

# A Survey of Nursing Home Physicians to Determine Laboratory Monitoring Adverse Drug Event Alert Preferences

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## Keywords

Nursing homes, therapeutic drug monitoring, clinical decision support systems, adverse drug event

## Summary

**Objective:** We conducted a survey of nursing home physicians to learn about (1) the laboratory value thresholds that clinical event monitors should use to generate alerts about potential adverse drug events (ADEs); (2) the specific information to be included in the alerts; and (3) the communication modality that should be used for communicating them.

**Methods:** Nursing home physician attendees of the 2010 Conference of AMDA: The Society for Post-Acute and Long-Term Care Medicine.

**Results:** A total of 800 surveys were distributed; 565 completed surveys were returned and seven surveys were excluded due to inability to verify that the respondents were physicians (a 70% net valid response rate). Alerting threshold preferences were identified for eight laboratory tests. For example, the majority of respondents selected thresholds of  $\geq 5.5$  mEq/L for hyperkalemia (63%) and  $\leq 3.5$  without symptoms for hypokalemia (54%). The majority of surveyed physicians thought alerts should include the complete active medication list, current vital signs, previous value of the triggering lab, medication change in the past 30 days, and medication allergies. Most surveyed physicians felt the best way to communicate an ADE alert was by direct phone/voice communication (64%), followed by email to a mobile device (59%).

**Conclusions:** This survey of nursing home physicians suggests that the majority prefer alerting thresholds that would generally lead to fewer alerts than if widely accepted standardized laboratory ranges were used. It also suggests a subset of information items to include in alerts, and the physicians' preferred communication modalities. This information might improve the acceptance of clinical event monitoring systems to detect ADEs in the nursing home setting.

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## 1. Introduction

Drug-related injury is a common and costly problem among patients in the nursing home (NH) setting. These adverse drug events (ADEs) [1] are associated with an estimated 93,000 deaths annually and as much as \$4 billion of excess healthcare expenditures [2–4]. As many as half of ADEs are the result of preventable errors occurring in the medication use process (e.g., prescribing, order communication, dispensing, administration, and monitoring) [4]. Data about preventable ADEs in NHs suggest that most (70–80%) are associated with monitoring errors which include inadequate laboratory evaluation of drug therapies or delayed/failed responses to signs or symptoms of drug toxicity [5, 6].

Medication monitoring by clinicians in the NH setting is difficult because NH patients are typically older, have greater medical comorbidity, are prescribed more medications, and suffer from greater functional and cognitive impairment than their community-dwelling counterparts [7, 8]. An additional challenge is that the NH healthcare workforce is generally understaffed and staff turnover rates are high [9–12]. Interventions that leverage informatics show promise for overcoming these obstacles. Of particular interest are *clinical event monitors* - systems that can detect ADEs by processing signals generated from laboratory test results and pharmacy orders [13–15]. In hospital and ambulatory care settings, these systems have been shown to prevent the development, progression, or mitigate the seriousness of ADEs by promoting the early detection of adverse events and an appropriate response [16–22]. Evidence from other care settings suggests that clinical event monitors might be particularly effective in the NH setting because that they can identify ADEs missed by clinicians more quickly and inexpensively than methods such as voluntary reporting (i.e., incident reports), direct observation of medication passes, and retrospective chart review [15, 23–27].

Although most NH facilities have yet to fully implement health information technology (HIT), [28] the majority generate laboratory, pharmacy, and Minimum Data Set [29] data in electronic format that can be used to build a clinical event monitoring system. However, careful research is necessary to ensure that the new systems have a positive impact on quality of care and do not result in operational inefficiencies such as alert burden and fatigue that have previously been identified as barriers to NH HIT interventions [30–32]. To this end, our investigative team determined a list of consensus-based triggers and tested their positive predictive values using a prototype clinical event monitoring system [33–35].

To translate the prototype system into production, we needed additional information to develop alerts that would be perceived specifically by NH physicians as clinically relevant, actionable, and communicated in a way that was consistent with their clinical workflow. The objective of this study was to survey NH physicians to better understand

1. the laboratory value thresholds that should be used to generate alerts about potential ADEs;
2. the specific information to be included in the alerts; and
3. physician's preference for communicating the alerts.

## 2. Methods

### 2.1 Participants

Eligible participants included all 1,061 NH physician attendees of the 2010 Conference of AMDA: The Society for Post-Acute and Long-Term Care Medicine, held in Long Beach, California. Physicians were selected as the target audience based on their medical-legal responsibility for all medication prescribing and responding to ADEs in the NH setting.

### 2.2 Survey Development

We developed a multi-component paper survey iteratively with input from our health professional co-investigators. The final survey was tested prior to distribution by co-investigators and an additional eight geriatricians within the Division of Geriatric Medicine at the University of Pittsburgh who provide care in the NH setting. It is provided as supplemental data.

### 2.2.1 Laboratory Value Thresholds

In the laboratory value thresholds component of the survey, physicians were asked to respond to eight questions. The 8 lab studies were selected based on our prior research where they met any of the following criteria:

1. reached the highest degree of consensus agreement that if present that it is likely caused by an ADE [33];
2. had excellent positive predictive validity for the detection of ADEs [35]; or
3. if the laboratory study was abnormal, a clinical intervention could be carried out to mitigate it (i.e., they were actionable).

For each question, the physicians surveyed were to keep in mind that their responses were to be based on the laboratory and pharmacy data associated with a hypothetical 85-year-old NH resident who had been taking all medications for at least three months at the current dose (i.e., achieved steady state). The resident's baseline labs were normal, and there were no previous ADEs, and/or drug-drug interactions. The respondents were asked to elect the single best abnormal laboratory value threshold at which the clinical event monitoring system should generate an alert about a potential ADE.

The laboratory/medication combinations included chemistry tests (drug-induced hyperkalemia, hypokalemia, hyponatremia, hypoglycemia, hypertransaminasemia, and acute kidney injury as indicated by high serum creatinine) as well as hematology tests (thrombocytopenia and elevated International Normalized Ratio (INR)). Each of the laboratory value response options and thresholds were derived from a variety of review articles, consensus statements and professional society white papers [36–46]. If there was disagreement across the aforementioned references, we used the Common Terminology Criteria for Adverse Events (CTCAE) developed and maintained by the National Cancer Institute [45]. These resources provided laboratory reference ranges that lie between the upper and lower limits constituting 95% of all values determined on a defined population of healthy individuals from all clinical settings.

### 2.2.2 Information to be Included in the Alerts

The goal of this part of the survey was to identify the information items that should be provided to physicians so that they would require no additional information or communication with the NH prior to responding to an ADE alert. Nineteen questions listed a patient- or facility-specific information item such as: admission/readmission date, active medication regimen, vital signs, allergy information, laboratory data preceding the alert, and history of same/similar ADE. For each question, the physician was presented with five response options ranging from “Strongly Disagree” to “Strongly Agree.”

### 2.2.3 Preference for Communication Modality for Alerts

In this part of the survey, physicians were asked to respond to six questions indicating their degree of agreement that a particular communication modality was the best way to communicate an ADE alert in real-time without disrupting the physician's work-flow. The communication modalities included: alphanumeric pager, direct phone/voice communication, email accessible from a personal computer, email accessible from a smartphone, electronic medical record system, and fax machine. For each of these questions, the physician was presented with five response options ranging from “Strongly Disagree” to “Strongly Agree.” There were no open-ended response options provided throughout the survey.

## 2.3 Survey Distribution

Following University of Pittsburgh institutional review board approval, the survey was distributed at the 2010 AMDA conference to a total of 800 physicians. Respondents who returned a completed survey by the end of the conference were given a complimentary AMDA-endorsed Clinical Practice Guideline worth approximately \$15.

## 2.4 Data analysis

Completed surveys were manually transferred using dual data entry from paper to a Microsoft® ACCESS database for analysis. We used frequencies and percentages to summarize survey responses and bar charts for graphical summarization. SAS® version 9.2 (SAS Institute, Inc., Cary, NC) was used for all statistical analyses.

## 3. Results

### 3.1 Survey Participants

A total of 800 surveys were distributed; 565 completed surveys were returned and seven surveys were excluded due to inability to verify that the respondents were physicians (a 70% net valid response rate). The majority (89%) of surveyed physicians provided medical direction in at least one NH. As ► Table 1 shows, most were male (69%) and doctors of allopathic medicine (90%), the majority completed an internal medicine residency program (56%), approximately one-third (34%) completed a fellowship in geriatric medicine, and almost half had been practicing clinical medicine for >20 years (46%). Most (57%) reported spending at least 25% of their clinical time providing care in the NH. Seven respondents indicated that they did not provide care in any NH. These observations were retained because, as medical directors, these individuals would still be responsible for setting institutional policies and procedures.

### 3.2 Laboratory Value Thresholds

► Figure 1 shows the percentage of NH physicians surveyed who prefer to be notified about a potential ADE by a clinical event monitoring system at a given laboratory threshold for the eight laboratory tests. For the chemistry lab tests, the majority of respondents selected thresholds of  $\geq 5.5$  mEq/L for hyperkalemia (a combined 63%) and  $\leq 3.5$  without symptoms for hypokalemia (54%). Seventy percent of respondents selected  $\leq 130$  mEq/L as the threshold for hyponatremia. For hypoglycemia, the two most commonly selected thresholds were  $\leq 55$  mg/dL and  $\leq 70$  mg/dL by 40% and 55% of respondents, respectively. The threshold selected for serum creatinine by the majority of respondents (70%) was an increase of  $>0.3$  mg/dL or a 1.5 to 2-fold increase in serum creatinine. For transaminasemia, 61% of physicians selected a threshold of  $\geq 3$  times the upper limit of normal. For the hematology tests, the majority of respondents selected thresholds  $>3.3$  for INR (a combined percentage of 54%) and  $\leq 75 \times 10^9/L$  as the platelet count threshold for thrombocytopenia (56%).

### 3.3 Information to be Included in the Alerts

► Figure 2 shows the distribution of physician preferences on information items to be included with a drug/lab ADE alert. While general agreement (i.e., more than 50% of physicians agreed or strongly agreed) was indicated for the inclusion of all surveyed items, strong agreement by the majority of surveyed physicians was found for showing the complete active medication list, current vital signs, previous value of the triggering lab to the value that triggered the alert, medication change in the past 30 days, and medication allergies. At least one-fifth of physicians were ambivalent about the inclusion of complete prescribing information, last 7 days food intake, and a pain assessment. The survey included an open-ended question soliciting “other information that should be included in the alert.” Several themes emerged from the respondents including:

1. clarification of the patient’s advanced directives or code status;
2. listing who the ordering clinician was;
3. stating the reason or indication as to why the lab test was ordered; and
4. the signs or symptoms associated with the laboratory abnormality (e.g., fall, bleeding, mental status changes).

### 3.4 Preference for Communication Modality for Alerts

The communication modality that most of the surveyed physicians agreed or strongly agreed would be the best way to communicate an ADE alert was direct phone/voice communication (64%), followed by email to a mobile device (59%), an electronic medical record system (53%), fax machine (52%), alphanumeric pager (52%), and email accessible from a personal computer (43%).

## 4. Discussion

To the best of our knowledge, this is the first survey of laboratory thresholds for ADE alerting among generally highly experienced NH physicians. A strength of this study is that it provides guidance on the optimal thresholds, alert content, and communication preference for a care setting that is relatively understudied in spite of the large number of patients at risk for adverse events.

An important finding is that, for all but one of the laboratory tests (hypokalemia), the majority of NH physicians prefer alerting thresholds that would generally lead to fewer alerts than if widely accepted standardized laboratory ranges (SLRs) were used [47]. The clinicians' preferred thresholds reflect intuitive estimates that might reduce false positive results and hence alert fatigue. However, further work is needed to establish the actual sensitivity, specificity, and positive predictive value of these alert thresholds when used in clinical practice. We are currently testing a system that uses the modal-selected thresholds chosen here (► Figure 1) for all of the laboratory tests except for INR. Although the majority of respondents wanted the INR threshold for notification to be  $>3$ , our research group decided to use a higher cut-off  $\geq 4.5$ . This higher level was selected primarily because recent evidence suggests that levels  $\geq 4.5$  are associated with increased risk of serious bleeding events and the American College of CHEST physician consensus guidelines provide specific recommendations using an INR cut-point of  $\geq 4.5$  as actionable [48].

Another important finding is that NH physicians strongly agree that five information items should be included in any laboratory ADE alert – complete active medication list, current vital signs, previous value of the triggering lab to value that triggered the alert, medication change in the past 30 days, and medication allergies. While there was strong agreement on other information items, these five reflect standard information needs that NH physicians have when reviewing an ADE alert that future clinical event monitors designed for the NH setting should address.

It is noteworthy that, of the six communication modalities, direct phone/voice communication and email to a mobile device were indicated by a greater proportion of NH physicians as the best ways to communicate an ADE alert. This finding suggests that alert communication by mobile device might be broadly accepted by NH physicians. The finding also is concordant with recent evidence that providing clinical event monitor alerts within the context of an electronic charting or order entry system is less likely to improve process or outcome measures [49]. Future work should explore if communication modality preference is influenced by age, gender, or other factors.

We previously reported that the proportion of physicians who use mobile devices to assist with prescribing is 42% [50], which is a rate lower than reported in other clinical environments [51]. However, it is likely that the rate of mobile device use with prescribing has increased since the survey was conducted. Further research is needed to better characterize the facilitators and barriers to adoption of technology in the NH and its precise impact on NH ADEs. The design of the alerts, workflow changes, and impact on ADEs will be reported in a separate publication.

A potential limitation of this study is that it was a descriptive cross-sectional survey of physicians sampled by convenience at a national conference. A high proportion of the NH physicians attending the AMDA Annual Symposium participated. However, they might not be representative of NH physicians in general. Other types of clinicians that prescribe (e.g., nurse practitioners or physician assistants), make prescribing recommendations (e.g., consultant pharmacists), or administer medications (e.g., nurses and medication technicians) were not included in this survey.

Another potential limitation is that, with the exception of acute kidney injury, the survey did not explore lab value *changes* that would be of concern to NH physicians. Future work should seek to fill in this knowledge gap and identify methods for tailoring laboratory alert triggering thresholds to specific clinical contexts. For example, acute kidney injury alerts for patients on hemodialysis might

be more acceptable if they fired less frequently to account for expected weekly variations. A decision rule refinement approach similar to that used by Boussadi *et al.* to customize rules for medication dosage based on renal function thresholds might be applicable [52].

An alternate approach to probing physician's desired information items would have been to ask participants to rank the items rather than consider them independently. While this approach might have led to a more concise list of preferred information items, we thought it would be difficult for participants to rank nineteen information items.

## 5. Conclusions

This survey of nursing home physicians suggests that the majority prefer alerting thresholds that would generally lead to fewer alerts than if widely accepted standardized laboratory ranges were used. It also suggests a subset of information items to include in alerts, and the physicians' preferred communication modalities. This information might improve the acceptance of clinical event monitoring systems to detect ADEs in the nursing home setting.

### Clinical Relevance Statement:

Adverse drug events are particularly common among older nursing home residents. Clinical event monitoring systems that automate the detection and management of these events in this particularly vulnerable population might be particularly effective. This manuscript reports on an approach to involve physicians who practice in the nursing home in the development of a clinical event monitoring system. We anticipate that this approach should lead to increased acceptance, use and satisfaction associated with adverse drug event alerts generated by a laboratory-value based clinical event monitoring system .

### Conflict of Interest

The authors declare that they have no conflicts of interest in the research

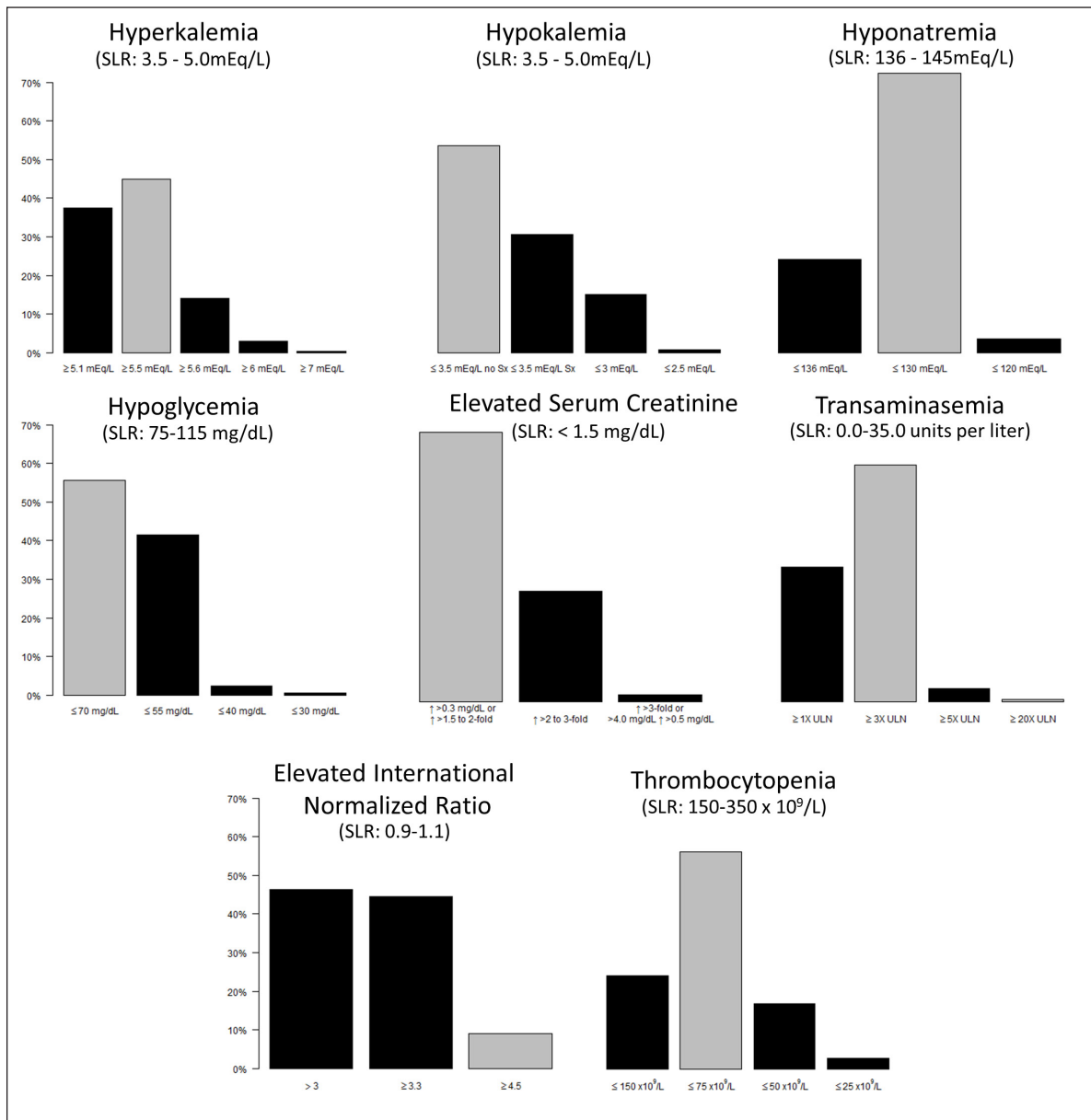
### Human Subjects Protections

Ethics approval was provided by the University of Pittsburgh Institutional Review Board.

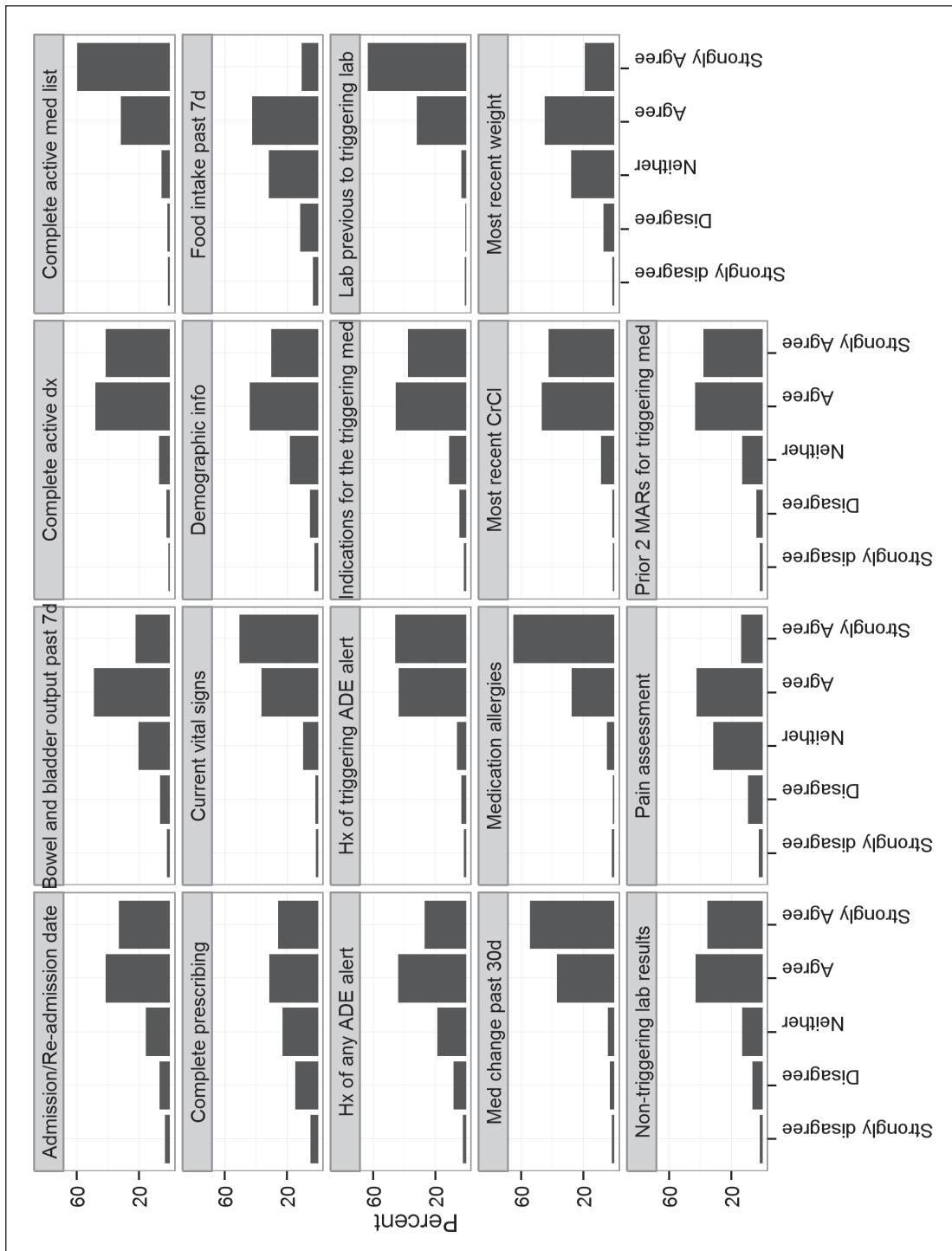
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**Fig. 1** The percentage of nursing home physicians surveyed who prefer to be notified about a potential adverse drug event by an active medication monitoring system at a given laboratory threshold. Standardized laboratory ranges (SLRs) are shown for those laboratory test if they were reported in a widely cited reference [47]. The gray bars show the threshold chosen for use in a clinical event monitoring system being tested in five nursing homes (see Discussion). ULN – upper limit of normal.



**Fig. 2** Physician preferences on information items to be included with a drug/lab ADE alert. Abbreviations: d – days, dx – diagnosis, med – medication, info – information, Hx – history, lab – laboratory result, CrCl – creatinine clearance, MAR – medication administration record.



**Table 1** Physician and Practice Characteristics of Survey Respondents

| Characteristic                                       | No. | %   |
|--|-----|-----|
| <b>Gender</b>  |     |     |
| Male   | 384 | 69% |
| Female   | 172 | 31% |
| No Response  | 2   | <1% |
| <b>Medical School Training</b>                       |     |     |
| Allopathic physicians (MD)                           | 504 | 90% |
| Osteopathic physicians (DO)                          | 44  | 8%  |
| Unspecified  | 10  | 2%  |
| <b>Residency Training*</b>                           |     |     |
| Internal medicine                                    | 310 | 56% |
| Family medicine                                      | 214 | 38% |
| Currently a resident/fellow                          | 21  | 4%  |
| <b>Fellowship Training*</b>                          |     |     |
| Geriatrics fellowship                                | 192 | 34% |
| <b>Number of Years Practicing Medicine</b>           |     |     |
| 1 to 10 years  | 122 | 22% |
| 11 to 20 years                                       | 140 | 25% |
| >20 years  | 258 | 46% |
| Still in training                                    | 36  | 6%  |
| No Response  | 2   | <1% |
| <b>Percentage of clinical time in the NH</b>         |     |     |
| None-10%   | 64  | 12% |
| 10–25%   | 175 | 31% |
| 26–50%   | 139 | 25% |
| 51–75%   | 72  | 13% |
| >75%   | 108 | 19% |
| <b>Number of NHs where clinical care is provided</b> |     |     |
| 1  | 166 | 30% |
| 2–5  | 296 | 53% |
| >5   | 88  | 16% |
| No response  | 8   | 1%  |

NH= nursing home \*Residency and Fellowship training responses add up to more or less than 100% due to multiple responses and omitted responses, respectively. Others may not add up to 100% due to roundin

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