Cardiac telemetry, designed to monitor hospitalized patients with active cardiac conditions, is highly utilized outside the intensive care unit (ICU) and generates a large number of automated alarms. Telemetry is also costly and requires substantial time and attention commitments from nursing and technician staff, who place and maintain the recording devices and address monitoring results.1,2 The staff address and dismiss invalid alarms caused by telemetry artifacts, such as misreporting of patient movement as ventricular tachycardia/fibrillation (VT/VF) or the mimicking of asystole by a lead disconnection.

One strategy for addressing telemetry alarms is to have dedicated staff observe telemetry monitors and notify nurses with any events or findings. Studies conducted in the 1990s showed that dedicated monitor watchers, compared with automatically generated alarms alone, did not affect most outcomes but can improve accuracy of arrhythmia detection.3 Since then, given the advances in telemetry detection software, the effect of monitor watchers has not been evaluated. Mindful of the perceived burden of nonactionable telemetry alerts, we wanted to quantify the frequency of automated telemetry alerts in the wards and analyze the proportion of alerts deemed nonactionable by monitor watchers.

**METHODS**

We conducted this retrospective study at a 545-bed urban academic hospital in the United States. We reviewed the cases of all non-ICU patients with telemetry monitoring ordered. The telemetry order requires providers to specify the indication for monitoring and adjust alert parameters for variables such as heart rate (preset to 60 and 100 beats per minute) and baseline rhythm (preset to normal sinus). Once a telemetry order is received, 5 leads are attached to the patient, and electrocardiographic data begin transmitting to a portable wireless telemetry monitor, or telemeter (Philips Intellispace Telemetry System), which in turn transmits to a central monitoring station in the progressive care unit (PCU; cardiac/pulmonary unit). The majority of patients on telemetry are in the PCU. Telemeters are also located in the general medicine, surgical, and neurologic non-ICU units. Data from a maximum of 96 telemeters in the hospital are simultaneously displayed in the central monitoring station.

At all times, two dedicated monitor watchers oversee the central monitoring station. Watchers are certified medical assistants with extra telemetry-specific training. Each receives a salary of $17 per hour (no benefits), or about $800 per 24-hour day for two watchers. Their role is to respond to audiovisual alerts triggered by the monitoring system—they either contact the bedside nurse or intercept the alert if deemed nonactionable. Consistent with the literature, nonactionable alerts and alarms were defined as either “invalid” or “nuisance.” Invalid alerts and alarms misrepresent patient status (eg, patient motion is electronically interpreted as VT/VF), and nuisance alerts and alarms do not require clinical intervention (eg, persistent sinus tachycardia has already been communicated to the nurse or provider). Monitor watchers must intercept the alert within a limited amount of time: 15 seconds for suspected lethal alerts (asystole, VT/VF), 30 seconds for extreme tachycardia/bradycardia, and 60 seconds for lead displacement or low battery.

If a watcher does not intercept an alert—either intention-
ally or because time ran out—the alert generates an alarm, which automatically sends a text message to the patient’s nurse’s wireless phone. The nurse acknowledges the alarm and decides on further action. If the bedside nurse does not acknowledge the alarm within the same time frames as mentioned, the alarm is escalated, first to the unit charge nurse and then to the monitoring station charge nurse (Figure). All alerts are available for provider review at the central monitoring station for the duration of the telemetry order, and select telemetry strips are printed and filed in the patient’s paper chart.

For this study, we analyzed telemetry system data for all monitored non-ICU ward patients from August 1 through September 30, 2014. We focused on the rate and relevance of alerts (system-generated) and alarms (text message to nurse). As cardiac arrhythmias leading to cardiopulmonary arrest can potentially be detected by telemetry, we also reviewed all code team activations, which are recorded in a separate database that details time of code team activation, to evaluate for correlation with telemetry alerts.

RESULTS
Within the 2-month study period, there were 1917 admissions to, and 1370 transfers to, non-ICU floors, for a total of 3287 unique patient-admissions and 9704 total patient-days. There were 1199 patient admissions with telemetry orders (36.5% of all admissions), 4044 total patient-days of telemetry, and an average of 66.3 patients monitored per day. In addition, the system generated 20,775 alerts, an average of 341 per day, 5.1 per patient-day, 1 every 4 minutes. Overall, 18,051 alerts (87%) were intercepted by monitor watchers, preventing nurse text-alarms. Of all alerts, 91% were from patients on medicine services, including pulmonary and cardiology; 6% were from patients on the neurology floor; and 3% were from patients on the surgery floor.

Fourty percent of all alerts were for heart rates deviating outside the ranges set by the provider; of these, the overwhelming majority were intercepted as nuisance alerts (Table). In addition, 26% of all alerts were for maintenance reasons, including issues with batteries or leads. Finally, 34% (6954) were suspected lethal alerts (asystole, VT/VF); of these, 74% (5170) were intercepted by monitor watchers, suggesting they were deemed invalid. None of the suspected lethal alerts triggered a code team activation, indicating there were no telemetry-documented asystole or VT/VF episodes prompting resuscitative efforts. During the study period, there were 7 code team activations. Of the 7 patients, 2 were on telemetry, and their code team activation was for hypoxia detected by pulse oximetry; the other 5 patients, not on telemetry, were found unresponsive or apneic, and 4 of them had confirmed pulseless electrical activity.

DISCUSSION
In small studies, other investigators have directly observed nurses for hours at a time and assessed their response to telemetry-related alarms.1,2 In the present study, we found a very large number of telemetry-detected alerts over a continuous 2-month period. The large majority (87%) of alerts were manually intercepted by monitor watchers before being communicated to a nurse or provider, indicating these alerts did not affect clinical management and likely were either false positives or nonactionable. It is possible that repeat nonactionable alerts, like continued sinus tachycardia or bradycardia, affect decision making, but this may be outside the role of continuous cardiac telemetry. In addition, it is likely that all the lethal alarms (asystole, VT/VF) forwarded to the nurses were invalid, as none resulted in code team activations.

Addressing these alerts is a major issue, as frequent telemetry alarms can lead to alarm fatigue, a widely acknowledged

### TABLE. Frequency of Alerts by Type and Proportion Being Intercepted by Monitor Watchers

<table>
<thead>
<tr>
<th>Alert Type</th>
<th>Alerts n</th>
<th>%</th>
<th>Intercepted Alerts n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asystole</td>
<td>2818</td>
<td>14</td>
<td>1945</td>
<td>76</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>3638</td>
<td>18</td>
<td>2849</td>
<td>78</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>498</td>
<td>2</td>
<td>376</td>
<td>77</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>7477</td>
<td>36</td>
<td>7215</td>
<td>90</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>898</td>
<td>4</td>
<td>881</td>
<td>92</td>
</tr>
<tr>
<td>Leads off</td>
<td>5032</td>
<td>24</td>
<td>4537</td>
<td>79</td>
</tr>
<tr>
<td>Battery</td>
<td>414</td>
<td>2</td>
<td>248</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>20,775</td>
<td>100</td>
<td>18,051</td>
<td>87</td>
</tr>
</tbody>
</table>

**NOTE:** Alert or alarm must be intercepted or acknowledged within described time limits to prevent escalation. Abbreviations: CN, charge registered nurse; RN, registered nurse.
safety concern. Furthermore, nonactionable alarms are a time sink, diverting nursing attention from other patient care needs. Finally, nonactionable alarms, especially invalid alarms, can lead to adverse patient outcomes. Although we did not specifically evaluate for harm, an earlier case series found a potential for unnecessary interventions and device implantation as a result of reporting artifactual arrhythmias.  

Our results also highlight the role of monitor watchers in intercepting nonactionable alarms and reducing the alarm burden on nurses. Other investigators have reported on computerized paging systems that directly alert only nurses, or on escalated alarm paging systems that let noncrisis alarms self-resolve. In contrast, our study used a hybrid 2-step telemetry-monitoring system—an escalated paging system designed to be sensitive and less likely than human monitoring to overlook events, followed by dedicated monitor watchers who are first-responders for a large number of alarms and who increase the specificity of alarms by screening for nonactionable alarms, thereby reducing the number of alarms transmitted to nurses. We think that, for most hospitals, monitor watchers are cost-effective, as their hourly wage is lower than that of registered nurses. Furthermore, monitor watchers can screen alerts faster because they are always at the monitoring station. Their presence reduces the amount of time that nurses need to divert from other clinical tasks in order to walk to the monitoring station to evaluate alerts. 

Nonetheless, there remains a large number of nonactionable alerts forwarded as alarms to nurses, likely because of monitor watchers’ inability to address the multitude of alerts, and perhaps because of alarm fatigue. Although this study showed the utility of monitor watchers in decreasing telemetry alarms to nurses, other steps can be taken to reduce telemetry alarm fatigue. A systematic review of alarm frequency interventions noted that detection algorithms can be improved to decrease telemetry alarm false positives. Another solution, likely easier to implement, is to encourage appropriate alterations in telemetry alarm parameters, which can decrease the alarm proportion. An essential step is to decrease inappropriate telemetry use regarding the indication for and duration of monitoring, as emphasized by the Choosing Wisely campaign championing American Heart Association (AHA) guidelines for appropriate telemetry use. At our institution, 20.2% of telemetry orders were for indications outside AHA guidelines, and that percentage likely is an underestimate, as this was reported in a self-reporting order. Telemetry may not frequently result in changes in management in the non-ICU setting, and may lead to other harms such as worsening delirium, so it needs to be evaluated for harm versus benefit per patient before order. 

Cardiac telemetry in the non-ICU setting produces a large number of alerts and alarms. The vast majority are not seen or addressed by nurses or physicians, leading to a negligible impact on patient care decisions. Monitor watchers reduce the nursing burden in dealing with telemetry alerts, but we emphasize the need to take additional measures to reduce telemetry-related alarms and thereby reduce alarm-related harms and alarm fatigue. 

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References