

INTRODUCTION

Despite a high level of spending, the US health care system is characterized by substandard quality and inefficiency. Hospitals, in particular, have been a target for change since approximately 45 percent of the health care budget is spent by hospitals. Hospitals are expected to apply strategies that reduce costs without the loss of quality. Hospital effectiveness is often measured by length of stay (LOS) and readmissions. While LOS and readmissions are being analyzed, policymakers recommend focusing greater amount of attention on the development of care processes for common conditions that afflict many people.

In this context, this study focuses on how to monitor process performance in LOS and readmissions by employing control charts for acute myocardial infarction (AMI) patients admitted to government hospitals in large metropolitan areas.



BACKGROUND

Length of Stay (LOS)

LOS is described as the duration of a single episode of hospitalization. When LOS is longer, patient experience, quality, and financial performance are negatively affected. Thus, to reduce costs and maximize capacity, hospitals must aim to reduce unnecessary and avoidable LOSs.

Readmissions

Readmissions refer to the number of patients who experience an unplanned return to the hospital after shortly being discharged. Readmissions are a measure of a hospital's quality of care. Low quality of care received during initial hospital stay, fragmented discharge planning, or inappropriate assessment of readiness for discharge may be reasons patients are shortly readmitted after discharge. Readmissions are also viewed as an area of potential cost savings as up to 75% of readmissions are preventable.

Statistical Process Control (SPC)

SPC involves inspecting a random sample of the output from a process and deciding whether the process is producing outcomes with characteristics that fall within a predetermined range. The most common tool for monitoring the process using SPC is a control chart constructed on time series analysis. Control charts allow for the visualization and analysis of a process over time.

MATERIALS & METHODS



Agency for Healthcare
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Data were abstracted from 2010 to 2016 from the Healthcare Cost and Utilization Project (HCUP) Nationwide Readmissions Database (NRD).

The study cohort consisted of AMI patients admitted to government hospitals in large metropolitan areas. Patients were excluded if they developed AMI secondary to another cause, died during initial hospitalization, or were admitted and discharged on the same day. Only patients discharged to home or self-care and with a median household income were considered. A total of 1,491 patients were examined.

Table 1. The number of patients between 2010 and 2016

	2010	2011	2012	2013	2014	2015	2016	Total
# of hospitalized	236	221	179	204	224	195	232	1,491
# of not readmitted	202	188	155	185	209	177	204	1,320
# of readmitted	34	33	24	19	15	18	28	171
Readmission rate (%)	14.41	14.93	13.41	9.31	6.70	9.23	12.07	11.47
Age, mean (SD)	65.85 (14.44)	62.11 (14.83)	63.65 (14.02)	62.88 (14.55)	63.85 (14.83)	64.09 (14.10)	64.16 (13.96)	63.83 (14.42)
Gender, female (%)	47.88	36.65	45.25	46.57	43.30	42.05	46.55	44.06
LOS, mean (SD)	3.16 (1.59)	3.24 (2.71)	2.780 (2.09)	2.73 (1.49)	2.74 (1.72)	2.54 (1.36)	2.67 (1.82)	2.85 (1.89)

Table 2. Descriptive statistics of variables

	Mean	Std Dev	Min	Max
Age	63.83	14.42	19	90
LOS (days)	2.85	1.89	1	28
Payer (%)				
	Medicare	Medicaid	Private	Other
	42.52	17.10	21.19	19.19
Gender (%)				
	Female	Male		
	44.06	55.94		
Teaching Status (%)				
	Teaching	Non-teaching		
	75.65	24.35		
LOS (%)				
	1-2 days	3-4 days	≥ 5 days	
	50.64	37.49	11.87	
Age (%)				
	18-59 yrs.	60-64 yrs.	Above 65 yrs.	
	40.17	13.28	46.55	

I-MR charts, which are control charts that monitor changes in the mean of a process, were used for monitoring LOS. For *I-MR* charts, data must be normally distributed. To achieve normality, rational subgroups were formed by calendar year, teaching status of hospitals, and gender of patient. In total, 28 rational subgroups were formed.

P charts are control charts that monitor the fraction nonconforming (defective) in samples of varying size. *P* charts were used to monitor 30-day readmission rates per month for each year.

RESULTS

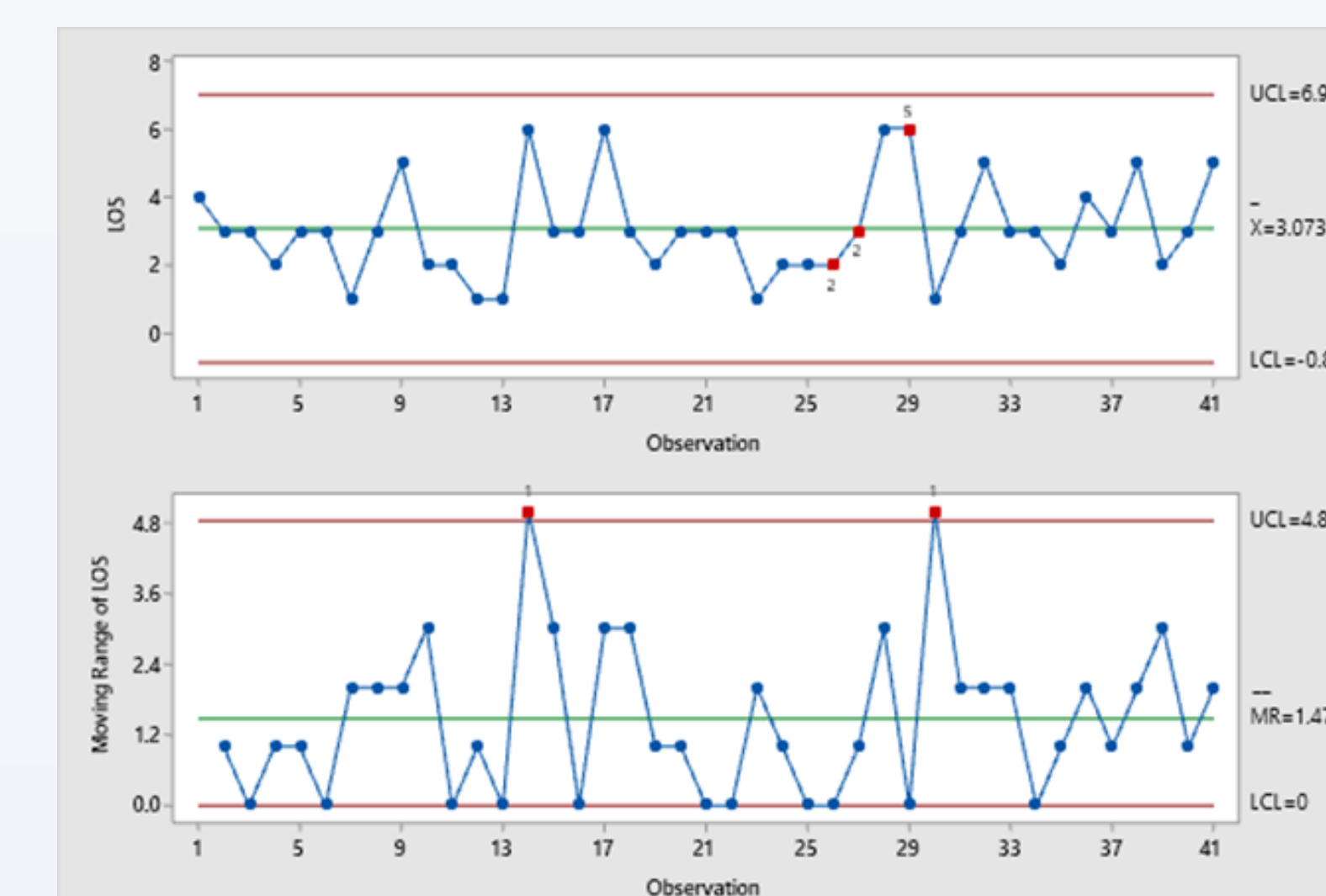


Figure 1. *I-MR* chart of LOS for male patients admitted to non-teaching hospitals in 2010.

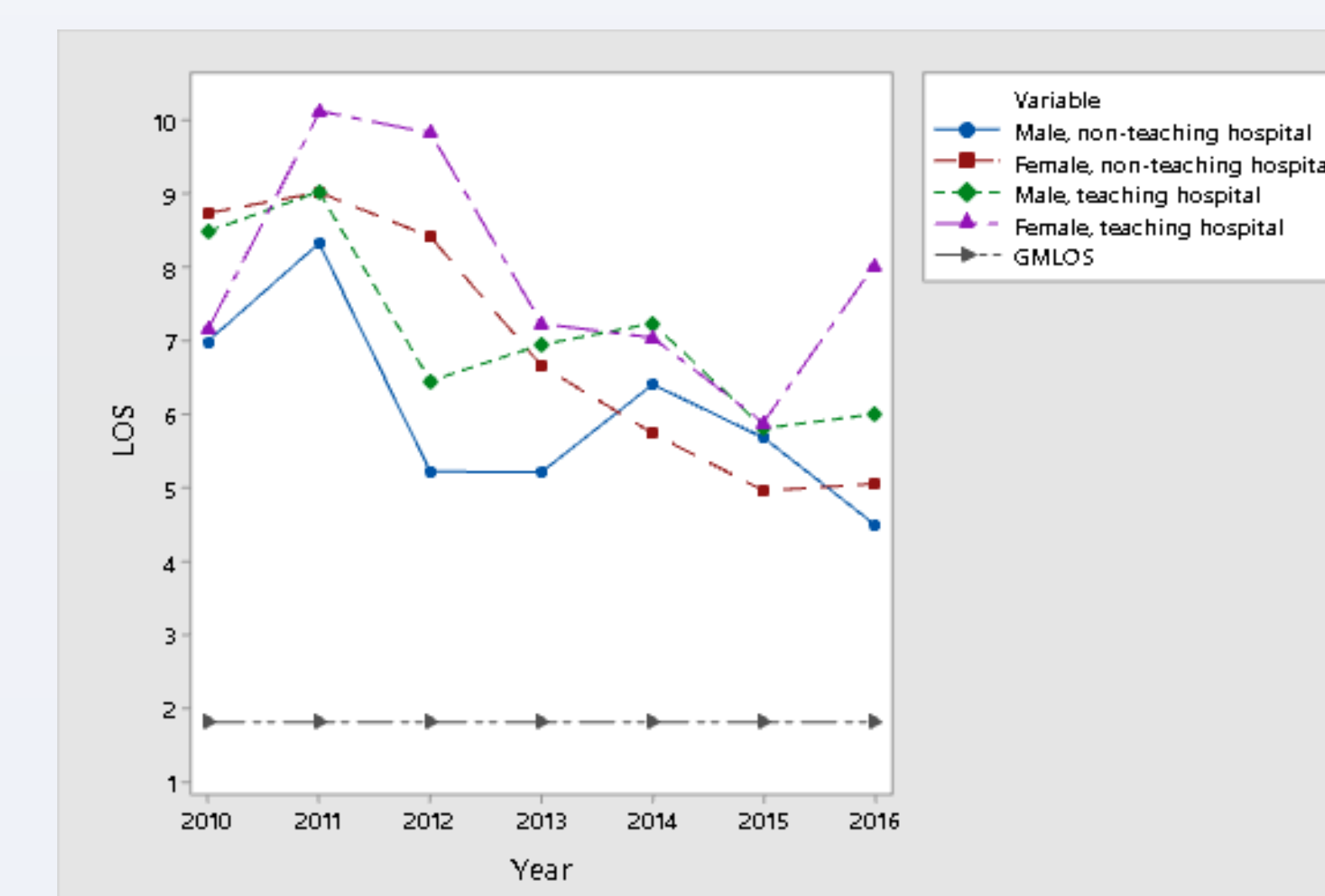


Figure 2. A patient's LOS as represented by *I* charts' UCLs from 2010 to 2016; the *I* charts' UCLs were calculated in *I-MR* charts.

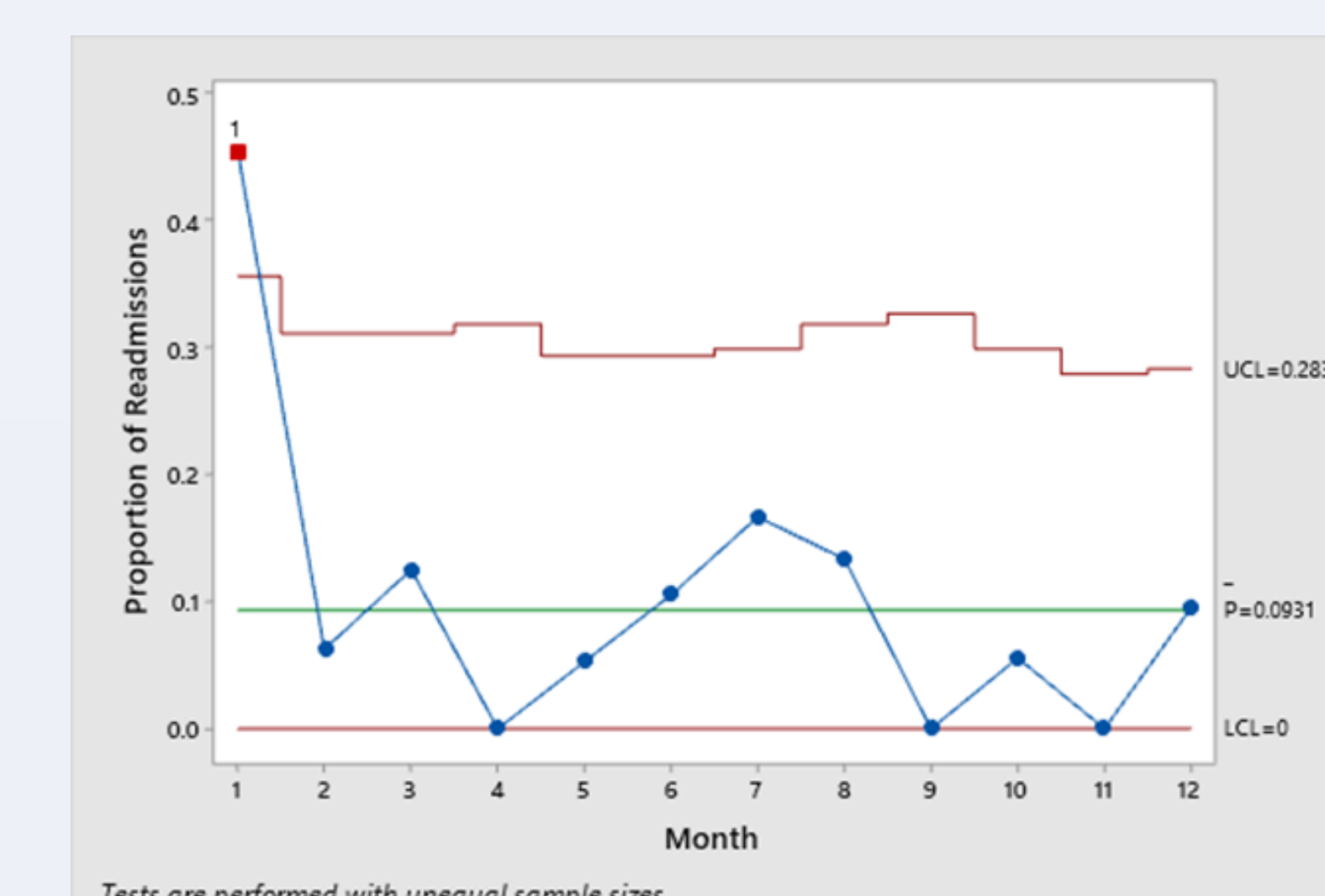


Figure 3. *P* chart based on the proportion of patients readmitted to a hospital within 30-days of discharge from index hospitalization in 2013.

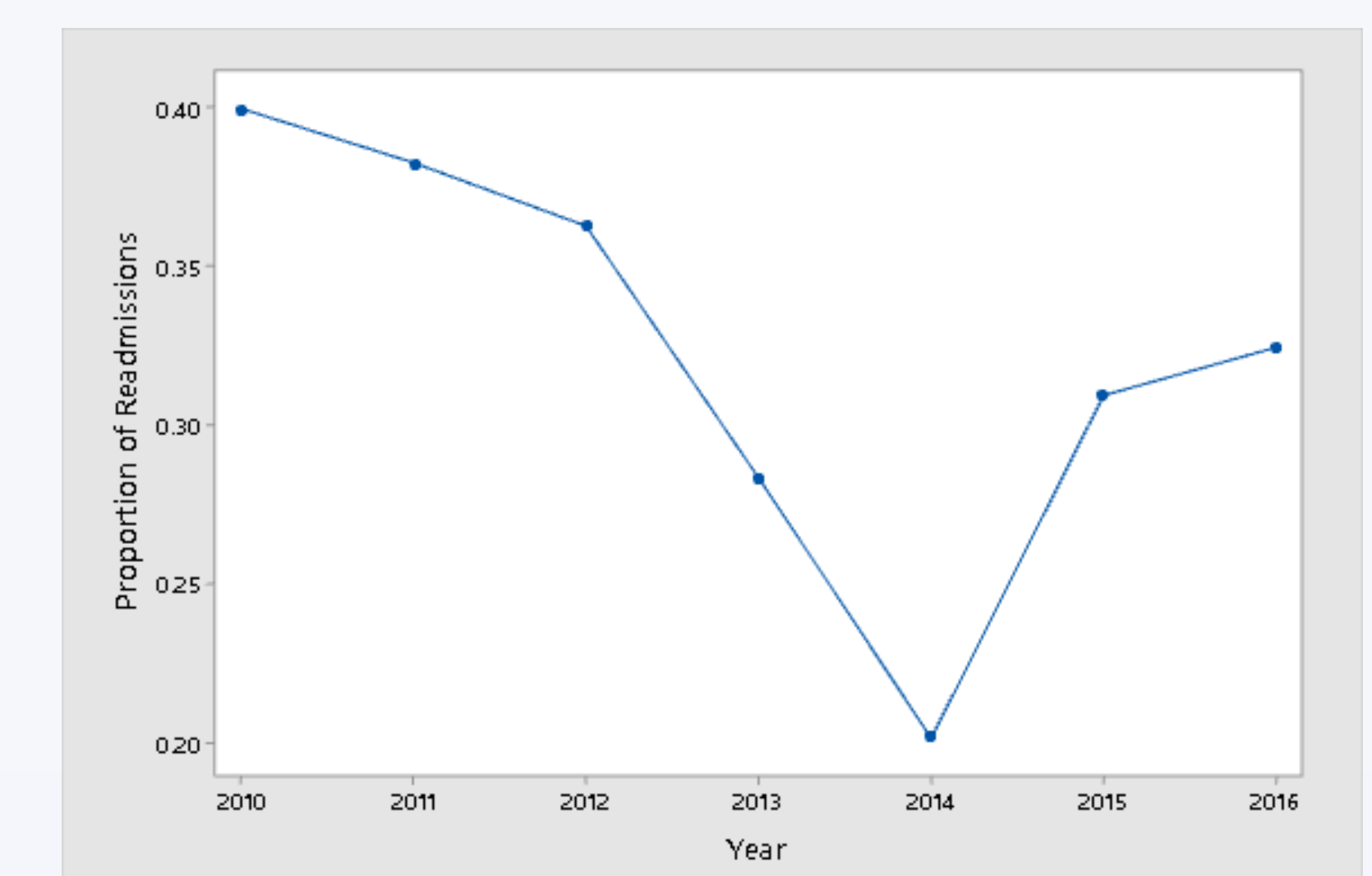


Figure 4. The proportion of 30-day readmissions as represented by the UCLs in the *P* charts from 2010 to 2016.

CONCLUSIONS

SPC and control charts can help healthcare providers and decision makers monitor and assess the healthcare delivery process over time. As the process is being monitored over time, control charts can detect assignable causes of variation. Once assignable causes are detected, healthcare providers and decision makers can identify the root causes of quality and process problems. An analysis of the root causes can help guide decisions about where improvement efforts should be focused. Next, healthcare providers and decision makers can develop and implement the appropriate corrective action to eliminate the quality and process problems. Control charts can verify whether changes made to the process resulted in improvement. If corrective action resulted in improvement, then the variation should be reduced, and the process should be in control in the control charts.

The application of SPC and control charts can facilitate improved decision making in healthcare organizations. Moreover, the application of SPC and control charts can drive continuous improvement in quality and productivity in healthcare organizations.

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