Clinical Decision Support Systems for Opioid Prescribing for Chronic Non-Cancer Pain in Primary Care: A Scoping Review

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Abstract

Background and objectives: Clinical decision support systems (CDSSs) may help clinicians prescribe opioids for chronic non-cancer pain (CNCP) more appropriately. This scoping review determined the extent and range of the current evidence on CDSSs for opioid prescribing for CNCP in primary care, and whether investigators followed best evidence and current guidance in designing, implementing and evaluating these complex interventions.

Methods: We searched nine electronic databases and other data sources for studies from January 1st 2008 to October 11th 2019. Two reviewers independently screened the citations. One reviewer extracted data and a second verified for accuracy. Inclusion criteria: study of a CDSS for opioid prescribing for CNCP in a primary care clinical setting. We reported quantitative results in tables and qualitative results in narrative form.

Results: Our search yielded 5068 records of which 14 studies met our inclusion criteria. All studies were conducted in the United States. Six studies examined local (eg, health centre) CDSSs and eight examined prescription drug monitoring program (PDMP) CDSSs. Three CDSSs incorporated evidence-based components. Study aims were heterogeneous and study designs included both quantitative and qualitative methodologies. No studies assessed patient health outcomes. Few studies appeared to be following guidance for evaluating complex interventions.

Conclusions: Few studies have rigourously assessed the use of CDSSs for opioid prescribing for CNCP in primary care settings. Going forward, investigators should include evidence-based components into the design of CDSSs and follow guidance for the development and evaluation of complex interventions.
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Introduction

Two countries at the epicentre of the opioid crisis, Canada and the US, (1–4) recently released clinical practice guidelines for opioid prescribing for chronic non-cancer pain (CNCP) (5,6). These guidelines recommend against using opioid analgesics for CNCP because the harms frequently outweigh benefits (7–10). When opioids are prescribed for CNCP, the guidelines recommend risk mitigation strategies and opioid dose tapering. Both guidelines target primary care providers (PCPs), since they write about half of all opioid analgesic prescriptions in North America (11–13). However, evidence shows that PCPs may have difficulty adopting recommended clinical practices (14–21). Clinical decision support may provide assistance.

Clinical decision support systems (CDSSs) are electronic systems that assist health care providers in clinical decision-making, by providing patient-specific data at the point-of-care (14–16). Studies show that CDSSs lead to improvements in clinician performance (a care process measure), such as ordering appropriate tests and safer prescribing (17–25). Some CDSS design components are evidence-based, including; requiring a reason for an over-ride; activating automatically (i.e., the CDSS runs without requiring provider initiation); integrating into the electronic medical record (EMR); and providing advice to patients (e.g. written materials), as well as clinicians (14,20,26–28). These components lead to improvements in care process outcomes. Studies in which the CDSS evaluators are also the developers tend to show positive impact on process outcomes (26,27).

However, the impact of CDSS on important patient health outcomes or population health outcomes is unclear (17–20), and widespread adoption is often limited by implementation issues (29–34). Additionally, CDSSs can be difficult to develop and evaluate because they are complex interventions that seek to change the functioning of a complex adaptive system such as a primary care clinic (35). Therefore, the Medical Research Council in the United Kingdom (UK) recommends that researchers design and evaluate these interventions through a carefully staged series of studies targeting key uncertainties as well as a definitive evaluation (35,36). All steps should include process evaluations and assess for unintended consequences (37).

CDSSs can have a variety of roles in improving adherence to opioid prescribing guidelines for CNCP. They can be used to reduce the number of new opioid prescriptions for acute pain (38)
and to reduce the initiation of opioid prescribing for CNCP. They can also be used to improve
prescribing and other measures like risk mitigation strategies for patients already receiving
opioids for CNCP. This is the most challenging role for a CDSS these patients are at high risk of
harms and changing prescribing is very difficult (39,40).

Several studies have evaluated CDSSs for opioid prescribing for CNCP in primary care settings
(41–44). These studies report that the use of a CDSS led to a reduction in opioid prescribing or
improved adherence to clinical practice guidelines (41–44). Several studies have also evaluated
prescription drug monitoring program (PDMP) CDSSs for opioid prescribing for CNCP in
primary care settings. PDMP CDSSs are large, centralized, government-run databases that
prescribers can provide point-of-care for information on a patient’s opioid prescriptions (45,46).
While one PDMP CDSS study found that physicians wrote fewer opioid prescription in 61% of
cases, (47); another study reported no association between PDMP implementation status and
requirement levels (from no requirements to a mandatory requirement to check the PDMP before
prescribing) and physicians’ opioid prescribing for CNCP (48). Four other PDMP CDSS studies
examined PCPs’ use of, and views on PDMPs (49–52). To date, however, the literature in this
emerging field has not been systematically summarized and analyzed so the benefits and risks of
implementing a CDSS are unclear.

This scoping review determined the extent and range of the current evidence on CDSSs for
opioid prescribing for CNCP in primary care. Our secondary aim was to determine whether
researchers followed best evidence for the design of the CDSSs and current guidance for the
evaluation of complex interventions.

Methods
We conducted a scoping review using the frameworks (53,54) described by Colquhoun et al (55),
and the methods outlined by The Joanna Briggs Institute (56). We followed the reporting
guidelines from the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-
Analyses) Extension for Scoping reviews (PRISMA-ScR) (57). We created an a priori protocol
and used an iterative approach. Modifications included a secondary research aim and a change to
the data extraction plan.
**Study eligibility**: We included peer- and non-peer reviewed studies that used quantitative, qualitative and mixed-methods methodologies. We excluded non-systematic reviews, letters, opinion articles, analysis articles, clinical practice guidelines and policy documents. We included all studies where the population was PCPs (ie, family physicians, emergency medicine physicians, nurse practitioners (NPs) and primary care internists) working in a primary care setting. Studies that reported less than 50% PCPs or did not report the percentage of PCPs were excluded unless results were reported by subgroup. We included all studies that assessed a CDSS that sought to improve opioid prescribing for CNCP patients in a primary care clinical setting. We excluded studies where primary care providers were working in a secondary and tertiary settings such as a pain clinic or addiction clinic. We excluded primary care pediatric clinics. We defined a CDSS as an electronic system that assisted health care providers in clinical decision-making, by providing patient-specific data at the point-of-care (14–16). We included studies where the CDSS was integrated into the EMR, or functioned independently (eg, web-accessed), or was embedded within a larger intervention. We excluded studies where CDSS use was not specified, where it was used for another reason, or where it was not implemented in clinical settings.

**Data sources and searches**

We searched electronic databases (MEDLINE (via OVID), EMBASE, CINAHL, CENTRAL, PsycINFO and International Pharmaceutical Abstracts (via OVIDSP)) from January 1st 2008 – October 11 2019. CDSSs developed prior to this period likely evolved or became obsolete (59). We built a comprehensive search strategy, including the terms “opioid,” and “clinical decision support systems.” Since studies used a large number of different keywords and medical subject headings (MeSH) for a CDSS, we had to conduct a broad search using a large variety of terms, including: computer systems, health informatics, clinical decision making (Appendix 1 Medline search strategy). The Medline strategy (Appendix 1) was adapted for the other databases. We used the Canadian Agency for Drugs and Technologies (CADTH) approach to our grey literature search (Appendix 2 Grey literature search) (60). We also searched trial registries (ClinicalTrials.gov, World Health Organization International Clinical Trials Registry Platform
(WHO ICTRP)), checked reference lists of additional eligible studies and contacted experts (ie, lead authors on included studies, registered protocols and systematic reviews of CDSSs).

**Screening and selection**
Two researchers independently screened abstracts to determine if they met inclusion criteria. Two researchers then independently screened the full-text of all relevant articles. For both steps, after we screened 10 to 15 titles and articles, we checked inter-reviewer agreement to ensure it was least 80% before continuing further. When there were disagreements, a third researcher (MAO) assisted in making the final decision. We contacted authors for more information when full text was not available online (58).

**Data extraction**
We created and pilot-tested a data extraction form to record the following items: study population and setting, description of the intervention and implementation process, type of CDSS, inclusion of evidence-based CDSS components (components that the literature has consistently found to have an impact on outcomes: requiring a reason for an over-ride; activating automatically; integrating into the electronic medical record (EMR); and providing advice to patients and clinicians \(14,20,26–28\)), study aims, methodology and design, study outcomes, funding information, conflicts of interest, and adherence to guidance for complex interventions (eg, study was part of a stepped approach to development and evaluation; assessment for unintended consequences; planned process evaluation; process and outcome measures; theoretical approach to guide implementation and/or evaluation). One reviewer extracted data and another researcher reviewed their work (SMS, MAO, QG, SM, SH). This was a modification from our protocol that specified that two researchers would independently extract the data.

**Data synthesis**
We used a flow diagram to report on study selection. We reported quantitative data in tabular format. We wrote narrative summaries using contextual and process-oriented data. We did not conduct a detailed assessment of study quality, assess for reporting bias, or risk of bias consistent with current guidance on conducting scoping reviews \(55–57\).
Results

Our literature search identified 5068 citations from which 14 were included in the scoping review (Figure 1). Six studies examined local CDSSs (e.g., specific health system, centre or clinic) (41,43,44,61–63) while eight examined state-run, web-based, central PDMP CDSSs (47,49–52,64–66) Results using these two typologies are summarized in Table 1. Study descriptions are detailed in Appendix 3.

CDSS description

Types of CDSSs included protocols (i.e., forms that guide clinical management) in the EMR, intranet dashboards, EMR alerts, data repositories and web-based clinical tools. Four local CDSSs were integrated into the EMR (43,44,62) and two automatically activated (44,62). The other two required the PCP to activate the CDSS. Studies assessing PDMP CDSSs did not report any evidence-based design components.

Study characteristics

All studies occurred in the US and practice settings were mostly primary care clinics. Three were set in the emergency department (44,47,49). All of the local CDSSs, and three of the PDMP CDSS studies (47,64,66) were designed to assess whether a CDSS alone or incorporated into a multi-faceted intervention improved prescribing or adherence to guidelines. The remaining PDMP CDSS studies determined providers’ behaviour, knowledge of, attitudes toward and use of CDSSs. Local CDSS study designs included four pre-post interventions, a cluster RCT and a mixed-methods evaluation. The eight PDMP CDSS studies included a wide variety of study designs including: three pre-post interventions, a cross-sectional survey, two qualitative, one mixed methods and one retrospective cohort. Study aims and designs are summarized in Table 2 and described in detail in Appendix 3. One study was part of a stepped approach in evaluating a complex intervention (63). About half of the studies that assessed the impact of an intervention included a process evaluation (measures assessing if program components had been implemented
as intended) (41,43,47,49,62–64). Two studies reported using a theoretical approach in implementation and evaluation processes (61,63).

**Implementation processes**

All of the studies on local CDSSs described their implementation process, but provided little detail. None of the PDMP CDSS studies described implementation processes.

**Study Findings**

**Local CDSSs**

Anderson et al. found that the CDSS and summary reports improved compliance with guidelines (41); Canada et al. reported that a CDSS plus monetary incentives improved adherence to guidelines (43); Downes et al. found that a CDSS and electronic reports reduced opioid prescribing and increased urine drug testing and use of pain contracts (62); Gugelmann et al. found that the CDSS reduced opioid prescribing (44); Liebschutz et al. reported that a multi-faceted intervention that included a CDSS in both study arms also reduced opioid prescribing (61); and Seal et al. found in a multi-component intervention (with CDSS in both arms) that providers “abandoned use” of the CDSS (63).

**PDMP CDSSs**

Baehren et al. found that physicians who used PDMP data wrote fewer opioid prescriptions in 61% of cases and more opioid prescriptions in 39% of cases (47); Binswanger et al. found that a multi-component intervention improved adherence to guidelines (64); Chaudhary et al. found that most PCPs reported always checking the PDMP before prescribing opioids to new patients (52). Click et al. found that providers have positive views about PDMPs, but reported barriers in using them (50). Coleman et al. found that in five of seven records of patient prescribed opioids, providers accessed the PDMP (51). Freeman et al. reported that PDMPs are key tools for PCPs and that barriers include a lack of integration (65); Kohlbeck et al. reported that an educational intervention increased providers’ knowledge of, behaviour and attitudes toward PDMP CDSSs (49); Patchett et al. reported that a multi-component intervention increased use of a PDMP and led to a reduction in opioid prescribing (66).
Funding and conflict of interest

All but two local CDSS studies reported on funding for CDSS evaluation (44,62); and three others were missing information on funding for CDSS development (44,63). All PDMP studies except one (66) provided information on funding for evaluation, but none provided information on funding for development. For all six local CDSS studies, the developers were also the evaluators or the relationship was unclear or not stated. No evaluators of PDMPs provided information on their relationship to the PDMP developer (Table 3).

Discussion

We identified 14 studies published between 2009 and 2019 that examined CDSSs for opioid prescribing for CNCP in primary care clinical settings. Six of the studies examined local CDSSs (that were used locally within a specific health centre, health system or clinic) and eight examined PDMP CDSSs. Studies evaluating CDSS impact found that the CDSS (alone or more commonly, part of a dual or multi-component intervention) led to more appropriate prescribing practices and/or adherence to guidelines. Several PDMP CDSS studies assessed providers’ views on, and/or their use of PDMP CDSSs. These studies reported frequent use of the PDMP CDSS and positive views towards the CDSS with some acknowledgement of the barriers and limitations. These findings are similar to a recent qualitative rapid review that asked providers about the use of PDMPs (67). No study, however, contained an assessment of patient health outcomes or assessed for unintended consequences. Additionally, in four studies the evaluators were also the CDSS developers, a potentially useful situation but one that presents a potential conflict of interest (26,27), that was not addressed by the investigators. We also found that few CDSSs included evidence-based components and that in only one study investigators reported following current guidance for development and evaluation of complex interventions (35,36).

Our finding that there were only 14 studies, and only one RCT, which met our inclusion criteria is surprising. In contrast, a 2015 systematic review found seven RCT studies of CDSSs for antibiotic prescribing by primary care providers (28). There may be several contributing factors. The prescription opioid crisis only gained widespread attention in the last decade (68), and it
takes time to develop a complex intervention like a CDSS (36). It is also possible that some CDSSs failed to show promise early on and development was subsequently stalled or halted. Accordingly, there are a number of reports on the development of a CDSS for opioid prescribing for CNCP where clinical outcomes have not been reported yet (69–72). And finally, it is possible that CDSSs are being used without an evaluation plan, as has occurred with many PDMP CDSSs (73). This may be because of a demand for immediate solutions to the opioid crisis and an evaluation of a CDSS takes significant time and money. However, since CDSSs frequently do not improve patient outcomes (17–20), and may lead to unintended consequences, a comprehensive evaluation is essential (74).

Most studies in our review that assessed the impact of the CDSS reported an improvement in prescribing or better adherence to clinical practice guidelines. This aligns with previous research in other fields: CDSSs have a modest impact on clinician performance (a care process outcome) (17–25). However, these results need careful interpretation. Most studies were pre-post, non-randomized control or observational designs. Although—consistent with guidance for scoping reviews (55,56)—we did not conduct a quality assessment; these types of study designs have greater threats to validity (75). Additionally, in most of the studies, the CDSS was part of a larger intervention, so its specific impact was unclear. Another reason for caution is that no studies assessed patient health outcomes, such as quality of life, morbidity and mortality (76–78).

Reductions in opioid prescribing and better adherence to guidelines may have unintended consequences (36). For example, studies report that patients often turn to illicit sources of opioids when they have reduced access to prescribed opioids, increasing their risk of overdose (79–84). Several studies in a systematic review found that heroin overdoses increased after a PDMP CDSS was implemented (74). A more recent systematic review, however, found no consistent association between population-level opioid-related harms (including heroin use and overdoses) and PDMP CDSSs (85). We also noted a conflict of interest in some studies where the developers were also the evaluators. Systematic reviews in other fields have demonstrated that when the CDSS evaluator is also the developer, outcomes are better (26,27). It is possible that developers achieve better outcomes because they design effective implementation plans (26), but it is possible that the conflict of interest leads to conscious or unconscious bias (26,86–92). Interestingly, none of the studies reported funding from or involvement of for-profit entities.
It is possible that CDSSs developed by for-profit entities are not undergoing a publicly-reported evaluation. This is problematic, and as a recent criminal case demonstrated, can lead to potential harm to patients (93).

We found that few of the CDSSs incorporated evidence-based design components. In only one study did researchers follow guidance for designing and evaluating complex interventions. Developers may not have incorporated evidence-based components because of the lag time between development and evaluation: when the CDSS was created the developers may not have had access to systematic reviews on the various components. The developer may also feel that the evidence does not apply to this particular subspecialty or setting (94). Another reason may be a general excitement and overconfidence in e-health technologies (95). Funders and developers may be too eager to solve the problem of unsafe opioid prescribing using e-health technologies and are not ensuring that developers are building on information from the medical literature (95). Changes are occurring. Between 2012 and 2016, the Substance Abuse and Mental Health Services Administration (SAMHSA) funded nine projects to integrate PDMP data into EMRs (96). Investigators might not follow guidance for complex evaluations because it is a lengthy and expensive iterative process prior to a definitive evaluation (35–37,97). This is a widespread issue—few complex interventions appear to undergo modelling, pilot and feasibility testing (98), and many lack process evaluations (99,100). This is problematic. If researchers conduct a trial without testing components, possible causal pathways, uncertainties, contextual factors, and implementation approaches, they risk wasting resources on an expensive trial and perhaps causing harm (35,37,101). Conversely, if the evaluation takes too long, the technology could become obsolete before it gains widespread uptake (59). Adopting rapid, concurrent and iterative pilot and feasibility studies may be the best approach (102–104).

**Limitations**

There are two main limitations in our review. In the grey literature search we may have missed non-English language studies, as we conducted the searches only in English. Second, several of the studies included both PCPs and other provider types (we excluded those with less than 50% PCPs), and, as these studies only reported aggregate outcomes, they may not accurately reflect the PCP population.
Conclusion and next steps

Our review reveals that few studies have rigourously assessed the use of CDSSs in the context of opioid prescribing for CNPP in the primary care setting. More high quality studies are needed. Going forward, investigators should include evidence-based components into the design of CDSSs and follow guidance for the development and evaluation of complex interventions, including pilot studies, process evaluations and an assessment for unintended consequences.
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Table 1. Study setting, participants, clinical decision support system (CDSS) type and inclusion of evidence-based components

| Characteristic          | Local | PDMP |
|-------------------------|-------|------|
| **Country**             |       |      |
| United States           | 6/6 (100%) | 8/8 (100%) |
| **Practice settings**   |       |      |
| Primary care clinic     | 5/6 (83%) | 6/8 (75%) |
| Emergency department    | 1/6 (17%) | 2/8 (25%) |
| **Types of PCPs**       |       |      |
| Physicians              | 6/6 (100%) | 7/8 (88%) |
| NPs                     | 6/6 (100%) | 4/8 (50%) |
| **CDSS type**           |       |      |
| Dashboard               | 2/6 (33%) | 0/8 (0%) |
| Protocol                | 2/6 (33%) | 0/8 (0%) |
| Alert                   | 1/6 (17%) | 0/8 (0%) |
| Clinical tool           | 1/6 (17%) | 0/8 (0%) |
| Data repository         | 0/6 (0%) | 8/8 (100%) |
| **Evidence-based**      |       |      |
| Integrated into EMR     | 3/6 (50%) | 0/5 (0%) *** |
| CDSS components*        |       |      |
| Automatically activates  | 2/6 (33%) | 0/5 (0%) *** |
| Requires a reason for over-ride | 0/6 (0%) | 0/5 (0%) *** |
| Provides advice to patients and providers | 0/6 (0%) | 0/5 (0%) *** |
Abbreviations: CDSS = Clinical Decision Support System; EMR = electronic medical record; N/A = Not Applicable; NP = nurse practitioners; PDMP = Prescription Drug Monitoring Program; PCPs = primary care providers;

*Local CDSSs are used locally within a specific health centre, health system or clinic

**PDMP CDSSs are large, centralized, government-run databases

***We excluded 3 studies because they included multiple PDMP CDSSs, and did not provide information on a specific CDSS (45,47,49)

* Unless a study stated a component was included (e.g. automatic activation), we assumed it was not
Table 2. Aims and designs of included studies

| Aims                                                                 | Design                        | Local CDSS* N (%) | PDMP CDSS** N (%) |
|---------------------------------------------------------------------|-------------------------------|-------------------|-------------------|
| To determine if a multi-faceted intervention improved prescribing/guideline adherence | • Cluster RCT***             | 1/6 (17%)         | 0/8 (0%)          |
|                                                                     | • Pre-post                    | 4/6 (33%)         | 0/8 (0%)          |
| To determine if a CDSS improved prescribing/guideline adherence     | • Pre-post                    | 0/6 (0%)          | 1/8 (13%)         |
| To determine if PCPs used a CDSS                                     | • Retrospective cohort       | 0/6 (0%)          | 1/8 (13%)         |
|                                                                     | • Cross-sectional survey     | 0/6 (0%)          | 1/8 (13%)         |
| To determine if an intervention affected provider knowledge, behaviour, attitudes and/or use related to CDSS | • Mixed-methods              | 0/6 (0%)          | 1/8 (13%)         |
|                                                                     | • Pre-post                    | 0/6 (0%)          | 2/8 (25%)         |
| To learn about factors affecting opioid prescribing for CNCP, including use of CDSS | • Qualitative                | 0/6 (0%)          | 2/8 (25%)         |
| To pilot a multi-component intervention, including a CDSS            | • Mixed-methods              | 1/6 (17%)         | 0/8 (0%)          |
Abbreviations: CDSS = Clinical Decision Support System; CNCP = chronic non-cancer pain; N/A = Not Applicable; PDMP = Prescription Drug Monitoring Program; RCT = Randomized controlled trial

*Local CDSSs are used locally within a specific health centre, health system or clinic

**PDMP CDSSs are large, centralized, government-run databases

***CDSS included in both study arms
Table 3. Funding and relationship between developers and evaluators

|                          | Local CDSS* | Local CDSS** |
|--------------------------|-------------|--------------|
| **Funding for CDSS**     |             |              |
| development              |             |              |
| Public/Non-profit        | 3/6 (50%)   | 0/8 (0%)     |
| Industry                 | 0/6 (0%)    | 0/8 (0%)     |
| Not sponsored            | 0/6 (0%)    | 0/8 (0%)     |
| Unclear or not reported  | 3/6 (50%)   | 8/8 (100%)   |
| **Funding for evaluation** |          |              |
| Public/non-profit        | 4/6 (67%)   | 5/8 (63%)    |
| Industry                 | 0/6 (0%)    | 0/8 (0%)     |
| Not sponsored            | 0/6 (0%)    | 2/8 (25%)    |
| Unclear or not reported  | 2/6 (33%)   | 1/8 (13%)    |
| **Relationship between developers and evaluators** |          |              |
| Same person, group or organization | 4/6 (67%) | 0/8 (0%) |
| Different person, group or organization | 0/6 (0%) | 0/8 (0%) |
| Unclear or not reported  | 2/6 (33%)   | 8/8 (100%)   |

Abbreviations: CDSS = Clinical Decision Support System; PDMP = Prescription Drug Monitoring Program

*Local CDSSs are used locally within a specific health centre, health system or clinic

**PDMP CDSSs are large, centralized, government-run databases
PRISMA 2009 Flow Diagram

Records identified through database searching  
(n = 10487)

Additional records identified through other sources  
(n = 88)

Records  
(n = 10575)

Duplicates removed  
(n = 5507)

Records screened  
(n = 5068)

Records irrelevant  
(n = 4693)

Full-text articles assessed for eligibility  
(n = 375)

Full-text articles excluded, with reasons  
(n = 361)
- 74 not a study
- 184 CDSS not used for opioid prescribing for chronic non-cancer pain (CNCP) in a clinical setting
- 74 not a primary care population
- 10 duplicates
- 16 could not locate full-text

Studies included in scoping review  
(n = 14)

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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