Optimization of Laboratory Services and Education at the UCSD Student Run Free Clinic Project during Electronic Health Record and Laboratory Information Systems Integration

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Abstract:

Clinical notes, consults, vital signs, labs, and more are expected to be a part of a patient's electronic file, so that they can be easily and quickly looked up to provide better patient care. The UCSD Student-Run Free Clinic Project (SRFCP) implemented Electronic Health Records (Epic) in 2013. However, the laboratory used by the free clinics had not been integrated electronically. Therefore, the free clinics had been entering lab results into EPIC via manual data entry for four years. In 2017, the UCSD Epic Information Technology team, including the Ambulatory Offices' Chief Medical Information Officer, decided that it was a UCSD Health Sciences priority to integrate Quest labs into Epic. This required a significant amount of retraining, writing new workflows, improving processes, re-thinking the role of the free clinic lab manager, optimizing education, and ensuring the correct provider receives results in a timely fashion in the UCSD SRFCP setting. This ISP assessed the laboratory workflow and allowed the student to serve as Project Manager for the laboratory systems change within the Free Clinic setting. This required seeking input from all stakeholders before, during, and after the changes to optimize the process in this setting. New protocols, documentation, and training processes were created as part of this ISP. In addition, an analysis of recent lab test costs was performed, and an overview of lab test expenditures was produced.

Background:

It is well established that a central source of medical records assists doctors and other clinical care personnel in providing comprehensive and high-quality care for patients, and that the advent of electronic medical records (EMRs) has the potential to further improve the quality of care.[1-4] Such systems have integrated not only with clinical notes, but also with referrals, examinations, visits, lab testing, orders, billing, and coding. This allows for better optimization and decreases the amount of errors that could occur with paper charting.[3] Even moving orders to an electronic system can reduce the occurrence of written errors and improve efficiency, although care must be taken to not be too disruptive in implementing workflows.[4] Regardless, implementing EMR systems have demonstrated many benefits and have changed the current healthcare landscape.

Meanwhile, an important part of patient care is objective data via laboratory results. Lab results play an important role in improving patient health, and having up to date results are just as important when it comes to decision making.[5,7] Having these results readily available through an integrated EMR system provides some evidence of increased efficiency of care and decreased waste as well.[6,9] There is also an increase in patient satisfaction by having results readily available electronically for their perusal, and even when patients may not be able to view their results electronically themselves, there is evidence for increased satisfaction via surveys for having results in an electronic database.[1,9-10]

Having an EMR system also assists with medical education and provides multiple advantages for those who are new to the healthcare system. A central repository of information helps students synthesize data and therefore give students additional support to critically evaluate patients as they are learning.[8,10] Students note that having access to an EMR also improves their ability to bring up information and document results, which is especially important when looking at lab results.[11] At the

same time, there are concerns over shortcuts in an EMR system such as copy-pasting that can hinder learning and patient care, which makes student education on EMR usage important in today's healthcare system. As such, it is important to train students early in proper usage of the EMR system, especially regarding laboratory data and clinical practice guidelines.[12]

One way that students can be better trained comes in the form of student run free clinics (SRFCs). They provide early exposure to patients and clinical experiences and examples that form a foundation for medical students to learn.[13] The University of California - San Diego Student Run Free Clinic Project (UCSD SRFCP) was founded in 1997 and provides medical care to the underserved populations of San Diego. It offers a multitude of free services including dental, social, acupuncture, and mental health. It is run largely by volunteer medical students with the help of both clinical faculty and volunteer physicians in many different specialties.[14] The UCSD SRFCP is an important stop for medical students in their education, and as such offers an excellent opportunity to integrate laboratory education for medical students, especially when laboratory medicine education is an important part of health care and early knowledge base for students.[15]

Currently, the UCSD SRFCP uses an EMR system provided by Epic Systems Corporation that is used concurrently with the UCSD Health System, providing a central repository of a patient's healthcare records for healthcare providers. The SRFCP relies on a single outside laboratory, Quest Diagnostics, to provide lab results. Quest does have an ability to integrate their labs into Epic, but UCSD did not automatically integrate lab ordering and results from Quest into Epic at the time of implementation at the SRFCP in 2013. Therefore, labs had been manually ordered through Quest's Care360 website and subsequent results were manually inputted into our EMR by end-users. This manual lab data entry was usually handled by medical student lab managers (approximately 1-4 at each SRFCP site), with initial verification of data entry by a second first or second year medical student lab manager. Each lab is then reviewed by faculty supervisors for accuracy and to determine clinical management plans. However, having different systems with multiple points of contact naturally allows for multiple points of error.

In the old laboratory workflow, lab entry usually required the provider to verbally provide lab orders to the lab manager, at which point the manager entered those orders into Care360 and printed out the labels and order form before drawing a patient's blood and sending to Quest. Afterwards, results were faxed to the main SRFCP office (which is located on the UCSD School of Medicine campus), where they were distributed to the appropriate inbox of the different clinic sites. These lab results were picked up by a clinic general manager (also a medical student) who would take these results to their respective clinic. These labs were then manually entered in Epic by the lab manager or the general manager. Every lab result entry had to be double checked by a different lab/general manager and signed by an attending physician. The hope was that this process would be a short-term solution until UCSD Epic Information Technology Outpatient Team leadership and Quest labs worked on a solution that would allow laboratory orders to be placed and laboratory results to automatically populate within Epic. This system within the Free Clinic lent itself well to medical student education as it was highly dependent on medical students entering and working with attending physicians to interpret lab results, yet it was laborious and prone to errors via loss of paperwork or manual entry of labs into the EMR system.

It had been four years since Epic implementation at the SRFCP until the UCSD Epic Outpatient team agreed that allowing Quest and Epic to communicate electronically so that UCSD Outpatient providers can order labs and receive lab results is a Health Systems priority. This was driven in large part from other Health Sciences clinic needs since certain payers (such as Medi-Cal) do not cover laboratory services provided onsite at traditional UCSD outpatient clinics, instead requiring patients get their labs performed at Quest Diagnostics instead. In addition, UCSD Health Sciences has opened multiple satellite sites that are not geographically close to an existing UCSD laboratory. With the upcoming changes in how the UCSD SRFCP needed to order, receive, and process labs, an opportunity to streamline the process and reassess opportunities for medical education was possible, all while evaluating the current state of laboratory orders, workflows, and optimizations at the UCSD SRFCP.

Methods:

Lab Integration and Verification

During this project, integration of lab results between Quest and Epic was implemented by UCSD Epic IT throughout the entire UCSD EMR system. We requested that Quest continue to send paper copies of lab results, which we used to verify that results for Free Clinic patients were correctly entered into the EMR system. Any discrepancies were noted, accumulated, and brought to the attention of a point person within the UCSD Epic IT team for correction. If possible, an analysis of the integration problems between Quest and the Epic EMR system was undertaken to prevent future occurrences. At the same time, workflows for student lab managers were adjusted so that they could also assist with verification of results.

For lab ordering integration, we worked with the UCSD Epic IT team and with Quest Diagnostics to bring ordering capabilities to the Free Clinic. We verified that appropriate lab ordering integration could be performed with the EMR system. Working with the Epic IT team, we strategized how to implement lab orders in Epic and obtaining orders through the Quest interface for lab draws on site.

Lab Manager Workflow/Protocol Optimization

Due to the changing nature of lab integration throughout the year, the lab manager protocols needed to be revised multiple times throughout the year. This was mainly performed by the current and previous medical student lab managers. As such, the current lab manager protocols were reviewed once or twice during the lifetime of this project to make sure that the minimal tasks for lab review and entry were included (such as lab entry verification and entry of FOBT results).

Cost Utilization Analysis

Overall lab utilization and costs were obtained from Quest Diagnostics for the entire year of 2017; data from the 2016 fiscal year was also previously obtained and used as a basis for comparison. This data was analyzed to determine the total costs of lab tests performed in the year. The data was also used to determine costs per test and the presence of any cost outliers.

Results and Discussion:

Integration of Lab Results into the EMR System

At the onset of the project, the UCSD Epic Information Technology Team had already begun the process of integrating lab results from Quest Diagnostics into the Epic EMR system. Discussion with a point person on the UCSD Epic IT team was necessary in order to bring the same system to the Free Clinic. During the process, we encountered difficulties in determining how lab results should be reviewed, as previously this was done via reviewing the paper copy in conjunction with a medical student lab manager and having an attending sign that it was reviewed. The lab manager then entered the data into the chart. However, once we were able to start receiving lab results directly from Quest into the Epic EMR system, this process was phased out. While this indeed improved accuracy of the results and eliminated the possibility of erroneous entries due to human entry, we discovered that some lab results never appeared in the Epic inbox of the ordering attending physician, meaning an abnormal result could go unnoticed. Naturally, such a thing is troublesome, as lab results may be important and would need to be addressed promptly. Therefore, we had Quest continue to send us paper results so that we could verify that the results in Epic, particularly those that came to the inbox of the faculty, were a complete and accurate copy of all lab results. Protocols for medical student lab managers were altered such that they would verify paper results matched with results in the EMR system. After speaking with the UCSD Epic IT team, we discovered that missing results could be due to a variety of factors, including: 1) no MRN number placed in the patient's Quest ID field; 2) patients with multiple MRNs; 3) improperly labeled lab tests between Quest and the Epic EMR system preventing association of the results between systems; and 4) incorrect provider or lack of provider information placed for lab draws in Quest's system, which resulted in errors on the Epic EMR side. These errors ended up in an "error queue" that had to be manually fixed and released by the Epic IT Team, resulting in anywhere from a day to two-week delay, depending on the availability and time constraints of the person in charge of the error queue. Unfortunately, this was and continues to be out of the Free Clinic's control, and the best that we can do is to try to prevent errors on the Free Clinic's end from mistypes or incorrect entries. In the meantime, we double checked that all lab orders placed through Quest had a correct MRN/ID number as well as associating the correct physician with each order placed. We also encountered difficulties with results not being sent to certain providers for review. This problem was also directed to the UCSD Epic IT team, who helped resolve the issue.

Lab Manager Workflow/Protocols

While previous lab workflows were more than adequate in the daily workflow of the clinic, changes had to be made because results were now being internally resulted into the EMR system instead of being faxed by Quest. The primary change was how medical student lab managers reviewed lab results. Previously, they had to review every single lab result with an attending and then manually enter those results into Epic. Now, the students review each lab result that has been faxed in from Quest with the results in Epic, thereby checking for consistency. Unfortunately, this has had the drawback of decreasing the amount of student/attending interaction, and specifically any teaching that might coexist with reviewing lab results. In addition, the attendings review and document the lab results ahead of time,

which further decreases the amount of time for interaction. What improved, however, is the efficiency of reviewing lab results, as well as decreasing the amount of time during clinic that an attending needs to focus on lab results, instead allowing that attending more time for patient encounters. Upon speaking with the lab managers, they expressed the usefulness of reviewing lab results with an attending at the onset of their time as a manager, but as they became more experienced the need to review every result with an attending became less useful. Although there is no clear answer as to what would be the optimal workflow to assist with both medical student education and the accuracy of lab results, the current workflow instituted by the lab managers strikes a balance, allowing for personal review of the results and, should certain results be confusing or of concern to that student, they can review that specific result with an attending.

Ordering Labs through Epic

The next phase of the project consists of integrating ordering of labs through the Epic EMR itself, instead of needing to go through a complicated process that introduces multiple avenues for error. Although this has been instituted at multiple UCSD outpatient clinic sites, the UCSD Free Clinic has not been able to turn on this feature, given the additional complications associated with the clinics acting as both an outpatient clinic site and a lab draw center. Currently, we are discussing how implementation of lab orders can occur, and how that implementation will work regarding having an order placed in Epic and propagating to the Quest system. For most clinic sites, this is done via sending a requisition to Quest, at which point the patient is free to go to any Quest lab draw center and have their blood taken for testing. However, the unique nature of the Free Clinic means that, as a lab draw point ourselves, we need to be able to both send a requisition to Quest (for patients who may choose not to have their blood drawn at clinic, or if the lab test needs specialized media for blood storage/transport) as well as pulling up a requisition and converting it to an active lab draw event (which requires printing of labels). This is the next most important step and figuring out whether the system can perform this will be crucial towards continuing future implementation.

Cost Utilization Analysis

The total number of lab tests and their corresponding Free Clinic price was obtained from Quest for a period from July 2015 to July 2016, and from January 2017 to December 2017. Using a 1-year period from July 2015 to June 2016, the total cost of lab tests for the Free Clinic was $30,407.77. If a patient had to pay for every test ordered out-of-pocket, the total cost would equal $360,234.38, thus indicating that the Free Clinic paid only 8.44% of the total out-of-pocket cost (and thus saving patients 91.56% of the costs) (see Appendix, Table 1).

For tests performed during the 2017 calendar year, the Free Clinic paid $26,529.10. Unfortunately, no patient out-of-pocket cost was provided. Therefore, out-of-pocket costs from the 2015-2016 data set were used instead to estimate what the out-of-pocket costs would be using the utilization data from 2017. Interestingly, the Free Clinic prices for all tests with associated patient costs were the same in both the 2015-2016 data set as well as the 2017 data set. In cases where the patient pricing was not available, they were omitted from the total patient cost. Therefore, the total patient (out-of-pocket)

cost was $305,683.91; this is an underestimate of what the true value would be, as 265 out of 4742 tests did not have an associated patient cost. If we only analyze those tests for which there were patient costs, then the total Free Clinic (discounted) cost sums up to $23,103.57, a 92.44% savings compared to the patient cost.

When looking at the most common lab tests ordered for 2017, the top 5 tests consist of routine testing, including the basic metabolic panel, comprehensive metabolic panel, complete blood count, and hemoglobin A1C (see Appendix, Table 2). Interestingly, the second highest "test" is actually a lab draw fee from Quest's patient service centers (PSC); our fees for sending our patients to a Quest lab draw center costs us 6% of our yearly total lab costs, and accounts for 559/4742 charges, or 11.8% of all of last year's charges for the Free Clinic. The actual number of lab tests that were drawn at Quest and not through the Free Clinic is slightly higher at 13.9% (this was calculated by removing the lab draw and other reflex testing numbers from the total count, which meant that 559/4022 tests were drawn at a PSC; this may still be a slight underestimate, as multiple lab tests can potentially be performed on a single blood draw vial). Also, a closer look at the entirety of the tests ordered last year, only 2 tests actually cost the Free Clinic more than a patient would pay, both related to PTH (PTH with calcium costs $48.46, a 124% increase over the patient price of $38.94, and PTH without calcium costs $59.40, a 183% increase over the patient price of $32.45). However, these two tests only made up a total of 4 individual charges, and therefore play such a minor role that it is unlikely any modifications to lab orders with respect to PTH will cause an appreciable difference towards patient care and costs. However, it is interesting to note that ordering the PTH with calcium is cheaper than a PTH without calcium, and therefore it might make more sense to always order the former test (however, as noted previously, with only 2 orders of each test for an entire year, the benefits would be minimal at best). The potential differences in pricing between tests that may cover similar components is a possible avenue of further analysis.

Although the patient cost is likely to be greatly inflated and even those paying out-of-pocket will likely get discounts on the cited patient price, using the patient cost as a comparison of the worst-case price point illustrates the cost savings that occur with lab orders in the Free Clinic.

Future Work

The biggest factor influencing what was not tackled during this project was the difficulty establishing Quest lab orders through the Epic EMR system. As such, future goals include:

- Roll out ordering labs in the Epic EMR system itself instead of through Quest's system
- Rewriting the lab manager workflow to include lab order draws after orders have been placed through Epic; will likely require lab managers entering Quest's Care360 website to print out labels after an order has been placed
- Continue analysis of lab utilization and determine if there are avenues of cost savings that can be done; this may be assisted if up to date patient costs could be obtained

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Appendix

TEST CODE	TEST NAME	TOTAL UTIL	CLIENT Price	PATIENT Price	Total Patient Cost	Total Client Cost	% Test Utilization*	% Client Cost Utilization**
496	HEMOGLOBIN A1C	773	$4.80	$71.39	$55,184.47	$3,710.40	14.95%	12.20%
3259	DRAW FEE, PSC SPEC.	520	$2.85	$21.63	$11,247.60	$1,482.00	10.06%	4.87%
10231	COMP METAB PNL	373	$5.04	$74.15	$27,657.95	$1,879.92	7.22%	6.18%
1759	CBC(H/H,RBC,WBC,PLT)	344	$2.67	$40.51	$13,935.44	$918.48	6.66%	3.02%
10165	BASIC METAB PNL	312	$4.03	$59.34	$18,514.08	$1,257.36	6.04%	4.13%
608	HDL-CHOLESTEROL	264	$2.12	$41.10	$10,850.40	$559.68	5.11%	1.84%
334	CHOLESTEROL, TOTAL	264	$2.94	$37.86	$9,995.04	$776.16	5.11%	2.55%
896	TRIGLYCERIDES	264	$2.94	$70.30	$18,559.20	$776.16	5.11%	2.55%
8459	CREATININE RAND (U)	210	$3.05	$55.16	$11,583.60	$640.50	4.06%	2.11%
899	TSH	188	$6.00	$125.47	$23,588.36	$1,128.00	3.64%	3.71%
5463	UA, COMPLETE	128	$3.13	$45.76	$5,857.28	$400.64	2.48%	1.32%
395	CULT, (U) ROUTINE	118	$7.60	$58.41	$6,892.38	$896.80	2.28%	2.95%
UR1P	PRESUMPTIVE ID 1 M	94	$7.60	$31.37	$2,948.78	$714.40	1.82%	2.35%
36127	TSH W/REFL FT4	87	$6.00	$125.47	$10,915.89	$522.00	1.68%	1.72%
457	FERRITIN	83	$5.50	$108.16	$8,977.28	$456.50	1.61%	1.50%
7573	IRON, TOTAL, & IBC	67	$7.51	$86.03	$5,764.01	$503.17	1.30%	1.65%
91431	HIV1/2 AG/AB,4 W/RFL	60	$9.40	$104.00	$6,240.00	$564.00	1.16%	1.85%
1UR	ORG ID 1	53	$7.60	$31.37	$1,662.61	$402.80	1.03%	1.32%
866	T-4, FREE	46	$7.67	$140.61	$6,468.06	$352.82	0.89%	1.16%
8847	PRO TIME WITH INR	42	$3.40	$35.69	$1,498.98	$142.80	0.81%	0.47%
Total (Top 20)		4290			$258,341.41	$18,084.59	82.99%	59.47%
Total (Entire set)		5169			$360,234.38	$30,407.77	100%	100%

Table 1: Lab utilization and costs from July 2015- June 2016. Top 20 labs shown based on utilization numbers. Totals from both the top 20 tests as well as the entire data set included.

**% Test Utilization is the number of specific tests done out of the entire number of tests performed*

***% Client Cost Utilization is the percentage of the total client cost of the specific test compared to the total overall client cost*

TEST CODE	TEST NAME	TOTAL UTIL	Client Price	Patient Price*	Total Patient Cost**	Total Client Cost	% Test Utilization***	% Client Cost Utilization****
496	HEMOGLOBIN A1C	669	$4.80	$71.39	$47,759.91	$3,211.20	14.11%	12.10%
3259	DRAW FEE, PSC SPEC.	559	$2.85	$21.63	$12,091.17	$1,593.15	11.79%	6.01%
10165	BASIC METAB PNL	328	$4.03	$59.34	$19,463.52	$1,321.84	6.92%	4.98%
10231	COMP METAB PNL	309	$5.04	$74.15	$22,912.35	$1,557.36	6.52%	5.87%
1759	CBC(H/H,RBC,WBC,PLT)	301	$2.67	$40.51	$12,193.51	$803.67	6.35%	3.03%
334	CHOLESTEROL, TOTAL	218	$2.94	$37.86	$8,253.48	$640.92	4.60%	2.42%
608	HDL-CHOLESTEROL	218	$2.12	$41.10	$8,959.80	$462.16	4.60%	1.74%
896	TRIGLYCERIDES	218	$2.94	$70.30	$15,325.40	$640.92	4.60%	2.42%
8459	CREATININE RAND (U)	198	$3.05	$55.16	$10,921.68	$603.90	4.18%	2.28%
91034	MICROALBUMIN RAND UR†	198	$7.13	-	-	$1,411.74	4.18%	5.32%
899	TSH	140	$6.00	$125.47	$17,565.80	$840.00	2.95%	3.17%
36127	TSH W/REFL FT4	106	$6.00	$125.47	$13,299.82	$636.00	2.24%	2.40%
395	CULT, (U) ROUTINE	88	$7.60	$58.41	$5,140.08	$668.80	1.86%	2.52%
5463	UA, COMPLETE	85	$3.13	$45.76	$3,889.60	$266.05	1.79%	1.00%
UR1P	PRESUMPTIVE ID 1 M	69	$7.60	$31.37	$2,164.53	$524.40	1.46%	1.98%
8472	HEP C AB W/REFL HCV	64	$7.68	$139.53	$8,929.92	$491.52	1.35%	1.85%
457	FERRITIN	57	$5.50	$108.16	$6,165.12	$313.50	1.20%	1.18%
866	T-4, FREE	56	$7.67	$140.61	$7,874.16	$429.52	1.18%	1.62%
17306	VIT D,25-OH,TOTAL,IA	53	$15.00	$232.54	$12,324.62	$795.00	1.12%	3.00%
7573	IRON, TOTAL, & IBC	51	$7.51	$86.03	$4,387.53	$383.01	1.08%	1.44%
Total (Top 20)		3985			$239,622.00	$17,594.66	84.04%	66.32%
Total (Entire set)		4742			$305,683.91	$26,529.10	100%	100%

Table 2: Lab utilization and costs for 2017. Top 20 labs shown based on utilization numbers. Totals from both the top 20 tests as well as the entire data set included.

**Patient price based off values from the 2015-2016 data set (see Table 1).*

***Total patient cost based on the patient price values from the 2015-2016 data set.*

****% Test Utilization is the number of specific tests done out of the entire number of tests performed.*

*****% Client Cost Utilization is the percentage of the total client cost of the specific test compared to the total overall client cost.*

†Microalbumin Rand UR did not have a corresponding patient price value from the 2015-2016 data set, so no value was placed and no value for the total patient cost was calculated.