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MICHIGAN STATE UNIVERSITY | College of Human Medicine

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Michigan State University College of Human Medicine

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The Medical Student Research Journal (MSRJ) is the only international academic journal in the United States authored, reviewed, and published by medical students for medical students. It is dedicated to promoting the scientific achievements of medical students, teaching principles of peer and article review, and providing editorial, publishing and leadership learning experiences. Medical students worldwide are invited to submit manuscripts and serve as trained reviewers. The MSRJ publishes original research, case studies, editorials, research letters, reviews, and reflections that meet required standards, are authored by a medical student, and advance science. It is sponsored by the Michigan State University College of Human Medicine. Visit www.msrj.org and www.facebook.com/msrjchm for more information.

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In this second issue for this year, there are articles from Tulane University SoM, American University of the Caribbean SoM, as well as our home institution Michigan State University's College of Human Medicine.

Many exciting events have happened with the MSRJ since the last issue was published. The recruiting class of 2013 has brought our executive editorial board to a total of 21 students representing first- to fourth-year students at the College of Human Medicine. I am proud to name my successors to the executive editor position of the MSRJ. Kevin Patterson is a fourth-year student who is planning a career in internal medicine that will incorporate a career in academic medicine. Jessica Wummel is a third-year student who is still undecided on her career choice, but feels it lies within the field of primary care. Having worked with these talented and dedicated individuals, I have great faith in their leadership ability and believe they will take the MSRJ to new heights.

Over the past nine months, we have put extensive work into upgrading and transforming our website. We came to the realization that this is our portal to the rest of the world and wanted it to better reflect the goals and aspirations of the journal's leadership. In mid-April 2013, we launched the new design. You can see the new website at our usual address: www.msrj.org. Please visit it periodically for updates and reports on events happening at the MSRJ as well as prospective topics for upcoming editions.

During the last week in April, the MSRJ sent four editors to the 54th National Student Research Forum at the University of Texas in Galveston. This forum is organized and run by medical students from the University of Texas Medical Branch School of Medicine. Medical students, residents, and graduate students doing research in the biomedical sciences present their research, surrounded by their peers. More information about the forum can be found on their website: www.utmb.edu/nsrf. We would like to thank the organizers of the conference, specifically Samuel Mathis for doing an exceptional job leading this endeavor. Our editors had the opportunity to interact with medical students from all over the country. They attended poster presentations and worked diligently to raise awareness of the MSRJ. We greatly appreciated the opportunity to have had a representation at the conference. You will find a full post of the experience written by Jessica Wummel on our website.

Working with the Michigan State University Library, we have produced physical copies of our editions. These copies will be produced once a year and are bound into a periodical format. The MSU library will index and keep them in perpetuity at the main campus library in East Lansing Michigan, where they will also be indexed digitally on the library's main website. This will ensure that the published works of our authors will be accessible in the foreseeable future.

The MSRJ is also moving forward with plans to be indexed in PubMed Central. After publication of the fall issue, scheduled for September of this year, we will be eligible to apply, and on completion of the application process all MSRJ articles will be retroactively indexed in this premier research archive. The MSRJ is also now a member of the World Association of Medical Editors (WAME), which will provide us with more resources, increase access to editorial experts worldwide, and build our capacity and skills. All of these strategic improvements will help us reach our goals while better serving MSRJ authors.

We would like to thank Michigan State University's College of Human Medicine for their continued support and funding. If not for them, this endeavor would not have been possible. As always, if you are considering submitting a manuscript, you can find more detailed instructions on the MSRJ website. It has been a pleasure to work as an editor over the past year. I believe that this can be a significant outlet for medical students to publish their research work, enabling them to receive credit for publishing, but even more importantly, contributing to the general body of medical knowledge and teaching valuable academic skills.

Sincerely,

Chad Klochko, M.S.
Executive Editor, MSRJ 2012–2013

All Heart

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The Heart of a physician is a conduit.

There has been a trend to portray doctors as ''all'' – all knowing, all thinking, all seeing, all doing. We're all brains, learning and memorizing, and all hands, cutting and suturing. Doctors can be any or none of these things, but sometimes we miss our greatest strength: we can be all Heart. And by being all Heart, we must be careful how our experiences affect us.

It is not a new idea to suggest life experiences determine who we are; every human being is just a sum of what is being poured into them. However, physicians have the unique privilege of affecting many other lives as well; our life experiences not only change us, but also determine how we will treat our patients. This is why a physician's Heart *must* be a conduit – it is our responsibility to transform our experiences so that we help rather than harm others.

Our good moments must be amplified; our bad moments must be tempered so that they can become strengths rather than weaknesses. How many times have pain and discrimination cycled through humanity simply because no one had the ability to transform that pain and break the cycle?

For me, my personal tragedies can be limiting, or they can help me better connect with patients going through their own pain. The love and support I have been shown along the way to medical school can either end with me, or can be nurtured so that I can be a lodestone for future patients.

As physicians, we have the opportunity to touch many lives, many Hearts. Let's not squander that opportunity.

A comprehensive stroke center patient registry: advantages, limitations, and lessons learned

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Introduction: *The use of a medical data registry allows institutions to effectively manage information for many different investigations related to the registry, as well as evaluate patient's trends over time, with the ultimate goal of recognizing trends that may improve outcomes in a particular patient population.*

Methods: *The purpose of this article is to illustrate our experience with a stroke patient registry at a comprehensive stroke center and highlight advantages, disadvantages, and lessons learned in the process of designing, implementing, and maintaining a stroke registry. We detail the process of stroke registry methodology, common data element (CDE) definitions, the generation of manuscripts from a registry, and the limitations.*

Advantages: *The largest advantage of a registry is the ability to prospectively add patients, while allowing investigators to go back and collect information retrospectively if needed. The continuous addition of new patients increases the sample size of studies from year to year, and it also allows reflection on clinical practices from previous years and the ability to investigate trends in patient management over time.*

Limitations: *The greatest limitation in this registry pertains to our single-entry technique where multiple sites of data entry and transfer may generate errors within the registry.*

Lessons Learned: *To reduce the potential for errors and maximize the accuracy and efficiency of the registry, we invest significant time in training competent registry users and project leaders. With effective training and transition of leadership positions, which are continuous and evolving processes, we have attempted to optimize our clinical research registry for knowledge gain and quality improvement at our center.*

Keywords: *stroke; registries; methodology; epidemiological methods; common data elements; source data verification.*

INTRODUCTION

Single-center registries of medical data are commonly created for clinical investigations across a variety of medical conditions, including stroke.[1–5] Over the past 30 years, the use of registries has been demonstrated to improve the quality of care, patient prognosis, and hospitalization costs by systematically delineating standards of care by which institutions are expected to abide. This holds true for stroke patient registries[6–8] as well as for other medical registries.[9–11] Additionally, registries are utilized to report hospital-level data for 'Get with the Guidelines'[12] (a multicenter effort to document and improve outcomes in patients with stroke and cardiovascular disease) and for maintenance of The Joint Commission Primary Stroke Center certification.

Despite the value in medical stroke registries, there are many limitations to establishing and maintaining an up-to-date and accurate medical data registry. Some of these shortcomings include incompleteness

[†]James E. Siegler and Amelia K. Boehme contributed equally to the production of this manuscript.

in registry data,[13] difficulties with prospective data collection during patient hospitalization,[14] errors in data collection and management,[15] and poor standardization in definitions among common data elements (CDEs).[15–18]

The purpose of this article is to illustrate the advantages, limitations, and lessons learned during the creation of the registry used by the stroke program at the Tulane Medical Center, as well as how the center strives to minimize these limitations in the production and maintenance of the registry.

METHODS

Patients and research personnel

The clinical registry was originally developed using a four-page case report form (CRF) to initiate data collection in preparation for the application for Primary Stroke Center certification and to address a specific study question related to the safety and efficacy of combined anti-platelet therapy during the acute phase of ischemic stroke.[19] The larger registry includes all but a handful of data points requested by 'Get with the Guidelines-Stroke'[12] and all of the data points needed for reporting to The Joint Commission. The Joint Commission requires that all certified Primary Stroke Centers maintain these data on their patient population, treatment rates, and other information for quality improvement.

After the approval of the initial four-page CRF by the Tulane Medical Center Institutional Review Board in 2009, the expanded stroke registry was approved in 2011 to allow for inclusion of all patients who had a stroke diagnosis since the start of the stroke program in July 2008.

This center includes a 350-bed tertiary care center in downtown New Orleans, LA, serving a predominantly Medicare and Medicaid, African American population. See Table 1 and several recent publications for a description of the patient population.[20–22] The stroke service evaluates approximately 500 patients with a stroke diagnosis each year ($<$15% transfers from outside hospitals) and are staffed by board-certified vascular neurologists. The stroke program meets the criteria of a comprehensive stroke center, offering 24/7/365 neurosurgical and endovascular care to its patients. Data from these patients are collected prospectively as described below. The senior leadership position is held by the Stroke Director, a vascular neurology fellowship-trained academic neurologist. Two hospital employees participate in data collection for the stroke registry, but they are not funded specifically for this activity. Neurology residents and medical students are also encouraged to participate. Their duties are described in the 'Creating a Primary Registry' section. Despite receiving no dedicated funding, the program has expanded yearly from three students in year 1 to nearly 20 active members by year 5.

Creating a primary registry

Each CDE is defined in a codebook in an effort to standardize variable definitions and to increase inter-rater reliability of data acquisition. While some CDEs are straightforward and objective (admission vital signs), other more subjective data points (pre-admission ambulatory status) achieve legitimacy through consistency with the National Institute of Neurological Disease and Stroke (NINDS) stroke-specific CDE standards.[23] Despite this standardization in CDEs being released after preparing the registry, the definitions used for the registry match those used in the CDE online module. This precise labeling and classifying has allowed collaboration with other institutional stroke registries so that registry variables can be synchronized between centers and parameters adjusted between respective institutions. The aim of this is to ultimately build larger studies and corroborate findings with those of other institutions.

Consecutive patients evaluated at the center with a high clinical suspicion for stroke are prospectively added to a ledger by the stroke program coordinator. Once the diagnosis of stroke is confirmed, either clinically or via imaging, eligible patients are assigned a registry code number. Core measures and key clinical CDEs including, but not limited to, baseline demographics, stroke classification, laboratory data, and

Table 1. Patient population.

Diagnosis	Year 1	Year 2	Year 3	Year 4	First 6 months of Year 5
No. ischemic stroke	185	261	309	291	174
No. treated with IV tPA (%)	27 (14.6)	69 (26.4)	75 (24.3)	100 (34.4)	78 (44.8)
No. treated with IA tPA (%)	4 (2.2)	18 (6.9)	16 (5.2)	16 (5.5)	10 (5.7)
No. TIA	62	74	79	74	33
No. intracerebral hemorrhage	38	57	60	58	34

IV tPA, intravenous tissue plasminogen activator; IA tPA, intra-arterial tissue plasminogen activator; TIA, transient ischemic attack.

other admission information (the sum of which comprises nearly half the total number of CDEs in our registry) are collected prospectively by the stroke program coordinator onto a standardized paper version of our CRF (see Figure 1). In the days following admission, a board-certified vascular neurologist will document onto this CRF key imaging and management data.

Key CDEs are selected for initial collection based on the ability to use responses as a filter for future studies. If an investigator establishes an ancillary project idea based on subpopulations of the registry, the key CDEs can aide in guiding the investigator to establish what additional information needs to be collected as well as how it should be collected. This is followed by applying for expedited Institutional Review Board (IRB) approval for the ancillary study, and additional needed variables can be collected from the electronic medical record and chart using a study-specific CRF (see further discussion in Supplementary Data Abstraction for details). The remaining data regarding a patient's hospitalization, complications during stay, and outcome at the time of discharge and at 3 months are collected retrospectively onto the CRF by other research team members (medical student volunteers, residents, nurse practitioners, faculty) trained in data collection. The only 90-day outcome measure collected is the modified Rankin Scale (mRS) score, a seven-point scale serving as the most commonly used functional outcome measure in neurological studies.[24] Because The Joint Commission requires collection of the 90-day mRS and follow-up phone calls for disease-specific certification, our stroke program coordinator obtains the 90-day mRS by a structured and validated telephone interview, except when a patient was seen in the stroke clinic within the $\pm$7-day range and the mRS is documented.

Reconciliation of CDEs

Once the CDEs have been gathered onto the paper version of our CRF, potentially inaccurate data points are validated manually by a more experienced research team member. In the event that inaccurate data are suspected, the medical record would be reviewed by a more experienced member of the research team and the variable of interest would be corrected on the CRF with a time/date stamp indicating when the reconciliation was made as well as the initials of the reviewing team member. After all data on a paper CRF have been reviewed in this manner, the CRF data are then transcribed via single-entry into a secure, password-protected electronic master spreadsheet – Figure 1 – where a second reconciliation process occurs after the data are electronically transferred. Prior to analysis, each CDE used in a given research study is then sorted from smallest to largest (for continuous variables) or A to Z (for text variables) in order to identify any gross transcription errors (a letter or word in the place of a number). This process is followed by identification of any continuous numerical data that lie beyond two standard deviations for that particular CDE (classified as 'potentially erroneous data'). These data are validated or corrected using source data verification (SDV) once a second review of that patient's medical record has occurred. After all data have been accurately collected and entered into this master electronic spreadsheet, it is then transferred to a statistical software package for analysis where the statistical files become recognized by the research team as the updated primary registry. Each of these phases in primary registry creation has been approved by the Tulane Medical Center IRB.

Supplementary data abstraction

Once the primary registry is established, a researcher can posit a study question that he/she would like to investigate. The study question is discussed with all investigators who would be involved in the data abstraction, analysis, and drafting of the manuscript, and then formed into a testable hypothesis by methodologists. The research team is then able to anticipate all quantifiable CDEs necessary to answer this question, which includes data collected in the primary registry as well as data necessitating re-review of patient medical records. The CDEs that are needed for the study question are used to create a supplemental CRF to collect the additional data. The new variables of interest are strictly defined and added to the master codebook by the project PI. Once IRB approval has been granted for the proposed study, data collection with the supplemental CRF begins where it goes through the same series of SDV as described above to ensure data validity. Once these additional data have been gathered and validated in a supplemental electronic spreadsheet, they can be added to the secure master electronic spreadsheet. A summary of our data collection and interpretation methods can be found in Figure 2.

ADVANTAGES

In an attempt to minimize some of the errors inherent to registry production and maintenance, the following three objectives were applied to the medical data registry:

(1) The same CDEs are collected accurately and completely;

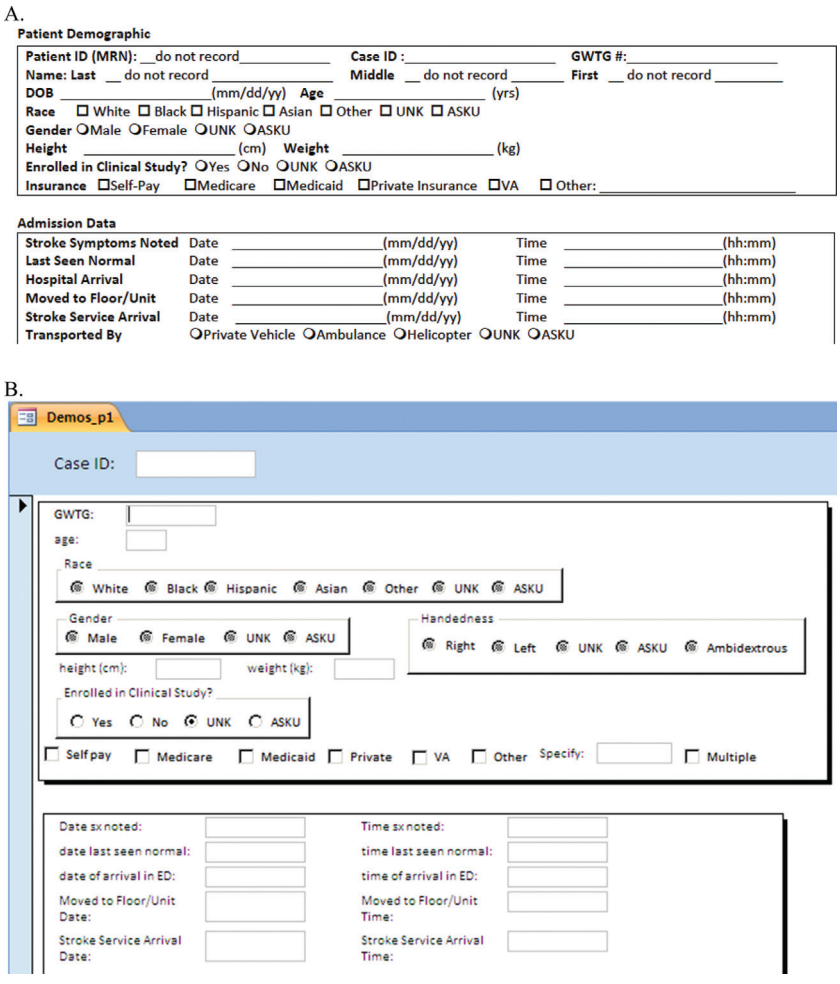

Figure 1. View of the paper and digital versions of our case report form (CRF).
A. Representative view of the paper case report form on which data are collected.
B. Screen view of the digital data collection tool (Microsoft Access 2007). Shown is a representative page in the collection tool that corresponds to the common data elements (CDEs) collected in the case report form (part A).

(2) Each CDE has a standardized definition; and
(3) Data which can be queried for future investigations are provided.

Objective 1 ensures the abstraction of accurate, verifiable, complete, and relevant information. However, less controllable sources of data error still exist, such as errors in laboratory results and other medical data documentation from electronic medical records. The completeness of information is valuable for two reasons:

(1) All of the important facts for a given patient during their hospitalization are collected; and
(2) Each of these facts is collected across all patients in the registry, reducing bias in data abstraction.

Objective 2 provides the framework for reliable and simple information. Simple but concrete definitions, standardized within the literature, are required to study specific associations between variables and to permit collaboration with other investigators when combining variables with the same definition.

Objective 3 facilitates economical and timely information abstraction. It is important to consider the timeliness of information abstraction as this is commonly a rate-limiting step in any methodology. It may take an experienced data abstractor up to 90 min to complete one CRF and an additional 30 min to validate and transcribe these data into an electronic master spreadsheet. Not all data from a given patient can be collected in a timely manner; therefore, fundamental

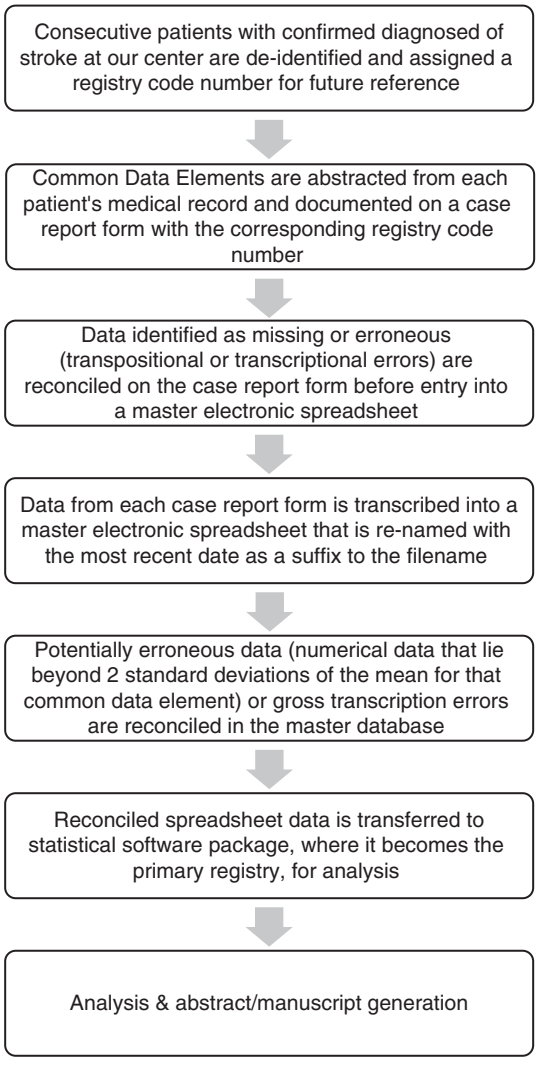

Figure 2. Summary of methods.

CDEs must be collected quickly for screening purposes and then reviewed retrospectively if any more specific questions regarding that CDE should arise. All of these key points within Objective 3 provide for flexible data that can be utilized in many different forms from reporting to 'Get with the Guidelines', creating reports for internal quality assurance, tracking changes within our institution, and contributing to scientific research.

These objectives are compliant with the MDR-OK categorization protocol (for mergeable data, dataset standardized, rules for data collection, observations associated over time, and knowledge of Outcomes) from a previous review that outlines effective medical data registry protocol[25] and is consistent with the recommendations of the American Heart Association.[26]

The stroke registry serves a key function, as it provides a foundation upon which other studies can originate, as well as generate new hypotheses. Because the registry also provides a foundation for ideas to cultivate, data abstractors may notice anecdotal trends or grow curious about certain functions pertaining to strokes. This encourages a team approach to discussing novel study ideas, providing students with the opportunity to design and implement a scientific investigation, and allowing faculty members to cultivate their mentoring skills.

The largest advantage of having a registry is the ability to prospectively add patients to the registry, while allowing investigators to collect information retrospectively if needed. The continuous addition of new patients increases the sample size of our studies from year to year. Furthermore, the combination of prospective and retrospective data collection methods has been suggested as the most efficacious means for gathering data in terms of completeness and accuracy.[13]

Impact on quality improvement

Furthermore, the use of this registry has allowed investigations into this center's practices in order to implement internal quality improvement measures. Whenever a question regarding complications or outcomes is raised by hospital staff, the registry is queried to obtain the needed data. For example, an emergency department (ED) nurse expressed concern for treating a patient who woke up with stroke symptoms with a thrombolytic. The registry was queried after IRB approval, and we were able to report complication rates for this group of patients and compare them to complication rates of patients treated within the American Heart Association guidelines; the results were similar. While neither research objectives nor quality improvement can be identified as the primary purpose of this registry, the registry has certainly afforded our institution both types of information. In an additional example, we examined whether outcomes were compromised by prolonged length of stay in the ED.[27] We found that it was not the amount of time spent by a patient in the ED, but rather the presence in the ED during the nursing shift change that was associated with increased frequency of pneumonia.[27] This is one of the best examples of a research query at this center that led to a change in hospital management; however, many small changes have been implemented following research queries of the registry. While significant, these have not always resulted in publications through peer-reviewed journals.

LIMITATIONS

As in all investigations and clinical data registries, there are drawbacks to our registry. One primary pitfall is that there is no specific study in mind while collecting the information for the registry. This leaves the team at the liberty of the treating physician as to whether specific laboratory values are collected, imaging studies are ordered, and so on. Much of the information within the registry is retrospective, which can create problematic issues if aspects of patient care needed for research purposes are not included within the medical record.

While there are advantages to the checks and balances of multiple points of data entry, there is a limitation to this feature as well. The multiple points of data transfer increase the likelihood that human error can affect the data transfer and also increase the total time spent on the process, thereby decreasing efficacy.[15] Because screening of data for irregularities is confined to outliers and gross typographical errors, it is possible that minor errors may go undetected if they fall within a normal distribution for a specific data point. Over half of the errors in clinical data gathering are due to data entry technique according to a recent study, but there is still a substantial portion of errors that are generated during the reconciliation process that appears to be dependent on the knowledge of research personnel.[28] One unique feature of the registry is the similarity of the paper and digital versions of our data collection tool (see Figure 1). Because the two forms are nearly identical with regard to the data copied from the paper version to the electronic version, we have found that this reduces the risk of human error during transcription.

Furthermore, the use of multiple team members in the abstraction of similar data points may risk inter-abstractor reliability (meaning lack of consensus in definitions of data elements between abstractors may lead to inaccurate gathering of these data)[29] and potentially lead to abstractor drift (meaning small changes in understanding CDEs by a given abstractor may result in unforeseen discrepancies in data collection). We strive to minimize this with the implementation of a very specific codebook of CDE definitions. Because the majority of our CDEs are collected prospectively by the Stroke Program Coordinator and a trained vascular neurologist, this leaves little room for potential error with our remaining data abstractors. These errors may be reduced with the implementation of a double-entry approach,[30] but such a methodology may not be efficient in large patient populations with large quantities of data.[31]

We also implement a mandatory training period of all new research personnel whereby a more experienced supervisor (usually a senior medical student with two or more years of experience with our team) is required to monitor any new data abstractors and data entry personnel until such a time when the junior student can carry out these tasks accurately, effectively, and without further assistance. During this time, the senior team member also allocates a sufficient amount of time educating junior team members regarding general aspects of stroke pathophysiology, clinical diagnosis, laboratory and imaging studies, and management. Bi-monthly meetings with research personnel on our team also afford us the opportunity to review and discuss clinical data and their definitions in an open setting as well as an opportunity to assess the status of our new and ongoing investigations.

Another disadvantage is that this is a single center that can only offer insight into a specific population of patients who present to our institution. This limitation prohibits our ability to generalize our results to other centers and other studies. Our center is very unique in that it serves patients in the New Orleans area regardless of insurance status, and the source population of New Orleans (being in the 'Stroke Belt') is not a representative sample of the United States.[32] This is why we have made clear, specific variable definitions so that we can combine our registry with other registries to increase sample size and improve our generalizability.

LESSONS LEARNED

In establishing a stroke registry, we have learned many lessons regarding initiation of the registry, developing CDE definitions, and commencing projects from the registry. One factor pertains to the responsibility of the research project leader, which may be a double-edged sword. While the leadership experience gained by medical students and residents in piloting an independent study, working with a team from start to finish, and presenting results in peer-reviewed journals and at conferences is invaluable, follow-through and keeping deadlines can be challenging due to conflicting obligations. We have learned that communication of goals and interests is paramount, which fosters a true teamwork approach where students, residents, and faculty work closely together to complete projects in a timely manner. Bi-monthly meetings to communicate the status of the registry and related projects, and the

dissemination of meeting minutes and a running list of projects, papers, and abstract deadlines have helped in establishing and re-establishing expectations and resource utilization.

We have also learned that investing the time to carefully train research personnel with regard to data collection techniques, variable definition classification, and data entry greatly reduces the errors in data collection. At this center, all members of the research team are required to be certified in the NIH Stroke Scale examination[33] as well as undergo IRB training and certification. New members also go through a period of proper training and supervision from a more experienced team member as explained above. In an attempt to maintain data accuracy, we also limit the reconciliation of data errors to trained and experienced clinical personnel, such as upper level medical students and residents who understand the biological and statistical meaning of these data elements and can more easily recognize outliers, errors, and inconsistencies (e.g., the erroneous coding of a patient who expired when he or she was discharged to home).

We have learned that it is important to inform faculty and residents at your center about your registry. They should know which data elements are included so that they can assist in the collection of information from patients and effectively dictate these pertinent elements in their patient notes. At our center, we keep other faculty and residents informed about our registry by inviting them to our bi-monthly research meetings and actively discussing the results of our research at regularly scheduled vascular conferences, grand rounds, and other meetings. We have also created templates for admission and discharge notes, which include the most important CDEs.

The main lesson learned in this process is that data are more effectively and accurately collected when a stroke coordinator or other trained clinical personnel collect the majority of patient information prospectively, rather than retrospectively via chart review. Because of the active, prospective collection of data by this team member, with many elements collected for reporting to The Joint Commission for maintaining Primary Stroke Center certification, any uncommon data elements needed for the registry that are not intuitively gathered by residents or medical students (such as a specific history of liver disease) can be collected by the coordinator before the patient might be lost to follow-up.

It is worth disclosing that in the generation of this registry, methods and protocols have been actively evolving. The lessons learned during the early phases of registry production have already been applied to the current phase. For instance, we began the data abstraction process in 2008 with an almost entirely retrospective approach using a limited version of a CRF (approximately four pages in length with just over 350 CDEs). In January 2011, the CRF was significantly revised for a number of reasons in order to improve the efficacy and completeness of our data collection. The revised CRF now includes more data points that can be used for research queries (approximately 18 pages in length with over 1,000 CDEs) and is better organized with respect to the order of information collection. From our experience, while there are more data to be abstracted, the improvement in organization has dramatically shortened the time necessary for data collection and improves the accuracy and completeness in each of the CDEs of the registry.

FUTURE DIRECTIONS

Stroke is a leading cause of disability and death in the US population,[34] and research with the use of registries has grown to be an effective way to improve the care and quality of life of individuals who suffer from this disease.[6, 35–37]

Now that the Tulane Medical Center's primary registry has been ongoing for several years (since 2008), future directions of the registry are under discussion. Currently, in the Electronic Health Records (EHR) being used, data cannot be captured by electronic means. Instead, all information must be abstracted through manual searches with individual data point abstraction. The center is actively looking into the adoption of a new EHR system to meet the objectives of meaningful use (in improving patient health care), which may help with future data collection when ultimately implemented. The next immediate step involves improving the integrity of our data abstraction and SDV. Currently, our data entry methodology involves several points of data transfer using a single-entry technique, which has been associated with a low risk of data error. While we recognize that double-entry would reduce this rate of error, we agree with other investigations which have demonstrated that double-entry is not cost-effective due to limited time and personnel. Furthermore, we restrict ourselves to an SDV process limited to identifying outliers in our data. In the future, we can improve the accuracy of our registry by performing a random selection of non-outlier data elements for SDV. In addition, we hope to inspire other centers to develop their own stroke registries with well-defined variable

definitions that are consistent with the literature and with other stroke center registries.

Conflict of interest and funding: This project was supported by Award Numbers 5 T32 HS013852-10 from The Agency for Healthcare Research and Quality (AHRQ) and 3 P60 MD000502-08S1 from The National Institute on Minority Health and Health Disparities (NIMHD), National Institutes of Health (NIH), and 13PRE13830003 from the American Heart Association. The content is solely the responsibility of the authors and does not necessarily represent the official views of the AHRQ or the NIH.

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Potential pathogen transmission on medical student anatomy laboratory clothing

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Introduction: *Despite great advances in the fields of medicine and sanitation, nosocomial infections remain a very common and serious issue. Many of these problems can be avoided by simple hand washing; however, pathogenic microbes can spread through other modes too. In our study, we aim to determine if the setting of an open cadaver laboratory was conducive to the transmission of pathogens such as* Staphylococcus aureus*,* Streptococcus pyogenes*, and* Enterococcus faecalis.

Methods: *For this investigation, 67 volunteer medical students had their laboratory coats swabbed and sampled during their time in anatomy laboratory class. Each coat was sampled prior to cadaver contact and at the end of their time in the laboratory, which coincided with the exploration of the gastrointestinal tract.*

Results: *We found that pathogens were present on the laboratory coats of the students. An increase in each of the three microbes for which we tested was detected at the end of the anatomy laboratory course on the garments of the participants. There were six more student laboratory coats with* S. aureus *in the post-dissection swabbing and there were three more student laboratory coats with* S. pyogenes *in the post-dissection swabbing than originally documented.* E. faecalis *was found on four student laboratory coats in the post-dissection swabbing compared to none pre-dissection.*

Discussion: *From these results, we conclude that stronger infection control measures are warranted to prevent the occurrence of unnecessary disease transmission in this setting. Our study provides data that support further investigation of potential pathogen transmission by student laboratory clothing and supports the use of universal infection control procedures to provide safer environments for medical students and their contacts, including laundering protocols for coats.*

Keywords: *pathogen transmission; infectious precautions; white coat; medical students; contamination; cadaver.*

INTRODUCTION

Nosocomial infections within hospitals and clinics remain an important topic of discussion. The role of hand washing in limiting disease transmission in the healthcare setting, as well as in the community, is well understood.[1–3] However, the role of clothing worn by medical students in disease transmission is not as well understood.

Infections that result from bacteria do not have to be foreign to the human body itself. Multiple sites in the body may contain *Staphylococcus aureus*, and it is mostly frequently carried in the anterior nares of the nose. Previous studies have estimated that 20% of the human population is a long-term carrier of *S. aureus*.[4] *Streptococcus pyogenes*, a ubiquitous microorganism that frequently colonizes throats of asymptomatic people, was found with carriage rates of 15–20% in infants and 10% in adult smokers.[5] As a normal colonizer of the gut, *Enterococcus faecalis* is also commonly found. One study performed on the feces of adult patients showed the presence of *E. faecalis* in 48.2% of adult outpatients and 80% of adult inpatients.[6]

While some species of bacteria are found in the normal flora, those same bacteria may gain resistance to antibiotics and become a danger to healthcare workers and patients. It has been demonstrated that methicillin-resistant *S. aureus* (MRSA) and vancomycin-resistant *Enterococci* (VRE) can be found on the clothes of healthcare workers, particularly on sleeves, waist areas, and neckties.[3,7] Consequently, guidelines have been established by the Centers for Disease Control (CDC) in the United States and the National Health Service (NHS) in the United Kingdom for the proper handling of clothing worn by healthcare workers, particularly visibly soiled clothes.[1–3,8] Notably, the NHS has instituted a 'bare below the elbows' policy that prohibits long sleeves for clinical healthcare workers.[8] Interestingly, the literature is silent on the occurrence of microorganism transmission via clothing

worn by medical students studying anatomy in cadaver laboratories.

Executed properly, the process of cadaveric preservation using common embalming agents such as formalin, ethanol, and phenols is believed to eliminate the presence and growth of bacterial microorganisms, although some uncertainty exists regarding the post embalming infectious potential of hepatitis viruses, human immunodeficiency virus (HIV), and prions.[9–11] Thus, it is believed that potential bacterial transmission via properly prepared cadaveric tissues is highly unlikely.

It is now common practice in medical education to assign a group of students to each cadaver, necessitating a close working environment for students. Physical encounters such as sleeves of laboratory coats brushing together are inevitable in such a close working environment. It is common in some institutions for medical students to wear or carry their scrubs and/or laboratory coats to and from the anatomy laboratory. Microorganisms acquired on scrubs and laboratory coats could potentially be transmitted to others if non-laundered garments are transported or worn outside of the confined environment of the anatomy laboratory.

It is currently unknown whether microorganisms can be transmitted in this manner. If such transmission proves to be frequent, the transmission of potentially pathogenic microorganisms is of concern to medical schools around the world. Furthermore, investigation of laboratory coats and scrubs for easily spread nosocomial pathogens, such as *S. aureus*, *S. pyogenes*, and *E. faecalis*, could warrant further studies into the detrimental effects caused by their transmission. It may also warrant changes in anatomy laboratory procedures, which may include changing the transport and washing procedure of laboratory garments and restricting the ability to take the garments outside of the anatomy laboratory to minimize patient and community exposure to potential pathogens. These changes could also directly affect procedures in hospitals and clinics.

METHODS

Medical students who were enrolled in the anatomy course at the American University of the Caribbean School of Medicine in St. Maarten were solicited to voluntarily participate in this experiment prior to beginning the anatomy laboratory segment of the course. In order to guarantee confidentiality, participants were assigned a random number and linked to that number in a database accessible only to the investigators. Students were instructed to wear their laboratory coats at all times inside the anatomy laboratory. Outside of the laboratory, students were not directed on how to manage their laboratory coats and were advised to maintain their normal cleaning and laundering routines. Students were not informed when the samplings would be conducted in order to prevent any changes to their routine that could potentially alter results.

Typical student management of laboratory coats involves bringing the laboratory coats from their place of residence to the laboratory and then leaving with the coats. Laboratory coats are not kept in the laboratory, and while regular cleaning of the laboratory coats was encouraged by the faculty, there were no specific requirements and cleaning regimens of individual students were not monitored. Thus, individual management of laboratory coats by students was expected to vary.

Culture samples were obtained from the sleeves and front of the laboratory coats on the participant's dominant side using sterile saline-moistened swabs. A culture sample was collected before the start of the first anatomy laboratory session prior to any engagement between the students and the cadavers. Another sample was collected from all participating medical student laboratory coats toward the end of the anatomy course, specifically after the gastrointestinal tract was explored by the students, which was 50 days after the initial sampling.

Each sample was first inoculated onto blood agar plates directly from the swab. After incubation for 48 hours at 37°C, distinctive colonies were then separately cultured on fresh blood agar plates for 24 hours at 37°C. Colony morphology and hemolytic patterns were observed for each isolate. Isolates were then subcultured on mannitol salt agar (MSA; 24 hours at 37°C), *Streptococcus*-selective agar (SSA; 24 hours at 37°C), and bile esculin agar (BEA; 24 hours at 37°C). Colony and gram stain characteristics of the organisms, along with subsequent catalase and coagulase testing, were then utilized to identify the different species of bacteria present from each swabbing using their respective bacterial properties.[12]

The results were then analyzed by chi-squared analysis and a standard t-test. The chi-squared analysis was done to compare the data as a nominal type defined by whether or not bacteria were present before and after dissection. A one tailed standard t-test was also done to see if the mean of bacterial presence on the laboratory coats was significant between the control and post-dissection data to justify further investigation with a larger sample size.

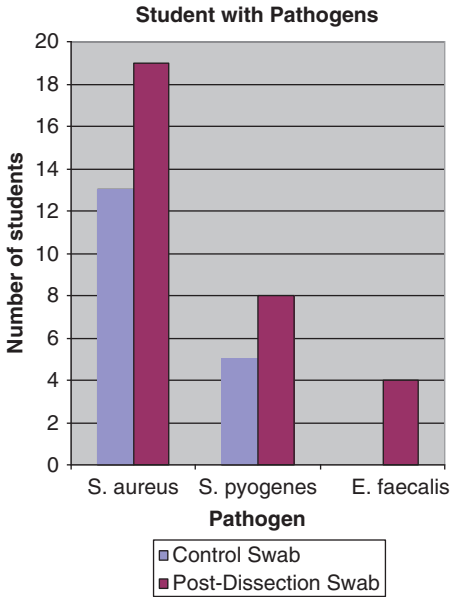

Figure 1. Pathogenic presence on laboratory coats based on organism type and number of students with microorganism presence.

RESULTS

Initial sampling, which was done before students had entered the anatomy laboratory, showed that *S. aureus* was found on the laboratory coats of 13 of 67 students (19.4%), *S. pyogenes* was found on coats of 5 of 67 students (7.46%), and *E. faecalis* was not found on any the coats of the 67 students (0%) (Fig. 1). In the laboratory coat sampling done after the cadaver was dissected and the gastrointestinal tract was exposed, laboratory coats of 19 of 67 students were found to have *S. aureus* (28.4%), 8 were found to have *S. pyogenes* 11.9%), and 4 were found to have *E. faecalis* (5.97%).

There were 6 more student laboratory coats with *S. aureus* in the post-dissection swabbing than in the first sampling, which is a 46% relative increase. There were 3 more student laboratory coats with *S. pyogenes* in the post-dissection swabbing compared to the initial sampling, which is a 60% relative increase.

DISCUSSION

The investigation began with the control swabbing, which would represent the normal conditions for which a laboratory coat was maintained. The alternative hypothesis was that the student laboratory coats would have a greater incidence of each bacterial type after exposure to cadavers than before any dissection occurred. The null hypothesis was that there would be no difference before or after exposure to cadavers. This experiment was designed as a one-tailed test, since the chance of disinfection as a result of cadaver exploration was not plausible.

Table 1. Analysis of control swabbing ($n = 67$).

	Absolute count	Mean	Standard deviation
S. aureus	13	0.194	0.159
S. pyogenes	5	0.075	0.070
E. faecalis	0	0.000	0.000

For all laboratory coat swabbings, a value of 0 was assigned if the particular bacteria did not grow on the specific media and a value of 1 was given if the bacteria were present. Data from the control and the post-dissection swabbings are shown in Tables 1 and 2, respectively. To check the significance of the data, a Chi-square analysis of the data and a two sample *t*-test of the means were carried out.

For the Chi-square analysis, the post-dissection swabbing was considered the observed value, and the control was the expected value. Table 3 describes the Chi-square analysis carried out for *S. aureus* that showed a *P*-value of 0.064, which was not statistically significant. Table 4 for *S. pyogenes* showed a *P*-value of 0.163, which was also not statistically significant. Table 5 showed the analysis for *E. faecalis*, which had to be done in two parts. Because the control value for the amount of *E. faecalis* found was 0, the Chi-square analysis could not be completed without a division by 0 error (as noted in Table 5). To assess the significance of the observed *E. faecalis* data, the expected bacteria found value was changed to 1 in order to calculate the limit of the *P*-value as the expected value approached 0. For the expected value of 1, the *P*-value was < 0.003, which was statistically significant. However, the Chi-square analysis is highly dependent on the sample size. While each swabbing group had a sample size of 67, the results suggest that the number of students would need to be increased in order to have a more definitive conclusion; a greater number of student participants while maintaining the same proportion of laboratory

Table 2. Analysis of post-dessection swabbing ($n = 67$).

	Absolute count	Mean	Standard deviation
S. aureus	19	0.284	0.206
S. pyogenes	8	0.119	0.107
E. faecalis	4	0.060	0.057

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Table 3. Chi-square for *Staphylococcus aureus* on laboratory coats.

	Observed (o)	Expected (e)	Deviation (*d*)	Deviation^2 (d^2)	$(d^2)/e$
No bacteria	48	54	−6	36	0.667
Bacteria found	19	13	6	36	2.769
$n = 67$, df = 1				X^2	3.436
				P	0.064

coats with and without bacteria would result in statistical significance for all bacteria tested.

In order to justify further investigation into this subject, we wanted to make sure that the difference in proportions between the pre- and post-dissection swabbing was significant. Therefore, a one-tailed two sample *t*-test of the means was conducted. Table 6 demonstrates the analysis of the *t*-test for the three tested bacteria. The results show that the mean of the post-dissection swabbing was higher than pre-dissection swabbing, with statistical significance for all three bacteria.

The laboratory coats tested in this study were purchased by students approximately 2 weeks before the start of the anatomy laboratory class; therefore, the coats were purchased 2 weeks before any solicitation was done for participation in the experiment. During the 2 weeks, the laboratory coats would have been exposed to the environment outside of the laboratory for enough time that it was assumed the control would be representative of any outside contamination. Thus, the presence of *S. aureus* and *S. pyogenes* in the initial samples was not surprising as they are commonly found in the normal upper respiratory tract flora. *E. faecalis*, which is part of the normal intestinal flora, was not expected to be on laboratory coats from environmental sources, which was confirmed by the control swabbing.

In the post-dissection swabbing, more students were found to have *S. aureus*, *S. pyogenes,* and *E. faecalis* on their laboratory coats. The time between the first day sample and the post-dissection sample was 50 days. During this time, the laboratory coats were exposed to dissection of the anatomy cadaver, including the most recent exploration of the gastrointestinal tract. The presence of *E. faecalis* on the laboratory coats in the post-dissection samples was not expected based on the assumption that students practiced acceptable sanitary and laundering measures in their day-to-day lives. The absence of *E. faecalis* in the control and its presence in the post-dissection swabbing implies that while the sanitary practices were acceptable, laundering was a concern.

In conclusion, while it is hard to attribute a specific source to the transmission of *S. aureus, S. pyogenes,* and *E. faecalis* to laboratory clothing from this study, the results do support the need for further investigation as there was an increase in bacterial acquisition on the laboratory coats. In addition, the findings indicate that laboratory garments worn in the anatomy laboratory setting were not sterile after exposure to the cadaver and thus harbor potentially pathogenic microorganisms. Given the current findings, proper timely laundering of laboratory clothing is recommended. The garments used in the anatomy laboratory should not be used for other activities, such as patient–clinical encounters, clinical interviews, diagnostic skills courses, or other formal activities requiring the use of laboratory coats, without first assuring that the garments have been properly disinfected.

Improvements could be made on the collection of data. As seen in the analysis, the Chi-square showed that only the presence of *E. faecalis* was statistically significant. A factor limiting the significance of the *S. aureus* and *S. pygoenes* data was the sample size. The analysis of the means through the *t*-test showed that the change in proportions for the appearance of bacteria on laboratory coats pre- and post-dissection

Table 4. Chi-square for *S. pyogenes* on laboratory coats.

	Observed (o)	Expected (e)	Deviation (*d*)	Deviation^2 (d^2)	$(d^2)/e$
No bacteria	59	62	−3	9	0.145
Bacteria found	8	5	3	9	1.800
$n = 67$, df = 1				X^2	1.945
				P	0.163

Table 5. Chi-square for *E. faecalis* on laboratory coats.

A – Using actual values					
	Observed (o)	Expected (e)	Deviation (d)	Deviation^2 (d^2)	$(d^2)/e$
No bacteria	63	67	−4	16	0.239
Bacteria found	4	0	4	16	ERROR
B – Assuming expected bacteria found value is 1					
	Observed (o)	Expected (e)	Deviation (d)	Deviation^2 (d^2)	$(d^2)/e$
No bacteria	63	66	−3	9	0.136
Bacteria found	4	1	3	9	9.000
$n = 67$, df = 1				X^2	9.136
				P	< 0.003

Table 6. Two-sample *t*-test for means of swabbings°.

	Mean	Standard deviation	t	P^*
S. aureus				
Post-dissection	0.284	0.206	2.831	0.0025
Control	0.194	0.159		
S. pyogenes				
Post-dissection	0.119	0.107	2.817	0.0028
Control	0.075	0.070		
E. faecalis				
Post-dissection	0.060	0.057	8.616	< 0.0001
Control	0.000	0.000		

°Values obtained from Tables 1 and 2.
*One-sided *P*-value calculation.

does justify further research and investigation into this matter. It would be our recommendation that the sample size be increased in order to obtain more conclusive results. While the means were analyzed using the *t*-test to justify further studies, the true significance of this study would be justified with significant Chi-square results due to the binomial nature of the data.

There were possible confounding variables that also warrant further investigation. The laboratory coats were not documented to which cadaver they were working with. There were 10 cadavers in the anatomy laboratory, and it is unknown if the positive laboratory coats were all in the same vicinity or worked with the same cadaver. In addition, no tests were performed on the cadavers themselves for the presence of bacteria.

Since the laboratory coats left the laboratory on a daily basis, the method of cleaning could not be standardized. While the control was designed to minimize any environmental contribution to the post-dissection swabbing, it is not possible to fully eliminate the environment as a possible contaminant given the current laundering protocol. This still leaves the environment outside the anatomy laboratory as a possible source of bacterial acquisition.

While there were variables that need to be better controlled, the experiment did show that there was a significant increase in the bacteria between pre- and post-dissection swabbings. It is the belief of the experimenters that the bacteria were transmitted from the anatomy cadavers. Whether due to the cadavers, environmental exposures, or improper laundering, the increased presence of bacteria on the laboratory coat does assert the need for specific laboratory coat cleaning protocols and warrants further investigation to prove the source of bacterial acquisition on the laboratory coats.

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Earlier this year, 3 days before the vernal equinox, my classmates and I gathered at the ballroom of the Michigan State University Club to learn about our placement in the 2013 Match (National Residency Matching Program – a program which annually assigns medical school graduates to residency positions). When the clock struck noon, we tore into white envelopes revealing the destination of the next 3–5 years of our lives. The room was abuzz with excitement, cheers, and tears as we shared this life-changing moment with one another. We had all matched, most of us to our top programs. Now we could finally breathe a sigh of relief as the anxious uncertainty about whether we would continue on our medical journeys melted away.

Unfortunately, this was not the case for every graduate in the United States this year. In fact, 2,076 of this year's graduating US seniors failed to match and entered the Supplemental Offer and Acceptance Program (SOAP – a secondary residency assignment program for those that fail to find a spot in the primary Match). After the SOAP, 528 US seniors remained completely unmatched, more than twice the number in that position in 2012.[1] SOAP was introduced in 2012, so no comparable data are available on the number of unmatched seniors prior to 2012. What is known is that this March, hundreds of US medical students found themselves with an average debt of $170,000, with no residency position to help them.

This is a problem that is expected to get worse, not better. The number of graduates is increasing every year, while the number of residency slots is not keeping pace. The reasons for this are multifactorial. To better understand why, it would be helpful to look back at the history of medical education policy.

> How shall the Nation be supplied with adequate numbers of well-qualified physicians?
>
> – The Bane Report[2]

In 1959, the US Public Health Service, under the leadership of Frank Bane, the Surgeon General's consultant, assessed the ability of US medical training to produce the number of physicians needed for the growing population. This came to be known as the Bane Report, and it predicted a deficiency of well-qualified physicians, if the number of medical students was not increased. The resulting government subsidies[3] would double the number of graduates over the next 23 years: from 6,900 in 1959 to 14,144 in 1982.[4]

This growth came to a halt in 1981, after the Graduate Medical Education National Advisory Committee (GMENAC) projected a surplus of 145,000 physicians by the year 2000.[5] To discourage further expansion of medical schools, congress slashed their subsidies. The intended results were achieved, and medical school enrollment remained frozen at the 1982 levels of about 16,000 freshmen per year. Enrollment would remain at this level until 2005.[4]

Despite the suspension of medical school growth, the total number of physicians in America continued to rise for at least two reasons: First, because medical training takes 7–10 years, it has been estimated that the effects of increasing medical school enrollment are not appreciated for 10–20 years, and the full effects may not be realized for 30–40 years,[6] when older physicians retire and are replaced. Therefore, it is conceivable that the effects of ceasing medical school growth in 1981 might not be noticed until 1991–2001. Second, the introduction of the Medicare Prospective Payment System in 1983 provided incentives for hospitals to raise the number of residency slots far above the number of US grads.[7] This led to an influx of thousands of international medical graduates (IMG), who increased the supply of physicians in the United States,[4] independent of medical school enrollment.[8] As a response to continued growth in the physician workforce, the Balanced Budget Act capped the number of residency positions in 1997, in an effort to reduce both cost and physician excess.

In 2006, the tides shifted, and the Association of American Medical Colleges (AAMC) projected a shortage – not surplus – of 90,000 physicians by 2020. The AAMC then prompted US medical schools to raise

enrollment by 30%, from 16,488 in 2002 to 21,434 by 2016.[9] Medical schools across the country responded to this call with increased enrollment, and in the 2012–2013 academic year, enrollment had reached 19,517. Furthermore, by 2012, 12 new medical schools received accreditation from the Liaison Committee on Medical Education and seven others had started the accreditation process. With the increased enrollment in existing medical colleges and the addition of new schools, the AAMC expects the goal of 30% growth to be achieved by 2016. After this, they have projected that enrollment should remain stable at around 21,500 for the foreseeable future.[9]

THE CURRENT STATE OF AFFAIRS

Currently, despite the imminent projected physician shortage, the cap on residency positions initiated in 1997 remains in place. It is true that even without increased federal funding, there has been some growth in the total number of accredited residents, an (increase of 15%, or 15,000 residents, between 2000 and 2010),[10] and we can identify several reasons for this. First, with every institution required to commit to an all-or-nothing listing of its programs in the Match, several thousand residency positions are now listed for the first time.[11] Second, multiple acts – most notably the Medicare Modernization Act of 2003[12] – have redistributed unused residency positions, increasing the number of residents by 4,500–6,000.[13] Third, a handful of new residency programs have been funded federally through non-Medicare acts, such as the Affordable Care Act.[14] Finally, several state hospitals and private groups have chosen to take on the costs of training residents themselves, and they have increased their resident count above the 1997 cap without federal funding.[15–18]

Nevertheless, while these measures have been able to raise the availability of residency positions above the federal cap, we are still projected to face a shortage of 90,000 physicians by 2020 due largely to limited residency slots. This shortage has been exacerbated by the Affordable Care Act, which is estimated to have increased the need for physicians by approximately 30,000,[19] while only raising the number of federally funded residency spots by about 300.[20]

Further worsening the situation is a push for reduction – not increase – in federal funding for graduate medical education (GME). Part of this is due to the lack of GME-labeled fund transparency. After money is transferred to healthcare facilities, it is nearly impossible to track whether it is actually used for its intended purpose of training residents. As a result, it is difficult to estimate the difference (positive or negative) between GME funds and resident costs on hospitals in order to determine whether the amount of funding is appropriate.[21] Accordingly, GME payments have often been the target of cuts in recent years. For example, last month President Obama announced the FY 2014 budget, which included $11B (about 10% of the total 10-year budget) in GME cuts over the next 10 years, to 'Better align GME payments with patient care costs'.[22]

HOW DO WE PAY FOR THIS?

One day prior to the 2013 Match, two bills were presented in congress: *H.R. 1201: Training Tomorrow's Doctors Today Act*,[23] and *H.R. 1180: Resident Physician Shortage Reduction Act of 2013*.[24] These bills would raise the federal cap on residency positions by 15,000 over the next 5 years. While these proposals were lauded by the AAMC,[25] such an increase has previously been estimated to only address about 30% of the expected physician shortage.[20] Unfortunately, the outlook for each of these bills is unfavorable. Similar proposals have been made in the past 2 years, without success,[26,27] and this year's bills currently have very little support in the House.[23,24]

Given the apparent federal opposition to increased funding of GME, some researchers have explored the possible outcomes of cutting GME funding. One analyst estimated that a 10% ($600M) cut in indirect medical education payments would result in a reorganizing, but overall negligible change in the number of residency positions.[21] In another study, a survey of 70% of all US residency and fellowship programs revealed that a 33% reduction in GME funding would result in an overall reduction of 19,879 (18% of all) residency and fellowship positions. A 50% reduction would cause a loss of 33,023 (29%) positions.[28]

Should a 33–50% cut come to pass, programs most commonly reported that they would look to private funding for ongoing support.[28] Such funding already exists in many places in the country. In Utah, Texas, and New York, non-profit hospitals and councils have contributed to the creation of hundreds of new residency programs.[16] Pharmaceutical companies have also stepped in to foot the bill for residency slots in fields expected to 'pay back' over time, such as dermatology.[18] Other organizations work with hospitals to fund the creation of medical residency slots for sponsored IMG.[17] Finally, an often-neglected source of funding is insurance providers. In the past year, the Center for American Progress, a progressive think tank,

called on private insurers to contribute to residency funding.[29] Other groups have stated that private insurers, who pay more per visit than Medicare does on average, are already contributing toward GME funding, albeit indirectly.[21,30]

CONCLUSIONS

The problems facing healthcare training today are not simple. Predictions about future demand for physicians have a poor track record, as the GMENAC studies of the 1980s showed. Even if one could predict perfectly the demand for physicians in the future, history has shown that it takes 10–40 years for the full effects of increased medical school enrollment to be felt. Increased enrollment of medical students will not necessarily result in meeting our nation's healthcare needs. As physician attitudes change with a new generation that places a higher value on quality of life, and personal time, total physician work hours may fall even if the number of physicians rises. Finally, the current cap on federally funded residency positions may stifle the effects of higher medical student enrollment.

These are a few closing thoughts I want to leave you with:

The rate of GME must rise. In its present state, GME could sustain reductions as great as 10% of funding without the loss of total residency slots, but any decrease in GME funding will undoubtedly perpetuate the inadequacy of the physician workforce. By 2016, without increased GME funding, there will be a substantial increase in the number of unmatched US seniors and a substantial decrease in the number of foreign medical grads. Unfortunately, current trends in healthcare policy and attitudes suggest lack of appreciation for the need for new residency positions by both the government and the public. There is broad public support for increasing the number of medical students, but comparatively less enthusiasm for raising the number of residents. If we want to change the direction of public allocation of residency funds, then we will need to raise public awareness of this problem.

If the federal government is unable to resolve the projected discordance between increasing physician shortages and decreasing federal supply, we may see a future where an increasing number of training positions are either eliminated, or funded through alternative channels. It begs the question: Why do the majority of residency slots need to be funded by the government? Private insurers, who already pay more than Medicare for the same procedures, could designate that a particular percentage of hospital reimbursements be contributed directly to residency training, when a resident is involved in a patient's care. Such earmarking could create more transparency in hospital payments and allow private insurers to receive credit for the funds they already contribute toward GME. Private and state hospital systems, and private organizations are also ready to fund expansions in residency, but again, public and professional support for such measures is needed to effect change.

When asked by a reporter from the State News as to how I felt about my Match results, I replied with relief that finally 'We can start looking for a new place to live in (and) start looking into what we're going to do as a family. Everything changes today'.[31] It is an uncertain future that I and the other 2013 College of Human Medicine (CHM) graduates face in the field of medicine, but we can take solace in knowing where we are going for the next few years, at least. I hope that next year's class can say the same.

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