Expanding Health Information Exchange Improves Identification of Frequent Emergency Department Users

Xiao Han, MD*; Tina Y. Lowry, MS; George T. Loo, DrPH, MPA; Elaine J. Rabin, MD; Zachary M. Grinspan, MD; Lisa M. Kern, MD, MPH; Gilad J. Kuperman, MD, PhD; Jason S. Shapiro, MD

*Corresponding Author. E-mail: xiao.j.han@gmail.com.

Study objective: Frequent emergency department (ED) users are of interest to policymakers and hospitals. The objective of this study is to examine the effect of health information exchange size on the identification of frequent ED users.

Methods: We retrospectively analyzed data from Healthix, a health information exchange in New York that previously included 10 hospitals and then grew to 31 hospitals. We divided patients into 3 cohorts: high-frequency ED users with 4 or more visits in any 30-day period, medium-frequency ED users with 4 or more visits in any year, and infrequent ED users with fewer than 4 visits in any year. For both the smaller (10-hospital) and larger (31-hospital) health information exchanges, we compared the identification rate of frequent ED users that was based on hospital-specific data with the corresponding rates that were based on health information exchange data.

Results: The smaller health information exchange (n=1,696,279 unique ED patients) identified 11.4% more high-frequency users (33,467 versus 30,057) and 9.5% more medium-frequency users (109,497 versus 100,014) than the hospital-specific data. The larger health information exchange (n=3,684,999) identified 19.6% more high-frequency patients (52,727 versus 44,079) and 18.2% more medium-frequency patients (222,574 versus 192,541) than the hospital-specific data. Expanding from the smaller health information exchange to the larger one, we found an absolute increase of 8.2% and 8.7% identified high- and medium-frequency users, respectively.

Conclusion: Increasing health information exchange size more accurately reflects how patients access EDs and ultimately improves not only the total number of identified frequent ED users but also their identification rate. [Ann Emerg Med. 2019;73:172-179.]

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INTRODUCTION

Background

Frequent emergency department (ED) users have been a concern for health care providers and policymakers for decades.[1] The 2011 National Hospital Ambulatory Medical Care Survey estimated that there were more than 136 million ED visits every year,[2] and 21% to 28% of all visits were from frequent ED users but comprised only 5% of ED patients.[3,4] Frequent ED users are more likely to have social issues, substance abuse and psychiatric disorders, complex medical conditions, frequent hospital admissions, and higher mortality rates than the general population.[5-8] Given the high degree of resource use, this group has attracted attention from politicians, policymakers, and hospital administrators. Because of their complex health and social needs, frequent ED users are often the targets of support programs to address their needs.[9] They merit focused attention and systematic research on targeted interventions to more effectively manage them as a unique cohort.[5]

The Health Information Technology for Economic and Clinical Health Act of 2009 encouraged the development of health information exchange,[10-12] which enables sharing health records across multiple unaffiliated hospitals. Health information exchange is primarily used by clinicians and support staff to find additional information on an individual patient at the point of care. However, health information exchange data are also valuable for secondary uses, such as understanding how patients access health care across multiple provider organizations.[13,14] Use of health information exchange data allows better identification of frequent ED users[7,13] who visit multiple hospitals at higher rates than the general population.[1,7]

Editor's Capsule Summary

What is already known on this topic

Health information exchange data improve identification of frequent emergency department (ED) users.

What question this study addressed

The authors compared the identification rate of frequent ED users when the health information exchange increased from 10 to 31 participating hospitals in a high-density metropolitan area.

What this study adds to our knowledge

Tripling the number of hospitals participating in the health information exchange resulted in an approximately 8% absolute increase in the identification rate of frequent ED users.

How this is relevant to clinical practice

The more hospitals that participate in a health information exchange within a specific geographic region, the more likely it is that ED providers will be able to detect frequent ED use.

Importance

Most studies of frequent ED users have used data from a single ED, although a few have combined data from multiple EDs using health information exchange.[6,7,12,15] Because patients seek care at multiple hospital sites ("crossover visits"), hospital-specific data cannot adequately reveal patients' ED visit patterns. This study adds additional insight to our previous study of the 10-hospital health information exchange by expanding to 31 hospitals and thus shows how increasing health information exchange size more accurately captures frequent ED users and their visits.[7] It is important to perform new analyses to better understand patients' ED visit patterns across the community using health information exchange.[13] With the Health Information Technology for Economic and Clinical Health Act, more hospitals are participating in health information exchange,[10] but little is known about the additional value of upscaling smaller health information exchanges to larger ones.[12]

Goals of This Investigation

We had 2 main research questions: does increasing the number of participating EDs in a health information exchange increase the ability to detect frequent ED visitors, and is there an optimal size for a health information exchange in which further expanding the participants does not yield better results? The primary goal of this study was to compare the identification rate of frequent ED users when increasing the size of a regional health information exchange from 10 to 31 hospitals. In addition, we studied the characteristics of these frequent ED users and their ED visit patterns. We hypothesized that expanding health information exchange size would not only increase the absolute number of identified frequent ED users but also improve their identification rate.

MATERIALS AND METHODS

Study Design and Setting

This was a retrospective observational study using data from Healthix, a regional health information exchange that included 31 hospitals in the New York metropolitan area and Long Island when the study was conducted. The New York Clinical Exchange, a precursor of Healthix, included 10 hospitals, which formed a subset of Healthix hospitals. Healthix was formed after the merger of New York Clinical Exchange with Long Island Patient Information Exchange and Brooklyn Health Information Exchange.[7,13] In this study, we referred to Healthix as the larger health information exchange and New York Clinical Exchange, a subset of Healthix, as the smaller one. It contains patient demographic, encounter, and clinical data linked by a centralized master patient index.[7,10,13] Matching of patients across sites is provided by IBM's Initiate product (IBM, Armonk, NY). In general, commercial master patient index systems are tuned to a high degree of specificity to prevent false-positive matches, which would commingle 2 different individuals' records.

Selection of Participants and Methods of Measurement

Healthix provided deidentified data for a 5-year study period, from March 1, 2009, to February 28, 2014. Spuriously entered visits were recorded for one ED from October 29, 2012, to February 28, 2014, when it was closed because of damage from Hurricane Sandy. We then removed duplicate visits with identical patient-level health information exchange–wide master patient index numbers, hospital, date, and time. Because of an idiosyncrasy with Healthix's platform, all ED visits that resulted in inpatient admissions were overwritten and labeled as inpatient visits. Our initial data set contained all ED visits and inpatient admissions, and the decision was made to remove all inpatient visits in the data cleaning process. Last, when determining frequency cohorts, we discounted consecutive ED visits for the same patient that were less than 6 hours

after the previous visit because many of these visits were likely the result of administrative or clerical errors based on expert opinions, a method followed in previous studies.[7]

Outcome Measures and Primary Data Analysis

All data analyses were performed with R statistical software (version 3.5.0; R Core Team, Vienna, Austria). We compared the detection rate of frequent ED users from 3 interrelated data sets: (1) hospital-specific data (by treating data for each hospital with a separate physical location and ED in the health information exchange as an independent data set); (2) smaller health information exchange data (a 10-hospital subset of the larger health information exchange that was the original premerger health information exchange); and (3) larger health information exchange data (from the 31-hospital Healthix). For each data set, we divided patients into 3 mutually exclusive frequency cohorts: high-frequency ED users, who had 4 or more visits in any given 30-day period; medium-frequency ED users, who had 4 or more visits in any given year; and infrequent ED users, who had fewer than 4 visits in each study year. Although the term "frequent ED users" has been most frequently defined in the literature as patients with 4 or more visits in a year (ie, medium-frequency users),[3,16-18] we wanted to further analyze the frequent ED users with much higher rates of use who were in the high-frequency group separately because they are potential targets for intervention.

For each patient, we collected data pertaining to sex, age, date and time of visits, number of ED visits, and number of facilities visited. Additional patient demographic and diagnosis data were not available from the larger health information exchange for our analysis. For each data set, we calculated the total number of ED visits, number of unique patients, and average number of ED visits per patient during the study period; and the number and percentage of high-frequency, medium-frequency, and infrequent ED users and their corresponding number of ED visits. We also calculated and compared the identification rate of frequent ED users when expanding from hospital-specific data to smaller health information exchange data and then to larger health information exchange data. In addition, we computed the number of patients by number of facilities visited for all patients in the larger health information exchange data sets, and further analyzed patients with multiple ED visits by subcategorizing them into high-frequency, infrequent, and medium-frequency ED users. Last, we performed a simulation with 50 iterations to determine whether there was an ideal health information exchange size in which the percentage of patients in the high- and medium-frequency ED user groups reached a plateau as health information exchange size increased. For each iteration, all 31 hospitals were randomly assigned a number from 1 to 31 for arrangement purposes. Then, medium- and high-frequency ED user percentages were calculated for the first hospital (health information exchange size=1), first 5 hospitals (health information exchange size=5), first 10 hospitals (health information exchange size=10), and so on, up to 31 hospitals. The percentages for all the iterations were averaged for each frequency cohort to minimize fluctuations from random sampling.

Results are presented without hospital names in accordance with Healthix research policy. The Mt. Sinai Hospital institutional review board reviewed this study protocol and determined that it was not human research and was exempt from further review.

RESULTS

Characteristics of Study Subjects

A total of 31 EDs, shown in Figure 1, participated in the larger health information exchange at the time of the study. The New York City public hospital system, Health and Hospitals Corporation, does not participate in Healthix because it has its own health information exchange. During the 5-year study period, 12,671,590 ED and inpatient visits were generated. After data cleaning, there were 3,684,999 unique ED patients and 8,184,599 ED visits in the larger health information exchange data set (Table 1). These patients had an average of 2.22 total ED visits during the 5-year study period. The median ages were 38 years (interquartile range 25 to 54 years) for high-frequency ED users, 34 years (interquartile range 19 to 56 years) for medium-frequency ED users, and 35 years (interquartile range 21 to 54 years) for infrequent ED users. High-frequency ED users consisted of 51.6% women; medium-frequency ED users consisted of 57.9% women; infrequent ED users consisted of 52.7% women. The smaller health information exchange contained 10 hospitals and had 1,696,279 unique ED patients and 3,885,747 ED visits. The average number of total ED visits per patient was 2.27.

Main Results

Using data from the larger health information exchange, we identified 52,727 high-frequency ED users (1.4% of total larger health information exchange ED users) and 227,574 (6.2%) medium-frequency ED users (Table 2). The corresponding hospital-specific data for the larger health information exchange identified 44,079 (1.2%) high-frequency ED users and 192,541 (5.2%) medium-frequency ED users. With data from the smaller health information exchange, we identified 33,467 high-frequency

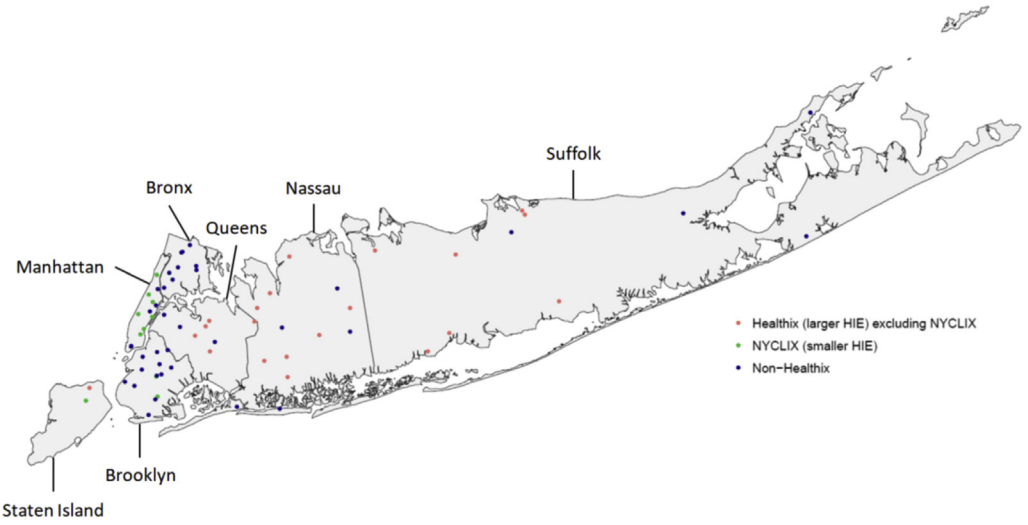

Figure 1. Geographic distribution of 31 EDs participating in the Healthix (larger health information exchange) in New York metropolitan area and Long Island, shown in green and red. Non-Healthix hospitals are shown in blue. *HIE*, Health information exchange.

ED users (2.0% of total smaller health information exchange ED users) and 109,497 (6.5%) medium-frequency ED users. When using hospital-specific data for the smaller health information exchange, we identified 30,057 (1.8%) high-frequency ED users and 100,014 (5.9%) medium-frequency ED users. The additional 21 hospitals that were not part of the original smaller health information exchange had 0.7% high-frequency ED users and 4.6% medium-frequency ED users. When the 10-hospital smaller health information exchange data were compared with the corresponding hospital-specific data, the increase in identification rate was 11.4% for high-frequency users ([33,467–30,057]/30,057), 9.5% for medium-frequency users, and 9.9% when medium- and high-frequency ED users were combined. When we compared the 31-hospital larger health information exchange data with the corresponding hospital-specific data, the increase in identification rate was 19.6% for-high frequency users ([52,727–44,079]/44,079), 18.2% for medium-frequency users, and 18.5% for medium- and high-frequency ED users. In expanding the comparison from the smaller health information exchange to the larger one, our ability to detect high- and medium-frequency users had an 8.2% absolute increase (72.9% relative increase) and an 8.7% absolute increase (92.0% relative increase), respectively.

Table 1. Number of ED visits and number of ED patients after each data-cleaning step.

Data Process Steps	No. of ED Visits	No. of ED Patients
Original data	12,671,590	4,668,872
Removed data because of Hurricane Sandy	12,478,965	4,630,390
Removed duplicates	11,441,591	4,630,390
Removed inpatient data	8,184,599	3,684,999

Figure 2 shows the number of patients in each frequency cohort as a function of total ED visits. The median of total ED visits during the study period from the larger health information exchange data set was as follows: infrequent=1 (95% confidence interval 1 to 5), medium frequency=7 (95% confidence interval 4 to 18), and high frequency=9 (95% confidence interval 4 to 56). During the study period, using data from the larger health information exchange, we were able to identify 404 patients with more than 100 ED visits and 42 patients with more than 300 ED visits, and the maximum number of ED visits by one patient was 987. However, there were no patients with more than 300 ED visits identified with hospital-specific data.

Figure 3 shows the number of patients in each frequency cohort as a function of total unique EDs visited. There were more crossover visits among high-frequency ED users. The number of patients who visited more than 10 EDs was 0 for infrequent ED users, 1 for medium-frequency ED users, and 135 for high-frequency ED users. There were 140 patients who visited more than 10 hospitals and 8 who visited more than 20 hospitals. The maximum number of hospitals visited by a patient was 29. The percentage of all the patients who visited more than one ED was 11.7%. The percentages of patients by frequency cohort who visited more than one ED were as follows: infrequent 9.3%, medium frequency 40.4%, and high frequency 44.9%.

Figure 4 highlights how the percentages of high- and medium-frequency ED users increased as the health

Table 2. Comparing the larger health information exchange and the smaller one with its corresponding hospital-specific data.*

	Smaller HIE vs Hospital-Specific Data			Larger HIE vs Hospital-Specific Data			
	Smaller HIE (%)	Hospital Specific (%)	Increased Identification Rate From Hospital-Specific to Smaller HIE, %	Larger HIE (%)	Hospital Specific (%)	Increased Identification Rate From Hospital-Specific to Larger HIE, %	Relative Increase From Smaller HIE to Larger HIE, %
High-frequency users	33,467 (2.0)	30,057 (1.8)	11.4	52,727 (1.4)	44,079 (1.2)	19.6	72.9
Medium-frequency users	109,497 (6.5)	100,014 (5.9)	9.5	227,574 (6.2)	192,541 (5.2)	18.2	92.0
high- and medium-frequency users	142,964 (8.4)	130,071 (7.7)	9.9	280,301 (7.6)	236,620 (6.4)	18.5	86.3
Infrequent users	1,553,315 (91.6)	1,566,208 (92.3)		3,404,698 (92.4)	3,448,379 (93.6)		
Total no. of patients	1,696,279	1,696,279		3,684,999	3,684,999		
Total no. of visits	3,855,747	3,855,747		8,184,559	8,184,559		

*Increased identification rate was calculated as ([HIE users−hospital-specific users]/hospital-specific users)×100%.

information exchange size increased to more hospitals during the 50-iteration simulation. This figure does not show that the average percentages of high- and medium-frequency ED users reached a plateau, which means that there is no evidence of an optimal health information exchange size up to the 31 hospitals in the larger health information exchange. Figure 4 also shows that for smaller health information exchange size, the interquartile range is wide and there are many outliers. As we increased the health information exchange size, the interquartile range narrowed and the outliers disappeared.

LIMITATIONS

This study has several limitations. First, although the larger health information exchange contains 3 times more hospitals than the smaller one, there are still many hospitals in the New York metropolitan area and Long Island that do not participate and are not represented in our data set. This includes all of the city hospitals that are part of Health and Hospitals Corporation. The omission of nonparticipating sites could have led to an underestimation of high- and medium-frequency ED users in our analysis. Second, we removed all inpatient data and omitted any ED visits that resulted in admissions. This decision in data cleaning decreased our detected effect such that there were likely even more frequent ED visitors than we reported. Third, although high rates of crossover have been measured in other locations,[9,12] the frequent ED user results may not be generalizable to other regions, given different transportation systems and a high geographic density of

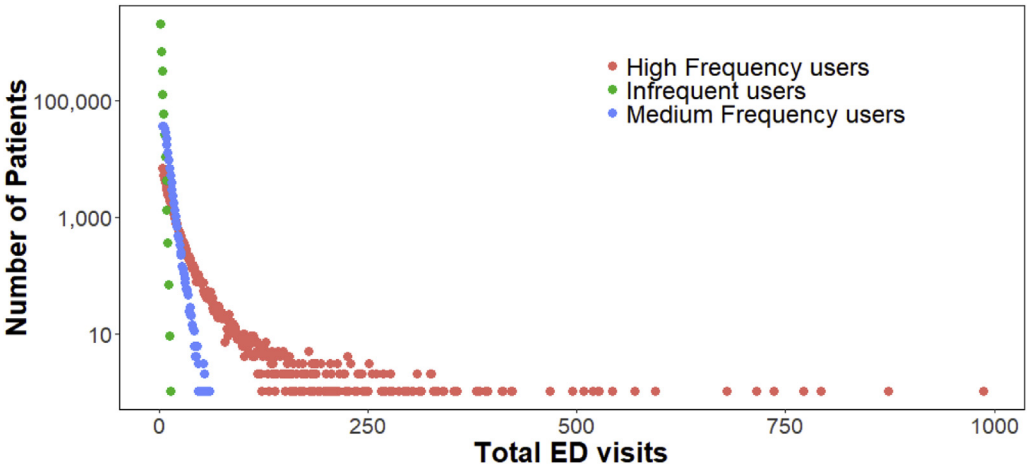

Figure 2. Distribution of patients in each frequency cohort as a function of total ED visits.

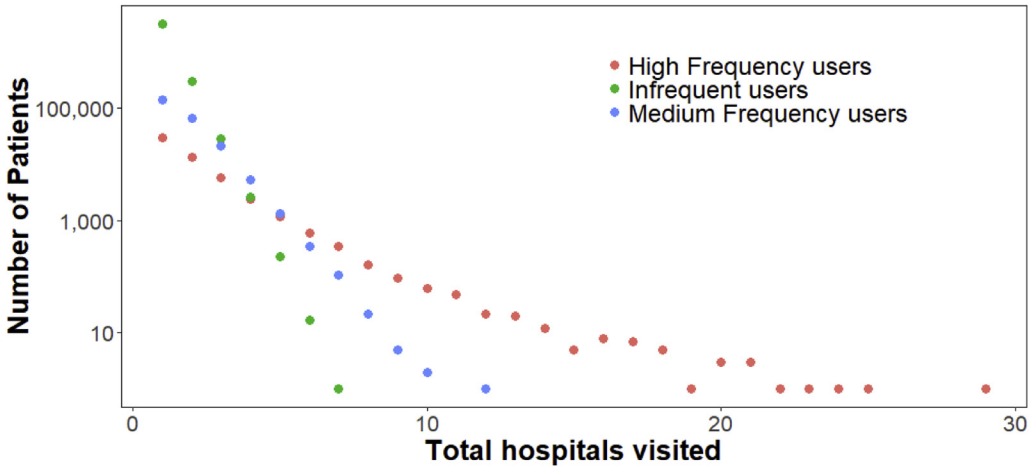

Figure 3. Distribution of patients in each frequency cohort as a function of total unique EDs visited.

patients and hospitals. This study is likely more pertinent to high-density metropolitan areas with robust public transportation systems. Fourth, there were limited patient- or site-level data available from the larger health information exchange to perform additional analyses or covariate adjustments, precluding further evaluation of patient characteristics by using diagnosis, medication, or insurance data, among others.

DISCUSSION

The results in Figures 2 and 3 show that medium- and high-frequency ED users not only have more total ED visits but also tend to seek care at multiple institutions more often than infrequent users. These data indicate that medium- and high-frequency users are more readily identified with a health information exchange–wide data set, and that such ED users might benefit more from health information exchange and health information exchange–enhanced services and quality measurement than infrequent ED users would.

When going from the smaller health information exchange to the larger one, the total numbers and identification rates of medium- and high-frequency ED users increased, but their percentages decreased. This is likely explained by a large difference in the percentages of medium- and high-frequency ED users between the 10 smaller health information exchange hospitals and the additional 21 hospitals in expanding to the larger health information exchange. The smaller health information exchange hospitals are more geographically concentrated in Manhattan compared with the additional 21 hospitals in the larger health information exchange, as demonstrated in Figure 1. Another possible explanation of why the percentages of medium- and high-frequency patients

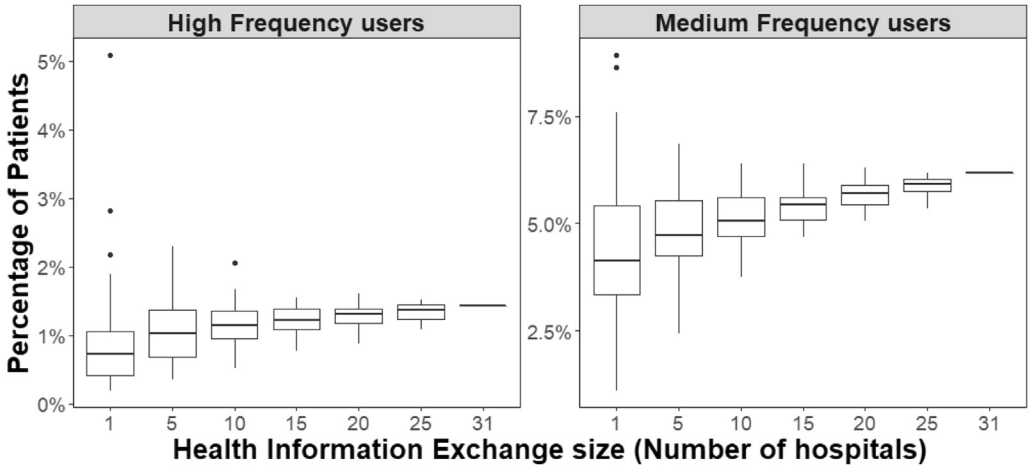

Figure 4. Simulation showing percentage of medium- and high-frequency ED users when health information exchange size was increased by increments of approximately 5 randomly chosen hospitals.

decreased in expanding from the smaller health information exchange to the larger one despite an increased identification rate could be that there is an optimal size for a health information exchange. We previously defined optimal size as the size of health information exchange beyond which any additional hospitals may yield minimal increase in the percentage of high- and medium-frequency ED users. Because medium- and high-frequency users are more likely to use multiple hospitals, adding hospitals may not identify more patients after a point. We could not determine whether an ideal health information exchange size exists by simply comparing the smaller health information exchange and the larger one, so we conducted a simulation with 50 iterations to determine the percentage of medium- and high-frequency ED users as a function of health information exchange size to minimize fluctuations from random sampling. The simulation results showed no optimal health information exchange size because Figure 4 does not show that the average percentages of medium- and high-frequency ED users reached a plateau. In addition, the wide interquartile ranges and multiple outliers in smaller health information exchange groups indicate a higher variability in identification rates of medium- and high-frequency users, and that smaller health information exchange size cannot reliably and effectively detect frequent ED users, as demonstrated by Figure 4. It is possible that the optimal number of hospitals for a health information exchange to be able to detect frequent users would vary according to characteristics such as size and geographic proximity of the health information exchange hospitals.

This analysis redemonstrates that frequent ED users tend to seek care at multiple institutions more often than other users.[19] It also suggests that medium- and high-frequency users may be different from infrequent users, at least in their use of EDs, and may uniquely benefit from health information exchange–enhanced interventions.

As health information exchanges expand the breadth and depth of patient-level data, future studies should further explore patient and visit characteristics for each frequency cohort to better understand the cause of frequent ED visits. When frequent ED users are identified without a concentration of visits to any one hospital, it raises the question of who should intervene (eg, emergency medical services, public health, individual hospitals) and what are proper methods of interventions, both of which are potential topics for future study. Additionally, work to consolidate and share data among the multiple health information exchanges in New York State may create opportunity to compare increasingly larger sizes of health information exchange and to further investigate whether an optimal size for health information exchange exists. Given the high rate of crossover visits for frequent ED users, a larger health information exchange size may further improve identification of frequent ED user characteristics so that we can better understand and develop clinical and social supports for these patients.

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Author affiliations: From the Icahn School of Medicine at Mount Sinai, New York, NY (Han, Lowry, Loo, Rabin, Shapiro); Weill Cornell Medical College, New York, NY (Grinspan, Kern); and New York–Presbyterian Hospital, New York, NY (Kuperman).

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