Enhancing Hospital Health Information Management using Industrial Engineering Tools

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Abstract

Hospital health information management (HIM) typically involves a number of stages, including medical records coding, processing, analyzing, archival, and retrieval. The exponential increase in healthcare spending, the need for quicker medical expense reimbursement, and the elevated security requirements for the sharing of medical records have added to the complexity and challenges of HIM. Moreover, the objective for HIM has always been to achieve better resource utilization, reduce the medical records processing time, meet regulatory requirements, and incorporate technology to streamline processes. This study focuses on applying various industrial engineering tools to improve the operations in the HIM department of a regional healthcare provider in upstate New York. This healthcare provider was in the process of implementing a Document Imaging (DI) initiative. Therefore, comprehensive time studies, workflow analysis, and value stream mapping were used to assess the current system operations. Then, various performance metrics were developed to serve as a baseline for quantifying improvements resulting from the introduction of DI technology. To delineate the future state, illustrate the impact of this technology on workflow changes, and provide scientific suggestions in the decision making process, a discrete-event simulation model was developed. After model verification and validation, the simulation results were used for specific operational suggestions, such as the determination of the 'optimum' batch size for patient chart arrivals, workflow modification, and personnel scheduling. Alternate scenarios for managing HIM work processes were also evaluated to provide decision makers with critical insight into their processes to enable change, improve the quality of work, and mitigate potential operational risks.

Introduction

Health information management (HIM) manages healthcare data and information resources. The functions of a hospital's HIM department typically encompass planning, collecting, analyzing and disseminating individual patient clinical data. The department is responsible for managing health records and abstracting data into useful information, within the context of dynamic rules, regulations and guidelines set by state law and the Health Insurance Portability and Accountability Act (HIPAA) [1].

To keep pace with the changing technology, and more importantly, to effectively manage the hospital's information systems, one of the initiatives taken by healthcare organizations is to convert their patient records into an electronic form. This not only makes health information management more efficient, but also saves cost and time in the long run. More specifically, it helps make the reimbursement process faster, increase system(s) security and makes it easier to share patient medical records. From the patient perspective, since electronic medical records contain information on his/her medical history, medication needs, health status, known allergies, and past services used, they can be assessed by various healthcare providers at different times and updated accordingly. This makes it possible for a healthcare provider in California to pull up information on a computer screen about a patient's hospital stay in New York two years earlier, thereby providing more effective care and avoiding unnecessary duplication of services [2].

This research endeavor focuses on an HIM department of a community hospital in upstate New York, which was in process of implementing DI. Various Industrial Engineering (IE) tools, such as time study, workflow analysis, value stream mapping and others, were used to analyze the current state of the HIM processes. After identifying the performance metrics, the current state processes were measured and established as a baseline. In order to fully evaluate the future state processes after the implementation of DI, a discrete-event simulation model was built, validated and verified, and used to identify potential operational bottlenecks, predict future performance and determine optimum batch size and backlogs. Hence, the objective of this research endeavor was to identify ways to effectively handle process changes in the HIM department's implementation of DI and provide operational improvement solutions accordingly.

Health Information Management Department

The HIM department under study comprises of different sub-units working in coordination with each other. Prior to the implementation of DI, these sub-units included an assembly area, an analysis desk, a coding area, and the physician's room, as shown in Figure 1.

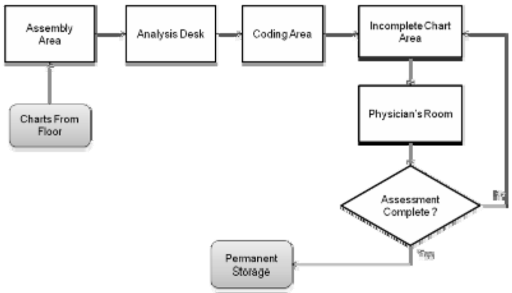

Figure 1. Current HIM Workflow

Assembly Area
The Assembly area represents the area in the HIM Department where the charts or miscellaneous pieces, such as lab reports and dictations, arrive from the floor. These miscellaneous pieces from the floor are brought to this area where they are categorized as per the patient discharge date and case type, such as inpatient, outpatient or emergency room (ER) cases. Then, these pieces are prepped in alphabetical order and are ordered in a standard form to be passed on to the analysis desk.

Analysis Desk
Once the charts are assembled, they are put on a cart to be picked up by the analyzer, who will then take them to another desk where they get manually scanned for missing dictations and physicians' signatures. Then, the analyzer labels the physician's job using colored stickers and embosses wherever required. In addition, another task for the analyzer is to attach an ER face-sheet, if required, as per the case. The charts are then finally put back on the shelf for further processing by the coders.

Coders Area
Once the coders bring the charts from the "analyzed charts" shelves, they start with verifying the demographic data and filling in any missing information. The coders then go through the complete chart including the discharge summary and the lab reports. Based on this information, the coders generate the Diagnosis-Related Group (DRG) codes.

Incomplete Chart Area
This area is assigned for incomplete charts, requiring assessment from the physicians, either in the form of signatures or missing dictations.

Physician's Room
In this room, the physicians complete the assessment of charts waiting in the incomplete shelf area. Once completed, charts are then sent to the hospital basement for storage.

Value Stream Mapping and Workflow Analysis
Processes for different sub-units of the HIM Department were observed and the workflows were mapped accordingly. The workflows for different units are provided in Appendices A-C. The next step was to identify the value and non-value added steps using value stream maps (VSM). VSM is a strategic management diagnostic tool that focuses on providing a representation of a specific operation or a portion of an operation from a localized or tactical perspective [3]. Process mapping, on the other hand, helps to reveal the symptoms of large problems by creating a visual representation of information, people and material flow. Process mapping could therefore be regarded as a blueprint for change and a strategic planning tool that helps prioritize opportunities for improvement and creates an implementation plan [4]. Through the time studies performed and the workflows maps, VSMs were generated for the HIM Department, as shown in Figure 2.

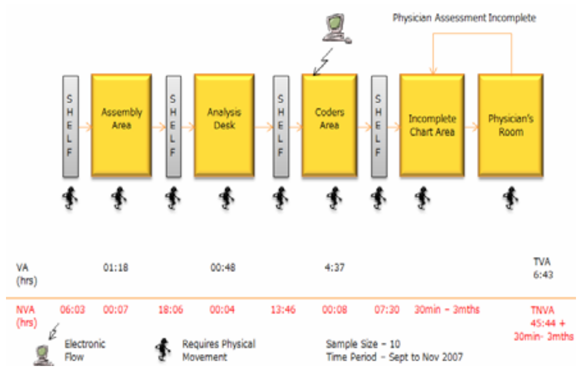

Figure 2. Value Stream Mapping for the HIM Department

The activities that the patient would value were termed as value added (VA) activities while those that consume time and/or resources, but do not add value to the service provided, were termed as non-value added (NVA) activities. It was observed that most of the non-value added time was associated with the waiting between the sub-units or stations. This was mainly due to the constraint of availability of charts at the station for processing, which restricted parallel processing. The maps also provided useful information, such as total value added time, total non-value added time, lead time, and cycle time. The last step was to determine the future state workflow for the HIM department, as shown in Figure 3, based on the observations and analysis presented in this section.

Comparing the system's current state (Figure 1) with the predicted future state (Figure 3), it is evident that the incomplete chart area would not be needed with DI. In addition, the shelves between the different units will no longer be required, thereby reducing significant waiting times. Furthermore, since the charts would be in electronic form and would be available online to physicians, the physician's room would no longer be needed. Another important change will be the Assembly Area, which will be split into Prepping, Scanning, Indexing and Quality Inspection areas.

As per this new workflow, the documents, once received from the floor, would be prepped in order. Then, they would be scanned and converted into electronic form, after which they would finally be indexed and checked for any scanning errors, such as font size and clarity. Once completed, the charts will be moved down to the analyzing station where they will be checked for any missing information. With the availability of charts online, the coding and the physicians' assessment can be done in parallel, thereby significantly reducing waiting time and improving the billing process. Thus, DI not only aims at making the system more efficient, but also enables faster reimbursements.

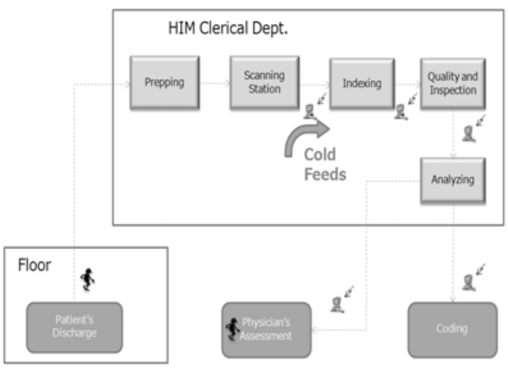

Figure 3. Future State Workflow with DI

Evaluation Metrics

In order to measure the efficiency of the current system, seven metrics were identified and developed.

Space Requirement

The space required in archiving the patient charts was measured in terms of room area, number of shelves and the shelf area required. The data were collected for the year 2007 just prior to the implementation of DI. The potential space saving could be regarded as an opportunity cost that could be used for storing lab equipments and other operational requirements of the hospital. However, this would not be fully realized before 2013, because of the in-process scanning of older charts to electronic files. Nonetheless, there would be gradual savings each year leading to a total saving of about 2,000 square feet of storage space along with 10,000 square feet in shelf area.

Percentage of Charts Delinquent

Charts that are not processed after 30 days of discharge are termed as delinquent charts, a performance metric that will help grade the efficiency achieved after the implementation of DI. The data collected was in the form of the number of delinquent charts per month and the total number of discharges for the respective months. The formula shown in equation (1) was then used to calculate the percentage of delinquent charts for each month.

$$\%Delinquent\ \ Charts = \frac{Average\ \ Delinquent\ \ Charts/Quarter}{Previous\ \ Month\ \ Discharges} \times 100 \qquad (1)$$

As per the Joint Commission, the percentage of delinquent charts should not exceed 50% [5]. However, it was found that the average percentage of delinquent charts was 45.06% with a standard deviation of 11.48%, with some months having a percentage of delinquent charts exceeding 50%. As a result, it really prolonged the reimbursement process. With DI, it could be expected that the charts would be processed faster, thereby lowering the percentage of delinquent charts.

Estimated Cost Savings

It was observed that a lot of money was spent on microfilms, chart folders, and other stationary items. With the introduction of DI, the HIM department will slowly become a paper-less and film-less system, leading to a significant reduction in these expenditures. The estimated annual cost savings was approximately $150,000 from the charts and films alone.

Opportunity Cost Savings

After the full implementation of DI, there would be no retrieval of charts from the basement or any storage area, thereby eliminating the need of volunteers who are currently required for this type of work. It was calculated that there would be around 600 volunteer-hours saved annually. There will also be savings in terms of personnel-hours involved in recruiting, training, and reallocating those volunteers in different units.

Chart Average Age or Turnaround Time

The chart average age or turnaround time (TAT) is defined as the time involved in processing of the chart from the assembly area until it is ready for assessment by a physician. This is again a performance metric that will indicate the improvement in terms of the department's efficiency in processing charts with DI. The average turnaround time measured from October 2007 until February 2008 was 7.8 days. This number is expected to reduce significantly with the implementation of DI because of the expected increase in the efficiency due to parallel processing of charts.

Person-Hours Required Per Month

The person-hours required by different sub-units or stations per month were measured. This provided a baseline to compare the system's efficiency with the one with DI. It was calculated that the combined effective person-hours required for the HIM clerical department was 1411.7 hours, which will be compared with the person-hour requirements with the introduction of DI.

Retrieval Time Per Year

In the current system, personnel spent significant amount of time retrieving the charts from the basement or the sub-basement area. It was observed that personnel within the HIM Department spent about 902.4 hours per year in retrieving the charts from the storage area. Converting these retrieval hours into business days (or 8 hour shifts) added up to around 113 business days per year spent on chart retrieval

The abovementioned metrics have been categorized into performance metrics, estimated cost and opportunity cost metrics, and potential space saving metrics. Performance metrics (i.e., person hours required per month, percentage of charts delinquent and chart turnaround time) provided information regarding the current state efficiency, and, consequently will be used later to compare the efficiency with DI. Further analysis of these metrics clarified that the value for the last two metrics will decrease once DI is implemented. However, the number of person hours required in the assembly area will increase because more employees will be needed once the assembly area is split into scanning, indexing and quality and inspection stations with DI.

The second category of metrics is the estimated cost and opportunity cost metrics, which represent the potential savings that will be incurred once DI is fully implemented. The first metric included in this category is the annual expense associated with microfilms and stationary. With DI being implemented, electronic files will replace the need of films or any paper-based charts. Hence, all the associated costs can be regarded as potential savings.

The other metric under this category is the total annual retrieval time spent by the personnel. This number is expected to reach zero once DI is fully implemented since patient records will be available online. However, due to the huge volume of charts in the storage area, this stage will be in transition mode until 2013. The last metric under this category is the annual volunteer person hours which are used for retrieval. Similar to the previous metric, this number will gradually decrease to zero once all the charts in the storage are scanned.

The third category of metrics is the potential space savings in terms of room area, shelf area, and the number of shelves required. Again, as per the gradual scanning of charts and converting them to electronic files, the space saving will increase gradually. The complete space saving is expected to be achieved by year 2013.

Simulation and Modeling

To delineate the future state, illustrate the impact of DI on workflow changes, and provide scientific suggestions in the decision making process, a discrete-event simulation model to represent the HIM clerical department was developed using Arena® 10.0 simulation software. The model was based on the information obtained through process mapping, time studies, and the HIM database. The methodology used to build the simulation model is shown in Figure 4 [6].

Building of Simulation Model

For building the simulation model, the data from the past three years was considered. Data was first grouped and filtered for existing outliers. Then, the data was analyzed for identifying any monthly, daily or hourly trends. Using analysis of variance (ANOVA) and Tukey's test, it was observed that the daily patient charts arrivals were statistically different for all three types of patients, namely inpatients, outpatients and ER patients. Hence, it was necessary to model the arrival rates separately for each day. Thus, the simulation model was built to capture both daily trends and hourly fluctuations.

Figure 5 shows the simulation model that was built to represent the HIM clerical workflow, with each block representing a daily process (Monday to Sunday). This was done to capture the randomness and difference in the arrival rate for different days. The left part of each block contains "create modules" that capture the arrival of patient charts into the HIM system and the "decision modules" which trigger the right "create module" according to the simulation time. The right part of the model represents the HIM Department with its individual units or station.

Simulation Model Development

Once the simulation model was built, the next immediate step was to verify and validate the results. To verify the model, the logical flow of the entities (i.e., patient chart) was monitored to highlight any flaws. In the validation stage, the simulation results were compared with actual system data collected over a period of 3 months. The model was validated using statistical hypothesis tests (i.e., paired t-tests). At a confidence level of 95%, it was observed that the simulation model was statistically identical to the actual system, using the number of arrivals and the service time as performance measures.

The validation of the model was presented to the HIM team and their suggestions were incorporated into the model to ensure its accuracy. Furthermore, sensitivity analysis of the arrival and service rates were conducted, indicating that the model holds true even if they varied by 11% and 13%, respectively.

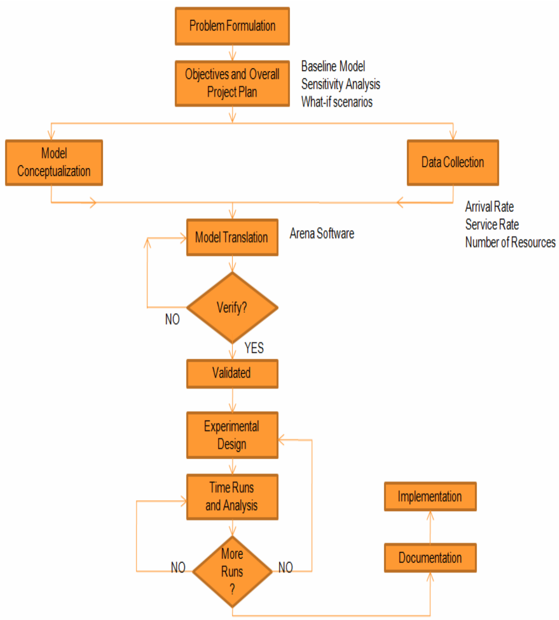

Figure 4. Simulation Modeling Methodology

Results

The results were collected in the form of expected arrivals for each day of the week, total time spent per chart in the system, and utilization of resources for all three types of patient charts: inpatients, outpatients, and ER patients. Using these results, it was possible to calculate the workload demanded by each type of patient chart at each station: prepping, scanning, indexing, quality and inspection, and analysis. Human efficiency factors and break times were also incorporated into the workload spread calculations. These results were then utilized for resource allocation in the future state (after the implementation of DI) and identifying ways to handle processes more efficiently.

Ways to Manage Processes

From the data collected, it was observed that the number of charts that will be available for the morning shift from the 11pm pick up (currently, charts are picked up twice a day at 3pm and 11pm) would not be sufficient. Thus, in order to keep the staff utilized in the morning shifts, there was a need to keep some charts as backlogs. There were two recommendations to start with, which were then evaluated using modeling and simulation.

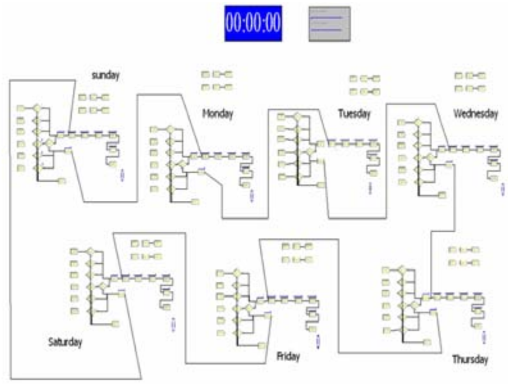

Figure 5. Simulation Model

The first recommendation was the *Standardization* approach in which dedicated resources were allotted for a particular activity of each chart type. This was similar to the current system without DI. Even though this approach provided standardized work, its disadvantages included the requirement of different types of specialized resources, difficulty of scheduling, and an increase in the number of backlogs. Keeping large backlogs directly relates to a delay in medical reimbursement which is a major drawback of this approach.

Therefore, to reduce backlogs and maintain high staff utilization, a second recommendation was given. This was termed as the *aggregation* approach, in which there will be a single prepping and analyzing person for all three types of charts. This will reduce the types of resources required from 7am to 5pm, but with a prerequisite of cross-training. The selection of the second approach was facilitated by comparing performance measures, such as the utilization of resources and the total time the charts spent in the system for the two scenarios, which was done through simulation. Finally, the aggregation approach was selected for the resource allocation, as will be discussed in the next section.

Resource Allocation

One of the main objectives of the study was to provide the management with a baseline for resource allocation well before the implementation of DI. For allocating resources, the results from the simulation model using the aggregation approach were used. One of the important considerations taken while developing the resource allocation was to move the more costly charts faster down the chain. This implies that the charts that were expected to incur less reimbursement will be kept as backlogs for the next day. Based on interviews with the HIM staff and an analysis of the collected data, it was observed that the inpatients charts incurred the highest reimbursements, followed by outpatient charts. For emergency patient charts, the hospital had the standards of processing the charts within 24 hours of discharge. Thus, resource allocation was done following the priority order of emergency, inpatients, and finally outpatient charts.

As per the designed resource allocation scheme, four different specialized resources, namely resource P for prepping, resource S for scanning and indexing, resource Q for inspection/quality, and resource A for analyzing, are all required to be cross-trained. The baseline resource allocation schedule (obtained through the simulation model) is discussed as follows. The morning shift for Tuesdays to Saturdays begins at 7:30 am with 10 outpatient charts as backlogs for resource S and resource Q, each as shown in Figure 6.

Also, resource A requires 20 outpatient charts as backlogs to maintain the resource utilization rate during the early hours of the shift. The down arrows indicate the time consumed in a particular activity. Once the backlogs are cleared, the staff person starts working on present day ED charts as per the priority discussed earlier. This ED chart cycle runs for 5 times with the batch size of 15. Then, the present day inpatient charts are begun to be processed with a batch size of 4 for 3 cycles, after which the outpatient charts are processed.

Figure 7 shows the evening shift resource allocation for Tuesdays to Saturdays. The shift begins with 5 outpatient charts as backlogs, each for resource S and resource A. Once the backlogs are cleared, the staff person begins with present day inpatient charts, similar to the pattern discussed earlier. Once the inpatient charts are completed, the outpatient charts are then worked upon with a batch size of 10 and for 3 cycles.

It should be noted that this resource allocation schedule was not designed as a traditional Monday to Friday and weekend schedule, particularly since the inflow of patient charts into the system is driven by Monday to Friday and weekend discharges. Therefore, a different schedule for weekend discharges (Sunday-Monday schedule) for the HIM staff is needed. Since there are no outpatients on weekends, the tail portions of the Tuesday to Saturday schedule were trimmed, but were designed on similar lines to those of Tuesdays to Saturdays.

Conclusions

From the study conducted in this project, the expected workload for each type of patient chart, at each station, on different days, was identified. This made it possible to track the expected idle and overburdened resources and subsequently apply resource leveling. Furthermore, the best possible way to allocate resources and manage processes was determined using simulation as a decision-making tool. The number of backlogs required to keep the staff totally equipped in the morning shift and vis-à-vis allow the charts to reach billing faster was investigated. Finally, the most ‘optimized’ batch size with the resource allocation was provided to the management in the design stage, for better understanding of the requirements and the expected behavior of the system with DI.

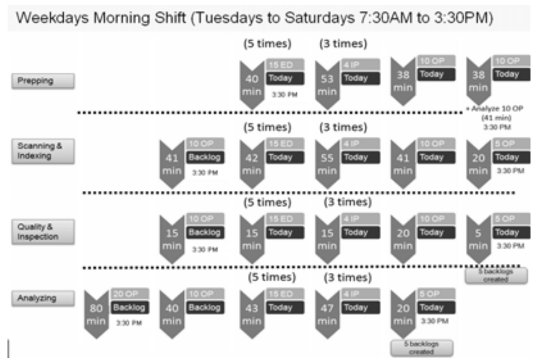

Figure 6. Morning Shift Resource Allocation

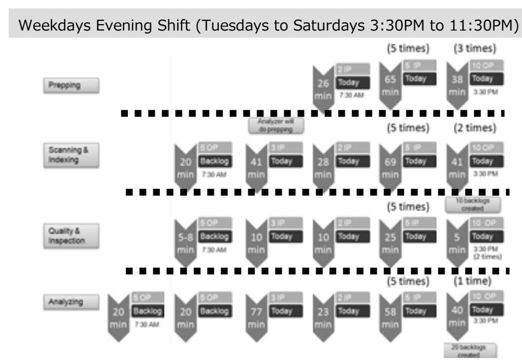

Figure 7. Evening Shift Resource Allocation

Future Work

The work presented in this paper was restricted to the objective of studying the impact of new technology on the current workflow and resource consumption. However, a careful observation of the results of the baseline model led to a conclusion that there could be further scope of improvement in managing patient chart queues. In the above resource allocation, emergency charts were processed first, followed by inpatient and outpatient charts. Further investigation can be conducted to devise a system that may expedite a chart through the entire system based on the reimbursement value of the chart. Another extension could involve the determination of the optimal number and timing of pick-ups of patient charts from the floor to the HIM department. Finally, based on trends and seasonality in forecasted demands, an optimal resource allocation scheme can be devised.

Biographical Sketches

Ankush Bhagat is currently pursuing his masters in Industrial and Systems Engineering in the Systems Science and Industrial Engineering department at the State University of New York at Binghamton. He is working as a graduate research associate with the Watson Institute for Systems Excellence. He obtained his bachelors degree in Mechanical engineering from S.P. University in India in 2006. His research interests include continuous process improvement in Healthcare and discrete event simulation.

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Dr. Mohammad T. Khasawneh is an Assistant Professor in the Department of Systems Science and Industrial Engineering at the State University of New York at Binghamton. He also serves as Assistant Director for the Watson Institute for Systems Excellence. He received his Ph.D. in Industrial Engineering from Clemson University, South Carolina, in August 2003, and his B.S. and M.S. in Mechanical Engineering from Jordan University of Science and Technology, Jordan, in 1998 and 2000, respectively. He is a member of the Institute of Industrial Engineers (IIE), the Human Factors and Ergonomics (HFES), and the American Society for Quality (ASQ).

Dr. Krishnaswami Srihari is a Distinguished Professor and the department chair of Systems Sciences and Industrial engineering at the State University of New York at Binghamton. He is also the Director of the Watson Institute for Systems Excellence. He obtained his doctoral degree from Virginia Polytechnic University in Industrial Engineering and Operations Research in 1988. His research interests include health systems, electronics manufacturing, and financial systems.

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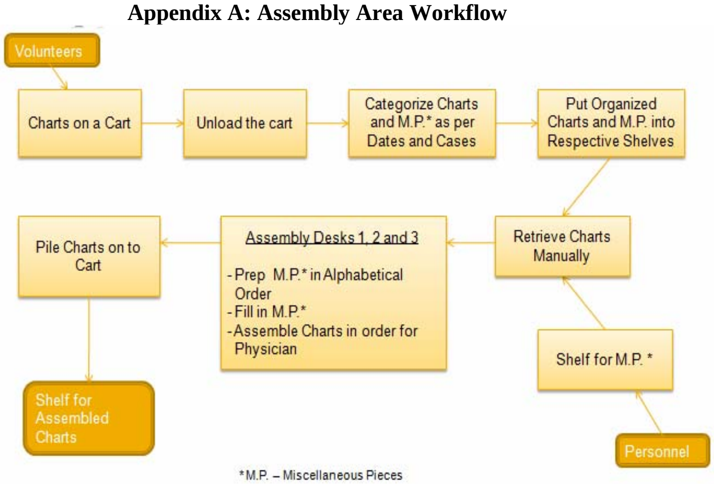
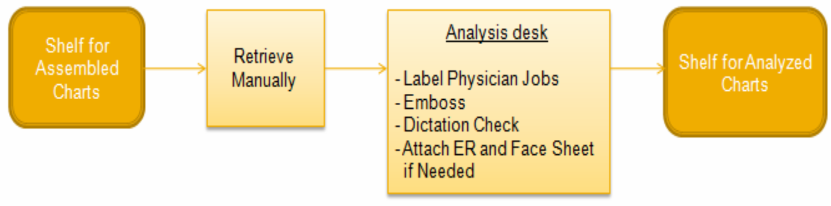
Appendix A: Assembly Area Workflow



Appendix B: Analyzing Area Workflow



Appendix C: Coders Area Workflow