination Act of 2008; HIPAA, Health Insurance Portability and Accountability Act of 1996; NAICS, North American Industry Classification System; NIOSH, National Institute for Occupational Safety and Health; ODH, Occupational Data for Health; OEHR, occupational EHR system; PHI, personal health information; SOCS, Standard Occupational Classification System.

and decreased lung capacity during pregnancy. In his role as a treating provider, he discusses potential administrative controls that may help reduce her symptoms at work.

His second patient is a 28-year-old woman presenting for a preplacement physical for the position of a stocker at the same distribution center. Using the same note template, he documents her last menstrual period and learns that she is pregnant. Working on behalf of the employer, the clinician again reviews how pregnancy may affect her ability to perform her duties. In performing an assessment of her physical ability to bend and lift packages, the clinician searches out heavy objects and challenges the employee to lift a 40-pound weight, which she does without issue. When the employee's onboarding is delayed, she calls the clinic to inquire whether the clinician's assessment contributed to her delayed start date.

Opportunities to Improve Data Stewardship

When acting as a treating provider for the first patient, the clinician was astute to identify, document and perform an assessment that included the patient's physiology of pregnancy. When acting as a medical examiner on behalf of the employer for the second patient, the clinician's attention on pregnancy physiology and concerns about pregnancy-related work ability may constitute discrimination under laws enforced by the US Equal Employment Opportunity Commission. Within the practice of OEM, a provider must be aware of employee protections and follow all laws and policies that may apply to different patients. An OEHR designed around the proper governance and stewardship of health data can assist clinicians in following relevant laws and policies through dynamic forms, information prompts, and warnings. An EHR note template that includes questions on pregnancy and family history should not be used for administrative preplacement examinations.

Informatics Considerations

OEM professionals serve multiple clients, including employees as well as employers, insurance carriers, and other healthcare providers, and must continuously adjust their responsibilities based on the client they are serving. All OEHRs must account for and manage health data governed by a patchwork of state and federal laws and policies that protect employee privacy, prohibit employment discrimination, and guarantee employee access to information. Health Information Management professionals supporting these providers must navigate the regulations applicable to distinct roles and relationships within the occupational health sphere. To ensure proper stewardship of employee health data and improve the workflows of OEM clinicians, however, OEHRs should also promote transparent communication of how laws and policies apply to data collection, data transmission, and clinical decision making at the point of care.

Minimum requirements for occupational health records are defined by the Occupational Safety and Health Administration (OSHA). Occupational health records are defined as any records that concern the health status of an employee and that are created or maintained by health care personnel, including medical and employment questionnaires or histories, medical opinions, progress notes, first aid records, prescription information, radiographic reports, and laboratory data.[6] OEM clinicians working on behalf of employers are required to retain all such occupational records for 30 years beyond the date of last employment, with limited exceptions for certain first aid records that are stored separately from other employee medical records, and medical records of employees who have worked for less than 1 year if provided to the employee following termination of employment.[6] Similar retention requirements apply to records that document or analyze occupational exposures, including sampling data generated by industrial hygienists and similar exposure group analysis conducted by occupational epidemiologists. The records of voluntary health promotion programs and Employee Assistance Programs, however, may be exempt from OSHA regulations if maintained separately from employee medical records.

In addition to OSHA regulations, occupational health clinicians and their information systems must also comply with all federal and state laws prohibiting employment discrimination and ensuring equal employment opportunities. Title I of the Americans with Disabilities Act (ADA) of 1990, administered by the Equal Employment Opportunity, explicitly prohibits private employers, including employment agencies, labor unions, and state and local governments, from discriminating against individuals with disabilities.[7] Under the ADA, occupational health clinicians working on behalf of an employer may not collect medical information from prospective employees until after the employer has extended a conditional offer of employment. The ADA further requires that the procedures and medical information obtained in postoffer examinations be the same across all candidates seeking similar positions and be kept confidential and separate from the employee's personnel file.[8]

The Genetic Information Nondiscrimination Act of 2008 (GINA) prohibits discrimination on the basis of genetic information for any aspect of employment, including hiring decisions, job assignments, or terms and conditions of employment.[9] Given that employers are prohibited from using genetic information, including information that may be routinely collected on a family history, to make decisions regarding employment opportunities, occupational health clinicians acting on behalf of an employer should neither use nor document such genetic or family information in their clinical assessments or documentation provided to the employer, with limited exceptions for compliance with Family Medical Leave Act requirements.[10,11] Any genetic information that is documented by an occupational health clinician, including information that may be volunteered on family history of COVID-19 infections, must be kept confidential and should not be transmitted to the employer or outside entities in accordance with GINA protections of genetic information.

Occupational health data that is beyond the scope of these federal laws may still be protected in other ways. For example, employees may also be considered consumers of workplace health promotion initiatives and data obtained from such wellness programs may be regulated by the Federal Trade Commission.[12] Increasingly, individual states are passing their own privacy laws to protect additional types of sensitive personal data, including health-related information that is not covered by Health Insurance Portability and Accountability Act of 1996 (HIPAA), but may be collected, maintained, or shared from OEHRs.[12] Ongoing efforts to consolidate this patchwork of rules into more comprehensive data health privacy laws are under review at the federal level and may result in additional requirements for OEM providers in the future. OEHRs developed on a foundation of these state and federal requirements can facilitate proper stewardship of employee health data.

2. Recommendations for Privacy and Security:

OEHRs ensure the privacy of employee health and exposure information and maintain EHR industry standards for security.

Clinical Case

Current Challenges

A 54-year-old man presents to an onsite corporate OEM clinic as part of a routine preplacement examination for a security job at a large chemical manufacturer. On a paper health questionnaire, the patient reports a seizure disorder, type 2 diabetes, and a recent emergency room visit for chest pain that was attributed to gastroesophageal reflux disease. During the interview, the patient reports several subsequent episodes of substernal chest discomfort that have not been relieved by his new prescription for pantoprazole or his usual over-the-counter antacid medications.

The examining clinician collects more information from the examinee's treating physicians before making a job fitness decision. The clinic administrative staff obtained a signed release to obtain information from the examinee's primary care provider (PCP) as well as from the recent emergency room visit. After sending several reminders requesting clinical assessment of the seizure disorder and the patient's atherosclerotic cardiovascular disease (ASCVD) risk, the OEM clinic receives extensive notes covering more than a decade of clinical encounters from the PCP's office and as well as a 150-page print out of electronic medical records from the hospital emergency department. The OEM clinician identifies a recent stress test and documentation of well-controlled epilepsy in five pages of these notes, but all documentation is retained by the employer as part of the employee's occupational health record.

Opportunities to Improve Privacy

Both the patient's PCP and the hospital system shared more clinical information than was requested by the OEM clinician to perform the job fitness evaluation. The transmission of excess clinical information not only made the OEM clinicians assessment more time consuming, but without a signed release of medical information, it could represent a violation of the employee's right to privacy and confidentiality of outside medical records. A trained occupational medicine clinician is able to discern employment and nonemployment related medical information and only take into consideration employment related medical information. OEHRs have the capacity to store vast amounts of health information but should seek to limit the information they receive through health information exchanges in compliance with state and federal laws and policies on health data privacy.

Informatics Considerations

Integrating an OEHR system into an employee occupational health practice continues to be challenging because of security concerns related to privacy and confidentiality of employees' PHI.[13] Security involves protecting data and resources, including data storage and transmission. A breach in data security can occur when information is shared with unauthorized personnel, either intentionally or unintentionally. Privacy is regarded as a fundamental employee right, granting the employee complete authority over access and sharing of their private information, subject to their consent. Confidentiality, closely related to privacy, focuses on protecting data from unauthorized access.

When providing medical treatment beyond first aid, occupational clinicians and their medical records are also subject to regulation by the US Department of Health and Human Services. In 1996, for the first time, national requirements were established for the protection of certain health information. To implement the HIPAA requirements, the US Department of Health and Human Services issued the *Standards for Privacy of Individually Identifiable Health Information* (Privacy Rule). The Privacy Rule seeks to promote high-quality health care by balancing the proper protection of PHI with the need to share relevant health information for the provision of healthcare services.[14] Although the Privacy Rule was designed to be flexible and sufficiently comprehensive to cover the various uses and disclosures that need to be addressed,[14] the overall effect was increased emphasis on the protection of EHRs from unauthorized access. Under HIPAA, occupational health clinicians are a covered entity when they transmit PHI electronically, even by fax, and must abide by the HIPAA rules addressing such transmissions.[15]

Although employers are generally not covered entities under HIPAA and OSHA itself does not directly enforce HIPAA regulations, OSHA does require employers to comply with specific confidentiality protocols when dealing with health-related information obtained through occupational health and safety activities. Additional federal and state privacy laws may further delineate the extent of privacy protections afforded to employee health information. Evolving laws and policies, for example, pertain to the privacy of specific categories of health information, including release of information on HIV/

AIDS,[16] substance use disorder or other mental health diagnoses,[17] and access to reproductive health services.[18] To assist both OEM clinicians and the privacy of their patients, OEHRs should account for and facilitate compliance with the changing privacy protections at the federal and state level.

Management of privacy and PHI in OEHRs is also distinct from the privacy protections commonly used in general medical records. Although general-purpose EHRs often have the capability to access PHI from state information systems, such as immunization information systems (IISs), Prescription Monitoring Programs (PMPs), and Electronic Lab Reporting, there are valid privacy and legal concerns that may prevent OEHRs from routinely accessing this data. Conversely, fitness for duty evaluations where drug testing is carried out either for cause or for workplace surveillance programs should not be visible to community providers in their EHRs.[8] In order to manage these privacy protections, OEHRs need to account for the purpose of an occupational health encounter, and differentiate between administrative visits conducted on behalf of an employer and clinical visits that are conducted in the role of a treating provider.

Workplace wellness and health promotion programs, sometimes designed by OEM or preventive medicine providers, may also collect and share data as entities that are not covered by HIPAA. Employee participants in such voluntary workplace wellness programs may not be aware that their data is not afforded the same regulatory or legal protections as other occupational health data. The management of health information collected during mandatory screening or voluntary wellness programs should be transparent to employees and should avoid unnecessary sharing with community-based providers. OEHRs should facilitate a separation of these data sources or treat all data as PHI under a covered entity.

In the absence of more comprehensive data privacy laws at the federal level, more than 10 states have now passed data privacy laws that protect additional types of sensitive personal information. Although data collected by HIPAA-covered entities and nonprofits are often exempt from these state laws, business entities that may store individual level data from health promotion initiatives or in human resources databases, such as return to work dates following COVID-19 or maternity leave, must ensure compliance with these emerging state laws as well.[12] The California Privacy Rights Act of 2020 is particularly noteworthy as it adopts elements of the General Data Protection Regulation in the European Union to protect data on race, religion, union membership, and biometrics as sensitive personal information.[19–23] Common elements of an OEHR, such as biometric data recorded from health promotion initiatives or religious affiliation recorded from vaccination exemptions, must therefore comply with all security requirements of the California Privacy Protection Agency to prevent unauthorized access or disclosure.[23]

Healthcare organizations have already adopted multiple safeguards, such as backups, firewalls, encryption, and multifactor authentication to enhance the security of their health databases. Security technologies are in constant flux, however, and protecting patient privacy also requires regular cybersecurity training, vulnerability assessments, penetration testing, and adoption of new strategies to meet emerging cybersecurity threats. To protect employee health and exposure information, OEHRs should maintain current industry standards for healthcare data security, incorporating technologies like encryption and facilitating business practices like cybersecurity audits.

3. Recommendation for User Access Controls and Permissions Management:

OEHRs utilize access controls and permissions management to facilitate access to occupational health data.

Clinical Case

Current Challenges

A 50-year-old man presents to the occupational medicine clinic for a preplacement examination on behalf of his future employer. The patient does not know what his official job title will be and only a general sense of what his required job tasks will include. He reports that he will be working an 8-hour night shift on the production floor of a company that manufactures metal-cutting equipment. He does not know the physical job demands of his job, whether he will be exposed to hazardous substances, or whether he will be expected to wear a respirator.

As part of a large healthcare system, the occupational medicine clinic has been required to adopt the newly installed institutional EHR. In an effort to comply with the institutional mandate while addressing data privacy protections, the OEM clinic has established a process to routinely request written permission from examinees to access their individual health records from the institutional EHR. During the office visit, the clinician uses an electronic note template that automatically imports a summary of the patient's past medical history, including a remote history of alcohol use disorder and psychiatric hospitalization from 10 years prior, and a current diagnosis of stable depression managed without medications. A sibling's suicide is also automatically imported into the family history section of the default note template.

Opportunities to Improve Access Control

Easily accessed office notes from the patient's PCP provide detail on the patient's remote personal and family history of mental health concerns that are unrelated to the patient's current ability to perform his physical duties on a production floor. The excessive and unnecessary sharing of such health information may leave the OEM provider and the employer potentially liable for a breach of both HIPAA's limited use criterion as well as GINA's restrictions on the sharing of family history. Employment-related medical notes should allow electronic customization to limit information that is irrelevant to employment. Health information exchange between OEHR and EHR databases must be conducted with clear user access controls to ensure compliance with all federal, state, and local laws and policies.

Informatics Considerations

Historically, many occupational health practices have maintained occupational injury and illness records in isolation, often separately from other medical records within the same health system. Although the privacy of employee health records is paramount, privacy concerns often impede any sharing of data across information systems rather than spur the integration of systems with appropriate user access permissions.[24] User access controls refer to the process by which organizations regulate the information a user may access, ensuring each user can view only information relevant to their needs and appropriate for their credentials. Defining access controls and permissions is especially important when sharing information between different employees within a single organization.

A primary goal of the HIPAA Privacy Rule was to balance patient privacy and data protection with permissions for the use and transmission of health information needed to provide high quality healthcare. Guided by a central principle of "minimum necessary" use, occupational health clinics are required to make reasonable efforts to use, disclose, and request only the minimum amount of PHI that is needed to accomplish the intended goal for information sharing.[14,24]

Under the Health Information Technology Economic and Clinical Health Act (HITECH), the HIPAA rules were strengthened, extending the HIPAA security provisions to business associates of covered entities.[25] If an employee or their designee requests their medical records from one of these entities, records are to be provided without cost or be apprised of the reason for delay in providing the medical record within

30 days of the request.[6] Select state governments have narrowed this window to within 15 days of the original request, and encourage the provision of all PHI as soon as possible.

In accordance with OSHA regulation 1910.1020, occupational health providers working on behalf of an employer must also be prepared to provide the complete occupational health records not only to the employee, but also any officially designated representatives, such as union representatives, within 15 working days of the request.[6] Personal health information can also be requested directly by OSHA itself. When OSHA requires access to personally identifiable employee medical information, OSHA will provide the employer with a written access order pursuant to 29 CFR 1913.10(d).[6] Upon receipt, the employer is obligated to provide the requested records. Release of information in such circumstances can be especially challenging for OEM clinicians that are also bound by confidentiality agreements with the employer, who retains the right to delete any information on processes and chemical substances that may be considered trade secrets.[6] Appropriate governance of these data sources requires sophisticated permissions management that allows different users to have different levels of access to information.

The 21st Century Cures Act Final Rule (2020), issued by the ONC established more extensive policies on the sharing of electronic PHI[26–28] through health information exchanges (HIE) as a standard practice. The core idea of HIE is straightforward: to ensure that all relevant data is available to the appropriate team members at the point of care. This shift toward HIE is aimed at enhancing the delivery of comprehensive care to individuals and populations, ensuring that healthcare providers have access to all health-related information needed to achieve better medical care quality and patient outcomes. In the context of occupational health, such interconnected electronic health systems can allow elements of an employee's health and exposure record to be electronically accessed and shared on a need-to-know basis across an organization. User access controls and permissions management are the technologies that allow the employee health information to be exchanged and shared while maintaining employee health data privacy and security.[29]

4. Recommendation for Interoperability:

OEHRs support interoperability and exchange of electronic PHI through APIs and current data standards.

Clinical Case

Current Challenges

A 45-year-old roofer who has been working for a construction company for the past year presents with a chief concern of acute onset low back pain following a fall at work. At an OEM clinic affiliated with a large healthcare system, the patient describes 9/10 sharp pain and provides a limited medical history. In the context of pain, he reports he cannot remember his prescribed medications, which have changed recently.

The OEM clinician, working as a treating provider on behalf of the injured worker, evaluates the patient and, following a reassuring x-ray of the lumbosacral spine, diagnoses him with a lumbar strain. To assist in acute pain management, the OEM clinician checks the state PMP prior to writing a prescription for tramadol. The following day, the patient presents to the emergency room with acute onset nausea, vomiting, tremors, and disorientation. His medication list from the general EHR contains a recent prescription for the SNRI venlafaxine and the patient is diagnosed with serotonin syndrome - a life-threatening condition that can result from interaction of tramadol with SSRIs, SNRIs, and MOAIs.

Opportunities to Improve Interoperability

Although the patient's two medication lists were housed within the same healthcare system, a complete firewall had been erected between the OEHR and the general EHR to ensure compliance with employee privacy laws. With the patient's consent and release of limited data on current prescription medications, an automated medical reconciliation of the OEHR and EHR databases could have flagged the drug-drug interaction at the time of tramadol prescription. A comprehensive health information exchange with proper user access controls between health professionals both within and across organizations can serve to improve treatment and worker health. In the current case, the lack of interoperability between the OEHR and the general EHR placed the patient at higher risk of injury.

Informatics Considerations

ACOEM supports interoperability of occupational data to be used for the health of working patients and populations when information exchange is performed in accordance with all applicable employee protection laws and policies.[2] The delivery of high-quality care relies upon OEHRs being able to seamlessly share patient data across different healthcare providers and information systems, a concept referred to as interoperability. Akin to the measures taken to bring seamless communication among various cellular phones, the adoption of data standards is beginning to close the gap between these disparate systems.

In recent decades, Standard Development Organizations have established industry standards such as SNOMED CT and HL7 (Health Level Seven), which have achieved widespread adoption and facilitated semantic interoperability—the capability of systems to exchange and comprehend shared health data (see supplementary material for glossary of relevant terms, http://links.lww.com/JOM/B717). SNOMED CT provides a comprehensive ontology for clinical terminology, akin to a dictionary, while HL7 establishes the standards for communication and messaging structure, like the grammar of a language.[30] Despite the widespread adoption, with 95% of US hospitals utilizing some version of HL7, the standard is hindered by outdated protocols, messaging limitations, and code largely unintelligible to humans.[31,32]

One example of these limitations is HL7's Consolidated Clinical Document Architecture (C-CDA) standard for record sharing. Its document-centric approach requires sending whole documents (eg, discharge summary), when only specific pieces of information are needed (eg, current medications). To overcome these challenges, HL7's latest standard, Fast Healthcare Interoperability Resources (FHIR) takes a new approach to interoperability.[33] FHIR leverages modern technology, enabling a more granular model of health data and incorporating APIs and web-based protocols.[34] This approach not only enables the building of documents like C-CDA but also an unparalleled capability to parse, search, and isolate each data point of the medical record.[34]

The C-CDA can be likened to an "everything pizza," layered with all the elements (toppings) of a medical record, including demographics, allergies, and plan of care. The limitation in the C-CDA is the inability to transform this "everything pizza" into a more specific "pepperoni pizza" by, for example, sharing only allergies. Conversely, FHIR offers the versatility to be any "pizza combination," accommodating both comprehensive records and precise data extraction. This model opens countless possibilities for promoting interoperability, occupational health research, and public health surveillance. One notable potential application is the automation of reportable conditions. Leveraging FHIR for electronic case reporting could allow for the automatic detection of reportable conditions within medical records and their subsequent electronic submission to appropriate public health authorities.[35,36]

Similarly promising for enhancing interoperability are SMART (Substitutable Medical Applications and Reusable Technologies) on FHIR applications. Inspired by the flexibility of mobile applications, this software can access EHR data via APIs and support the "plug-and-play" interoperability of third-party applications, enabling seamless integration without the need for costly development and custom EHR integration efforts.[35,37] This approach significantly lowers the barriers for smaller organizations, allowing them to affordably incorporate advanced functionalities into their EHRs, and may be productively implemented by OEHR vendors to interface directly with audiometry equipment, spirometers, blood pressure monitors, as well as personal monitors and wearable devices.[37–40] Such applications offer exciting new opportunities for OEM providers to interface with and utilize data that is otherwise beyond the scope of an OEHR, including safety records and exposure assessments.

In an increasingly fragmented healthcare system, the exchange of health information among OEM treating providers, primary care physicians, and specialists is critical for patient safety and the effective management of worker health. Despite the legal requirements to keep medical records confidential, there is also a need to ensure clinicians can access comprehensive knowledge about an injured worker's relevant medical history across healthcare professionals when necessary. Just as we have previously recommended implementing the standardized industry and occupational data in general purpose EHRs based on the United States Core Data for Interoperability, ACOEM further affirms the importance of OEHRs to access and utilize this data collected from other healthcare providers through the implementation of health information exchange standards such as FHIR.[2] Implementing improved electronic health information exchange systems can facilitate quality improvement in the delivery of occupational medicine and improve the health of all current and former workers.

5. Recommendation for Documentation and Data Entry:

OEHRs facilitate structured documentation of occupational exposures and hazards to improve quality and outcomes in occupational health.

Clinical Case

Current Challenges

A 45-year-old outpatient nurse presents to an independent OEM clinic for a needlestick injury. In evaluating the injured worker's risk of infection, the OEM clinician documents the patient's immunosuppression and increased susceptibility to infection due to ongoing treatment of breast cancer with cyclophosphamide. After a thorough review, the clinician administers postexposure prophylaxis to mitigate the risk of HIV transmission and orders serial bloodwork to evaluate HIV status and liver function. A week later, the same patient returns for an unrelated ankle injury after slipping on a wet floor while at work. The same OEM clinician manages both the ankle injury and the follow-up bloodwork for the needlestick injury in several clinical encounters over the subsequent months.

As part of the routine workers' compensation process for the work-related ankle injury, the occupational medicine clinical staff are requested to send clinical notes to the employer's human resources department for claims adjudication. A medical assistant compiles printouts of clinical notes that include overlapping health information on both the needlestick injury and the work-related ankle injury. As part of this process, the employee's cancer diagnosis and ongoing chemotherapy are shared with worker's compensation office in the human resources department.

Opportunities to Improve Documentation

Sharing information on the needlestick injury, cancer diagnosis, and chemotherapy treatment violated the employee's privacy and confidentiality since this information was not pertinent to the work-related injury under review for the workers' compensation claim. To properly safeguard employee privacy, documentation in an OEHR requires more sophisticated data entry procedures than a general purpose EHR. OEHRs must enable OEM clinicians to collect and document data that is not only specific to the employer, but also the incident of injury. OEHRs that do not properly segment past medical histories and clinical encounter notes increase the risk of privacy breach. By leveraging structured data entry, an OEHR should be able to categorize the minimum data that is required by workers' compensation or other third party to accomplish the purpose of data transmission.

Informatics Considerations

Structured data entry for diagnosis codes and level of service are commonly implemented in EHRs for billing purposes, but such structured data entry can also facilitate diagnostic accuracy and consistency across providers. OEHRs, for example, can help ensure consistency in the documentation of occupation, industry and work activities through reference to standardized hierarchical classifications such as North American Industry Classification System, the Standard Occupational Classification System, the US Census Codes for both Occupation and Industry, and the Occupational Information Network (O*NET).[41] The National Institute for Occupational Safety and Health (NIOSH) has already adapted these coding systems in the Occupational Data for Health (ODH) framework for data collection and transmission of occupational information in EHR systems, with implementation guides and concept dictionaries made available through the CDC Public Health Information Network Vocabulary Access and Distribution System (PHIN VADS).[42] The ODH framework is also in alignment with the HL7 Work and Health Functional Profile (WHFP) standards[43] that are part of the HL7 Electronic Health Record System Functional Model (EHR-S FM) and which seek to optimize the use of occupational data to improve health outcomes rather than billing or administrative purposes. ACOEM has previously recommended the implementation of the ODH in general purpose EHRs,[2] and use of the same codes in OEHRs would ensure consistency across providers and interoperability among health care systems.

A comprehensive OEHR can further improve the quality and efficiency of clinical documentation by integrating templates tailored for routine administrative exams, common injuries, and frequent exposures. A library of templates, for example, could improve the consistency of clinical documentation of occupational histories and exposure assessments by providing structured data entry fields for date, time, duration, location, and estimated intensity of exposure or mechanism of injury. Although such structured data entry can be time consuming during an encounter, the data can often improve downstream clinical efficiency by prepopulating forms and letters, greatly reducing the time required to complete required paperwork such as Department of Transportation, workers' compensation forms, return to work letters, or medical clearance for respiratory protection programs.[44]

Structured data entry is also important for follow-up, as such data can be used to systematically assess patient progress for re-evaluations of functional restrictions, estimate return to work dates, or establish maximum medical improvement. The NIH's Patient-Reported Outcomes Measurement Information System (PROMIS) initiative, for example, provides a set of validated measures of physical, mental and social health that have been increasingly used in occupational medicine practices.[45] These standardized measures can be used to document a patient's self-assessment of their own capabilities over time, enable OEM clinicians to track patient progress on their return to work goals, or facilitate the clinical assessment of maximal medical improvement following treatment such as physical therapy.

Structured data entry is often viewed as a cumbersome requirement for providers who are more fluid with free-text notes. Data entry need not interrupt the clinical workflow, however, both the NIOSH ODH and the PROMIS measures discussed above are collected through patient self-report and can be administered at any time through employee portals or secure transmission of electronic forms. Implementation of these forms can therefore shift some of the burden of data collection onto patient-centered electronic forms and thereby improve the overall efficiency of data collection. In addition, software features such as Natural Language Processing (NLP), Artificial Intelligence (AI) Virtual Scribes, and Large Language Models are increasingly available in EHRs, and these tools may further improve clinical workflows by automated coding of structured data directly from audio recordings or free-text encounter notes.

Ultimately, improved documentation can facilitate review of occupational injuries and illnesses, medical surveillance, and the assessment of occupational hazards. In addition, more consistent documentation in an OEHR is the foundation for leveraging CDS systems and driving improvements in clinical care across providers and over time. Finally, structured data entry enables data exchange with proper access controls. Given the high likelihood that elements of clinical notes will subsequently be accessed for administrative purposes, compensation claims, or independent medical evaluations, it is important that the occupational health note be designed with downstream data use and transmission requirements in mind. By structuring the data entry of PHI into discrete data fields, OEHRs may facilitate communication and transmission of the minimum required health data to other clinical providers and administrative personnel. OEHRs that structure clinical encounter notes can ensure employee privacy is maintained during future sharing of PHI.

6. Recommendations for Clinical Decision Support:

OEHRs implement CDS systems to improve decision-making at the point of care.

Clinical Case

Current Challenges

A 50-year-old warehouse worker presents to the occupational health clinic for a fitness for duty evaluation following medical leave for a low back injury he sustained while landscaping at his house. The patient reports that he is desperate for a paycheck and eager to return. On further questioning, he reports improvement at physical therapy, which he has attended once a week for the past 3 weeks. A note from his treating PCP states simply 'ok to return to work', without specifying the type of work or tasks the patient is capable of performing. The clinician has not been provided any information from human resources regarding job requirements or work tasks, and the employee is not aware whether he will be operating a forklift or unpacking palettes upon his return. The clinician recalls several low back injuries in the same warehouse over the course of the past year, but she has not had the time to perform a chart review or assess whether injuries follow a pattern by shift, machine operator, or work task.

Given the absence of data and the worker's desire to return to work, she approves him for full duty. Several weeks later, the patient returns after sustaining a low back injury while unloading palettes at work. He reports that he has been working double-shifts to cover back rent and has not rotated job tasks since returning to the warehouse. A different clinician now removes the patient from work, completes an OSHA work-related injury form and provides the patient with information on how to file a workers' compensation claim for a work-exacerbated low back injury.

Opportunities to Improve Clinical Decisions

With limited access to information, the occupational health clinician made a poorly informed decision on fitness for duty that ultimately resulted in worse outcomes for both the patient and the employer. OEHRs can assist clinicians by aggregating, analyzing, and presenting relevant information to clinicians at the point of care in the form of CDS. By leveraging access to existing information resources, OEHRs can present OEM clinicians job descriptions from local human resources databases or the most common job tasks associated with occupational titles from the O*NET database. Epidemiology dashboards can provide comparisons between internal injury reports and the rates of injury for corresponding job titles from the Bureau of Labor Statistics. Return-to-work guidance from resources like MDGuidelines® can present clinicians with suggested return to work timelines following specific injuries and illnesses, such as low-back pain. In each instance, CDS systems that present the clinician with relevant data and evidence-based reference materials can facilitate more informed decision making, and promote safe and effective return to work plans, a goal shared by both employees and employers.

Informatics Considerations

A central purpose for adopting an EHR is to drive quality improvement in clinical practice through integration of clinical resources and implementation of CDS systems. OEHR systems can play a crucial role in enhancing the health and safety of employees by integrating a broad range of medical, exposure and public health data to support clinical decision making. OEHR systems have the opportunity to integrate internal employee health data—including medical histories, workplace injury reports, and periodic health assessments—with exposure data, such as noise, air, and chemical monitoring data.

As highlighted in prior NIOSH research, CDS can improve clinical workflows by delivering what has become known as the five rights: "the right information to the right person in the right intervention format through the right channel at the right time in the clinical workflow."[46,47] At the individual level, decision support can be as simple as flags and color coding to ensure proper documentation and completeness of records. CDS may also employ automated clinical calculators to streamline repetitive tasks, such as the documentation of body mass index and ASCVD risk scores, or flag known drug-drug interactions with warnings or reminders.

By interfacing with organizational-level data, decision support may also assist OEM clinical assessments by providing detailed job titles, work tasks and work locations from human resource databases, as well as real-time occupational exposure data such as air monitoring or noise levels recorded in industrial hygiene databases. By further incorporating publicly available data such as regional health statistics and environmental health alerts, OEHRs can offer additional contextual insights that are critical for accurate risk assessment and management. Integration of these disparate data sources and synthesis of this information into a single window can provide OEM clinicians with a comprehensive view of the occupational and environmental hazards and enable healthcare providers to make more well-informed decisions at the point of care.

An OEHR can further facilitate quality improvement and promote adherence to clinical guidelines and best practices by integrating reference libraries and relevant information sources to clinicians within their existing clinical workflow. In addition to general medical resources such as UpToDate® or Dynamed that are commonly linked within EHRs, an OEHR may benefit from integration from diverse occupational resources, including: work tasks from O*NET[41]; registries of Safety Data Sheets (SDS); the NIOSH Pocket Guide to Chemical Hazards with Recommended Exposure Limits[48]; the ACGIH Threshold Limit Values and Biological Exposure Indices through the Digital Library[49]; as well as both national and state OSHA Permissible Exposure Limits.[50] Direct links to guidelines can be especially important in the context of rapidly evolving practices, such as the Centers for Disease Control and Prevention's (CDC) guidance on infection control and management of SARS-CoV-2 exposure among healthcare personnel[51] throughout the early COVID-19 pandemic period.

When the CDS is tailored to a specific patient's occupational injury or illness, it can be particularly effective in promoting adherence to clinical best practices. Prior NIOSH research[46] has demonstrated the value of CDS in the management of common work-related concerns in primary care,[52] including work-related asthma,[53] acute low back pain,[44] and diabetes.[54] An OEHR could equally utilize a patient's diagnostic codes (ICD-10) to deliver relevant material from MDGuidelines® or *AMA Guides® to the Evaluation of Permanent Impairment* at the point of care.

OEHRs can also facilitate outreach and clinical consultation by reducing barriers to e-consultation or promoting external consultative services, such as the University of California, San Francisco National Clinical Consultation Center PEPline for Post-Exposure Prophylaxis of Bloodborne Pathogens[55] or a local Poison Control Office through Poison Help.[56] Although such consultation services may already be widely available, integration of these tools directly within a clinician's workflow reduces barriers to access these services and may increase uptake by clinicians. An OEHR, which links to or integrates the PEPline chatbot into the user interface of a bloodborne pathogen exposure template, for example, might promote confirmation of local PEP practices with national guidelines and improve a clinician's ability to respond urgently to challenging situations, such as breastfeeding employees who experience an occupational needlestick exposure. Depending on the context, an OEHR may also facilitate e-consultation services with other clinical specialties, such as physical medicine and rehabilitation, orthopedics or neurology.

The synthesis of internal employee health data with exposure assessments, industrial hygiene data, and publicly available datasets can enable OEM clinicians to make well-informed decisions at the point of care, reducing workplace injuries and illnesses and enhancing overall workplace health.

7. Recommendations for Reporting and Medical Surveillance:

OEHRs enable real-time reporting, epidemiology, and medical surveillance to identify sentinel events and prevent occupational injuries and illnesses.

Clinical Case

Current Challenges

A 32-year-old worker from a manufacturing plant presents to an occupational health clinic for concerns of worsening shortness of breath while at work. He reports that his symptoms typically get worse over the course of the week and improve when he returns home to Puerto Rico on vacation. The company produces polyurethane foams and coatings using methylene diphenyl diisocyanate, a volatile compound known to cause skin sensitization, dermatitis, and asthma, and the employee has received periodic spirometry testing throughout his employment. Despite the use of engineering controls and adherence to safety protocols, the employee reports ongoing concerns regarding prolonged exposure effects. The occupational health clinician orders a spirometry test, provides the patient with a peak flow meter and diary, and schedules follow-up in 2 weeks.

On follow-up, the patient presents with ongoing symptoms. The peak flow diary demonstrates decreased airflow over the course of the workday with lowest flows observed at night after he has left work. Spirometry was performed on a Monday morning and demonstrates only a very mild reduction in forced expiratory volume in one second (FEV1) compared to the prior exam, and little change in forced vital capacity (FVC). The FEV1/FVC ratio remains above 0.7. The clinician briefly examines prior spirometry results and observes only a slight decrease in the FEV1 over time, which she attributes to aging. She does not diagnose the patient with airflow obstruction, but encourages follow-up for his routine annual spirometry, which is scheduled in 8 months.

Opportunities to Improve Medical Surveillance

Medical surveillance programs can provide critical insights into the health of workers exposed to known occupational hazards, such as methylene diphenyl diisocyanate, and are designed to enable early detection of work-related illnesses from well-characterized occupational hazards. Most medical surveillance programs examine workers on an individual and case-by-case basis, and do not routinely aggregate or analyze data across a panel of workers or over time. OEHRs provide opportunities to generate reports on medical surveillance programs and perform analysis of the aggregate level data in real-time. Ongoing longitudinal analysis of worker cohorts involved in screening programs, such as the respiratory protection program above, offer the potential using epidemiologic analysis methods to uncover emerging trends in incidence of occupational symptoms and disease by worksite, job title, job task, shift, or chemical exposure.

Informatics Considerations

In addition to providing direct patient care, OEM clinicians are active practitioners of population health management through medical surveillance programs, immunization administration and tracking, and reporting on work-related injuries and illnesses. An OEHR can facilitate these tasks through reporting modules that track and display summary information on work-related injuries and illnesses; compliance rates for vaccine mandates; results from annual screening questionnaires, such as for occupational asthma, allergies, or latent tuberculosis; and follow-up schedules for hearing conservation or respiratory protection programs.

Real-time health analytics by diagnosis, job title, location, and mechanism of injury can also enable OEM practitioners to identify novel exposures and perform early intervention to reduce occupational exposures. Visualization of epidemiology data can, for example, identify emerging health hazards from reported symptoms or injury rates following the introduction of a new technology or chemical compound in the work site; demonstrate increasing risk of exposure and the need for increased masking from trends in COVID-19 incidence across work areas and departments; and flag important sentinel health events, such as silicosis, that require immediate exposure assessment.

In addition to organizational data, OEHRs can also leverage external data sources to further facilitate medical surveillance activities. The COVID-19 pandemic, for example, highlighted the numerous challenges of tracking and reporting immunizations within an organization. Historically, compliance with mandated vaccinations, common among health care personnel, had been documented in occupational health records but shared outside the organization only rarely, and with written authorization by the employee. Following the introduction of broad-based employer vaccination mandates during the COVID-19 pandemic, the need for interoperability[24,57,58] and data exchange with IISs that consolidate vaccination information for persons living in a geopolitical area[59] became clearer. The pandemic highlighted how timely data exchange might facilitate tracking of workforce vaccine rates; improve compliance with state and local public health requirements; and encourage strategies to improve vaccine access, decrease hesitancy and leverage acceptance.[60,61] However, significant gaps remain: implementation of IISs vary by state, and provider knowledge of the registries and reporting of data varies by medical specialty.[62] OEHRs that facilitate the electronic release of information and offer capabilities for data exchange with IISs or the CDC's Immunization Gateway can greatly enhance reporting and medical surveillance of worker populations.

Similar data exchange strategies may be applied with work-related injuries and other notifiable conditions. Data exchange with state and federal agencies in this context not only facilitates compliance with statutory reporting requirements but also enables

OEM clinics to compare organizational injury and illness rates with those of surrounding businesses and industries in real-time. When linked with exposure data, health information exchange with general-purpose EHRs that use the Occupational Data for Health framework can further facilitate the identification of novel occupational diseases. Ultimately, OEHR reporting and medical surveillance modules that use data exchange to integrate multiple data sources can provide OEM clinicians with more comprehensive information and highlight opportunities to promote a healthy workforce. With access to such advanced reporting capabilities, OEM providers should be able to better track and develop population-based approaches to improve the health of workers.

Reporting modules can also assist OEM clinics to review and manage the delivery of healthcare services. Clinic administrators and medical directors frequently use diagnostic, billing, and health record metadata to ensure that healthcare operations meet current standards and to identify opportunities for further improvement in service delivery. To facilitate these processes, OEHRs should offer sufficient reporting and analysis tools to identify gaps and areas for improvement, which may include internal metrics on clinicians and support staff operations; clinic practice efficiencies such as patient throughput times and completeness of clinical documentation; and metrics used to assess the patient experience and outcomes.

8. Recommendations for Patient Education Materials:

OEHRs improve access to easy-to-read, multilingual patient education materials relevant to the employee diagnosis and context.

Clinical Case

Current Challenges

A 38-year-old assembly line worker who primarily speaks Portuguese visits with her occupational health physician after experiencing low back pain when lifting a thirty-five-pound box that day at work. After obtaining a clinical history through an over-the-phone interpreter, the physician diagnosed the patient with a mild lumbar strain and recommended anti-inflammatories, physical therapy, and work restrictions. The patient affirmed her understanding but was unable to repeat the instructions when asked.

Recognizing the language barrier, the physician decided to utilize patient education materials in Portuguese. After confirming the patient had the ability to read and write at an eighth-grade level in Portuguese, the physician proceeded to search various information resources on the Internet. She was able to identify an illustrated Portuguese language pamphlet on managing lumbar strain with instructions on what to do for red flag symptoms and a useful English-language exercise handout on three basic stretches for lumbar strain, which she translated into Portuguese using an AI service. Recognizing that she could not verify the accuracy of the Portuguese language pamphlet or the Portuguese translation herself, she emailed the materials to the over-the-phone interpreter to confirm. After several minutes, the physician and interpreter reviewed the documents, and made minor changes to improve comprehension of the translated text. After resaving the documents to her desktop, the physician printed out the revised materials and provided them to the patient.

Opportunities to Improve Patient Education

Occupational health literacy may be low among injured workers, who are more likely to be newer employees with more limited experience of the occupational hazards specific to that workplace. Language barriers provide an additional barrier to occupational safety and health in both the workplace and the occupational health clinic. Patient education materials provide patients with an opportunity to review recommendations for prevention and treatment of occupational illnesses at their own pace but are often underutilized by occupational health clinics due to the time required to identify relevant materials on diverse occupational hazards. OEHRs can facilitate occupational health literacy by presenting clinicians with readily accessible, approved patient education materials in the language of interest within a typical encounter workflow.

Informatics Considerations

More than one quarter of US adults exhibit low health literacy, with pronounced disparities according to age, level of education, and race.[63] Systematic reviews have demonstrated consistent associations between low health literacy and poor health outcomes, including increased hospitalization rates and higher mortality, and have further highlighted how health literacy may mediate racial disparities in healthcare outcomes.[64] Improving the resources available to clinicians and the education materials provided to patients has been associated with increased health seeking behaviors, such as adherence to cancer screening recommendations, as well as decreased emergency room visits and hospitalizations.[65]

An OEHR can greatly facilitate use and distribution of education materials by presenting relevant patient handouts to clinicians based on clinical encounter data, such as diagnostic codes (ICD-10). Given the diversity of occupational exposures and broad range of clinical concerns that OEM providers may see, easy access to such patient handouts can reduce the time required to search across websites and may facilitate better communication with patients. Improving health literacy among patients has become increasingly important in the context of misinformation distributed through social media feeds and unreliable websites.

Easy-to-read patient education handouts are often readily available through free, publicly accessible websites from national agencies, such as the National Library of Medicine MedlinePlus Easy-To-Read Health Information,[66] the CDC's Communication Resources,[67] healthcare systems such as National Jewish Health,[68] and medical organizations such as the American Academy of Family Physicians.[69] Patient handouts are also available through subscription services, such as AccessMedicine, DynaMed, and UpToDate®.[70–72] Patient handouts relevant to OEM clinicians may also derive from resources such as the Agency for Toxic Substances and Disease Registry ToxFAQs[73] or the NPIC's Pesticide Fact Sheets.[74]

Services that produce patient education materials may also offer the same content across multiple formats, including text in multiple languages and at multiple reading levels, as well as audio, video and braille resources in collaboration with membership organizations such as the National Federation of the Blind.[67] Greater implementation of these diverse resources within an OEHR can assist the OEM clinician and also facilitate the employer's compliance with requirements under the Equal Employment Opportunity Commission and the ADA.

Most recently, clinicians have begun documenting success of using large language models and AI services to generate patient-specific handouts across a range of dermatology and neurology conditions.[75–77] If these novel AI methods continue to demonstrate effectiveness in improving patient health literacy, OEHRs may find value from including these resources into the context of a clinical encounter. Large language models that are trained from authoritative knowledge bases may be able to integrate data from industrial hygiene, epidemiology, and occupational medicine resources and deliver comprehensive patient handouts that are individually tailored to the patient's reading level and preferred language.

9. Recommendations for Employee Health Portals:

OEHRs connect employees with an occupational health portal that fosters worker participation and engagement in occupational health.

Clinical Case

Current Challenges

A 23-year-old machinist presents to the occupational health clinic for ongoing sinus congestion, cough, and shortness of breath which he suspects may be related to his work environment. At the time of evaluation, he cannot recall the names of the chemicals or metalworking fluids that he uses at his job and does not have ready access to the SDS. Following history and physical, the occupational health clinician refers the worker for spirometry testing; provides him with a daily activity and symptom diary; and requests him to return for follow-up in 4 weeks.

At follow-up, he presents with ongoing symptoms. He missed his spirometry testing because it was not in his calendar, and he did not recognize the clinic phone number when they called him. Of the past 21 days, he has only completed 4 days of the symptom diary, and there is insufficient information to draw conclusions on the relationship between his symptoms and his work environment. He was still waiting on his supervisor to provide him with the SDS on the metalworking fluids. The clinician provides the patient with a paper handout on metalworking fluids and encourages the patient to follow-up with spirometry, document symptoms in the diary, collect SDS sheets, and return in another 4 weeks.

Opportunities for Employee Health Portals

Occupational health portals provide employees access to information on occupational health concerns and offer new opportunities for patient-provider communication. By providing a central resource dedicated to occupational health, employee health portals can encourage employees to become more active participants in the maintenance of their own health and well-being at work. Occupational health portals can provide information on occupational hazards, such as a repository of SDS, as well as resources on work-related health concerns, such as risk of asthma from metalworking fluids. Interactive portals can allow workers to schedule follow-up appointments; receive reminders for diagnostic tests, such as spirometry; and complete questionnaires, such as symptom and exposure diaries. By facilitating access to information and communication with occupational health providers, health portals may also encourage worker participation in occupational health and safety.

Informatics Considerations

Meaningful patient engagement is one of the main goals of the Health Information Technology for Economic and Clinical Health Act,[78] and patient access to personal health information was further reaffirmed in the 21st Century Cures Act. The 21st Century Cures Act Final Rule (2020) promoted secure and streamlined patient access to their own personal health data at no cost and prohibited entities from putting up barriers to health information exchange, or information blocking. In addition to establishing these principles, the Cures Act promoted a standardized API, or data standard by which any computer system, including those of third-party vendors, may request and gain access to personal electronic health records.[26,27] The vast majority of healthcare systems comply with these requirements through the implementation of patient-facing online health portals which enable direct access to personal health records and secure communication with healthcare providers.[79]

Although the evidence of benefits for patient health portals in the general population is mixed,[80–82] well-designed health portals can facilitate patient-provider communication, patient engagement and quality of care.[83,84] Based on existing evidence from patient health portals, employee health portals are more likely to be used if they are developed through iterative design with end-user participation; systematically assess health literacy, digital access, patient skills, and scope of content; and use principles of implementation science to address usability barriers.[79,81] The benefits of introducing an employee facing portal in an OEHR will also be determined by ongoing employee training and in-person support on how to use the software, especially among older workers and those with low health literacy.[85,86] Despite the implementation challenges observed in the general population,[80,87–89] occupational health portals focus on a more limited set of health concerns and serve populations that are younger and with better access to digital technology.

A robust employee portal may serve as an information hub for employees and ensure employer compliance with providing access to SDS, documentation of occupational hazards, and provision of language-specific occupational health resources as required under the OSHA Hazard Communication Standard and the Equal Employment Opportunity Commission. By presenting information on relevant health topics such as injury and disease prevention, wellness strategies, and ergonomics, health portals may help improve overall health literacy and empower employees to make more informed decisions about their health and well-being. Such systems may potentially decrease the administrative burden and costs often associated with the day-to-day operations of an OEM practice, including the need to have additional staff to take phone calls and messages. To be most effective, an employee health portal must be readily accessible and easy to navigate on platforms that employees use the most, especially mobile devices.

OEHRs that provide employee-facing health portals can also offer employees an opportunity to communicate directly with OEM providers and other occupational safety and health professionals. To ensure compliance with relevant health and legal privacy laws, portals should provide a messaging platform over secure and encrypted communication channels. Employees should be discouraged from communicating PHI through personal or work email accounts, which are typically characterized by much less restrictive security protocols, and which may leave an employer liable for privacy breaches under HIPAA. Health portals may also allow employees to complete online forms, such as symptom questionnaires for medical surveillance, and upload personal health data from wearables and other medical devices, such as electronic peak flow meters and portable spirometers. While providing means for employees to upload data, employee health portals should also be careful to discourage workers from downloading PHI on publicly accessible work computers.

Another type of occupational health portal is employer-facing, and allows supervisors and human resources personnel access to limited data on the work status and restrictions of their assigned employees. Such employer-facing occupational health portals can be effective in communicating occupational safety and health (OSH) concerns and ensuring compliance with OSH policies throughout an organization. If managed directly by occupational health as an employer-facing OEHR portal, user access controls must be tightly coordinated with human resources to ensure that employee's health concerns are shared with only current and appropriate supervisors on a need-to-know basis. Employer-facing occupational health portals may also be managed and operated as part of human resources management software, which may pull limited data from an OEHR through API calls, for example.

By providing access to information on occupational health concerns and opportunities to engage with occupational safety and health professionals, employee-facing health portals can facilitate worker participation and engagement in workplace health, which is central to well-functioning occupational health and safety management systems.

10. Recommendation for Workflow Customization:

OEHRs allow sufficient flexibility to enable OEM providers to customize OEHR processes to existing clinic workflows.

Clinical Case

Current Challenges

A 55-year-old worker from a Concentrated Animal Feeding Operation presents to an offsite occupational health clinic for evaluation of fever and shortness of breath. The patient completes a paper form documenting several occupational exposures to sick contacts. The clinician performs a point-of-care rapid antigen test for COVID-19 and documents the negative result in another paper form. She then uses a computer system to order a chest x-ray and a respiratory viral panel to evaluate other sources of fever by polymerase chain reaction. Aware of recent news stories on avian flu, the astute OEM clinician looks up the current epidemiology of multistate outbreak of H5N1 and the state public health guidance on evaluation of livestock workers with fever. As a precautionary measure, she collects a second viral swab for viral subtyping of influenza H5N1 at the state public health laboratory.

The patient questionnaire and point of care test results are subsequently scanned into an electronic health information system for storage. To follow-up on results, clinic staff use three separate credentials to log into the third-party laboratory system for the viral panel, the radiology system for the chest x-ray reading, and the state public health laboratory that conducted the viral subtyping. The OEM clinician observes that the COVID-19 polymerase chain reaction test is positive and documents her assessment in the clinic notes; calls the patient and documents her call in the clinic notes; composes a letter to the employer with an anticipated return-to-work date; and documents the letter in her clinic notes.

Opportunities for Workflow Customization

Even in the relatively straightforward evaluation of fever in a worker at a livestock operation, the OEM provider's workflow included the use of both paper forms and electronic data entry, and required accessing at least five different websites. Evaluation and documentation of test results required logging into four different information systems, and required the OEM clinician to document each of her procedures separately.

An OEHR customized to this clinicians workflow might have improved efficiency by presenting the clinician with ongoing H5N1 epidemiology trends and public health guidance in the form of CDS based on occupational classification and recorded vital signs; pulled the laboratory and radiology results through interoperable health information exchanges; automatically generated the return-to-work letter to the employer by prepopulating a template with clinical encounter data; posted the clinical results and relevant patient education materials to the patient health portal; and alerted the patient by text and email messages to the presence of new results.

Informatics Considerations

While addressing the complexities of health data governance, employee and patient privacy regulations, data exchange and interoperability are all challenging technical issues, the actual use and value of an OEHR is typically determined by its overall ability to simplify clinical workflows and improve efficiency. Given the diversity of medical services that OEM clinicians provide on behalf of patients and employers, OEM clinical workflows in home-grown clinical information systems are often highly fragmented and inefficient, characterized by redundant processes and constrained by missing or conflicting information. The healthcare data that is generated and documented in OEM clinics is often confined to the information system in which it was originally collected, resulting in proprietary information silos that are unable to communicate with each other. Implementing a new OEHR in this context can be especially challenging, and improvement in clinical operations is not guaranteed.

To address the implementation hurdles with general purpose EHRs, multiple government and nongovernmental agencies have developed practical implementation toolkits, including the AMA,[3] ONC,[4] and the AHRQ.[5] These toolkits, summarized in the ONC Health IT Playbook,[4] document evidence-based best practices to assist healthcare providers and information technology professionals implementing EHR systems. The resources emphasize the importance of process mapping, workflow analysis, and workflow redesign, outlining how to map out each step and decision point in clinic processes such as patient check-in, medication reconciliation, measurement of vital signs, and scheduling follow-up appointments.

In the context of occupational medicine, clinic processes and workflows are often highly variable between OEM providers, clinics, and workplaces. To be successful, each OEHR implementation must be aligned with clinical needs and customized to the existing workflows in each individual OEM clinic. A well-designed and customized OEHR, however, has the potential to dramatically improve OEM clinic operations by automating patient workflows from clinic check-in to discharge and scheduling; generating return-to-work notes and email messages to supervisors from clinical encounter notes; performing batch communications for the follow-up of administrative and routine screening exams; and managing medical surveillance data and summarizing epidemiologic trends into reports. OEM clinics with the most inefficient workflows are also the most likely to benefit from transition to OEHRs.

Although the prior recommendations have focused on the common elements and core functionalities of an OEHR, innumerable features may be layered on top of these systems to further improve the workflows and efficiency of OEM clinicians. These innovative features include dictation or automated speech-to-text scribes; integrated telehealth interfaces with secure messaging on mobile applications; self-scheduling modules with automated appointment reminders and pushed results notifications; as well as coding and CDS systems informed by AI and large language models. OEHRs that successfully implement the architectural features and core capabilities outlined above will provide the best foundation for integrating these emerging technologies and further improving the efficiencies of OEM clinical workflows.

Conclusions

A robust and well-designed OEHR should focus on the experience of the primary end users: occupational medicine clinicians and the workers who attend their clinics. OEHRs that provide simple and efficient user experiences can improve the quality of OEM practices and promote health and well-being in the workplace.

Despite this concentrated focus of users, the effects of OEHRs are often organization-wide and the benefits can be far-reaching. Through information exchange, OEHRs provide an opportunity to improve communication and efficiency across the entire spectrum of workers involved in occupational health and safety, including: health and safety officers, infection control workers, and industrial hygienists; human resources and workers' compensation staff; medical review officers, independent medical evaluators, and community-based treating providers; health officers from relevant federal, state and local agencies; as well as, data scientists and researchers performing data analytics and medical surveillance.

Although the potential benefits of an OEHR are well-recognized, too often, these benefits remain unrealized. In this document, ACOEM has provided 10 specific recommendations to facilitate information management in the practice of OEM. The recommendations serve as a framework for occupational health clinicians and IT professionals to consider in the development, implementation, and optimization of OEHRs. To be clear, many of the recommendations are interdependent and should be understood as complementary.

A central foundation for every OEHR is data stewardship and governance: ensuring patient privacy and data security are maintained through user access controls and permissions management in compliance with all applicable federal, state, and local laws and policies. OEHRs that facilitate documentation of structured data and interoperability with other information systems provide the underlying platform for features that promote quality improvement in the delivery of OEM services, including CDS, real-time medical surveillance and epidemiology, individually tailored patient education materials, and employee-facing occupational health portals. Although these rich features offer the potential to improve efficiency, OEHR implementations that enable OEM providers to customize OEHR processes to the existing context and clinical workflows are likely to demonstrate the most significant clinical and operational benefits.

ACOEM looks forward to further advances in the rapidly changing landscape of health informatics and plans to update these recommendations as information systems and the practice of OEM evolve.

ACKNOWLEDGMENTS

The authors thank the following for their review of this guidance statement: Robert Filler, MD, MBA, MPH, Laura Radke, MD, Gregg Stave, MD, JD, MPH, Rachel Leibu, MD, MS, MBA, and Julia Klees, MD, MPH.

REFERENCES

1. American College of Occupational and Environmental Medicine (ACOEM). ACOEM strategic plan. Available at: https://acoem.org/About-ACOEM/ACOEM-Strategic-Plan. Accessed March 20, 2024.
2. Kowalski-Mcgraw M, McLellan RK, Berenji M, et al. Electronic health records and occupational data: a call for promoting interoperability. *J Occup Environ Med* 2023;65:e520–e526.
3. American Medical Association (AMA). EHR improvements. Available at: https://edhub.ama-assn.org/steps-forward/pages/ehr-improvements. Accessed July 10, 2024.
4. Health IT playbook. Available at: https://www.healthit.gov/playbook/electronic-health-records/. Accessed July 10, 2024.
5. Workflow assessment for Health IT Toolkit | Digital Healthcare Research. Available at: https://digital.ahrq.gov/health-it-tools-and-resources/evaluation-resources/workflow-assessment-health-it-toolkit. Accessed July 10, 2024.
6. Occupational Safety and Health Administration. Occupational Safety and Health Standards. 1910.1020 - Access to employee exposure and medical records. Available at: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1020. Accessed March 19, 2024.
7. U.S. Equal Employment Opportunity Commission. Titles I and V of the Americans with Disabilities Act of 1990 (ADA). Available at: https://www.eeoc.gov/statutes/titles-i-and-v-americans-disabilities-act-1990-ada. Accessed March 19, 2024.
8. Geaney JH. The relationship of workers' compensation to the Americans with Disabilities Act and Family and Medical Leave Act. *Clin Occup Environ Med* 2004;4:vi:273–293.
9. U.S. Equal Employment Opportunity Commission. Genetic Information Nondiscrimination Act of 2008. Available at: https://www.eeoc.gov/statutes/genetic-information-nondiscrimination-act-2008. Accessed March 20, 2024.
10. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Genetics in the workplace: implications for occupational safety and health. November 2009. Available at: https://www.cdc.gov/niosh/docs/2010-101/pdfs/2010-101.pdf. Accessed March 20, 2024.
11. Silver K, Sharp RR. Ethical considerations in testing workers for the -Glu69 marker of genetic susceptibility to chronic beryllium disease. *J Occup Environ Med* 2006;48:434–443.
12. Theodos K, Sittig S. Health information privacy laws in the digital age: HIPAA doesn't apply. *Perspect Health Inf Manag* 2020;18:1l Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7883355/. 2021. Accessed August 13, 2024.
13. Basil NN, Ambe S, Ekhator C, Fonkem E. Health records database and inherent security concerns: a review of the literature. *Cureus* 2022;14:e30168.
14. U.S. Department of Health and Human Services. Office for Civil Rights. Summary of the HIPAA Privacy Rule. Available at: https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/index.html. Accessed March 19, 2024.
15. U.S. Department of Health and Human Services. Office for Civil Rights. Covered Entities and Business Associates. Available at: https://www.hhs.gov/hipaa/for-professionals/covered-entities/index.html. Accessed March 19, 2024.
16. D.C. Law 24-170. HIV/AIDS Data Privacy Protection and Health Occupation Revision Clarification Amendment Act of 2022. | D.C. Law Library. Available at: https://code.dccouncil.us/us/dc/council/laws/24-170. Accessed April 21, 2024.
17. Confidentiality of substance use disorder (SUD) patient records. Federal Register. Available at: https://www.federalregister.gov/documents/2024/02/16/2024-02544/confidentiality-of-substance-use-disorder-sud-patient-records. 2024. Accessed April 21, 2024.
18. U.S. Department of Health and Human Services. HIPAA and Reproductive Health. Available at: https://www.hhs.gov/hipaa/for-professionals/special-topics/reproductive-health/index.html. Accessed July 8, 2024.
19. California Privacy Protection Agency. Proposition 24 - The California Privacy Rights Act of 2020. Available at: https://cppa.ca.gov/regulations/. Accessed August 13, 2024.
20. European Commission. Data protection in the EU. Available at: https://commission.europa.eu/law/law-topic/data-protection/data-protection-eu_en. 2024. Accessed August 13, 2024.
21. Regulation (EU) 2016/679 General Data Protection Regulation (GDPR) EUR-Lex. Available at: https://eur-lex.europa.eu/eli/reg/2016/679/oj. Accessed August 13, 2024.
22. General Data Protection Regulation (GDPR) Compliance Guidelines. *GDPR.eu* Available at: https://gdpr.eu/. Accessed August 13, 2024.
23. California Privacy Protection Agency. Law & Regulations. Available at: https://cppa.ca.gov/regulations/. Accessed August 13, 2024.
24. Isakari M, Sanchez A, Conic R, et al. Benefits and challenges of transitioning occupational health to an enterprise electronic health record. *J Occup Environ Med* 2023;65:615–620.
25. U.S. Department of Health and Human Services. Direct Liability of Business Associates. Available at: https://www.hhs.gov/hipaa/for-professionals/privacy/guidance/business-associates/factsheet/index.html. 2019. Accessed March 19, 2024.
26. Jones JR, Gottlieb D, McMurry AJ, et al. Real world performance of the 21st Century Cures Act Population-level application programming interface. *J Am Med Inform Assoc* 2024;31:1144–1150.
27. Standardized API for patient and population services | HealthIT.gov. Available at: https://www.healthit.gov/test-method/standardized-api-patient-and-population-services. Accessed March 21, 2024.
28. 21st Century Cures Act: Interoperability, Information Blocking, and the ONC Health IT Certification Program. *Federal Register*. Available at: https://www.federalregister.gov/documents/2020/05/01/2020-07419/21st-century-cures-act-interoperability-information-blocking-and-the-onc-health-it-certification. 2020. Accessed March 21, 2024.
29. Holmgren AJ, Adler-Milstein J. Health information exchange in US hospitals: the current landscape and a path to improved information sharing. *J Hosp Med* 2017;12:193–198.
30. Benson T, Grieve G. *Principles of Health interoperability: FHIR, HL7 and SNOMED CT (Health information technology standards)*. Cham: Springer International Publishing; 2021. DOI: 10.1007/978-3-030-56883-2.
31. Braunstein ML. *Health informatics on FHIR: how HL7's new API is transforming healthcare*. Cham: Springer International Publishing; 2018. DOI: 10.1007/978-3-319-93414-3.
32. HL7 Standards Product Brief - HL7 Version 2 Product Suite | HL7 International. Available at: https://www.hl7.org/implement/standards/product_brief.cfm?product_id=185. Accessed April 10, 2024.
33. Kukhareva P, Warner P, Rodriguez S, et al. Balancing functionality versus portability for SMART on FHIR applications: case study for a neonatal bilirubin management application. *AMIA Annu Symp Proc* 2019;2020:562–571.
34. Ayaz M, Pasha MF, Alzahrani MY, Budiarto R, Stiawan D. The Fast Health Interoperability Resources (FHIR) Standard: Systematic literature review of implementations, applications, challenges and opportunities. *JMIR Med Inform* 2021;9:e21929.
35. Mac Kenzie WR, Davidson AJ, Wiesenthal A, et al. The promise of electronic case reporting. *Public Health Rep* 2016;131:742–746.
36. HL7 International. HL7 FHIR® Implementation Guide: Electronic Case Reporting (eCR) - US Realm v2.1.1. Available at: https://build.fhir.org/ig/HL7/case-reporting/. Accessed April 10, 2024.
37. Mandel JC, Kreda DA, Mandl KD, Kohane IS, Ramoni RB. SMART on FHIR: a standards-based, interoperable apps platform for electronic health records. *J Am Med Inform Assoc* 2016;23:899–908.
38. Torab-Miandoab A, Samad-Soltani T, Jodati A, Rezaei-Hachesu P. Interoperability of heterogeneous health information systems: a systematic literature review. *BMC Med Inform Decis Mak* 2023;23:18.
39. Kasthurirathne SN, Mamlin B, Grieve G, Biondich P. Towards standardized patient data exchange: integrating a FHIR based API for the open medical record system. *Stud Health Technol Inform* 2015;216:932.
40. Dixon BE, Taylor DE, Choi M, Riley M, Schneider T, Duke J. Integration of FHIR to facilitate electronic case reporting: results from a pilot study. *Stud Health Technol Inform* 2019;264:940–944.
41. O*NET OnLine. Available at: https://www.onetonline.org/. Accessed April 21, 2024.
42. Centers for Disease Control and Prevention. PHIN Vocabulary Access and Distribution System (VADS). Available at: https://www.cdc.gov/phin/php/phinvads/?CDC_AAref_Val=https://www.cdc.gov/phin/tools/phinvads/index.html. Accessed March 20, 2024.
43. Wallace B, Luensman G, Storey E, Brewer L. A Guide to the Collection of Occupational Data for Health: Tips for Health IT System Developers. Publication No. 2022-101. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for

Occupational Safety and Health. October 2021. DOI: 10.26616/NIOSHPUB2022101.
44. McLellan RK, Haas NS, Kownacki RP, Pransky GS, Talmage JB, Dreger M. Using electronic health records and clinical decision support to provide return-to-work guidance for primary care practitioners for patients with low back pain. *J Occup Environ Med* 2017;59:e240–e244.
45. Intro to PROMIS. Available at: https://www.healthmeasures.net/explore-measurement-systems/promis/intro-to-promis. Accessed April 21, 2024.
46. Filios MS, Storey E, Baron S, Luensman GB, Shiffman RN. Enhancing worker health through clinical decision support (CDS): an introduction to a compilation. *J Occup Environ Med* 2017; 59:e227–e230.
47. Sirajuddin AM, Osheroff JA, Sittig DF, Chuo J, Velasco F, Collins DA. Implementation pearls from a new guidebook on improving medication use and outcomes with clinical decision support. Effective CDS is essential for addressing healthcare performance improvement imperatives. *J Healthc Inf Manag* 2009;23:38–45.
48. Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH). NIOSH Pocket Guide to Chemical Hazards. Available at: https://www.cdc.gov/niosh/npg/default.html. 2022. Accessed March 19, 2024.
49. ACGIH. ACGIH Digital Library. Available at: https://www.acgih.org/publications/introducing-digital-library/. Accessed March 19, 2024.
50. Occupational Safety and Health Administration. Permissible Exposure Limits – Annotated Table Z-1. Available at: https://www.osha.gov/annotated-pels/table-z-1. Accessed March 19, 2024.
51. Centers for Disease Control and Prevention (CDC). Interim Guidance for Managing Healthcare Personnel with SARS-CoV-2 Infection or Exposure to SARS-CoV-2. Available at: https://www.cdc.gov/covid/hcp/infection-control/guidance-risk-assesment-hcp.html?CDC_AAref_Val=https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-risk-assesment-hcp.html. Accessed March 19, 2024.
52. Baron S, Filios MS, Marovich S, Chase D, Ash JS. Recognition of the relationship between patients' work and health: a qualitative evaluation of the need for clinical decision support (CDS) for worker health in five primary care practices. *J Occup Environ Med* 2017;59:e245–e250.
53. Harber P, Redlich CA, Hines S, Filios MS, Storey E. Recommendations for a clinical decision support system for work-related asthma in primary care settings. *J Occup Environ Med* 2017;59:e231–e235.
54. Allen A, Welch L, Kirkland K, Trout D, Baron S. Development of a diabetes mellitus knowledge resource for clinical decision support assisting primary care physicians with work-related issues. *J Occup Environ Med* 2017;59:e236–e239.
55. National Clinician Consultation Center. PEP: post-exposure prophylaxis. Available at: https://nccc.ucsf.edu/clinician-consultation/pep-post-exposure-prophylaxis/. Accessed March 19, 2024.
56. America's Poison Centers. Poison Help. Available at: https://www.poisonhelp.org/. Accessed March 19, 2024.
57. Kowalski-McGraw M, Green-McKenzie J, Pandalai SP, Schulte PA. Characterizing the interrelationships of prescription opioid and benzodiazepine drugs with worker health and workplace hazards. *J Occup Environ Med* 2017; 59:1114–1126.
58. Green-McKenzie J, Field-Flowers C, Peairs K, Barnes K, Shofer F, Kuter BJ. Best practices for implementation of an employee health COVID-19 vaccine clinic—a model for future pandemic preparedness. *J Occup Environ Med* 2023;65: 621–626.
59. Centers for Disease Control and Prevention. Progress in immunization information systems — United States, 2012. *MMWR Morb Mortal Wkly Rep* 2013;62:1005–1008.
60. Privor-Dumm L, Excler J-L, Gilbert S, et al. Vaccine access, equity and justice: COVID-19 vaccines and vaccination. *BMJ Glob Health* 2023;8:e011881.
61. Keehner J, Horton LE, Binkin NJ, et al. Resurgence of SARS-CoV-2 infection in a highly vaccinated health system workforce. *N Engl J Med* 2021;385:1330–1332.
62. Kempe A, Hurley LP, Cardemil CV, et al. Use of Immunization Information Systems in primary care. *Am J Prev Med* 2017;52:173–182.
63. Paasche-Orlow MK, Parker RM, Gazmararian JA, Nielsen-Bohlman LT, Rudd RR. The prevalence of limited health literacy. *J Gen Intern Med* 2005;20:175–184.
64. Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low health literacy and health outcomes: an updated systematic review. *Ann Intern Med* 2011;155:97–107.
65. Berkman N, Sheridan S, Donahue K, et al. *Health Literacy Interventions and Outcomes: An Updated Systematic Review.* Rockville, MD: Agency for Healthcare Research and Quality U.S. Department of Health and Human Services; 2011, 155, 97.
66. MedlinePlus. Easy-to-read health information. Available at: https://medlineplus.gov/all_easytoread.html. Accessed March 19, 2024.
67. Centers for Disease Control and Prevention (CDC). Health promotion materials. Available at: https://www.cdc.gov/ncbddd/humandevelopment/materials/index.html. Accessed August 11, 2024.
68. National Jewish Health. Download free patient education materials. Available at: https://www.nationaljewish.org/patients-visitors/patient-info/patient-education-support/download-free-patient-education-materials. Accessed March 19, 2024.
69. American Academy of Family Physicians (AAFP). AFP patient handouts. Available at: https://www.aafp.org/pubs/afp/collections/handouts.html. Accessed March 19, 2024.
70. McGraw Hill. Patient education handouts. Access Medicine Available at: https://accessmedicine.mhmedical.com/patientEdHandouts.aspx?groupID=1126&categoryID=41763&selectedletter=A. Accessed March 19, 2024.
71. DynaMed. Available at: https://www.dynamed.com/. Accessed March 19, 2024.
72. UpToDate®. Patient Education. Available at: https://www.uptodate.com/contents/table-of-contents/patient-education. Accessed March 19, 2024.
73. Agency for Toxic Substance and Disease Registry. ToxFAQs™. Available at: https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsLanding.aspx. Accessed March 19, 2024.
74. National Pesticide Information Center. Pesticide Fact Sheets. Available at: http://npic.orst.edu/npicfact.htm. Accessed March 19, 2024.
75. Kianian R, Sun D, Giaconi JA. Can ChatGPT aid clinicians in educating patients on the surgical management of glaucoma? *J Glaucoma* 2024; 33:94–100.
76. Tao BK, Handzic A, Hua NJ, Vosoughi AR, Margolin EA, Micieli JA. Utility of ChatGPT for automated creation of patient education handouts: an application in neuro-ophthalmology. *J Neuroophthalmol* 2024; 44:119–124.
77. Chang CT, Ticknor IL, Spinelli J-A, et al. Comparison of large language models in generating patient handouts for the dermatology clinic: a blinded study. *JAAD Int* 2024;15:152–154.
78. Gold M, McLaughlin C. Assessing HITECH implementation and lessons: 5 years later. *Milbank Q* 2016;94:654–687.
79. Lyles CR, Nelson EC, Frampton S, Dykes PC, Cemballi AG, Sarkar U. Using electronic health record portals to improve patient engagement: research priorities and best practices. *Ann Intern Med* 2020;172:S123–S129.
80. Gordon NP, Hornbrook MC. Differences in access to and preferences for using patient portals and other ehealth technologies based on race, ethnicity, and age: a database and survey study of seniors in a large health plan. *J Med Internet Res* 2016;18:e50.
81. Sarkar U, Karter AJ, Liu JY, et al. The literacy divide: Health literacy and the use of an internet-based patient portal in an integrated health system-results from the diabetes study of Northern California (DISTANCE). *J Health Commun* 2010;15:183–196.
82. Goldzweig CL, Orshansky G, Paige NM, et al. Electronic patient portals: evidence on health outcomes, satisfaction, efficiency, and attitudes: a systematic review. *Ann Intern Med* 2013;159: 677–687.
83. Laukka E, Huhtakangas M, Heponiemi T, et al. Health care professionals' experiences of patient-professional communication over patient portals: systematic review of qualitative studies. *J Med Internet Res* 2020;22:e21623.
84. Carini E, Villani L, Pezzullo AM, et al. The impact of digital patient portals on health outcomes, system efficiency, and patient attitudes: updated systematic literature review. *J Med Internet Res* 2021;23:e26189.
85. Tavares J, Oliveira T. Electronic health record patient portal adoption by health care consumers: an acceptance model and survey. *J Med Internet Res* 2016;18:e49.
86. Tieu L, Sarkar U, Schillinger D, et al. Barriers and facilitators to online portal use among patients and caregivers in a safety net health care system: a qualitative study. *J Med Internet Res* 2015;17:e275.
87. Tieu L, Schillinger D, Sarkar U, et al. Online patient websites for electronic health record access among vulnerable populations: portals to nowhere? *J Am Med Inform Assoc* 2017;24: e47–e54.
88. Wildenbos GA, Peute L, Jaspers M. Facilitators and barriers of electronic health record patient portal adoption by older adults: a literature study. *Stud Health Technol Inform* 2017;235: 308–312.
89. Peacock S, Reddy A, Leveille SG, et al. Patient portals and personal health information online: perception, access, and use by US adults. *J Am Med Inform Assoc* 2017;24:e173–e177.