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Patient monitoring

IntelliSpace Console

Combatting information overload in the ICU

July 2018

Information overload in the modern ICU

Critical care departments are the most information-rich areas in the hospital. For every patient, clinicians on morning rounds are asked to absorb and understand more than 2000 variables, including vital signs, laboratory tests, clinical assessments, medications, and images.[1] In fact, it is estimated that the average patient in the ICU generates over 1200 data points per day.[2]

Although this information is necessary for decision-making, it can also be a source of increased workload and possibly life-threatening errors. A study estimated that an average of 178 processes of care are delivered to each ICU patient per day with 1.7 of them associated with some error.[3] The same study identified 554 errors and over 200 serious errors in a single ICU over a 4-month period. Nearly all ICU patients suffer a potentially life-threatening error during their stay,[4] with medication errors accounting for 78% of serious medical errors.[5] These errors result in harm to patients, with more than 100,000 patients dying every year in US hospitals because of human errors.[28] There is also a high cost involved with nearly $324 million in monthly costs to the Centers for Medicare and Medicaid Services (CMS).[6]

Errors in the ICU

To analyze errors in the ICU, Drews et al.[7] build on Reason's model in identifying organization accidents, and distinguish between two elements present in cases of human error: active failures and latent conditions.

Active failures include the following types of errors:

- **Action slips** – e.g. selecting the wrong menu when programming an infusion pump.
- **Lapses** – e.g. forgetting an important step in a structured task.
- **Mistakes** – e.g. misdiagnosis or therapeutic errors due to an incorrect understanding of a situation.
- **Violations of operating practices, procedures, or standards** – e.g. not performing hand hygiene or not adhering to guidelines in treatments.

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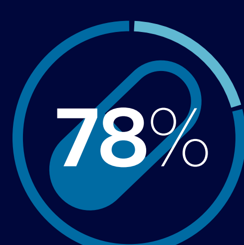

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Latent conditions can be thought of as resident pathogens within the system that lead to errors. They can be created by management or senior clinicians with responsibility for decisions at the unit level, in addition to organizational inefficiencies. Very common latent conditions in the ICU include high workloads, insufficient training, insufficient supervision and auditing, as well as inadequate or confusing equipment/software interfaces.

In many cases, adverse events are caused by more than one error or underlying condition. For example, unfamiliarity with a situation, combined with time pressure and impoverished information quality can lead to prescribing the wrong dose of medication (wrong dosages of insulin for example[8]). Approximately, one fifth of these medication errors in the ICU are life threatening, and almost half are of sufficient clinical importance to warrant additional life-sustaining treatments.[9]

The following are some of the reasons why errors are common in the ICU compared to non-critical areas in the hospital:

- **The severity of illness of ICU patients:** Critically ill patients are assigned twice as many medications as patients outside the ICU. In addition, several conditions, such as sepsis and kidney injury, are highly related and affect multiple organs.[10]
- **The complexity of decisions:** An intensivist is faced with several decisions involving patient pathology, treatments provided, medications and clinical history.
- **The ICU environment:** Highly stressful with a high turnover of providers. Patients can deteriorate rapidly and require urgent attention.
- **Multiple care providers:** challenges in integrating different care-plans.
- **Human factors, accounting for a high percentage of errors:**[7]
  – Interruptions: These are very common in critical care areas, with about 1 interruption every 2 minutes in trauma centers[11]
  – Unfamiliarity with situations
  – Time pressure
  – Low signal to noise ratio (also relating to alarm fatigue)
  – Communication problems between different teams[3]
  – Impoverished information quality
  – Ambiguity in performance standards
  – Disruption in normal work-sleep cycles and physician burnout[12]
  – Mismatch between an operator's mental model and that imagined by the device or software designer
  – High cognitive load required to analyze conditions and relate them to patient history and interventions

These factors combined can lead to errors in treatments, and can make decision making more difficult for clinicians. The next section looks into the types of decisions that could go wrong.

Decision making in a busy ICU

To evaluate the decision making process of intensivists, a recent study analyzed a 24-bed ICU over 80 days, revealing a high number of decisions made per round. On average, more than 100 decisions are made per round over 3.7 hours.[13] In reality, the numbers are higher as many decisions are made outside these rounds. The most frequent decisions by intensivists (36.4%) are related to medication management. For critical care nurses, the number of decisions is actually higher, with 1 decision made every 30 seconds. The most frequent types being assessment and evaluation decisions (51.4%), communication (29.5%) and intervention (19.3%).[14]

Misdiagnosis is 50% more common in ICU patients than in general hospital patients, as revealed by a Hopkins survey that analyzed 540,000 deaths in the ICU.[15] The study also revealed that more than one in four patients had a missed diagnosis at the time of their death. In about 8% of these patients, misdiagnosis was serious enough to have caused or contributed to the patient's death. Misdiagnosis of infections and vascular problems, such as heart attack and stroke, accounted for about three-fourths of the fatal errors.

EMRs and decision making

EMRs were originally developed as accounting tools to capture billing information, making their architecture and display rooted in that application.[16] In most EMRs, data display is "database centered" showing a record of data fields - usually in table form. The display, as well as the delayed and un-contextualized presentation of data,[2] can be problematic for fast-paced clinical environments where clinicians are prone to interruptions and multi-tasking.[17] Clinicians are asked to make faster, yet more calculated decisions while being given a large number of data points due to the availability of new devices and measurements. This information overload leads to limited processing abilities by clinicians affecting their decision making process. The latter results in detrimental effects on patient centered outcomes, such as:

- Incorrect diagnosis of conditions due to the failure to recognize.
- Late interventions due to the failure to rescue.
- Increased cost due to inefficient resource utilization.
- Communication breakdown between medical teams.
- Process failure or omission in care delivery.

How much of this data do we use in clinical decision-making?

The previous sections highlighted the errors that are caused by, among other factors, information overload, interruption and multi-tasking by clinical teams. An important question is that of the right amount of data. How many data points do we actually use when making a decision?

To answer this question, the Mayo clinic observed inter-hospital transfers[18] to assess how clinicians utilize the large amount of data available. The study recorded data fields that receiving clinicians requested, and asked them to complete surveys on the usefulness of data fields in clinical decision-making. The results showed that critical care providers use a small number of data points during the inter-hospital admission process. On average, 13 data points are used for patients with "mild" illness, whereas 18 data points are used for "severe" illnesses. Cognitive science shows that people have difficulty understanding how more than two variables relate without assistance.[19] Thus, it is not surprising that clinicians select only a few fields to view in context. In another study, 156 clinicians were surveyed in 3 sites and the process of admitting new patients was observed.[20] The survey showed that most clinicians (77%) worry about overlooking important information due to the volume of data (74%) and inadequate display/organization (63%).

Despite the overwhelming amount of data and alarms, ICU clinicians actually receive a paucity of useful information. A quick glance at a snapshot of vital signs displayed on a bedside monitor, without context, fails to provide the true meaning of a patient's current physiologic state.[1] Recommendations in literature include presenting only the most important information for concurrent tasks, reducing the number of screens with similar information, and using the proximity-compatibility principle for display layout in EMR screens and dashboards.[21] This principle specifies that displays relevant to a common task or mental operation should be rendered close together in perceptual space. For example, related buttons and tables are arranged closer together.

Addressing the problem

IntelliSpace Console Critical Care is based on a multi-year research/clinical collaboration between Philips, Ambient Clinical Analytics and the Mayo Clinic. IntelliSpace Console is rendered using evidence-based guidelines to provide clinicians with an overview of their ICU patient population including acuity level, life support details and other key information.[22] It extracts high fidelity information from different data sources such as the EMR, the lab systems and monitoring devices in order to present organ-based summaries. It also provides the following features that can positively affect patient care.

Organized data for actionable insights

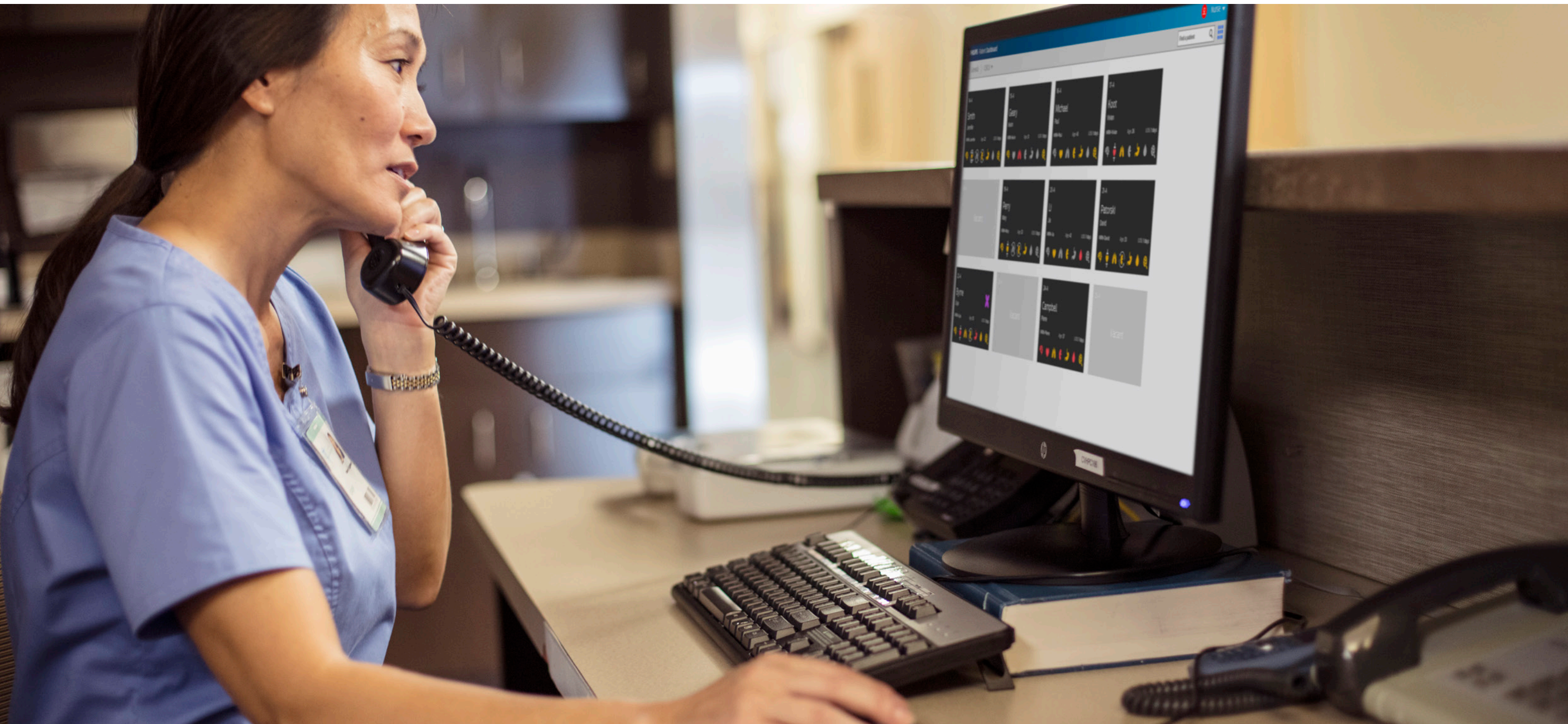
The patient-centric dashboard includes acuity levels, details on life support and changes in patient clinical data. These components support collaboration and ease information sharing during rounding or shift changes. Figure 1 shows an example of a multi-patient view with organ representation highlighting the most pertinent conditions. Figure 2 shows a single patient view with the most relevant data. Irregular values are emphasized, allowing for improved decision-making.

Supporting efficient workflow

Developed to improve workflow, IntelliSpace Console supports transitions between teams. It also offers reports on compliance status in addition to quality measures (such as Medicare Medicaid quality measures in the US). It can also be seen as a tool that can standardize care and help reduce variability in clinical decision making among different hospitals.

Reflecting the way clinicians think

Rather than showing hundreds of data points, the organ-based representation reflects the approach of most clinicians in assessing the patient in a holistic way. It also uses around 250 evidence-based rules and algorithms that were tested by Mayo Clinic clinicians.



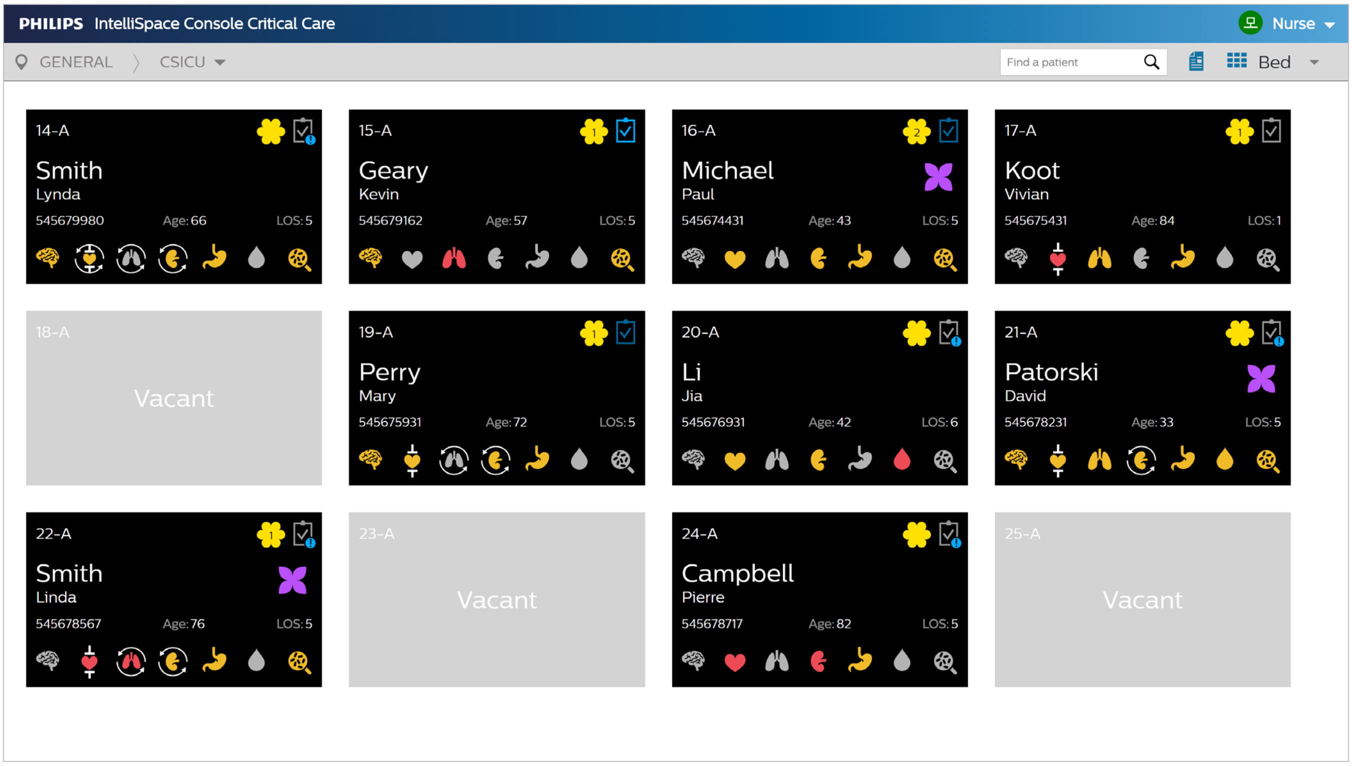


Figure 1: Multi-patient view with the most pertinent conditions displayed per patient.

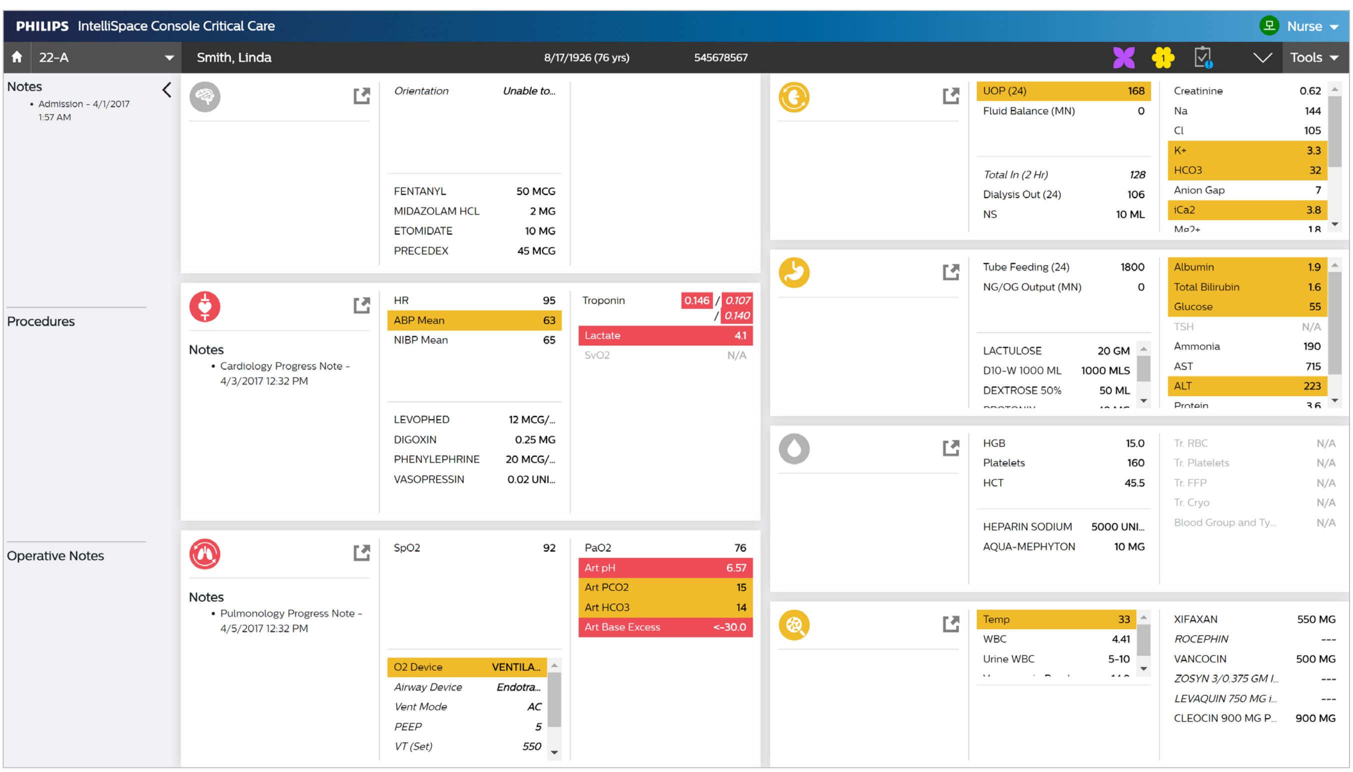


Figure 2: Single patient view- showing the most relevant data per organ and highlighting irregular values.

55%

Potential reduction in medical errors.[23,24]

50%

Reduction in ICU length of stay.[25]

37%

Reduction in hospital length of stay.[25]

30%

Reduction in total charges for hospital.[25]

IntelliSpace Console addresses some of the key critical care challenges as shown in Table 1. Compared to a traditional EMR, the use of systems like IntelliSpace Console has been shown to reduce time to task completion and cognitive load when viewing patient health data of critically ill patients.[23] This has the potential to reduce medical errors by 55%.[23,24]

Use of systems like IntelliSpace Console has been shown to result in statistically significant reductions in overall and ICU length of stay and in total hospitalization charges. The ICU length of stay decreased by about 50%, the hospital length of stay by 37%, and the total charges for hospital stay by 30%.[25]

Critical care challenge	IntelliSpace Console Critical Care
High cognitive load	Organ-based summary of the actionable information in a simplified yet highly informative framework
Data overload with low focus on context	Presenting only what is needed, based on years of clinical co-development with the Mayo clinic
Inefficient workflows and interruptions	Easy to access contextual information when it is needed
Communication between teams	Clinical rounding tool that supports collaboration and eases information sharing during rounding or shift changes
Complexity of relationships between different organs	Organ-based summary of the actionable information. By seeing it all at once, clinicians can make easier mental relationships
Lack of clinical decision support at the point of care	Includes well-researched tools for decision support based on more than 250 rules, guidelines and clinical analytics research[26,27]
Unavailability of checklists and guidelines at the point of care	Includes important checklists and guidelines

Table 1: Showing how IntelliSpace Console can address several of the most pressing challenges that can lead to errors in critical care.

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