PHILIPS

Connected care

The future of patient care is now

Connected critical care at Philips

Introduction

The demand for acute care is expected to grow, driven by an aging population and a rise in chronic conditions and co-morbidities. This demand is accompanied by several challenges as healthcare systems struggle with the reduced availability of expert clinicians, financial constraints, and lack of standardization in many areas of care.

The graphic below shows some statistics revealing some of the challenges intensive care units (ICUs) are facing in the United States. Many of these challenges could be even more pronounced in other geographies.

Digitization has had a positive influence in addressing challenges in critical care, leading to a growing trend of healthcare IT adoption in many countries. Digitization has been shown to reduce errors in care - in particular medication errors[5] - halving the rates of preventable adverse events as shown by several studies.[6] It has a positive effect on reducing documentation time (by up to 30% in some cases[7]), improving nursing workflows,[7,8] and optimizing resource utilization.[8] Its impact on clinical outcomes has also been shown in several studies, with an improvement demonstrated in ventilator use,[9] nutritional support,[10] as well as a reduction in both length of stay[11] and mortality.[9] These benefits, combined with medical error reduction and improved quality of care, can lead to significant financial improvements. We refer the reader to the **recent white paper** showing the positive effects of digitization.

Although the effects of digitization are generally positive, it is accompanied with a set of challenges that could negatively affect care. These challenges are:

Data interoperability lacking between different systems

Interoperability of different systems emerged as one of the main challenges faced by Health Systems in a recent report reflecting the opinion of healthcare C-suite leaders from 40 major U.S. health systems.[12] A lack of interoperability has made it more difficult for health systems to exchange information across different vendors, and address certain key priorities, most commonly improved efficiency / cost reduction, tracking longitudinal patient data and performing advanced analytics. Integration with the EMR has been flagged as one of the most challenging areas in another recent federal report.[13] Although integration can be feasible, many vendors limit the type and fidelity of the data shared.

ICU challenges

Less than 15% of ICUs are able to provide intensivist care.[1]

Almost half of critical care physicians and nurses **are reporting severe burnout**.[2]

Misdiagnosis in the ICU is 50% more common than other areas in the hospital.[3]

Delayed transfer from the ICU is very common and is associated with mortality – **each 1 hour delay is associated with a 3% increase in odds of mortality**.[4]

Devices and data entry compete for clinician's attention

Alarm fatigue is one of the most serious problems that clinicians face in the ICU, with devices competing in what is dubbed "the alarm race". Devices such as ventilators, drug infusers, and patient monitors could be sounding alarms due to the same underlying physiology. However, they do not interact with each other, and their alarms (mostly non-urgent) compete for clinicians' attention. In fact, nurses answer a false alarm on average every 90 seconds.[14] They also face an average of 200 duties per shift, and spend a lot of time double-checking orders and logging data, sometimes from one device to another, reducing the time they actually spend with their patients.

High demands of technology

The increased use of technologies (both devices and software) in critical care is accompanied by an effort to learn and integrate them in daily clinical workflows. The introduction of new technology can cause nurses to experience high levels of stress before they achieve technological competence.[15] Nurses who are poorly prepared for the use of new technologies could suffer major stress and overload.[16] This could lead them to focus on the equipment, and not have enough time to attend to their patients.[17]

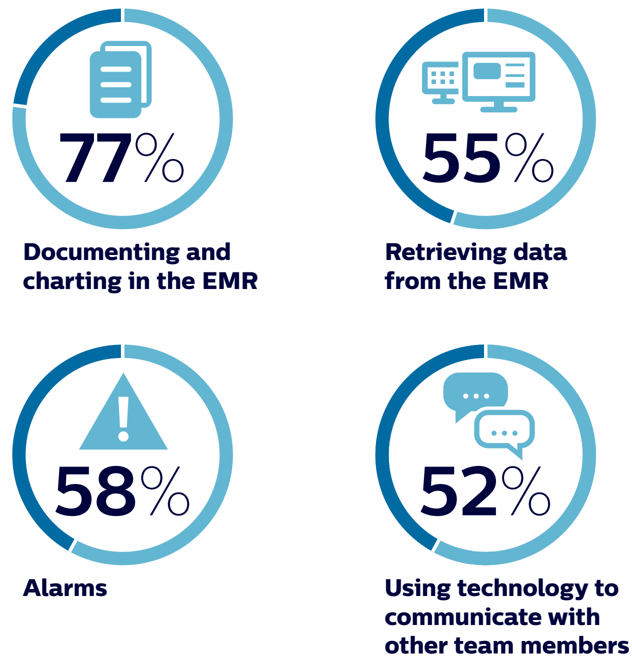
Cognitive overload

It is estimated that the average ICU patient generates over 1,200 data points per day.[18] For every patient, clinicians on rounds are asked to absorb and understand variables including vital signs, laboratory tests, clinical assessments, medications, and images. This data, although necessary for decision-making, can be a source of increased workload and possibly life threatening errors; mainly due to the high cognitive load required. Although there have been attempts to streamline this data and represent it on different screens, there is still a lot of work to be done. EMRs, ventilators, and monitoring devices usually represent their data separately, forcing clinicians to check several screens. In fact, only a small portion of this data is used for decision making at particular points in the patient journey.[19]

In a recent study that surveyed 323 clinicians and IT leaders, cognitive overload due to technology emerged as a serious threat to care.[20] The following table shows some of the sources of cognitive overload due to technology:[20]

Sources of cognitive overload

(% of respondents agreeing)[20]



Miscommunication between teams

Poor communication in critical care teams has been frequently shown as a contributing factor to adverse events.[21] An analysis of published ICU critical incident studies found that just under half of all contributory factors underlying critical incidents were related to non-technical skills (e.g. teamwork and decision-making), with poor communication frequently being reported as contributing to the occurrence of critical incidents.[22] The large amount of data plays a negative effect on the clinicians' ability to select information to share.
A report compiled by patient safety experts CRICO Strategies, investigated how miscommunication affects health delivery.[23] The report estimated that miscommunication alone costs the US healthcare system $1.7B per year. Errors occur because "information can be unrecorded, misdirected, never received, never retrieved or ignored."

Coordinating care delivery across multiple sites and departments

Studies have shown that hospitals with a dedicated intensivist on staff had a significant reduction in ICU mortality and length of stay.[24] However, there is a shortage of intensivists worldwide, and the demand for them will get higher with an increasingly aging population.[25] This is also contributing to the need for additional critical care beds and stressing resources. Particularly in remote geographies and secondary hospitals, the critical care specialist shortage can make it necessary to transfer patients to receive appropriate levels of care. The complexity of today's ICU services emphasizes the need for sharing health information through off-site ICU centers.

Some data can also be at risk of loss as patients move between different departments even within the same hospital. This results in gaps in monitoring during transport, which presents risks to the patient and an incomplete record for the provider. Missing and incomplete data can lead to misdiagnoses, wrong treatment and ineffective care, resulting in unnecessary costs and medical errors that can potentially cause harm to the patient.

Operational dilemmas

Several recent studies have shown that ICU patients, who are ready for transfer, end up staying in the ICU for longer than necessary; on average up to 15 extra hours.[26] This ends up causing a bottleneck in the ICU and causing congestion in other areas, such as the Emergency Department (ED) and post-surgery care areas. Non-necessary stays also lead to overcrowding, delays in care and financial consequences.[26] Delayed stays or unnecessary ICU admissions can also increase the risk of overly aggressive treatments, exposure to errors, or nosocomial infections (high rates of 8% of ICU patients in Europe[27]), pain and discomfort, deconditioning, cognitive impairment, and psychological problems such as posttraumatic stress disorder and depression.[28]

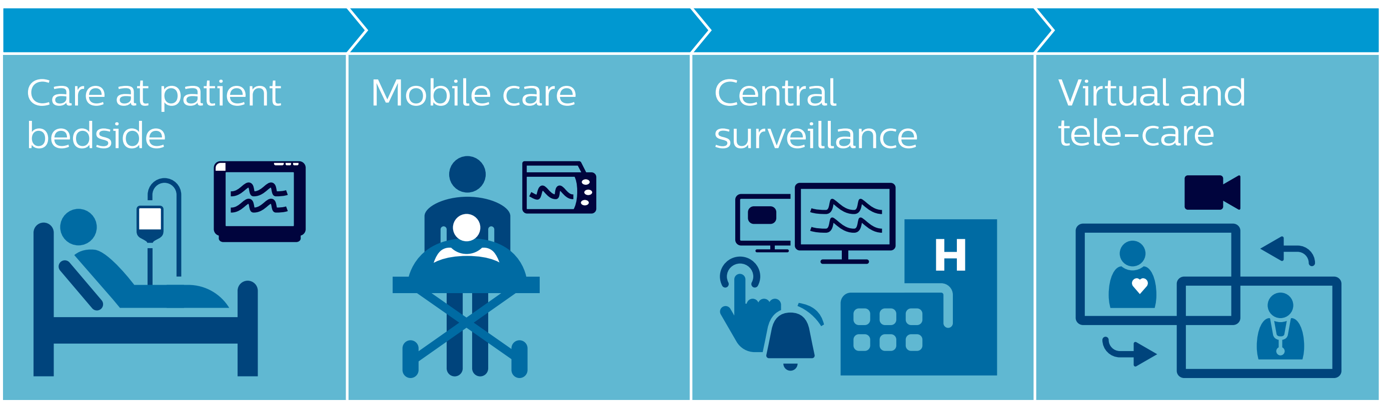
Protecting privacy and cybersecurity

Security has emerged as a priority as hospitals worldwide go digital, storing and processing large amounts of sensitive patient data. This data needs to be protected from hackers and cybercriminals who have stepped up their attacks over the last few years.[29] Healthcare systems are expected to increase spending in this area, focusing on staff education and technology.[29] With the move to cloud data-storage, an increased effort is needed to protect all parts of the system from Malware, raising cybersecurity to be one of the top challenges that health system information officers expect to face.[29]

Providing connected care throughout the patient journey

Philips is in a unique position to collaborate with your clinical teams to provide connected care for patients at any point in their critical care journey. Our portfolio of interoperable products developed with clinical teams worldwide offers solutions to your most pertinent critical care bottlenecks, leading to improved clinical[30] and financial outcomes.[31]

The following sections follow patients through their critical journey, and highlights some of our solutions with a focus on interoperability, clinical guideline adherence, communication, clinical decision-making, optimizing remote care, analytics and clinical transformation.



Continuous vigilance

Care team mobility and remote access

Interoperability

Adherence to clinical guidelines

Communication and collaboration

Clinical decision making through continuous demand surveillance

Tele-care capabilities

Benchmarking, data-analytics and novel AI tools

Clinical transformation

Continuous vigilance

Highlighted solution: **IntelliVue transport monitors**

Philips IntelliVue patient monitoring with IntelliVue X3 transport monitors enables continuous monitoring that supports improved clinical workflow, and eliminates the need to exchange cables in order to transport the patient between different departments. It aims to increase patient throughput by decreasing transition time in mission critical operations, as well as providing a continuous stream of clinical quality data-helping clinicians with decision making at all stages of the patient journey.

Case study:

Hirslanden Klinik increasing patient throughput and optimizing transport[32]

Hirslanden Klinik Aarau in Switzerland treats 10,000 inpatients annually across two surgical departments and four operating suites. They needed efficient processes in order to increase the number of patients they treat daily and maintain their high quality standards. They used IntelliVue transport monitors to enhance their clinical workflows and enable continuous clinical monitoring. They obtained a decrease in time between surgical cases by 5.5 minutes by optimizing anesthesia related tasks. They also eliminated a 15-minute gap of coverage per patient during transport.[32]

Care team mobility and remote access

Highlighted solution: **Philips Patient Information Center iX (PIC iX) and CareEvent event management system**

Philips provides an end-to-end patient monitoring solution that includes primary monitoring at the bedside, monitoring at the central station within the unit, and mobile applications on caregivers' smartphones. When clinicians are on the front line providing patient care, they are often expected to be everywhere at once. Delivering quality care to all their patients requires keeping abreast of patients' conditions, carefully scheduling their time, relying on teamwork, and responding quickly to critical situations. Philips Patient Information Center (PIC iX) provides a powerful central monitoring system that gives them one, intuitive view of each patient's status, including ECG waveforms, numerics, trends, labs, and more. Each view is personalized to the patient's clinical condition and configured for each department.

In association with PIC iX, Philips provides an enterprise event management solution - CareEvent. This solution includes a mobile application to send informative alerts directly to clinicians' smartphones so they can make informed decisions and take fast action when required. With clinical context in their hands, clinicians can determine the validity and priority of an alarm, and make an informed decision to respond, escalate it to a colleague, or rule it non-actionable. Teams also can communicate with each other using the CareEvent mobile application through secured text messaging.

Case study:

Enhancing nurse alarm management and workflow in a Cardiac Telemetry Unit with Philips CareEvent – Lingen Germany[33]

A time-motion study was performed in Bonifatius Hospital Lingen, involving 60 cardiology beds on 2 regular wards and a central monitoring system, allowing for visualization of the 26 patient monitoring units covering both wards. Twelve of the patient monitoring units were telemetry units, whereas the others were fixed bedside monitoring systems. This conventional alarming system was augmented with Philips CareEvent. Philips Professional Services customized the alarm management solution and provided dedicated on-site training. The system was evaluated for 128 days with the following findings:[33]

- **100% of Arrhythmia alarms were confirmed to be forwarded through CareEvent with no alarm escalation failure.**
- **21% of average walking time per day could be saved by using CareEvent instead of walking to the central station.**
- **35% of alarms were escalated beyond the first smart phone during the day, with a median time to accept an alarm of 8 seconds. 26% of alarms were escalated beyond the first smart phone during the night, with a median time to accept an alarm of 9 seconds.**

Interoperability

Highlighted solution: **IntelliBridge Enterprise**

As the volume of patient data increases, so does the complexity of the interfaces among medical devices, hospital information systems, and the electronic health record (EHR). Philips IntelliBridge Enterprise (IBE) provides a single, standards-based point of contact between the EHR and Philips clinical solutions. This reduces the number and cost of point-to-point interfaces, and offers workflow efficiencies to help improve the quality of patient care. It also facilitates the collection of data from multiple sources for research, comparative effectiveness and baselining activities. IBE can also automate the export of features (such as waveform snippets) along with the patient's demographic information to simplify workflows.

Case study:
Improved interoperability at Hardin Memorial

Leaders at Hardin Memorial Hospital, a 300-bed hospital in Elizabethtown, Kentucky integrated IBE as an interfacing solution as part of their overall interoperability strategy. The following are some of the targets they achieved:[34]

- Improved charting of vitals: In the post-anesthesia care unit (PACU), where constant vital signs monitoring is required, vital signs data are sent from the IntelliVue monitors through IntelliBridge Enterprise to the EMR, and charted more frequently.
- Eliminating double charting on the patient chart and the EMR.
- Having real-time data flow directly from the point of care to the EMR when needed (despite the EMR having a slower requirement for vitals charting). This allowed physicians to access vitals data from any location, and eliminated problems with legibility, which existed with paper flow sheets.
- Transmitting ADT info to the monitors: This is done through IBE's bidirectional flow, and it helped match patients to their EMR records and simplify workflows.

Adherence to clinical guidelines

Highlighted solution: **IntelliSpace Critical Care and Anesthesia (ICCA)**

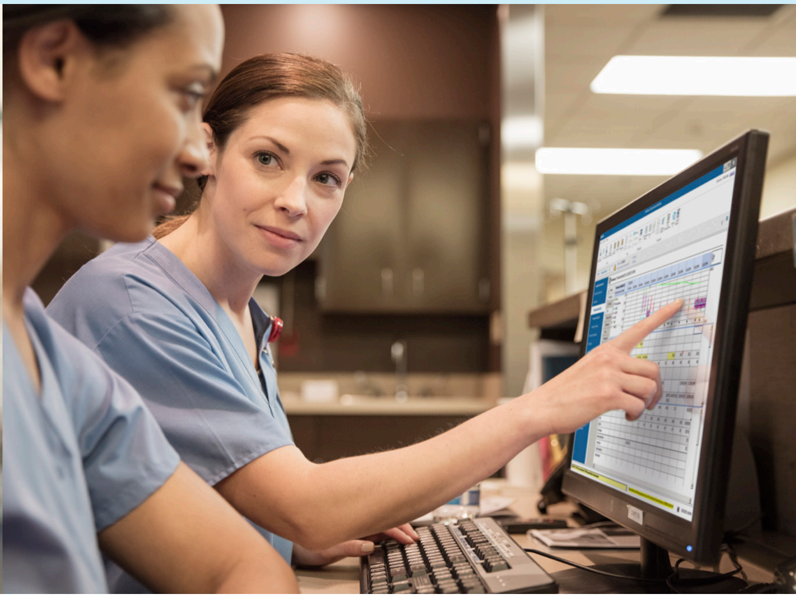
Access to comprehensive patient information is vital in the clinical decision-making process. Nowhere is this more evident than in the hospital critical care environment, where patient care generates a massive amount of data and decision-making needs to be timely and precise. IntelliSpace Critical Care and Anesthesia (ICCA) is an advanced clinical decision support and documentation solution. Specializing in the complex critical care environment, ICCA works with other documentation systems and features interoperability that supports patient documentation throughout the care continuum. ICCA centralizes and organizes patient data, including admissions documents, vital signs, labs, and consult notes to put the clinical information needed front and center. Through embedded clinical decision support, ICCA transforms patient data into actionable information, helping clinicians make informed decisions, highlighting and identifying adverse events, and enhancing the quality of patient care through adherence to clinical guidelines.

Case study:

ICCA's smart data representation and drug prescription modules aim to reduce errors in the ICU

ICCA's prescribing module includes a drug dictionary and orders based on weight and body surface area for most drugs in the ICU. The module also includes dispensing instructions and user alerts for nursing staff when drugs are due. This helps teams avoid medication errors by prescribing the right drug for the right patient at the right time.

These functionalities have been shown to increase medication safety. Imperial College London utilized ICCA's electronic prescribing features in their pediatric ICU, reducing the prevalence of omitted doses by more than 9 times (from 10.6% pre-intervention to 1.4% afterwards).[35] In fact, by the end the six-month period, dose omissions due to reasons other than drug unavailability were eliminated. They also eradicated prescriptions with insufficient information and illegible prescriptions, which had been an issue with the paper-based system. In another study, the team at Oxford University Hospitals NHS trust modified their Philips electronic prescribing system and combined it with an efficient training for its users, achieving significant reductions in the time to the first dose of antibiotics for patients with severe sepsis in the ICU.[36]



Communication and collaboration

Highlighted solution: **IntelliSpace Console Critical Care**

Realizing the need for improved representation and decision-making tools, Philips collaborated with the Mayo Clinic (among other partners) to bring IntelliSpace Console Critical Care to market. 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.[37] It acquires data from the EMR, and presents an organ-based summary of the actionable information.

Case study:

Designed to address key critical care challenges

IntelliSpace Console is intended to reduce time to complete tasks and provide clinicians with decision-making support. Console is designed to reduce both cognitive load, when viewing patient health data of the critically ill, and medical errors, which are estimated to be the third biggest cause of death in the US.

Clinical decision making through continuous demand surveillance

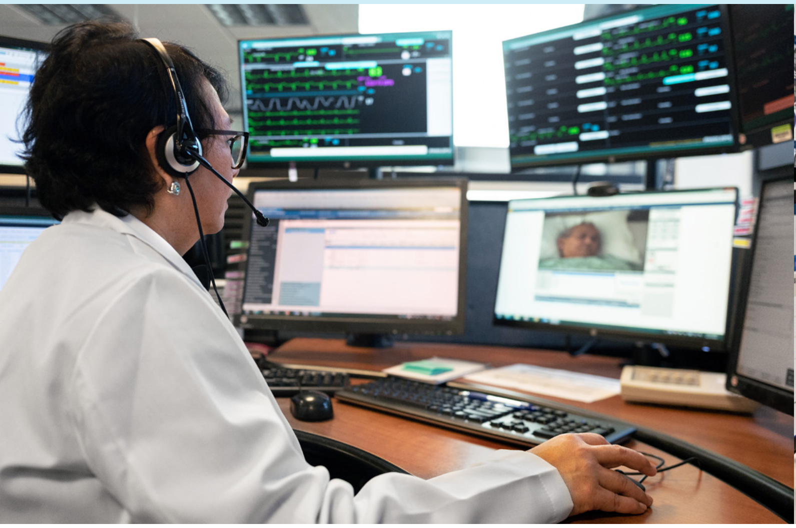
Highlighted solution: **Philips eICU Program**

Philips eICU Program offers centralized, remote surveillance by skilled professionals, proprietary algorithms that provide early warnings for proactive care, and continuous programmatic improvement. This clinical model can help organizations offer constant assessment and care delivery during peak census times as well as during off-hours, expand access to specialized care to remote locations, and transform the cost/care equation. In terms of clinical decision support, eICU offers efficient means of triaging patients by using automated acuity scores, guideline-based scores, predictive analytics and improved data representation through customized watch lists for vulnerable patients.

Case study:

Clinical decision support for ventilation management using eICU

Ventilator-induced lung injury is a major contributor to mortality in patients with ARDS (acute respiratory distress syndrome). Lung protective ventilation has been shown in many studies to reduce ventilator-induced lung injury in patients suffering from ARDS.[38,39] However, adherence is low[40] and results show a large variability in practice. Philips eICU was used in a multicenter population based effectiveness study that covered eleven hospitals to improve adherence to protective lung ventilation strategies.[41] The established target for the clinical project was to facilitate a daily, organized appraisal of proper adherence to lung protective ventilation in intubated patients and when appropriate, extubation. The central organizing instrument of this process was a clinical decision support checklist to help ensure that tele ICU practitioners evaluated ventilation parameters and vitals. Before this study, there was wide variation in hospital adherence to low tidal volume in all 11 hospitals. Participating institutions were moderate-sized community hospital ICUs from a wide geographic distribution. Longitudinal improvement was seen across hospitals in the three quarters after implementation, reaching statistical significance by the third quarter post implementation. **After implementation, a significant reduction in mean ventilator duration was observed**. Intensive care unit mortality ratio also demonstrated longitudinal improvement, reaching significance after the third quarter post-implementation.[41] Results show that the combination of a clinical decision tool with clinical transformation and training can lead to evident improvements in patient safety.



Tele-care capabilities

Highlighted solution: **Philips Tele-ICU solutions eICU and IntelliSpace Consultative Critical Care (ICCC)**

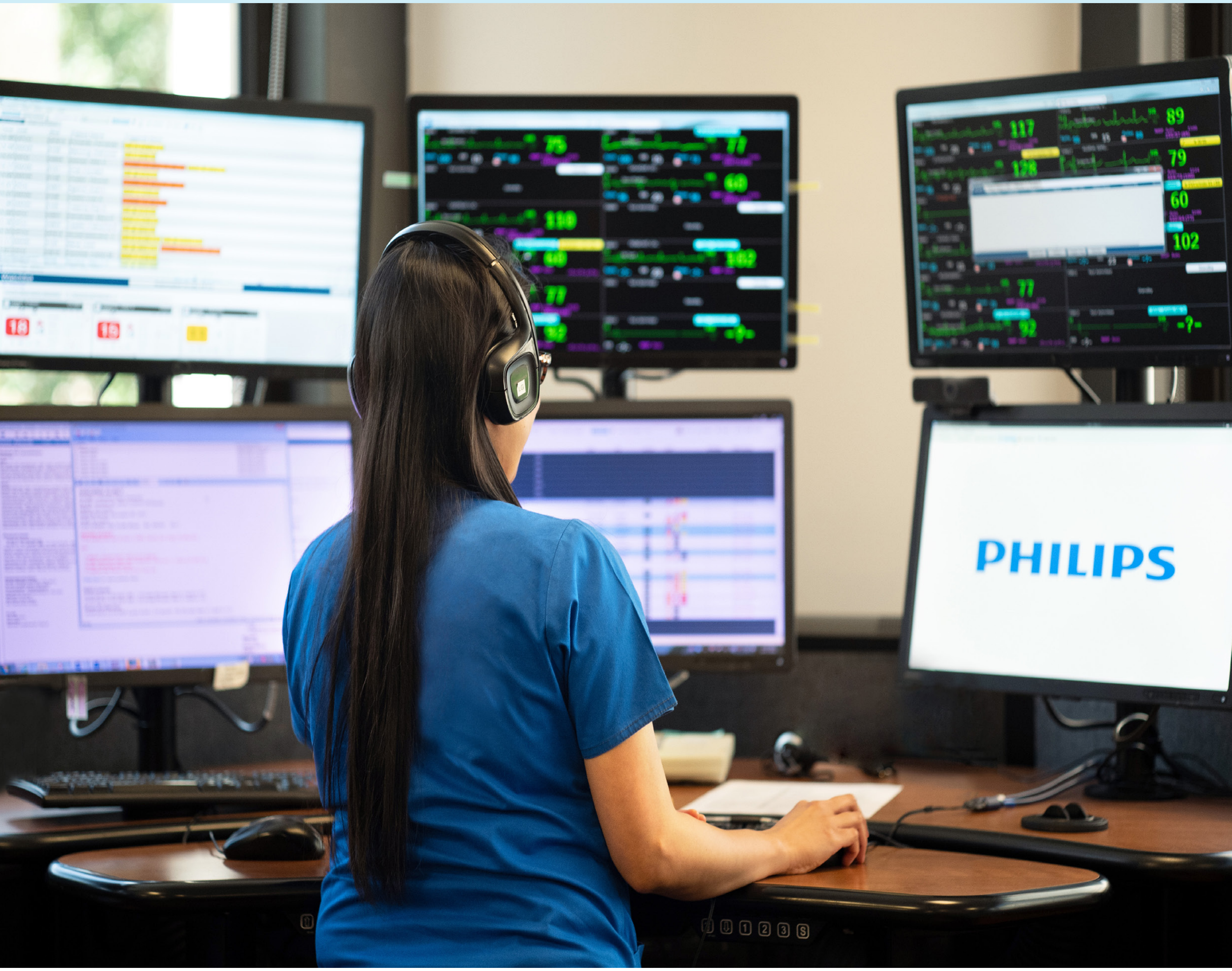
Philips has deployed the largest national tele-ICU network in the United States, covering more than 11% of ICU beds through the eICU Program.[42] This provided Philips access to extensive clinical-quality datasets from hundreds of ICUs, helping them develop tools for clinical decision support, advanced analytics, as well as improved patient care.[43] In addition to clinical data-acquisition, such an extensive network of hospitals has allowed Philips to develop best practices in terms of clinical transformation, training and efficient deployment of ICU telemedicine. **The following table shows some of the effects of tele-ICU on hospitals, focusing on clinical and financial outcomes**.

Worldwide, Philips also provides a pioneering consultative critical care solution: IntelliSpace Consultative Critical Care (ICCC), which allows virtually continuous monitoring of multiple intensive care units from a single remote location known as the Command Center from any geographically distributed location. It provides tools to enable supplemental monitoring support through its ability to integrate, aggregate and present meaningful clinical data. Some of its features include prioritizing patient profiles based on acuity, bi-directional audio video communication, interoperability with EMRs and providing decision support indices to assess patient risk.

Boosting health outcomes	Financial impact
Patients who receive their ICU care from a hospital with a tele-ICU program are: 26% **more likely to survive the ICU.** 16% **Overall hospital mortality fell by 16% due to tele-ICU.**[44]	Over a 15-month period from April 2014 to June 2015, Emory health system achieved the following results across 136 beds at five hospital sites due to tele-ICU:[45] • **Saved an estimated $4.6 million** – a $1,486 reduction in average Medicare spending per patient • **Discharged more patients to less expensive home healthcare services** (+4.9%) rather than more costly nursing homes or long-term care hospitals (-6.9%) • **Decreased 60-day inpatient readmission** by 2.1%
Shorter length of stay due to tele-ICU (9.8 vs 13.3 days.[30])	**Increasing annual case volume** from 4,752 (pre-ICU telemedicine) to 5,735 (ICU telemedicine) and 6,581 (logistic center- ICU tele medicine with logistic support).[31]
Improved guideline adherence (post tele ICU vs pre tele-ICU):[30] • **Prevention of deep vein thrombosis** (99% vs 85%, respectively) • **Prevention of stress ulcers** (96% vs 83%, respectively) • **Cardiovascular protection** (99% vs 80%, respectively) • **Prevention of ventilator-associated pneumonia** (52% vs 33%, respectively) • **Lower rates of preventable complications** (1.6% vs 13%, respectively)	**The annual direct contribution margin improved** from $7,921,584 (pre-ICU telemedicine) to $37,668,512 (ICU telemedicine) to $60,586,397 (logistic center) due to increased case volume, higher case revenue relative to direct costs, and shorter length of stay.[31]

Case study:
ICU telemedicine reduces inter hospital ICU transfers of critically ill patients

An earlier study evaluated the impact of a 15 hospital, rural multi-state ICU tele medicine program in the US showing improvements in the quality of critical care services and reduced transfers for smaller facilities.[46] More recently, a study by teams from the Department of Veteran's Affairs (VA) tracked 553,523 patients admitted to 306 VA hospital ICUs from October 2009 through September 2015, excluding those for whom vital data were missing.[47] During this period, the VA implemented Tele-ICU at 52 ICUs in 23 facilities in nine states aiming to provide remote access to comprehensive acute care expertise for smaller, community, and regional ICUs in its health system. **The study showed that the use of tele-ICU allowed local ICUs to treat more critically ill patients on site and reduce hospital transfers to other hospitals**. The findings were not affected by the day of admission or ICU patient volume levels. The decrease in transfers was seen in all patient groups except those presenting with mild illness severity. Tele-ICU did not change overall adjusted or unadjusted 30-day mortality in this study.[47]



Benchmarking, data-analytics and novel AI tools

Highlighted solution: **Philips eICU Research Institute**

The access to large amounts of clinical quality data from multiple sites has facilitated the creation of reference critical care datasets that have been used for benchmarking, discovering the relationship between morbidity, treatments and outcomes.[43,48] An example is the eICU Collaborative Research Database, which is a large multi-center critical care database made available by Philips Healthcare in partnership with the MIT Laboratory for Computational Physiology. These datasets combined with Machine Learning techniques, have allowed the development of several novel AI tools with a focus on deterioration detection and therapy recommendation.[49] Philips eICU Research Institute (eRI), a non-profit institute established by Philips and governed by customers, is a platform built from a repository of data that is used to advance knowledge of critical and acute care. These platforms has provided a collaborative framework for the research that we'll highlight in the case studies below.

Case study:
The AI clinician learns optimal treatment strategies for sepsis in the ICU

Sepsis is the third leading cause of death worldwide and the main cause of mortality in hospitals, but the best treatment strategy remains uncertain.[50] In particular, evidence suggests that current practices in the administration of intravenous fluids and vasopressors are suboptimal and likely induce harm in a proportion of patients.[51] To address this, researchers from Philips collaborated with others from Imperial College London and the Massachusetts Institute of Technology (MIT) to develop an AI agent, based on reinforcement learning. They proved that based on their existing data, the value of the AI Clinician's selected treatment is on average reliably higher than human clinicians.[49] In fact, in a large validation cohort independent of the training data, mortality was lowest in patients for whom clinicians' actual doses matched the AI decision. The large datasets available played an important role in making this work possible. The Medical Information Mart for Intensive Care version III (MIMIC-III) was used for model development,[52] and the eICU Research Institute Database (eRI) for model testing. This work was recently published in Nature Medicine.

Case study:
The discharge readiness score

Prolonged duration of stay in the intensive care unit (ICU) is costly, stressful for patients and families, reduces the number of beds available for other patients, and can increase risk for complications.[53] Determining who is ready for ICU discharge is a daily challenge for ICU leaders, especially in units with high occupancy rates. Traditionally these decisions are made by attending physicians, in collaboration with other members of the ICU care team. Due to the highly subjective nature of these decisions, there is considerable variability in determining discharge readiness.[54] Based on the rich eICU Research Institute Database, the Philips team developed a new discharge readiness score.[54] This index was used as a continuous marker of severity of illness and compared to existing scores such as the APACHE and SOFA scores. It showed to perform better than other scores for predicting mortality with higher under the receiver operating characteristic curve (ROC).[55] Having improved scores that provide continuous measurements would allow clinicians to improve the triaging of patients and their flow to appropriate levels of care.

Clinical transformation

Highlighted solution: **Philips Healthcare Transformation Services**

Philips Healthcare Transformation Services was established to provide a support framework for long-term healthcare transformation. The teams provide strategic healthcare consulting to help customers achieve clinical excellence and operational efficiency while improving financial performance and delivering quality care. Philips Healthcare Transformation Services team brings a highly collaborative approach, working side-by-side with client teams. They use data as a foundation and leverage deep clinical expertise to help transform the patient experience and achieve strategic objectives.

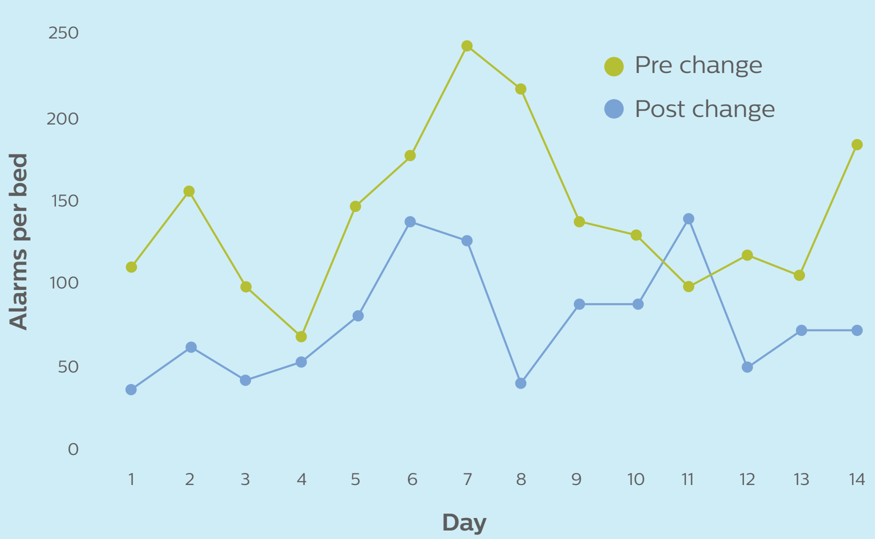
Case study:
A holistic approach to reducing alarm fatigue

Augusta University Health (AU Health) was looking to reduce their non-actionable alarms, decrease hospital alarm fatigue, and create a comprehensive alarm management system. Philips clinical consultants stepped in and reviewed the alarm data and settings, interviewed stakeholders, and documented current AU Health processes. A Clinical Alarm Management Policy was implemented. An alarm reporting application dashboard was created to monitor results and identify future areas of concern. AU Health achieved strong results quickly: 32% reduction in non-actionable alarms in the first three months with no adverse patient outcomes identified.[56] Over one year post changes, the pilot units have continued to show health system improvements, reducing alarms in the MICU by 41.4% and alarms in the Telemetry Unit by 55.3%.

32% reduction in non-actionable alarms in 3 months

Reduced disruption caused by non-actionable alarms

55.3% reduction in alarms in the Telemetry Unit



Through a unique understanding of clinical issues and continuous collaboration with customers, Philips has become the go-to company for connected care solutions across the hospital. **Our solutions from bedside care, to mobile and virtual care, provide our customers with the right tools to help them in their journey towards value-based healthcare.**

The case studies highlighted in this piece give only a small example of our daily success stories with customers worldwide. We are committed to providing connected care solutions, including AI and novel sensors that optimize clinical outcomes as well as patient and staff satisfaction. All the while, reducing the cost of providing quality critical care.

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