A Web-Based Clinical Decision Support System for Depression Care Management

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Objective: To inform the design of future informatics systems that support the chronic care model.

Study Design: We describe the development and functionality of a decision support system for the chronic care model of depression treatment, known as collaborative care. Dissemination of evidence-based collaborative care models has been slow, and fidelity to the evidence base has been poor during implementation initiatives. Implementation could be facilitated by a decision support system for depression care managers, the cornerstone of the collaborative care model. The Net Decision Support System (https://www.netdss.net/) is a free Web-based system that was developed to support depression care manager activities and to facilitate the dissemination of collaborative care models that maintain high fidelity to the evidence base.

Methods: The NetDSS was based on intervention materials used for a randomized trial of depression care management that improved clinical outcomes compared with usual care. The NetDSS was developed jointly by a cross-functional design team of psychiatrists, depression care managers, information technology specialists, technical writers, and researchers.

Results: The NetDSS has the following functional capabilities: patient registry, patient encounter scheduler, trial management, clinical decision support, progress note generator, and workload and outcomes report generator. The NetDSS guides the care manager through a self-documenting patient encounter using evidence-based scripts and self-scoring instruments. The NetDSS has been used to provide evidence-based depression care management to more than 1700 primary care patients.

Conclusion: Intervention protocols can be successfully converted to Web-based decision support systems that facilitate the implementation of evidence-based chronic care models into routine care with high fidelity.

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For author information and disclosures, see end of text.

Depression care managers (DCMs) are the cornerstone of the depression chronic care model, known as collaborative care.[1] Their activities include activating patients (ie, engaging the patient in care), promoting self-management, assessing symptoms and comorbidities, and monitoring adherence and treatment response. Depression care managers facilitate timely communication and coordination among patients, primary care providers (PCPs), and mental health specialists. In randomized trials of collaborative care, DCMs typically receive extensive training and use spreadsheets to monitor the clinical progress of patients.[2-4] As emphasized in the chronic care model[5] and in the patient-centered medical home,[6] clinical information systems are needed to increase fidelity to evidence-based protocols. In the Partners in Care study, fidelity to the DCM protocol was lower than anticipated, and a computerized tracking system was subsequently recommended.[7] To address this need, we developed a Web-based clinical decision support system (Net Decision Support System [https://www.netdss.net/]) to support DCM activities. The NetDSS provides context-specific decision support in real time during patient encounters by guiding DCMs through a self-documenting and evidence-based encounter using self-scoring instruments, scripts, and clinical algorithms. The NetDSS has been used to provide evidence-based depression care management to more than 1700 primary care patients.

The objective of this article is to inform the design of future informatics systems that support the chronic care model. We describe the development of a decision support system for collaborative care and its functionality. We conclude with a discussion of future development plans.

METHODS

The NetDSS was developed with federal research funds and is available to use free of charge. It is based on a highly structured intervention protocol used during a randomized trial of collaborative care conducted in the Department of Veterans Affairs (VA), which significantly improved medication adherence, treatment response, symptom remission, health-related quality of life, and satisfaction with care.[8] Hence, the NetDSS is based on an evidence-based research protocol. Core values informing the design include (1) faith-

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The Net Decision Support System (NetDSS) is a free Web-based decision support system that was developed from the research protocol of a randomized effectiveness trial of collaborative care (chronic care model for depression). The NetDSS supports depression care manager activities and facilitates the dissemination of collaborative care models that maintain high fidelity to the evidence base. The NetDSS guides the care manager through a self-documenting patient encounter using evidence-based scripts and self-scoring instruments. The NetDSS has the following functional capabilities:

- Panel management (patient registry and patient encounter scheduler)
- Trial management (management of treatment trials and phases)
- Clinical decision support
- Progress note generator and workload and outcomes report generator

fulness to evidence-based protocols, (2) user friendliness and flexibility, and (3) parsimonious collection and dissemination of clinical data. The NetDSS was also designed to have the desired features of a clinical information system as outlined by Kilbourne and colleagues[9] that includes the following: (1) short training time, with uncluttered screens that are easy to navigate; (2) Web-based; (3) use of pull-down menus and logic checks; (4) compliance with Health Insurance Portability and Accounting Act of 1996 standards and conformance to standards of Internet security and encryption; (5) use of clinical reminders; (6) capability of creating individual care plans with self-management information and disease severity rating; (7) capacity to print out summary data on quality and other patient outcomes; and (8) capacity to be linked with, but not a substitute for, electronic medical records.

The NetDSS was developed jointly by a cross-functional design team of psychiatrists, DCMs, information technology specialists, technical writers, and researchers. The design process followed the concurrent engineering model, which includes end users on the design team and emphasizes early and iterative releases of prototypes for end-user testing.[10-12] Version 1.0 was published after 2 years of rapid prototype-test-prototype product development cycles involving alpha testing with hypothetical patients. Later versions were published over 3 years of beta testing during 3 collaborative care implementation research projects conducted in the VA and federally qualified health centers (clinicaltrials.gov identifiers NCT00304915, NCT00317018, and NCT00439452) involving 11 DCMs, 845 patients, and 21 primary care clinics. A formal usability test was also conducted with 5 DCMs involved in the national rollout of depression care management in the VA. This rollout, known as the primary care–mental health integration, was a centrally organized and funded initiative to promote adoption of collaborative care in VA primary care clinics across the country. In the usability test, the DCMs used the NetDSS to support clinical encounters with patient actors, and DCM feedback was incorporated into version 2.0. Outside of the context of research, version 2.0 has been used during the VA primary care–mental health integration initiative by 12 DCMs to care for 871 patients.[13]

RESULTS

Platform

Rather than develop the NetDSS as a personal computer–based application, we chose a Web-based platform to facilitate dissemination and ease of updates. It is located at the University of Arkansas for Medical Sciences, Little Rock. A mirror version is hosted behind the VA firewall (http://vaww.dcms.visn16.med.va.gov/), available by VA intranet only. The NetDSS was developed using the Microsoft .Net Framework version 2.0 (Microsoft Inc, Redmond, WA). The Web site uses JavaScript and Ajax to provide a rich user interface that supports asynchronous data manipulation. The application is hosted on a Microsoft Server 2008 by Microsoft Internet Information Services, which is secured using 128-bit SSL standard encryption. Passwords are encrypted using triple DES encryption. The Web application is distributed across a data and Web server. For data access, the system uses ADO.NET (Microsoft Inc) and connects to a Microsoft SQL 2008 server. The *NetDSS User's Manual* provides instructions for using the application and can be downloaded from the home page (https://www.netdss.net/).

Patient Registry

Depression care managers add patients to the registry and assign them to a clinic and PCP. The administrator (the first individual to register from an organization) can add or delete clinics and PCPs, as well as reassign patients from one DCM to another or from one PCP to another. Patient identification is displayed in a call list, which can be filtered for specific clinics or providers. The NetDSS tracks the schedule of follow-up encounter dates and automatically sorts (and color codes) the call list according to whether follow-ups are due, past due, or recently completed.

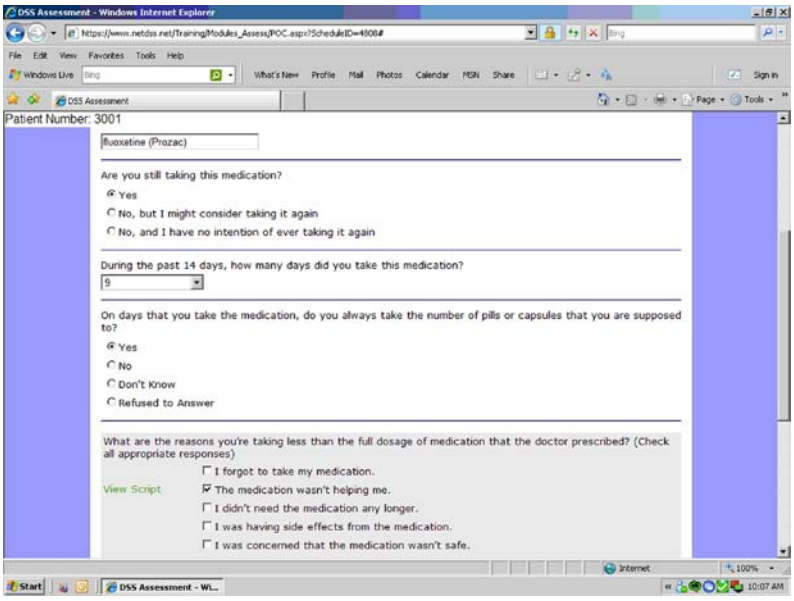
Encounter Scheduler

The encounter scheduler displays information for a unique patient, including contact information, encounter history, current trial type and phase, past trial history, progress notes, DCM comments, and DCM call notes (eg, "No answer at 10:00 AM on Friday" or "Call back after 5:00 PM on Monday"). The encounter scheduler also displays target encounter dates, which can be modified by the DCM. Assessment modules are launched from the encounter scheduler.

Trial Management

Trials are evaluations of treatment plans for individual patients. Trials are divided into the following 4 categories: (1) watchful waiting (symptom monitoring and self-management, but no active treatment), (2) medications alone, (3) counseling alone, and (4) a combination of medication and counseling. Trial duration is defined by start and end dates (eg, an 8-week antidepressant trial), and outcomes are assessed at the end of trials. Trial type is determined by asking the patient about prescribed antidepressants (eg, prescription date, name, and dosage) and about referrals for counseling (eg, referral date and number of appointments). The NetDSS automatically updates the trial type whenever pharmacotherapy or psychotherapy is initiated, whenever the treatment plan is modified, or whenever the patient discontinues treatment. To identify failed or successfully completed trials, the NetDSS uses hierarchical algorithms based on changes in depression symptom severity. Trial phases are classified as acute or as continuation.[14] For medication trials and for medication with counseling trials, encounters are conducted more frequently in the acute phase (every 2 weeks) than in the continuation phase (every 4 weeks) to closely monitor side effects and medication adherence. Trials in the acute phase are considered successful if patients respond to treatment (50% improvement in the score of the 9-item depression scale of the Patient Health Questionnaire [PHQ9] on or before the trial end date) or are in remission (2 consecutive encounters with PHQ9 scores <5).[14] Patients enter the continuation phase after they successfully complete the acute phase. During the continuation phase, the NetDSS uses algorithms to monitor depression symptoms for signs of relapse (2 consecutive PHQ9 scores >5 points higher than the last acute-phase PHQ9 score or a PHQ9 score ≥10).[14] Trials in the continuation phase are considered successful if the patient remits or does not relapse for 6 months. The NetDSS notifies the DCM whenever patients enter a new phase of treatment or fail to proceed to the next phase after an adequate trial (eg, an 8-week antidepressant trial).

Figure. Subset of Questions and Scripts in the Medication Adherence Clinical Module



Clinical Decision Support

To guide the DCM through an evidence-based encounter, the NetDSS presents a series of multiple-choice questions (with point-and-click menus of predetermined responses), scores patient responses in real time, and branches to the next clinically appropriate question or script. For example, the Figure shows a series of questions and script links for the medication adherence module. In this example, the causes of nonadherence questions and scripts are triggered because the patient reported taking his or her medication 9 of the last 14 days. Questions and scripts are divided into the following clinical modules, which are summarized in the Table: education and activation, barriers, self-management, symptom monitoring, comorbidity, counseling adherence, medication adherence, and side effects. Additional decision support is provided in a companion *Depression Care Manager Training Manual*, which can be downloaded from the NetDSS home page (https://www.netdss.net/).

Progress Note Generator

The NetDSS is self-documenting. All clinical information collected during an encounter is summarized in an automatically generated progress note. Although highly structured, the progress notes are unformatted to facilitate copying and pasting into an electronic medical record. In addition to documenting the encounter date and trial type or phase, the progress note summarizes barriers, depression severity, suicide risk, comorbidities, adherence, side effects, and self-management goals or progress. The progress note also documents that specific scripts were administered (eg, the DCM addressed medication side effects with the patient). The subject line of the progress note is determined by a hierarchical algorithm that identifies the most clinically important information. When applicable, the title of

Table. Net Decision Support System (NetDSS) Clinical Modules

Clinical Mode	Clinical Content
Education and activation	The NetDSS provides DCMs with evidence-based scripts to support the education of patients about depression and depression treatment, to encourage patients to initiate treatment (ie, activation), and to determine patients' treatment preferences.
Barriers	The NetDSS includes a checklist of potential barriers to depression treatment and evidence-based scripts (based on motivational interviewing) to help patients overcome endorsed barriers (eg, worried about becoming addicted to antidepressants).[3]
Self-management	The NetDSS facilitates the recording of goals for physical activities (eg, walking), enjoyable activities (eg, hobbies), and social activities (eg, having lunch with a friend), and assists the DCM in tracking success in accomplishing these goals over time.
Symptom monitoring	The NetDSS monitors the severity of depression symptoms using the PHQ9 and launches a suicide risk assessment for patients endorsing suicidal ideation on the PHQ9. The suicide risk assessment was developed for the Health Resources Services Administration Depression Collaborative and is a 5-item assessment of risk of self-harm that categorizes the patient into low-, medium-, and high-risk categories.
Comorbidity	The NetDSS has validated instruments to assess for comorbid mental health disorders, including the AUDIT (for alcohol), Blessed Orientation Memory Concentration Test (for cognitive impairment), GAD-7 (for generalized anxiety disorder), PRIME-MD panic module (for panic disorders), PC-PTSD and PCL (for posttraumatic stress disorder) and MDQ (for mania). Depending on the severity of the comorbid illness, the NetDSS provides specific recommendations for the DCM. For example, for at-risk drinkers, the NetDSS provides evidence-based motivational interviewing scripts developed by the National Institute on Alcohol Abuse and Alcoholism to help the patient cut down on his or her drinking.[15]
Counseling adherence	The NetDSS assesses appointment attendance and calculates the percentage of scheduled appointments attended.
Medication adherence	The NetDSS assesses medication adherence and calculates the percentage of days missed and/or days taking a lower dose than prescribed. For patients experiencing adherence problems, there is a checklist of reasons, and for each reason endorsed (eg, the patient feels that the medication is not helping), the NetDSS provides evidence-based scripts for DCMs' use in helping patients overcome the problem.[4]
Side effects	The NetDSS has a checklist for common side effects (eg, nausea), a severity assessment for endorsed side effects, and evidence-based scripts for helping to resolve endorsed side effects (eg, take medications with meals).[4]

AUDIT indicates Alcohol Use Disorders Identification Test; DCM, depression care manager; GAD-7, 7-item Generalized Anxiety Disorder Scale; MDQ, Mood Disorder Questionnaire; PHQ9, 9-item depression scale of the Patient Health Questionnaire; PRIME-MD, Primary Care Evaluation of Mental Disorders Patient Health Questionnaire; PC-PTSD, Primary Care Posttraumatic Stress Disorder Screen; PCL, Posttraumatic Stress Disorder Checklist.

the progress note states whether the patient has successfully completed the trial or if the trial has failed. Failed trials in the acute phase are defined as less than 50% improvement in PHQ9 score after the trial end date. The NetDSS also alerts the DCM of the following: (1) if there are 2 consecutive encounters with an increase in PHQ9 score that is 5 points higher than baseline, (2) if there are 2 consecutive encounters with side adverse effects, or (3) if there is less than 80% adherence (eg, in the number of days taking medication or attending counseling sessions).

Workload and Outcomes Report Generator

In addition to producing progress notes that summarize each encounter, the NetDSS generates workload and outcomes that present data aggregated by DCMs, clinics, or PCPs. The current date report provides information about all patients in a DCM's panel and can be used to measure the current workload level. Information in this report includes the total number of patients; the percentages in first, second, and third trials; the mean depression severity; the percentage with suicide risk; the percentage who are nonadherent; the percentage failing the acute-phase trial; and the percentage who are relapsing in the continuation phase. The date range report provides information about all patients in a DCM's panel within a specified date range and can be used to assess historical workload productivity (eg, the total number of encounters and the mean number of days between encounters), fidelity to the evidence base (eg, the percentage assessed for side effects and the percentage with self-management goals), and overall patient outcomes (eg, the percentage responding to treatment in the acute phase and the percentage completing the continuation phase without relapse).

DISCUSSION

The NetDSS has the potential to facilitate the implementation of highly structured evidence-based research protocols into routine care. A cross-functional team designed the NetDSS to be user friendly and intuitive. Routine clinical use of the NetDSS led to the identification of unanticipated clinical issues, and continuous refinement has resulted in a robust and flexible decision support system. The NetDSS provides context-specific decision support in real time during encounters with patients by using scripts, self-scoring instruments, and clinical algorithms to identify new trials, treatment phases, and outcome milestones such as nonadherence, treatment response, remission, and relapse.

Other clinical information systems have been developed to support depression care management and have features similar to those of the NetDSS. The IMPACT system[16] includes a Web-based patient registry that tracks encounter history, current trial type and phase, and past trial history. It cues care manager activities according to a built-in schedule. The system calculates trial end dates and percentage change in PHQ9 scores. Progress notes are automatically generated and, although highly structured, can be exported as simple text to facilitate copying and pasting into an electronic medical record. The system generates treatment summaries for the patient and the PCP and various reports, including ones similar to the NetDSS workload outcomes report and current date report. Behavioral Health Laboratory software[17] is installed and run on a central server. The software is designed to address multiple behavioral health issues, including depression, anxiety, posttraumatic stress disorder, alcohol misuse, and cognitive impairment. It includes self-scoring instruments, decision support about diagnosis and severity, and treatment recommendations. The software facilitates triage to specialty mental healthcare and provides decision support for care management. It also facilitates tracking of symptoms and adherence, generates progress notes, and produces reports similar to those of the NetDSS. The TIDES informatics package (http://vaww.portal.gla.med.va.gov/sites/Research/HSRD/ClinicalPart/GTIDES%20Informatics/Forms/AllItems.aspx) is embedded within an electronic medical record (the VA's computerized patient record system), which has advantages compared with other stand-alone systems. For example, queries can be run to identify important sentinel events such as missed appointments or inpatient admissions. It uses reminder dialogue templates, with self-scoring instruments, check boxes, and free-text fields, to generate progress notes that are saved directly into the electronic medical record, thereby maximizing data security. Outcomes can also be stored as patient data objects, known as health factors, so that data can be aggregated across patients to generate clinic and provider outcome reports. Compared with these other systems, the strengths of the NetDSS are the highly structured clinical algorithms and scripts that provide real-time decision support to DCMs.

The NetDSS lacks one important feature recommended by Kilbourne et al,[9] namely, the ability to support multiple chronic illnesses. The NetDSS supports care management for depression only. Data from other depression quality improvement trials suggest that PCPs prefer to implement best practices that offer broad-based support for a range of chronic conditions rather than piecemeal support for a single chronic illness.[18] This limitation of the NetDSS results from a lack of research about how to design effective chronic care models for multiple disorders. Because many patients have comorbid psychiatric disorders, the challenge will be to design future clinical information systems around the needs of patients rather than around treatments for specific illnesses. We are developing version 3.0 of the NetDSS from the ground up using Microsoft .Net Framework version 3.5. Version 3.0 offers decision support for multiple mental health disorders that are commonly managed in primary care, including depression, posttraumatic stress disorder, generalized anxiety disorder, panic disorder, and alcohol abuse.

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