Rural Inpatient Telepharmacy Consultation Demonstration for After-Hours Medication Review

Stacey L. Cole, M.B.A.,[1,2] John H. Grubbs, M.S., M.B.A., R.Ph.,[3] Cathy Din, Pharm.D.,[3] and Thomas S. Nesbitt, M.D., M.P.H.[2]

[1]University of Utah School of Medicine, Salt Lake City, Utah.
[2]Center for Health and Technology and [3]Department of Pharmacy, University of California Davis School of Medicine, Sacramento, California.

Abstract

Objective: *Medication errors contribute to a significant number of fatal and nonfatal adverse medical events each year. Many actions, from both a policy and innovation standpoint, have been taken to reduce medication errors in the inpatient setting; yet, these actions often target larger urban hospitals. Rural hospitals face many more challenges in implementing these changes due to fewer resources and lower patient volumes. Our article discusses the implementation and results of a telepharmacy demonstration implemented between the University of California Davis Health System and six rural hospitals.* ***Materials and Methods:*** *A retrospective chart review obtained baseline medication errors for comparison with the prospective review of medication orders through telepharmacy. Medication orders from rural hospitals were transmitted via fax to the University of California Davis Pharmacy for after-hours review. If a medication required after-hours removal from the pharmacy, it was requested that video verification by a telepharmacist be used to verify that the correct medication was removed from the pharmacy.* ***Results:*** *Baseline findings from the retrospective chart review indicated that 30.0% of patients had one or more medication errors and that these errors occurred in 7.2% of the medication orders. None of these errors were found to have resulted in harm to the patients. During the telepharmacy demonstration, 2,378 medication orders were screened from 504 independent order review requests. In total, 58 (19.2%) patients had one or more medication errors. The errors from the telepharmacy demonstration represented potential errors that were identified through telepharmacy medication review.* ***Conclusions:*** *Telepharmacy represents a potential alternative to around-the-clock on-site pharmacist medication review for rural hospitals.*

Key words: *telemedicine, pharmacy, business administration/economics*

Introduction

Medication errors contribute to 250,000 nonfatal injuries each year.[1] Furthermore, of the estimated 44,000 deaths in the United States due to medical errors, 7,000 deaths each year are attributable to or associated with medication errors.[1,2] By extrapolating study results obtained from two U.S. hospitals to encompass all hospitals and inpatients in the United States, the annual cost of preventable adverse drug events has been estimated at 2 billion dollars.[2]

Numerous legislative and regulatory actions have been undertaken in efforts to reduce medication errors. Such initiatives, however, have been principally focused upon larger urban hospitals that are more likely to be able to marshal the multimillion dollar investments in equipment and personnel required to implement and support capabilities such as computer-based prescribing systems. Although many studies have shown that these systems do reduce medication errors,[1,3] small rural hospitals are often exempted from regulatory mandates because there is a general recognition that they lack the requisite financial and technical resources to implement such sophisticated systems.

Recent studies on rural hospitals have begun to identify the clinical, financial, and demographic constraints that may predispose rural facilities to higher incidences of medication errors.[4,5] Rural hospitals often have a difficult time retaining pharmacists[6–8] and, in general, lack many of the modern pharmaceutical innovations that urban hospitals have used to improve accuracy and efficiency.[9] Lower patient volumes at rural hospitals often do not cost-justify retention of a full-time pharmacist, let alone specialized pharmacists (e.g., pediatric or geriatric pharmaceutical specialists), or permit extended hours of pharmacy support.[4,10] A study by the University of Washington found that rurally situated critical access hospitals only employ, on average, 0.67 pharmacist full-time equivalents.[4] In a national study by Casey et al.[9] only 46% of rural hospitals in their study employed 1 full-time equivalents or greater of a pharmacist.

Further exacerbating the difficulties faced by rural hospitals are the national shortage of pharmacists as well as the proliferation of new pharmaceuticals.[11–14] Last year the Food and Drug Administration approved 35 new chemical modalities and received numerous additional requests for approval of new therapeutic applications of existing drugs.[15] The increasing rate of introduction of so many new pharmaceutical products has increased the difficulty of pharmaceutical management of patients[12,13,16] and has amplified the importance of expert pharmaceutical consultations, with resulting increased reliance

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upon pharmacists. All of these factors result in more challenges to the prevention of medication errors, particularly in a rural setting.[12]

Although it may be impractical for most rural hospitals to implement many of the costly, labor-intensive processes used at urban hospitals, telemedicine can offer a practical, cost-effective alternative.[5,17,18] Telepharmacy, as defined by the Health and Human Services Administration Glossary of Pharmacy-Related Terms, is "the use of electronic information and communication technology to provide and support comprehensive pharmacy services when distance separates the participants."[19] A pool of telepharmacists, or pharmacists who review medication orders remotely, can be shared among a group of hospitals, thus reducing costs at each participating hospital to a level far below that required to support 24/7 on-site pharmacist coverage. This report describes the development of such a telepharmacy consultation model and further describes the implementation of a proof of concept project, titled "The UC Davis Health System Telepharmacy Demonstration Project." This article explores the quantitative reduction in medication errors during the course of the study that were directly attributable to telepharmacy consultations.

Materials and Methods

The University of California Davis (UCD) Center for Health and Technology received funding from the California HealthCare Foundation to implement a proof-of-concept telepharmacy demonstration in collaboration with small rural hospitals in California. Six rural hospital partners (*Table 1*) were invited to participate in the project based upon the following selection criteria: (1) strong support of the project (including concept) by hospital senior leadership; (2) physician and nursing support and engagement in the project; and (3) commitment of at least one pharmacist on-site to participate.

PRELIMINARY DISCOVERY

Each hospital partner had the opportunity to participate in the design of the project. Site visits were conducted at each of the six hospitals in order to gain an understanding of each hospital's scope of hospital services and to become familiar with the rural pharmacist(s) and the operations of the pharmacy services, as well as to obtain the input of physicians, nurses, and pharmacists regarding the challenges and needs presently faced related to hospital pharmacy services. The data were initially used to further inform the investigators of the current pharmacy practices at the rural hospitals and were instrumental in developing an effective, practical experimental methodology.

DATA COLLECTION

Predemonstration baseline medication error data were collected from five of the six participating hospitals by performing selected reviews of medication orders and patient charts. Medication error evaluation was based on a form (*Table 2*) developed from the National Coordinating Council for Medication Error Reporting and Prevention and modified to meet the needs of the demonstration. Medication orders from all inpatient visits (excluding hospice) occurring for a 1-week period prior to the telepharmacy implementation were collected and reviewed for medication errors. Errors and potential errors were defined by the medication error evaluation form criteria and further categorized by their result on the patient's level of care and outcome (*Table 2*). Inpatients were defined as patients either admitted to an inpatient unit or who were placed in 24-h observation units. Seventy patients met these inclusion criteria. The data were used to derive medication error frequencies that served as baseline measurements to be subsequently compared with the demonstration results. Potential medication errors caught by telepharmacy were intervened upon in real-time and later reviewed and evaluated using the same evaluation form mentioned above (*Table 2*).

THE DESIGN

Each remote hospital was independently operated and had different medication systems. Some of the hospitals had electronic medication order systems, but each used a different system. Given the technological limitations and the desire to create a cost-effective solution that could be used with all hospitals, fax transmission was the method selected for transmission of after-hours medication orders between the remote hospitals and the UCD Pharmacy. Fax

Table 1. Descriptions of Remote Hospitals

SITE NUMBER	NUMBER OF GENERAL ACUTE LICENSED BEDS	APPROXIMATE ANNUAL PATIENT VOLUME	DESIGNATION	DRIVING DISTANCE FROM UCDHS
Site #1	40–45	1,200	Rural	70 miles
Site #2	20–25	500	Frontier	150 miles
Site #3	25–30	900	Rural	120 miles
Site #4	35–40	1,300	Rural	100 miles
Site #5	35–40	1,400	Rural	160 miles
Site #6	20–25	750	Frontier	230 miles

UCDHS, University of California Davis Health System.

Table 2. Medication Error Evaluation Criteria

CRITERION	POSSIBLE FINDINGS
Type of error	No medication error
	Medication given but not ordered
	Drug given different from drug ordered
	Wrong dose (too much, too little)
	Wrong drug preparation
	Wrong/inappropriate drug ordered for condition (your opinion)
	Wrong route (IV, PO, PR, SQ, IM, NG)
	Missing route of administration
	Wrong medication units
	No weight/medication units
	No amount/dose indicated
	Wrong rate of administration
	Wrong dosage form
	Error related to patient information (allergy, drug interaction, renal, hepatic disease)
	Other
Result of error on level of care	Antidote/reversal agent administered
	Code Blue
	Death
	Drug therapy initiated/changed
	Hospitalization initiated
	Hospitalization prolonged
	Laboratory tests performed
	Observation initiated/increased
	Surgery performed
	Transferred to higher level of care
	None
Error outcome	
Potential error	
Category A	Circumstances or events that have the capacity to cause harm
Error, no harm	
Category B	Error occurred but the treatment was not administered (near miss)
Category C	Medication or procedure reached the patient but did not have the potential for harm
Category D	Error occurred that reached the patient resulting in the need for increased patient monitoring, but no patient harm
Error, harm	
Category E	The need for treatment or intervention and caused temporary patient harm
Category F	Initial or prolonged hospitalization and caused temporary patient harm
Category G	Permanent patient harm
Category H	A near-death event (e.g., anaphylaxis, cardiac arrest)
Category I	A patient death
Other	Unknown impact
Potential cause(s) of error	
	Abbreviations
	Calculation error
	Decimal point error
	Documentation inaccurate/lacking
	Knowledge deficit
	Leading zero missing/trailing zero
	Look alike/sound alike medication
	Monitoring inadequate/lacking
	Transcription
	Incorrectly transcripted on MAR
	Incorrectly charted on MAR
	Not charted/transcribed on MAR
	Illegible transcription
	Written order confusing/incomplete
	Other

IV, intravenously; PO, by mouth; PR, per rectum; SQ, subcutaneous; IM, intramuscularly; NG, nasogastric; MAR, medication administration record.

machines dedicated to the telepharmacy demonstration were installed immediately next to the fax machines that received all internal medication orders, to ensure timely receipt of the orders.

The team developed a 1-page telepharmacy procedure to be used by the rural hospital nurses during the hours when their pharmacy was not staffed with an on-site pharmacist. We observed that the most imminent need expressed was for after-hour pharmacy services in the primary nursing unit of each hospital (typically the medical/surgical unit). The investigators and rural hospitals jointly determined that a limited scope in this focused area would be the best venue to pilot the demonstration.

In addition to providing for the verification of orders via fax, the telepharmacy program also addressed the issue of verifying the accurate dispensing of medications from the pharmacy when

a pharmacist was not physically present. High-resolution telemedicine systems were installed in the pharmacy at each of the six participating hospitals. Through the use of high-resolution video, UCD pharmacists identified that medications removed from the pharmacy after-hours were appropriate with respect to both identity and dosage.

UCD performed detailed testing of commercially available telemedicine systems in order to select units that provided the requisite features, functionality, and image clarity deemed necessary for accurate and reliable performance. We determined that the video codecs required an optical zoom rather than a digital zoom feature because digital zoom did not provide the resolution necessary to read small labels on pharmaceutical packages. UCD ultimately standardized on the Tandberg MXP 550 video codec for the telepharmacy units. The units deployed at each facility were either GCX pole-mount or wall-mount units built by the UCD Center for Health and Technology. Portable pole-mounted units were equipped with battery back-up. Each hospital was assessed by a technical team member to determine telecommunications capabilities and whether a mobile pole-mounted system or a wall-mounted system would best meet the remote site's pharmacy layout and needs. The UCD Pharmacy video unit was mobile and had a self-contained power supply. It connected wirelessly to the campus 802.11 WiFi network.

The video verification component required high-speed telecommunication connections. Connections were selected based on each site's locally available telecommunication options and the ability to support 384 kilobits per second video connections. Three sites connected to UCD through T1 lines, one through a hybrid T1 to an Integrated Services Digital Network (ISDN), and the other two through ISDN.

PROCEDURE

Initially the rural hospitals were concerned that introduction of telepharmacy would potentially disrupt their existing work flow, especially during after-hours periods when staffing was typically reduced. UCD Pharmacy management expressed similar concerns that their turnaround time for internal customers might not be as prompt if each hospital immediately began sending all medication orders to the UCD night pharmacy. It was therefore jointly decided that each hospital would begin by enrolling one patient per week for after-hours medication order review and continue to expand the coverage as the hospital's personnel felt comfortable.

Through ongoing dialog and coordination among the participants, the overall telepharmacy volume was adjusted according to the UCD Pharmacy's current ability to accommodate the telepharmacy order volume, as well as through regular assessments by the individual rural hospitals regarding their comfort level with the telepharmacy procedures. To prevent selection bias, the hospitals were asked each week to start with the first patient who required after-hours orders starting each Monday. Later, as the Pharmacy felt it could take on more volume, patients were added so that every time a patient was discharged from telepharmacy the next consecutive patient requiring after-hours orders was enrolled. Patients continued to be added as the rural hospitals and UCD Pharmacy felt comfortable.

In order for the rural hospitals to distinguish telepharmacy patients from other patients, a simple manual system was developed to identify these patients. Because none of the rural hospitals had implemented electronic medical records, a simple laminated orange flag sheet was placed on the front of each telepharmacy patient's paper chart. This visual cue alerted nursing staff to the need to send their after-hours orders to the UCD Pharmacy for medication order review.

Each site was provided with a procedure binder containing instructions and included supporting materials such as the telepharmacy fax cover sheets and UCD Pharmacy staff contact information. A Website was created for the UCD Pharmacy that contained all of the resources that participating UCD pharmacists would require in order to provide telepharmacy medication order review and consultation. Each remote site's formulary, contact phone, and fax numbers were listed on the Website.

MEDICATION ORDER REVIEW

The medication order review process for the study involved rural hospital nursing staff and pharmacists from a 24-h inpatient pharmacy at the UCD Medical Center. The first step for the medication review required a minimum of three documents to be faxed from the rural hospital to the UCD Medical Center Pharmacy. These documents included (1) a patient cover sheet, (2) a list of currently active medications for the patient, and (3) the new medication order(s).

The patient cover sheet included the patient's name, date of birth, drug allergies, and weight. Based on the reviewing pharmacist's judgment, the pharmacist called the remote hospital to obtain additional pertinent laboratory or other information in order to determine if dose adjustments were required. Examples of additional information requested include serum creatinine, liver function tests, electrolytes, and drug levels. In addition to dose adjustments, the reviewing pharmacists were responsible for screening for drug allergies and drug–drug interactions and providing pharmacokinetic recommendations for follow-up by the outside hospital's pharmacist the following morning. Additionally, copies of the rural hospital formularies were also available to the reviewing pharmacist to assist in adherence to the hospital's formulary medications. Admixtures were only verified if the content had to be pulled from the pharmacy and video verification was requested.

After this initial review, the pharmacist faxed a copy of the reviewed orders back to the rural hospital. Medication approval or denial was communicated via a series of standardized symbols on the medication order. If a medication was denied pending further clarification by the ordering physician, the pharmacist would call the nursing staff and inform them that further clarification by the physician was necessary. Under circumstances when rural hospital nursing staff needed to enter the pharmacy to retrieve medications after-hours, a final step in the medication review process involved real-time video review of the medications. This video review was implemented to ensure that the appropriate medication had been removed from the pharmacy.

TRAINING

The week before each site was to "go live," the UCD telepharmacy staff visited the facility and trained the nursing staff and the pharmacist(s) on the telepharmacy project protocol and use of the telemedicine systems. A checklist of competencies was reviewed with each of the staff members who were present at the meeting. Between 4 and 30 nurses received an average of 40 min of training at each site. Because not all nursing staff could be present, a train-the-trainer approach was used to reach the entire staff who would potentially be using telepharmacy. UCD Pharmacy staff were trained in a manner similar to that at the remote sites, but also received training on procedures that were specific to the host site, such as remote control procedures for the video camera.

Results

PRE- AND POSTDEMONSTRATION EVALUATION RESULTS

Pre- and postdemonstration chart review and medication order results are presented in *Tables 3* and *4*. Seventy patients met entry criteria for the predemonstration chart review. In all, 950 medications were either ordered and/or administered to these patients during their hospital stays. Of these, 500 medications were ordered between 5:00 p.m. and 7:00 a.m. or on the weekend, periods during which a pharmacist was not typically present. Study findings from the predemonstration data indicated that 30.0% of patients experienced one or more medication errors and that these represented 7.2% of the total medication orders for the predemonstration cohort. There was no evidence in the patients' charts that any of these errors caused demonstrable patient harm, such as increases in length of stay or the requirement of other medical interventions as a result of the errors.

During the demonstration project, in total, 302 telepharmacy patients were referred by the six participating hospitals. *Tables 3* and *4* summarize the data obtained for these patients. In total, 2,378 medication orders making up 504 independent order review requests were screened during the project. Fifty-eight patients, or 19.2% of the total complement of enrolled patients, experienced one or more medication errors that were prevented through telepharmacy review. In total, 97 medication errors were identified through telepharmacy.

Table 4 presents a breakdown of "type by errors" and "cause of error." The four most common "types of errors," in order of frequency, were (1) wrong dose (29.3%), (2) missed route of administration (22%), (3) missing amount listed (e.g., dose, number of tablets, etc.) (11%), and (4) missing allergy indication (11%). The two most common "causes of errors" were (1) "knowledge" errors (62.2%) and "unclear orders" (51.2%), as described below. Some errors resulted from multiple error causes. Knowledge errors, as described in *Table 4*, were errors that the investigators attributed to knowledge deficits related to the providers' incomplete understanding of the medications, such as those related to drug–drug interactions or dosing. Unclear orders included errors related to incomplete or unclear information (i.e., no route of administration or missing concentration units).

Only 65 medications were reviewed via video during the study. The majority of these reviews were from a single site that initiated a requirement that all medications removed from the pharmacy after-hours be reviewed by video prior to removal. Of the 65 medications reviewed by the telepharmacists using video verification, 2 medication errors related to incorrect medication strengths were identified.

Discussion

Higher rates of medication errors were found in the predemonstration review data than in the demonstration data. However, the errors identified during the demonstration phase had more potential to cause harm, according to the "error outcome" classification. We are unable to speculate on the reasons for these discrepancies other than to note that the datasets are small and further noting that the individual hospitals are disproportionately represented between the two sets of data (i.e., some hospitals initiated a larger volume of telepharmacy requests).

In accounting for the variable rates of participation among the various hospitals, we chose to evaluate the data in aggregate, considering rural patients as a whole, and did not control for or evaluate differences in frequency or severity of medication errors among the rural hospitals. We felt that participating hospitals would be more comfortable participating in this study if the evaluation was based

Table 3. Medication Error Comparison

	PREDEMONSTRATION	POSTDEMONSTRATION
Total number of patients	70	302
Total number of medications ordered	500	2,378
Average number of medications ordered per patient	7.14	7.87
Total number of errors	38	97
Total number of orders with errors	36	82
% medication orders with an error	7.2%	3.5%
Total number of patients with errors	21	58
% patients with medication errors	30%	19.2%

upon aggregated data, as opposed to categorization by specific institution. As a result, individual hospitals were not evenly represented in the pre- and postdemonstration evaluations.

Other published studies have reported medication errors occurring in 3–6.9%[1–5,7] of inpatients, comprising 0.03–16.9%[1,4,6,8,10] of total medication orders. Our data indicate that errors may occur in a much greater percentage of patients, but at similar rates per total medication orders. However, these statistics are not directly comparable because we only looked at errors occurring "after-hours" in rural hospitals.

In contrast to the predemonstration data, which represented errors that had already occurred, the postdemonstration data represent potential errors that were caught by the telepharmacist before the medications were administered. None of the errors identified preadministration resulted in patient harm, and, consequently, no unambiguous assessment of the severity of consequences could be made. However, reasonable assumptions can be made regarding the potential severity of outcomes from the identified errors, had telepharmacy intervention not occurred. In most cases the potential risk for harm was low. For example, consider the situation where a

Table 4. Medication Error Type

	PREDEMONSTRATION		POSTDEMONSTRATION	
	N	%	*N*	%
Error type[a]				
Medication given, but not ordered	7	19.4	–	–
Drug given different from drug ordered	1	2.8	–	–
Wrong dose	4	11.1	24	29.3
Wrong route	0	0	1	1.2
Missed route	20	55.6	18	22.0
Wrong medication units	0	0	1	1.2
No weight listed	0	0	6	7.3
No amount listed	0	0	9	11.0
Wrong rate	1	2.8	0	0
Wrong dose form	0	0	7	8.5
Error in patient information	0	0	6	7.3
Wrong preparation	0	0	2	2.4
Allergy	0	0	9	11.0
Frequency	0	0	4	4.9
Other formulary error	–	–	7	8.5
Other video	–	–	2	2.4
Other error	5	13.9	1	1.2
Cause of error[b]				
Calculation error	0	0	1	1.2
Documentation error	8	22.2	1	1.2
Knowledge error	8	22.2	51	62.2
Transcription	0	0	1	1.2
Unclear order	23	63.9	42	51.2

[a]Medications could have more than one type of error.

[b]Medication error could have more than one cause.

prescriber did not indicate the route of administration. This often occurred with drugs that are typically administered orally with no other administration option. In other cases, however, the potential risk for harm was much higher, especially in regard to dosing errors and missing allergy alerts. For example, 1 patient had an order to receive a narcotic medication that should only be given every 12 h in the dosage ordered, but the order stated administration on an every 4-h schedule. Had several doses of this drug been administered as ordered, the patient could have experienced a respiratory arrest. Another patient was prescribed a dose of a topically applied narcotic that was twice the patient's normal home dose. Patients whose drug allergies were not documented and were prescribed drugs to which they had allergies could have experienced anaphylactic reactions.

Video review was not used to the extent we had originally anticipated. Through continued study, it is hoped that sufficient evidence of the effectiveness of video verification as a means of reducing medication errors will be collected to justify this method as a means of meeting the Joint Commission on Accreditation of Healthcare Organizations medication review standards. Even with the limited use of video, two medication errors related to the strength of the medication pulled were identified.

CHALLENGES AND LIMITATIONS

During the project several unanticipated challenges were encountered by UCD, as well as the participating rural hospitals. Initially the demonstration project plan included hiring of full-time telepharmacists; however, the project team soon experienced firsthand the effects of the pharmacist shortage—our repeated and extensive recruitment efforts were unsuccessful. Alternatively, telepharmacy was integrated into the routine work flow of the UCD inpatient pharmacists, and compensatory adjustments (reductions) were made to the volume of telepharmacy referrals that would be accommodated. A dedicated telepharmacy staff would have allowed the hospitals to send all after-hours medication orders and cover all units with telepharmacy review rather than a select number of patient orders each week in specific hospital units. Dedicated telepharmacy staff would have also allowed the demonstration to expand beyond the medical/surgical units at each of the rural hospitals.

The rural hospitals also experienced operational and resource challenges in implementing the project. Telepharmacy involved substantial changes to the existing work flow for the rural hospitals, and some experienced significant challenges adopting the required changes. Unlike computer systems that are programmed to require that a drug order be reviewed before it is given, the system we designed relied upon the cooperation and individual decision-making of the nursing staff. In effect, rather than forcing them to use the system, they had the option of choosing to use the system. One hospital quickly saw the value of the system and began sending all after-hours orders to the UCD Pharmacy for review a short time into the project. A fruitful area for future study would be to determine those individual and institutional characteristics that predispose effective participation.

Conclusions

With the dramatic increase in computerized physician order entry and the use of electronic health records, many medication errors will be identified at the time of order.[20] Many potential medication errors such as allergic contraindications or adverse drug interactions will be automatically detected at the time of order. However, the phenomenon of "alert fatigue" occasionally causes prescribers to miss important warnings, and a pharmacist review of the order provides an important stopgap in these instances. Additionally, most electronic systems are not yet sophisticated enough to identify situations when doses of medications should be adjusted based upon the patients' renal or hepatic function and fluid status. For these reasons, pharmacist review of orders will continue to serve an important role in ensuring patient safety.

Based upon the nature of errors that were prevented in this study, especially those related to incorrect dose and allergy, we can infer that adverse patient outcomes including prolonged hospitalization and potentially death may have been averted. Although this impact was seen in a relatively small number of patients (302), it is reasonable to consider that telepharmacy, if implemented on a larger scale, could improve the care of many thousands of patients treated in small hospitals that lack 24/7 pharmacy services.

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Address correspondence to:
Stacey L. Cole, M.B.A.
University of Utah School of Medicine
Dean's Office, Room 1C109
30 North 1900 East
Salt Lake City, UT 84132-2101

E-mail: slcole@ucdavis.edu

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