CDSS for Opioid Use Disorder

Naga Praneeth Cheela, Harshitha Kandi, Prakashini Reddy Kottha, Divya Sri Mukku, Sai Kavya Muthyala, Leelamrutha Vanamu, Venkata Pavan Kumar Reddy Yeruva

Department of Health Informatics, IUPUI

INFO B642: Clinical Decision Support Systems

Josette Jones, RN, Ph.D., FAMIA

May 02, 2024

Introduction

"A clinical decision support system is defined as software that is designed to be a direct aid to clinical decision-making, in which the characteristics of an individual patient are matched to a computerized clinical knowledge base, and patient-specific assessments or recommendations are then presented to the clinician or the patient for a decision" (Sim et al., 2001, p. 528). CDSSs have been categorized and subdivided into various types based on factors such as intervention timing and delivery method. They are often classified as knowledge-based or non-knowledge based. In our system, we have developed a knowledge-based approach, wherein rules (IF-THEN statements) are created. The system retrieves data to evaluate these rules and generates an action or output accordingly. These rules can be derived from literature-based evidence, practice-based experience, or patient-directed evidence (Sutton et al., 2020).

This paper will explore the significant role of CDSS in tackling major public health issues, specifically focusing on OUD. OUD is a chronic, relapsing condition marked by an uncontrollable compulsion to use opioid drugs, despite adverse consequences. It arises from a complex interplay of genetic, environmental, and psychosocial factors ranging from genetic predispositions affecting the brain's reward systems to external pressures such as availability of drugs and social influences (Hasan et al., 2021).

Approximately 16 million people globally suffer from OUD its prevalence poses a substantial global health concern, with over 500,000 deaths attributed to opioid overdose annually underscoring the severity of the issue (United Nations Office on Drugs and Crime, 2021). Current treatment protocols often exhibit a fragmented approach, lacking cohesion between pharmacological therapies (such as Methadone and Buprenorphine) and non-pharmacological interventions (like cognitive-behavioral therapy). This disjunction not only

heightens the healthcare burden but also diminishes the effectiveness of interventions. Data shows that less than 20% of individuals with OUD receive any form of treatment, and among those treated, the relapse rate within six months post-treatment is as high as 80% (SAMHSA, 2022). There is an urgent need for a standardized approach that facilitates early detection and integrated treatment. In addressing this challenges, CDSS emerge as valuable tools for general practitioners.

This paper discusses about the implementation of Clinical Decision Support System which addresses this necessity by developing evidence-based Clinical Decision Rules that include both the identification of pre-clinical risk factors and the deployment of cohesive, personalized treatment strategies, aiming to enhance intervention efficacy and reduce the healthcare impact of OUD.

Research Question

~~***How can CDSS be effectively developed and implemented to improve the early diagnosis and management of Opioid Use Disorder thereby providing valuable support for healthcare professionals?***~~

Objective

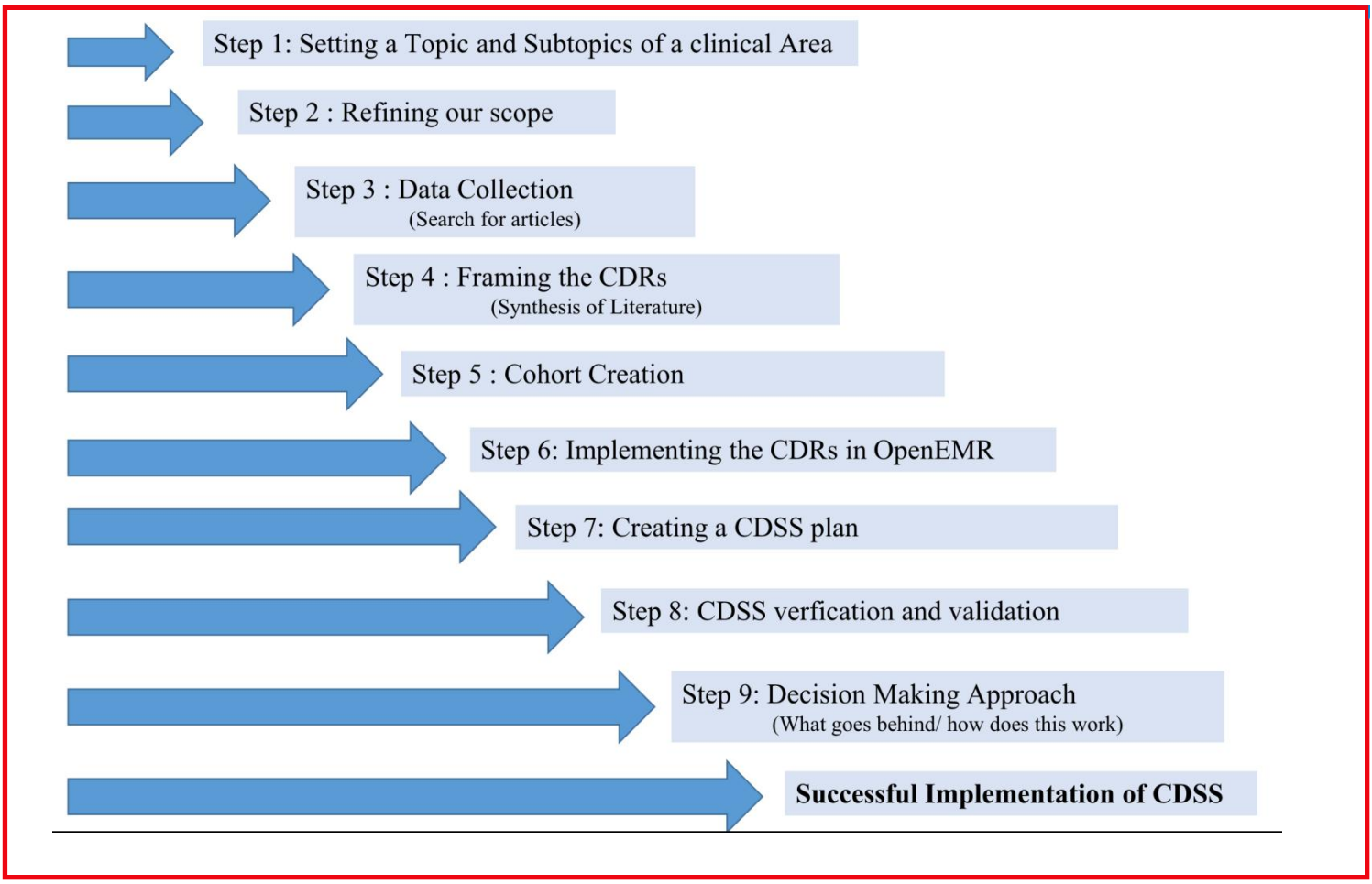
The objective of our project is to create Clinical Decision Support System that encompasses various aspects of medical management, from pre-clinical manifestations and diagnostic criteria to management strategies, both pharmacological and non-pharmacological. The first CDSS plan aims to identify and describe the early signs and risk factors (pre-clinical manifestations) that could indicate a higher probability of a patient developing OUD before clinical diagnosis. It will focus on developing a set of diagnostic criteria to screen and identify

individuals at risk for OUD. This plan will concentrate on identifying early signs and behaviors that may indicate a predisposition to OUD, creating standardized methods for healthcare providers to screen for OUD even in patients who may not present obvious symptoms of substance abuse, and establishing clear guidelines that clinicians can use to assess the risk of OUD. The second CDSS plan will outline effective pharmacological and non-pharmacological strategies to treat individuals diagnosed with OUD. It will encompass a broad range of pharmacological treatments aimed at addressing the physiological aspects of OUD and non-pharmacological strategies that support the psychological and social facets of recovery. We have also considered comorbid conditions, the drug of choice in case of ineffective treatment, and special pregnancy. This balanced and integrated approach to treatment ensures that individuals diagnosed with OUD receive a holistic and personalized management plan. These CDSS rules represent a stride towards a more effective response to the OUD epidemic. They reflect an evidence-based, patient-centered approach that emphasizes early detection and comprehensive care. The anticipated outcome is a reduction in the incidence and impact of OUD, with the ultimate goal of improving patient outcomes and quality of life while reducing the societal and healthcare burden posed by opioid addiction.

Methods

This section describes our journey of developing a CDSS for OUD. It outlines how relevant information is gathered for creating individual CDRs, how we implemented them in the OpenEMR and how we constructed a comprehensive CDSS plan.

Below is the figure which depicts the steps we followed.



Step 1: Setting a Topic and Subtopics of a clinical Area

Our main topic of focus is Opioid Use Disorder, under which our two sub-topics: First, Preclinical symptoms and Diagnostic Criteria, and second, Management including both Pharmacological and Non-Pharmacological approaches.

Step 2: Refining the Scope

Choosing a demographic criterion

Initially, we examined the demographic most impacted by Opioid Use Disorder. Our investigation revealed that numerous studies indicate the highest rates of opioid misuse and dependence occur among young adults aged 18–25. This age group is notably more prone to

initiating or escalating substance use compared to other demographics (Lu et al., 2023; Rath et al., 2022; SAMHSA, 2023).

Step 3: Data Collection

Criteria we followed for searching articles:

I. We ensured that all articles were published from 2018 onwards to guarantee access to the latest medical and scientific research.

II. We compiled articles pertaining to the risk factors associated with Opioid Use Disorder and treatment. Relevant data was sourced from databases including PubMed, OVID, and Science Direct. We cross-referenced the information obtained from these articles with resources such as UpToDate and standard sources like CDC, American Society of Addiction Medicine's treatment recommendations for OUD and American Lung Association.

III. Search keywords included OUD, Young adults, Risk factors, pre-clinical symptoms, diagnostic criteria, treatment, management, pharmacological interventions, and non-pharmacological approaches.

Step 4: Framing the CDRs (Synthesis of Literature)

This section focuses on the comprehensive process of information gathering and its transformation into CDRs and a CDSS. It outlines the specific information we utilized from various data sources and how this information is instilled into our CDRs.

For framing CDR 1

Research indicates a complex interplay between substance use, mental health diagnoses, and opioid misuse. Factors such as past or current substance abuse, untreated psychiatric disorders, younger age, and early childhood sleep problems contribute to an increased risk of

opioid misuse and opioid-use disorder. Depression appears to have a bidirectional relationship with opioid use, with approximately one-third of long-term opioid users with concurrent depression meeting criteria for OUD. Moreover, over half of individuals diagnosed with OUD also have co-morbid depression. PTSD is also associated with a higher prevalence of OUD, possibly due to abnormalities in the endogenous opioid system. Family history of substance abuse, disturbances in circadian rhythms and sleep, and tobacco use are identified as general risk factors for OUD. In individuals with pain conditions, the relationship between mood/anxiety, pain, and medication-seeking behavior is intricate, with chronic opioid use affecting mood, anxiety, and the functioning of the endogenous opioid system. Integrating these findings suggests that addressing mental health issues, early childhood sleep problems, and substance abuse prevention, particularly in individuals with depression or PTSD, may help mitigate the opioid epidemic and improve patient outcomes (Alhammad et al., 2022; Bernardy et al., 2019; Cheatle et al., 2020; Cragg et al., 2019; Fathi et al., 2020; Hasin et al., 2022; Tumenta et al., 2021).

From this literature, we considered factors like history of opioid use, untreated depression, post-traumatic stress disorder, family history of substance abuse, sleep disturbances, tobacco use and current opioid use for pain to frame our 7 clinical decision rules on Pre-clinical Manifestations and Diagnostic Criteria in Young Adults.

	Demographics	Target	Action	Message to Physician
Praneeth	18-25	H/O OU	Screen for OUD	Patient is 18-25 years and has a history of OU. Please screen for OUD.
Harshitha	18-25	H/O OU + Untreated Depression	Screen for OUD	Patient is 18-25 years, has a history of OU, and untreated depression. Please screen for OUD.
Prakashini	18-25	H/O OU + Post traumatic stress disorder	Screen for OUD	Patient is 18-25, has a history of opioid use, and post-traumatic stress disorder. Please screen for OUD
Divya	18-25	H/O OU + Family history of substance abuse	Screen for OUD	Patient is 18-25, has a history of opioid use, and family history of substance abuse. Please screen for OUD.
Kavya	18-25	H/O OU + Sleep disturbances	Screen for OUD	Patient is 18-25, has a history of opioid use, and sleep disturbances. Please screen for OUD
Pavan	18-25	H/O OU + Tobacco Use	Screen for OUD	Patient is 18-25, has a history of opioid use, and uses Tobacco. Please screen for OUD.
Leelamrutha	18-25	Currently using opioids > 30 days	Screen for OUD	Patient is 18-25 and currently using opioids for more than 3 years. Please screen for OUD.

For Framing CDR 2

Researchers considered Methadone as a gold standard medication for treating Opioid Use Disorder, approved by the FDA for this purpose. It serves as a crucial element within a comprehensive treatment framework, which integrates counseling and various behavioral health therapies to offer patients a holistic approach to recovery. Studies have shown that combining Physician Management with Cognitive Behavioral Therapy yields superior outcomes in terms of abstinence from all forms of substance abuse, particularly among individuals with primary prescription opioid use, compared to Physician Management alone. Potential contraindications to

methadone usage encompass allergies, acute asthma, elevated CO2 levels due to lung disease, and paralytic ileus. In such cases, administering methadone requires careful consideration, often necessitating lower doses and heightened caution. Studies say that transitioning from methadone to buprenorphine frequently occurs due to the occurrence of side effects associated with methadone. Buprenorphine/naloxone and methadone are recommended as the primary and secondary treatment choices, respectively, according to clinical guidelines. If these treatments prove ineffective, a trial of oral slow-release morphine is advised. Furthermore, a case study suggests that once-daily sustained-release oral hydromorphone could be a promising alternative treatment for patients with OUD who do not respond well to or tolerate first-line therapies. Constipation is notably common among patients undergoing methadone maintenance treatment, with an estimated prevalence of opioid-induced constipation around 40%. Despite its frequent occurrence as a side effect of opioid substitution therapy, constipation remains a problem that is often overlooked, inadequately diagnosed, and insufficiently addressed within the addiction treatment domain. While the existing evidence is constrained, the data available imply that utilizing naltrexone during pregnancy could be a viable option for Medications for Opioid Use Disorder, showing favorable perinatal outcomes when compared to methadone or buprenorphine (Atluru et al., 2024; Azhar et al., 2020; Braithwaite et al., 2019; Kennalley et al., 2023; Lintzeris et al., 2018; Sason et al., 2021; Sofuoglu et al., 2018)

Using the above information we collected from the articles we created 7 clinical decision rules for management of OUD including the pharmacological and non pharmacological approaches. The first CDR recommends prescribing Methadone, the gold standard treatment, alongside behavioral therapy for effective OUD management as a second CDR. The third CDR advises adjusting Methadone dosage cautiously in patients with co-morbid asthma, where it is

contraindicated. The fourth CDR suggests transitioning to Buprenorphine if Methadone side effects arise, fifth CDR focused on constipation side effect, suggesting to prescribe osmotic laxatives. In cases of Methadone ineffectiveness, the sixth CDR proposes a trial of Slow-release Oral Morphine. The seventh CDR addresses the special population of pregnant women with OUD, suggesting Naltrexone as a suitable medication option.

	Demographics	**Target**	**Action**	**Message to Physicians**
Kavya	18-25	OUD	Methadone	Patient has OUD. Prescribe Methadone
Leelamrutha	18-25	OUD	Behavioral Therapy	Patient has OUD. Recommend Behavioral Therapy
Prakashini	18-25	OUD+ Asthma	Start methadone with low doses	Patient has OUD and Asthma. Start Methadone with low doses
Divya	18-25	OUD + Methadone side effects	Switch to buprenorphine	Patient has OUD and side effects to Methadone. Switch to Buprenorphine
Praneeth	18-25	OUD + Methadone causing constipation	Prescribe osmotic laxative	Patient has OUD and has constipation due to Methadone. Prescribe Osmotic Laxative like polyethylene glycol
Pavan	18-25	OUD +Methadone not effective	Prescribe slow-release oral morphine	Patient has OUD and Methadone is not effective. Prescribe Slow-release Oral Morphine
Harshitha	18-25 Female	OUD+Pregnant women	Naltroxene	Patient has OUD and is pregnant. Naltrexone is a better treatment option

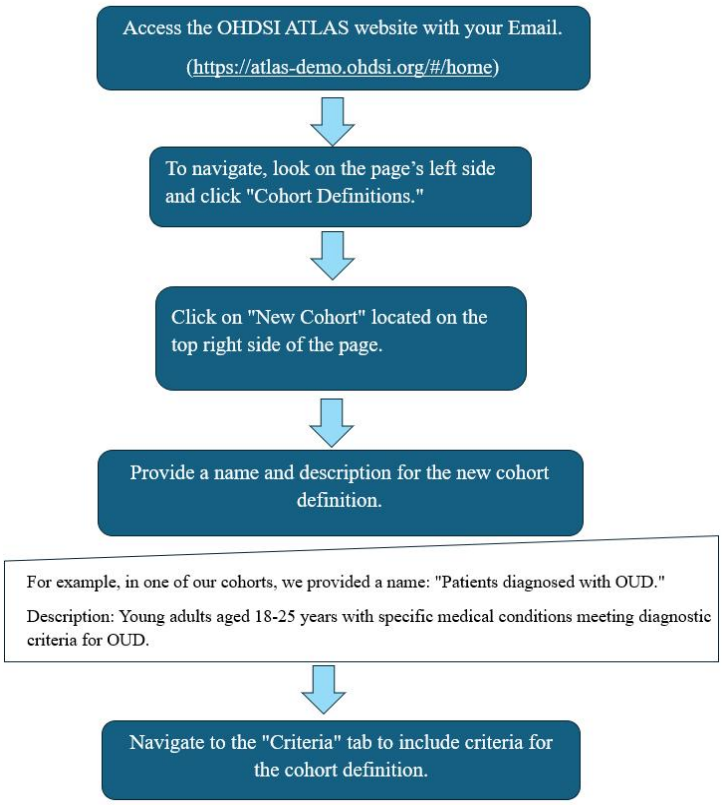
Step 5: ATLAS Cohort Creation and Selection

Creating cohorts is essential when using observational data for research purposes because it allows researchers to define and identify specific groups of interest within a larger dataset. Cohort creation enables researchers to precisely define the population they want to study.

Search for Cohort: Firstly before creating the cohort, we need to search if we have any cohort related to our CDSS. We searched and we could not find it, later created a cohort using the below steps

Cohort Creation: Here we are taking our CDSS for diagnosis as an example to explain how we created the cohorts in ATLAS. The site for OHDSI ATLAS website is (https://atlas-demo.ohdsi.org/#/home)

The image below shows the steps to be taken for creating a cohort.



Adding Criteria:

Add the following criteria to define the cohort:

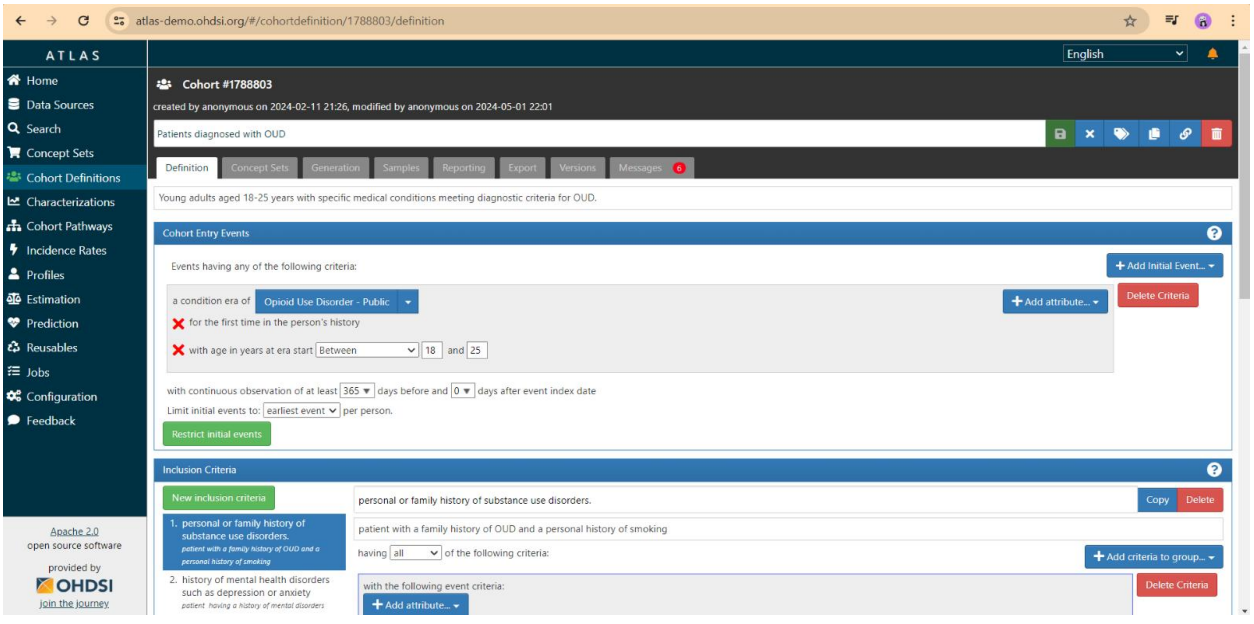
- Age Criteria: Include individuals aged 18 to 25 years.
- Diagnosis of OUD: Include individuals with documented diagnosis of OUD
- High-Risk Factors: Include individuals with documented high-risk factors such as substance use disorders, mental health disorders, history of trauma or adverse childhood experiences. -----> Review and Save

Criteria for ATLAS Cohort Creation For Our CDSS

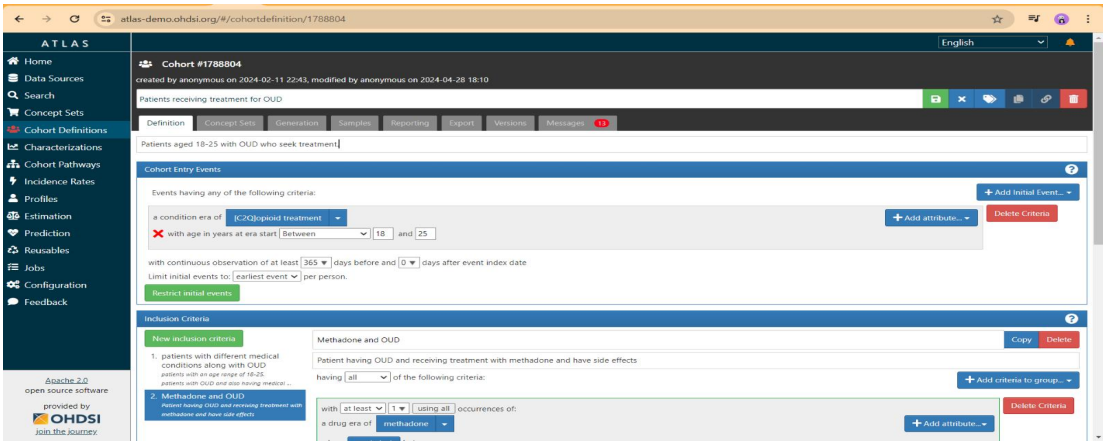
ATLAS sections	Cohort 1 for CDSS 1	Cohort 2 for CDSS 2
Cohort Entry Events	People with continuous observation of 365 days before event may enter the cohort when observing any of the following: • Condition era of 'Opioid Use Disorder - Public' for the first time in the person's history, who are between 18 and 25 years old. • Limit cohort entry events to the earliest event per person.	People with continuous observation of 365 days before event may enter the cohort when observing any of the following: • Condition eras of '[C2Q]opioid treatment', who are between 18 and 25 years old. • Limit cohort entry events to the earliest event per person.
Inclusion Criteria	• Personal or family history of substance use disorders • History of mental health disorders such as depression or anxiety • History of trauma or adverse childhood	• Patients with different medical conditions along with OUD (asthma and pregnancy) • Methadone and OUD • Methadone and OUD with side effects

	experiences • OUD diagnosis through a comprehensive evaluation for Opioid use. • Patients with sleep disturbances and OUD.	
Cohort Exit	Death by any form or at the end of continuation observation	Death by any form or at the end of continuation observation
Cohort Eras	Entry events will be combined into cohort eras if they are within 30 days of each other.	Entry events will be combined into cohort eras if they are within 30 days of each other.

Cohort for CDSS 1: Patients diagnosed with OUD



Cohort for CDSS 1: Patients diagnosed with OUD



Step 6: Implementing the CDRs in OpenEMR

Based on the insights gathered from the articles, each team member formulated two Clinical Decision Rules: one addressing pre-clinical manifestations and diagnostic criteria, and the other focusing on treatment strategies including both pharmacological and non-pharmacological.

i. We're all provided with credentials to access openEMR for creating our rules

ii. We followed this path: Admin---->Practice------>Rules

iii. We ensured that we have gathered all the necessary information to complete the fields.

iv. We were given the Clinical Decision Rules Manual as part of our materials, which we utilized to progress further.

v. The fields are

   a) **Summary**

i. *Title:* Each team member choose a particular titles associated with different risk factors (CDR -1) and management approaches (CDR-2) concerning Opioid Use Disorder.

ii. *Bibliographic Citation:* We included the references of the articles we selected.

iii. *Developer:* Name of the team member who created it.

iv. *Funding Source:* We entered "NIL" into this field.

v. *Release:* After reviewing the CDR manual, we retained version 1.1.

vi. *Web Reference:* We provide the Link for article we selected in this section.

vii. *Referential CDS:* We were unable to locate appropriate reference CDs codes for our rules. Consequently, we opted for ICD-10 codes relevant to Opioid Use Disorder. For instance, when searching RxNorm for methadone, we did not find any suitable codes.

b) **Reminder Intervals:** It has two sub sections to fill, one Clinical Warning and Past Due; and Patient Warning and Past Due. We incorporated only values related to clinical warnings and past due notifications into the our CDRs avoiding patient's as our CDR only notifies to the physician but nothing to the patient.

c) Demographics filter criteria

i. *Age:* Each of us incorporated the age range of 18-25.

ii. *Gender:* In one of our CDRs for CDSS 2, which involved pregnant women, we selected the female gender.

iii. *Lifestyle:* For CDR-1, we included sleep disturbances, recreational drugs and tobacco use as risk factors in three of our rules, so we included them here.

d) Target/Action Groups

i. Clinical target: This section indicates the targets of our CDR, we included the medical condition in this field. For example, one of our CDRs dealt with young adults with depression so we have included depression in this field, where all patients with depression are filtered here.

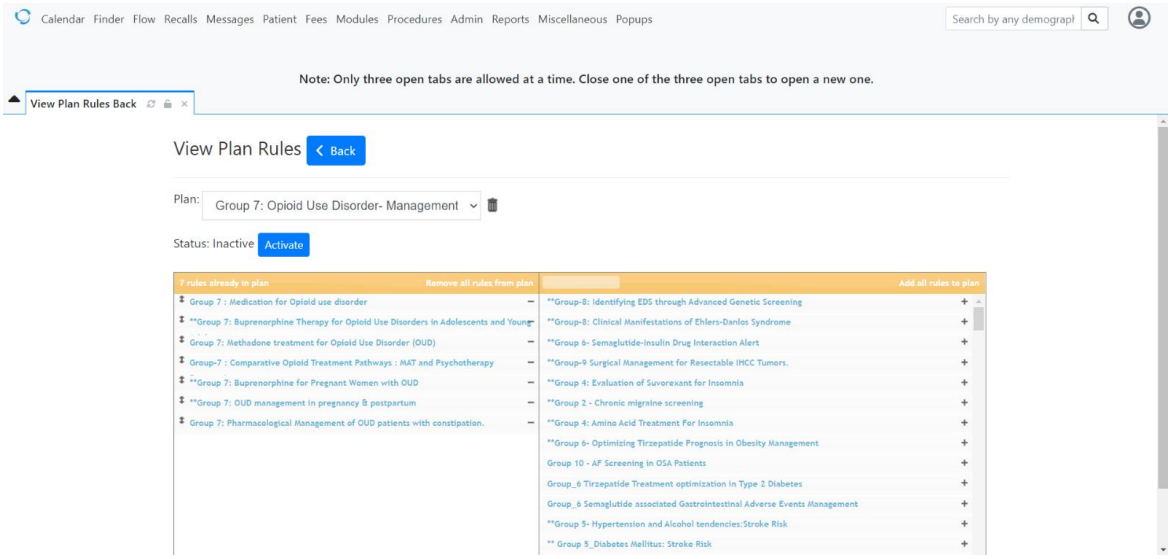
ii. Clinical Action: In this section, we need to input the actions to be carried out by the physician. Building upon the previous example, if patients with depression are filtered, the action of the rule, which is "Screen for Opioid Use Disorder," must be inserted in this section.

Step 7: Creating the CDSS Plan

To create a CDSS plan, it was important that all formulated rules were accurate. Initially, we encountered challenges in crafting a plan. However, we successfully developed one by introducing distinct categories and items, by adding our names at the end. This ensured that each team member could exclusively utilize their designated category and item.

We integrated all our CDR 1's into a CDSS plan "Opioid Use Disorder- Pre-clinical manifestations and diagnostic criteria" and all our CDR 2's into a CDSS plan "Opioid Use Disorder- Management (pharmacological and non-pharmacological)"

Here is an image of our CDSS for Management:



Step 8: CDSS Verification and Validation

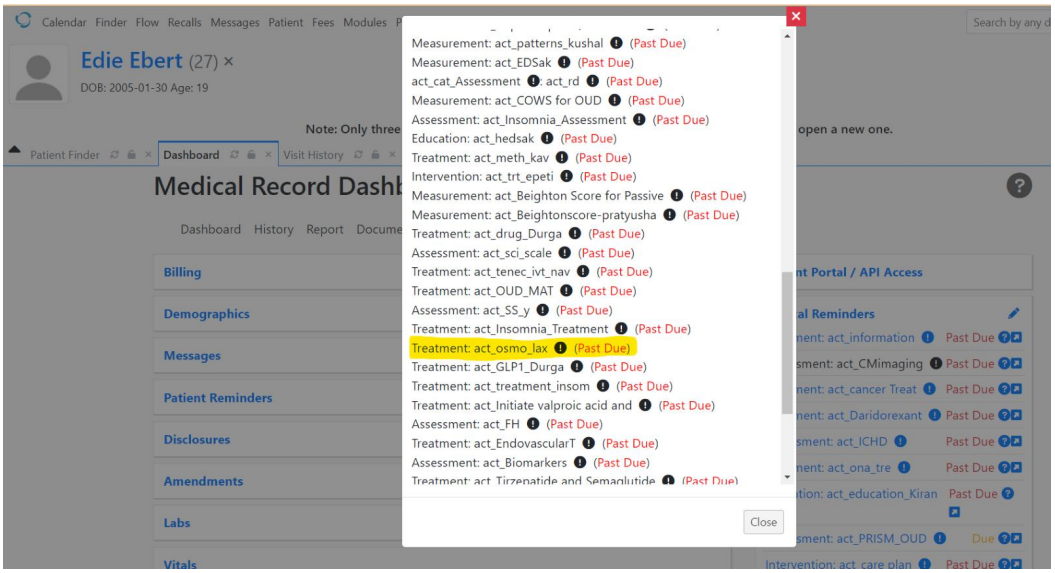
Utilizing feedback from peers and literature, we improved the inclusivity and depth of our study by refining the objectives and functionality of both the CDSS prototypes.

To assess the validity of our created CDSS, we propose evaluating its performance by identifying patients within the age group of 18-25 with relevant medical conditions (target conditions). If no such patients are found, we can artificially create a patient with these conditions to test the CDSS response.

Specifically, we aim to validate a rule stipulating that patients aged 18-25 with Opioid Use Disorder (OUD), using methadone, and experiencing constipation should be prescribed osmotic laxatives. To confirm this rule's effectiveness, we need to find a patient aged 19 with OUD, using methadone, and suffering from constipation, and observe if the CDSS triggers the

suggested prescription. However, during testing, we observed the rule triggering for patients within the specified age range without considering other relevant factors.

Below is an image of our CDSS verification in OpenEMR.



Step 9: Decision Making Approach (How goes behind/How does this work)

A decision rule serves as a structured representation of knowledge within a specific domain, encapsulating the logical sequence utilized in deterministic reasoning for decision-making. Essentially, decision rules function similarly to algorithms, often depicted as discriminative questions or conditional IF-THEN statements guiding the path toward reaching a conclusion. In systems employing production rules, each unit of knowledge is expressed as an individual IF-THEN logical statement. An inference engine evaluates the existing data and statements, determining which statement to execute next based on the available information (Jenders, 2014).

CDSS Plan: ***Opioid Use Disorder- Pre-clinical manifestations and diagnostic criteria***

The production rules that runs at the back are:

IF (Age between 18 and 25 AND History of Opioid Use) THEN CONCLUDE “Patient is 18-25 and has a history of opioid use. Please screen for OUD”

IF (Age between 18 and 25 AND History of Opioid Use AND Untreated Depression) THEN CONCLUDE “Patient is 18-25, has a history of opioid use, and untreated depression. Please screen for OUD.”

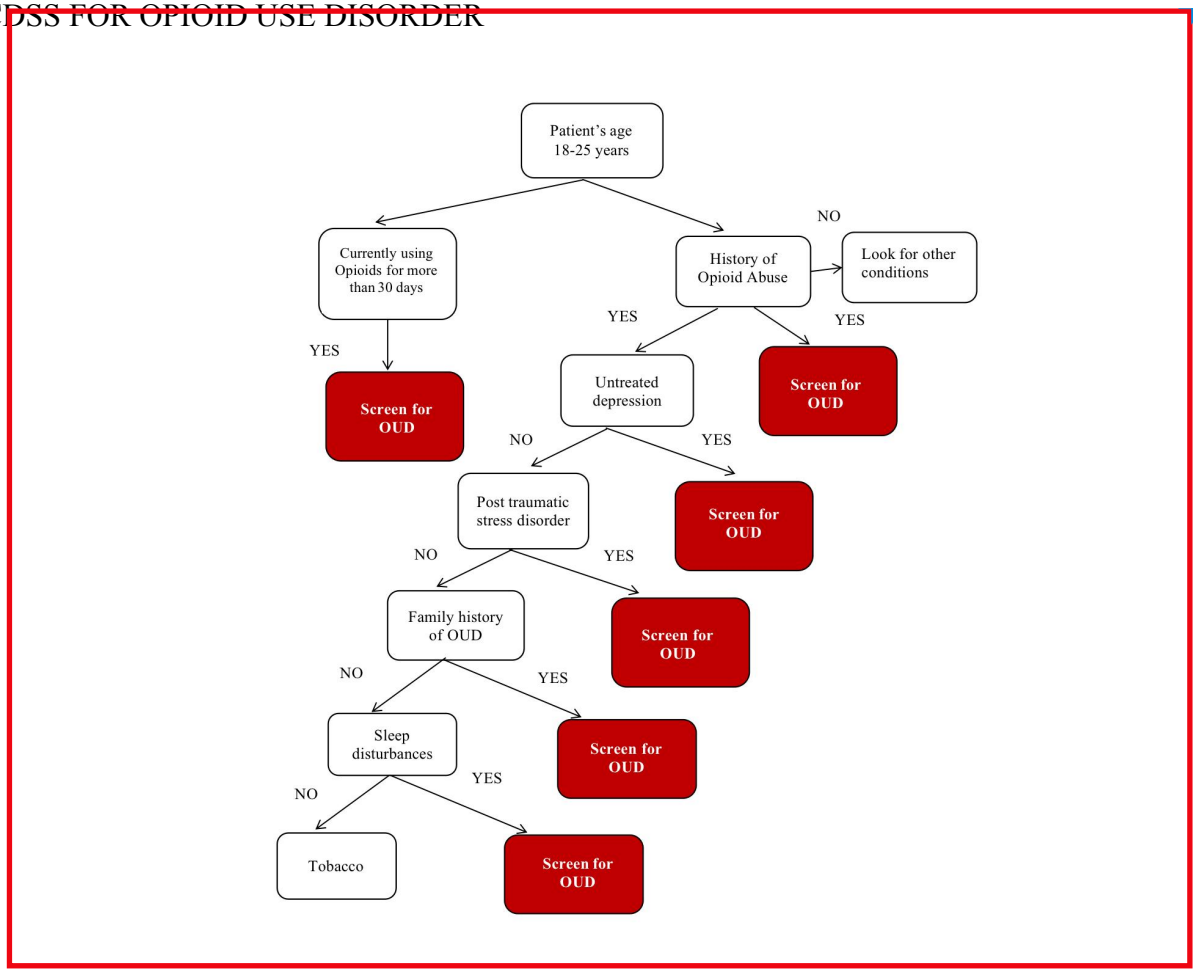
IF (Age between 18 and 25 AND History of Opioid Use AND Post Traumatic Stress Disorder) THEN CONCLUDE “Patient is 18-25, has a history of opioid use, and post-traumatic stress disorder. Please screen for OUD.”

IF (Age between 18 and 25 AND History of Opioid Use AND Family History of OUD) THEN CONCLUDE “Patient is 18-25, has a history of opioid use, and family history of substance abuse. Please screen for OUD.”

IF (Age between 18 and 25 AND History of Opioid Use AND Sleep Disturbances) THEN CONCLUDE “Patient is 18-25, has a history of opioid use, and sleep disturbances. Please screen for OUD.”

IF (Age between 18 and 25 AND History of Opioid Use AND Tobacco Use) THEN CONCLUDE “Patient is 18-25, has a history of opioid use, and uses tobacco. Please screen for OUD.”

IF (Age between 18 and 25 AND Currently using opioids for more than 3 years) THEN CONCLUDE “Patient is 18-25 and currently using opioids for more than 3 years. Please screen for OUD.”



The functionality of the Decision Tree for Diagnosis

When a patient consults a physician, if their age falls within the range of 18-25, they are filtered. If they have a history of opioid abuse, they receive an alert prompting screening for OUD. If no history is present, screening for other conditions is initiated. In the case where the patient has a history of opioid abuse and untreated depression, an alert is triggered for OUD screening. *If NO, the system moves to evaluate the next risk factor,* such as post-traumatic stress disorder. If the patient exhibits this condition along with a history of opioid use, an alert prompts OUD screening, continuing this process for subsequent steps. Another branch of the decision tree involves patients aged 18-25 who have been using opioids for more than thirty days. In this scenario, they receive an alert to undergo screening for OUD.

CDSS Plan: ***Opioid Use Disorder- Management (pharmacological and non-pharmacological)***

The production rules that runs at the back for this CDSS plan:

IF (Age between 18 and 25 AND Diagnosed with Opioid Use Disorder) THEN CONCLUDE "Patient has OUD. Prescribe Methadone."

IF (Age between 18 and 25 AND Diagnosed with Opioid Use Disorder) THEN CONCLUDE "Patient has OUD. Recommend Behavioral Therapy."

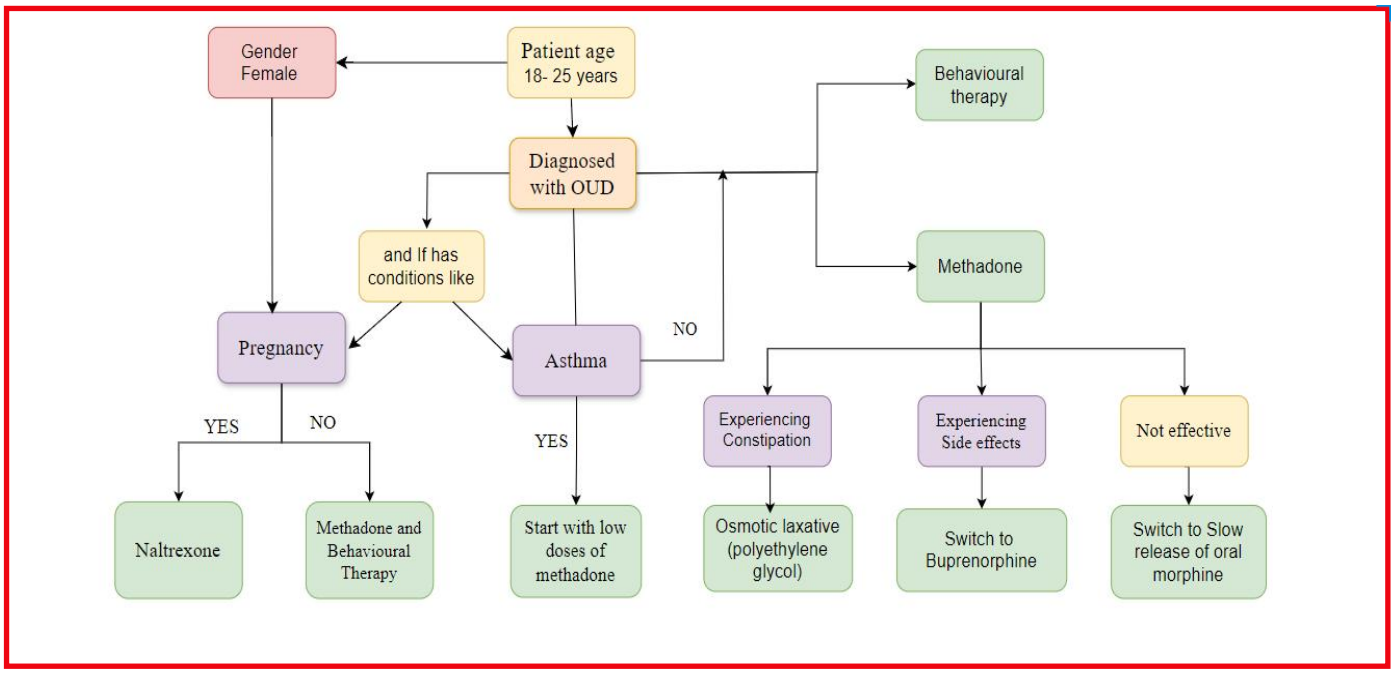
IF (Age between 18 and 25 AND Diagnosed with Opioid Use Disorder AND Asthma) THEN CONCLUDE "Patient has OUD and Asthma. Start Methadone with low doses"

IF (Age between 18 and 25 AND Diagnosed with Opioid Use Disorder AND Experiencing Methadone Side Effects) THEN CONCLUDE "Patient has OUD and side effects to Methadone. Switch to Buprenorphine."

IF (Age between 18 and 25 AND Diagnosed with Opioid Use Disorder AND Experiencing Methadone-Induced Constipation) THEN CONCLUDE "Patient has OUD and has constipation due to Methadone. Prescribe Osmotic Laxative like polyethylene glycol."

IF (Age between 18 and 25 AND Diagnosed with Opioid Use Disorder AND Methadone is Ineffective) THEN CONCLUDE "Patient has OUD and Methadone is not effective. Prescribe Slow-release Oral Morphine."

IF (Age between 18 and 25 AND Female AND Diagnosed with Opioid Use Disorder AND Pregnant) THEN CONCLUDE "Patient has OUD and is pregnant. Naltrexone is a better treatment option."



The functionality of the Decision Tree for Management

When a patient diagnosed with OUD consults a physician, this decision tree facilitates the selection of appropriate treatment options tailored to the individual patient. For such patients, our CDSS prompts the physician to administer Methadone and behavioral therapy, recognized as the first line treatment options. If the patient presents with a co-morbid condition like asthma, the physician receives an alert indicating his patient has asthma alongside OUD, advising initiation of Methadone at low doses. In cases where Methadone proves ineffective, an alert prompts consideration of alternative treatment options such as slow-release oral morphine. If the patient experiences constipation, the physician is alerted to prescribe an osmotic laxative. In instances where the patient encounters side effects, the physician is advised to transition from Methadone to buprenorphine. For pregnant women diagnosed with OUD, the CDSS alerts the physician to prescribe Naltrexone.

Discussion

This section of the paper provides an evaluative and reflective analysis, addressing the limitations of the project, future requirements and potential directions, significant implications for practical application or scientific advancement from the study.

Limitations of our Project

While our CDSS prototype represents a significant advancement in addressing opioid use disorder management, it is essential to acknowledge several limitations that may impact its effectiveness and comprehensiveness.

1. *Limited Risk Factors Inclusion in our CDSS 1*: The scope of risk factors included in our CDSS was restricted due to space constraints, allowing for the incorporation of only seven

primary risk factors for OUD. Despite covering the main risk factors comprehensively, there is a possibility that other significant risk factors were overlooked. Researchers have highlighted additional factors such as childhood adversity, mood fluctuations, unemployment, and numerous others, all of which are crucial consideration for inclusion in our paper (Webster, 2017).

2. *Incomplete Coverage of Comorbidities and Specific Population Groups in CDSS 2:* Despite prioritizing comorbidities such as asthma and unique populations like pregnancy in our CDSS 2, there remains a possibility that other comorbidities and specific population groups relevant to OUD therapy were not adequately addressed. Chronic pain, lasting for three months or more, is a notable comorbid condition among individuals with opioid use disorder, highlighting the importance of considering such factors (Ellis et al., 2020). Additionally, OUD patients with Acute Myocardial Infarction exhibit comparable mortality rates but experience superior cardiovascular outcomes compared to non-OUD patients (Ascandar et al., 2023).

3. Narrow Scope of Treatment Options: Our CDSS prototype may have overlooked additional efficient treatment methods for OUD since it only contained first-line medications including buprenorphine, methadone, naltrexone, and behavioral therapy. Additionally, our CDSS lacked consideration for treating co-morbid conditions, such as depression, which is prevalent among OUD patients, potentially necessitating the prescription of antipsychotics, as highlighted by Ronsley et al. (2020).

4. *Lack of Relevant Criteria in Existing Cohorts in ATLAS*: Despite efforts to utilize ATLAS cohorts, we encountered challenges in finding comprehensive criteria related to our CDSS

topic within existing concept sets, limiting the integration of real-world data into our prototype.

5. *Technical Challenges Encountered with OpenEMR Integration:* During the initial stages, we encountered obstacles integrating our CDRs with OpenEMR, stemming from both errors on our part and occasional glitches within the OpenEMR system. Additionally, we faced difficulties in fully integrating bibliographic citations and inserting category and items. Eventually, we devised a solution by creating unique categories and items, ultimately enabling us to generate a complete CDR.

Understanding these constraints is crucial for refining and enhancing our CDSS to better serve patients and healthcare providers alike.

Future Needs and Directions

As we look towards the future of our CDSS for OUD management, it becomes evident that continued evolution and enhancement are essential to meet the evolving needs of patients and healthcare providers.

- *Continuous Updates and Knowledge Maintenance:* To keep the CDSS accurate and up to date for diagnosing and treating OUD and recommending suitable treatments, it is imperative that it receives regular updates including the most recent evidence-based research and guidelines.

- *Proactive Identification of At-Risk Individuals:* Health systems must identify patient characteristics associated with future OUD to prevent opioid addiction among naive

populations. This involves developing interventions to provide additional support and outreach to those most at risk of addiction.

- *Seamless Integration with Telehealth Platforms:* Enhancing the CDSS interface to seamlessly integrate with telehealth platforms is crucial. This integration enables remote management and monitoring of patients with OUD, particularly in rural or underserved areas, ensuring continuous care and support.

By prioritizing these areas, we can ensure that our CDSS remains a valuable tool in the ongoing battle against OUD while upholding the highest standards of care and ethics.

Critical Implications

The implementation of our CDSS for OUD management carries profound implications that extend far beyond the realm of healthcare technology. By streamlining decision-making processes.

1. *Reducing Physician Burnout:* By simplifying decision-making procedures and lowering cognitive burden, implementing alerts with up-to-date information through our CDSS will lessen physician burnout and eventually improve the well being of healthcare professionals.

2. *Enhancing Patient Care:* Beyond the benefits to doctors, patients with opioid use disorder OUD greatly benefit from the timely warnings offered by our CDSS. This is because it guarantees that patients receive appropriate and timely therapy for their chronic illness, potentially enhancing their overall quality of life and health outcomes

3. *Preventing Medication Errors:* Our CDSS has the ability to drastically lower medication errors and inaccuracies by offering real-time information and alarms, protecting patient safety and minimizing adverse drug events related to OUD treatment.

4. *Preventing Information Oversight:* Our CDSS plays a critical role in preventing doctors from overlooking crucial patient data, including comorbidities, social history (such as tobacco use), and pregnancy status. By incorporating this information into the alert system, physicians can readily access and consider these factors when making clinical decisions.

Conclusion

Throughout the process of developing our CDSS, we have encountered numerous learning opportunities. We've come to realize that data collection entails more than just selecting articles; it necessitates rigorous comparison with established guidelines and other CDSSs like UpToDate. We were introduced to the new concept of an aggregate database known as ATLAS, and comprehended its utility in enabling researchers to construct cohorts tailored to their desired study populations. Thoroughout this process we have explored the OpenEMR platform, despite encountering challenges in creating a CDR, has significantly deepened our knowledge base. We learned how important is to verify the CDSS we made. While writing this paper, we have acquired an intricate understanding of synthesis and annotations. While implementing our CDSS for OUD, we recognize the potential for enhancement by addressing additional conditions outlined in our limitations section, thereby increasing its real-world applicability. Above all, we conclude stating the critical importance of designing CDSS to deliver timely and pertinent information to clinicians, guiding decision-making at the right moment and in the appropriate context of patient care workflows.

References

Alhammad, M., Aljedani, R., Alsaleh, M., Atyia, N., Alsmakh, M., Alfaraj, A., Alkhunaizi, A., Alwabari, J., & Alzaidi, M. (2022). Family, Individual, and Other Risk Factors Contributing to Risk of Substance Abuse in Young Adults: A Narrative Review. *Cureus*, 14(12), e32316. https://doi.org/10.7759/cureus.32316

Ascandar, N., Vadlakonda, A., Verma, A., Chervu, N., Roberts, J. S., Sakowitz, S., Williamson, C., & Benharash, P. (2023). Association of opioid use disorder with outcomes of hospitalizations for acute myocardial infarction in the United States. *Clinics* (Sao Paulo, Brazil), 78, 100251. https://doi.org/10.1016/j.clinsp.2023.100251

Atluru, S., Bruehlman, A. K., Vaughn, P., Schauberger, C. W., & Smid, M. C. (2024). Naltrexone Compared With Buprenorphine or Methadone in Pregnancy: A Systematic Review. *Obstetrics & Gynecology,* 143(3), 403. https://doi.org/10.1097/AOG.0000000000005510

Azhar, N., Chockalingam, R., & Azhar, A. (2020). Medications for Opioid Use Disorder: A Guide for Physicians. *Missouri medicine*, 117(1), 59–64.

Bernardy, N., & Montano, M. (2019). Opioid Use Among Individuals with Posttraumatic Stress Disorder. https://www.ptsd.va.gov/publications/rq_docs/V30N1.pdf

Braithwaite, V., Fairgrieve, C., & Nolan, S. (2020). Sustained-release Oral Hydromorphone for the Treatment of Opioid Use Disorder. *Journal of addiction medicine*, 14(4), 345–347. https://doi.org/10.1097/ADM.0000000000000585

Cheatle, M. D., Falcone, M., Dhingra, L., & Lerman, C. (2020b). Independent association of tobacco use with opioid use disorder in patients of European ancestry with chronic non-cancer pain. *Drug and Alcohol Dependence*, 209, 107901. https://doi.org/10.1016/j.drugalcdep.2020.107901

Cragg, A., Hau, J.P., Woo, S.A., Kitchen, S.A., Liu, C., Doyle-Waters, M.M. and Hohl, C.M. (2019). Risk Factors for Misuse of Prescribed Opioids: A Systematic Review and Meta-Analysis. *Annals of Emergency Medicine*, 74(5), pp.634–646. doi:https://doi.org/10.1016/j.annemergmed.2019.04.019.

Ellis, M. S., Kasper, Z., & Cicero, T. (2020). Assessment of Chronic Pain Management in the Treatment of Opioid Use Disorder: Gaps in Care and Implications for Treatment Outcomes. *The Journal of Pain*. https://doi.org/10.1016/j.jpain.2020.10.005

Fathi, H. R., Yoonessi, A., Khatibi, A., Rezaeitalab, F., & Rezaei-Ardani, A. (2020). Crosstalk between Sleep Disturbance and Opioid Use Disorder: A Narrative Review. *Addiction & health*, 12(2), 140–158. https://doi.org/10.22122/ahj.v12i2.249

Hasan, M., Young, G. J., Shi, J., Mohite, P., Young, L. D., Weiner, S. G., & Noor-E-Alam, M. (2021). A machine learning based two-stage clinical decision support system for predicting patients' discontinuation from opioid use disorder treatment: retrospective observational study. *BMC Medical Informatics and Decision Making*, *21*(1). https://doi.org/10.1186/s12911-021-01692-7

Hasin, D. S., Shmulewitz, D., Stohl, M., Greenstein, E., Aharonovich, E., Petronis, K. R., Von Korff, M., Datta, S., Sonty, N., Ross, S., Inturrisi, C. E., Weinberger, M. L., Scodes, J., & Wall, M. M. (2022). Diagnosing prescription opioid use disorder in patients using

prescribed opioids for chronic pain. *The American Journal of Psychiatry*, 179(10), 715–725. https://doi.org/10.1176/appi.ajp.21070721

Jenders, R. A. (2014). *Chapter 15 - Decision Rules and Expressions* (R. A. Greenes, Ed.). ScienceDirect; Academic Press. https://www.sciencedirect.com/science/article/abs/pii/B9780123984760000154

Kennalley, A. L., Fanelli, J. L., Furst, J. A., Mynarski, N. J., Jarvis, M. A., Nichols, S. D., McCall, K. L., & Piper, B. J. (2023). Dynamic changes in methadone utilisation for opioid use disorder treatment: a retrospective observational study during the COVID-19 pandemic. BMJ open, 13(11), e074845. https://doi.org/10.1136/bmjopen-2023-074845

Lintzeris, Nicholas, et al. "Transferring Patients from Methadone to Buprenorphine: The Feasibility and Evaluation of Practice Guidelines." *Journal of Addiction Medicine*, vol. 12, no. 3, 2018, pp. 234–240, www.ncbi.nlm.nih.gov/pmc/articles/PMC5976217/, https://doi.org/10.1097/ADM.0000000000000396.

Lu, W., Lopez-Castro, T., & Vu, T. (2023). Population-based examination of substance use disorders and treatment use among US young adults in the National Survey on Drug Use and Health, 2011–2019. *Drug and Alcohol Dependence Reports*, *8*, 100181. https://doi.org/10.1016/j.dadr.2023.100181

Rath, J. M., Perks, S. N., Vallone, D. M., Barton, A. A., Stephens, D. K., Simard, B., & Hair, E. C. (2022). Educating Young Adults about Opioid Misuse: Evidence from a Mass Media Intervention. *International Journal of Environmental Research and Public Health*, *19*(1), 22. https://doi.org/10.3390/ijerph19010022

Ronsley, C., Nolan, S., Knight, R., Hayashi, K., Klimas, J., Walley, A., Wood, E., & Fairbairn, N. (2020). Treatment of stimulant use disorder: A systematic review of reviews. *PLOS ONE*, *15*(6), e0234809. https://doi.org/10.1371/journal.pone.0234809

Sason, A., Adelson, M., Schreiber, S., & Peles, E. (2021b). The prevalence of constipation and its relation to sweet taste preference among patients receiving methadone maintenance treatment. *Drug and Alcohol Dependence,* 225, 108836. https://doi.org/10.1016/j.drugalcdep.2021.108836

Sim, I., Gorman, P., Greenes, R. A., Haynes, R. B., Kaplan, B., Lehmann, H., & Tang, P. C. (2001). Clinical decision support systems for the practice of evidence-based medicine. *Journal of the American Medical Informatics Association*, *8*(6), 527-534.

Sutton, R., & Pincock, D. (2020). An overview of clinical decision support systems: benefits, risks, and strategies for success. *NPJ Digital Medicine*, *3*(1), 1–10. https://doi.org/10.1038/s41746-020-0221-y

Sofuoglu, M., DeVito, E. E., & Carroll, K. M. (2018). Pharmacological and behavioral treatment of opioid use disorder. *Psychiatric Research and Clinical Practice*, 1(1), 4–15. https://doi.org/10.1176/appi.prcp.20180006

Tumenta, T., Ugwendum, D. F., Chobufo, M. D., Mungu, E. B., Kogan, I., & Olupona, T. (2021). Prevalence and Trends of Opioid Use in Patients With Depression in the United States. *Cureus*, 13(5). https://doi.org/10.7759/cureus.15309

SAMHSA. (2022). *2020 NSDUH Detailed Tables. CBHSQ Data*. Www.samhsa.gov. https://www.samhsa.gov/data/report/2020-nsduh-detailed-tables

SAMHSA. (2023). *SAMHSA Announces National Survey on Drug Use and Health (NSDUH) Results Detailing Mental Illness and Substance Use Levels in 2021*. HHS.gov. https://www.hhs.gov/about/news/2023/01/04/samhsa-announces-national-survey-drug-use-health-results-detailing-mental-illness-substance-use-levels-2021.html

Webster, L. R. (2017). Risk factors for Opioid-Use Disorder and Overdose. *Anesthesia and Analgesia/Anesthesia & Analgesia*, 125(5), 1741–1748. https://doi.org/10.1213/ane.0000000000002496

World Drug Report 2021_Annex. (n.d.). United Nations : Office on Drugs and Crime. https://www.unodc.org/unodc/en/data-and-analysis/wdr2021_annex.html