Using Health IT to Prevent Adverse Effects

COLLIN BUCKLEY: Hello and welcome to the AHRQ webcast, Using Health IT to Prevent Adverse Effects. At this point I'd like to introduce today's moderator, Doctor Amy Helwig. She's a medical officer and leads the Patient Safety Organization Team at AHRQ. Dr. Helwig, the floor is all yours.

AMY HELWIG: Thank you, Collin. Again welcome everyone, to our national teleconference on Using Health IT to Prevent Adverse Events.

I'm delighted that we have three speakers today and I will introduce each of them. Our first is George Hripcsak. And George is the Vivian Beaumont Allen Professor and Chair of Columbia University's Department of File Medical Sematics, the Director of Medical Sematic Services for New York Presbertarian Hospital, as well as a Senior Informatics Advisor at the New York City Department of Health and Mental Hygiene.

Our second speaker today is Tejal Gandhi. Dr. Gandhi is a board certified internist and associate professor of medicine at Harvard Medical School. Dr. Gandhi's research interests focus on patient safety and reducing errors using information systems.

And our third speaker today is Kevin Johnson. Dr. Johnson is Professor and Vice Chair of Biomedical Sematics. It's a joint appointment in the Department of Pediatrics at Vanderbilt University Medical Center. Dr. Johnson is an internationally recognized and respected developer and evaluator of clinical information technology.

We'll begin with Dr. Hripcsak and he'll begin the teleconference and discuss using informatics techniques such as natural language processing and machine running to develop methods to detect new event types and to measure the rate of known error types. Dr. Hripcsak, I'll let you begin.

Mining electronic health records for patient safety research, Dr. George Hripcsak, MD, MS

DR. HRIPCSAK: Thanks, Amy. Okay, so as we said I'll talk about using the electronic health record for patient safety research. The nation's moving forward quickly. EHR's adopted. As many of you know today the final rule for meaningful use and for one of the certification rules was announced today. I hope you've all read your 800 pages.

If this work is successful, we're going to have a lot of data available across our nation. One billion visit notes and a lot of other data shown on the screen. And this would seem to be, you know, a prime area for patient safety research.

The electronic health record brings symptoms, signs, detailed treatments over say just a traditional administrator data set. It details the temporal cores, it shows the clinician's reasoning, and it shows things, it shows many different redundant, it redundantly shows what's going on with the patient in a good way so we can figure out the truth of what's going on with the patient. One of the challenges that much of it is locked in narrative notes and I'll be talking about that in a little bit.

There's been work over the years on using electronic health records for patient safety research. David Bates did a nice review back in 2003, and there's been subsequent work on using it. I'm going to review what our work has been in showing our future direction.

The framework for the previous work is that you select target events. What kind of patient safety research do you want to do. You manually analyze your clinical data repository to see what, how your data matched what you're looking for. Then you need to prepare the data. Take the raw data from the repository and turn it into something that's computable, often using natural language processing. I'll show you that example.

You write a set of queries or rules to bring out what you're looking for, and I'll show you examples of that. And then you manually verify to see that it's going right and classify event. And based on your performance, say sensitivity and specificity, that goes feedback to improve your queries and improve your system. And as I said, I'll give some example with that.

What are examples of target areas? Well one thing we've looked at is explicit voluntary error reporting. When does the healthcare provider, say a physician, actually say they've made an error. We can also learn about errors that are standard reported errors that reported to Government agencies. We can look conflicts and I'll explain that in more detail in a minute. Or look for different kinds of errors that have been published in the literature.

We use data from any part of the electronic health record. So there's administrative data in there which ubiquitous and coded but they don't always reflect the truth. There's a lot of errors, they lack temporal information, there are things called code creep and so forth.

Our laboratory and medication data are primarily structured and that's good, and they have direct evidence of what's going on with the patient, as well as indirect evidence; for example rescue medications to prove that there's been an adverse event, that the doctor's been trying to solve.

There's narrative data which I'll be talking about in a little bit of broad range. And work flow information like order entry and various forms of coded documentation.

One of the challenges is terminology in the data model. Different sources use different coding. For example I noted in our institution, we have six different ways of coding smoking history. Something we'll need to solve with meaningful use in fact. And so there's a lot of work there in terms of standardization.

Much of our data and much of what's most useful for patient safety research is in narrative form, not in structured format. And what you need to do to do automated research across a large population of patients is to generate coded information.

So you need to define the structure, the vocabulary and handle things like negation and distribute modifers. The simplest way is keyword searching, that's what most people do on a first take on this, which is kind of like doing a Google search. You find all the relevant words and then often you'll do some simple improvement on that, like get rid of the all words that have no in front of them, getting rid of negation.

What I'll call deep natural language processing as shown here, where you take a set and merely try to understand everything that's being said, and I'll use as an example just the part in blue, the first phrase, slight increase of pulmonary vascular congestion which is shown on the right here as pulmonary vascular congestion, change increase, that means it's increasing, degree low which is the slight. But you'll notice that degree is indented under increase, which means that it's a low degree of increase, not a low degree of pulmonary vascular congestion.

So these systems have gotten to the point where they can be pretty sophisticated is my point there. And in fact as we see here, I'll show you an example. This is, this is using natural language processing on chest X-ray reports. In the green are expert radiologists and internists and ideal performance in the upper left corner. Our system performs similar to them, that's the red square, and superior to the other alternative message which was a key word search and lay person.

And then as part of a large study of about almost one million reports, we said is there a way to verify the kind of statistics I get out of these systems. This is important for patient safety research, because if I'm going to set error rates, if I'm going to publish a paper that says here is how often a certain error occurs, I want to know that there's some way to verify that that's a reasonable error rate.

So one of the ones that was a little bit eclectic was looking at bullet and stab wounds in our emergency department. And I found that looking at that using natural language processing , the rate of that happening dropped 46% over ten years. That's the bottom bullet.

We then looked at the crime statistics in our neighborhood, and over that period of time, violent time and aggravated assault dropped 52 and 41%. Nicely, you know, sandwiching that other number. So it seems like when we get rates out of natural language processing, unless we're trying to help correct the data, we get response, we get, we can derive rates that seem reasonable compared to external data sources.

Murder dropped a lot more, but presumably the murdered ones did not end up in the emergency department. So now we did – we followed that up with calibration on falls in the hospital. So we look for evidence of a fall severe enough

to warrant a radiological report and we're looking for a say status poll's full but not think like fallopian tube or no fault.

And we didn't want falls that were not related to it – we didn't want falls related to admission, so we made sure they were at least two days after admission. And our results as shown here, we found 1400 visits with falls out of about half a million or a rate of about 2.6 per thousand. And then shown below is the rate that's stratified by age and we found .35 per thousand had a fracture.

If you look on the right there's the literature rate. The estimate is 6.6 which seems a little high, but when you stratify by age, you find that the literature results very well match our results through natural language processing on our electronic health record data. And in fact the injury rate of .4 very well matches our injury rate of .35.

So then we used another technique which is looking for conflicts in the record. Identifying adverse events where what we want to do is take a record and know with pretty good certainty that this record has an adverse event that we need to know about. A conflict is mainly a mismatch between the admit and discharge diagnosis. Our design as we looked at 150 cases from each of five target areas using two internal medicine reviewers.

Here's an example where the patient's admitted for deep venous thrombosis and they're discharged with cerebral vascular accident. In other words something went wrong along the way. And in fact if you look at the admission, there are several things to tell you something went wrong. They had an elevated coagulation profile, they had a midline shift on their CT scan, meaning they bled into their head. And Protamine was given reversing the effect of the drug they were given. So in other words there's been an adverse event here.

So we looked at conflicts in the record over a ten year period at myocardial infarction, stroke, aspiration pneumonia, pulmonary embolism and catheter related infections as the outcome that was mismatched to the admit diagnosis. As you can see in the middle column shown here, the number of patients, the number of average patients who have these things in their chart is very low, .01, .06 and so on. But when you apply our conflict rule to it, you see it raises the rate of finding an adverse event to .18, .16 and so on.

In other words we raise the positive predictive value of finding an adverse event about ten fold. So if we manually review the cases with conflicts, approximately 1/6th of them are going to have actual adverse events that we're interested in.

Let's look for a second at self reporting electronic health records. One of the problems with using electronic health records to support patient safety research, is you tend to find what you're looking for and not the unexpected. Yet as we know in patient safety research, we precisely have to look for the unexpected. So we ask do clinicians actually report errors in the record? New error types that we hadn't thought of. So we looked at discharge summaries, outpatient notes and resident signup notes for evidence of providers reporting errors.

We looked for all kinds of errors. These are about half the number of key words we looked for. Here's the kind of thing we found. For example he did not take the antibiotics because I mistakenly prescribed augmentin when he had the penicillin allergy. Luckily his pharmacist caught the error. That's an example of a near miss.

It was noted that the patient had been given albuterol inhaler instead of vancenase for intranasal use. Patient alerted to mistake made by pharmacy.

So what we found is that if we look for key words like mistake, error, inadvertent, incorrect or iatrogenic, the charts that include any word like that have about a, say 15 on average, about a 15 % chance of having an adverse event but we're interested in there, and furthermore that may be a new kind of adverse event we haven't noted before.

We also noticed that in things like discharge summaries, if we narrow down on specific sections of that discharge summary, like hospital cores, then the predicted value goes up even further. Because you would expect that that's where we'd be reporting the errors.

When people report errors – now these are mainly physician notes that we're looking at and they mainly report errors about physicians, but sometimes about nurses, the pharmacy, radiologists and so on. They mainly report errors inside the institution, but largely away from themselves. So they report their own error 4%

of the time and about others a larger percent, 40% of the time, and then we're not sure about 60% of that number.

Most of them are without adverse outcome, but a large proportion, 41% actually have an adverse outcome. So these are not just mere misses that these doctors are reporting.

And then lastly for the old work I'll just talk about large scale event reporting. New York State had a system called nine ports (phonetic) in which 45 events were defined by the State and needed to be reported by hospitals. They included things like hemorrhage during a procedure, new deep venous thrombosis, post-op infection and so on.

We use natural language processing in 45 rules to detect these errors in discharge summary. Our methods for the study was that we reviewed 1000 randomly chosen charts by a physician and reviewed an additional or almost additional because some overlap but, 1400 charts that had positive detected from a total of 60,000 discharge summary. So it was a fairly large scale retrospective study.

We found that adverse events occurred in our charts at about a 5.3% of the time. That's the prevalent shown above. When our manual, when our patient safety officers were reviewing the charts, they found what we estimate to be about 9% of total errors that were actually occurring in our hospital. When we turned on our automated system with natural language processing, we found 28% of the errors or in other words three times as many errors as we found by manual review, with a fairly high specificity.

The case specificity is .98. That means what's the specificity for finding a case with any kind of adverse event. The bottom shows by event which means if I pick a particular event like post-op myocardial infarction, the specificity is .9996. so very high specificity allowing us to study these things accurately.

So that's what we have been doing over the last ten years. Now let me talk a little bit about where we're headed. So there are a lot of challenges to using electronic health record and I divide them into the solvable ones and the hard ones. Not to say that the other ones are insolvable, but they're harder to get to. So lack

of penetration of electronic health records hopefully will solve with meaningful use incentives. That the systems are distributed, that the formats are inconsistent and patient privacy I think are things that are difficult but I can envision a solution.

The things that really knock us back are the quality of the data. Accuracy, completeness and complexity of the data and various forms of bias. And that's really what we've been working on lately.

As was said back in the 1980's, all medical record information should be regarded as suspect; much of it is fiction. We need to counteract that.

Here's our framework for what goes wrong basically. First we have the truth. What we really want to know is the truth of the patient. Then either the care provider or the patient themselves observes and interprets the patient and comes up with a conception in their head of what's going on. They then author some artifact and create the electronic health record or the personal health record. Usually with the intention that a human being is going to read that thing and create a concept in their head. Either the patient, another physician , a lawyer or so forth. And what we're trying to do is pull the data out of the record and create a computable model.

Errors can occur at any of these levels. The observe and interpretation, the authoring of the record, the processing and furthermore there's a special kind of error that occurs when a doctor writes something in a record, they only save part of what, of what needs to be conveyed, assuming that the doctor reading it will insert implicit information. This makes it very difficult. They don't state explicitly everything that's going on. They know that the other doctor through lack of saying something, that means something to the following person. Our electronic systems need to insert the same implicit information as a following reader.

So one thing is we can learn from the data and patient safety research, one of the most important things are the chronology of the data. You want to know did the heart attack precede or follow the operation to know if this was a post-op myocardial infarction.

What we've done is we've taken for example everywhere where someone has said something temporally about a record, so here in this example it's three days ago. We normalized it so when they were talking about something in the

past, it always occurred where this arrow was. Whether it's three years ago, three days ago, 14 weeks ago.

And over here on the right side is the now, when it occurred, when the note was written. And this spread here that's almost normal distribution you see here, not quite (inaudible), is the spread of when the thing really occurred. Because we always used examples where we had structured data that told us the truth, for example when the person was really last discharged from the hospital.

And what you see here is that if someone says something occurred three days ago, then on average it occurred plus or minus 50% of that claim. So if you're doing patient safety research, you need to account for that uncertainty.

But if they say 31 days ago versus one month ago, that has different levels of accuracy. So we have a formula that tells us, given any statement, what's the average accuracy of that temporal statement. And we use that in our patient safety research.

We're also studying the record because what we want to do is understand how the record works or how it doesn't work so that we can counteract it and then understand what's really going on with the patient. And we call that the physics of medical records because we're borrowing a number of records from non-linear time period analysis, mainly used in atmospheric physics. And what's shown here is just a formula for initial information, but actually we're doing a lot of conceptual work and theoretical work on doing that.

And let me just show two slides from this right now. The first one, this is using – let me just say what this slide tells you. If you see these ridges over here, this is the patient's glucose and it's stratified by how long ago it happened on one access and the number of measurements the doctor's doing. In other words if the doctor's doing a lot of measurements, then there's probably some problem here. And what these ridges show is that patients who get their glucoses in the middle of the night are probably more sick and more prone to adverse events than the ones that get their glucose measured at nine a.m. That's obvious to us now and obvious even before I said that, but this thing automatically discovered that fact, and so what we're doing is applying these methods to situations where we don't know where the errors occur to try to find them through these methods.

And then lastly just to say that looking at the time, if you see these dots here, this is the time between measurements. As you can see, when a patient is healthy and everything is stable, you have infrequent measurements. As the measurements increase in frequency, there's probably something wrong, the patient's predictability is falling and they're becoming less stable and that's where you're most susceptible to errors, so that's kind of following on the previous slide.

So I'm not recommending anyone do this yet, but this is the kind of the thing that we're looking at for the future.

So I would say that electronic health records can be very useful in patient safety research, but of course you have to start off, you need an electronic health record and hopefully you'll all be adopting one or have one already.

The sources are imperfect. The electronic health record and processing of that record is imperfect. Records are collected for different purposes, although redundancy helps. And complex reports like (inaudible) summaries require complex processing.

But even simple things like looking for key words in the record can be used effectively by someone with minimal experience in this kind of research. And performance depends mainly on what is in your electronic health record. And with that I will hand it back to Amy.

Bar Coding and Medication Safety, Tejal Gandhi, MD, MPH

AMY HELWIG: Alright. Thank you, Dr. Hripcsak.

What I'd like to do is we'll save all questions until the end. So I'd like to now turn to our second speaker. Dr. Gandhi will be discussing the results of a AHRQ funded study on the impact of bedside bar code, electronic medication administration and medication errors work flow and nursing satisfaction.

Dr. Gandhi, I'll turn it back to you.

TEJAL GANDHI: Thank you, Amy, and thanks for having me here today. So I think you mentioned I'm going to talk about bar-coding and its impact on

medication safety. So the typical hospital medication process has several stages, as I'm sure most of you know, there's ordering where the physician orders a medication; transcription where in most hospitals still in the country, the nurse copies the order onto a paper medication administration record known as the MAR. Dispensing, pharmacy sends the medication to the floor. Administration. The nurse gives the medication to the patient and documents this on the MAR and then there's subsequent monitoring to assess whether the patient has had an adverse effect or a good effect. And medication errors in hospitals are common and can have serious consequences and can occur at any of the stages.

So the same stages are shown here on a flow diagram and in sort of orange I guess, it displays – it shows the percent of errors that occur at each stage based on at least one study that was done back in the mid-90's from Brigham and Women's Hospital by David Bates. And it shows that ordering errors occur about half the time. Dispensing 14%, the transcription 11% and administration error is 26%. And so what that means is out of the errors that were identified in that study, these are the percentages that occurred at each stage.

So what are some IT solutions by stage? So ordering errors, computerized solution order entry has been sort of touted as the way to reduce ordering errors. Then there's transcription errors which I will talk about that electronic medication administration records can hopefully handle. Dispensing errors which bar-coding can help with as well as things like robots for example. And then there's administration errors at the bedside, which again bar-coding – we've shown benefit from bar-coding that I'll show you today as well as from electronic medication administration records. And then there's other technologies like smart pumps.

So the system that I'm going to talk about today, I'm going to call it barcode/eMAR and this is a system that we implemented at Brigham and Women's Hospital at the bedside. Orders flow electronically from our CPOE system to an electronic medication administration record called eMAR, and eliminated the transcription step entirely. And then nurses have laptops with the eMAR on it and use this to track what medications need to be administered.

The nurses also use barcode scanning of the medication and the patient at the bedside to verify that the drug they're administering matches the physician's

orders. And it can look for – the barcode can help identify that it's the right drug, the right patient, etcetera, and eMAR will alert if any of these is incorrect once the nurse scans the barcode. And we hope that this would potentially reduce administration errors.

So here are the components of the eMAR bar-coding system. On the left is the screen from the eMAR and then there's an example of a scanner and medication bottles with barcodes and then scanning of the patient wristband.

Okay, so these are the types of alerts that the nurse would actually see with the eMAR system. This is an example of a wrong medication alert. Sorry to go back. The wrong medication alert and then a wrong patient alert. So it says the scanned wristband is either the wrong patient or the wristband was unreadable. So that's the kind of alert the nurse would see when they're scanning.

So we had an AHRQ funded project to evaluate the impact of barcode eMAR on medication administration records, errors. It was a non-randomized controlled observational study comparing error rates on units with and without bedside barcode scanning. And our primary study outcomes were directly observed medication administration errors. And then the subset of those that were the directly observed potential adverse drug events, which are the errors that had potential to harm the patient.

And the data collection was conducted through direct observation of medication administration by trained research nurses, and then all errors that were identified were adjudicated by two clinicians.

So these are the main findings of the study in terms of the impact of the barcode standing technology on administration errors and potential adverse drug events. And as you can see there was a 41% reduction in total administration errors. And then if you look at the subset of errors with the potential for harm, there was a 61% reduction.

And again the thing of potential adverse drug events in terms of the types of severity, it was reasonably similar across the three severity levels in terms of reductions ranging from 48% to 54%.

And then transcription errors. Bottom line here is transcription essentially went away because the orders were electronically going to the eMAR so we went from transcription error rates of about 6% and then potential adverse drug event rates due to transcription errors were about 3% down to the zero because that step was eliminated.

So to conclude the results of that study, barcode scanning could now significantly reduce the incidence of medication administration and transcription errors and the errors with potential for harm. At our hospital at least, we extrapolated that there are about 90,000 potential adverse drug events prevented per year during the administration phase and around 50,000 prevented per year during the transcription stage.

Obviously errors are not completely eliminated. We were still on a learning curve at the time of the study and actually even today, identifying ways to improve the system and there's always a possibility of new errors being introduced.

We still have issues with incomplete compliance with scanning, that has improved over time, but there's always the need as with CPOE and any kind of technology, there's always a need for ongoing monitoring and improvement.

We also did a study to look at nursing satisfaction. There was a lot of concern that nurses were going to hate this when we first implemented, and so we did pre and post surveys of nursing satisfaction with the medication process. And the main results of that study were that nurses felt the medication administration process was safer and more efficient after implementation of barcode technology.

And then we also looked at work flow, because again there were concerns that this would be very laborious and would take away potentially from other clinical responsibilities, so we did over 200 observation sessions of work flow before and after implementation of the system, and the primary result was that the proportion of time spent on medication administration did not change after the implementation.

The proportion of time spent in the presence of the patient increased, not surprisingly because a lot of the medication administration task is now going on with a laptop at the bedside as opposed to in a medication room somewhere.

And so if we go back to our flow diagram, as I mentioned, computerized physician order entry can help tackled the ordering errors and one said he showed a 55% reduction after implementation of CPOE.

And then pharmacy decision for the core obviously can help with some of the dispensing errors, but bar-coding in the pharmacy in a study I haven't talked about today, was shown to have a 2/3rd's reduction of dispensing errors. And now we're adding reduction of administration errors to this diagram. This study that I just talked about, about a 51% reduction in administration errors and 100% reduction in transcription errors. So this whole portfolio is trying to get a quite significant reductions in overall serious medication errors throughout this process.

So I don't think that many hospitals have asked us about after implementation of the system or what are the clinical pearls about implementation since this is obviously a big effort to implement. So I'll just talk about a few of the factors or considerations that we, that we have.

So the software for this was developed by Partners Information System Analysts, and we've customized to Brigham and Women's Hospital system. And we did have the ability to have some real time enhancement in the initial phases. And the system was networked with our existing order entry system and pharmacy systems and really was a long project, ten years. Much of that was also on bar-coding in our pharmacy, which again I did not talk about today. So this wasn't all for the eMAR bar-coding at the besides. But, a long project nonetheless.

In terms of implementation, we did an initial pilot back in 2004 for about two weeks and there were a lot of supports for that pilot including computer based training, a four hour class for all the nurses. There were nurse super users which I'll talk about in a minute. And also IS analysts readily available.

And then after that pilot, there are many enhancements to the software. After – prior to the hospital wide rule out, and the key lesson I think with that is just, is as I'm sure everyone knows, that the real benefits to doing regular pilots of this kind of technology.

Subsequent to that we rolled out to a bunch of units which are listed there. And the first phase to mainly med surge an ICU, and then in the second phase to

hematology oncology. And we plan still to go to newer special units which we aren't in yet, but that's the goal over the next several years. So again this is something that can take many years to get throughout the entire institution.

So for the full roll out as well as for the pilot, we had super users available to all staff nurses to assist with medication administration until proficient. These super users were nurses and relatively senior nurses who were trained on the system and who were available 24/7 to help folks get through the initial growing pains of the first several weeks.

We also had information systems analysts who were also available 24/7 to troubleshoot issues with the application and the hardware and act as a resource for the super users.

Hardware. A lot of time was spent on finding the right hardware, even the right cart to put the hardware on. What was very interesting is when we first started this out; we thought the nurses would want small PDA type handheld devices. And in doing user groups with the front line nurses, they didn't want the handheld and they wanted an actual full laptop based on their work flow, based on the size of the screen, etcetera. So it was really important to involve the end users in selecting the hardware.

And even the cart as I mentioned, initial version didn't have a place where you could write, so that was a problem. And they also identified that people were using them to keep their beverages and that was a problem as well.

For the scanners, a lot of discussions as well in terms of what the right scanner was. If we want it to be tethered to the laptop or not tethered to the laptop. Needing to find ways to make sure that it was that it fit the work flow, be light and easy to use, but hopefully not easily lost. For those were some of the considerations that were used for the scanners.

So what have we discovered? One issue with bar-coding inconsistencies. A lot of questions about where the barcodes, where the barcode is, which one gets scanned, why won't it scan. Very subtle differences in quality of a barcode can result in it not scanning, and also noting that scanning is really in some ways an art form and some people were much better at scanning than others. Some of the

solutions to this was better data base management of the barcodes and trying to standardize the display of barcodes for all of our medication.

Physician work flow was another interesting thing that came up that maybe we didn't think about up front. Initially they had always been looking for the paper MAR's. Now they had to find it on the computer and they felt like there was an inability to access this data quickly because of a lack of computers on the units.

So dedicated devices for physicians were purchased so that physicians could always get on a computer to identify what meds have been given and improved log on time and user friendly displays as well for the physicians.

Another issue that came up and I think that always comes up with technology was that, you know, there was potentially an over reliance on the technology. So some comments that were received were, you know, the computer told me to give the meds, so I gave it, or the eMAR set me up to make the mistake, and so there's always the concern that the technology can replace critical thinking skills and potentially we can vigilant, so we always try not to rely on vigilance anyway when we think about safety solutions.

So in many of our trainings we emphasize that the technology was really a double check, but we reviewed safety data regularly and shared stories with clinicians about times when people overrode things that they shouldn't or the system maybe didn't act the way we wanted it to, but also tried to avoid over engineering, keeping things simple and continually seeking user feedback for improvements. If the eMAR set someone up to do the wrong thing, we want to know about it and then potentially improve the eMAR so that doesn't happen again. So feedback was a big component of our post implementation strategy. And feedback was very easy for the users to give pretty much on the front screen of the eMAR there was a very easy button to click to provide feedback.

So in terms of lessons learned, training seemed to be most successful when clinicians taught clinicians. There were extreme variances in staff acceptance. When you implement something like this, you need to be ready to uncover unknown processes that have been supporting the existing system up until now and as I mentioned, end user feedback is essential for design implementation and

maintenance of the technology. But the technology should never replace the critical thinking of clinicians.

And so in summary, barcode technology with eMAR significantly reduces transcription and administration errors, a well designed and fully supported system did not increase the proportion of time nurses spent on medication administration, and nurses using the system had higher satisfaction with the medication process. And key is involvement of end users from the beginning in design, hardware selection and piloting. And actually another key that I didn't list here is having the support of those super users and other folks during the initial implementation to really make that piece of it go smoothly.

So I think I will pass it back to Amy.

Improving the Safety of Pediatric e-Prescribing, Kevin B. Johnson, MD, MS

AMY HELWIG: Alright, thank you, Dr. Gandhi.

Our last speaker, Dr. Kevin Johnson, will conclude the teleconference and discuss a project where decision support results were added to computer generated prescriptions.

Dr. Johnson, I'll turn it over to you.

KEVIN JOHNSON: Thank you, Amy. I'm actually going to discuss two different projects. I've really appreciated hearing the presentations by Tejal and George and I think you'll find that in some ways, this kind of leverage is a lot of what I've learned from their work as well.

One of these projects is about a thing called show your work, which we'll talk about briefly. And I'm going to refer you to the paper for more details. And the second is actually an ongoing AHRQ funded project which is called STEPSTools.

Beginning with show your work, this is a project that was funded by AHRQ as I mentioned in the paper references here. And this was essentially a project whose goal was to address these problems.

First as we've all mentioned, adverse events are a very large problem right now as I think everyone knows. But one of the things that Tejal mentioned is that the pharmacists often get very involved in the process of mitigating these events.

George talked a bit about near misses and in fact that process is the primary way in which adverse events are often stopped. Callbacks are the primary mechanism of communication between authorized prescribers and agents and the pharmacists.

ePrescribing systems actually are the primary way now that we can actually provide cognitive support to prescribers. But as it turns out, what's interesting is that despite the types of decision support that may be prevalent in ePrescribing systems, those data are actually not communicated to the pharmacist.

So one of our hypotheses and the main one for this study is that the use of methods that automatically annotate prescriptions may improve communication and may reduce the risk of adverse drug events.

So in this pilot study, we used a single site using an internally developed ePrescribing system here at Vanderbilt called RxStar. We then conducted a randomized trial to examine callbacks in three pharmacies and specifically looked at the reasons for callbacks, the date and time, and the types of prescriptions that were generating callbacks.

We also gave a 7-item survey to 50 high volume local pharmacies to specifically ask about the potential impact of show your work if you will, satisfaction of it and its impact. And then any free text information that they were willing to give us.

On the right of this slide, you can see an example prescription. And what we talk about as show your work, is this material here which are things that we type at the bottom of a prescription or add in a note field of an electronically transmitted prescription that relate to warnings that were seen by authorized prescribers.

The results of the study were essentially that there was no impact on the volume of callbacks. But to go to a little bit of depth about this, one of the tables in the paper talks about the reasons for callback and you can see that essentially

with show your work off and with show your work on, we had roughly the same numbers of each of the different callback reasons shown here.

A histogram of the different types of show your work responses during the study period has shown it's below that, and as you can see the majority of where information only dose alerts. Things related to higher, slightly higher, slightly low doses, but a significant number of pieces of information related to dose calculation formula in pediatrics. The fact that someone had turned off dose calculating for a particular medication for which no calculating was required. And then some severe dose alert overrides and then many, many allergy overrides.

What's interesting is that we then had a chance to talk to the high volume pharmacies and ask them specific questions about their perception of the tool. And as you can see from the Likert scale data show here, there was general agreement that show your work did appear to have positive impact in terms of checking for potential errors and potentially avoiding some callbacks due to patient reported allergies.

But what's interesting is that also, there was also some disagreement about – or some agreement that it did cause people to make an additional callback. Going into some detail about that, you can see the performances perceptions included things like, it increased – it improved communication between prescribers and dispensers, decreased callbacks in some cases, but pediatric dosing information did help for checking errors and in some cases, two comments here, it increased callbacks. As you can see the other items below.

One of the interesting – so the impact of it was that there was essentially no change in the volume of the callbacks. However, the comments suggested that there may be some impact on the reasons for the callbacks and the quality of the callbacks. We considered this to be reassuring, that we should consider doing a larger study of this, but it's worth noting that it's an incredibly easy intervention to implement.

Structured sig/e-prescribing can simply support the note fields that would expose results of clinical decisions support. Importantly we also received no information about negative aspects of this. In other words there was nothing on the prescription that was in any way causing potential errors. Then additional studies

should more carefully examine both the quantity and the quality of pharmacist communication resulting from e-prescribing.

The second study that we've been involved with is a project called STEPSTools. I'm a pediatrician and a big focus of our lab here has been thinking through those things that tend to cause errors in pediatrics. And this particular project is based on a couple of observations we've had here in the world of prescribing.

For most of us who write prescriptions, especially in pediatrics, four different types of knowledge are required. There is some – it's important that we have knowledge about how to round a dose, it's important that we understand milligram per kilogram or body surface area based dosing. It's important that we have warnings such as the types that are found in show your work and that are generated by e-prescribing tools. And obviously we need to know which formulations are appropriate given the age of the child, the ability of the child to swallow pills, etcetera.

What's interesting is that if you look at e-prescribing systems, dose rounding and formulation choice are typically not as well developed as some of the milligram per kilogram systems and obviously the decision support that we've all talked about.

The ramifications of that are that there have been studies showing mismatches between the formulation that is recommended by e-prescribing system and what should actually be prescribed for a child, which obviously generates both a callback or potentially a lack of medication adherence.

And incorrect dosing recommendations must be overridden in e-prescribing situations. Many times and there's a study by Eclaire (phonetic) that talked about this particularly. Many times it is the overriding of a dosing recommendation that actually generates an error. The most common error in kids is what's called a 10-fold error, where decimal points may be misplaced as a result of correcting so to speak, those things that may be generated by an e-prescribing system.

So the problem that we were trying to solve with STEPSTools is that the data that are needed to improve pediatric e-prescribing actually do not exist in a

form that is really computable and therefore usable by pharmacists or vendors. And so the question is how can we construct and disseminate this knowledge nationally.

The project is called STEPSTools and the goal of STEPSTools is to improve the safety and usability of e-prescribing and pediatrics. Specifically we are developing a knowledge base of rounding tolerances for commonly prescribed medications, developing an algorithm to round computer-calculated doses safely. Developing tools using this knowledge based algorithm that can be integrated into disparate e-prescribing systems, and then evaluating the impact on dose acceptability and pharmacy callbacks.

We are about midway through our evaluation, so all I'm going to talk about now is the work that we've done to develop the knowledge base and to disseminate it.

Our methods of collecting the data about the rounding algorithm and philosophies was based on literature review, prescriber interviews and an advisory group which is called a STEPSTools working advisory group or SWAG, a survey that we did to them.

And then a second literature review and work to understand different drug rounding categories that was generated by our pharmacists and by other prescribers. And then finally knowledge validation, that was also done by the SWAG.

The data collection process allowed us to discover 115 medications that are actually it's probably better to say active ingredient of medications. That can be rounded. And those represented just slightly over 90% of the most commonly prescribed pediatric drugs at a combined set of children's hospitals.

We then went through a series of drug literature review references to look at weight based dosing guidelines, minimum and maximum dosing, and then specific issues related to drug toxicity and side effects.

That process allowed us to build the following drug information model. The circles that are or the (inaudible) that are black represent those new components of a drug information model that this project generates.

We also took a look at many of the commonly available dosing implements and you'll notice as we – sorry, you'll notice that many different implements exist. Pharmacists are able to provide any of these to families who ask for them. And of note, many of them allow dosing in as small as .1 ml increments, although those are not usually readable depending on the number of ml's in a syringe. And most of them do designate fractional teaspoon doses. So while we might say it's not generally a good idea to administer or to prescribe a teaspoon of a medication, as long as the correct dosing implement is used, it's actually possible to deliver fractional teaspoon doses accurately.

We then completed our literature review and found four categories of active ingredients. Category one, avoiding unintentional consequences. This would be the typical example where a medication when rounded has dose dependent side effects which therefore would make us not want to round too aggressively.

Another would be controlling intended effects. In this situation the impact of dose-dependent effects is significant such as Lasix.

Another category would be simply a narrow therapeutic index or a toxicity issue like digoxin.

And the fourth which is an important one, is that safety and efficacy are unknown, therefore there's no pediatric dosing information.

When we look at our roughly 115 drugs, we come up with this overall percentage breakdown. 15% of the medications – I'm sorry, yeah 29 medications were able to be rounded by 15%. 24 medications were able to be rounded by 10%. 31 medications were able to be rounded by 5%. And this is all based on toxicity. And 24 medications were actually not recommended to be rounded at all. These include digoxin, insulin and a few other medications.

We then had been developing a web services model to distribute the use of our rounding knowledge. For those people who are not familiar with the idea of a web service. What web services do is allow multiple groups over here to use e-prescribing systems. And while they're using those e-prescribing systems, messages are able to go through the internet to other servers, in this case our Stepstool server, that can process specific requests, return specific responses and in

so doing allow the vendor to be in control of some of the performance issues, many of the work flow issues and the specific ways in which they would like to integrate this knowledge into that work flow.

This is a very exciting model. You'll hear more and more about it. There have been many activities going on both at the CDC as well as outside of healthcare.

To use a web services model for this particular project, we require a patient's weight in kilograms, the patient's age in months, medication name and medication encoding so that we know essentially from some standardized coding scheme as George mentioned, which medication it is. And a milligram for kilogram dosing formula.

We then take that information and we standardize it using a tool call RxNorm which allows us to develop the right terminologies. And we've done a lot of work over the last year looking for where there might be problems with the way our RxNorm translates its medication knowledge into all of the different vendor systems. From there we have a medication that is recognized by our knowledge base.

We then determined common frequencies by the process of our literature review and we've had to create a specific data base for this. And using that knowledge base, we have known frequencies that are simplified by times per day. For each known frequency, we take the patient's weight in kilograms, we take the milligram per kilogram dosing formula, divided by the known frequency and we end up with an exact calculated dose which will then need rounding.

That dose is then compared with the minimum and maximum recommendations. A very common problem in pediatrics is that milligram per kilogram dosing will exceed an adult maximum, and in many systems that's a common cause of problems. And we will take the same information and calculate a rounding range. So once we've calculated a dose, we calculate a range plus or minus 15% of that dose.

And then finally we generate a list of possible doses by going through all possible formulations using the information we have about the working range,

using the formulation specific dosing ranges, collecting all of the possible doses and then for each dose range looking to see if there are doses that could be easily administered by adults. And then scoring each of those doses so that we have an ordered list, ideal formulations and ideal doses based on the information that we've learned from pediatricians and pharmacists.

So our process now is to implement that entire system and actually that has been done. These are some example business rules for our possible doses. So if the age of the patient is less than 7, we would boost the score. For that reason if the form is a liquid, we would boost the score for any doses that are whole ml doses and if the form's a liquid, we would boost the score of a dose that is greater than one milliliter but less than ten milliliters because most parents would like to get their children under ten ml's of medication as you might imagine.

All of that is now a part of a series of web services that are being implemented by two different vendor systems and we are now evaluating log files to assess the frequency of use, differences between the high scoring doses and final orders, and we're conducting site visits to assess overall satisfaction with this process and pharmacy callbacks.

So I wanted to talk a little bit about this because we should have a fair amount of work being published in the next year in this area and I thought it might be of interest to some of our listeners.

I want to obviously acknowledge our group which is our STEPSTools grant, AHRQ funding, the STEPSTools team and the members of our SWAG who are listed here.

Amy, it's all yours.

AMY HELWIG: Great. Thank you, Dr. Johnson. Now we're going to begin to take questions. You will also notice a survey on the screen and we would appreciate it if you would take a few moments to complete the survey as we greatly value your feedback.

If anyone has any questions, they can feel free to enter them electronically. At this moment I don't see any on the screen.

One more comment while we're waiting. This audio conference itself will be posted at the AHRQ website about one week from today, so if you're looking for either the powerpoint or the audio conference, you'll be able to receive it there.

Collin, do you see any questions on your screen?

COLLIN BUCKLEY: At this moment, Amy, I do not. The survey has just popped up. Again people can go ahead and fill that out right now online.

Also I know that the recording of today's event is going to be hosted on the AHRQ website and available in the next week or so. And I see that we just received a question.

AMY HELWIG: Okay, the question comes from Linda and is there any research being done on adverse drug events in community clinics.

So I guess I could pose that to all of the presenters today. So either Dr. Hripcsak, Dr. Gandhi or Dr. Johnson, if you have any responses to that.

TEJAL GANDHI: I'm happy to start. This is Tejal. So I'm guessing when you say community clinics, you're really thinking about for example the primary care setting and those types of areas. And you know, we've done some work on identifying what adverse drug event rates are in the primary care setting that we've published, that about 25% of patients who get a drug in primary care have an adverse drug event in the next three months, and those kinds of data. And then I know there's data as well on, that's starting to come out about the impact of things like e-prescribing on preventing medication errors in those settings. And I would guess, you know, as Dr. Hripcsak said, you know, as EMR's come out as well, there will be, I think it will become much easier to study those settings than it has in the past when we've had to do paper charts and chart reviews and things like that which made it very difficult.

AMY HELWIG: Alright. A second question we have. Please name two e-prescribing vendors that were involved in this study.

KEVIN JOHNSON: This is Kevin. In our study right now, we have been working very closely with two different e-prescribing vendors. NexGen who we were, we were working very hard to get up on the STEPSTools project before we

were kind of into your three, and we were unable to get that to happen. And Office Practicum who is our other partner in the STEPSTools project.

It's worth noting that Epic has a terrific e-prescribing system as well, heavily used in pediatrics as probably many of you know, and they have been very interested in understanding how to improve e-prescribing, but as a large vendor it's been a bit tricky to work with them.

AMY HELWIG: If we have any other questions from the audience, please feel free to submit them.

GEORGE HRIPCSAK: On patient safety in community health centers, you might look at the work of the Institute for Family Health, Neal Calman. He's done a lot of work on quality improvement and health disparities, but I believe there's some work on patient safety also.

COLLIN BUCKLEY: And for the audience, you can submit questions at any time, just click on the Q&A tab and then click on submit a question and you'll be able to send that in to us.

AMY HELWIG: Collin, do you have any other administrative details that you'd like to announce while we wait questions?

COLLIN BUCKLEY: Well I would just like to thank everybody and all of our speakers. I did want to point out that we do have in the event coming up a webinar examining health information technology and underserved and valuable populations. And we'll be having more information about that coming out soon.

And then as I said, the recording of today's webconference will be available on the AHRQ National Resource Center website within the next two weeks. And you can visit that at http://HealthIT.AHRQ.gov.

AMY HELWIG: Thank you, Collin. We'll wait another, just one more minute, waiting to see if there are any other questions that come in.

At this time we may not have any additional questions for our presentation today.

COLLIN BUCKLEY: Well Amy, I think that means that our presenters just did a wonderful job today.

AMY HELWIG: Well as well on behalf of AHRQ, but to thank Dr. Hripcsak, Dr. Gandhi as well as Dr. Johnson for their presentations today.

And again we will be having another national teleconference upcoming dealing with Health IT and underserved populations and we look forward to folks looking for more details on that.

COLLIN BUCKLEY: Well thank you everyone for attending today's webcast. We look forward to seeing you again in the future. This does conclude today's event. Have a nice day.