



Innovative Designs for the Smart ICU

Part 1: From Initial Thoughts to Occupancy

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Designing a smart ICU is a time-consuming, complex, multiphased, political, and costly exercise. This process begins with two notions: First, all hospital parties agree that a new or renovated ICU is required, and second, the hospital has agreed to allocate space, personnel, and fiscal resources for the project. In this first of a three-part series on innovative designs for the smart ICU, we will explore the roles of the ICU design team in managing the design process. The team must be administratively empowered, knowledgeable, and forward thinking. The first charge of the design team is to develop a clear vision for the goals, look and feel, and functionality of the new ICU. This vision must be guided by the imperative to positively impact patients, staff, and visitors. The team must concentrate on innovative but practical ideas that are in compliance with building codes and design guidelines and address issues related to renovation vs new construction. Mock-ups, both physical and computer generated, and a simulation laboratory for advanced technologies should be used to test design assumptions and reveal problems well in advance of actual ICU construction and technology implementation. Technology platforms need to be standardized within the ICU and equipment purchases protected against early obsolescence. The ramifications and expectations of the new ICU must be thoughtfully considered and dealt with during the design process. Last, it is essential that the design group continue its involvement in the new ICU during construction, occupancy, and post occupancy.

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Abbreviation: CCM = critical care medicine

There are approximately 94,000 ICU beds in the 6,300 ICUs that are used to care for the critically ill in the 3,200 acute-care hospitals of the United States.^{1,2} Intensivists are frequently asked to participate in efforts to design new ICUs or renovate old ones. The primary goal of this three-part series on innovative designs for the smart ICU is to help intensivists fully engage in the design process by gaining insights into innovative design concepts. This set of

articles is meant to supplement existing ICU and hospital facility guidelines and recommendations with information from relevant reports and experiences gained through the design of two new adult medical surgical ICUs,³ the renovation of one surgical ICU, and ICU design consultations.⁴⁻⁹ Although the focus is on

For editorial comment see page 205

adult ICUs, many of the concepts are applicable to neonatal and pediatric units. In this first article, we focus on the thought processes, politics, design committee roles, technology acquisition strategies, and expectations that accompany innovative and smart ICU design.

WORKING WITH THE ORGANIZATION AND BUILDING THE ICU DESIGN TEAM

ICU design can succeed in creating top-of-the-line ICUs only if the critical care medicine (CCM) team and the hospital administration share similar design aspirations and clinical goals. Four core principles

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should be considered from the outset. First, an ICU is a semiautonomous mini-hospital. Second, designing an ICU is a complex and time-consuming process. Third, the successful design balances innovation with functionality, space availability, physical limitations, and cost. Last, the design should combine a healing environment with security for patients, staff, visitors, and all ICU equipment and supplies.¹⁰

ICU design projects ideally are guided by a design team with operational autonomy and clearly defined space and cost mandates. The team's core membership should reflect its broad scope of responsibilities (Table 1)⁷ with ad hoc representatives invited as needed. The team should be conjointly chaired by the CCM clinical chief and a hospital's facilities project manager. Importantly, only architects with prior successful ICU design experience should be engaged.

The CCM representatives need to be fully involved in the process and knowledgeable of ICU design guidelines and relevant regulatory issues.^{4,5} Transparency about design assumptions and openness to new and even "out-of-the-box" ideas should be encouraged. Concomitantly, silo thinking and excessive reliance on past approaches ought to be discouraged. However, not all good ideas will be implemented, because competing priorities exist for limited resources and the team members will also have varying perspectives of the ultimate design goals (eg, aesthetics vs operations).¹⁰

Outside pressures may try to influence the course and outcome of the ICU design. This may result from the hospital's desire to proportion ICU space toward revenue generation (patient rooms) rather than ICU support. Additionally, the hospital may seek to shrink the design and construction timeline, constrain costs, and divert already assigned ICU space or resources to other hospital endeavors.

DESIGN TIMELINE

From the start of design to occupancy may take 3 to 5 years. Efficiency requires that the design team be rapidly exposed to excellent ICU design concepts. This may be accomplished through review of video presentations and descriptions of ICU design award winners⁹ (Award Winning ICU Designs at SCCM.org) and visits to select ICUs. Frequent team meetings are necessary, and the process will benefit from regularly scheduled reviews of updated schematics and computerized renderings of the design ideas. Full-scale mock-ups of the patient rooms are crucial to the design process as they permit the bedside teams to experience the design through the prisms of patient throughput; staff workflow; technological functionalities; and visual, tactile, and audio profiles. Complex design dilemmas are best addressed off-line, with their potential

Table 1—ICU Design Team

Team Members
Critical care
Physician leader
Nurse leader
Family and/or patient representatives
Hospital representatives
Administrator
Facility planning
Fiscal oversight
Informatics
Logistics
Biomedical engineering
Outside consultants
Architect
Interior design
Medical equipment
Hospital clinical representation ^a
Pharmacy
Infection control
Renal
Respiratory therapy
Nutrition
Others ^a
Housecleaning
Social work
Patient representative

^aAd hoc representatives.

solutions and ramifications presented to the design committee. The ICU design process is iterative and cannot be overly rushed; nevertheless, the committee chairs must maintain the project's forward momentum to avoid delays and the insidious onset of project fatigue.

THE VISION

The vision of the new ICU precedes the details of the design and should reflect the "hoped for" look, touch, and feel of the new ICU. The vision also addresses the big-picture issues of patient care, workflow, technology, environment, and the ICU relationships with the remainder of the hospital.⁸ Several questions are optimally considered early in the process so the vision and design are reality based. Is the ICU project a renovation or new construction? How will the ICU be physically related to other ICUs and hospital areas (Fig 1)?²⁵ Is the ICU a multipurpose or specialty unit? How many ICU beds are planned (ie, 8-12 beds optimal for patient care and unit management vs more common 20+ beds)? Will the patient rooms be acuity adaptable?²⁶ How much space is available and how will the space be apportioned (ie, patient vs supportive areas)? Will the ICU have centralized or decentralized care and supportive services or a mix of both? Will the ICU function with paper-based or electronic records or both? Will advanced informatics be incorporated? Will the ICU participate in telemedicine coverage?

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