Original Research

Using Electronic Medical Record To Identify Changes In Inpatient Learner Experience

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Abstract

Background

COVID-19 has been disruptive to inpatient medical care. While changes in prevalence of inpatient diagnoses have been published, little has been published about the impact on learner exposure to various diagnoses. Such changes are likely impacted by national and global trends, as well as local disease prevalence and policies. We hypothesized that the electronic medical record (EMR) may offer a tool to track learner experiences as they evolve in a time of rapid change.

Methods

The top 20 most common diagnoses between April-July 2019 vs April-July 2020 on the resident inpatient internal medicine service were extracted from the Epic EMR and compared. This data was analyzed using a chi squared test and Bonferroni correction to identify statistically significant changes in case distribution in this time frame. Changes over this period were also compared for the nonteaching service.

Results

The resident teaching service saw a statistically significant decrease in pulmonary cases (13% vs 2%, $p < 0.005$) from 2019 to 2020. Acute exacerbation of chronic obstructive pulmonary disease (COPD) and pneumonia, previously the 5th and 7th most common diagnoses in the 2019 period, dropped off the top twenty list for the teaching service. These 2 diagnoses remained on the non-teaching common encounter list, suggesting that COVID-19-related service/team assignments rather than disease prevalence may be a factor. There was also a statistically significant increase from 2019 to 2020 in cases pertaining to substance use intoxication on both teaching and non-teaching teams (0 vs 0.05 and 0 vs 0.02, respectively), mirroring trends in national data.

Conclusion

Use of the EMR was able to rapidly identify changes in the most common diagnoses on the teaching service. This may be a tool to monitor the inpatient experience of learners over time, particularly in times of rapid local, regional, or global change.

BACKGROUND

Historically, the inpatient internal medicine teaching service has had tremendous diversity in the types of diagnoses admitted to the service. Despite this variability, some diagnoses, such as heart failure, pneumonia, urinary tract infection, chronic obstructive pulmonary disease and stroke, have been consistently common.[1] These historic norms have built a foundation of expected learning experiences in the clinical setting.[2,3] Globally there have been reports of COVID-19 changing the landscape of inpatient diagnoses due to disease prevalence and patient behaviors.[4,5] For example, non-COVID admission volumes were found to have substantially declined by over 30% for nearly all common primary medical diagnoses during the initial months of the pandemic.[6] However, despite these significant trends, little has been reported about the impact of these changes on the most common diagnoses encountered by trainees during this time; nor is there a good understanding of the tools that may be helpful in identifying changes and adapting curricula as needed. Given that physicians spend a significant portion of their working hours in the electronic medical record (EMR), this system has been suggested as a valuable education resource with regards to assessing clinical com-

petency, though there have been very few studies on this subject.[7-9]

The learner experience may be affected by not only massive global changes such as a pandemic but also by local policy decisions. Over the course of the pandemic, teaching institutions have adopted different policies, including restrictions about whether trainees can care for patients with COVID-19.[10] These policies may change over time, further impacting and evolving the learner experience. Curricular plans are based on anticipated exposure to historically common diagnoses; those that do not adapt to the changing landscape of diagnoses have potential to leave unanticipated knowledge gaps. While there is literature describing regional, national, and diagnosis-specific trends, relying on publications to guide curricular content forces a marked time delay and ignores hospital-specific factors, such as local disease prevalence and hospital admission policies, that may alter the diagnoses local learners are seeing. We hypothesized that our learners were seeing a different patient mix than a year prior and that using the electronic medical record (EMR) may give the ability to rapidly recognize these changes and to feed this information back to medical educators.

METHODS

This retrospective study was conducted at a 369-bed tertiary community hospital affiliated with an academic medical center. Patients admitted to the internal medicine service at our facility are cared for either by direct-care hospitalist services or by internal medicine resident teaching teams. Internal medicine resident teaching teams at this institution are composed of an attending, senior internal medicine resident, intern, medical and physician assistant students, as well as a pharmacist and pharmacy student. Epic is the EMR used at this institution. This study received exemption from the institutional review board (IRB).

The period of interest for this study was chosen to be from April to July 2020, representing the early stages of the pandemic; this was compared to the April to July 2019, representing the expected historic baseline. The 20 most common principal diagnoses (CMS) at discharge were extracted from the EMR for the patients on the resident internal medicine teams for April-July 2020 and compared to April-July 2019. The top 20 diagnoses on the non-teaching service were also compared during these time periods. Consistent with local health system policy, resident teams at our hospital were not involved in direct care of patients with COVID-19 or patient under investigation (PUI) for possible COVID-19 during the period of interest. Determination of whether a patient should be considered a PUI was made by the clinicians involved in the case based on clinical features and if symptoms were related to alternative diagnoses.

Assignment of admissions to the resident versus direct care hospitalist service during the study period was determined by resident review of case, discussion with triaging hospitalist, timing of admission, resident admission caps, and COVID-19 related policies.

After extraction from the EMR, the top diagnoses were subsequently organized by primary organ system (infectious, cardiac, renal, pulmonary, endocrine, gastrointestinal, neurologic, psychiatric, orthopedic). Notably, due to the role of the PUI designation in distributing cases, the category for infectious diagnoses in this study specifically excluded respiratory infections such as pneumonia; these were instead allocated to the pulmonary diagnoses group.

A Chi Squared Test of Homogeneity was performed comparing the proportion of cases (as organized by primary organ system) on teaming teams in 2019 vs 2020; a similar calculation was done for non-teaching teams in the same time frame. The null hypothesis here was that the proportion of cases seen in 2019 vs 2020 were identical. A post-hoc analysis was performed with the Bonferroni correction to determine if there were significant changes between the diagnostic groups.

RESULTS

The top 20 diagnoses on the internal medicine resident service represented 251 cases for the 2019 period and 221 cases for the 2020 period. The most common diagnoses on the resident teaching service in these respective time periods are shown in Table 1; similar data for the non-teaching hospitalist service is shown in Table 2. Heart failure, pneumonia, chronic obstructive pulmonary disease and stroke, common diagnoses in the literature, were represented well in our historic control. In the 2020 period, pneumonia and COPD were no longer on the top 20 most common diagnoses for the teaching service, whereas they previously were found in the top 10 most common. For the direct-care hospitalist service, heart failure, pneumonia, COPD, and UTI (common inpatient medicine diagnoses identified by literature) were seen in both the 2019 and the 2020 periods (table 2). In the 2020 period, COVID-19 became the second most common diagnosis for the non-teaching service. Diagnoses related to substance abuse (such as alcohol or cocaine) were more common on the 2020 list for both the teaching and nonteaching service compared to the year prior.

When the diagnoses were organized by organ systems, notable patterns of distribution were identified. For the teaching teams (Table 3), pulmonary cases decreased from 13% of cases to only 2%, a statistically significant change in this time frame. As described above, pneumonia and COPD cases were no longer being distributed to resident teaching teams, leaving pulmonary embolism as the only pulmonary diagnosis (table 1). There was a statistically significant increase in the proportion of psy-

Teaching April - July 2019	
Primary Diagnosis Name	Volume
Sepsis, unspecified organism (CMS-HCC)	56
Hypertensive heart and CKD with heart failure and stage 1-4 CKD (CMS-HCC)	34
Hypertensive heart disease with heart failure (CMS-HCC)	24
Acute kidney failure, unspecified (CMS-HCC)	16
Chronic obstructive pulmonary disease with (acute) exacerbation (CMS-HCC)	15
Type 2 diabetes mellitus with ketoacidosis without coma (CMS-HCC)	11
Pneumonia, unspecified organism	10
Other pulmonary embolism without acute cor pulmonale (CMS-HCC)	10
Non-ST elevation (NSTEMI) myocardial infarction (CMS-HCC)	10
Sepsis due to Escherichia coli (e. coli) (CMS-HCC)	8
Type 1 diabetes mellitus with ketoacidosis without coma (CMS-HCC)	7
Hypertensive heart and CKD with heart failure and with stage 5 CKD or ESRD (CMS-HCC)	7
Hypo-osmolality and hyponatremia	7
Atherosclerotic heart disease of native coronary artery with unstable angina pectoris (CMS-HCC)	6
Paroxysmal atrial fibrillation (CMS-HCC)	6
Other chest pain	5
Diverticulosis of large intestine without perforation or abscess with bleeding	5
Cerebral infarction, unspecified (CMS-HCC)	5
Type 2 diabetes mellitus with hyperosmolarity without NKHHC (CMS-HCC)	5
Chronic or unspecified gastric ulcer with hemorrhage	4

Teaching April - July 2020	
Primary Diagnosis Name	Volume
Sepsis, unspecified organism (CMS-HCC)	30
Hypertensive heart and CKD with heart failure and stage 1-4 CKD (CMS-HCC)	30
Hypertensive heart disease with heart failure (CMS-HCC)	23
Non-ST elevation (NSTEMI) myocardial infarction (CMS-HCC)	16
Acute kidney failure, unspecified (CMS-HCC)	13
Type 2 diabetes mellitus with ketoacidosis without coma (CMS-HCC)	12
Hypertensive heart and CKD with heart failure and with stage 5 CKD or ESRD (CMS-HCC)	11
Other cerebral infarction due to occlusion or stenosis of small artery (CMS-HCC)	9
Cerebral infarction, unspecified (CMS-HCC)	8
Alcohol induced acute pancreatitis without necrosis or infection	8
Urinary tract infection, site not specified	8
Type 2 diabetes mellitus with other specified complication (CMS-HCC)	7
Poisoning by cocaine, accidental (unintentional), initial encounter (CMS-HCC)	6
Paroxysmal atrial fibrillation (CMS-HCC)	6
Gastrointestinal hemorrhage, unspecified	6
Type 2 diabetes mellitus with hyperosmolarity without NKHHC (CMS-HCC)	6
Alcohol dependence with withdrawal, unspecified (CMS-HCC)	6
Other chest pain	6
Infection and inflammatory reaction due to indwelling urethral catheter, initial encounter (CMS-HCC)	5
Other pulmonary embolism without acute cor pulmonale (CMS-HCC)	5

Table 1. Comparison of the top 20 diagnoses on teaching teams in 2019 and 2020. Total cases in 2019 and 2020 were 251 and 221, respectively.

Non-Teaching April - July 2019	
Primary Diagnosis Name	Volume
Sepsis, unspecified organism (CMS-HCC)	180
Unilateral primary osteoarthritis, right hip	108
Unilateral primary osteoarthritis, left hip	95
Hypertensive heart and CKD with heart failure and unspecified CKD (CMS-HCC)	93
Hypertensive heart disease with heart failure (CMS-HCC)	70
Acute kidney failure, unspecified (CMS-HCC)	55
Urinary tract infection, site not specified	53
Chronic obstructive pulmonary disease with (acute) exacerbation (CMS-HCC)	51
Unilateral primary osteoarthritis, left knee	40
Sepsis due to Escherichia coli (e. coli) (CMS-HCC)	40
Type 2 diabetes mellitus with ketoacidosis without coma (CMS-HCC)	34
Non-ST elevation (NSTEMI) myocardial infarction (CMS-HCC)	33
Unilateral primary osteoarthritis, right knee	33
Pneumonia, unspecified organism	26
Hypertensive heart and chronic kidney disease with heart failure and ESRD (CMS-HCC)	23
Hypo-osmolality and hyponatremia	22
Acute and chronic respiratory failure with hypoxia (CMS-HCC)	21
Atherosclerotic heart disease of native coronary artery with unstable angina pectoris (CMS-HCC)	19
Type 1 diabetes mellitus with ketoacidosis without coma (CMS-HCC)	18
Type 2 diabetes mellitus with hyperglycemia (CMS-HCC)	17

Non-Teaching April - July 2020	
Primary Diagnosis Name	Volume
Sepsis, unspecified organism (CMS-HCC)	149
COVID-19	149
Acute kidney failure, unspecified (CMS-HCC)	55
Hypertensive heart and CKD with heart failure and unspecified chronic kidney disease (CMS-HCC)	52
Hypertensive heart disease with heart failure (CMS-HCC)	46
Unilateral primary osteoarthritis, right hip	42
Other specified sepsis (CMS-HCC)	36
Chronic obstructive pulmonary disease with (acute) exacerbation (CMS-HCC)	31
Non-ST elevation (NSTEMI) myocardial infarction (CMS-HCC)	30
Urinary tract infection, site not specified	28
Unilateral primary osteoarthritis, left hip	26
Sepsis due to Escherichia coli (e. coli) (CMS-HCC)	23
Type 2 diabetes mellitus with ketoacidosis without coma (CMS-HCC)	20
Pneumonia, unspecified organism	18
Hypertensive heart and chronic kidney disease with heart failure and ESRD (CMS-HCC)	18
Unilateral primary osteoarthritis, left knee	17
Unilateral primary osteoarthritis, right knee	17
Cerebral infarction, unspecified (CMS-HCC)	15
Alcohol dependence with withdrawal, unspecified (CMS-HCC)	15
Acute respiratory failure with hypoxia (CMS-HCC)	14

Table 2. Comparison of top 20 diagnoses on direct care non-teaching teams in 2019 and 2020. Total cases in 2019 and 2020 were 1031 and 801, respectively.

chiatric cases (specifically substance use relating to either cocaine or alcohol). An increase in neurologic cases (cerebral infarctions) was also identified. Notably, at baseline, resident teaching teams received no admissions related to orthopedic surgeries as the primary diagnosis, as these cases were instead distributed to the direct-care teams.

Non-teaching teams similarly demonstrated patterns in case distribution during the time period of interest, as shown in Table 4. Pulmonary cases doubled in proportion from 10% to 26%, caused by an increase in COVID-19 diagnoses; furthermore, diagnoses such as COPD exacerbation and acute hypoxic respiratory failure were funneled to these teams due to their PUI designations, which similarly contributed to the increase in pulmonary cases. Similar to the teaching teams, there was a statistically significant increase in psychiatric cases (cases related to alcohol intoxication) and neurologic cases (cases related to cerebral infarctions). Orthopedic cases decreased significantly from 26% to 12%, possibly related to cessation of elective surgeries. Notably, the non-teaching team uniquely demonstrated a statistically significant decrease in the number of endocrine cases from 7% to 2%, as seen with overall reduction in admissions relating to diabetes with/without complications.

DISCUSSION

This study demonstrated that use of the EMR was able to rapidly identify significant changes in the variety of admissions seen on the internal medicine resident teach-

Teaching Team Diagnoses by Primary Organ System			
	April-July 2019	April-July 2020	p value
Cardiology	92 (0.36)	92 (0.41)	0.23
Infectious (non-respiratory)	64 (0.25)	43 (0.19)	0.11
Pulmonary	35 (0.13)	5 (0.02)	<0.005 *
Renal	23 (0.09)	13 (0.06)	0.185
Endocrine	23 (0.09)	25 (0.11)	0.443
GI	9 (0.04)	14 (0.06)	0.174
Neurology	5 (0.02)	17 (0.08)	<0.005 *
Psychiatry	0	12 (0.05)	<0.005 *
Orthopedic	0	0	na

Table 3. Comparison of teaching team diagnoses as organized by primary organ system between 2019 and 2020. Data was first compared using the Chi Squared Test of Homogeneity and followed up with a post-hoc analysis using the Bonferroni correction (statistically significant at p value < 0.005).

GI – gastrointestinal.

Non-Teaching Team Diagnoses by Primary Organ System			
	April-July 2019	April-July 2020	p value
Cardiology	238 (0.23)	146 (0.18)	0.01
Infectious (non-respiratory)	273 (0.26)	236 (0.29)	0.15
Pulmonary	98 (0.10)	212 (0.26)	<0.005 *
Renal	77 (0.07)	55 (0.07)	0.63
Endocrine	69 (0.07)	20 (0.02)	<0.005 *
GI	0	0	na
Neurology	0	15 (0.02)	<0.005 *
Psychiatry	0	15 (0.02)	<0.005 *
Orthopedic	276 (0.26)	102 (0.12)	<0.005 *

Table 4. Comparison of non-teaching direct care diagnoses as organized by primary organ system between 2019 and 2020. Data was first compared using the Chi Squared Test of Homogeneity and followed up with a post-hoc analysis using the Bonferroni correction (statistically significant at p value < 0.005).

GI – gastrointestinal.

ing services from April to July 2020. Most notably, there was a significant reduction in pulmonary cases encompassing diagnoses such as bacterial pneumonia, COPD exacerbations, and acute hypoxic respiratory failure, despite these cases typically being found in the top 10 most common diagnoses in the historic baseline. It is likely that this pattern reflects local policy decisions to label patients with respiratory symptoms as PUI and to therefore assign them to direct care service lines, as these diagnoses were preserved on the non-teaching team lists.

Our study additionally confirmed a significant increase in cases related to substance abuse such as alcohol and cocaine, a finding which mirrors the trend of increased alcohol related emergencies nationally.[11] Consistent with other American institutions, the number of admissions on both teaching teams and non-teaching teams were decreased (251 to 221 and 1031 to 801, respectively); however, given that we did not incorporate additional data from past years, we cannot determine the significance of this reduction.[6,12,13] In line with national trends, the non-teaching teams saw a significant decrease in the number of endocrine admissions, such as those related to complications of diabetes. This trend was not seen on the teaching teams, perhaps due to distribution of admission volumes to offset the lack of pulmonary cases. Notably, despite data suggesting an expected decline in admissions for stroke, our teams on both teaching and non-teaching demonstrated a statistically significant increase in cases of cerebral infarctions.[6]

Given the impact of COVID-19 on case diversity and volume, many internal medicine residency programs have implemented strategies to maintain meaningful levels of exposure for trainees. These interventions include virtual learning, simulation sessions, and expansion of telehealth engagement.[14-17] These were designed as broad, program-wide changes that may not necessarily account for variations in individual learning. As such, using the EMR as a tool to rapidly review the common diagnoses that learners have exposure to may provide a mechanism for rapid feedback to ensure curricular goals are being met and to assess the educational impact of local policy decisions. Decreased exposure to a unique diagnosis during a single rotation does not necessarily mean an educational gap exists when considered among the other educational experiences that a learner may encounter. Early recognition of changing patterns may be a tool for curricular and program leadership to take advantage of to ensure delivery of key content. Residents may still get key learning about COVID-19, COPD and pneumonia on dedicated COVID-19, pulmonary, or intensive care services. The methods for assigning patients to the inpatient teaching service also vary across programs and tools may exist to make this assignment process more nimble to adapt to changes in the prevalence of patient diagnoses.[18] Use of existing curricular resources including online cases, podcasts, question banks, lectures or creation of new content may be required in some situations to fill gaps. Increased prevalence of cases related to substance abuse and changing patterns of admission for non-COVID-19 diagnoses are findings that were ultimately reported, but waiting for the timeline of publications to address curricular changes may miss an opportunity to improve the educational experiences of learners while they are still undergoing training.[4,5]

Limitations of our analysis include that it was a single site with only 1 year of retrospective data for comparison. Comparison to the nonteaching service and to published literature was used to mitigate this. Our study utilized principal diagnoses, which excluded secondary diagnoses that may also contribute importantly to hospitalization (eg, COPD exacerbation triggered by heart failure) and contribute to learning opportunities. The approach of using primary diagnosis offers one look at the patient diagnosis mix but loses nuance. We also acknowledge that our approach for grouping diagnoses by organ system may be confounded by overlapping diagnoses such as alcohol pancreatitis (could be considered substance abuse disorder or GI disorders). Another limitation is that the

pandemic was a time of dramatic and rapid change. It is possible that the tools used here will be less useful during periods of greater stability. However, given that prevalence of diagnoses do change over time, tracking over a longer period may offer insights. While this was not done in this single pilot study, a longer term study could be done to assess the usefulness of this strategy for ongoing curricular feedback and monitoring.

As this retrospective study has demonstrated, our resident teams experienced significant changes in the prevalence of some primary diagnoses during this time period. Given the pace at which the pandemic evolved, safety concerns and clinical workforce needs, our institution was unable to implement specific policies to counteract these potential educational gaps, which continued to evolve. We believe that we have identified a potential area for improvement within the realm of medical education. Future work can include assessing the impact of embedding a streamlined process to deliver this information to front-line educators and educational leadership regularly to establish an ongoing process of rapid cycle improvement and adaptation. Use of the EMR to review the diagnoses learners are encountering is a tool that may also be able to used prospectively to assess the impact of new admission policies in the future. While COVID-19 was a seismic shift in the inpatient medical education landscape, smaller changes are common and the EMR represents a tool with enduring potential.

CONCLUSIONS

By using the EMR, changes in learner exposure to common diagnoses were identified. Integrating review of resident team diagnoses through the EMR offers a tool to review attainment of curricular objectives.

Conflicts of Interest

The authors declare no conflicts of interest.

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Author Contributions

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- Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND
- Drafting the work or revising it critically for important intellectual content; AND
- Final approval of the version to be published; AND
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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